



Ain Shams University
Faculty of Engineering
Department of Architecture

The Use of Interactive Applications in the Design of Public Buildings

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Master of Science Degree in Architecture

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Dina Soliman Baghdady

Dedication

I dedicate this to my family, especially

My beloved mother and father

And

My supporting brother and sister

Every one of you had set an example in a way that brought along this success, without your continuous support, attention and encouragement; it would have been a lot harder for me to accomplish any of this.

Statement

This thesis is submitted to Ain Shams University for the degree of Master in Architecture . The work included in this thesis was accomplished by the author at the Department of Architecture, Faculty of Engineering, Ain shams University from 2006 to 2013.

No part of this thesis has been submitted for a degree or a qualification at any other university or institute.

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Abstract

Nature is always in a changing state of flux, its development and evolution is through creating an interactive dialogue between its elements. So interactivity was always found in nature as an essential need for survival, but only recently researches focus on the concept of interactivity in terms of computer systems creating interconnected, changeable models of information that changes the borders of both time and space that until now have been consolidated. Interactivity so far applied in architecture in terms of; context awareness by reflecting the surrounding interior and exterior conditions. Interacting within the spaces by combining the ideas of video games and surveillance the changes are reflected audio or visual. Spatial sharing and control by enhancing spatial organization, creating environments that act as mediating devices for a social statement. Sensing and controlling the surrounding space by challenging the senses that guide the users to new potentials. Allow communication and information flow, responding to real time information. Spatial reconfiguration, responding to exterior and interior environment conditions in a kinetic manner.

Development of interactive architecture applications has become a necessity. Changes in lifestyles and cultural developments are now occurring fast and are more radical than ever before. There is a necessity for public architectural spaces to be enhanced in ways that would allow them to perform an active dialogue with their content. This trend forces architects to design flexibly and consider the potentials of emerging new spatial requirements; where buildings can dynamically change over time.

The research aims to determine the effect and essences of interactive applications in public buildings and to draw out a comprehensive frame work for identifying to which extent the term interactive is explored and used in architecture and how it affected the performance of buildings with respect to their surrounding environment and users needs.

In order to achieve that, the research had to investigate, explore and determine the roots, aspects, and tools of interactive architecture, and its means of design and application. So the research had to study the following:

The earlier attempts starting from the sixties and the evolvement of architectural approaches like kinetics, responsive and intelligent environment. This was done to identify and determine the meaning and the

ideological concepts of interactive architecture and its development with relevance to technology.

The theory of cybernetics which was behind the ideological concepts defining interactivity as a two way approach and hence setting the relevant foundation of all the digital technologies responsible for the development of the interactive applications. The development of artificial intelligence and virtual reality concepts and technological tools, were also shaded to produce immersive, self-aware systems able to interact. This study helped in understanding the ways and potentials of applying such application in public buildings.

Analyzing the term interactivity in all the fields of its application whether it is in media, art or architecture to realize the main themes of achieving interactive systems and the main features of interactive applications properties, with relevance to public building requirements.

Studying the influence of interactive applications on public buildings through, analyzing case studies of public buildings according to characteristic model generated with relevance to the ideological concepts, design process and tools, interactive applications properties and public requirements.

At the end of the study it was concluded that:

Interactive applications give architecture a chance to express itself away from the traditional constrains and enhance its performance between its built environment and contemporary social demand to create new possibilities satisfying the desires of challenge and change.

So far interactive applications in architecture are limited to buildings and built spaces which are capable of simple responsive adaptations and spatial customizations of various kinds. The potential of having fully interactive spaces and buildings which are able to physically reconfigure form and space by creating a dialogue between the users and their built environment was achieved on the experimental level, this rises the expectation of developing fully integrated interactive applications in buildings in the near future.

The results of this research were that; the development of interaction design, interface design and embedded computation constitutes the main design techniques that guide the behavior of users in public space and maintain a dialogue with them, not only responding to their demands, but also engaging them in all kinds of spatial activities.

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The Use of Interactive Applications In the design of Public Buildings

Introduction

Technological development has become an essential part of everyday activities. Since raising the notion of information age and the development of digital media and remote communication allowed individuals to have their own share of technology giving them wider options of how to perform a certain task with more ease, by Smart phones, I- pads, X-box, android and whatsapp and other the applications opening up new experiences and more expectations of life quality with more interaction. The essence of interactivity is creating loops that widen the experiences through interaction bringing a whole new set of outcomes driven from a different set of inputs.

The last few years have seen distinct escalation of mass development in interactive digital media, portable gadgets, and communication devices, where technological development leans towards being more interactive with its users; has impacted architecture to create places dynamic, adaptive and intelligent enough to be more interactive with its environment. Although architecture has considered these concepts before it was enabled by the current digital technology development.

Buildings were designed as static forms that is able to accommodate users and provide comfortable spaces through design, lighting, thermal control and visual appeal. Changing or redesigning these environments to suit changing human needs are always challenging as human needs vary over time. The challenge now is to develop an architecture that responds and adapts to our needs and demands.

So the main aim of interactive design in architecture is to create spaces and objects that can meet changing needs with respect to evolving individual, social, and environmental demands. Interactive architecture is not only about communication between people, but about building relations between people and the built components.

Interactive Architecture is used in different academic and practical settings to describe different approaches to hybrid digital and physical spaces. From a technological perspective, Interactive Architecture investigates how embedded pervasive and ubiquitous computing systems will provide information and data about structures, environmental impact and human behaviors in spaces. In Architecture, this emerging field introduces new possibilities for building sciences and structural engineering, as well as

new aesthetics for interactive and transformative structures and facades. As for Interaction and Experiences Designers, Interactive Architecture opens up new possibilities for engaging with the built environment in which spaces would not only react or respond to human inputs, but come to recognize and interact with people on a daily basis. Additionally, in many of these fields there has been a renewed interest in both cybernetic systems for the design of new interactive architectural spaces, bringing up how new technologies might encourage adaptive and emergent architectural systems.

Since contemporary ways of life are so rapidly changing in all their aspects, there is an urging necessity for architectural spaces to be enhanced in ways that would allow them to perform an active dialogue with their fluctuating content, to dynamically deal with changing needs of social groups, as well as to directly serve particular individuals. This trend forces architects to design flexibly, to take into account potential emergence of new spatial requirements that cannot be anticipated before the actual building use comes to place and which can dynamically change over time.

Research Problem:

- The features, mechanisms and tool for designing interactive application in architecture are in need of study and research to determine its technical concept and technological tools in order to be used on a wider range.

Research Objectives:

The main objective of the research: to analyse and evaluate the physical aspects of interactive applications in the design of public buildings

The objectives of this research can be summarized as follows:

- 1- Investigating the roots and concepts behind the development of interactive architecture and identify its meaning, through studying the architecture trends and the early works of pioneers.
- 2- Exploring the theory and technological tools necessary for designing interactive applications in public buildings.
- 3- Investigating the possibility of creating an architecture that is flexible and smart enough to change its context according to the surrounding environment and users demands.
- 4- Discussing the potentials of the used applications according to the design requirements of public buildings in enhancing the spatial

efficiency, security, aesthetics, and the overall experience of the built environment.

- 5- Developing a characteristics model based on the interactive architecture requirements and public building's needs, in order to evaluate such applications.
- 6- Applying the proposed characteristics evaluation model on case study projects in order to assess the applications implemented so far in different public buildings.

Research Hypothesis:

The main hypothesis of the research is; applying interactive applications in public buildings will improve the overall performance of the building.

Research Limitations:

- The study is concerned with the physical aspects of implementing interactive applications.
- Studying and analyzing case study projects that show features of applying interactivity within its context.
- The research is limited by the type and quantity of data and information sources available for the subject and it depend mainly on published literature; books, scientific papers, researches and conferences proceeding, as well as experiments in research labs and international design applications.

Research Methodology:

The research in general adapts an analytic methodology based on observations.

A characteristic model is developed based on case studies to assess the uses of interactive application in public buildings. The methodologies used are as follows:

- **Methodology of theoretical framework:**
 - 1- Theoretical methodology in chapter one: Exploring interactive architecture the roots of its constitute based on previous architectural trends influenced architecture to be more dynamic and intelligent
 - 2- Analytical methodology in chapter two:

Analyzing design process, tools, and techniques used in generating interactive applications in architecture.

- **Methodology of practical framework:**

- 1- Analytical/ Comparative methodology technique in chapter three: Analyzing the interactive systems used in different fields including media and art and the needed design requirements of public buildings to develop the characteristic model.
- 2- Comparative analysis methodology in chapter four: Applying the proposed characteristic model on case studied projects.

Research Structure:

The research consists of five chapters arranged as follows:

Theoretical framework:

Chapter one: History and development of interactive architecture

This chapter discusses the factors behind the development of interactive applications and the basic ideological concepts of interactive applications.

Chapter two: Ideological and Technological Tools Influencing Interactive Architecture

This chapter explores the theory behind interactive architecture and the design process used to implement interactive applications.

Practical framework:

Chapter three: Analyzing The Use of Interactive Systems

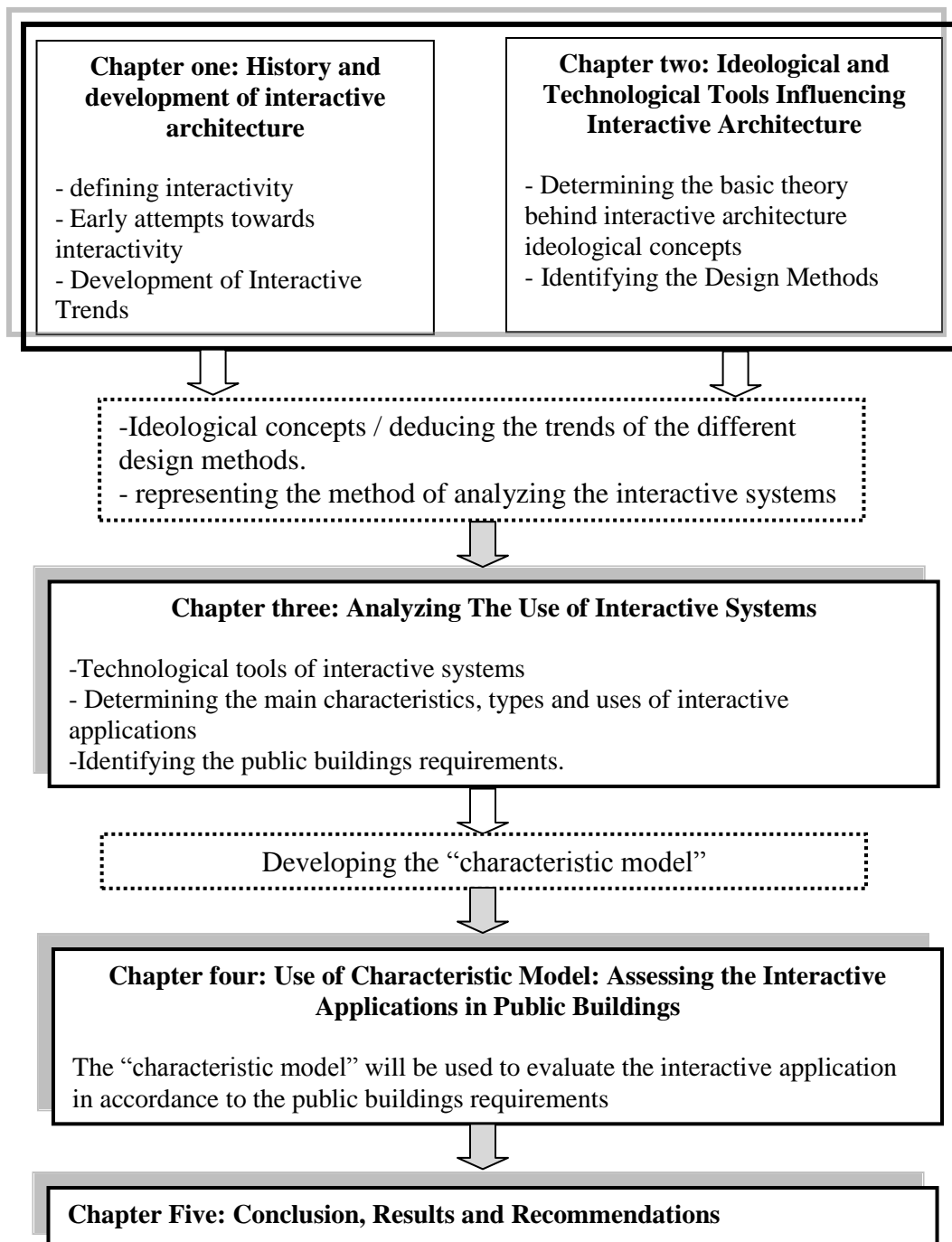
This chapter explores the tools used in the design process of interactive applications and investigates the ways of implementing the different types of interactive applications. A “characteristic model” will be developed to assess the different interactive applications used in public buildings.

Chapter four: Use of Characteristic Model: Assessing the Interactive Applications in Public Buildings

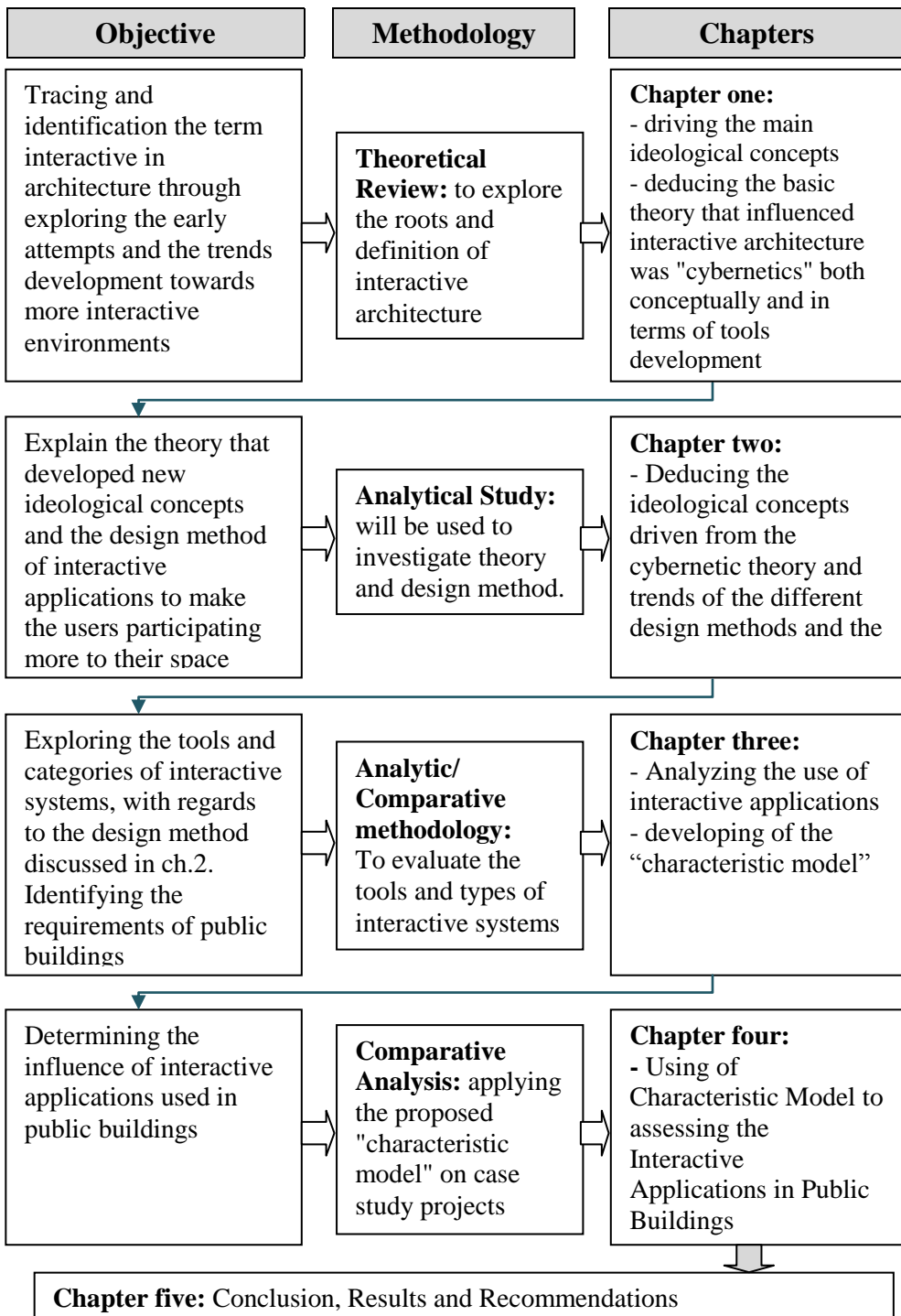
The “characteristic model” will be used to evaluate the interactive application in accordance to the public buildings requirements.

Chapter Five: Conclusion, Results and Recommendations

Research structure:



Research Methodology:



Chapter 1

History and Development of Interactive Architecture

Introduction:

Before the evolvment of the term interactive architecture in the last two decades, there were several attempts, since the second half of the last century, aiming at making architecture flexible and adaptable enough to change and respond to environmental and users' needs.

In order to explore this notion, the term “interactive” will at first be investigated, by exploring its definition, the meaning of the term and its aspects of theory, as well as the development of the trend through analyzing the earlier practices in architecture.

This chapter will focus on the factors, influences and preliminary practices that helped develop interactive applications in architecture with regards to the fast development of technology implementation in architecture.

To achieve this, the chapter will focus on the themes that affected and constituted the basics of ideological and conceptual roots towards interactivity. These themes are:

- The development of the term interactive (definition, concept, aspects);
- The early works and the development of the basic idea;
- The prior trends which led to interactivity in architecture.

1/1 Interactive architecture

Interactive architecture is a new concept in architectural design which is rooted in the global development of the information technology. However, unlike other recent developments which are a result of the employment of digital technologies, interactive architecture has the potential to provide solutions to complex problems and information overflow which has emerged as a result of the new conditions of the digital era. Interactive architecture aims at having spaces that are able to reduce complexity, improve functionality and result in higher productivity and satisfaction for users. Spaces should not only be reactive but proactive as well. For this to happen, they have to be able to sense the needs and react accordingly.

1/1/1 Definition

The definition of the term interactive has been relevant to many fields; architecture, computer science, information, media and communications, but if we look it up in the dictionary, it is found that the term interactive has various definitions based on the level of interaction between users and computers relevant to the flow of information.

According to the oxford dictionary the term interactive means; allowing a two-way flow of information between a computer and a computer-user; responding to a user's input.¹ Another definition involves the communication or collaboration of people or things; allowing or involving the exchange of information or instructions between a person and a machine, such as a computer or a television.² It is a Live presentation in which the audience can participate. The term Interactive is most often heard when discussing "interactive media," such as computers or video games. When technology is interactive, people are able to interact with it. The Internet is an interactive medium. It creates an interactive dialogue, with both the user and internet contributing to the discussion.

According to architecture the term interactive involves the user. It achieves this by using special computer technologies to react to people behaviors and motions. When a building or a part of architecture is called interactive it means that it integrates, or is, a system which detects, and reacts to, human behavior or external parameters. Interactive architecture would be ideal when the space

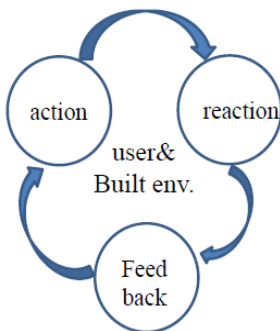
¹On –line oxford dictionary. <http://oxforddictionaries.com> (Accessed May 2010)

²“V2” Vocabulary Building Dictionary. <http://vocabulary-vocabulary.com/dictionary/interactive.php> (Accessed May 2010)

could change according to users' needs over time. Interactivity is a communication process in which each message is related to the previous messages exchanged, and to the relation of those messages to the message preceding them.³

Interactive Architecture explores emerging practices within architecture and wider disciplinary fields that forge digital technologies and virtual spaces with tangible and physical spatial experiences. Instead of defining a fixed architectural product, an interactive architecture is in constant flux, best suited often to prototyping and semi-permanent installations.⁴

Interactive architecture in general is responsive to its inhabitants and environment via a feedback loop of communications, creating a two way dialogue between the users and their built environment, generating new actions and design solutions through using an interface which permits interaction (Fig. 1.1). Essentially, it is a building that reacts to its surroundings, explores digital technologies and virtual spaces, and is "alive" insofar as it can sense, interact, fluctuate, adapt, and learn, changing depending on users' needs. Taking in the fields of architecture, design, computer programming, and engineering, it is a hybrid discipline that constructs adaptive environments for a hybrid media society.



(Fig. 1.1): a diagram shows the relation between users and their environment in an interactive dialogue through a continuous feedback loop of actions and reactions. *Ref., (the Researcher)*

1/1/2 Concept and Approach

Interactivity enables users to make optimum use of the space. Therefore the design minimizes the barrier between human cognitive model of what they want to accomplish and the environment understanding of the user's task.

³ Magdalena Garbarczyk. "Does interactive architecture have a style?" Literature and media 2006, p.4

⁴ Kevin Holmes. Creativity Bytes: A Brief Guide to Interactive Architecture., 2011, p.2

Interactive architecture resists strictly virtual or physical definitions. Instead, it acts on the constantly shifting boundary between the two. In reality architecture is in constant flux as people, the environment and now digital information flows in, out and around these built environments. If the response to user's interaction is sent back in real time the user bond with the space is increased; the space starts to work at the user's biological and psychological level of cognition. Interactivity is necessary to give intelligence to this process so that the feedback loop that occurs does not become predictable, but instead grows in complexity as your experience of the space does.⁵ Interactivity in architecture is addressed at the level where building components and buildings become dynamic, acting and re-acting in response to environmental and user-specific needs.

Interactive architecture is a total integration of the disciplines of interaction design and architecture. It is built upon the convergence of embedded computation including intelligence and a physical component of kinetics that satisfies adaptation. The combination of these two areas will allow an environment to have the ability to reconfigure itself and automate physical change to respond, react, adapt, and be interactive.⁶

Interactive architecture aims at achieving more than buildings and built spaces which are capable of simple responsive adaptations and spatial customizations, through automation. Interactive architecture creates spaces which are active in nature, that guides the users behavior by having the ability to reason and learn, leading to the creation of spaces which are able to maintain a dialogue with their users, not only responding to their demands, but proactively engaging themselves in all kinds of featured spatial activities.⁷

The concept of applying Interactive systems can be categorized into two main levels according to their ability of response to the requirements of their surrounding environments:

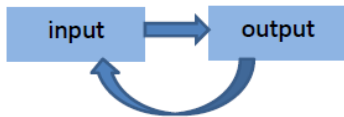
Single-loop interaction; where the system had already determined particular outputs for particular inputs (Fig. 1.2). It is reactive in nature, single-loop devices satisfy functional goals, like having building management systems that seek to optimize sunlight distribution or thermostats that regulate

⁵ Christina Ann Rangel. "Interactivity in Architecture." Faculty of Architecture, TU Delft, Netherlands.2007, p.3

⁶ Michael A. Fox. "Interactive Architecture Will Change Everything." 2010. p.6

⁷ Tomasz Jaskiewicz . "Dynamic Design Matter[s]. Practical considerations for interactive architecture." TU Delft, the Netherlands. 2008. p.5

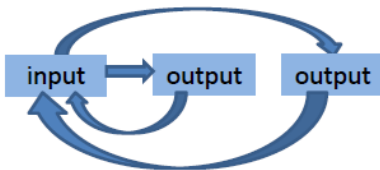
internal temperature. Such systems satisfy very particular efficiency criteria that are determined during, and limited by, the design process.⁸



(Fig. 1.2): a diagram of Single- loop interaction where a particular set of inputs determines a set of outcomes.

Ref., (the Researcher)

Multiple-loop interactive systems; which is much more difficult to achieve than the first level, as a certain action triggered provokes its environment or user to interact so the outcome affects the first trigger itself, giving another outcome causing another cycle of outputs and inputs in continuous cycles (Fig. 1.3). Multiple-loop interaction does not depend upon complexity; it depends upon the openness and continuation of cycles of response. It also depends on the ability of the interacting systems, to have access to, and to modify, each other's goals.



(Fig. 1.3): a diagram of Multiple-loop interactive systems where outputs affect their triggered inputs continuously.

Ref., (the Researcher)

However, for the occupants of a building to have the sensation of a contributing to the organization of a building, the most stimulating and potentially productive situation would be a system in which people build up their spaces through "conversations" with the environment, where the history of interactions builds new possibilities for sharing goals and sharing outcomes. In such architectural systems, inhabitants themselves would be able to determine efficiency criteria.

The cybernetician Gordon Pask, who collaborated with architects in the 1970s and 1980s at the Architecture Association, London, provides precise guidance on how to develop such systems. His "Conversation Theory" – which will be discussed later – gives us a clear framework for designing interactions in which systems, humans, machines or environments may engage in the constructive exchange of information.

⁸ Usman Haque. "Architecture, interaction, systems." 2006. P.2

1/1/3 Development of interactivity

The cybernetics in the 1960s laid the foundation upon which interactive architecture was constructed with the idea that interactivity was a two-way road. This and other ideas were adapted by the architects of the time for use in their work. Cedric Price was one in the un-built Fun Palace his aim was to build a “laboratory of fun” in a grid-like steel structure, where temperature systems would control fog, warm air, and moisture, so as to be responsive to the public’s needs. But it was a few decades before the technology caught up, during the 1970s and 1980s, when groups like MIT Architecture Machine Group – now MIT Media Lab – carried on exploring the relationships between humans and technology, with artists and scientists from various disciplines experimenting with interactivity and design. In the 1990s, advancements in technology finally allowed for prototypes of interactive architecture to be made.⁹

1/1/4 Technologies of interactive architecture

There were several technologies impacted the development of interactive architecture. These technologies are related to information, digital and remote communication technologies.

1/1/4/1 Information technology

Multimedia, hypermedia, telecommunications technology, networks, interactive art and media art are symbol words of what is recognized now as the Information Age. Information technology is the underlying ‘mental landscape’ of today’s architecture. Information technology (IT) is based on the characteristic of building ‘mobile’ and ‘interconnected’ models of information.

Interactivity in this context results in architecture being constantly modifiable and forming a sensitive setting in constant transformation; that is, a setting that can also react with, and adapt to, a shift in users’ desires through the creation of scenarios that can be explored as though they were hypertexts. So today’s architecture is struggling to be ‘information-able’; it is struggling to incorporate within itself the dynamic, interconnected and, above all, interactive essence of the IT based paradigm.¹⁰

⁹ Creativity Bytes: A Guide to Interactive Architecture.
<http://www.thecreatorsproject.com/en-uk/blog/creativity-bytes-a-guide-to-interactive-architecture>. (Accessed 27 April 2011)

¹⁰ Lucy Bullivant. “4d Interactive Architecture, Interactivity at the Centre of Avant-Garde Architectural Research published,” by Wiley- Academy Vol. 75 No. 1. Jan/Feb 2005, pp23-26.

1/1/4/2 Digital and media technologies

The revolution of Digital technologies, especially in computation, first produced digital architectures of topological, non-Euclidean geometries, kinetic systems, and genetic algorithms. Digitally driven design processes are characterized by being dynamic, open-ended and unpredictable but consistent transformations of three-dimensional structures, this rises up new architectural possibilities. The generative potential of digital media opened up the possibilities of spaces that allow the flow of communication and sense of control and personalization of space.¹¹

Starting from the new millennium digital and interactive media, computers and networks form the nervous system of the architectural body. By adding the use of sensors and actuators connected to computer system it becomes possible to make the space interactive. Such spaces sense the activity of people, and act through a variety of displays: auditory, visual, kinetic and haptic. Technologies are now becoming available to enable dynamic structures, to control them and to interact with them.¹²

1/1/4/3 Remote communications technology

Remote communications is a field of science which allows two users or systems to communicate, independent of the place they are located in. With several advancements in the field of cellular and satellite communications, it has become easier and simpler for humans to communicate. Remote communications can be done via different transmission media, such as: mobile, internet computers and radio devices.

The growing number of digital embedded computing technologies introduces a new paradigm for how we interact with the built environment, while remote communications like mobiles and pervasive devices offer new possibilities for sensing and communicating with the physical world around us. These technologies can be used not only for collecting and providing data about the world, but also as a way to introduce new forms of interactivity between humans, computers and architectural spaces. It creates an immersed mixed reality where physical space and digital spaces intersect. These hybrid physical and digital worlds present new possibilities for connected experiences in dynamic space.¹³

¹¹ Kolarevic, Branko. "Designing and Manufacturing Architecture in the Digital Age." University of Pennsylvania, USA.2005 p.12

¹² Robert Miles Kemp. "Interactive Interfaces in Architecture The New Spatial Integration of Information, Gesture and Cognitive Control." Variate Labs, Series Design/Build, Schematic, Inc.2009, p6

¹³ Jennifer Stein, Prof. Scott S. Fisher. "Interactive Architecture: Connecting and Animating the Built Environment with the Internet of Things." Mobile and Environmental Media Lab USC School of Cinematic Arts Los Angeles.2005 p.22

1/2 Early architectural attempts towards interactivity

There have been several attempts starting from the second half of the last century from several architects towards having architectural and built spaces that are flexible enough towards their current social situations. This section investigates the works of Cedric Price, Buckminster Fuller and Usman Haque; as their attempts towards having more flexible and dynamic architectural and built spaces influenced the early practice of deploying interactive architecture.

1/2/1 Cedric Price

Cedric Price (1934-2003) was one of the most challenging figures in the field of architecture in Britain during the second half of the twentieth century. Throughout his career, Price stressed the need for flexibility in architectural design in view of the unpredictability of possible future uses. Price argued for evoking delight and pleasure in users and empowering them as co-designers. *"I'm only radical because the architectural profession has got lost. Architects are such a dull lot – and they're so convinced that they matter."* – Cedric Price.¹⁴ He was interested in lightweight structures and the idea that buildings should have a fixed, short life span in continuous change, during a period of time. His work was evoking and open-ended, offering new possibilities for the society.

1/2/1/1 Theory

Using cybernetics (that will be discussed in detail in Chapter Two) and the latest computer technologies, Price hoped to create an improvisational architecture which would be capable of learning, anticipating, and adapting to the constantly evolving program. An array of sensors and inputs would provide real-time feedback on use and occupancy to computers which would allocate and alter spaces and resources according to projected needs.¹⁵

He engaged his basic concepts of the projects with existing economic, political and structural networks. Price explored architecture's potential to nurture change, intellectual growth and social development. To him architecture was not about the finished building, but more about an ability to allow for and facilitate the change in a changing world and to *"allow us to think the unimaginable"* – Cedric Price. His ideas and concepts were familiar with the Internet and ubiquitous computing.

¹⁴ Canadian centre of architecture Cedric price archives.

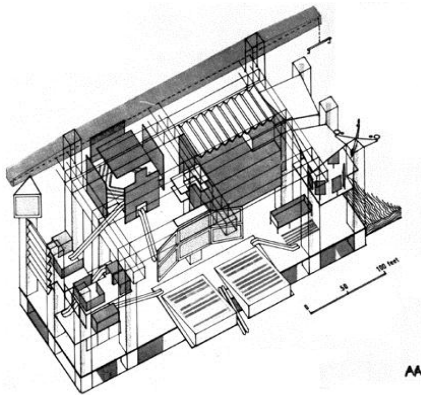
<http://www.cca.qc.ca/en/collection/540-cedric-price-archive>. (Accessed 2 Sep. 2011)

¹⁵ The guardian Uk. <http://www.guardian.co.uk/society/2003/aug/15/urbandesign.artsobituaries> (Accessed 2 Sep. 2010)

1/2/1/2 Projects

The research discusses the Projects of the “Fun Palace” and “Interaction Centre” as they were designed with the aim of having architecture that is flexible enough to reconfigure itself according to the user’s needs.

The “Fun Palace” in 1964 was a proposal of a community center designed to serve as a community-directed learning environment where working-class people could go and learn new trades or whatever else they desire. The “Fun Palace” was a project where the spaces could be reconfigured and organized according to the changing needs of the users. The building had a visual perception of incompleteness to provoke the users to change and adapt. It was also a representation of an architecture that can never be finished where the site was in a state of continuous change rather than a permanent one (Fig. 1.4). It was a work continually in progress, being constructed by the project’s occupants. The building offered no fixed score to follow, only some rules of engagement.¹⁶



(Fig. 1.4): Cedric Price, Fun Palace, 1964. Perspective shows the building as if it is not finished yet.

It was considered a reflection to the rapidly changing conditions of knowledge and society in post-war Britain. It was not a proposal for buildings in any conventional sense, but instead it was impermanent, improvisational and interactive systems, highly adaptable to the volatile social and economic conditions of its time and place.¹⁷

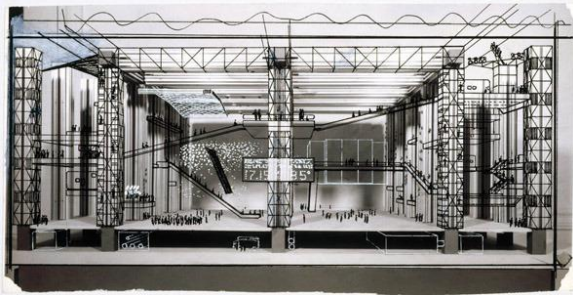
The design procedure was done by using an operating system of seventy-five tower-skeletons framing the wide enclosure and a giant crane running overhead to allow parts of the building to be moved and stacked in

¹⁶ Philip Beesley and Omar Khan. “Situated Technologies Pamphlets 4: Responsive Architecture/Performing Instruments.” The Architectural League of New York 457 Madison Avenue, New York.2005, p.22

¹⁷ Interactive architecture.

<http://www.interactivearchitecture.org/fun-palace-cedric-price.html>(Accessed 10 Sep. 2010)

different ways, and a gangway system for people to circulate between them (Fig. 1.5).



(Fig.1.5): axonometric section, of Fun Palace 1964. Cedric Price and structural engineer Frank Newby designed a structural matrix with overhead cranes, to allow assembly of prefabricated modules.

The “Inter-Action Centre” in 1977 was a multiple purpose community resources centre providing a wide range of services. The building was aimed to last as long as it was useful. The centre was designed on condition that it had a twenty year life span and was accompanied by a manual detailing showing how it should be dismantled. For Price, time was the fourth spatial dimension. “Inter-Action Centre” incorporated many of the concepts and features of the "Fun Palace" on a much reduced scale. It provided community services and creative outlets for local citizens until its demolition in 2003.

It was meant to be flexible, allowing for different alternatives. The component parts were – purposely – artless and cheap. The idea was innovative, yet the architecture was casual. Price was seeking an architecture that was value-free. The flexible architecture approach, indeterminacy and impermanence were meant to provide the fusion of information technology, entertainment, and educational activities.¹⁸

The building constitutes an open framework into which modular, pre-fabricated elements can be inserted and removed as required. Shipping containers are used, as manufactured houses, for classrooms, studios, workshops, and eating facilities (Fig. 1.6).



(Fig.1.6): Cedric Price, the “Inter-Action Centre”, 1977. The framework structure with plug-in, readymade port cabins used for offices, toilet rooms, and utility spaces.

¹⁸ Robert Kronenburg “Flexible: Architecture that Responds to Change.” - Publishers; Laurence King First Edition ,May 17, 2007. PP.80-82

1/2/2 Buckminster Fuller

Richard Buckminster Fuller (1895- 1983) was an architect, engineer and inventor. Convinced that the way the world managed its human and material resources needed to be rethought, he was committed to seek long term, technology-led solutions to some of the most urgent problems of his time, especially in the fields of construction and transport. Despite all of his inventions, it was not until Fuller's large-scale, multifunctional geodesic domes began to appear around the world in the 1950s that he really made his name.¹⁹

Buckminster Fuller's main aim was to benefit the largest segment of humanity while consuming the minimum of the earth's resources; i.e. doing "more with less", which evolved the term Ephemeralization. Although Fuller believed in utilizing the latest technology, much of his work developed from his inquiry into how nature builds.²⁰

1/2/2/1 Theory

Ephemeralization; it is a result of the Evolution of Technology, by which technological advancement is able to do more and more with less and less until eventually you can do everything with nothing. A gradually smaller and smaller amount of materials and effort will accomplish more and more useful functions with increased acceleration. Fuller's vision was that ephemeralization would result in ever-increasing standards of living for an ever-growing population despite finite resources.²¹

As a technology ephemeralizes its problem, it becomes both smaller and cheaper, with the result that it can be packed into the same space with other technologies ephemeralizing other problems. Now, the example of the Internet represents a degree of ephemeralization that allows one individual to influence or interact with other people, with a use of resources that is negligible.

1/2/2/2 Projects

The research discusses the Projects of the "4d tower" and "4D (Dymaxion) House". They both aimed to implement the latest technologies of their time to improve the resource usage and adapt to their surrounding environments.

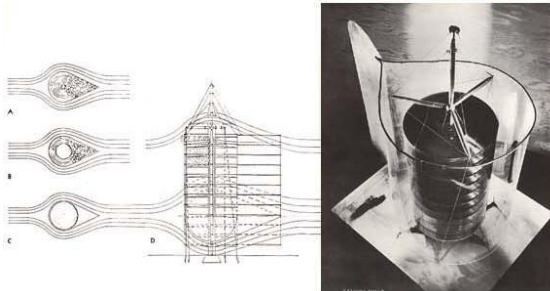
¹⁹ Design museum. <http://designmuseum.org/design/r-buckminster-fuller>. (Accessed 30 March. 2010)

²⁰ NoéMie Schwaller. "Starting with the Universe." (Accessed 30 March. 2010)

²¹ Sean Michael Ragan. "The Ephemeralization of Educational Objectives by the Infostructure." 1999. P.10

“4d tower” it was a proposal designed in 1982, it is a lightweight, prefabricated, multi-storey apartment tower to be delivered anywhere in the world by airship. Once delivered the towers would generate their own light and heat with an independent sewage disposal system.

The main aim was to create a light-weight, self-sufficient building using the most modern means of transportation and telecommunications at that time, to use the world's surface and resources with efficiency. Fuller's philosophy of 4D designs was defined as thinking in time instead of only the three dimensions of space; thinking of consequences for humanity instead of only immediate personal gain (Fig. 1.7). The tower was delivered by an airship to make this method of delivery possible. Fuller used tension with metal. Tension, as opposed to compression, made the building light enough to be carried under airships.²²



(Fig.1.7): 4d tower. In the later stage, a windbreaker was placed around the tower to direct wind around the building. Fuller discovered that the drag created by wind passing through was a major source of heat loss.

The “4d tower” was designed to be a twelve-story building, constructed around a central mast with the hexagonal floor rings making a tensile building. The central mast also facilitated services and circulation, and served as a support. The flats would come already equipped with all the conveniences of modern life of their time, from telephones to typewriters already installed. Because the building was fully constructed by time of delivery, the house would be transported by airships. The idea is that a bomb would be dropped from the airships to create a crater (Fig. 1.8). Then the house would be dropped into the hole and the hole filled with cement.²³



(Fig.1.8): 4D Tower (1928) perspective showing the foundation installation of the tower.

²² The architectural newspaper.

<http://archpaper.com/news/articles.asp?id=4672> (Accessed 13 April. 2010)

²³ Design museum.

<http://designmuseum.org/design/r-buckminster-fuller> (Accessed 1 March. 2010)

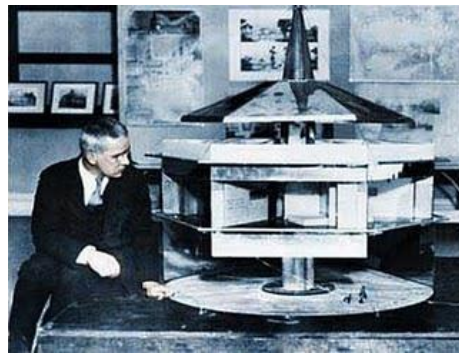
“4D (Dymaxion) House” designed in 1945 the project gathered much interest as the residential project became one unit instead of a tower. The tower was an abstract idea whereas the "Dymaxion House" was much more achievable. One of Fuller's "Dymaxion Houses" is on display as a permanent exhibit at The Henry Ford in Dearborn, Michigan (Fig. 1.9).

The building had little to do with the current architecture styles or theories of its time and took its sole manifesto to be the comfort and projection of its occupiers by using; factories, workers and the latest technology, which had produced World War II aircraft. The house was self-contained with its own power generator, sewage disposal and an automobile transport unit. Sustainability introduced a gardening program on the balcony. Fuller was moving towards an ‘off-the-grid’ suburbia that included self-agriculture.

This prototype is a round structure (not a dome) with a central mast keeping for tension, circulation, organization of rooms and spaces. The central mast also houses the reflective mirrors that allowed passive lighting. Hexagonal geometry is also seen in this building to make the use of tension in aluminum possible; this also contributed to the idea of a light, transportable house (Fig. 1.10). A circular structure at the top of the house was designed to rotate around a central mast to use natural winds for the purposes of cooling and air circulation. It has several innovative features, including revolving dresser drawers, and a fine-mist shower that reduces water consumption.²⁴



(Fig.1.9) A "Dymaxion House" at the Henry Ford exhibition.



(Fig.1.10) A "Dymaxion House" First model showing the central mast.

²⁴ Robert Kronenburg. “ Flexible: Architecture that Responds to Change. ” Publishers: Laurence King First Edition ,May 17, 2007. PP. 75-77

1/2/3 Usman Haque

Usman Haque is a London-based architect and artist. His projects focus on the ways that relate people to each other and to their surrounding space. The level of interactivity he seeks not only the one that alter the physicality of space to respond to environment and users, but also the one that interacts on the level of senses. He develops both physical spaces and the software and systems that bring spaces to life. These systems, based on the software's algorithms to fulfill several functions: the detection of a position in space, sound, odor, temperature and cellular phone signals. Architecture is here conceived as an operating system. He has also created interactive installations, environments with projections, digital interfaces, choreographic performances and works for computer.

1/2/3/1 Theory

He differentiates architecture into hard and soft space. The hard space in architecture has traditionally been understood as the physical, static objects that make up our environments, and enclose us, like walls, roofs and floors. The soft space proposed by Haque is an architecture that cares about the pleasure of the senses. According to him, the "delight" in architecture comes from the non-tangible, non-physical "stuff" in between: the sounds, the smells, the heat, the colors. If soft space encourages people to become performers within their own environments, then hard space provides a framework to animate these interactions

"The new language of architecture would have to entice each of the five senses, because each culture understands space in a different way, using a different combination of the senses." Usman Haque.²⁵

1/2/3/2 Projects

An architecture that is interactive with its occupants should acquire some of the human characteristics, by being familiar with the human senses – soft architecture. Thus each of Haque's projects has an interactive installation depending on the interaction of individuals through challenging one or more of the senses, as an attempt to widely spread such installation in the architectural system as a whole, to have a more vivid architecture.

²⁵ Daniel Langlois. Foundation for science and technology. <http://www.fondation-langlois.org/html/e/page.php?NumPage=374#n3>. (Accessed 1 April 2010)

Moody Mushroom Floor (1996) is an example of using the senses – changing the mode through learning from its occupants – to define the space pattern. In other words, it is a smell, sound, light floor that develops moods and aspirations in response to the ways that people react to the outputs.

The original intention was to make a behaviorally self-modifying device which would operate as an architecture that is to decide room size and scale (Fig. 1.11). The "mushroom" actions are determined by their goals. Each mushroom sets its own particular goals at any particular moment. These goals are given anthropomorphic labels like "spoilt brat" or "alluring" or "capricious" and define what the mushroom hopes to achieve.

For example, a "sullen" mushroom will try to keep people away from it. However, it does not know how to do this - it has to learn through trial and error which patterns of light, smell and sound are best for repelling people. As a whole, the community of mushrooms begins to converge on particular behaviors after they have spent time in their environment.



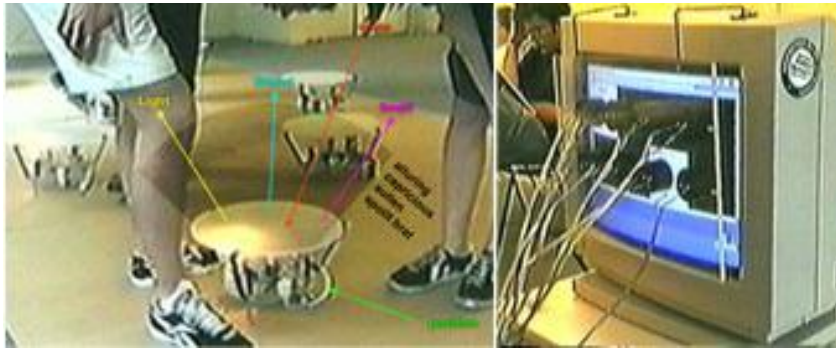
(Fig. 1.11): The mushroom installation in prototype and its interaction to users.

The constructed project, the Moody Mushroom Floor, is a system of 8 input-output devices which are programmed by 48 concurrent genetic algorithms in such a way that the devices collectively seem to display intelligent behavior. Each device forms an internal representation of its surrounding environment and outputs a sequence of light, smell and sound which will tend either to attract human beings or repel them.

The devices fall somewhere between unintelligent 'nodes' and more sophisticated 'agents'. The 'agents' form an internal representation of their surrounding environments from the following inputs: Sound, as sampled by the Macintosh computer. Presence, as detected by the combination of infrared motion detectors and pressure pads which give an indication of human beings' distances from each 'agent'. Output capabilities as perceived by humans include: The combinations various odor levels of two smells in varying quantities. The combination of various aural levels that include sounds of varying frequencies and human speech synthesis. The combinations of various visual pulsing that include 240 volt light bulbs in three levels of wattages 25,

40 and 60. Information details of a particularly "successful" (in terms of ability to attract or repel a human being) output sequence may be relayed to another 'agent'.

The 'agents' emit output sequences which depend on the particular mode they happen to be in. They then check to see how successful that particular output sequence was, and a new output "strategy" is emitted, having undergone quasi-genetic operation to try and improve the output strategy for that particular mode, for that particular 'agent'(Fig. 1.12).

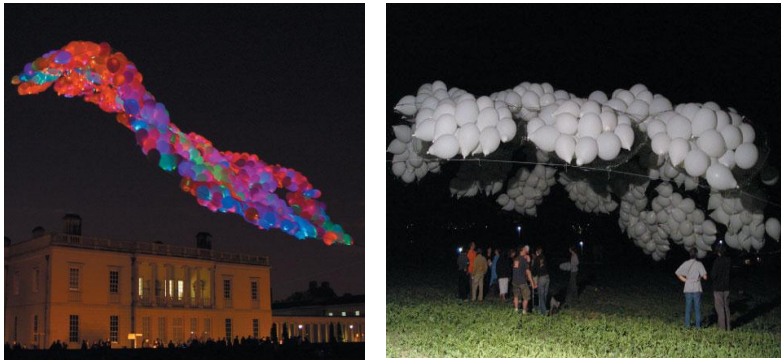


(Fig. 1.12): The mushroom connection to the computer to learn to act from experience.

Sky Ear (2004) is a non-rigid carbon-fiber "cloud" floating in the air; it is embedded with one thousand glowing helium balloons and several dozen mobile phones. Sky Ear started its voyage at Fribourg, Switzerland, in spring 2004, at the "Belluard Bollwerk" International Festival and ended in September 15th, 2004, at "Greenwich Park," London. The cloud climbed to a height of over 100 meters, watched by over 3,500 people.

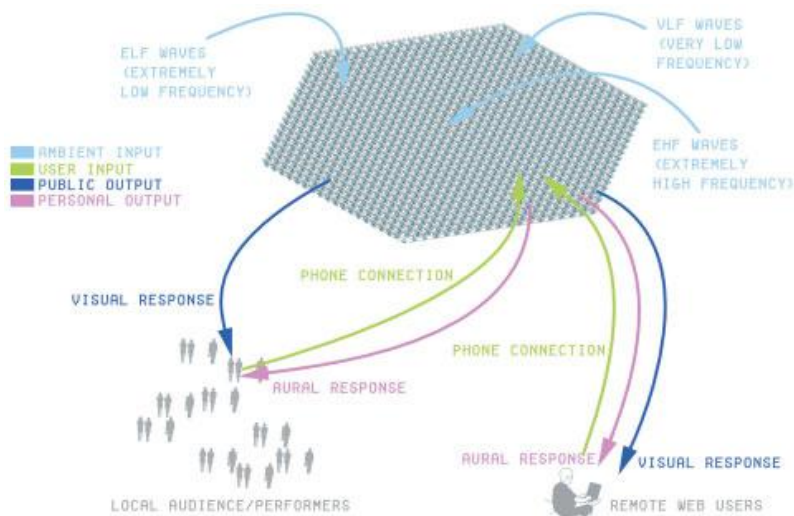
Sky Ear breaks the perceptual boundaries between the physical and virtual by encouraging people to become creative participants in a Hertzian performance, allowing them to see their daily interactions within the invisible topographies of Hertzian space. Electromagnetic space – also called Hertzian space – is physical and non-virtual since the universe is the oldest radio in the world (distant storms, radio waves emanating from distant stars, gamma rays from elements on earth). However, the urban locations in particular have a diverse and vibrant Hertzian culture, with mobile-phone, television broadcasts, and radio transmissions from wireless laptops.²⁶ The cloud showed both how a natural invisible electromagnetism could pervade our environment and also how our mobile-phone calls and text messages delicately affect the new and existing electromagnetic fields (Fig. 1.13).

²⁶ Lucy Bullivant, "4d space: Interactive Architecture," by Wiley- Academy, 2005 PP. 24-26



(Fig. 1.13): By nightfall, the balloons, enclosed in a fiber-and-net structure 25 meters in diameter and thread to the ground by six cables, were ready to be released

The Sky Ear balloons contain miniature sensor circuits that respond to ambient electromagnetic waves produced by, spectators on the site and remote Web user's, phone up the cloud of balloons to hear the electromagnetic sounds picked up by the miniature sensor circuits (Fig. 1.14). When activated as people using phones at ground-level, the sensor circuits coordinate to cause ultra-bright colored LEDs to illuminate and distant natural electromagnetic sounds of the sky were heard (including whistlers and spherics). Such responses motivate the audience to continue phoning, creating further disturbances in the electromagnetic fields inside the cloud.



(Fig. 1.14): Diagram by Usman Haque showing how Sky Ear's interactive elements come together, the ambient electromagnetic waves, spectators and remote Web users. The disturbances in the electromagnetic fields inside the cloud cause changes in light and color.

'Remote' (2007) connects together two spaces, one in Boston, the other in Virtual Life, and treats them as a single contiguous environment, bound together by the internet so that things that occur in one space affect things that happen in the other and vice versa - remotely controlling each other (Fig. 1.15). The intention is to explore an architecture that is resolutely "human" in the sense of being inhabited, configured and determined by its occupants, yet context-free because it does not privilege geographical location.



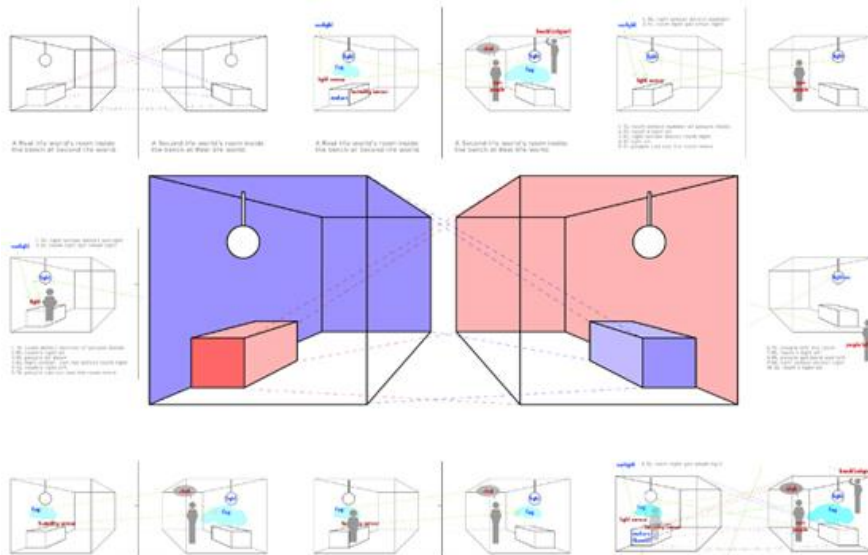
(Fig. 1.15): The space in Boston and the other in Virtual Life, each showing the reactions of other's environment.

Communication between the two halves of this extended environment is coupling the environmental phenomena of humidity, temperature, light, speech, mist, wind, sound and proximity across the two. The object in Boston appears to be a seat but experientially, the Virtual Life space appears to be inside the seat (Fig. 1.16).

Boston's effect on Virtual Life (VL): As humidity around the chair in Boston rises, the amount of mist around the VL chair increases. As the light level falling on the Boston chair decreases (for example when you sit on it), the fog in VL gets darker. As the temperature rises in Boston, the lamp in VL changes from blue to red. As the light level on each side of the Boston chair changes (e.g. if you sit on it and wiggle from side to side), the VL chair starts to wiggle from side to side too. The more times you sit on the Boston chair, the taller the VL chair becomes. As time progresses in Boston, the VL big chair slowly rotates.

Virtual Life's (VL) effect on Boston: As the number of avatars near the chair in VL increase, the Boston lamp gets brighter and brighter. If someone sits on the VL small chair, the mist machine in Boston switches on. If someone starts chatting near the VL chair, the lower blue fan in Boston starts blowing and pushes out the mist. Every time an avatar collides with the underside of the VL big chair, the Boston chair starts knocking underneath. Every time an

avatar touches the VL big chair, it changes the color of the Boston lamp. As the wind in Virtual Life increases speed, the upper blue fan in Boston blows more strongly.



(Fig. 1.16): The diagram shows the actions done in each environment and their reaction, whether in Boston or in the virtual environment.

Natural fuse (2009) it was activated to public in August 2009, where the system is connected to the internet to allow collaboration between different users in different locations, to determine their electrical appliances CO2 foot print and energy consumption. The project is about the structures of participation as it is about energy conservation. The network, through its users' interaction, determines the amount of energy flow in the system.²⁷

A system was not just end-to-end single-point communication, but it increased its efficiency over time through more geographically-dispersed connections. Natural Fuse units apply networked plants to harness the carbon-sinking capabilities of plants to create a city-wide network of electronically-assisted plants that act both as energy providers and as shared “carbon sink” circuit breakers (Fig. 1.17). By sharing resources and information between the plants, energy expenditure can be collectively monitored and managed.

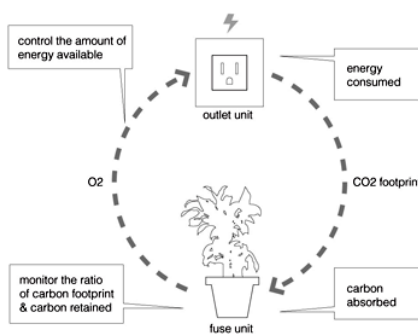
²⁷ Pachube, Patching the Planet: Interview with Usman Haque.
<http://www.ugotrade.com/2009/01/28/pachube-patching-the-planet-interview-with-usman-haque/>.(Accessed 28 Jan. 2009)

The purpose is to create a collective "carbon sink" that offsets the amount of energy consumed by the plant owners creating a natural "circuit breaker". If people cooperate on their energy expenditure then the plants thrive (and they can all use more energy); but if they do not then the network starts to kill plants, thus diminishing the network's energy capacity.

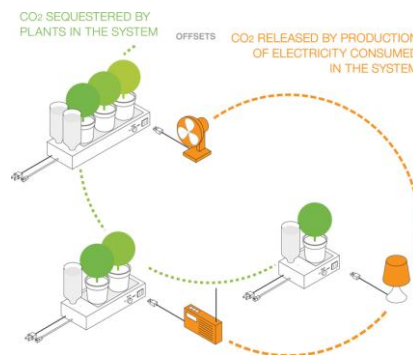


(Fig. 1.17): Appliances connected to the natural fuse unit. There is a power activation switch, which the owners can adjust depending on how much they want to use the energy.

Each Natural Fuse unit consists of a houseplant and a power socket. The amount of power available to the socket is limited by the capacity of the plant to offset the carbon footprint of the energy expended (Fig. 1.18). So it acts as a micro scale CO₂ monitoring and overload protection framework that works locally and globally, harnessing the carbon-sinking capabilities of plants. Natural Fuse allows only a limited amount of energy to be expended in the system; that amount is balanced by the amount of CO₂ that can be absorbed by the plants that are growing in the system (Fig. 1.19).

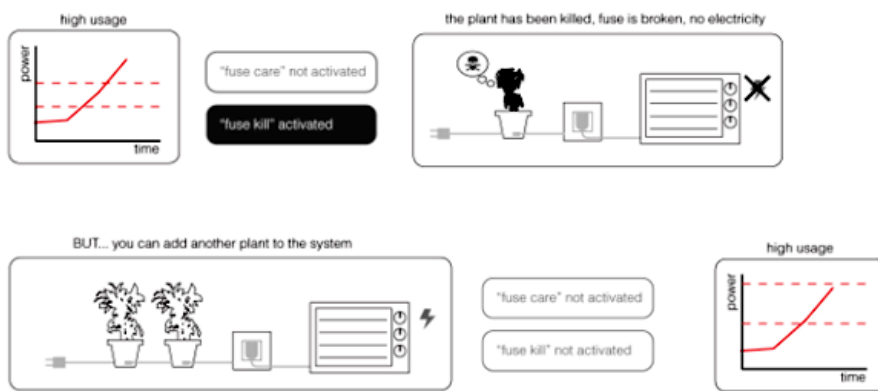


(Fig. 1.18): The main concept of operating the system according to the carbon level.



(Fig. 1.19): A diagram showing connections of various appliances to the system

If the plugged in appliance draws so much power that it requires more carbon-offsetting than is available, then the unit will not power. Therefore, all the units are connected together via the internet so that they can communicate and determine how much excess capacity of carbon-offsetting is available within the community of units as a whole (a sort of "social-networking site" for plants). In the same way by which circuit-breakers are useful for preventing excessive current use, the Natural Fuse plants break the CO2 footprint "circuit". In response, use less energy or increase the fuse (Fig. 1.20). Part of this project's approach is to raise awareness of energy expenditure and encourage people to collaborate to share their energy use and nurture their plants.



(Fig. 1.20): The system circuit breaker starts to work when the carbon level rises off its limit.

In general by exploring Haque's works and practices, it can be concluded that there are three major objectives that define his design strategies: First, minimizing the border between art and architecture, and inviting the public to participate in this reflection. Second, centering a lot of his work on large-scale, mass-collaboration interactive "spectacles" involving thousands of members of the public at once in order to explore strategies for collaboration that take account of the diversity of participation. Work at an urban scale, in a way that has an effect on the scale of buildings, parks, and streetscapes. Third, taking into consideration the change in how the space is "programmed", which changed the way the 'inhabitants' relate to each other and how they relate to their space. This approach to architecture became his challenge: how to translate such strategies into the general architectural discourse and how to bring into reality such possibilities for the construction industry.

1/3 Development of Interactivity Trends

The projects discussed in section two showed that in order to have an adaptable and flexible architecture that can interact to changes used the means of: physically changing or moving parts of the architecture contents, or through responding to the different stimuli of the surrounding environments, or by having intelligent agents that are able to take decision. So the discussed trends are kinetics, responsive and intelligent environments.

1/3/1 Kinetic Motion in Architecture

The increased awareness of intelligent and interactive architectural environment in terms of how spaces and objects can have the ability to gather information on users activates and predicts future uses of occupants and raises a question of how architecture can physically use this information and adapt to it? Here the term “kinetics” plays a great role in physical adaptation through kinetic movement at a variety of scales and applications.

1/3/1/1 Definition

Kinetic architecture is a concept where buildings are designed so that significant portions can move while retaining structural integrity. A building's capability for motion can be used just to enhance its aesthetic qualities, but can also allow it to respond to environmental conditions and to perform functions that would be impossible for a static structure.²⁸

Kinetic architecture is defined generally as either transformable objects that dynamically occupy predefined physical space or moving physical objects that can share a common physical space to create adaptable spatial configurations.²⁹ Robert Kronenburg in his book defines such systems as “buildings and/or building components with variable mobility, location and/or geometry.”³⁰ Generally, it relates to dynamically changing architectural elements or spatial layouts that address desires to have public or private space, to optimize thermal, visual, lighting and acoustic condition.

²⁸ Wikipedia free encyclopedia.

http://en.wikipedia.org/wiki/Kinetic_architecture. (Accessed 15 May 2010)

²⁹ Michael Fox and Miles Kemp. “Interactive Architecture,” Princeton architectural press, 2009. PP.15-20

³⁰ Robert Kronenburg, “transportable environment 2,” London: Spon Press, 2003. P.52

1/3/1/2 History and Development

The History of kinetics can be explored by its means of movement and adaptation through mobility.

First through movement: Primary forms of kinetic architecture, such as the drawbridge, date back to the middle ages or earlier. Yet it was only in the early 20th century that architects began to widely discuss the possibility for movement to be enabled for a significant portion of a buildings' superstructure.

Second through adaptability: Nomadic style of living was one of the first examples of adaptation through mobility, following the source of food and escaping climatic situation. This shows that there has always been the need to adapt and move. Kronenburg states that "because of the way in which the world is changing technologically, socially, economically, and culturally, it is probable that flexible, transportable design is as important now as it was when, in past millennia, the nomadic way of life was the dominant one across the planet."³¹ This is due to the introduction of mobile technology which has enabled self-sufficiency.

The development of kinetics started in the first third of the 20th century, interest in kinetic architecture was one of the thoughts emerging from the Futurism movement. Kinetic architecture was almost entirely theoretical, but by the 1940s innovators such as "Buckminster Fuller" began experimenting with concrete implementations, though his early efforts in this direction are not regarded as totally successful.

In 1970, a wide range of actual-working kinetic buildings started to develop. Since the 1980s, which witnessed new concepts, such as Fuller's ephemeralization, as well as developments in robotics, kinetic buildings have become increasingly common worldwide. Practical implementations of kinetic architecture increased sharply in the late 20th century with developments in mechanics, electronics and robotics opening up new architectural possibilities.

1/3/1/3/1 Kinetic Typologies

Kinetic structures in architecture are classified into three general categorical areas:

Embedded Kinetic structures are systems that exist within a larger architectural whole in a fixed location; simply they represent an integral and necessary part of the entire building (Fig. 1.21).

³¹ Robert Kronenburg. "[transportable environment 2](#)," London: Spon Press, 2003. PP. 11-13

The primary function is to control the larger architectural system or building in response to changing factors. Changes are brought by both environmental and human factors and may include axial, torsion, flexural, instability and variation. The engineer Guy Nordenson indicates that "if a building could change its posture, tighten its muscles and brace itself against the wind its structural mass could literally be cut in half ".³² Embedded kinetic structures can often replace other systems used to control the building as whole, in terms of adaptability to external environmental conditions acting as an active control. This system is usually coupled with computational control with the aid of tendons or moving masses tied to a feedback loop to sensors to the building.



(Fig. 1.21): Falkirk Wheel Scotland, movable structure

Deployable Kinetic structures typically exist in a temporary location and are easily transportable. Such systems possess the inherent capability to be constructed and deconstructed in reverse affording mobility rather than motion within a fixed structure. Applications may include traveling, exhibits, pavilions and self-assembling shelters (Fig. 1.22) in disaster areas .Apart from these recent design needs it has its roots in nomadic dwelling types that needed to be lightweight and durable as well as quick to assemble.



(Fig. 1.22): Instant military shelter that can be transported into various locations.

³² In a paper by Guy Nordenson, he is a Professor of Architecture at the University of California. He has collaborated on structures ranging from power stations in China to a glass cantilever stair in New York, the first of its kind.

Dynamic kinetic structures are the most recognized of kinetic systems in architecture. They also exist within a larger architectural whole, but act independently with respect to control of the larger context. Historically, dynamic systems were strictly kinetic, but are now becoming increasingly automated and intelligent. Applications shift from simple elements, like doors, louvers and elevators to ceilings and partitions that reconfigure themselves to adapt to users' needs and space performance, (Fig. 1.23) like auditorium ceiling that configures according to the audience and the performer location to obtain optimal acoustic properties.

Such systems can be subcategorized as: Mobile; includes all types that can be physically moved about within an architectural space to a different location. Transformable; can change in to different spatial configurations and can be used for space-saving or utilitarian need (Fig. 1.24). Incremental; can be added or subtracted from to create a larger whole out of discrete parts like LEGO pieces. Where such categories are not exclusive, a system can be both Transformable and Incremental:



(Fig. 1.23): Dynamic façade, by Giselbrecht & Partner.



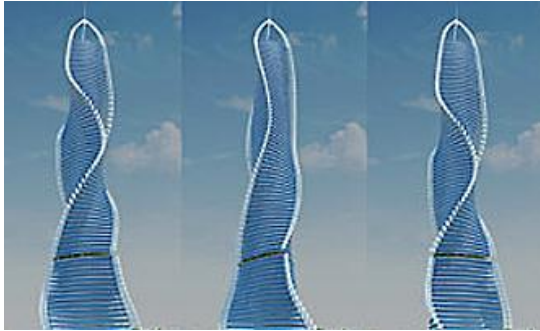
(Fig. 1.24): Moving stadium ceiling, Magnolia Stadium, by Mitsuru Senda.

1/3/1/4 Kinetic Systems

Kinetic employment for pragmatic adaptability and its various applications range today from creating full mobility to interior reconfiguration, where it can be categorized into four general applications:

Spatial Optimization System It is generally described as how systems can facilitate flexible spatial adaptability, or serve as means for adjusting spatial configuration based on changing stimuli, triggered by environment or human actions. Applications arise through addressing how transformable

objects can dynamically occupy predefined physical space. Such applications can be found in convention centers, banquet halls and offices. Applications may range from multiuse interior reorganization to complete structure transformability (Fig. 1.25).



(Fig. 1.25): David Fisher, Dubai rotating tower.

Multi-function Design System It can be defined as how movable architectural objects can share a common physical space to provide the means for a plurality of uses.³³ Systems that are component-based and deployable are ideally suited to accommodate and respond to changing needs. Applications can be identified at the scale of interiors, which are driven by pragmatic needs for privacy rather than by any humanistic need for spatial definition in terms of mood, acoustic or light (Fig. 1.26).

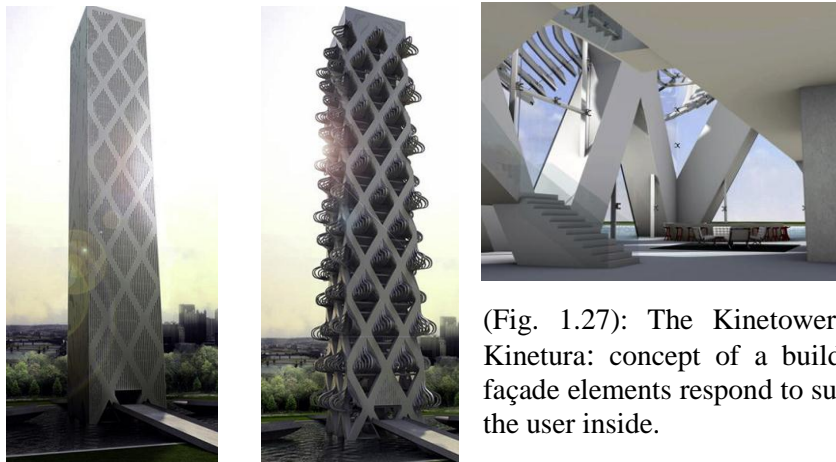


(Fig. 1.26): Bloom Frame is an innovative window frame which also allows balcony

Contextual Adaptability System It can be defined as how kinetics can be employed to dynamic or unknown contextual situations. It can be categorized into three areas; form, activity and climate pattern (Fig. 1.27). Contextual adaptability is typically interpreted as a response to the surrounding architectural environment in terms of types and typologies. Philip Beesly points out that “a common approach is augment buildings with kinetic

³³ Michael Fox and Miles Kemp. “Interactive architecture,” Princeton architectural press, 2009. PP. 15-17

capability, allowing buildings to alter their physical shape in response to climate conditions”.³⁴ Gary Brown explains that “ecological issues and sustainability reintroduce the importance of appropriate architectural interaction with the local and universal environment in which it is built”.³⁵



(Fig. 1.27): The Kinetower Designer, Kinetura: concept of a building whose façade elements respond to sunlight or to the user inside.

Mobility System It can be defined as a building or building component with variable constructability, location or geometry to physically adapt to change (Fig. 1.28). It is mostly referred to as an application which has a predetermined architectural life span. Applications are found in exhibitions design, and facilitate activity spaces more than permanent architecture, like schools and outdoor concerts.



(Fig. 1.28): Rolling bridge, England.

³⁴ Philip Beesley, Sachiko Hiroue, Jim Ruxton and Camille Turner: “Responsive architecture, subtle technologies,” Cambridge, Ontario: riverside architectural press, 2006. (p. 20)

³⁵ Gary Brown: “Introduction to transportable environments. 2nd ed. Robert Kronenburg.” London: Spon Press, 2003. P. 32

1/3/2 Responsive environments

It is an evolving field of architectural practice and research that predates the field of interactive architecture by a number of years. Responsive architectures distinguish themselves by using responsive concepts to change the qualities of architectural form and space – rather than being a series of patched intelligent systems – improving the energy performance of a building and reflecting the technological condition of our time. These technologies open new aspects – personalization of architecture – enabling a shift in the experience of inhabited space.

1/3/2/1 Definition

The term “responsive architecture” is commonly defined as a dynamic shape-shifting building system that can alter a building’s shape and physical properties in response to environmental conditions, user activities, and social contexts. The characteristics of responsive architecture are mainly defined by simulating behaviors from human and natural systems.

Responsive architectures aim at refining and extending the discipline of architecture by improving the energy performance of buildings with responsive technologies (sensors / control systems / actuators), while at the same time producing buildings that reflect the technological and cultural conditions of our time.

In his works, Negroponte proposes that responsive architecture is the natural product of the integration of computing power into built spaces and structures.³⁶ He also extends this belief to include the concepts of recognition, intention, contextual variation and meaning into computed responses, as well as their successful and ubiquitous integration into architecture.

1/3/2/2 History and development

The term "responsive architecture" was given to us by "Nicholas Negroponte" and the Architecture Machine Group at the MIT from the late 1960s to the mid-1970s. Negroponte first conceived the term during the late 1960s, when spatial design problems were being explored by applying cybernetics to architecture. Negroponte proposes that responsive architecture is the natural product of the integration of computing power into built spaces and

³⁶Which are published in his books called, “The Architecture Machine”, 1970; “The Soft Architecture Machine”, 1975; and multiple papers entitled: “The Semantics of Architecture Machines”, 1970, comprising the first significant attempts to define and produce a responsive architecture.

structures, and that better performing leads to more rational buildings. Negroponte also extends this mixture to include the concepts of recognition, intention, contextual variation, and meaning into computing and its successful (ubiquitous) integration into architecture.

Negroponte proposed the application of computers in architectural design and endorsed their integration in built structures and spaces. The initiation of the research program was a consequence of the crisis of architectural rationalism and the endless repetition of industrialized architectural forms. The goals of the program were to make buildings' context responsive and to create an intelligent environment that responds to the requirements and desires of users.³⁷

But this movement was short-lived. It came to an end in the mid-1970s as architects struggled to build the computational and structural systems needed to implement their new architectures. By the 1980s the idea of using responsive systems within buildings had completely transferred from architecture into the domain of engineering. It is here where the relationship between user comfort, building envelope, and the natural environment becomes most obvious.

Recently, the actual work of Tristan d'Estrée Sterk, head of the Office for Robotic Architectural Media and Bureau for Responsive Architecture, takes on the conceptions of responsive architecture as developed by Negroponte but takes into account more recent developments within the fields of robotics and machine intelligence.

1/3/2/3 Concepts of application

Responsive environments in generally are used to preserve the level of thermal comfort inside the buildings by responding to the external environmental conditions. Responsive environments can be categorized into four general applications:³⁸

Altering weather condition; used to preserve a comfortable climatic environment unlike the outside conditions such as, cold, heat, wind and rain, controlled by background related technologies (Fig. 1.29).

³⁷ Daniel Grünkranz: "Towards a Phenomenology of Responsive Architecture: Intelligent Technologies and Their Influence on the Experience of Space." University of Applied Arts, Vienna. 2009.p12

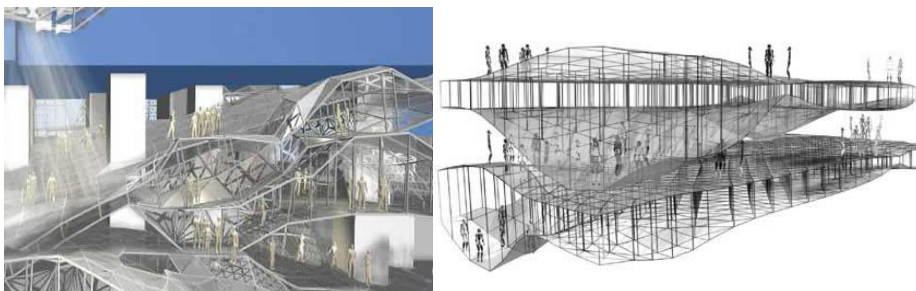
³⁸ Tristan d'Estrée Sterk: "shape control in responsive architectural structures – current reasons & challenges." 2009.p6



(Fig. 1.29): Al “bahar” tower in Abu Dhabi. The façade of triangular prototype is computer-controlled to respond to optimal solar and light conditions. Each triangle is coated with fiberglass and programmed to respond to the movement of the sun as a way to reduce solar gain and glare.

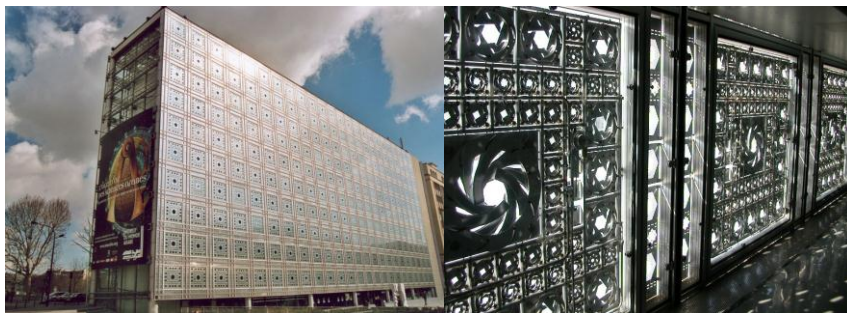
Preserving energy losses; this can be done by monitoring all spaces for human activities and only heating up the spaces which are actually occupied; or monitoring the active body itself. Bodily activities have an effect on the perception of space climate and, in turn, on the amount of energy which is spent to change it.

Changing its architectural form (shape shift); It is the ability to change its architectural form according to environmental conditions, weather and user’s needs. In responsive architecture, the building or space envelope itself is a conditional indicator (Fig. 1.30).



(Fig. 1.30): Topotransegrity - Non-Linear Responsive Environments – by Robert Neumayr. It is a generic responsive structural system, which adapts to isolated spatial requirements. The structure is capable of various transformations, which range from small-scale surface articulations to large-surface deformations, which can generate temporary enclosures.

Transporting the environmental conditions inside; this is done through responsive building envelopes. Building envelopes clearly mediate between our needs and the natural environment. Responsive building envelopes have an advantage over traditional building envelopes in that they may actively use several aspects of the natural environment to condition spaces. Responsive building envelopes also transmit loads in ways that traditional buildings cannot. They can help minimize unhelpful or dangerous loads and they can enable spaces to cooperate with air conditioning or other systems that support occupant needs (Fig. 1.31).



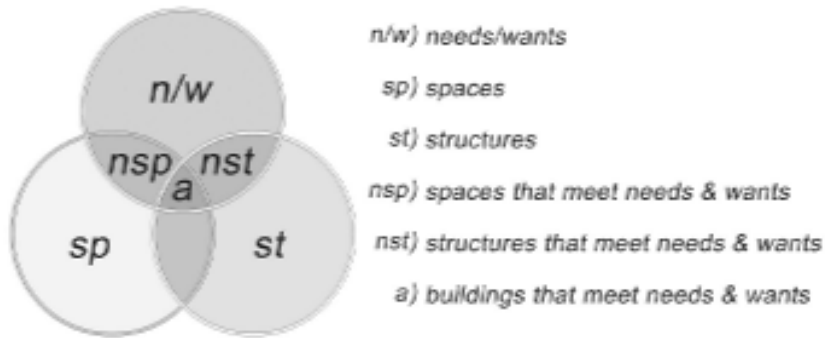
(Fig. 1.31): Arab cultural center in Paris. The façade made of numerous and variously dimensioned metallic diaphragms operate like a camera lens to control the sun's penetration into the interior of the building. The changes to the irises are revealed internally while externally a subtle density pattern can be observed.

1/3/2/4 Mechanisms

Before discussing the control mechanisms required within responsive architecture, a model for integrating the needs and wants of users into architecture will be proposed “A Discrete Model of Architecture”.

The model consists of three different functional components:³⁹ The needs and wants of building users. A building structure (the sheltering building envelope). A configuration of spaces that are serviced (for example: heated or lit). (Fig. 1.32) represents the different ways in which the needs and wants of users are (or are not) met by each element. It also suggests that the ideal form of architecture is one that is composed of a well-balanced mix between space and structure.

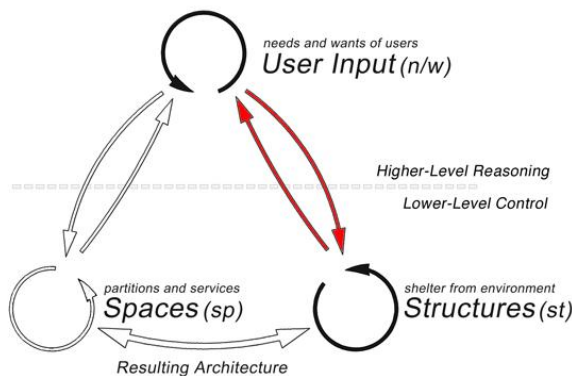
³⁹ Usman Haque. “Architecture, interaction, systems, in *Past Present.*” ed. Ranulph Glanville. Wien: edition echoraum, 2008.P.11.



(Fig. 1.32): The three components of a discrete model of architecture which are the needs / wants, space and structure, by Usman Haque

“Hybridized model of control” ;It is used to control structural responses that shelter, and spatial responses that serve, different user activities, as well as to categorize high-level and low-level responses, providing a base from which a new model of responsive architecture can be proposed.⁴⁰

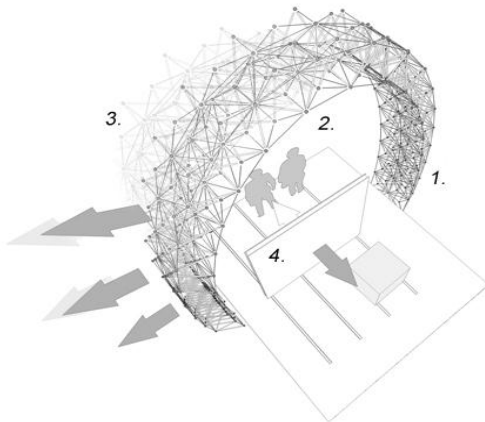
The resulting model borrows the general structure of the model proposed in (Fig. 1.33), and combines it with symbolic and sub-symbolic processes to produce a form of responsive architecture that relates user needs to actual building components and their responsive behaviors, be they generated by low or high level processes. The model, described by (Fig. 1.34), has three major parts, two types of connections between parts, and one implied connection that has been given the label “resulting architecture”. The parts consist of:



(Fig. 1.33): Proposed hybridized control model used cooperatively in response to changing patterns of use (by Tristan d’Estrée Sterk).

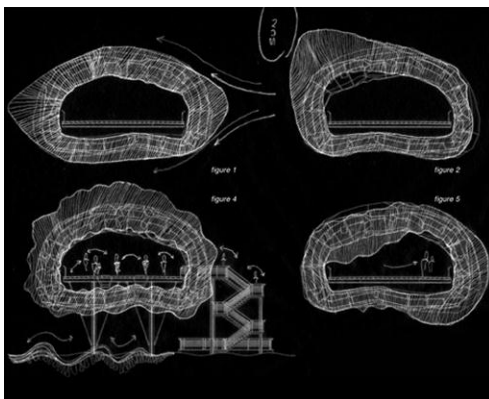
⁴⁰ As discussed in several papers and research by ,Tristan d’Estrée Sterk,. head of the Office for Robotic Architectural Media & Bureau for Responsive Architecture.

User input; which provides users with the means of controlling or manipulating responses that extend throughout a building. A building structure; that has a responsive capability which enables it to respond directly to environmental loads. Spatial response; that is used to control the partitioning and/or servicing of internal spaces.



(Fig. 1.34): Structure and internal partition working functional responsive architecture (by Tristan d'Estrée Sterk). The key:
 1&2- Lower structure and Upper structure.
 3- By adjusting the tension and rigidity of the structure physical movements are enabled;
 4. When coordinated with other responsive elements (i.e. an internal partition) the functional abilities of buildings may be further extended.

This lead to the deployment of actuated “tensigrity” structures. It provides an opportunity to change, for example, the aerodynamic profile of a building to minimize the wind load.⁴¹From the physical alteration of the envelope it is possible to give an interpretation of the environmental condition. The decisive step made here is a shift from background relations towards focal relations. Shape-shifting envelopes can draw focal attention and meaning to the boundary between inner and outer environments compared to static envelopes and their “being to the side” (Fig. 1.35).



(Fig. 1.35): "Frais" is an Experimental performance space over Chicago Harbor by Tristan d'Estrée Sterk. It has the ability to change its architectural form according to environmental conditions and weather. The tensigrity structures allow for the form to change according to the aerodynamic profile of a building to minimize the wind load.

⁴¹ Tristan d'Estrée Sterk.” shape control in responsive architectural structures – current reasons & challenges.” 2009. P.15

1/3/3 Intelligent Environments

As buildings become flexible enough to move and change position, by introducing kinetics in architecture, and responsive enough to stimulations, the next step is introducing intelligence to the buildings, where not every kinetic or responsive environments can be intelligent but the opposite can become true, as it is a system based on ubiquitous computing, in which the environment interacts with its inhabitants through embedded dedicated devices. So the next step is to be interactive, instead of only responsive, to an environmental or human need, by having the ability to learn from previous experience.

1/3/3/1 Definition

The definition of intelligent environments has been evolving with different emphasis, mainly driven by the development of relevant technologies and the changing needs for the built environment. It can be summarized as follows: From 1980 to 1985 intelligent buildings are buildings automatically controlled to function. From 1986 to 1991 intelligent buildings are buildings capable of responding to the changing needs. From 1992 to present: intelligent buildings are buildings with features effectively satisfying the changing needs.

This is shown in the following definitions evolved across the decades: “Intelligent Environments in building combine innovations, technological or not, with skillful management to maximize return on investment.”⁴² This definition contains, in addition to innovations and technology, a required achievement, which is to maximize return on investment. Other achievements like users’ productivity and comfort are not mentioned in the definition. “Intelligent Environments in building maximize the efficiency of its occupants and allows effective management of resource with minimum life costs.”⁴³ Here it considered the users comfort in a direct relation without having the ability to adapt to the changing needs, until the technology caught up another definition appeared “Intelligent Environments are more responsive to user’s needs and have the ability to adapt to new technology or changes in the organizational structures.”⁴⁴

Intelligent Environments in building know what is happening inside it and outside it and can decide the most effective way to create the right environment for users on time. This definition is adding to the ability to know (input) and the ability to respond (output) – the time factor.

⁴² The International Symposium, 1985, in Toronto.

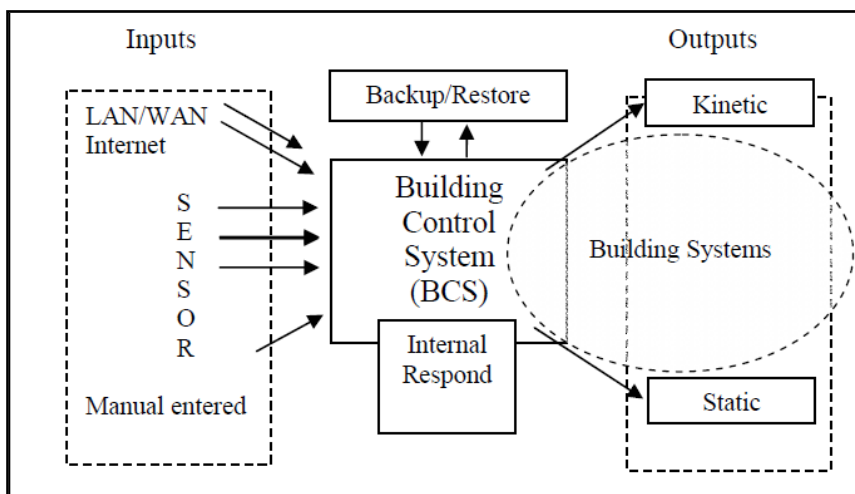
⁴³ According to the EIBG (European Intelligent Building Group).

⁴⁴ (DEGW), (1998) (the architecture of Duffy, Eley, Giffone and Worthington).

1/3/3/2 Concept

Intelligent architecture started as an interest in the latest integrated building systems operating a single building or facility, so that systems can communicate and exchange information. The communication among these systems allows the right responses and decisions to operate buildings in a productive, economical and convenient way. Communication and information-sharing prevent decisions from interfering with other systems' responses or operations, where technology and communication systems make it possible to combine several operations by using system integration and computerization, providing a variety of decisions according to different sources of information.⁴⁵

The intelligent environments require integrated systems by users using computer abilities to achieve users' needs, which may include productivity, efficiency, energy savings, entertainment, delight, comfort, return investment, and low life cost. The intelligent environments should have an operation concept that has the ability to be adjusted according to the different needs, including the following (Fig. 1.36): Input system that receives information by means of information receiver. Processing and information analysis system. Output system that reacts to the input in form of a response. Time consideration that causes the response to happen within the required time and finally a learning ability.



(Fig. 1.36): a diagram shows the Intelligent System Anatomy. The relation between inputs and outputs are controlled by building control system.

⁴⁵ Paper, A Middleware for Smart Environments, Christian Alberto Noriega Guerra and Flavio Soares Correa da Silva. 1999, p.18

1/3/3/3 Mechanism

The design and construction of an intelligent environment requires collaboration among several areas, which are:

First: ubiquitous connectivity in sensor-rich environments. The scale of the ubiquitous computing system is significant to the design of both the distribution of sensor information and the way in which sensors and information are represented. Second: adaptive technologies that allow access from multiple devices with varying capabilities. Third: context information drawn from what the Intelligent Environment can sense about its current physical and computational environments. This context information relates to aspects of the environment which include: who is in the environment, what they are doing, what they have done, and what their actions are.⁴⁶

The proposed architecture for the Intelligent Environment depends on determining methods for capturing such information at the lowest level, interpreting by historical reference, and aggregating into increasingly more abstract forms (Fig. 1.37).



(Fig. 1.37): a home automated environment showing different levels of sensors to capture the different information about its surrounding environment

⁴⁶ Matthias Kranz, Radu Bogdan Rusu, Alexis Maldonado, Michael Beetz, Albrecht Schmidt. “A Player/Stage System for Context-Aware Intelligent Environment.” 2000.P.7

Sensors are the most used methods for capturing information. Intelligent sensor-equipped environments can be much more helpful if they are capable of recognizing the actions and activities of their users, and inferring their intentions, as well as understanding human activities and characterizing them into expressive and detailed activity models. Here, sensors' information capable of being integrated against its own history, adapted from one representation to another and combined with other sensors into richer forms of sensor information, which are categorized into two levels: ordinary sensors and smart sensors, according to their ability to interpret data:⁴⁷

Ordinary sensors; they are mechanisms in both hardware and software to integrate both the physical and computational environments. These sensors include: Hardware to measure the physical environment, such as temperature, motion, light, vibration, and pressure; Software sensors which detect user login, network activity, and application activity.

Smart sensors; rather than providing the sensor data at the lowest level of detail (raw data) to an application programmer, the smart sensor layer includes methods for aggregating and filtering the raw sensor data. For example, a location context agent would gather data directly from a range of physical and software sensors. This data is used to determine a person's physical location. This location information is then deposited into the intelligent environment memory by the context agent.

Smart environment agents provide the second layer of context abstraction. These agents form two classes: rich-context providers and performance enhancers.

Rich-context agents; accesses a range of information from the intelligent environments repository to form higher level context information. For example, gathering information about physical location of users, temperature and noise level, to decide that a meeting is taking place, and taking the necessary actions to make it quarry all the needs of the meeting. Such agents build this high-level abstraction by the use of first-level smart sensor information, historical smart sensor and user model information.

Performance enhancers; represent the second class of smart environment agents which act with environmental knowledge over the smart sensor layer to improve their individual and collective performance. One approach is for these agents to include learning and reasoning algorithms to discover patterns which enable the agents to improve the performance and scalability of the underlying smart sensor layer.

⁴⁷ Bob Kummerfeld, Aaron Quigley, Chris Johnson and Rene Hexel. "Towards an Intelligent Environment Architecture for Multi-granularity Context Description." 2003, p 16

Concluding summary:

“Interactive” as a term was already found in nature as it is an emergent need for continuing by repeatedly changing in a continuous loop to meet the demands of different stimuli. It is a natural need necessary for survival. The relevance of interactive applications nowadays was related to the technological development brought by the information age, digital media and technologies, and remote communications. Thus interactive architecture is not a result of technology development but a means of expressing the occurred development.

The roots of interactive architecture were based on previous practices done by architects like Cedric Price in the sixties and Buckminster Fuller. The main concept which motivated their design approaches was the use of the cybernetics theory in terms of both conceptual design and computational tools.

There were always attempts to reach the goal of more adaptable and flexible architecture that interact to changes through practicing the trends of: kinetics, responsive and intelligent environments.

Kinetics can be explored by means of movement or adaptation through mobility, through different typologies: Embedded kinetic structure, where the system that controls architecture as a whole according to changing factors. Deployed kinetic structure, where the system is transportable and found in temporary locations. Dynamic kinetic structure, that acts independently with respect to control of a larger context.

“Responsive environments” was actually an attempt towards dynamic interactive architecture, but it was reactive in approach; it responded to environmental conditions, isolating the occupiers from their outer environments. However, exploring the technologies and concepts used in their practice helped in the development of interactive applications.

After using kinetic motion and responding to stimuli, Intelligent environments is the representation of the use of latest technologies of ubiquitous and embedded computation in buildings, defining the mechanism and the computational properties to have a sort of intelligence to be able to react to different needs and stimuli in a more active way.

In general, an intelligent environment has the ability to respond on time according to processed information that is measured and received from exterior and interior environments by multi-input information detectors and sources to achieve users’ needs and with the ability to learn.

This could happen by bringing computation into the real, physical world to allow computers to participate in activities that have never previously involved computation and to allow people to interact with computation systems the way they would with other people via gesture voice movement and context.

Sensors and micro-controllers are used within the environment in a way that can optimize comfort of the inhabitants, minimize the consumption of resources, and maintain safety of the environment and its inhabitants. Intelligent environments are considered a link between the previous trends to make them interactive by giving them the ability to take decisions.

Some of the main ideological concepts that helped in moving towards more interactive design approach were: the ability to move and change forms through "kinetics", the ability to adapt to changes through "responsiveness", and to be flexible enough to different stimuli through the use of "intelligent environments". This will be later used in the assessing of interactive applications.

From this chapter, we learn that the basic theory that influenced interactive architecture was cybernetics, both conceptually and in terms of tools development, mainly computers, which helped in the development and practicing of interactive applications in architecture. This will be further investigated in the next chapter.

Chapter 2

Ideological and Technological Tools Influencing Interactive Architecture

Introduction

This chapter discusses the basic theory that constitutes the ideology of interactive architecture and the necessary concepts and tools for its design process. This will be done by exploring the following:

Cybernetics theory by defining its concepts, development and how it set the basic guide lines of the concept of interactivity; and in digital computation, developing Artificial Intelligence (AI) and Virtual Reality (VR), which helped in resigning new tools that changed the way of implementing technology in architecture.

The design process and tools used to make the users more participants to their built environment, improving the performance of the buildings due to the technology development of embedded computation, interaction design and interface design.

2/1 Cybernetics

Architecture is continually re-inventing itself with the evolution of new technology. Most traditional architecture was static until buildings or their components recently had the ability to respond to external stimuli. Thus the relevance of studying cybernetics is to discuss the possibility of creating autonomous buildings, which are able to act and interact with different stimuli.

2/1/1 Definition

According to Oxford dictionary the term cybernetics is defined as: the science of communications and automatic control systems in both machines and living things. Origin: 1940s, from Greek *kubernētēs* 'steersman', from *kubernan* 'to steer' governor, or pilot. ¹

Cybernetics is the interdisciplinary study of the structure of complex systems, especially communication processes, control mechanisms and feedback principles. Cybernetics is the science that studies the abstract principles of organization in complex systems. It is concerned not so much with what systems consist of, but with how they function. Cybernetics focuses on how systems use information, models, and control actions to “steer towards”, and maintain, their goals, while counteracting various disturbances. Cybernetic reasoning can be applied to understand, model and design systems of any kind, whether physical, technological, biological, ecological, psychological, social, or any combination of those. ²

Cybernetics is a broad field of study, but the essential goal of cybernetics is to understand and define the functions and processes of systems that have goals and that participate in circular, causal chains that move from action to sensing, to comparison with desired goal, and again to action. Studies in cybernetics provide a means for examining the design and function of any system. ³

Cybernetics as a science has gone into several phases, since it evolved until now; and at each phase there were additions to its definition by several cybernation pioneers which can be referred to as follows:

¹ On-line oxford dictionary <http://oxforddictionaries.com> (Assessed March 2010)

² On -line dictionary <http://cybernetic.askdefine.com/> (Assessed March 2010)

³ Wikipedia free encyclopedia <http://en.wikipedia.org/wiki/Cybernetic> (Assessed March 2010)

The word was first used by Plato ⁴ in the sense of "the art of steering" or "the art of government". In 1834, Ampère ⁵ used the word cybernetics to denote "the study of ways of governing." Cybernetics has in fact the same root as government: the art of managing and directing highly complex systems. It was defined by Norbert Wiener ⁶ in 1948 as the study of control and communication in the animal and the machine.

Later on, Gordon Pask ⁷ extended the term to include information flows in all media. It included the study of feedback, black boxes and derived concepts such as communication and control in living organisms, machines and organizations, including self-organization. Its focus is how anything (digital, mechanical or biological) processes information, reacts to information and changes, or can be changed, to better accomplish the first two tasks.

Another definition, suggested by Louis Couffignal in 1958, ⁸ one of the pioneers of cybernetics, characterizes cybernetics as "the art of ensuring the efficacy of action". The most recent definition has been proposed by Louis Kauffman, President of the American Society for Cybernetics: "Cybernetics is the study of systems and processes that interact with themselves and produce themselves from themselves."

In general, cybernetics is the discipline that studies communications and control among living beings and the machines built by man, including artificial systems.

⁴ Plato was a Classical Greek philosopher, mathematician, writer of philosophical dialogues, and founder of the Academy in Athens, the first institution of higher learning in the Western world.

⁵ André-Marie Ampère (1775 –1836) was a French physicist and Mathematician who is generally regarded as one of the main discoverers of electromagnetism.

⁶ Norbert Wiener was an American mathematician. He was Professor of Mathematics at MIT. contributing work relevant to electronic engineering, electronic communication, and control systems. Wiener is regarded as the originator of cybernetics, a formalization of the notion of feedback, with many implications for engineering, systems control, computer science, biology, philosophy, and the organization of society.

⁷ Gordon Pask (1928-1996) was an English cybernetician and psychologist who made significant contributions to cybernetics, instructional psychology, experimental epistemology and educational technology. Famously known for interactions of actors theory and conversation theory.

⁸ Louis Couffignal (1902-1966) was a French Mathematician and Cybernetics pioneer. He published a variety of notes at the Academy of Sciences, with a focus on using binary computation by machines to solve new problems.

2/1/2 Concept

Cybernetics is the interdisciplinary studies that use models of organizations, feedback, goals, and conversation to understand the capacity and limits of any system; they consider powerful descriptions the most important result.

Cybernetics is most applicable when the system being analyzed is involved in a closed signal loop, that is, where action by the system causes some change in its environment and that change is fed to the system via information (feedback) that causes the system to adapt to these new conditions; the system's changes affect its behavior. This circular relationship is necessary for a cybernetic perspective. Thus the concept of cybernetics made it possible to link mechanization to biological and cognitive processes.⁹

To be able to perform in such a behavior the system should be aware of its surroundings, self-organizing and capable of taking decisions. Pask had in his opinion: self-organizing systems were “*systems that we regard as though they have elements in them that make decisions.*” It depended on the ability of the viewer to make sense of them. This demanded both a degree of self-identification of the observer with the system, as well as the presence of a common language between the two.¹⁰

This led to the emergence of artificial intelligence field in architecture, as cybernetics theory made it possible to mimic certain aspects of architectural design by artificial intelligence computer programs (provided, incidentally, that the program is able to learn about and from architects and by experimenting in the language of architects i.e. by exploring plans, materials specifications). Such programs are potential aids to design. Furthermore, they offer a means for integrating the constructional system (the machinery of production) with the ongoing design process since it is quite easy to embody constraints of current technology into a special part of the simulation.

Cybernetics studies systems of control as a concept, attempting to discover the basic principles underlying such things as robotics and adaptive systems. Computer science directly applies the concepts of cybernetics to the control of devices and the analysis of information, (robotics, simulation technology, cellular and automaton).¹¹ Especially all "value-added" computer-supported communication technologies (electronic mailing list,

⁹Christopher Hight. “Architectural principles in the age of cybernetics,” 2002.P.12

¹⁰ Francis Heylighen. “Cybernetics and Second-Order Cybernetics.” 2001. P.5

¹¹ Article by Bernard Scott in the "Independent".

<http://www.venus.co.uk/gordonpask/gpaskobit.htm> (Accessed May 2010)

such as PRNCYB-L, newsgroups and bulletin boards, and various forms of groupware, electronic publishing tools such as FTP or WWW) fall under this heading. They make it possible to exchange information in a very fast, simple and reliable way, so that it is automatically stored and ready for immediate further processing or transfer.

The domain of computing applications has grown so quickly, by that labelling anything that uses a computer as "cybernetic" is more obscuring than enlightening. Therefore we would restrict the label "cybernetic technology" to information processing and transmitting tools that somehow increase the general purpose (intelligence) of the user, i.e., the control the user has over information and communication.

2/1/3 Theory

Cybernetics tends to focus on complex systems such as organisms, ecologies, minds, societies, and machines. Cybernetics regards these systems as complex, multi-dimensional networks of information systems. Such systems are generally called "cybernetic systems". Cybernetics presumes that there are underlying principles and laws which can be used to unify the understanding of such types of systems.

Cybernetics has always been related to computer technology and computer modelling. Attempting to cybernetic theory before the development of computational technology would have been practically impossible. Therefore, as cybernetics grew out of the earliest developments in computer science, the development of this same technology is the fundamental to practice Cybernetics.

More theories having an important role in the development of computers evolved; the research will discuss some of them, namely the conversation theory and Interactions of Actors Theory, due to their role in developing more intelligent and interactive environments.

2/1/3/1 Conversation Theory

Pask and other cybernetics developed the Conversation Theory, it suggests how in the growing field of ubiquitous computing, humans, and their shared environments might coexist in a mutually constructive relationship. It suggests having a conversations with our environments in which we each have to learn from each other, Pask's early experiments with mechanical and electrochemical systems provide a conceptual framework for building interactive artefacts that deal with the natural dynamic complexity that environments must have without becoming prescriptive or restrictive. Pask recognized, that interpretation and context are necessary elements in

language – as opposed to locating meaning itself in language – which is particularly important to consider for any design process, not least the construction of architectural experience.¹²

It is a cybernetic theory that explains how interactions lead to "construction of knowledge", or, the emergence of knowledge by means of multi-level agreement oriented conversations among participants, supported by modeling facilities and suitable communication and action interfaces, as Pask referred to. Pask conceived human-machine interaction as a form of conversation, a dynamical process, in which the participants learn about each other. Conversation Theory described learning systems that involve at least two participants, a modeling facility and at least three levels of interaction these levels are:¹³ interaction with a shared modeling facility, conversational interaction about how to solve a problem and a conversation about why that method should be used.

Pask through his theory was concerned with the role that computers and the new information technologies can play in making positive contributions to our lives. He foresaw most of today's new developments decades ago in his books. Pask looked to the day when all human knowledge would be located in self-organising, interactive, multimedia archives, with intelligent agents to support learning and access. He referred to such support systems as "vehicles for driving through knowledge".¹⁴

2/1/3/2 Interactions of Actors Theory

Interactions of actors theory was also developed by Gordon Pask. It took a broader look at communications and the dynamics of social systems. It is also driven from the conversation theory. It is a generalized account of the eternal kinetic processes that support kinematic conversations bounded with beginnings and ends in all media.

Conversation Theory distinguishes between Psychological, Social, Educational and Learning Individuals which are called P-individuals and mechanically or biologically specified individuals which are called M-individuals according to Pask explanation. The former are 'productive and, incidentally, reproductive systems'.¹⁵ The Conversation Theory concentrates on the development of P-individuals as participants in conversations with

¹² Usman Haque. "The Architectural Relevance of Gordon Pask." 2005, p4

¹³ Interview by Bernard Scott in "the Independent.":

<http://www.venus.co.uk/gordonpask/gpaskobit.htm> (Accessed March 2011)

¹⁴ Gary McIntyre Boyd. "Conversation theory." Concordia University Canada 2006 ,p,9

¹⁵ Gerard de Zeeuw. "Interaction of Actors Theory." Center for Innovation and Cooperative Technology Faculty of Mathematics, Computer Science, Physics and Astronomy, University of Amsterdam. 2008. P.5

other P-individuals. Thus the need to include more M- individuals with P-individuals leads to the development of Interactions of Actors Theory.

2/1/4 Development

The term cybernetics was always related to a creation of a new technology development which had its influence on architecture, opening a gate for a new shift in architectural paradigm. Going through the history of its development and its relation, Cybernetics creates a responsive adaptive architecture all the way to interactivity.

In a quick review on Cybernetics, it can be said that it was previously defined as the science of “communication and control”, and it grew out of Shannon's ¹⁶ information theory, which was designed to optimize the transfer of information through communication channels and the feedback concept used in engineering control systems. This led to the introduction of the computer as an information processing tool. Most of the present computing applications, such as neural networks, machine learning, autonomous agents and artificial intelligence, are derived from ideas originally proposed by cyberneticists several decades ago.

The study of teleological mechanisms in machines with corrective feedback started at 1788 when James Watt's steam engine, called a “*governor*”, was equipped with a governor, a centripetal feedback valve for controlling the speed of the engine. That was an early attempt of using cybernetics through the feedback concept without naming it. With this invention leading to the industrial revolution a new paradigm in architecture evolved, which was modernism, although it failed later due to its negligence of humanistic role; yet it showed the relation between evolved technology and architecture.

2/1/4/1 First order cybernetics

Contemporary cybernetics in the early 20th century began as an interdisciplinary study. First-order cybernetics was concerned in particular with the study of a system as if it were a passive, objectively given “thing” that can be freely observed, manipulated, and taken apart. However, it still had an important influence on the birth of various modern sciences: control

¹⁶Claude Elwood Shannon an American mathematician, electronic engineer, and cryptographer. Shannon is famous for having founded information theory with one landmark paper published in 1948. But he is also credited with founding both digital computer and digital circuit design theory in 1937.

theory, computer science, information theory, automata theory, artificial intelligence and artificial neural networks, cognitive science, computer modeling and simulation science, dynamical systems, and artificial life.

Many researchers from the 1940s to 1960 worked within the tradition of cybernetics without necessarily using the term. R. Buckminster Fuller was one of them, as discussed earlier in chapter one. In the 1940s, the first step forward led to the move from the machine to the living organism, transferring to the ideas of feedback and finality, opening the way for automation and computers. In the fifties, it was the return from the living organism to the machine with the emergence of the important concepts of memory and pattern recognition, of adaptive phenomena and learning, and new advances in bionics (which attempts to build electronic machines that imitate the functions of certain organs of living beings), artificial intelligence and industrial robots. There was also a return from the machine to the living organism, which accelerated progress in neurology, perception and the mechanisms of vision. In the sixties the extension of cybernetics was foreseen in industry, society, and ecology.¹⁷

2/1/4/2 Second-order cybernetics

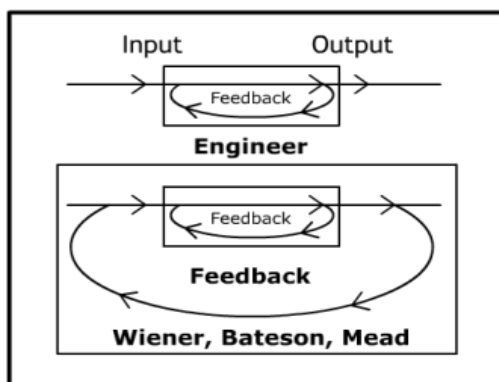
Cybernetics had from the beginning been interested in the similarities between autonomous living systems and machines. In this post-war era, there was a great interest in the new control and computer technologies, which tended to focus attention on the engineering approach, where it was the system designer who determines what the system would do. After the control engineering and computer science had become independent disciplines, cyberneticists felt the need to clearly distinguish themselves from those more mechanistic approaches by emphasizing autonomy, self-organization, cognition, and the role of the observer in modeling a system. In the late 1960s and the early 1970s, this movement became known as second-order cybernetics, which was concerned about studying the role of the (human) observer in the construction of models of systems, as well as other observers.

This led to the development of the “Conversation Theory” – as discussed earlier in this chapter of the research –, which made advancements toward understanding and identifying the field of interactive architecture. Rather than strictly interpreting people's desires, an environment should allow users to take a role in configuring their environment. This notion seized

¹⁷ <http://www.venus.co.uk/gordonpask/gpaskobit.htm> (Accessed 1 march 2011)

to continue due to the lack of funding, and the desired technology to make such a performance was not developed yet.¹⁸

Thus "first-order" cybernetics will study a system as if it were a passive, objectively given "thing" that can be freely observed, manipulated, and taken apart. Second-order cybernetics recognizes that system as an agent on its own, interacting with another agent – the observer (Fig. 2.1). As quantum mechanics states, observer and observed cannot be separated, and the result of observations will depend on their interaction. The observer too is a cybernetic system, trying to construct a model of another cybernetic system.¹⁹



(Fig. 2.1) The anthropologists Gregory Bateson and Margaret Mead contrasted first and second-order cybernetics with this diagram in an interview in 1973. It emphasizes the requirement for a possibly constructivist participant observer in the second order case⁽²¹⁾

2/1/4/3 Cybernetics attempts toward interactive architecture

Through the development of cybernetics theory, the idea of having architecture that is more aware of its surroundings went through many attempts. The research will discuss the trends evolved due to the technologies related to cybernetic theory.

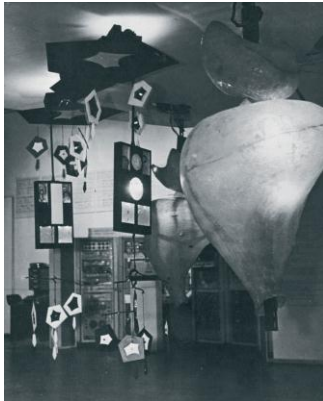
The cyberneticians of the 1960s laid the foundation upon which interactive architecture was constructed with the idea that interactivity was a two-way street. This and other ideas were adapted by the architects of the time for use in their work. Cedric Price was one whose project Fun Palace was to be a "laboratory of fun," built in a grid-like steel structure where temperature systems would control fog, warm air, and moisture; thus it was responsive to the public's needs.

¹⁸ interview by Bernard Scott in "The Independent".

<http://www.venus.co.uk/gordonpask/gpaskobit.htm> (Accessed 1 may 2011)

¹⁹ Francis Heylighen , Free University of Brussels , Cliff Joslyn. "Cybernetics and Second-Order Cybernetics." Los Alamos National Laboratory. 2001 p.12

Pask also showed primary attempts of using cybernetics concepts in creating participating, performative, interactive environments. This was clear in his projects of (Colloquy of Mobiles, music box and saki). This depended on interaction loops of cybernetic systems that became the inspiration for many future interaction designers. The Colloquy of Mobiles is a material implementation of a complex theory of artificial organisms and self-organizing systems before the advent of artificial life. Pask's mobiles were machines that could "learn" and interact with each other and potentially with humans (given that they learned the mobile's visual language using a mirror and a flash light) (Fig. 2.2). This was a significant innovation. It may be argued that these collaborations were too far ahead of their time and were not fully grasped by the wider architectural community, but they did help to set the foundations for dynamic, responsive and interactive environments.²⁰



(Fig. 2.2) Gordon Pask, Colloquy of Mobiles, ICA, London, 1968 The system was installed at the seminal exhibition 'Cybernetic Serendipity'; the 'female' bulbous forms here were designed by Yolanda Sonnabend.

But it was a few decades before the technology caught up over the 1970s and 1980s when groups like MIT Architecture Machine Group (now MIT Media Lab) led by the architect, William Brody, carried the torch by exploring the relationships between humans and technology, with artists and scientists from various disciplines experimenting with interactivity and design, proposing to teach our environments first to be complex, then self-organizing, and finally intelligent.²¹

Nicholas Negroponte, on the other hand, was more interested in the relation between the design process and computers, creating interactive interaction between them. To open more possibilities in design as published in his book "The Architecture Machine". The applications he described were

²⁰Lucy Bullivant. " 4dsocial: Interactive Design Environments ." willey & sons ,2007.PP.25-29

²¹ <http://aminima.net/wp/?p=858&language=en> (Accessed 1 May 2011)

more concerned with digital media and design processes than the physical built environment.²²

Proposing the Adaptive-Conditional Architecture in 1972 by expanding upon the earlier ideas explored in cybernetics by Pask and Norbert Wiener, in which architects interpreted spaces and users (participants) as complete feedback systems. Eastman proposed that feedback be used to control an architecture that self-adjusts to fit the needs of users. These cybernetic ideas essentially describe such responsive actions of users and architecture as “dynamic stability”. Andrew Rabeneck made a very pragmatic interpretation in 1969 by proposing the use of cybernetic technologies to produce an adaptive architecture that would increase the useful lifespan of a building through adaptation.

With the evolution of computer technologies in the 1980s and the 1990s, intelligent environments started to be feasible. And for something to be intelligent it must be able to learn about its world and develop its own ability to interact with it. Architecture should be a living, evolving thing. John Frazer (who was a consultant for Price and also worked with Pask) said: “Natural ecosystems have complex biological structures: they recycle their materials, permit change and adaptation, and make efficient use of ambient energy”.²³

Lately in the 2000s, Hybridization is a concept that has prevailed today in modern robotics where, by simple automated feedback, is coupled with higher-level deliberative processing. This makes it clear that we need to be able to make coherent connections with our environmental systems. Rather than simply doing exactly what we tell them (which relies on us knowing exactly what we want within the terms of the machines, terms that are predetermined by the original designer) or alternatively the systems telling us exactly what they think we need (which relies on the environment interpreting our desires, leading to the usual human-machine inequality), it is about developing ways in which people themselves can become more engaged with, and ultimately responsible for, the spaces they inhabit. It is about investing the production of architecture with the poetics of its inhabitants.

²² Nicholas Negroponte. "The Architecture Machine," published by Massachusetts institute of technology, 1970.P.10

²³ John Frazer. "an evolutionary architecture," published by the architectural association USA ,1995.P.28

2/1/5 Artificial intelligence (AI)

It is a discipline emerged from the cybernetic theory. Artificial intelligence is a domain that mimics any sort of intelligence in living creatures. It has been used in architecture as it had the ability to analyze any gathered information and perform accordingly enhancing the performance of the built environment. It has been used in architectural fields that regard ecological demands and minimizing energy consumption. Artificial intelligence will be discussed in terms of its definition, concept and means of its implementation.

2/1/5/1 Definition

In order to define artificial intelligence (AI) we have first to define what intelligence is, and the most quantifiable definition is the ability to apply knowledge in order to perform better in an environment. Thus AI can be defined as the study and construction of agent programs that perform well in a given environment for a given agent architecture, where the term “agent” is meant to be an entity that takes action in response to an environment.²⁴

There were many definitions of AI from different approaches across its evolvement which are: reasoning, thought processing, behavior and knowledge acquisition. This led to two main dimensions in defining AI, the first one measures success in terms of fidelity to human performance, while the second uses an ideal performance measure, called rationality. A system is rational if it does the right thing, according to the information provided to it. So in human performance, or in rationality, the definition is concerned with the way the system is thinking and acting. These approaches to AI have been followed, each by different people with different methods. A human-centered approach must be in part an empirical science, involving observations and hypotheses about human behavior.

A rationalists approach involves a combination of mathematics and engineering. These approaches are defined as:²⁵ One concerned with thinking humanly; the automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning. The other one that creates machines which perform functions that require intelligence when performed by people.

²⁴Stuart Russell, peter nerving. "instructor's manual exercise solutions for Artificial intelligence a modern approach," second edition Pearson hall ,2003.P.12

²⁵ Stuart Russell, peter nerving. "Artificial intelligence a modern approach," third edition Pearson hall ,2010.P.32

2/1/5/2 Concept

The main concept of artificial intelligence is that a machine is to simulate any kind of intelligence already found in living creatures by having the ability to learn. It is an attempt to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. This notion was first explored by John McCarthy.²⁶ Where cybernetics creates a universal system of part to whole interaction, AI does not operate on so broad a scale; it is a set of models and methods on how intelligence works. It is about creating systems that incorporate models of intelligence, interact with and respond to both designer and end user, and adapt and evolve over time.²⁷

The main aim of artificial intelligence is to understand the principles that make intelligent behavior possible, in natural or artificial systems. Artificial intelligence is roughly divided into two main methodologies:²⁸

One methodology is the symbol system states that; intelligence operates on a system of symbols. The idea is that perception and motor interfaces are sets of symbols on which the central intelligence system operates. The central system, or reasoning engine, operates depending on the symbols. Their meanings are unimportant to the reasoned, but the coherence of the complete process emerges when an observer of the system knows the groundings of the symbols within their own experience.

The second methodology is the Physical Grounding states that; to build a system that is intelligent it is necessary to have its representations grounded in the physical world, with the help of sensors and actuators that connect the system to the world. The observed world is its own best model. It is up to date and contains every needed detail.

2/1/5/3 Means of Implementation

In order to perform AI we need an agent that can act in an environment which was mentioned in the definition before, so there is a need to explain an agent and environments.

The intelligent agent is something that acts in a given environment. It is a system that acts intelligently; it acts in way that is appropriate for its circumstances and goals. It is flexible to the changing environments and the

²⁶ John McCarthy "[A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence](#)," (1955). AI used information theory to model the brain, examining how computers could learn, problem solve and use natural language. P29

²⁷ Herbert A. Simon. "[The Sciences of the Artificial](#)," MIT Press, Cambridge, MA, 1969.

²⁸ Rodney A. Brooks. "[Paper, Elephants Don't Play Chess](#)," MIT Artificial Intelligence Laboratory, 1990.P. 19

changing goals. It learns from experience and it makes appropriate choices given perceptual limitations and finite computation. An intelligent agent, a tool for analyzing systems, can be viewed as perceiving its environment through sensors and acting upon that environment through actuators. For example, a robotic agent might have cameras and infrared range finders for sensors and various motors for actuators.

An agent functions through perception, which is meant to be the agent's perceptual inputs at any given instant. An agent's perception sequence is the complete history of everything the agent has ever perceived. In general, an agent's choice of action at any given instant can depend on the entire percept sequence observed to date, but not on anything it has not perceived. An agent can be categorized into two main themes:

A rational agent is one that is capable of planning and executing the right task at the right time by having percept sequence, so an agent can select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and the built-in knowledge the agent has.

An omniscient learning and autonomous agent; Working autonomously, an ideal agent should be intelligent enough to learn from its experience, which requires basic reasoning capabilities. Its agent knows the actual outcome of its actions and can act accordingly. So it is realized that rationality maximizes expected performance, while omniscience maximizes actual performance.²⁹

This agent relies on the knowledge of its own percepts not on that provided in advance by its designers. This is done by giving the system the ability to learn and gain experience through random acting to perform well. Unless the designer gives some assistance, it would be reasonable to provide an artificial intelligent agent with some initial knowledge as well as an ability to learn. After sufficient experience of its environment, the behavior of an agent can become effectively independent of its prior knowledge, to design a single agent that will succeed in a vast variety of environments.

The task environment is where the agent is functioned. It comprises a specified performance measure, an environment, and the agent's actuators and sensors. This is the PEAS (Performance, Environment, Actuators, and Sensors) description. In designing an agent, the first step is to specify the task environment as fully as possible

²⁹ Alexander Serenko Brian Detlor. "Intelligent agents as innovations Received." Springer-Verlag London Limited, 2004.P.38

2/1/6 Virtual Reality (VR) Models

The virtual world is interactive; it responds to the user's actions. Virtual reality evokes a feeling of immersion, a perceptual and psychological sense of being in the digital environment presented to the senses. The sense of presence or immersion is a critical feature distinguishing virtual reality from other types of computer applications. Virtual reality will be discussed in terms of definition, concept, means of implementation and applications

2/1/6/1 Definition

The computer-generated simulation of a three-dimensional image or environment that can interact with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors.³⁰

Virtual reality is commonly involved in its definition with the use of various computer graphics systems in combination with various display and interface devices to provide the effect of immersion in an interactive three-dimensional, computer-generated environment in which the virtual objects have spatial presence, creating an interactive three-dimensional computer-generated environment.

Other words, it is creating the illusion of participation in a synthetic environment rather than external observation of such an environment. Virtual reality relies on a three-dimensional, stereoscopic head tracker displays, hand/body tracking and binaural sound.³¹ Creating this illusion relies on immersive, interactive, multi-sensory, viewer-centered, three-dimensional computer-generated environments as well as the combination of technologies required to build these environments.³²

In general, virtual reality is a technology to simulate environments and create the effect of an interactive three-dimensional world in which objects have a sense of spatial and physical presence and can be manipulated by the user. It is an immersive, real time, and interactive simulation of a space that can be experienced by users via three-dimensional input and output devices. In the context of this research, VR is defined as a three-dimensional computer representation of a space in which users can move their viewpoints freely in real time.

³⁰ on-line oxford dictionary. <http://oxforddictionaries.com> (Accessed 1 may 2011)

³¹ M. Gigante. "Virtual Reality: Definitions, History and Applications". "Virtual Reality Systems", Academic-Press, 1993 P.42

³² C. Cruz-Neira. "Virtual Reality Overview". SIGGRAPH'93 Course, No. 23, PP.1.1-1.18

2/1/6/2 Concept

Virtual reality as it was defined depends primarily on: immersion, which means the sense that either the user's point of view or some part of the user's body is contained within the computer-generated space where the user can watch and manipulate the simulated environment in the same way it acted in the real world. Secondly, it depends on presence, which means that the computer-generated objects in the virtual environment have an apparent position in three-dimensional spaces both in terms of display and interaction relative to the user.

The main vision of (VR) is creating intuitive environments that facilitate user tasks by reducing the amount of computer interaction technology, making the computer hardware invisible, which the user would be required to master. This could happen by using anthropomorphic character of interaction in virtual reality to create environments which closely mimics human real world interaction, creating computer-generated environments which feature highly intuitive human computer interaction.³³ In relation to that, there are two important concepts that must be mentioned when talking about (VR); these are Telepresence and Cyberspace. They are both tightly coupled with (VR), but have a slightly different context.

Telepresence; it is a specific kind of virtual reality that simulates a real, but remote – in terms of distance or scale –, environment. Telepresence occurs when at the work site, the manipulators have the dexterity to allow the operator to perform normal human functions; at the control station, the operator receives sufficient quantity and quality of sensory feedback to provide a feeling of actual presence at the worksite.³⁴

Cyberspace; was invented and defined by William Gibson as a consensual hallucination experienced daily by billions of legitimate operators, a graphics representation of data abstracted from the banks of every computer in human system.³⁵ Today the term Cyberspace is rather associated with entertainment systems and World Wide Web – Internet.

Thus Virtual Reality refers to a technology which is capable of shifting a subject into a different environment without physically moving the user. To this end the inputs into the subject's sensory organs are manipulated in such a way that the perceived environment is associated with the desired Virtual Environment and not with the physical one. The manipulation process is

³³ Steve Bryson. "Approaches to the Successful Design and Implementation of VR Applications." Computer Science Corporation/NASA Ames Research Center Moffett Field, Ca. 2000, P.19

³⁴ R. Held, N. Durlach." Telepresence. Presence." Vol. 1, No. 1, 1993 .PP. 109-113

³⁵ According to W. Gibson, novel: Neuromancer in 1983

controlled by a computer model that is based on the physical description of the Virtual Environment.

VR modeling concepts needed to develop the desired Virtual Environment require further explanation. Such a conceptual specification contains a high level description of virtual world, the objects inside the virtual world, the relations that hold these objects and how these objects behave and interact with each other and with the user. These modeling concepts are very intuitive to be able to address different types of users. This means that the vocabulary used should be familiar to most of its users. The expressive power of the different modeling concepts must be sufficient to allow using the resulting models as input for an automatic implementation phase. This is called A Conceptual Modeling Approach, and is done through the following phases:³⁶

Conceptual Specification Phase; where the designer can specify the virtual world at a high level using the intuitive modeling concepts approach. The specification consists of two levels, since the approach follows to some degree the object-oriented paradigm. The first level is the domain specification; it describes the concepts of the application domain needed for the virtual world and the possible relations among these concepts. The second level of the specification is the world specification; it contains the conceptual description of the actual virtual world to be built.

The Mapping Phase; the purpose of the mapping step is to bridge the gap between the conceptual specifications and the implementation. Appealing visualizations and graphics are very important in the field of (VR). Therefore, it is necessary to describe how the objects should be visualized in the virtual world.

The Generation Phase; during this step the actual source code for the virtual world is generated. This means that the conceptual specifications are converted into a working application by means of the mappings given during the mapping phase. In principle, different VR implementation languages can be supported.

Virtual reality models falls mainly into two categories either static or dynamic. Modeling the Static Structure; to develop the context of Virtual Reality with the enabled Intuitive Specifications, the virtual reality objects in the actual virtual world are modeled as instances of concepts. In this way an instance inherits all the properties defined for the concept. In virtual reality application, many objects are in fact assemblies of other objects. Therefore, we distinguish between simple objects and complex objects. Another

³⁶ Ivan Sutherland. "The Ultimate Display," Proceedings of IFIP Congress 2, 1965 PP. 506-509

important aspect that needs to be modeled for a virtual reality application is the scene. The scene contains the virtual reality objects. These objects have a position and an orientation in the scene. To model this we have to introduce spatial and orientation relations: A spatial relation specifies the position of an object relative to some other object in terms of a direction and a distance. Orientation relations in VR, it is also necessary to indicate how objects are oriented in relation to each other and their environment.³⁷

Dynamics Model; In order to obtain animated and interactive behavior, the system has to update its state in response to changes initiated by sensors attached to input devices, such as timers or trackers. The application can be viewed as a network of interrelated objects whose behavior is specified by the actions taken in response to changes in the objects on which they depend.³⁸

The idea behind virtual reality is to make a visual presentation to take better advantage of the human ability to recognize patterns and see structures. So it is more than visualization of a system and more about Perceptualization of it. With virtual reality sound and touch, as well as visual appearance, may be used effectively to represent data. Perceptualization involving the sense of touch consists of both tactile feedback such as passive touch, feeling surfaces and textures, and haptic feedback such as active touch, where there is a sense of force feedback, pressure or resistance. Visualization, on the other hand, is representing information in ways that can engage any of our sensory systems, and drawing on our extensive experience in organizing and interpreting sensory input.³⁹

2/1/6/3 Means of Implementation

The key feature of all virtual reality systems is that they provide an environment created by the computer or other media where the user feels present, that is, immersed physically, perceptually and psychologically.

Virtual reality systems enable users to become participants in artificial spaces created by the computer. These systems were classified

³⁷ Tomasz Mazuryk and Michael Gervautz. "Virtual Reality, History, Applications, Technology and Future." Institute of Computer Graphics, Vienna University of Technology, Austria. 2005 P.13

³⁸ Nadia Magnenat, Daniel Thalmann "Virtual Reality Software and Technology." MIRALab, Centre Universitaire d'Informatique University of Geneva, Switzerland.2003 p16

³⁹ Minsky, M. "Force feedback: The sense of touch at the interface." Paper presented at the Virtual Reality '91 Conference, San Francisco. (1991, September 23).

according to the development of the technological tool. They can be classified as follows:⁴⁰

Immersive systems involve computer interface devices such as a head-mounted display (HMD), fiber-optic wired gloves, position tracking devices and audio systems providing 3-D (binaural) sound. Immersive virtual reality provides an immediate, first-person experience, with interface to simulate the experience of walking through virtual space in a photo-realistic way. In immersive VR, the user is placed inside the image; the generated image is assigned properties which make it look and act real in terms of visual perception and in some cases aural and tactile perception.

Augmented Reality is a variation of immersive virtual reality is Augmented Reality where a see-through layer of computer graphics is superimposed over the real world to highlight certain features and enhance understanding. Augmented Reality is about augmentation of human perception, supplying information not ordinarily detectable by human senses. Augmented Reality technology provides means of intuitive information presentation for enhancing the situational awareness and perception of the real world. This is achieved by placing virtual objects or information cues into the real world as the user perceives it.⁴¹

Through the Window this kind of system, also known as desktop VR, the user sees the 3D world through the window of the computer screen and navigates through the space with a control device such as a mouse. Like immersive virtual reality, this provides a first person experience.

Mirror World in contrast to the first person systems described above, "Mirror Worlds" projected realities provide a second person experience in which the viewer stands outside the imaginary world, but communicates with characters or objects inside it. Mirror world systems use a video camera as an input device. Users see their images superimposed on, or merged with, a virtual world presented on a large video monitor or video projected image. Using a digitizer, the computer processes the users' images to extract features, such as their positions or movements.⁴² Another application is an teleconferencing project called "Virtual Cities" In this application; students in different cities around the world are brought into a networked common virtual environment using videophones.

⁴⁰ S. Bryson et al.: "Knowledge-Based Augmented Reality". Communications of the ACM, Vol. 26, No. 7, 1993. P. 56-62

⁴¹ - Azuma, R. Augmented reality. http://www.cs.unc.edu/azuma/azuma_AR.html. (Accessed 1 April 2011)

⁴² Mandala VR News. Futurewatch: "Interactive teleconferencing." Mandala VR News. Toronto, Canada: The Vivid Group. (1993, Fall/winter) P3.

A Chamber World is a small virtual reality projection theater controlled by several computers that gives users the sense of freer movement within a virtual world than the immersive VR systems, and thus a feeling of greater immersion. Images are projected on all of the walls that can be viewed in 3D with a head-mounted display showing a seamless virtual environment. Sony Omnimax 3D theaters are a “Chamber World” example where all members of the audience wear a head mounted display in order to see 3D graphics and hear 3D audio.

The Vision Dome is an immersive, multi-user, single projection Virtual Reality environment featuring a full-color, raster-based, interactive display. This differs from the chamber world type of virtual reality in that it does not require restrictive interface devices such as head mounted displays. Upon entering the Vision Dome, the user views are into its hemispherical structure, which forms a fully immersive 180 degree hemispheric screen. The Vision Dome is highly interactive. For example, it allows designers and clients to interact in real time with a proposed design.⁴³

2/1/6/4 Applications

VR systems allow the user to go beyond the limits of physics as known. With a Virtual Reality system, the user has the choice to closely model reality or to permit things that would be impossible to do in real life conditions. This may offer great advantages over more conventional methods of communicating ideas. This is particularly true for architectural applications where you may want to go freely from one point of view to another in the room.⁴⁴ The main categories of virtual reality applications are:

Data and architectural visualization; it attempts to apply VR as visualization tool were architectural walkthrough systems;⁴⁵ the feeling of presence and the sense of space in a virtual building, which cannot be reached even by the most realistic still pictures or animations. One can watch it and perceive it under different lighting conditions just like real facilities. One can even walk through nonexistent houses and destroyed ones (Fig. 2.3).

⁴³ Alternate Realities Corporation (ARC), 1998; Design Research Laboratory, 2001; Elumens Corporation, 2001. Elumens Corporation, Inc. Vision Dome Models. Posted on: <http://www.elumens.com/products/visiondome.html> (Accessed 1 April 2011)

⁴⁴ <http://vresources.org/applications/applications.shtml> (Accessed 1 May 2011)

⁴⁵ F. Brooks Jr. “Walkthrough - A Dynamic Graphics System for Simulating Virtual Buildings.” Proceedings SIGGRAPH Workshop on Interactive 3D Graphics (1986).



(Fig. 2.3) VR in architecture: left Ephesus ruins (TU Vienna), right reconstruction of destroyed Monument in Dresden (IBM)

Modeling, designing and planning; in modeling, virtual reality offers the possibility of watching in real time and in real space what the modeled object will look like. The user can change colors, textures and positions of objects, observing instantaneously how the whole surrounding scene would look like. VR was also successfully applied to the modeling of surfaces.⁴⁶ The advantage of this technology is that the user can see and even feel the shaped surface under his fingertips (Fig. 2.4).



(Fig. 2.4): Fraunhofer Institute: Virtual Design directs manipulation of the interior design to see the direct impact of such changes.

Telepresence and teleoperating; the goal of telerobotics is autonomous operation, a supervising human operator is still required in most of cases.⁴⁷ Telepresence is a technology that allows people to operate in remote environments by means of VR user interfaces.

Cooperative working; network-based, shared virtual environments are likely to ease the collaboration between remote users. The higher bandwidth of information passing may be used for cooperative working. Some practical applications, however, already do exist – just to mention a collaborative CO-CAD desktop system that enables a group of engineers to work together within a shared virtual workspace.⁴⁸

⁴⁶ J. Butterworth, A. Davidson, S. Hench, M. Olano: 3DM: “A Three Dimensional Modeler Using a Head-Mounted Display.” SIGGRAPH Symposium on Interactive 3D Graphics, (1992) (p. 135).

⁴⁷ M. Bolas, S. Fisher: “Head-Coupled Remote Stereoscopic Camera System for Telepresence Applications.” SIGGRAPH’93, Course, No. 23, 1993 .PP. 12

⁴⁸ M. Gisi, C. Sacchi: Co-CAD: “A Collaborative Mechanical CAD System. Presence.” Vol. 3, No. 4, 1995 .PP. 341

2/2 Interactive Design Methods

To implement interactive applications the design method requires interaction design mainly with computers, interface to facilitate the interaction and embedded computation to control the actions.

2/2/1 Human-computer interaction (HCI)

The most revealing interaction influencing architecture now is between humans and computers, as recent concepts in Human Computer Interaction (HCI) have demonstrated relevance in physical objects and spaces, turning them into elements of physical interface to mediate particular human actions, aspects of communication, entertainment and aesthetic expression. The research will focus on studying this particular interaction.

2/2/1/1 Definition

Architecture paradigms have gone through many changes from being static to more dynamic, responsive, and finally interactive. In this context, “interaction” in general can be defined as mutual influence between both partners in the discourse, whether machine or human, changing their state, frames of mind or views after the interaction. This can take place when the technology has means to sense, process, and act. Generally, interaction can be defined as the mutual influence of two or more entities leading to a change of state in all parties involved, either human or machine.⁴⁹

Human computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use for both hardware and software, and with the study of human interaction with computers.⁵⁰

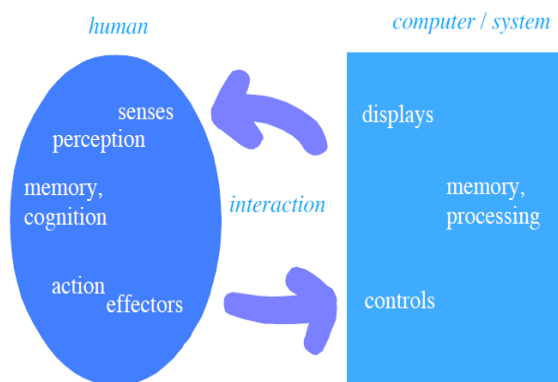
In other words, it focuses on interfaces of humans and the surrounding technological devices, Human Computer Interaction can be defined as the research field that studies the relationship between humans and the technological environment. It develops interfaces that enable the interaction.

⁴⁹ A. J. Bongers. “Interactivation Towards an e-ecology of people, our technological environment, and the arts.” Vrije Universiteit Amsterdam, June 2006. P62

⁵⁰ Theo Mandel. “User/System Interface Design, Interface Design and Development.” Encyclopedia of Information Systems, Volume Four by Academic Press, 2002. P83

2/2/1/2 Concept

To explain the interaction between people and technology it is relevant to refer to the domain of Human-computer interaction (HCI). It is the area of intersection between psychology and the social sciences on one hand, and computer science and technology on the other (Fig. 2.5). It expanded from early graphical user interfaces to include myriad interaction techniques and devices, multi-modal interactions, and host of emerging ubiquitous and context-aware interactions.



(Fig. 2.5): diagram developed by A. J. Bongers, June 2006. It shows the basic aspects of the interaction between a human (senses and actions) and a computer system, with a focus on the physical aspects of the interaction. Interaction is a two-way process of control and feedback, and is shown in the diagram by the large arrows in the middle.

When two entities interact, both will change state during or after the processes taking place at both sides. In order for two entities, users and computer systems, to interact, they must both have the ability to act, and have internal processes of some degree of complexity that can change. The computer system can be an embedded system, and it can be a system expanding over networks worldwide. The human can control the system by using effectors, for example, manipulating with the hands, speaking with the voice, which will be taken in by the system through its controls or input devices. After processing, the system can output a result through its displays such as screens, loudspeakers, motors, which can then be perceived by the user through their senses. The person can process the information, and continue the loop.

According to the interaction loop concerning the relation between human and computers, information, presentation and feedback are major elements for the interaction loop to continue. They are discussed as follows:⁵¹

⁵¹ Carroll, John M. (1997): "Human-Computer Interaction: Psychology as a Science of Design." In International Journal of Human-Computer Studies. (Accessed May 2011) http://www.interaction-design.org/encyclopedia/human_computer_interaction_hci.html.

Information is the result of the communication between objects and processes, whether real, virtual, or computer generated. In interactive systems, information can be presented as signs which are classified into: signals, the information from objects themselves that they provide giving feedback on their actions; icons, mimicking the object through a gesture that imitates a certain action which in the case of the computer interface can have its own behavior or processes; and symbols, abstract signs that have no resemblance to the object.

The information that the computer displays can be described as presentation and feedback. Through its displays whether visually, auditory and possibly addressing other senses as well, it presents which objects and processes it has to offer and what affordances they have. When being used, manipulated, interacted with by the user, it should convey information about the process at use, by feeding back information to the user, in different scales. Feedback can be known on several levels. Articulatory feedback is presented to guide the user's actions, to support them in articulating their intentions. It is particularly relevant in gestural interfaces, and feed-forward. When the system is generating information, this actively draws the user to something. This can be found in haptic systems, which actively pull the user towards some location. There is also active feedback, which is actively generated by the system, and passive feedback, which comes from passive elements of the system, like click of a mouse.

2/2/1/3 Design Approach and Process

The main goal is to design a space to describe the interaction between people and the electronic environment in terms of sensory modalities, modes, and layers of interaction.

The term “modalities” is used to differentiate between the different flows of information and to describe the interaction or communication. It can be found in terms of visual modality, which is concerned with the ability to see things, such as the information displayed visually on a computer screen, or the haptic modality through feeling the things that are manipulated. Different forms of communication can exist within a modality, depending on the range of the potential communication. The interaction can take place using several modalities at the same time. A combination of visual, auditory and haptic feedback addresses the human senses.⁵² A framework for such interactions can be described in terms of levels of interaction (physical, syntactic, semantic, task, goal), modes (textual, continuous, non-verbal, subconscious, intentional), senses or modalities.

⁵² Laurence Nigay and Joëlle Coutaz, “The Design Space for Multimodal Systems.” 2005.10

Any Levels of interaction can be described according to several layers: taking the user from a goal and intention, formulating a task and subtasks, carrying out these actions while receiving feedback on the physical level, and evaluating the result. An action is usually initiated in order to achieve some higher goal or intention, which has to be prepared and finally presented and articulated through physical actions. The presentation and feedback by the computer passes through several stages as well, before it can be displayed, possibly in various modalities including the haptic, in order to be perceived by the user, the actual interaction takes place at the physical level. Interaction of active haptic feedback including physical level requires higher level feedback which deals with the user's expectations of the system and a lower level Feedback which interprets the user's actions to the system.⁵³

Modalities can be divided into; human input modalities where an interaction can be based on involving multiple sensory modalities, such as the visual and the auditory. Action human output modalities: at the level of physical interaction we can influence our surroundings. The progression of technological stages enables new human output modalities, such as speech recognition, to be applied in the interaction. Every output modality has the goal to establish communication, and therefore aims to be perceived, whether it is a human output modality or computer system output.⁵⁴

Interactions can take place in several modes, like a text mode or a manipulation mode (also called continuous). The description of modes primarily reflects the human output modalities with which a person influences its environment and communicates with other people or mediates through technology. Modes are classified into: symbolic, which involves language, made up of words, and can be spoken or written text, using the alphabet or other characters; iconic or mimicking, involving semantic communication by icons, gestures; expressive subtle and non-verbal communication, usually used in combination with another level of communication. Most human communications involve all these modes at the same time. The manipulative or continuous output or action comes under “expressive”.⁵⁵ People interact with their computers mostly in a combination of symbolic and iconic modes in the direct manipulation, or only in the symbolic way with the command line interface.

⁵³ Engel,” Improved efficiency through I- and E-feedback: a trackball with contextual force feedback.” 1994. Journal.

⁵⁴ Gibson , “The Ecological Approach to Visual Perception.” 1979.

⁵⁵ For an ERCIM Workshop. www.nis.sdu.dk/~nob/modalitytheory.html. (Assessed Dec. 2011)

2/2/1/4 Trends in HCI

Recent trends in computing demonstrate a growing desire to interweave computational intelligence and HCI concepts into physical spaces, objects and surfaces, turning them into elements of distributed ambient interface, making use of human spatial reasoning capabilities, and concentrate on inferring human intentions through their actions in order to provide enhanced interaction techniques in physical environments. Human-computer interaction uses the ubiquitous computing paradigm into physical and ambient interfaces tying up objects to information manipulation and computational control, where specific stimuli from the object's surroundings determine its behavior. Human computer interaction can be classified into the following main categories:

Tangible paradigms; reinforce the interaction through motion sensing, tactile feedback, or gesturing. It is a system that gives physical form to digital information, employing physical artifacts both as representations and controls for computational media (Fig. 2.6).⁵⁶



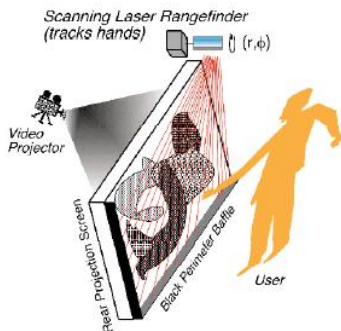
(Fig. 2.6) Turkey Pavilion at Yeosu expo 2012 in Korea; it creates an underwater ocean experience by 3D images of fish which swim under the visitors feet that turn and run away when the visitors accidentally stepped on them

It is an integration of physical computing objects which primarily include physical representations coupled with the underlying digital information and the physical representation of digital state of a system. In that description there is a separation between Graphical User Interface and Model Control Representation (physical/digital). Such systems demonstrate the potential for coupling actively mediated digital representations to physical objects where digital information is manipulated or controlled through sensing mechanisms embedded within physical entities, or

⁵⁶ This definition was according to Hiroshi Ishii and Brygg Ullmer: "Tangible Bits: Towards Seamless Interfaces Between People, Bits, and Atoms." Proceedings of Conference on Human Factors in Computing Systems, Atlanta, 1997, GA, (pp. 234–241).

information represented through changing the physical state of embedded actuation media within objects.⁵⁷

Surface based interaction; largely involves embedded sensor systems. Existing methods rely on a variety of systems based on Infrared, LASER, photo, and electromagnetic, ultrasonic or acoustic means for sensing location and pressure. Additional parameters and more sophisticated perceptions are enabled by application of algorithms, interpolation techniques, and computational processes on obtained raw information. Although much development in sensing techniques over large surfaces either relies on a particular surface plane, or creates a virtual surface against an existing plane; in turn, this limits their applicability to flat surfaces. Laser Range Finder (Fig. 2.7) demonstrates one such example where separate control and response planes calibrate with each other forming a large sensate wall in which position sensing is enabled by a reflected LASER beam forming a virtual plane against the physical surface.⁵⁸



(Fig. 2.7): The LaserWall; schematic (left) and with users (right).

There is another simpler system that is used for outdoor installations based on tracking knocks and taps made by users, (Fig. 2.8) relying on an electric field sensing user force, sensitive resistors for generating the primary electric impulse, with piezoelectric pickups mounted on the surface, detecting the arrival of bending waves generated by impacts. In measuring the differential time of arrival of these bending waves, it can locate the position of the impact, thereby implementing a tracking interaction where the users point through their knocks.⁵⁹

⁵⁷ Sachin Anshuman and Bimal Kumar. "Architecture and HCI: a review of trends towards an integrative approach to designing responsive space." International Journal of IT in Architecture, Engineering and Construction. Volume 2/Issue 4/Dec. 2004, Millpress. P29

⁵⁸ Joseph A. Paradiso. "Sensor Systems for Interactive Surfaces." IBM Systems Journal 39, No.3-4, 2000.P.32

⁵⁹ Downie, M., Eshkar, S., and Kaiser, P. "'Loops' - A Digital Portrait,"



(Fig. 2.8): The acoustic knock tracker at an American Greetings Store near Rockefeller Center. The system ran on a large window (2x2 meters, glass), as it drove a complex interactive art visualization that evolved in intricate ways with each knock. This system also used a simple pair of radars to measure the movement of people in front of the screen.

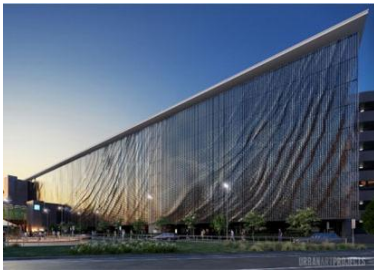
Kinematic; describes the simulated action of visual response. For example computer-simulated motion graphics and video-works combining moving images with dimensional elements are considered kinematic, not kinetic. Notions of response in systems based on CAVE, (Virtual Reality) and interactive cinema work with manipulating spatiality using surface bound visual means (Fig. 2.9). Scopes of such response also include simulated motion, attribution transformations, such as shape, scale, color and other optical aspects, in addition to video and other dynamic media. Such systems work on human cognition in two different ways to demonstrate the idea of motion, physical space and perception. One attaches physical movement to virtually navigate through a representation of physical space (video), and the other enables virtual movement within a representation of physical space.⁶⁰



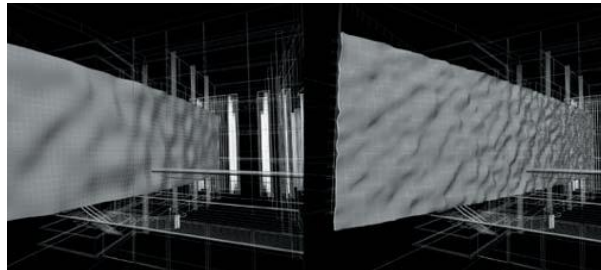
(Fig. 2.9) An immersive multimedia installation replicating a Chinese cave temple built over 1,300 years at Washington, D.C. 2012, where the visitor can virtually navigate through the temple spaces

⁶⁰ Technical sketch, <http://web.media.mit.edu/~marcd/nws/process/npr.html>. (Assessed Jan 2012)

Kinetic Typologies; Inducing kinetic response in architectural surfaces may include transformations in surface shape, topology, position and other physical properties, whether embedded, deployable and dynamic systems based on complexity of control and kinetic properties. (Fig. 2.10) shows a 160-foot-long kinetic wall in New York. It is an architectural installation; a dynamic system responding to pedestrian activity on the street where surface mounted whiskers like motor-driven bars rhythm point towards mobile targets creating ripple effects through the field. Like the kinetic wall, but more complicated, is the Hyposurface developed by dECOi (Fig. 2.11).⁶¹ It negotiates with the digital information for its eventual translation into physical animate-skin, capable of inducing endless topological variations driven by over 8000 pneumatic pistons.



(Fig. 2.10): kinetic wall (left)



(Fig. 2.11) Hyposurface (right)

2/2/2 Interface design

The growing emphasis on using space to organize information in current interface design will begin to evolve into interfaces that are more integrated with their immediate surroundings. We are beginning to see possibilities developed for how people can control their environments through integrated touch-and gesture-based languages with software and hardware that were developed for media projects. Some of the current themes continue to be based on a desire to create user-friendly, customizable, and immersive interactive experiences for users.

2/2/2/1 Definition

An interface is the place at which independent systems meet and act on or communicate with each other. The user interface is composed of input and output devices, as well as the information that users see and interact with on the computer screen. A broader definition is that it includes everything that shapes user's involvement with the systems, information, and humans as

⁶¹ <http://www.hyposurface.net>. (Assessed Jan 2012)

they perform tasks using computers. This includes on-line and hardcopy product documentation, additional documentation, training, personal and remote technical support, and other tools needed to perform the task.⁶²

A user experience is the environment encompassing all aspects of the end-user's interaction with a computer system, program, or website. In order to achieve a high-quality user experience, there must be a seamless merging of multiple disciplines, including engineering, marketing, graphical design, and interface design. Interfaces can be through Physical Interface Design Space, a proposal to describe the interface in terms of range, precision, and haptic feedback.⁶³ Object-oriented user interfaces; is a graphical user interface that also represents objects the user works with and the behaviors and interactions users have with those objects.

2/2/2/2 Concept

The field of architecture has always been involved in the development of spatial interfaces for people, making the building suitable for human use. However, architecture is undergoing serious changes over the last decades due to the increased use of computer technologies, with the merging of buildings with electronic computer systems and other technologies, and the dominant role of the computer in the design and manufacturing process, towards more dynamic responsive and interactive architecture. Ubiquitous computing can be another source of knowledge and inspiration for creating interfaces and developing new interaction paradigms in architecture.

The interface facilitates the interaction loop between the user and new technologies embedded in buildings. Generally an interface is a two-way device or group of devices, which facilitate the two-way process of interaction. The interface enables the computer to communicate with its physical environment through its controls and displays, consisting of sensors and actuators, elements which translate one form of energy, physical quantity, into another.

The interface design is a discipline that draws from a number of fields. In simple terms, the basic goals are to design and build systems that are effective, intuitive, and meet the goals of a set of users. Following is the definition of the terms "User" one who uses the system to accomplish tasks

⁶² Theo Mandel. "User/System Interface Design," Interface Design and Development 1992 P.42

⁶³ A. J. Bongers. "Interactivation Towards an ecology of people, our technological environment, and the arts," Vrije Universiteit Amsterdam, June 2006. P82

and achieve goals. “System” a set of connected things or parts that form a whole or work together. Specifically, a computer program designed to provide information and functionality to the user. “Interface” the presentation, communication, and interaction between the user and the system. Finally a “Designer” the person responsible for building the system based on their understanding of users and their tasks, goals, abilities and motivations.

2/2/2/3 Design Approach and Process

Developing the user interface focuses on the interface elements and objects that users perceive and use, rather than on program functionality. Throughout the development process, usability test, feedback and user interface should drive program design. A process specifically geared towards designing and developing user interface passes through four major phases: Gather and analyze user information; design the user interface; construct the user interface; validate the user interface. This process is independent of the hardware and software platform, operating system, and tools used for product design and development. Industry user interface design guides all promote an interactive interface design process.⁶⁴

Gather and Analyze User Information; the interface design process starts with an understanding of the users. Before designing and building any system, first define the problems that customers or users want to solve and figure out how they do their jobs. Learn about users’ capabilities and the tasks they must perform. Watch and learn from people actually doing their work and using the product and other related applications and Web sites. Product solutions should not only satisfy the users’ current needs, but also their future needs. Gathering and analyzing activities can be broken down into five steps: Determine user profiles; Perform user task analyses; Gather user requirements; Analyze user environments; Match requirements to tasks.

Designing software user interface; usually requires a significant commitment of time and resources. The design phase includes a number of well-defined steps that should be followed in sequence. It is tempting to start writing code now rather than designing the interface. Follow the steps through the design process. The design phase includes the following steps: Define product usability goals and objectives, Define interface objects and actions, Determine object icons, views, and visual representations, Design object and window menus, Refine visual designs.

⁶⁴ Theo Mandel. “The elements of user interface design.” New York: Wiley,1997 (PP 20-41).

Construct the User Interface; the interactive design process should be one of prototyping, rather than constructing the user interface. Prototyping is an extremely valuable way of building early designs and creating product demonstrations and is necessary for early usability testing. When prototyping, it is most important to remember that prototypes must be disposable. Do not be afraid to throw away a prototype. The purpose of prototyping is to quickly and easily visualize design alternatives and concepts, not to build code that is to be used as a part of the product. Prototypes may show visualizations of the interface, the high-level concepts, or they may show “functional” slices of a product, displaying how specific tasks or transactions might be performed with the interface.

Validate the User Interface; usability evaluations are a critical part of the interactive development process. A usability evaluation is the best way to get a product in the hands of actual users to see if, and how, they use it prior to the product’s release. Usability evaluations quantitatively and qualitatively measure user behavior, performance and satisfaction.

2/2/2/4 Trends in user interface design

Technologies that allow users new means to control and interact with digital information can be broken down into three general categories: touch and multi-touch or haptic, gesture and cognitive control.

Haptic interfaces; enable person-machine communication through sensing a natural or synthetic mechanical environment through touch, and in response to user movements (Fig. 2.12). Haptic interfaces are concerned with the association of gesture to touch to provide communication between the humans and machines. There are two kinds of haptic devices, conventionally termed passive or active:⁶⁵

Passive devices are often designed with programs that differentiate between the function of position and time. To this category belong the devices having controllable brakes. Another category of passive devices consists of those that rely on non-holonomic constraints (constraints involving velocity). Yet another possibility is to modify the elastic behavior of an element to become harder or softer.

As for active devices, the energy exchange between a user and the machine is entirely a function of the feedback control which is applied. Then

⁶⁵ Vincent Hayward, Oliver R. Astley, Manuel Cruz-Hernandez, Danny Grant and Gabriel Robles-De-La-Torre. “Tutorial Haptic interfaces and devices, Sensor Review,” Emerald Group Publishing Limite, Volume 24. pp. 16–29

two categories arise: either the actuators act as a force source (a variable of effort), and position is measured, or the actuators act as a position source and then force is measured.



(Fig. 2.12) The “reactable” is a multi-touch surface sound synthesizer. It changes sounds according to the user’s direct manipulations of cubes on the table. It also draws dynamic animations on its surface, providing a visual feedback of the sounds produced by the audio synthesizer.

Gesture interface; a number of different types of gesture-based control systems are significant to architecture in that they allow a user the ability to directly control and interact with real objects in an environment. The gesture control system, for instance, allows such control from a distance using cameras and infrared technology (Fig. 2.13). Much of the current gestural language used to control these types of interfaces continues to be developed by various interactive media agencies worldwide.⁶⁶



(Fig. 2.13): An ad features a 3D model of car that can be controlled remotely by hand movement recognition to explore the different parts of the car model. Designed by JCDcaux , Sydney, Australi

Cognitive control; Users wearing a headset will have the ability to wirelessly control objects, formerly through gesture, through cognitive, emotional, and physiological commands registered in their brain activity. These new technologies, in combination with current trends in user experience and interface design, are beginning to blur the space between user control and digital information as becoming more interactive. As these new interfaces continue to embrace spatial constructs, simultaneously new models

⁶⁶ http://www.peyote.cc/e_frame.html. (Assessed Jan 2012)

of control, whereby users are able to manipulate and interact with digital content more tangibly, further blur the lines between digital and physical space. As objects in space become increasingly empowered with computational intelligence, by means of sensors, computational logic and information, users will have the ability to interact with the architecture around them.⁶⁷

2/2/3 Embedded Computation (EC)

The roots of EC rose from the need to solve social demands of pragmatic system management coupled with constant advancements in technology.

2/2/3/1 Definition

An embedded computing system is a special-purpose system in which the computer is completely encapsulated by the device it controls. Physically, embedded systems range from portable devices, such as MP3 players, to large stationary installations like traffic lights or factory controllers. Embedded systems are designed to do some specific task, rather than be a general-purpose computer for multiple tasks. Embedded computation systems communicate with each other and with the surrounding infrastructure, seamlessly coordinating their operation to provide support for a wide variety of work practices.⁶⁸

2/2/3/2 Concept

Embedded computation used in interactive architecture is a system that is embedded into the building and that has the ability to gather information, process it, and use it to control the behavior of the actual physical architecture.⁶⁹ EC can be reduced to possessing a combination of both sensors and processors computational logic to interpret the actual physical architecture. EC is important not only in sensing change in the environment, but also in controlling the response to this change.

⁶⁷ Michael fox and Miles Kemp. "interactive architecture." Princeton architectural press, 2009. PP 62-65

⁶⁸ R. Want. "An Introduction to Ubiquitous Computing." V5 , 2009. P10

⁶⁹ Michael Fox and Miles Kem. "Interactive architecture." Princeton architectural press, New York, 2009. PP.38-42

Embedded computation to facilitate adaptation to changes is coupled with mechanical means (kinetics in architecture). It is the beginning to facilitate a paradigmatic shift from the mechanical to the biological. Change in the mechanical world is cyclic, but there is no development, since the factors are continually repeated with a set of outcomes; the organic paradigm is developmental and reciprocal. Organic theory emerges from nature, an environment that possesses evolutionary patterns that produce forms of growth and strategies of behavior, optimizing each particular pattern to the contextual situation.⁷⁰ Embedded (computer) systems are characterized by being self-contained and running specific predefined tasks. Embedded systems are economical due to their small sizes, and cost less than a full regular CPU, as they rely on microcontrollers to operate a certain system.⁷¹

2/2/3/3 Architecture trends involving Embedded computation

Active control; It is used to design intelligent systems; it focuses on the active control to modify the structural behavior in a building. This enhancement can be used to actively stiffen or strengthen a given structure, depending on the changing demands of the system. Wind loads, seismic conditions, life (people) and mechanical loads, and even temperature, make up the complexity of changing variables that buildings are confronted with on a changing basis. A number of projects have been already implemented that include response to wind variation, environmental hazards, and seismic conditions. Active control systems are structures that are affected by an externally active device to change the response in general terms; the activation of external force is based on the measurement of external disturbance and/or structural response. Sensors are employed for measurement purposes, and with the help of computers, the digital signal activates the required external force.⁷² A combination of these two methods of structural control has been used to evolve hybrid control methods, for realizing stringent control requirements.

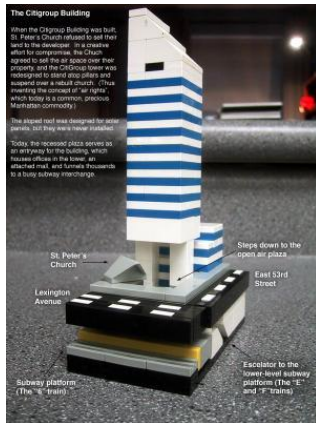
Such systems have been successfully employed in numerous large buildings situated in high wind or earthquake prone locations. Such actively controlled structures can modify their physical properties to become either stiffer or more flexible as preprogrammed. An example is the Citicorp center (Fig.2.14) designed by Le Messurier in 1979 in New York City, which was

⁷⁰ Gary Brown, *transportable Environment 2*, ed. Robert Kronenburg (London: spoon press, 2003.PP. 3-14

⁷¹ Stefan Poslad. "Ubiquitous Computing: Smart Devices, Environments and Interactions," 2009 John Wiley & Sons, Ltd. PP. 18-21.

⁷² T.K. Datta. "A state of the art review on active control of structures," ISET Journal of earthquake technology 40, no.1 , 2001.PP. 1-17.

constructed using 400 tons of concrete of tune mass dampers, which make the weight lie on multiple roller sleds and can freely move across steel I-beams in an x-y coordinate system. A series of sensors attached to the four corners of the building monitor the amount of wind force that was being applied to the building at any one time. A computer takes this data and issues commands, causing the massive counterweight to move slowly and dampen the swaying movement of the top of the building.



(Fig.2.14): (left) Citicorp center model; (right) Citicorp center view in New York City.

In active control systems there are a great deal of system uncertainties that are controlling an equally immense amount of structural complexities. The idea is to use numerous members, cables as active tendons or hydraulics as muscles, to provide control through a very specific response for suppressing forces. The important point is that each individual actuating device is controlled by a decentralized controller at a local level. This model of decentralization identification and control is based on neural networks and simplifies the implementation of the control algorithm.

Decentralization is a system theory concept also used to describe political, economical, computer science, internet and other phenomena where the more decentralized a system is, the more it relies on lateral relationships, and the less it can rely on command or force. It is important both in terms of control and resistance to failure. Control of decentralization is applicable for systems with a great number of sensors and actuators to avoid the communications and processing bottlenecks, and flexible global controller design.

Simplified implementation based on decentralization shows a great deal both in terms of the robustness of the system and economic feasibility. Although in a decentralized system there is normally no centralized control structures dictating systems how individual parts of a system should behave, local interaction between discrete systems often lead to the emergence of global behavior. When a large architectural element is responding to a single

factor, a centralized system can be effective in executing a command to a single agent, but when there are many unknown stimuli, decentralized system is the most effective way to handle the sensing and response.

Adaptive control; It is used to develop a control for systems that change its output over a set of intervals, and it is often a hybrid combination of active and passive systems. Such systems have proven to learn in just three or four user settings according to the lowest acceptable energy settings. Using Integrating computer detectors or thermostats, a system can respond to various environmental conditions. Like controlling the amount of heat or cooling, a timed program is used to schedule the performance of a certain action at regular times, like opening the garden sprinkles.

Adaptive control is widely applied in relation to the user's behavior within a home environment. It is also applied commercially. Adaptive control in manufacturing is one of the latest technologies to emerge in the instrumentation and control field. Adaptive control method offers a means to revolutionize plant and process efficiency, response time and profitability, by allowing a process to be regulated by a form of rule-based artificial intelligence without human intervention. Adaptive building controls can optimize everything from fire safety, to security system solutions, to energy efficiency. Optimization through a system that learns to adapt can make buildings more comfortable, safe and productive, as well as more efficient, and therefore less costly to operate. It can improve building performance by automatically adjusting to fluctuations in the mechanical system, adjusting loads, and adapting to seasonal changes in variable environments, while at the same time minimizing errors.

Computers are becoming more integrated in buildings and inhabited spaces. Recently, processors and sensors have shifted from strictly looking at the environmental conditions outside the building and performance-based aspects of the building to include predicting, and reacting to, information inside the building, which includes understanding and monitoring the needs of the users of space.

Home automation; While the control systems dealt with building automation in terms of adapting to environmental changes, generally limited to systems designed to monitor and control the mechanical and lighting systems of larger buildings, an exciting area that is rapidly developing is focused on changes in human actions, these systems are commonly referred to home automation. They response to human behaviors and adapt to the use of architectural space. While it is for homes, it shows a great deal of promise for the development of other applications. These systems are typically fully automated and deal with all of the systems in a home, such as lighting, climate, security and entertainment. A rapidly evolving area is that which

includes the ability of the home to notify the owner with alerts as to potentially dangerous situations, such as motion at the front door, leaks in plumbing, freezing, or overheating, by e-mail or text-based message on a phone.⁷³

The main use of such systems is energy and power optimization; and all these individual systems should be linked together so that one action by the owner can cause many actions across several subsystems. It is used to maximize the sense of personalization experiential quality of space, by allowing the user to hack their own system to make anything move and respond in various other ways.

External communication; the main aim of this system is having the ability to monitor and physically control remote environments. It is the ability to actively control architectural spaces and physical objects in real time. Unlike home automation that relies on interpreting information from local sources and reacting, external communication allows local automation to take place based on information being remotely inputted into the system. Terminology includes reciprocal space, remote communication and coexistence, suggesting that an architectural environment can be interactively viewed, controlled and experienced, both within the confines of the space and beyond its walls.

External communication started when the wiring of systems is used to connected external devices such as computers. In the last ten years, advancements in mobile technology from both a technological and cost standpoint have paved the way for people to have the ability to communicate information across networks in a new wireless way. This gives people an unprecedented way of enacting influence on space, on activities in space, and most importantly on the people that use space.

Such projects involve a robotic system that is controlled through the World Wide Web and a live camera that can allow the controller to view what he is manipulating. Technology being used in remotely-controlled space is allowing for higher levels of interactivity that involve much larger audiences, as entire populations become outfitted with mobile devices and cell phones. As remote control becomes more integrated into public viewing, a desire to have the ability for the medium to adapt to our changing needs rather than solving purely pragmatic human and environmental conditions, embedded computation and the software that powers it will evolve to allow the systems that control space to adapt to our changing desire.

⁷³ Edward B. Driscoll Jr. A Timeline for Home Automation.
<http://www.eddriscoll.com/timeline.html>. (Assessed Dec. 2012)

2/2/3/4 Ubiquitous computation

Ubiquitous computation is defined as Computers disappearing into the background of an environment consisting of smart rooms and buildings. Ubiquitous computing represents a powerful shift in computation, where people live, work, and play in a seamless computer-enabled environment, interleaved into the world. Ubiquitous computing makes the existence of a world where people are surrounded by computing devices and a computing infrastructure that supports every activity possible.

Computer systems behave as distributed computer systems that are interlinked using a communications network. In conventional information communications technology, the role of the physical environment is restricted; for example, the physical environment acts as a conduit for electronic communication and power and provides the physical resources to store data and execute electronic instructions, supporting a virtual information communication technology environment.⁷⁴

Means of applying Ubiquitous computation are;⁷⁵ Smart devices, like mobile smart devices, personal computer, smart cards, operate as a single portal to access sets of popular multiple application services that may reside locally on the device or remotely on servers. Smart environment, computation is used to enhance ordinary activities. It is able to acquire and apply knowledge about the environment and its inhabitants in order to improve their experience in that environment. It Consist of a set of networked devices, using sensors, controller and computers that are embedded in, or operate in, the physical environment, like robots. Smart interaction focuses on more complex models of interaction of distributed software services and hardware resources, dynamic cooperation and completion between multiple entities in multiple devices, in order to achieve the goals of individual entities or to achieve some collective goal. For example, multiple lighting devices in a physical space may cooperate in order to optimize lighting, yet minimize the overall energy consumed.

⁷⁴ R. Want. "[An Introduction to Ubiquitous Computing.](#)" 2009. P6

⁷⁵ Stefan Poslad. "[Ubiquitous Computing: Smart Devices, Environments and Interactions.](#)" John Wiley & Sons, Ltd. 2009 . PP. 32-35

Concluding summary:

Interactive architecture has been influenced by the cybernetics theories evolved in the sixties by pioneers like Norbert Wiener and Gordon Pask. It is concerned about the control of information flows in a continuous loop, where the system generates and regenerates.

Cybernetics as a science is a broad field. It helped in the development of computers and electronic publishing tools like FTP and WWW. It supports communication and interaction between the machines (computer-or digital technology) in the built environments and humans to increase the participation of the users in their environment.

The relevant theories of conversation theory and interaction of actors theory generated from cybernetics, constituted the main structure of the interaction between ubiquitous computing, humans and the built environment through the production of intelligent agents that are able to support learning and adapting.

Artificial intelligence and virtual realities used in architecture were the result of the development of cybernetics in computation. Artificial intelligence is used to give the architecture the ability to learn and interact by using an intelligent agent that is a software entity which is continuous, autonomous and reactive. It adapts its behavior under the changes in the external environment and collaborates with users, other agents or electronic processes. Virtual reality is a means of making the digital environment more immersive to its users.

Interaction design in interactive environment is the mutual influence between user and technology to change the state in all parties. Human computer interaction (HCI) is a discipline concerned with the design, evaluation and implementation of interactive computing systems. Trends of (HCI) in architecture are: Tangible paradigms: It is a system that gives physical form to digital information; it reinforces the interaction through motion sensing, tactile feedback or gesturing. Surface based: interaction largely involves embedded sensor systems over large surfaces, either relying on a particular surface plan or creating a virtual surface against an existing plan, to enhance spatial experience and augment spatial performance. Kinematic Surface-Response: describes the simulated action or motion of visual response. Kinetic Typologies: include transformation of physical properties.

Interface design is the place at which independent systems meet and communicate with each other. Its trends in architecture are: Haptic interfaces: enable person/machine communication through touch, and in response to user movements. Gesture interfaces: it gives the ability to directly control and interact with real objects in an environment; it also allows distance control, mostly deployed in interactive media. Cognitive control: the ability to wirelessly control objects, by blurring the space between user control and digital information, by using objects in space increasingly empowered with computational intelligence, sensors receiving input and computational logic and information.

Embedded computation is the physical means of acting in interactive environments. The roots of (EC) rose from the need to solve social demands of pragmatic system management, coupled with constant advancements in technology. It is smaller and more economical than a regular computer (CPU).

The ability of EC to gather and process information in the built environment needs artificial intelligence. The trends of EC in architecture are: Active control: modifying the structural behavior in a building using a decentralized system which, responds to environmental stimuli to modify their physical properties of its space. Adaptive control: It is used to develop a control for systems that change its output over a set of intervals, and it is often a hybrid combination of active and passive systems. Automation: responds to human behaviors and adapts to the use of architectural space. It is used to maximize the sense of personalization of space. External Communication: a system that has the ability to monitor and physically control remote environments. It allows local automation to take place based on information being remotely inputted into the system.

Ubiquitous computation is a branch of EC. It has the ability to physically understand how the space is used, interpret this data, and respond to this data in interactive ways.

The next chapter will analyze interactive applications with relevance to the discussed design process; embedded computation, interaction design and interface design. The next chapter will also discuss the tools of implementing interactive systems.

Chapter 3

Analyzing the Use of Interactive Systems

Introduction

This chapter discusses the necessary technological tools and techniques used in interactive environments. This chapter will also have a brief analysis on public buildings needs and requirements.

The chapter investigates the different systems of interactive application in the fields of art, media and architecture by analyzing different examples, with relevance to the design process and tools discussed in the previous chapter, to determine the main themes of achieving interactive systems in architecture that generated new concepts of space perception.

Assessing the types of interactive application used in public buildings is relevant to the following factors:

Determining the main characteristics and the design process of interactive system.

Evaluating interactive application in all fields (art , media , architecture) to draw a frame work of its features and uses.

Determine the requirements of public buildings to identify the possible uses of interactive applications.

2/3 Tools of Interactive Systems

This section of the research will discuss the necessary tools, techniques and materials used in the process of developing interactive application into different spaces. The tools and techniques are sensors, microcontrollers, robotics, hyper surface and soft space.

3/1/1 Sensors

Sensors are the tool of gathering and detecting information about the space within interactive systems. It is discussed in terms of definition, classification and application.

3/1/1/1 Definition:

Sensors are the perceptual interface between system and environment. They are devices that gather information from the real physical world, such as light, motion and temperature. Sensors have become increasingly developed, from being an invisible infrared beam that is broken to detect motion, to ones which can detect color definition, motion directionality, voice and facial characteristics, by which individual characteristics can be detected. A more comprehensive definition of sensors enables a more personalized response to the ability to detect not just where and what a person is doing within a space, but also who that person is.¹

The systems built to be more integrated with users' need sensors to be able to interact with the world and the users. Sensors are becoming more flexible in terms of what they can sense, cheaper and sensitive.²

3/1/1/2 Concept of Application:

Sensors are a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an electronic instrument. For example, a thermocouple converts temperature to an output voltage which can be read by a voltmeter.³

Sensors are being developed so that when combined with processing software, can provide extremely detailed individual information as a means of providing information to the building of individual users' behavior. Means of gathering information can be seen currently in webcams and optical input

¹ Michael Fox and Miles Kemp. "Interactive architecture." Princeton architectural press. 2009. P.77

² Embodying Cognition in Future Networks with Dynamic Neural Fields, <http://www.blog.telecomfuturecentre.it/2011/10/11/horizon-2020-sensors/>. (Accessed 4 Feb. 2012)

³ on-line encyclopedia. <http://en.wikipedia.org/wiki/Sensor>. (Accessed 3 Feb. 2012)

devices, in addition to conventional sound/text input. Cameras and sensors with embedded microcontrollers, radio frequency and infrared communications, as well as some rudimentary sensors, can be commercially found and set up with little technical expertise.

Sensors can be divided into two main categories: Contact-based; which rely on a direct exchange of information and this could mean physical human touch, or the presence of moisture, pressure, wind, or other environmental features. Non-contact based; which rely on sensing some sort of presence. They include infrared, sonar, tilt, light, cameras, and microphones.

3/1/1/3 Classification of Sensors

Sensors can be divided into two main categories: Passive sensors; such as cameras where they act as observers of the environment and capture signals that are generated by other sources in the environment. Active sensors; such as sonar, they send energy into the environment and this energy is reflected back to the sensor. Active sensors tend to provide more information than passive sensors.⁴

Active or passive, sensors can be divided into three types, depending on how they sense the environment and the system location:

Range finders; are sensors that measure the distance of objects. Such sensors emit directional sound waves, which are reflected by objects back into the sensor. The time and intensity of the returning signal indicates the distance to nearby objects.

Stereo vision; depends on multiple cameras by taking images of the environment from different perspectives, analyzing the resulting images to compute the range of surrounding objects.

Optical-range sensors; emit active signals (light) and measure the time until a reflection of this signal arrives back at the sensor. Common range sensors include Radar sensors, which can measure distances of multiple kilometers. Another example is tactile sensors, such as touch-sensitive skin. These sensors measure range based on physical contact, and can be deployed only for sensing objects very close to the system.

⁴ Stuart Russell and Peter Norving. "Artificial intelligence a modern approach." third edition, Prentice hall an imprint of Pearson, 2010.P. 973

3/1/1/4 Applications

Their applications range from a variety of sensing different actions, like motion, environmental condition, even gesture recognition (Fig. 3.1). They can be used as follows:⁵

Motion detectors; can detect displacement and position with good stability, high speed, and wide extremes of environment. These are based on the Infra-Red, Ultrasonic, and Microwave.

Detecting pressure sensors; like Fiber optic, vacuum and elastic liquid based manometers, use pushbutton and fingerprint as a way of sensing the presence of occupants.⁶

Detecting the environment conditions sensors; like moisture level, humidity, heat and temperature. For example in the home automation, sensors operate soft-touch dimmer switches to lower the energy consumption

light sensor; using infrared light to transmit information like ones in remote control; also cameras with light sensors help in adjusting the various lighting conditions to have a clear picture whether the surroundings are dim or not.



(Fig. 3.1): a range of different types of sensors.

⁵ L. K. Baxter. "Capacitive Sensors." 2000. P.29

⁶: <http://www.engineersgarage.com/articles/sensors>. (Accessed 9 Feb. 2012)

3/1/2 Microcontrollers

Microcontrollers are the tool of interpreting information gathered from the space and act upon it, in interactive systems. It is discussed in terms of definition, classification and application.

3/1/2/1 Definition

A microcontroller is a kind of miniature computer found in electronic products. Microcontrollers are found in anything that needs onboard computational intelligence to monitor an executable action, like engine control in automobiles, any appliance that has an LED or any on-screen display that has a microcontroller in it.⁷ Microcontrollers are functioned like a computer except that they are programmed to perform a single task, not multi tasks like a computer. This makes them smaller, cheaper, less power-consuming and more affordable.

3/1/2/2 Concept of Application

A microcontroller contains a processor core, memory, and programmable input-output peripherals. This makes microcontrollers like small computers on a single integrated circuit, where they are designed to have pin connections that allow information stored in the read-only memory (ROM) to be written and rewritten directly to the controller. These pins also allow for signals to be transmitted to networked or linked devices.

Microcontrollers act as an intermediary between the digital world and physical world, they work on human levels starting from receiving information from sensors, controlling basic motors and other kinetic parts, sensing information to other computers. There are several features to consider when deciding to choose a microcontroller; these are:⁸

The Programming Environment; Microcontrollers need a programming language to execute their task. Types of programming languages vary depending on the bridge being created between various software and hardware connections. Microcontrollers are mostly programmed in assembly language, like C programming language, and using different variations of Microsoft Visual Basic which include Basic Stamp, BX-24 or Basic Atom Pro24. Choosing a program depends on their degree of complexity. The BX-24 is more complex and more powerful than the other BASICs, while the C language is a lower-level and more complex and powerful language.

⁷ What's a Microcontroller? Student Guide, version 2.2. 2004.P.1

⁸ Dan O'Sullivan and Tom Igoe. "Physical computing, sensing and controlling the physical world with computers." Thomson Course Technology PTR, 2004. P. 417

Digital Input and Output; these are the number of the digital input and output pins that the microcontroller has. Most of the microcontrollers have 16 to 33 digital Input and Output pins.⁹ Input is used for taking in sensor data, while output is used for sending commands to external hardware.

The Speed of Execution; It depends on the number of instructions per second the microcontroller can execute. In other words, it means how fast it can execute a task given to it. Another speed factor to consider is the maximum baud rate the chip can use for serial communication. If you need to communicate with a device that has a particular baud rate then you need to make sure your microprocessor can operate at that speed.

The Amount of Memory This is the capacity of the microprocessor memory. It affects how complex a program can be.

The power; knowing the consumption rate, whether it can run on batteries and for how long should be taken into consideration during design language. However, all of these different languages rely on the user to code simple routines or programs to be run on the microcontroller to interpret data information and act accordingly.

3/1/2/3 Classification of Microcontroller

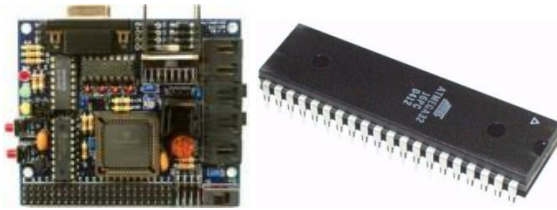
Microcontrollers are classified according to their level of complexity of programming and implementation.

High-Level Microcontroller Modules; these types contain the most popular physical computing tasks, such as digital and analog input-output and serial communication, but hide most of the wiring and electrical components from sight. They have simple connectors for power, serial ports, switches, potentiometers and motors. They are much expensive, but they save a lot of time if the needed tasks are clear and simple. Examples: Making Things' Teleo system, Infusion Systems' I- Cubed, Electrovoce's MIDITools, Ezio.

Mid-Level Microcontroller Modules; these modules are like training wheels for the lower-level microcontroller contained within them. The modules themselves are more expensive than lower-level processors, because they contain all the extra wiring necessary to turn on the microcontroller. These modules often run slower than the lower-level processors because their programming languages achieve efficiency at the expense of use. The software environments for programming mid-level modules are simple and can be reprogrammed, and the feedback is quick. Other accessories such as carrier boards or demo boards make these seem very much like the higher-

⁹ Pins are software configurable to either an input or an output state. When pins are configured to an input state, they are often used to read sensors or external signals. Configured to the output state, pins can drive external devices such as LEDs or motors.

level boxes (Fig. 3.2). Examples: Parallax's Basic Stamp 2, NetMedia's BX-24, Basic Micro's Basic Atom Pro 24, the Basic Stamp, and later the Basic Stamp 2 (BS-2), made by Parallax.



(Fig. 3.2): mid-level microcontrollers; showing the internal components of the system.

Low-Level Solutions; They are easier to assemble all of the circuitry on the module, but they need an additional piece of hardware between a desktop computer and the processor in order to program them, using chips programmed with languages like BASIC or C, which are easy to experienced programmers. Most chip programmers require removing the processor from the circuit in order to program it, but some offer the option of in-circuit programming, using a cable adapted for the job. Examples: PIC chips, SX chips, Atmel (AVR) chips.¹⁰

3/1/2/4 Applications

Their applications concern with controlling the kinetic actions of a system, they can be used as follows:

Motion microcontroller; it makes control on the motion of objects to attain the right function they are designed for; a simple example is the automatic doors in public buildings that are opened or closed as passengers walk through.¹¹

Signal-receiving microcontroller; which is used to control basic motor or kinetic parts by receiving signals sent through LEDs.

Embedded design; A microcontroller can be considered a self-contained system with a processor, memory and peripherals, and can be used as an embedded system, or embedded in other machinery, such as automobiles, telephones, appliances and peripherals for computer systems.

Microcontrollers are used in robotics; as they are programmable, cheap, and small, can handle abuse, require almost zero power, and have so many varieties to suit every need.

¹⁰ On- line encyclopedia.: <http://en.wikipedia.org/wiki/Microcontroller>. (Accessed 15 Feb. 2012)

¹¹ On- line encyclopedia. http://www.societyofrobots.com/microcontroller_tutorial.shtml (Accessed 15 Feb. 2012)

3/1/3 Robotics

Robotics is a physical means of performing interactive system actions. It is discussed in terms of concept of applying, means of operation and application.

3/1/3/1 Concept

Robotics is the physical equivalent to artificial intelligence; they are physical agents that perform tasks by manipulating the physical world. To do so, they are equipped with effectors, to assert physical forces on the environment, and sensors, which allow them to perceive their environment. Robotics employs a diverse set of sensors, including cameras and lasers, to measure the environment, and gyroscopes and accelerometers, to measure the robot's own motion.¹²

For current applications there is a shift in design from using the figural humanoid robots to transformable systems made up of a number of smaller robots, as the recent advancement in computer intelligence technologies allows robots to be smaller, smarter and more responsive. This allows them to be embedded into architectural applications involving dynamic situational activities and interactive materials (Fig. 3.3-3.4).



(Fig. 3.3): Pixel skin is developed as a modular surface made up of robotic pixel tiles. Each panel has 255 potential states of adjustment, in order to create moving patterns and imagery.¹³



(Fig. 3.4): The modular surface creates new environments of the building by using sensors and embedded microcontrollers. The opening can be controlled according to the fluctuations of light, sound and movement.¹⁴

¹² Stuart Russell, Peter Norving. “Artificial intelligence a modern approach,” third edition, Pearson hall, 2010.PP. 993-1030

¹³ posted on: <http://transmaterial.net/index.php/2006/10/01/pixel-skin/> (Accessed 4 March 2012)

¹⁴ <http://www.archispass.org/?p=183>. (Accessed 4 March 2012)

Although there may be no centralized control structure dictating how individual parts of a system should behave, local interactions between individual modules can lead to the emergence of global behavior. Most architectural applications are neither self-organizing nor have higher level intelligence functions of decision-making abilities, but most applications have performed behavior similar to those using swarms¹⁵ based on low level intelligent functions of automatic response and communications. Such distributed control produces an emergent behavior when it is applied to a large system. An emergent behavior can occur when a number of simple systems operate in an environment forming more complex behaviors.¹⁶ The response can be simple and the interactions between each system can be simple, but the combination can produce interactions that become emergent and very difficult to predict. The more decentralized a system is, the more it relies on lateral relationships, and the less it can rely on overall commands (Fig. 3.5).



(Fig. 3.5): Hod Lipson and other scientists at the Cornell Computational Synthesis Lab have begun developing multiple types of modular reconfigurable robots and evolutionary robots. These self-replicating prototypes were designed to allow for each object to be able to attach, detach, and reattach to different self-similar faces based on predetermined computational logic. These modular objects are able to connect to each other through electromagnetic connections, and the entire system has the ability to change its physical shape based on how it is programmed.

3/1/3/2 Means of Operation

A robot is an important type of application which combines control and sensors. After the rise of cybernetic science in the early 1960s, robots

¹⁵ Swarm intelligence is an artificial intelligence technique based on the study of collective behavior in decentralized, self-organized systems. Swarm intelligence systems are typically made up of a population of simple agents interacting locally with one another and with their environment.

¹⁶ Fox Michael and Kemp Miles, “Interactive Architecture.” New York: Princeton Architectural Press, 2009. PP. 229-236

started to be used to automate industrial tasks, particularly in manufacturing, until they were developed to be used in the field of intelligent environments, such as an entire house that is equipped with sensors and effectors. In terms of positioning and movement the main components of robots are:¹⁷

End effectors or actuators; an end part of a robot that acts on the world in some way such as grabbing, drilling or stacking and that is attached to some moveable arm, gantry or chassis.

Drive; powered by air, water pressure or electricity. The power is used to drive some controlled motion defined by the number of degrees of freedom of movement. The major electronic component that produces motion is the electric motor. There are different types such as AC motors and DC motors, such as servomotors and stepper motors.

Controller; governs the movement of the end effectors based upon inputs from sensors, motion planning and control theory. Controllers are programmable so that robots can be configured to handle a range of tasks. The control may be quite simple; it might reflect some fixed pattern in a static environment or it might need to be variable because of uncertainty.

Sensors; provide input information about the state of the physical world, to determine position and orientation and to track the motion of some end effector and input these into the controller in order to adapt the behavior of the effector and the state of the world.

Another important aspect for the robotics to operate is Perception. It is the process by which robots map sensor measurements into internal representations of the environment. Internal representations for robots have three properties: they contain enough information for the robot to make good decisions, they are structured so that they can be updated efficiently, and they are natural in the sense that internal variables correspond to natural state variables in the physical world.

Perception also includes Localization and mapping which is about finding out where things are, including the robot itself. This is the core of any successful physical interaction with the environment. For example, robot manipulators must know the location of the objects they seek to manipulate; navigating robots must know where they are to find their way around. Taking into consideration that not all of robot perception is about localization or mapping, robots also perceive the temperature, odors and acoustic signals.

¹⁷ Stefan Poslad. "Ubiquitous Computing: Smart Devices, Environments and Interactions." John Wiley & Sons, Ltd. 200 .PP. 204-209

3/1/3/3 Robotics Categories

They are categorized according to their applications into the following:

Manipulators; they are physically anchored to their workplace; they have a linked chain of rigid bodies connected by joints that lead to an end effector, like in a factory assembly line or on the International Space Station. Manipulator motion usually involves a chain of controllable joints, enabling such robots to place their effectors in any position within the workplace.

The mobile robots; they move about their environment. They carry out tasks in different places using locomotion. They have been put to use delivering food in hospitals, moving containers at loading docks and even used for unmanned ground vehicles for NASA robots on Mars Exploration Rovers and unmanned air vehicles (UAVs), commonly used for surveillance and military operations.

Mobile manipulator robots; they are robots that combines mobility with manipulation like humanoid robots mimicking the human behavior. Mobile manipulators can apply their effectors further than anchored manipulators, but their task is made harder because they do not have the rigidity that the anchor provides.¹⁸

The field of robotics also includes intelligent environments (such as an entire house that is equipped with sensors and effectors), and multi-body systems, wherein robotic action is achieved through swarms of small cooperating robots.

Robotics can cope with environments that are partially observable, dynamic and continuous dealing with a large, complex world. Many robot environments are sequential and multi-agent as well. Practical robotic systems need to embody prior knowledge about the robot, its physical environment and the tasks that the robot will perform so that the robot can learn quickly and perform safely.

3/1/4 Materials

The relationship between architecture and materials had been straight forward. Materials were chosen either pragmatically for their utility and availability, or formally for their appearance and ornamental qualities.

¹⁸ Classification according to Garcia, E., Jimenez, M.A., De Santos, P.G. "The evolution of robotics research." IEEE Robotics & Automation Magazine, 2007. PP. 90-103
And according to Stuart Russell, Peter Norving, "Artificial intelligence a modern approach third edition." Pearson hall, 2010. PP. 993-1030

Contemporary architecture and the introduction of the information age gave a new material practice where materials are highly engineered and customized for their particular purpose. Concerning the development of digital technologies, materials could be manipulated either for their form into limitless shapes by using computer numerically controlled (CNC) machines, that is why it is called CNC fabrication or digital fabrication, or for its internal molecular structure, changing its characteristic property, usually known as smart materials. This allows for a wider range of flexibility and adaptability for the surrounding built environment and design requirements towards more interactive spaces.¹⁹

3/1/4/1 Digital fabrication

It is a process that joins architecture with the construction industry through the use of 3D modeling software and computer numerically controlled machines. Digital fabrication technologies are giving the chance for architecture to propose complex surfaces where the properties of materials should push the design.

The continuous, highly curvilinear surfaces that feature in digital architectures allow for the production of spatial and tectonic recodification of non-Euclidean forms. The new experience of spatial complexities and architecture topological geometries require means to make such spaces come to their physical form. Being computationally generated also means that their construction is perfectly attainable by means of computer numerically controlled (CNC) fabrication processes, such as cutting, subtractive, additive, and formative fabrication.²⁰ An example of that is the production of the laminated glass panels with complex curvilinear surfaces, in the project of Bernhard Franken's BMW pavilion (Fig. 3.6).



(Fig 3.6): Bernhard Franken's BMW pavilion in Berlin that was formed from individual glazing panels curving in a three dimensional curve to cause a dramatic effect.

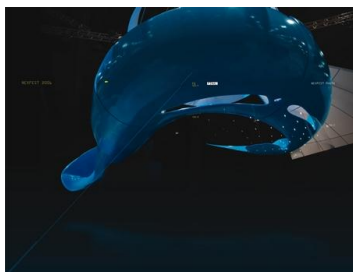
¹⁹ Thomsen, Mette Ramsgard. "Computational materials: Embedding Computation into the Everyday." proceeding of the digital arts and culture conference, university of California, 2009.

²⁰ Branko Kolarevic. "Designing and Manufacturing Architecture in the Digital Age" University of Pennsylvania, 2012. P.118

Using Digital three-dimensional models can be used to determine the location of each component, to move each component to its location, and finally, to fix each component in its proper place. New digitally-driven technologies, such as electronic surveying and laser positioning, are increasingly being used on construction sites around the world to precisely determine the location of building components. For example, Frank Gehry's Guggenheim Museum in Bilbao was built without any tape measures, during fabrication; each structural component was bar-coded and marked with the nodes of intersection with adjacent layers of structure.

The CNC-driven production processes, which afford the fabrication of non-standardized repetitive components directly from digital data, have also introduced into architectural discourse the new logic of the local variation and differentiation. The intersection of digital and physical design opens up new realities of form and experience, where digital tools like CAM and CAD allow for innovation and experimentation in the built form. The following examples explore the relationship between the physical form and the digital process:

Hitachi Company commissioned Tronic²¹ to create a large-scale sculpture installation exploring the theme of water. Water has an unusual form because it is formless on its own. The process of creating form from non-form shows the need for sculpting containers to hold the liquid rather than sculpting the liquid itself. The containers gave form to the liquid (Fig. 3.7). Liquid simulation software was used to generate the water and then the shape of the containers was designed, giving the liquid its recognizable forms (Fig. 3.8).



(Fig. 3.7):The computer-generated model



(Fig. 3.8): The Hitachi sculpture installed.

²¹ Tronic is practice in which it worked in projects that explored melding of the digital and physical for the last 7 years.

A similar process can be applied to architecture on a larger scale, allowing movement to inform circulation, program and form. With such process, space can be explored as something in a state of becoming rather than in a fixed state.

Another example is the Federation Square building designed by Lab architecture studio in Melbourne, Australia, where a grid system was developed to allow the building facades to be treated in a continuously changing and dynamic way, while simultaneously maintaining an overall site coherence, instead of being traditionally composed as a regularly repeating flat surface (Fig. 3.9).

Three cladding materials: zinc (perforated and solid), sandstone and glass have been used within a modular basis established by the triangular pinwheel grid. This partially incremental system uses a single triangle, the proportions of which are maintained across the single tile shape. The panel is composed of five tiles, and the mega-panel construction module is composed of five panels (Fig. 3.10). The unique quality of the pinwheel grid lies in the possibility of surface figuration and framing shapes to be independent from the grid's smallest component unit, the triangle.²²



(Fig. 3.9): The exterior façade of the building



(Fig. 3.10): The atrium utilizing a limited number of standard components. A series of non-uniform frame shapes have been developed to form a continuous structure. The lattice supports glass panels on both its inner and outer faces.

3/1/4/2 Smart Materials

Smart materials respond to environmental stimuli with particular changes in some variables. Depending on changes in some external conditions, smart materials change either their properties, whether mechanical or electrical, or appearance, their structure or composition, or

²² Arc space online architecture magazine.
http://www.arcspace.com/architects/Lab/federation_square.htm, (Accessed 27 June 2012)

their functions. Mostly, smart materials are embedded in systems whose inherent properties can be changed to meet performance needs. This makes the architectural experience more interesting responsive, adaptable and interacting.²³

This implies that the term “smart materials” either refers to materials as substances, such as elements, alloys or compounds, or to materials as a series of actions. According to the first consideration, NASA defines smart materials as materials that remember configurations and can conform to them when given a specific stimulus. As for the second consideration, on the other hand, as found in the Encyclopedia of Chemical Technology; smart materials and structures are those objects that sense environmental events, process that sensory information and then act on the environment. Both definitions imply that smart materials should have embedded quick response capabilities.

These features can potentially be exploited to either optimize a material property to better match input conditions, or to optimize certain behaviors to maintain steady state conditions in the environment. According to that the classification of materials are divided into two main categories:²⁴

The first category of materials is defined by; changing one of its properties, whether chemical, mechanical, optical, electrical, magnetic or thermal, in response to a change in the conditions of its environment. This happens without the need of external control. This category of materials includes:

Chromic or color-changing smart materials; these constitute a class of materials in which a change in an external energy source produces a property change in the optical properties of a material. Such materials do not really change color, but they change their optical properties under different external stimuli. Like Photochromic materials; change color when exposed to light. Thermochromic materials; change color due to temperature changes. Mechanochromic materials; change color when imposed to stresses or deformations. Chemochromic materials; change color when exposed to specific chemical environments. Electrochromic materials; change color when a voltage is applied.

²³ Interactive Buildings Exploration of Smart Material, <http://iaac-digitalarchitecture.blogspot.com/2007/11/interactive-buildingsexploration-of.html>. (Accessed 9 June 2012)

²⁴ D. Michelle Addington and Daniel L. Schodek. “Smart Materials and New Technologies: For the architecture and design professions,” Harvard University architectural press, 2005. PP. 90-106

Phase-changing materials; are also called Thermo tropic, where a change in the temperature or pressure on a material can cause it to change from one state to another. An input of thermal energy or radiation alters its micro structure through a phase change. In a different phase, most materials demonstrate different properties, including conductivity, expansion and solubility. Thus, where energy is absorbed or released can be predicted according to the composition of the material. Phase-changing materials deliberately seek to take advantage of this absorption and release actions. These processes are reversible and phase-changing materials can undergo an unlimited number of cycles without degradation. They have been explored for use in architecture as a way of helping deal with the thermal environment in a building.

Magneto rheological; the application of a magnetic field or an electrical field causes a change in microstructural orientation, resulting in a change in viscosity of the fluid.

Shape memory; an input of thermal energy, which can also be produced through resistance to an electrical current, alters the microstructure through a crystal line phase change. This change enables multiple shapes in relationship to the environmental stimulus.

The second category is; materials or devices that transform energy from one form to another to achieve the desired final state. Thus, electro restrictive material transforms electrical energy into elastic mechanical energy which, in turn, results in a physical shape change where changes are direct and reversible. Responses can be computationally controlled or enhanced. This category of materials includes:

Photovoltaic; an input of radiation energy from the visible spectrum or the infrared spectrum for a thermo photo voltaic produces an electrical current.

Thermoelectric; an input of electrical current creates a temperature differential on opposite sides of the material. This temperature differential produces a heat engine, essentially a heat pump, allowing thermal energy to be transferred from one junction to the other.

Piezoelectric; an input of elastic energy produces an electrical current. Most piezoelectric are bidirectional in that the inputs can be switched and an applied electrical current will produce a deformation.

Photo luminescent; an input of radiation energy from the ultraviolet spectrum, or electrical energy for an electro luminescent, chemical reaction for a chemo luminescent, is converted to an output of radiation energy in the visible spectrum.

Electrostrictive; the application of a current, or a magnetic field for a magnetostriuctive, alters the interatomic distance through polarization. A change in this distance changes the energy of the molecule, which in this case produces elastic energy strain. This strain deforms or changes the shape of the material.

3/1/5 Hyper surface

It is a 3D dimensional space concerning the notion of space time information. It will be discussed in terms of definition and concept.

3/1/5/1 Definition

Hyper surface is defined in mathematics as a surface in hyperspace. Hyperspace is four-dimensional space concerning the notion of space time information. As a verb, hyper surface considers ways in which the realm of representation, like images, information and forms, are respectively becoming deconstructed into new image-forms of intensity. It produces intensities that are tangible and proprioceptive experiences of space, time and information. "Hyper" implies human agency reconfigured by digital culture, and "surface" is the enfolding of substances into differentiated topologies.²⁵

According to Marcos Novak, the hyper surface can be defined as a membrane or interface between the current zones, physical and virtual, taking place in an architectural and urban space rendered more fluid and cinematic action by the new media, digital tools and an exponential increase in information flow.²⁶

For Perrella, "hyper" means the excess of information related to the development of media, especially the exponential growth of the category of virtual and cyberspace; and "surface" means the undermining of the foundations of Cartesian architecture at work in the topological architecture. Furthermore, he defines the "hyper surface" as an attempt to combine these two trajectories (media-based culture and topological architecture) in a dynamic way.²⁷

²⁵ Stephen Perrella. "Hypersurface Architecture II," John Wiley & Sons, 1999. P.15

²⁶ Article by; Marion Roussel, "A seam of worlds and Transarchitecture hypersurfaces," on <http://dnarchi.fr/culture/a-la-couture-des-mondes-transarchitecture-et-hypersurfaces-une-introduction/>. (Accessed 7 march 2012)

²⁷ Stephen Perrella, "hypersurface theory: architecture" culture ", architectural design press, Vol 68 No. 5/6, 1998. P.11

3/1/5/2 Concept

The development of digital technologies had a great impact on the contemporary culture involving every aspect of it; this has affected architecture too. Hyper surface is a new architectural concept that promotes broader interfaces and interactivity between the virtual and the built environment. Hyper surface theory promotes increased accessibility to the Internet, initiates new ideas regarding architectural ornament and instigates new explorations of architectural surfaces and materials. Hyper surface is the connection between mediatized culture and topological architecture.

"Hyper surface is an emerging architectural/cultural condition affected through an intertwining of often opposing realms of language and matter into irresolvable complexities that create middle-out conditions. In an effort to avoid thermalizing this effect and to consider it in its fullest complexity, the term hyper surface is introduced, to describe and render productive an Otherness that resists classical definitions but that is simultaneously produced by the tenets of traditional culture." Stephen Perrella²⁸

Hyper surface is an effect that occurs within the interface between two disparate trajectories of culture which is the division between the aesthetic culture and academic discourse of architecture as distinct from the operations and machinations of everyday consumer culture. The change which is affecting culture in the era of computerized media revolution is also concerned with space and its representation and organization systems. Space becomes a media itself; nowadays space can be transmitted, stored and recovered in a snapshot. Space can be squeezed, re-formatted, changed into a flow, filtered, computerized, programmed and interactively managed.²⁹

Hyper surface embodies dynamic, durational and transitional spaces. It is the way by which physical surfaces reconfigure new perception and merge the realms of the real and the virtual. It is the activation of virtual potential within forming substrates, membranes and surfaces, as an interstitial relation between bodies and objects, each distended as language or substance matter. This does not occur as an intervention into an existing context, but

²⁸ Stephen Perrella is an architect and editor/designer at the Columbia university .There, he produces both news line and Columbia documents of architecture and theory. He has taught architecture at various universities in the United States. He is president of hypersurface systems, Inc., a 3d world wide web site design firm. Stephen Perrella began exploring the relationship between architecture and information in 1991 on Silicon Graphics workstations. He developed the term "hyper surface."

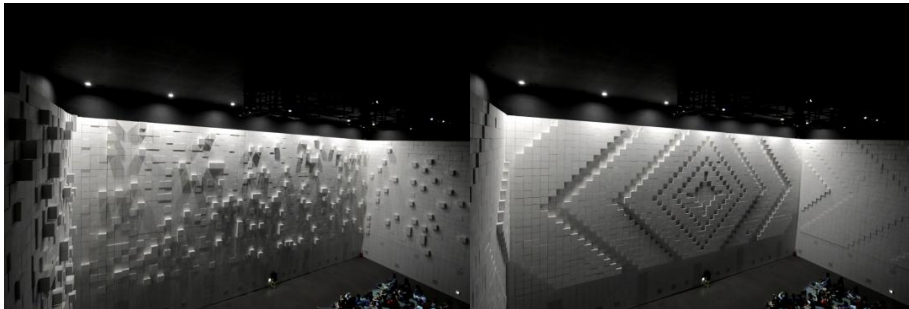
²⁹ Annamaria Monteverdi. "Hypersurface and Mediafacade. Urban Screen And new Former." Article in "DIGIMAG" The digicult's project journal, issue 52, March 2010.

becomes manifest due to complex interactions between technological and media development.³⁰

Hyper matrix is an example describing the notion Hyper surface embodies dynamic spaces. it is an installation created for the Hyundai Motor Group Exhibition Pavilion in Korea, 2012 “Yeosu” EXPO. It was designed by Seoul based media arts group “Jonpasang”. The matrix is composed of pixels that can physically change its pattern; it is installed on a 180 ° vertical landscape. The installation is made of a steel construction supporting thousands of stepper motors controlling 300x300mm cubes projecting out of the internal facade of the building (Fig. 3.11). The cubes move in and out of the facade, creating infinite number of possibilities in the vertical, 180 degree, landscape. The audience is taking part of the pattern shaping as the cubes move with the sounds produced by them (Fig. 3.12).



(Fig. 3.11) The installation system shows the steel structure holding the cubes (pixels) on the stepper motors.



(Fig. 3.12) The different patterns and ripples produced by the sounds of the audience.

³⁰ Collin Anderson, *Hypersurface and Sanctuary*:
<http://www.arch.columbia.edu/work/courses/studio/sp10-rothstein/collin-anderson> (Accessed 13 Aug 2012)

3/1/6 Soft space

Traditionally, architecture has been thought of as hardware: the static walls, roofs and floors that enclose us. An alternative approach is to think of architecture as software: the dynamic and ephemeral sounds, smells, temperatures, even radio waves that surround us, also taking into consideration the social infrastructures that surround the designed spaces.³¹

3/1/6/1 Definition

Soft space is a fluid, ephemeral form of digitally enabled design based on personalized experiences and responses. Soft space deploys new spatial systems including wearable computing, Wi-Fi, RFID and custom designed digital software incorporating light, heat, sound and electromagnetic fields. These not only rely on people's individual ways of interacting with them, but are enriched by narratives people contribute to, creating new metaphors of use.³² Soft space is a framework for exploration in the human scale and constructed mediation of space; an emergent exploration determined by the public itself. The space is then defined by a concrete conceptual foundation of form and material, yet embodies a virtual and indeterminate process of time, intervention and response.

Soft space is projective, rather than documentary, in nature, and looks to suggest many possible futures rather than define discrete outcome. Through technologies, energies and intensities, such as air, gas, fire, sound, odors, magnetic forces, electricity and electronics, have become architectural materials that can be visualized and operated upon as systematically and accurately as the forces that guide structure and geometry. Soft space examines the opportunities available today to employ such energy matter as catalysts of innovation.

3/1/6/2 Concept

Architectural design that emphasizes soft space over hard space is a little like software design rather than hardware design in computer terminology, where hardware refers to the physical machine and software refers to the programs that animate the machine. In an architectural context, technology is used to provoke interactions between people, and between people and their spaces. If soft space encourages people to become performers within their own environments, then hard space provides a

³¹Usman Haque. "[hardspace, softspace: open source architecture.](#)" Archfarm, Non-periodical fascicles on architecture. Issue no.7, 2005.P.2

³² Softspace: interactive environments. http://www.omnispace.org/professional_practice/. (Accessed 5 may 2012)

framework to animate these interactions. The idea of an architectural operating system lies in the design of the systems that integrate the two. Furthermore this notion suggests that architecture would be thought of as an operating system, where people create their own programs for spatial interaction.

Soft space begins to identify the potential inherent in the use of digital tools to articulate this traditionally intangible space, while referring to its precedent and then projecting and suggesting possible futures. The concept employs new media and digital fabrication techniques.³³

To achieve that, a need for architecture to design interaction systems then produce architecture, which exists only at the moment of use, is placed in the hands of the end user (Fig. 3.13). Challenging the sensations can be provided by meta-programs within which people construct their own programs. In computers, an operating system is the software (like Windows or Mac) that runs a computer at its core level and which provides a platform upon which to run other programs. Extending the analogy to architecture, a spatial operating system provides frameworks to encourage multitudes of architectural programs. In this conception, people are the designers of their own spaces; architects simply design the meta-systems.³⁴

Interaction systems conflate distinctions between audiences and performers, users and designers, and occupants and architects, and open up creative possibilities for designed space, designed events and designed situations. They also raise challenges for the social role of designers in providing Meta systems that foster individual creativity and encourage people to create their own spatial programs, design their own spaces and invent their own logics. The quandary is to design operating systems that promote creativity without adding further layers of prescriptive control.



(Fig. 3.13) The Son-O-House, by NOX. The system generates its own sounds in real-time, with depending on the activity of the visitors. The results are stored in a growing data base. The previously generated sounds can be re-used in the future in new combinations.

³³ Softspace Contemporary Interactive Environments. <http://www.tate.org.uk/modern/eventseducation/talksdiscussions/9811.htm>. (Accessed 18 Sep. 2009)

³⁴ Usman Haque. “Hardspace, softspace and the possibilities of open source architecture.” 2004.P.2

3/2 Analyzing the Applications of Interactive Systems

This section discusses interactive systems applied in the fields of media, art and architecture to categorize the types of interactive applications, their function and the way of their implementation in spaces.

The analyzing of interactive systems properties and the way of their application in space, are determined with relevance to the ideological concepts, design process and technological tools. The analysis of interactive systems also realizes the levels of interactivity present in the applications which are present in terms of; ³⁵ Interactivity which combines real and virtual projection systems, and Physical interactivity where the architecture itself changes, the buildings environment is modified according to the situation. The analysis identifies the way in which interactive systems act; ³⁶ describing the environment in which the person occupies, defining and altering the space according to the user, directly communicating with a person or allow for communication between people.

interactive design method												Levels of interactivity	interactive systems									
ideological concepts		design process					technological tools															
responsive	kinetic	virtual reality	intelligent environment	artificial intelligence	Human computer interaction		user interface design		Embedded Computation			sensors	microcontrollers	robotics	hypersurface	(CNC)/smart materials	soft spaces	combines real and virtual	Physical interactivity	Describing the environment	Defining and altering the space	allow for communication
					Tangible paradigms	Surface based	Kinematic	Kinetic Typologies	Haptic interfaces	gesture	Cognitive control											

Table (3.1) represents the method of analyzing the interactive systems. *Ref*, the researcher.

³⁵ According to Antonino Saggio published in Peter Cachola Schmal, digital real: blobmeister, (book) Birkhauser publishers, 2001. PP. 11-12
 Antonino Saggio is professor of architecture at the University of Rome La Sapienza, an architect and planner, and the founder and editor of the book series The IT Revolution in Architecture, which now numbers 25 titles. He is the author of several books, including publications on Giuseppe Terragni, Peter Eisenman and Frank Gehry, and co-founded the magazine Il Progetto. He lectures internationally.

³⁶ Lucy Bullivant, 4D space : interactive architecture, Architectural Design Vol 75 No 1 , Published by Wiley Academy, 2005. P.13

3/2/1 Enter Active

It's an art installation placed in the lobby with a connection to the façade of a seven story apartment building at Los Angeles, California. It is designed by Electroland, a firm founded by Damon Seeley and Cameron McNall. The project was completed in 2006 .The main concept was, reflecting the vast network of electronic information surrounding us, navigating and participating in it all the time.³⁷

3/2/1/1 Project Explanation:

“Enter active” is installed as an interactive carpet for the entryway of the building, it interact with the pedestrian as they step on it. The interaction is also reflected on the grid installed on the building façade. Hence the installation is made of two main components; the carpet installed in the lobby and the grid installed on the façade.

The carpet is made of an array of electronic tiles that is installed outside the entrance to the building lobby. The tiles have of a riser system that sets into the surrounding concrete, and then placing a grid of 176 inch-square tiles within it. Each tile is a sandwich of fritted glass and plastic that holds 96 red LEDs and has four compression sensors and microcontrollers. The carpet serves as an interface with the pedestrians (Fig. 3.14), when someone steps on a tile, the sensors and microcontrollers send data to a master computer located in the lobby, that computer in turn signals the tile to illuminate.³⁸

The grid installed on the façade is made of illuminated squares mounted on the building’s west elevation. Java software translates the human movements and the computerized patterns into graphics flashing on the façade. A video camera facing the building transmitted images to a plasma screen in the lobby, so the users inside can see the effect of their footwork on the outside, detecting the relation between themselves and the building face, and understand their influence on the urban landscape (Fig. 3.15).



(Fig. 3.14): the images below, the project integrates many fields of interactive LED tiles which are placed into the ground. When people walk on them, they automatically start working and create a red-light ambiance.

³⁷ Great Examples of Interactive Architecture for Your Inspiration by Christian Vasile.
<http://www.1stwebdesigner.com/inspiration/great-interactive-architecture-examples/>
(Accessed 17 May 2012)

³⁸ article by David Sokol posted at “Architectural Record” magazine, August 2007



(Fig. 3.15): The massive display of lights on the outside of the building mirrors the patterns of the interactive tiles inside. There is also a built-in video display to show how the building looks from the outside.

3/2/1/2 Project Analysis:

Ideological concept: using virtual reality models of mirror world
(Remotely affecting the pattern of the elevation)

Design process:

- Surface based sensing and response human computer interaction design. it has embedded sensors to track position
- Haptic user interface. Actions are sensed through direct contact of the users.
- Active control of embedded computation. The LEDs modified according to the behavior of the user

Technological tools: using tactile sensors, microcontrollers and hyper surfaces techniques, as the elevation gives information about the user's position inside the building.

Level of interactivity: combines real and virtual projection systems

Interactive system: communicating with the users

Type of application: Combining the ideas of video games and surveillance. It invites user's participation by Interacting with buildings spaces and each other.

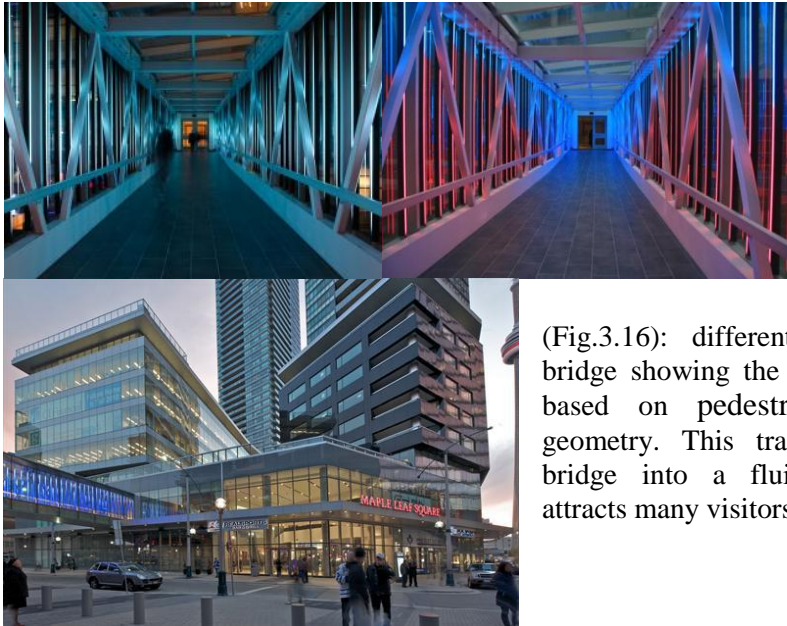
3/2/2 Connection

It is a bridge linking two different residential - commercial complex buildings in Toronto, Canada, interacting to the users as they walk through. It is designed by London-based art and design practice United Visual Artists. It was commissioned by Lanterra Developments, Cadillac Fairview Corporation Ltd and Maple Leaf Sports and Entertainment, for their Maple Leaf Square development, the completion year was in 2010.³⁹

³⁹ Ibid P.103

3/2/2/1 Project Explanation

The bridge is responsive to the pedestrians walk way, it illuminated in three different colors based on the pedestrian's movement (Fig. 3.16). It consists of an array of vertical luminaires integrated into the bridge, that create oscillations of colors and geometry based on human movement, thus transforming the rigid structure of the bridge into a fluid entity that transmits the rhythm of the crowd to its surroundings.⁴⁰



(Fig.3.16): different views of the bridge showing the different colours based on pedestrians movement geometry. This transforms a rigid bridge into a fluid entity which attracts many visitors.

3/2/2/2 Project Analysis:

Ideological concept: using responsive environments reflecting the current status of the walkway depending on the number of users.

Design process:

- Tangible human computer interaction design. Through sensing the motion and level of crowd, the information is translated physically by changing the color of the light.
- Gesture interface. The level and the color of lighting are manipulated depending on the pedestrian's movement.
- Active control of embedded computation. The light installation is physically changed in color and geometry according to the motion stimuli.

⁴⁰ United Visual Artists, <http://www.uva.co.uk/work/connection#/0> (Accessed 23 March 2012)

Technological tools: using optical sensors and chromic materials.

Level of interactivity: combining reality and virtual.

Interactive system: communicating with the users.

Type of application: context awareness of the surrounding environment.

3/2/3 Constellation

Constellation is a light-based sculpture where the users can set their own color scheme through experiencing the sculpture. United visual artists Ltd (UVA) designed the responsive installation they were commissioned by “Covent Garden”, London, as part of its delight Christmas campaign in the year of 2008, but the light-based sculpture was also used for other purposes later.⁴¹

3/2/3/1 Project Explanation

The installation featured 600 custom-designed mirrored LED tubes hanging above the entire Covent Garden market space, lighting up the market halls in a responsive manner in which a three dimensional light formation were made possible (Fig. 3.17). Constellation was also individually controllable using a custom-designed control panel, enabling the viewers at given times to create their own formations within Constellation, allowing the installation to have an intimacy with the public.



(Fig.3.17): shows the three-dimensional arrangement of the tubes and the different color deformation made to the light installation at the Covent Garden market.

The main objective is to explore and examine the landscape through media and light. The design is oriented towards the audience; to unite the

⁴¹ TARMLED and UVA team up on LED installation at London's Covent Garden -case studies . <http://ledsmagazine.com/casestudies/17430>. (Accessed 5 Dec 2008)

stage and the public space by focusing on how the user will experience the installation, be part of it and play with it.⁴²

To power the installation a number of 578 two meters long LED-strips which are double-sided and video-compatible were used and 37 DPDU's (Data Power Distribution Units). The LED strips were incorporated into polycarbonate tubes coated with a semitransparent reflective film, in accordance with UVA's design (Fig. 3.18).⁴³

The DPDU's allow for cable runs of a maximum of 20m from the fixture using a single cable carrying data and power to each fixture (Fig. 3.19). The 25mm pixel spacing of the strips and UVA's regular grid layout of the tubes allow for 3D displays of voluminous, complex, geometric patterns and effects. The system is entirely driven by UVA's custom-built application "Dragonfly" production controller system.



(Fig. 3.18): on the left shows the units of 1156 x 2m LED strips (Fig. 3.19) On the right shows the 20m long strips hanging over the market.

3/2/3/2 Project Analysis:

Ideological concept: using responsive environments by manipulating the light installation

Design process:

- Surface based sensing and response human computer interaction design. Giving digitally physical deformation of the light through the manipulation using control panel.
- Haptic interface. The audience are allowed to use control panels to control part of their environment, the installation

⁴² Lighting design unites the stage and the public space.
<http://www.danishdesigners.com/?page=284> (Accessed 1May 2012)

⁴³ Lighting Design United Visual Artists.
http://www.mondoarc.com/projects_video/210061/constellation_london_england.html.
(Accessed 1March 2009)

- Active control of embedded computation. The installation is modified according to the changes applied to it.

Technological tools: using microcontrollers and chromic materials

Level of interactivity: combining reality and virtual

Interactive system: interact with users

Type of application: sensing and controlling the surrounding space by allowing for the communication between the audience and the installation

3/2/4 D-tower

It is a permanent public art work activated by the users through answering a questionnaire on its own website. D-tower was opened in 2004 in the city of Doetinchem, in the eastern Netherlands. It is designed by the architect “Lars Spuybroek”, and “QS Serafijn”, a Rotterdam-based artist.⁴⁴

3/2/4/1 Project Explanation

The D-tower is a hybrid of different media, where architecture becomes part of a larger interactive system of relationships. It is a project where the city can show its emotions and networking it through filling an internet questionnaire.⁴⁵

The project consists of a physical structure (the tower) and a questionnaire on the website (www.d-toren.nl). It is connected to the website which visualizes the inhabitant's response to the questionnaire updated every six month by adding four new questions that deals with daily emotions like Hate, Love, Happiness and Fear. The four emotions are represented by four colors, respectively: Green, Red, Blue and Yellow, which are the colors of the lamps illuminating the structure. Each evening the computer concludes from the responses which emotion is mostly felt that day and lights the D-tower in the color corresponding to that emotion (Fig. 3.20).



(Fig. 3.20): D - Tower it is a tall, prefabricated epoxy structure, lit up at night, showing the emotion of happiness for the next six month until the questionnaire is updated again

⁴⁴ The cultural landmarks of the next 10 years, by Oliver Good.

<http://www.skyscrapercity.com/showthread.php?p=50718591> (Accessed 25 Jan. 2010)

⁴⁵ Lucy Bullivant, 4dSPACE: Interactive Architecture, Wiley Academy, 2007. PP. 68,69

3/2/4/2 Project Analysis:

Ideological concept: Virtual reality through using the window model(internet based)

Design process:

- Kinematic interaction human computer interaction design. Visual representation of virtual data that has an effect on physical space.
- Cognitive user interface. It creates a relation between the digital data of the questionnaire to the physical space, the color changing sculpture.
- External communication of embedded computation. Allowing to remotely changing the colors of the tower.

Technological tools: using CNC fabrications and hyper surface techniques

Level of interactivity: combining reality and virtual

Interactive system: communicate with the users

Type of application: responding to the users emotions, showing the social current status, through communication.

3/2/5 Volume at the Victoria and Albert museum

Relating to the transformations in digital technologies the UVA office designed a large-scale Digital installation "Volume" placed in the courtyard of the Victoria and Albert (V&A) museum in London and opened in 2006.

3/2/5/1 Project Explanation

"Volume" is an interactive pavilion made of LED lights columns placed in the open garden of the museum where the visitors could touch, push on and run through it. Acting like MySpace Profiling on the Internet but in physical matter the user can create his own personal space, creating their own unique journey in light and music as they pass through it (Fig. 3.21).



(Fig. 3.21): It consists of a field of 46 luminous, sound-emitting columns that respond to movement. Visitors weave a path through the sculpture, creating their own unique journey in light and music

The columns form a grid of 46 LED lights columns, where each column is connected to an audio system, computer and separate synthesizer network that play its own piece of music. The notes generate changes the colors scheme in real time. The designer uses its own custom-built application software “Dragonfly 3” to control the installation. The installation tracks the user’s behavior through using a camera with an infra-red filter capturing information about the user’s movement. The information feedback goes through a visualization system, which controls the LED. Midi signals also travel between a mac running Logic (for audio) and the visualization system, to allow audio to trigger graphics and vice versa.⁴⁶

The installation was designed to work well as an experience on different scales; with no people, with one person, with less than 10 and with much larger numbers of people. The installation avoided determining color according to visitor density and struck a balance between pure responsively and controlled composition, creating a series of audio-visual experiences. Each visitor entered into a personal exploration of the installation, and their actions influenced others, and this was fundamental to the work, with people regularly switched from viewing to participating (Fig. 3.22). Visitors were invited to step inside and see their actions and play with the energy fields throughout the space, triggering a display of light and sound.⁴⁷



(Fig. 3.22): Walking up to it activates the “Volume” no movement deactivates it. This simple system of rules generates complex emergent patterns as the number of people increases. The arrangement each person hears depends on his or her path through the installation, as well as the movements of the people around the individual.

3/2/5/2 Project Analysis:

Ideological concept: using intelligent environments technique as the outcome is variable according to the filtered data the sensors gathers.

Design process:

⁴⁶ Interview with United Visual Artists by Andy Polaine .
<http://www.polaine.com/2007/02/interview-with-united-visual-artists/> (Accessed 19 Feb. 2009)

⁴⁷ Lucy Bullivant, 4dsocial: Interactive Design Environments, Wiley academy, 2007.PP.8-9

- Tangible human computer interaction design. The visitors walk through the pavilion and their movement change the surrounding space
- The interface is a combination between haptic and gesture interfaces
- Embedded computation through automation. The LEDs respond to the visitor's behaviors personalizing the space around them through changing its color and sound.

Technological tools: using optical and tactile sensors and soft space techniques

Level of interactivity: combining reality and virtual

Interactive system: communicate with users and allow for the user to communicate with each other.

Type of application: it constantly reacts to the users shifts, and reflects these changes; whether in sound, or visually.

3/2/6 Light Scraper

It's a deployable pavilion made for Rainbow Serpent festival in Beaufort, Victoria, Australia. It is a media artwork of light and sounds designed by Melbourne-based interactive design company ENESS.⁴⁸

3/2/6/1 Project Explanation

The Light Scraper is a towering vortex of visuals and sound feeding off its surroundings. Featuring real-time 3d graphics and a motion tracking system, the Light Scraper explores new forms of engagement with technology and ultimately each other. The Light Scraper is a custom built aluminum structure, fabricated with a layer of semi translucent mesh (Fig. 3.23).The structure can be easily erected in a single various compositions in an outdoor or indoor setting.⁴⁹

Using Real time 3D graphics and human motion-tracking technology the structure fully interacts with its surroundings. A computer and two projectors are used to bring the sculptures' visuals. The Light Scraper also acts as a giant musical instrument, people's location influence the melodies emitting from the sculpture. Visitor's positions are tracked via an infrared camera mounted at the peak of the structure, and translating movement information into musical melodies and eye-catching visuals (Fig. 3.24).

⁴⁸ Eness was Established in 1997. it is an award winning art & design practice based in Melbourne Australia. <http://openbuildings.com/buildings/> (Accessed 11May 2012)

⁴⁹ From Eness web site. <http://staging.touchmypixel.com/eness/?r=Project&p=3&c=2> (Accessed 11 May 2012)



On the left (Fig. 3.23): the lightweight aluminum structure .On the right (Fig. 3.24): exterior view of the sculpture with the color variations according to the user movement and surrounding environment.

3/2/6/2 Project Analysis:

Ideological concept: it's a deployable kinetic structure, using immersive virtual reality model by placing the user inside the structure light and sound variations

Design process:

- Tangible human computer interaction design. The graphics are manipulated by the visitor's tracked motion.
- Gesture interface allowing the visitors to manipulate the sound emission through their motion.
- Embedded computation through active control.

Technological tools: using stereo vision sensors and soft space techniques

Level of interactivity: combining reality and virtual

Interactive system: communicating with users

Type of application: interacting with built environments through sensing the visitors motions

3/2/7 From Dust Till Dawn

It is an Interactive sound installation designed by “Dietmar Offenhuber” and “Markus Decker”. It was presented at Ars Electronica center in Austria in the year of 2006.

3/2/7/1 Project Explanation

The main theme of "From Dust Till Dawn" is kicking up a lot of dust and producing noise in the form of acoustic trace. The atmosphere here is used as the installation sole medium of interaction. The project is a sound

installation for a room with a dusty floor, on which a number of phonographs are placed, playing back silent vinyl records. As a result of the visitors' movements, particles of dust accumulate in the grooves of empty records and define a musical score. A carpet of monochromatic light visualizes the turbulence in the atmosphere and detects its ephemeral structures, which are directly linked to the noise generated by the dusty records (Fig. 3.25). Over time, the physical impact of the interaction irreversibly consumes the interface and destroys the needles of the phonographs.⁵⁰



(Fig. 3.25): different views of the installation .The designers tend to introduce the audience with their small dark urban 'sandstone' where users can play with dust and light as long they wish, since there is no tempo, no rhythm, and no time limitations, only existing limitations are those that could be created by participants.

Dust behaves unpredictably and is difficult to control, but as elusive as time seems to us, it leaves physical traces in the form of dust. Here the dust and atmosphere in the empty room form the installation's interactive medium. Dust is identified by a surface laser and a photographic identification system and becomes a highly unusual means of interaction. A grid of line lasers installed just above the floor produces a homogeneous carpet of light which is at first invisible. Objects and particles that pierce this carpet, such as dust, cigarette smoke or larger objects, become visible in the laser beams as a silhouette or an outline (Fig. 3.26). The outlines and dust patterns are recorded and their two-dimensional movements converted to sound on an XY raster synthesizer. Every step the visitor makes sets the air moving and causes dust to swirl up. "From Dust Till Dawn" deals with a fragile, barely controllable, interactive medium and robs the term tangible media of its intangibility. The installation immerses the visitor in a synesthetic experience where movement through space, vision, sound and dust meet in unpredictable ways.⁵¹

⁵⁰ [interactivearchitecture.org](http://www.interactivearchitecture.org), Posts filed under 'Audio'.

<http://www.interactivearchitecture.org/category/audio/page/3> (Accessed 30 Jan.2010)

⁵¹ K-030 Touch Me Festival 2008

<http://www.kontejner.org/fromdusttilldawn-english>. (Accessed 30 Jan.2010)



(Fig. 3.26): The sound form is predominately based on sensations stimulated by mechanical vibrations, letting the visitors to feel the pulses of their own steps, jumps and scuffs with neon lights created around shoes as a result of light usage and dark scenography. That makes the whole play organic, in line with the meaning of dust.

3/2/7/2 Project Analysis:

Ideological concept: immersive visual reality model

Design process:

- Surface based human computer interaction design.
- Haptic interface, the steps of the visitors on the installation carpet is transformed into sound and light variations
- Active control Embedded computation, the system is modified according to the visitors stimuli.

Technological tools: using chromatic light materials, tactile sensors and soft space techniques

Level of interactivity: combining reality and virtual

Interactive system: describing the surrounding environment

Type of application: interacting with the built environment, by sensing and controlling of space

3/2/8 Aegis

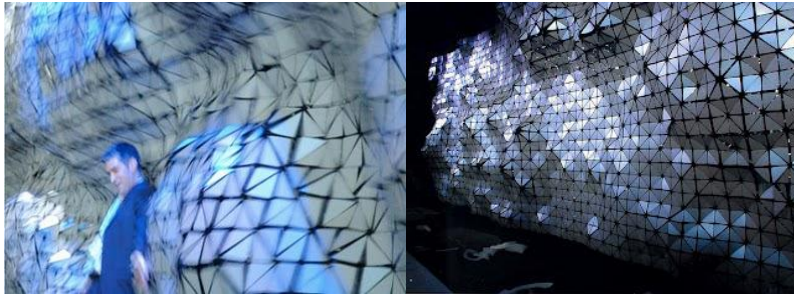
The design of the Aegis project was initially conceptualized in response to an interactive art work competition hosted by the “Birmingham Hippodrome” Theatre in England. The competition proposed an art work that would translate the interior actions of the theatre to the exterior. It was designed by “dECOi” lab in 1999

3/2/8/1 Project Explanation

Aegis is a physically kinetic reconfigurable 3D screens, producing precise and high speed deformation across a fluid surface (Fig. 3.27). It is enabled by high speed information of hyper surface technology. It effectively

links information systems with physical form to produce dynamically variable, tactile informatics surfaces, Where Information translates into form.⁵²

It respond to external stimuli, such as sound, touch, motion, light, temperature, and electronic information, through the use of active and passive sensors. The input data is used to describe a parametric variable, such as direction, amplitude, and speed, allowing for near limitless articulations of the surface. The surface can produce any possible mathematically generated pattern or form. As a result, it is not a designed surface but rather generated by random sampling, a deployment of electronic sensory input. This offers full interactivity with an audience, and a simple User Interface allows hyper surface to be tuned to any event.⁵³



(Fig. 3.27): Decoi - Hypo Surface, generates an emotional connection as it responds to sound, movement and body.

The hyper surface can create a truly responsive terrain in real time. This is made possible through the use of powerful generative computer to a vast matrix of actuators and highly per-formative components. The digital control is able to calculate a response to input data in real-time because of extremely high flow rates of information and its parallel-processing ability.⁵⁴ Composed of small metal triangles Prototype powered by a matrix of 896 pneumatic actuators with the ability to pulse every 0.01 sec, (Fig. 3.28) the surface is able to displace its skin up to 500mm two to three times per second and create wave fronts propagating at speeds of up to about 60kmh .

⁵² prix ars electronica.

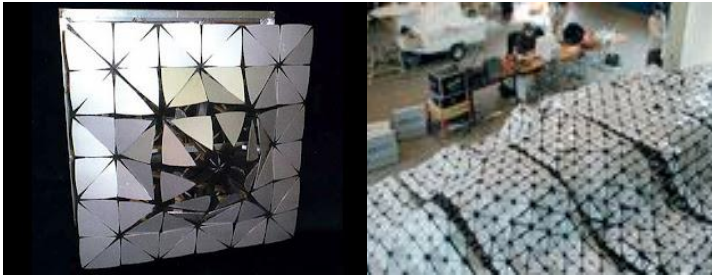
http://90.146.8.18/en/archives/prix_archive/prix_projekt.asp?iProjectID=12452. (Accessed 23June 2012)

⁵³ Michelle Addington and Daniel Schodek, "Smart Materials and Technologies," Architectural Press, 2004. PP.160-163

⁵⁴ Neil Leach (ed.), "Designing for a Digital World," London: Wiley, 2002.PP.103-105

It deploys sophisticated 3D patterning in time, running text, graphics or video images in relief, using a generative algorithmic program.⁵⁵

As a digital matrix, the hyper surface is inherently interactive; any digital input can be linked to any digital output to surface effect. It allows interactivity with dancers' or with musicians' movement and, video and sound recognition systems offering a programmed responsiveness. Most effectively it allows interactive systems to be physically articulate in their capacity for spatial reconfiguration.



(Fig. 3.28): Aegis prototype consists of a latent surface, its pixels given vector freedom potential to make the surface spatial and dynamic

3/2/8/2 Project Analysis:

Ideological concept: artificial intelligence

Design process:

- A combination between Kinetic and tangible human computer interaction design.
- The interface is a combination between haptic and gesture interfaces
- Adaptive control Embedded computation.

Technological tools: using robotics (actuators, passive and active sensors) and hyper surface techniques

Level of interactivity: physically shape shift

Interactive system: alter space according to the user

Type of application: Hyper surface generates an emotional connection as it responds to sound, movement and body. It can be used in a kinetic manner for environmentally responsive architectural surfaces, sensitized to changes in climate or security needs.

⁵⁵ Hyposurface. <http://www.hyposurface.org>. (Accessed 12 April 2011)

3/2/9 The Muscle Tower 1

The Muscle Tower designed by Kas Oosterhuis is a working prototype (model scale 1: 20) for a building's structure which responds to external stimuli like the weather and internal conditions like the users. It was first shown in an exhibition, part of the 'Industrial Week', for the Dutch industry (Fig. 3.29).

3/2/9/1 Project Explanation

The structure is programmed as a process relating to the people, and the environment behavior displaying their actions in real time. As a real-time adaptive structure the Muscle Tower could be used as an adaptive façade, adapting to changing external environmental conditions and internal usage patterns. Also it can be used as a responsive roof, responding to changes in solar radiation and as a pro-active space. The building morphology augments itself in real time to suggest and provoke the possibilities of engaging with space, and balancing the structure to dynamically resist external forces, making a skyscraper stand perfectly upright when enduring strong winds.⁵⁶



(Fig. 3.29) :Muscle Tower 1 the tower tilts according to the visitor's movement.

3/2/9/2 Project Analysis:

Ideological concept: artificial intelligent using rational agents.

Design process:

- Kinetic human computer interaction design.
- Gesture interface, for controlling the structure.
- Adaptive control for embedded computation, for the response of external environmental conditions and

⁵⁶ Paper by Kas Oosterhuis and Nimish Bioria, "Interactions with Proactive Architectural Spaces: The Muscle Projects," 2008.

automation control for embedded computation for adapting to users stimuli.

Technological tools: using robotics (actuators, passive and active sensors).

Level of interactivity: physically shape shift.

Interactive system: alter space according to the user and environmental conditions.

Type of application: responding to exterior and interior environment conditions.

3/2/10 The Muscle Tower 2

The second Muscle Tower prototype a sequel to tower 1 was an interactive advertising billboard structure with built-in behaviors for reacting to its environment, through bending and rotation of its elements.⁵⁷

3/2/10/1 Project Explanation

The tower consists of a network of aluminum rods, connected flexibly to each other and to pneumatic muscles by means of hollow iron spherical nodes. The positioning of muscles allows the 3D frame to be bent, twisted and deformed while maintaining a sense of balance of the entire tower, thus avoiding it from toppling over. A cumulative stacking and attaching of subsequent frames allows for a higher degree of movement. The tower is programmed using “Virtools”, which obtains data about the presence of people by means of a sensing field with motion sensors laid out in the periphery of the tower. The tower can elegantly bend, twist and turn towards the sensed spatial coordinates of people around it, in order to attract attention to an advertisement displayed on the tower’s surface (Fig. 3.30).



(Fig. 3.30) : The Muscle Tower 2 the structure is flexible enough to move and rotate according to different stimuli .

⁵⁷ ibid P.122

3/2/10/2 Project Analysis:

Ideological concept: artificial intelligent using rational agents.

Design process:

- Kinetic human computer interaction design.
- Gesture interface, for controlling the structure
- Adaptive control for embedded computation, for the response to the environmental stimuli.

Technological tools: using robotics (actuators, passive and active sensors)

Level of interactivity: physically shape shift

Interactive system: alter space according to the environmental conditions

Type of application: responding to environment conditions

3/2/11 The Muscle Body

The Muscle Body also designed by Kas Oosterhuis is a fully kinetic and interactive prototype of an interior space. Muscle body project designed as an integrated architectural body.⁵⁸

3/2/11/1 Project Explanation

The project is an architectural body constituting a continuous Lycra skin that makes no categorical distinctions between floor, wall, ceiling or doors (Fig. 3.21). This continuous skin is structurally supported by a spiraling three dimensional PVC tube framework, thus endowing it with flexibility and stiffness. A total of 26 Festo muscles are intergraded into this spiraling structure to control the physical movement. Using these materials, the Muscle Body can change its shape, its degrees of transparency, and the sound that it generates in real-time, as it interacts with people who enter it. The translucency of its Lycra fabric varies according to the degree of stretching induced by this shape augmentation. The thin strips of light mounted between the tubing and the skin, in combination with the altering translucency of the fabric results in an intriguing play of light upon activation. There are also a number of speakers integrated into the skin that generate sound from several sound samples combined and transformed according to the actions, proximity and movement of the people inside the Muscle Body.⁵⁹

⁵⁸ Organic User Interfaces, a special issue of communication of the ACM.
http://www.organicui.org/?page_id=36. (Accessed 31 march 2011)

⁵⁹ ibid P.122



(Fig. 3.31): The Muscle Body showing an interior with no specific definite limit of walls ceiling and floor in a changing state

3/2/11/2 Project Analysis:

Ideological concept: artificial intelligent using rational agents

Design process:

- Kinetic and surface based sensing human computer interaction design.
- Haptic interface, for controlling the structure
- automation control for Embedded computation, to manipulate the structure in order to attract more visitors

Technological tools: using robotics (actuators, passive and active sensors) and CNC materials.

Level of interactivity: physically shape shift

Interactive system: alter space according to the user needs

Type of application: responding to exterior and interior environment conditions

3/2/12 The Bamboostic

The Bamboostic installation is an interactive architectural space by Kas Oosterhuis, also reacts to movements (Fig. 3.32).

3/2/12/1 Project Explanation

It operates as an interactive forest that could be placed in a public space like a square, and is composed of a series of mechanical trees. These trees are the result of coupling three pneumatic muscles utilized for actuation, with a central mast of bamboo specifically chosen for its flexibility. A series of trees was created and grouped together to create an organized forest of kinetic bamboo structures. The kinetic behavior is regulated in accordance

with the position of people near each bamboo structure. The position of people is tracked in real-time via a tracking system using “Virtools”. The tree nearest to a tracked individual bends towards him or her, and its movement is replicated in a decreasing extent by surrounding trees. This produces a rather natural landscape feel, via a set of mechanized entities.⁶⁰



(Fig. 3.32): A “Bamboostic forest” installed in a public building main foyer. It creates a playful experience as the sticks change its orientation according to the movement near it.

3/2/12/2 Project Analysis:

Ideological concept: responsive techniques

Design process:

- Kinetic computer interaction design.
- Gesture interface
- active control for Embedded computation, to manipulate the structure in order to attract more visitors

Technological tools: using optical sensors and microcontroller

Level of interactivity: physically shape shift

Interactive system: interact to the users

Type of application: sensing the users movement

3/2/13 Dune

Dune 4.0 by “Daan Roosegaarde” is an interactive landscape which physically changes its appearance in accordance to human presence. Placed in the Maas tunnel in Rotterdam first installed in the year of 2007 (Fig. 3.33).

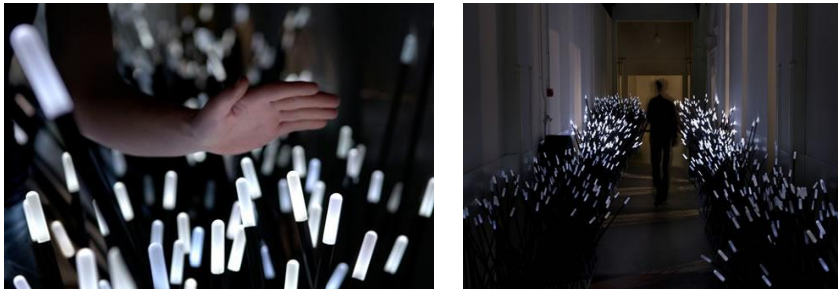
3/2/13/1 Project Explanation

Dune 4.0 is composed of hundreds of fibers which react in correspondence to the movements and sounds of the visitors. Daan described this as a hybrid of nature and technology which functions as a platform on

⁶⁰ ibid P.122

which the relationship between visitor and the existing architecture is enhanced. By means of looking, walking and interacting, visitor and space merge into one coherent environment.⁶¹

The installation spans 40 meters and consists of hundreds of fibers which react to the movements and sounds made by the visitors. When humans are present, the landscape physically changes its appearance, based on the recorded data. The data is collected using embedded microphones and presence sensors, and causes the fibers to light up, accordingly.⁶²



(Fig. 3.33): the installation change its illumination and orientation to the movement around them.

3/2/13/2 Project Analysis:

Ideological concept: responsive techniques

Design process:

- Tangible computer interaction design.
- Gesture interface
- Active control for embedded computation, to manipulate the installation.

Technological tools: using tactile sensors and chromatic materials

Level of interactivity: combining virtual with reality

Interactive system: describing its environment

Type of application: sensing the users movement enhancing their sense of place

⁶¹ Lucy Bullivant, “4dsocial Interactive Design Environments,” wiley academy, 2007. P7

⁶² Dune 4.0 ,Daan Roosegaarde, 5Jan. 2007 posted on

<http://www.interactivearchitecture.org/dune-40-daan-roosegaarde.html>. (Accessed 5 Jan. 2010)

3/2/14 Tower of Winds

The project was designed by Toyo Ito in Yokohama Japan in the late eighties. It's a renovated 21-meter-high existing tower, formerly used as ventilation for an underground shopping area, now covered with acrylic mirror plates and an oval cylinder of perforated aluminum encloses a regulating system of light-devices.⁶³

3/2/14/1 Project Explanation

The resulting image illustrates the variety of patterns and values of transparency achieved by a combination of more than 1,000 lamps, twelve surrounding neon rings, and thirty flood lights which are situated on the ground and directed upwards within the tower's shell (Fig. 3.34).

An electronic system recognizes the fluctuations of air and noise are recorded by a central computer which translates them into a visual experience of light color codes. This reflects on the tower's shell and modifies both the object as its environment. The transformation from transparency to opacity, depends on time day and night as well as on wind-velocity and radiation, for this reason, unlike a traditional arrangement of lights, this installation does not follow a predetermined program or routine, and offers an ever-changing spectacle of light and color. Using light both as a temporal and as a physical parameter, made possible by the perforations through the most elementary component of tele-visual technology, dots and light.⁶⁴



(Fig. 3.34): The oval cylinder geometry of the Tower of the Winds is distinguished from the other volumes in the surroundings.

⁶³ Interview with Toyo Ito by Carly Berwick in The Take-magazine.2002.
http://www.mediaruimte.be/digital_territories/projects/cybernetic/Tower-of-Winds_Toyo-Ito.html (Accessed 1 Jan. 2010)

⁶⁴ Toyo Ito: A Tribute to the Winds.
<http://architecturalmoleskine.blogspot.com/2010/06/toyo-ito-tribute-to-winds.html>.
(Accessed 29 June 2010)

3/2/14/2 Project Analysis:

Ideological concept: rational agents of artificial intelligence

Design process:

- Tangible computer interaction design.
- The interface doesn't involve users the application is a reflection to the level of noise and wind of the surrounding environment.
- Adaptive control for embedded computation.

Technological tools: using active and passive sensors and chromatic materials

Level of interactivity: combining virtual with reality

Interactive system: describing its environment

Type of application: interacting to the surrounding environment by reflecting the surrounding noise and the speed of wind.

3/2/15 ISpa - Interactive Urban Retreat

The "ISpa" Interactive Urban Retreat was a student based environmental design project constructed by 13 students of the Art Center College of Design in 2007. The aim of this project was to create a getaway from stress-ridden life due to urban dwelling, through the use of a light and sound based environment (Fig. 3.35).

3/2/15/1 Project Explanation

The main goal was to construct a space that would act, respond, interact and adapt like a person would in the hopes of providing a calming area that would propagate relaxation. It is a hyper technologically enhanced environment. The central issues explored are human and environmental interaction, embedded computational infrastructures and kinetic engineering. "ISpa" is constructed of CAD/CAM manufacture, robotics, and the translation of robotics to full-scale real works to create a space with behaviors that users can interact with. Altering the user's environment is made through sight and hearing to escape the stress and reality of life.⁶⁵

⁶⁵ robotecture interactive architecture,i-spa(art center).
<http://www.robotecture.com/showcase/i-spa-art-center/>. (Accessed 4 Aug. 2009)



(Fig. 3.35): ispa interior having different arrangements of light and sound

3/2/15/2 Project Analysis:

Ideological concept: autonomy agents of artificial intelligence

Design process:

- Tangible and surface based sensing, computer interaction design.
- Haptic and gesture user interface.
- Automation control for embedded computation.

Technological tools: using robotics (actuators, passive and active sensors) and soft space techniques

Level of interactivity: combining virtual with reality

Interactive system: communicate with users

Type of application: changing in response to users conditions

3/2/16 No place

An interactive installation connected to a website designed for it. The installation was designed by Marek Walczak and Martin Wattenberg, commissioned by Tate, as part of the Synthetic Times exhibition at the National Art Museum of Beijing in 2008.⁶⁶ It is a sequence of physical and online art installations that explore utopian visions.

3/2/16/1 Project Explanation

The designers developed software that collects data, images, and texts via the web and arranging these hundreds of feeds according to categories such as "fantasy," and "dreamscape". This grouped material is then

⁶⁶ Marek Walczak, Martin Wattenberg Noplace.
<http://creative-capital.org/projects/view/58>. (Accessed 19 Jan. 2012)

composited and projected, producing virtual architectural structures, by tangibly manifesting the contemporary experience of information.⁶⁷

These structures expand as utopias added to the project. In the final installation, projected shadows on the gallery walls represent the architecture evolved from the data, creating a physical browser which viewers can manipulate and transform with a wave of their hands. “Noplace” online consists out of a remix culture, through its interactive webpage, where different individuals from around the world get the chance to create and share videos (Fig. 3.36).⁶⁸



(Fig. 3.36): the different views generate on the Noplace installation according to the online gathered data from different groups of visitors.

3/2/16/2 Project Analysis:

Ideological concept: virtual models of immersion for the exhibition installation and through the window for the online application

Design process:

- Kinematic computer interaction design. Giving physical form to the gathered on line data.
- Cognitive user interface, blurring the limits between the digital online data and the projected videos on the exhibition walls
- External communication Embedded computation, remotely control the projected videos.

Technological tools: using soft space technique

⁶⁷ Rhizome, noplace (2007) by MW2MW.

<http://rhizome.org/editorial/2008/jan/31/noplace-2007-by-mw2mw/>. (Accessed 19 Jan. 2012)

⁶⁸ Art and Electronic Media. <http://www.artelectronicmedia.com/artwork/noplace>. (Accessed 21 June 2012)

Level of interactivity: combining virtual with reality

Interactive system: communicating with users

Type of application: responding to the users views and wishes and allow for charring this with different people's culture.

3/2/17 Vital Signs

It is a media installation designed for the Liberty Science Center in New York in 2005. The design was collaboration with, Batwin and Robin, Sawad Brooks/OPENWORK, Paul Yarin/BLACKDUST, Images and animations courtesy of nArchitects.⁶⁹

3/2/17/1 Project Explanation

Vital Signs is an interactive installation designed to disseminate breaking news about science to visitors in the museum. A continuous and permeable moebius strip of LEDs presented with projections would allow visitors to view streaming information from all sides of the atrium. A simple ladder-rung structure consists of an outer aluminum edge rail joined together by intermittent rungs. Plexi ribs supporting the LED's and translucent plexi projection surfaces span between the edge rails (Fig. 3.37). Visitors can dynamically select topics or upload information from various points along the mezzanine handrails.⁷⁰



(Fig. 3.37): the installation of Vital Signs represent information in real time.

3/2/17/2 Project Analysis:

Ideological concept: virtual models of through the window for the online application

⁶⁹ Moebius, 2005 by Sawad Brooks (OPENWORK), Batwin + Robin, nArchitects, Paul Yarin (BlackDust).

<http://www.open-work.com/sawad/portfolio/general/>. (Accessed 2 June 2012)

⁷⁰ interactive architecture.org , Vital Signs nArchitects.

<http://www.interactivearchitecture.org/vital-sign-narchitects.html>. (Accessed 22 July 2012)

Design process:

- Kinematic computer interaction design.
- Cognitive user interface.
- External communication Embedded computation.

Technological tools: using CNC materials

Level of interactivity: combining virtual with reality

Interactive system: allow for communication with the users

Type of application: responding to real time information

3/2/18 Smart Wrap Pavilion

Smart wrap is a building envelope responding to the surrounding environmental conditions. Designed by Kieran Timberlake who began the research and development of Smart Wrap in 2002, collaborating with various industry partners to engineer and fabricate a prototype of the material as a mass customizable print façade. It was first showed at the “SOLOS” exhibition at the Cooper-Hewitt National Design Museum in New York in 2003, (Fig. 3.38) and traveled to the Institute for Contemporary Art in Philadelphia, then in San Francisco and the “Zeche Zollverein” exhibition in Essen, Germany.

3/2/18/1 Project Explanation

Smart Wrap represents a new way of thinking about a building envelope. It proposes to replace the conventional "bulky" wall with a composite of millimeter scale surface that integrates climate control, power, lighting, and information display on a single surface. Through the deployment of deposition printed organic photovoltaic and organic light emitting diodes onto thin plastic layers, visitors are able to walk through the smart wrap installation and customize their own design of a smartwrap wall.⁷¹

It consists of phase change materials for temperature control. The phase change materials provide latent heat storage for thermal moderation by absorbing, storing, or releasing heat as they change state. Organic light emitting diodes (OLED)⁷² are used for lighting and data display, performing

⁷¹ Kieran Timberlake, SmartWrap: Building Envelope of the Future.

http://kierantimberlake.com/research/smartwrap_research_1.html#_ (Accessed 15 May 2012)

⁷² OLED technology is based on organic molecules that emit light (photons) when an electric current is applied. OLEDs are either made in polymer form, or small molecules that can be deposited onto glass and plastic substrates. (OLED technology is currently used in the

in conjunction with organic thin film transistors, and organic photovoltaic cells to power the OLED system. Smart Wrap is lightweight resulting in a lower total embodied energy when compared to glass, and its thickness, just 3mm, results in large surface area coverage with a minimal volume of material relative to glass curtain-wall assemblies. Due to its lightness it can be applied with greater efficiency and at the end of its useful life, Smart Wrap can be easily disassembled and fed into a recycling stream.



(Fig. 3.38): smartwrap, on display in the cooper-hewitt museum's

3/2/18/2 Project Analysis:

Ideological concept: responsive to environmental conditions

Design process:

- Surface based computer interaction design.
- Haptic user interface.
- Adaptive Embedded computation.

Technological tools: using chromic, shape memory, phase changing and photovoltaic materials, with active sensors.

Level of interactivity: combining virtual with reality.

Interactive system: describing the environment.

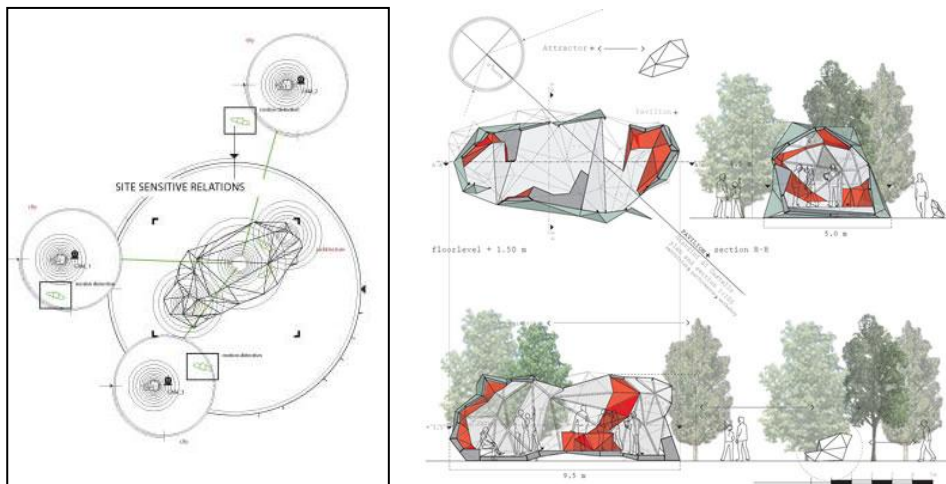
Type of application: interacting with the environmental conditions.

3/2/19 NoRA

The NoRA structure designed by students of Architecture & Design, Aalborg University in 2007, was presented at the Venice Architecture Biennale as an interactive architecture exploring how advanced architectural computing and sensor technology could attach the individual perception of place. The temporary structures acts as agents for urban experiences.

3/2/19/1 Project Explanation

The structure is able to be disassembled and moved to other locations as research platform and exhibitions. The design concept for NoRA was initiated through using fluid dynamics software absorbing site characteristics as cultural movements, light and shadow into the organic mass. The sensors located around the building are tracking the flow activity using infrared cameras and translate this signal into a variation light and sound scheme (Fig. 3.39). During performances the building sound, light and cameras can be controlled by the performers and the activities recorded to database and the internet.⁷³



(Fig. 3.39): an illustrations prepared by the NoRA Design Team. Showing the tracking and sensors devises that tracks the activities motions around the pavilion.

As a build structure NoRA was programmed to release its variable sound and light scheme according to the movements of people around the building as well as acting as a medium for the users to facilities their projection into the urban environment (Fig. 4.30).

⁷³ performative environments, NoRA – Nordic Research Application. <http://performative.wordpress.com/page/2/>.(Accessed 17 Jan. 2012)

Architectural entities often close up communication with the urban environment. In this way the moveable structure of NoRA embedded the potential for in-between spaces to become new meaningful places and hence new types of public domains. This thinking leans on performative environments as a notion of what a building does instead of what it is. This opens up for an urban architecture to be dynamic, open and facilitating self-organising communicative environments.⁷⁴



(Fig. 4.30): NoRA the color variation after construction

3/2/19/2 Project Analysis:

Ideological concept: responsive and deployable kinetic mechanism

Design process:

- Tangible computer interaction design.
- Gesture and haptic user interface.
- Automation Embedded computation.

Technological tools: using optical and stereo vision sensors

Level of interactivity: combining virtual with reality

Interactive system: communicates with users

Type of application: enhance the perception of place.

3/2/20 Body Movies

It is an art installation by Rafael Lozano-Hemmer in 2001. The installation was placed in different countries. In Body Movies, a thousand portraits taken in the streets of Montreal, Rotterdam and Mexico City were projected on the facade of the Pathé cinema in Rotterdam where the work was first presented.

⁷⁴ interactive architecture. <http://www.interactivearchitecture.org>. (Accessed 13 may2009)

3/2/20/1 Project Explanation

Three networked computers controlled the installation, a camera server, video tracker and a robotic controller. The portraits were muted by two xenon light sources located at ground level. Passers-by saw their shadows projected on the facade. The portraits only became visible inside a shadow between 2 and 25 meters high, depending on how far people were from the light sources. Participants could match or embody a portrait by walking around the square to adjust the size of their silhouette. When shadows matched all the portraits a computer selected a new set. A video projection on the square displayed the tracking interface.⁷⁵

Most people's attention focused less on the portraits than on their own shadows. Participants with large shadows could overpower, threaten or play with small shadows; those with small shadows could interact with each other, challenge or 'tickle' the larger silhouettes. Spontaneous skits were generated among strangers and an atmosphere reigned in the plaza for the duration of the piece (Fig. 3.41).



(Fig. 3.41): Body Movies: Relational Architecture in, Rotterdam, the Netherlands, 2001, Portraits on the facade of the Pathé cinema and public interaction in the plaza.

As Lozano-Hemmer indicates that, there is no guarantee that a work will function in the same way everywhere. The artist explains that when Body Movies was exhibited in Lisbon, it was expected that “Latino” who loves to be out in the streets, partying to have a lot of interaction with the piece. However people were trying their best not to overlap with other people's shadows. In Rotterdam, neighborhood residents regarded the piece as a wonderful revitalization of the plaza as it allowed people who did not know each other to meet and better yet, to play with each other like children.⁷⁶

⁷⁵ Lucy Bullivant, “4dsocial: Interactive Design Environments,” published by Wiley academy. 2007.PP.80-84

⁷⁶ Rafael Lozano-Hemmer, Re:Positioning Fear, Relational Architecture. <http://rhizome.org/artbase/2398/fear/>. (Accessed 3 June 2012)

3/2/20/2 Project Analysis:

Ideological concept: using intelligent environment mechanisms using intelligent agents

Design process:

- Tangible computer interaction design. Blurring the physical boundaries of space.
- Cognitive user interface.
- Embedded computation through communication.

Technological tools: passive and active sensors and soft space techniques.

Level of interactivity: combining virtual with reality

Interactive system: allow for communication with users

Type of application: enhancing the sense of space and encourage the interaction between the users.

3/2/21 Remote Home

Remote home was designed in 2003 with the aim of visualizing the presence between two or more remote places in a way to explore the borders between art, design and technology (Fig. 3.42). It was designed by the German architect Tobi Schneidler, with his team at the Smart Studio of the Interactive Institute in Stockholm, Sweden. It integrates interactive media and network technologies within spatial environments.⁷⁷



(Fig. 3.42): prototype of remote home

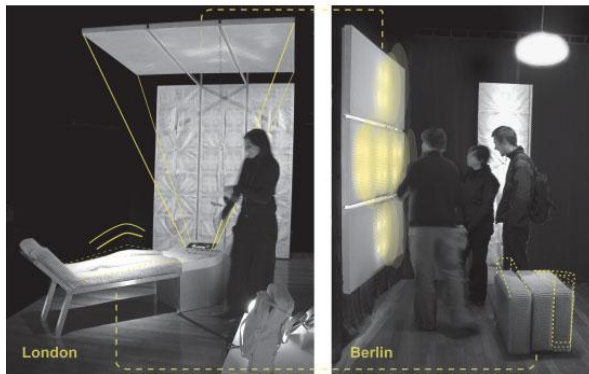
3/2/21/1 Project Explanation

The project is a way to express the responds to changing cultures of living and the rise of distant relationships. Communications and media technologies including mobile phones and instant messaging are already

⁷⁷ Visualizing presence.

<http://labs.stijn Coppens.com/thesis/visualizing-presence-update/>. (Accessed 3 Nov. 2012)

creating new scenarios of sharing friendship over long distances. The model apartments were set up at the Science Museum in London and at the Raumlabor in Berlin, (Fig. 3.43) and distant audiences were allowed to participate and interact with each other in real time.⁷⁸



(Fig. 3.43): The two Remote Home spaces in London and Berlin were designed with matching elements, to relay tactile, evocative communication between the two via furniture and wall surfaces.

All the furniture and fittings becomes part of the media electronic network space, embedded with sensors detecting the impressions done by distinct users from both sides, transmitted this through the internet to the respective other side (Fig. 3.44). This is done through kinetic, tangible features and light installations, tactile and visual cues on furniture and other physical surfaces. Tobi Schneidler explains the procedure. *"The home stretches beyond borders, and helps friends to stay in touch, literally, through tangible and sensual communication, an emotional and intuitive form of presence"*. Tobi Schneidler⁷⁹



(Fig. 3.44): diagram of the Remote Home project showing its concept applied through a range of scales, from the personal level of artefacts and furniture, to an architectural scale of spatial organizations and, finally, to distributed spaces.

⁷⁸ Smart studio, interactive institute.

http://smart.tii.se/smart/projects/remotehome/index_en.html. (Accessed 28 April 2012)

⁷⁹ Lucy Bullivant, *"4dspace: Interactive Architecture,"* published by Wiley academy, 2005. P.73

In London an interactive lounge table was suspended from the ceiling. When someone drew on or moved it, the surface became animated, triggering ambient music on a wall of lights in the Berlin apartment, a sound shaft, suspended over an inflatable couch. Inhabitants of this space could in turn reply with spoken messages by grabbing the sound shaft and moving it over a table (Fig. 3.45). Small light sensors picked up the movement of a light beam travelling over the sensor field, relaying it to the table in London. ⁽⁴⁴⁾



(Fig. 3.45):The lounge table in London the sound shaft on Berlin



(Fig. 3.46):The Busy Bench is a piece of furniture designed to express distant motion. Occupying the bench in one of the apartments, transforms the corresponding bench in the other apartment into an animated object.

3/2/21/2 Project Analysis:

Ideological concept: using intelligent environment mechanisms using intelligent agents

Design process:

- Tangible and kinetic typologies in human computer interaction design. The furniture and fittings are physically moved by the sent digital data from the internet
- Haptic and gesture user interfaces. For manipulating the space in their current location and the allowing to control this motion in the other location.
- Embedded computation through external communication.

Technological tools: using robotics (actuators, passive and active sensors)

Level of interactivity: physically altering the space

Interactive system: allow for communication between users.

Type of application: enhance spatial organization. It creates environments that act as mediating devices for a social statement.

3/2/22 Ada

Ada was an interactive pavilion at the Swiss National Exhibition Expo 2002. It was designed by a multidisciplinary team led by the psychologist Paul Verschure, who works at the Institute of “Neuroinformatics” University in Zurich, Switzerland. Named after Lady Ada Lovelace, one of the pioneers of computer science, Ada functioned continuously for 10 hours a day over six months.

3/2/22/1 Project Explanation

The project depended upon Ada real-time interactions. It is a functional creature, programmed to balance visitor density and flow, identify, track, guide and group specific visitors, and play games with them. The experience is sequenced, visitors approach a waiting area named as a "conditioning tunnel", where they were introduced to Ada's components and their functions (Fig. 3.47). They then enter a 175-square-metre space, an octagonal room where all interaction with Ada occurs. In a corridor around this space visitors can observe the activities without interacting directly. Next they enter the "Brainarium", a technical display room that shows the internal processing states of Ada, which has windows providing views into the interaction space. On the way out, visitors can pass through the "Explanatorium", a room explaining and discussing the key technologies behind Ada and if they want to see backstage the Lab area and the operating room that contains more than 30 custom-built computers.⁸⁰



(Fig. 3.47): The ‘conditioning tunnel’ positioned at the main entrance to Ada. Here, visitors were introduced to her individual elements via a sequence of illuminated wall panels.

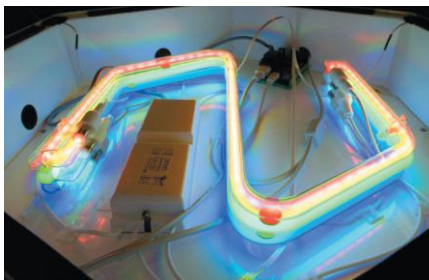
⁸⁰ interview Looking at the first neuromorphic space. A conversation with Paul Verschure by Marialuisa Palumbo. http://architettura.it/interview/20040205/index_en.htm. (Accessed 16 April 2012)

Ada is given an artificial intelligence to generate its own senses of vision, audition and touch. Once visitors are inside the central interaction space locates and identifies them through its floor made of pressure sensors, neon tubes and a microcontroller. Ada expresses its behavioral mode and internal emotional states to visitors through, sound light and projections. This is shown by using a 360-degree ring of 12 LCD video projectors to give a visual display capability (Fig. 3.48). Ada does this by using the screens as a single virtual display; rendering 3-D objects in real time, and display live video.



(Fig. 3.48): A responsive environment which, like a human being, has many faculties, Ada tracked visitors as they wandered around the space, tested their compliance by gauging their responsiveness to cues

Ada Uses its floor surface to track visitors, tests their responsiveness to visual and sensual cues, and interact with them through different types of games. Local visual effects can also be created with the RGB-colored neon lights in each tile a ring of ambient lights sets the overall visual emotional tone of the space (Fig. 3.49), while nine gazer lights with pan, tilt and zoom capabilities make up Ada's 'eyes'. Ada has the ability to learn how to coordinate its various components, such as the floor plates, the movable eyes and the light fingers. Ada is able to remember the visitors she played with and whose gestures, movements and sounds she has observed. Like humans, Ada learns from experience, she can store an incident and later build upon it. Ada can furthermore link various pieces of information and draw conclusions from it, like observing two individuals standing close together for a long period of time; she concludes that they are a pair.⁸¹



(Fig. 3.49): Inside one of Ada's patented floor tiles, showing the red, green and blue neon tubes, the small control board and the internal cabling.

⁸¹ Lucy Bullivant, "4dspace: Interactive Architecture," published by Wiley academy, 2005. PP. 86-89

This stems from the fact that the underlying software is a mixture of simulated neural networks, agent-based systems and conventional procedural or object-oriented software. Continuing system upgrades increased Ada's capabilities throughout the four-month exhibition, so that she interacted with visitors, expressed herself and grew just like human beings. Represent a set of interconnected, interdependent, simultaneously evolving internal processes.

3/2/22/2 Project Analysis:

Ideological concept: using artificial intelligence with autonomy agents

Design process:

- Surface based sensing and kinematic as it simulate action without the space physically move for in human computer interaction
- Haptic and gesture user interfaces.
- Embedded computation through adaptive control

Technological tools: using robotics (actuators, passive and active sensors) and soft space techniques

Level of interactivity: combines virtual with reality

Interactive system: communicate with users

Type of application: reconfigurable space through challenging the senses guiding the users to new potentials.

3/2/23 Blurring Space: Ubiquitous Life

This project was exhibited at "Insa" Art Center, Seoul, Korea for the special program entitled "10 Years After" in 2003, with the theme of creating no boundaries between physical and virtual, inside and outside. The project teams are from Digital Media Lab, Information and Communication University, Korea.

3/2/23/1 Project Explanation

The installation is a Wireframe of the construction made up of 3x3x3.5 meter cube using aluminum profile. Translucent acrylic plates are fitted in walls except front wall. When it came to the floor, 16 parts of it were divided equally in lattice shape so that 16 monitor could be included each. On

top of this floor, another acrylic plate is covered to protect monitors from external impact.⁸²

The project aims to create immersive spaces with blur boundary with means of virtual realities techniques of Tele presence; To jump to an immersive space by teleporting to other worlds and Multi-tele presence Space; To superimpose and intertwine with physical and cyber spaces. The first design strategy focuses on developing how to interact and communicate with physically and virtually different spaces. By stepping onto the teleport matrix or stretching hands out to the interactive wall, where interactive walls and teleport matrix can be a metaphor of linking one space to others. (Fig. 3.50)



(Fig. 3.50) the installation where the floors are embedded with location sensors and the interactive walls are reconfigured according to the users choices

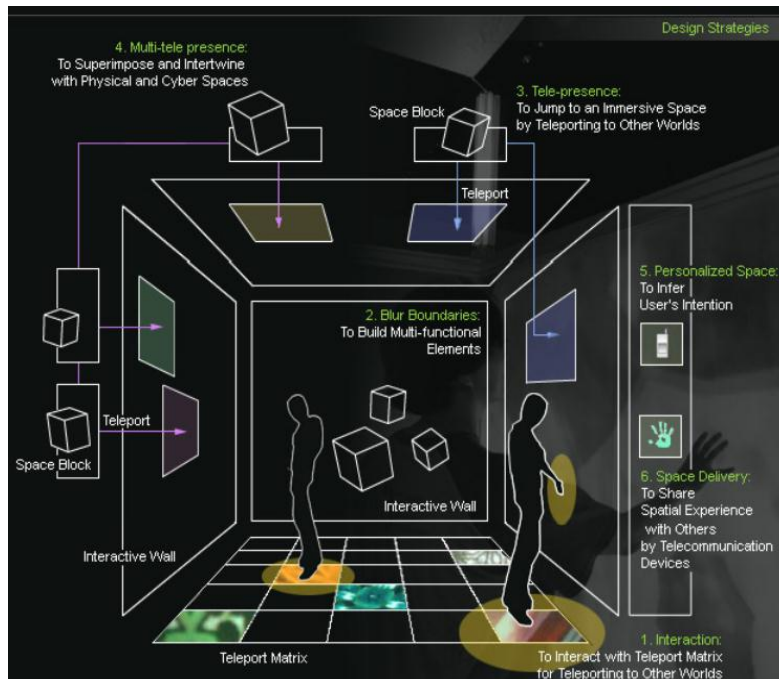
The application generates; space Personalization to infer user's Intention using different displays of the bio-palm pad that recognizes automatically according to each person and even to one emotional state. Space delivery; by sharing spatial experience with others uses Telecommunication devices. Being able to capture these specific spaces in telecommunication devices such as a mobile phone, to carry and share individual spaces with others. This method of storing and loading system will enrich memories and experiences in space (Fig. 3.51).

Means of implementation where through using; Bio-Palm Pad, Bio-Palm Pad transmits personal physical information to main system when user enter the blurring space. Floor Location Sensor; Each module of floor display has its own switch to get input data and Microprocessor from Numeric Keypad is used for transmitting these data to PC. Interactive wall; provide dynamic environment which changes according to the user's emotion. Emotion Light; develop changes of light color and brightness in accordance with users emotional state. Implemented changes of lighting color and

⁸² Epilogue, Digital Media Lab, Korea.

<http://dcom.arch.gatech.edu/jklee/blurringspace/contents/05.asp>. (Accessed 8 July 2012)

brightness according to present user's emotional data controlled by PC parallel port. Display Contents where according to Cave Exploration and Motion Graphic.



(Fig. 3.51) the design strategy of the installation, it shows the steps of interaction to blur boundaries using Tele presence and Multi-tele presence To Personalized Space and share spatial experience.

3/2/23/2 Project Analysis:

Ideological concept: virtual reality model of cave installation.

Design process:

- Surface based sensing for human computer interaction
- Haptic user interfaces.
- Embedded computation through automation control

Technological tools: tactile sensors and microcontrollers

Level of interactivity: combines virtual with reality

Interactive system: communicate with users

Type of application: personalization of the space and allowing for spatial sharing.

3/2/24 Warm and cold

Warm and cold is an artistic home automation system designed by Electronic Shadow⁸³ in order to take control of a real space through virtual images. It was introduced for the first time in one of Paris design show-room in 2005.

3/2/24/1 Project Explanation

The principle is to merge electronic world with the old electric one using the oldest and simplest home network, the electric network. Through this network, the system send very simple orders such as on/off or variation of electricity, so the light and electrical devices can be controlled trough a computer interface. In “Warm and Cold”, the interface is a metaphorical image, that the user can touch to change and control the space.

The system proposed different lightning ambient, from warm, all red, to cold, all blue. Between those two extremes, different patterns and gradients create lot of different configurations. During the day, the computer launches the different lightning configurations following a scenario evolving with the time of the day, the whole space changing regularly according to it. In the space, a large glass wall became the heart of the intervention. The system Uses 100 colored neon with horizontal and vertical gradients which are controlled through different channels. The whole space became a lighting playground for the main program, developed in real-time 3D software that make corresponds to each real light to a virtual one, so the program knows what light is on or off and can control them such as they were virtual.⁸⁴

In the space, the tactile screen displays a transparent real-time 3D heart, moving on an animated texture background that correspond to the different ambient. There is one animated texture per ambient, all natural elements filmed and transformed. When someone touches the heart, its shape changes and so does the animated texture. At the end of the transformation, the lightning ambient has totally changed on the 4 levels of the store

⁸³ Electronic Shadow an office based in Paris created in 2000 by Naziha Mestaoui, architect and artist, and Yacine Ait Kaci, director and artist. Electronic Shadow focuses its research in the physical relations between space and image. Using its patented space/image projection system, Electronic Shadow has many exhibits to its credit (e.g. at MOMA in New-York, Museum of Photography in Tokyo, the Centre Georges Pompidou and La Villette in Paris, the French cultural center in Milan, the MoCA Shanghai.). It won the Grand Prize at the 2004 Japan Media Art Festival.

⁸⁴ electronic shadow, hybrid design.

<http://www.electronicshadow.com/cassina/index2EN.htm>. (Accessed 3, July 2012)

according to the image. The space's light becomes an extension of the image which reflects it. (Fig. 3.52)



(Fig. 3.52) In the entrance space, a tactile screen shows the literal heart of the space. A transparent membrane in movement reflects the ambient of the space on a background which corresponds to it: snow, smoke, ice, fire, by touching the screen, the heart transforms itself, changing in the same time the whole space's light ambient. The lighting of the space becomes an extension of the image which reflects it.

The system uses also the existing lights in the space and as it used the electric network, no additional system had to be installed, just automation interfaces in the electrical panel and directly with the space's power plugs. It is also transparent and the technology totally integrated into the walls.

3/2/24/2 Project Analysis:

Ideological concept: virtual reality model

Design process:

- Surface based sensing for human computer interaction
- Haptic user interfaces. The interface is a metaphorical image that the user can touch to change and control the space.
- Embedded computation through automation control

Technological tools: tactile sensors and chromic materials.

Level of interactivity: combines virtual with reality.

Interactive system: communicate with users.

Type of application: provide control of the physical space and making new relations between space and image. The space becomes as easy to change as an image and the image becomes more immersive.

3/2/25 Interactive Systems Analysis

In general the applications ranges from combining video games with surveillance, towards responding to environmental conditions and responding to spatial organization. These systems generally change what the person is able to perceive. The interactive systems eliminate the communication barrier between humans and the built environment, interpreting the actions of people and respond to them.

From the previous case studies the main themes of application used and the way of their implementation are:

1- Combining the ideas of video games and surveillance

Interacting with buildings spaces and each other, shifts and reflects these changes; whether it is sound, or movement or visually

The ways of implementing such application are:

First through:

Ideological concept: virtual reality model

Design process:

Surface based sensing and response human computer interaction

Haptic user interfaces.

Active control embedded computation

Technological tools: microcontrollers and hyper surface techniques

Second through:

Ideological concept: intelligent environment

Design process:

Tangible human computer interaction

Haptic and gesture user interfaces.

Automation control embedded computation

Technological tools: sensors and soft space techniques

2- Context awareness

Reflecting the surrounding environmental conditions increasing the sense of space

The ways of implementing such application are:

First through:

Ideological concept: virtual reality model or responsive environments

Design process:

Tangible human computer interaction

Haptic or gesture user interfaces.

Active control embedded computation

Technological tools: sensors, smart materials or soft surface techniques

Second through:

Ideological concept: artificial intelligence

Design process:

Tangible human computer interaction

Adaptive control embedded computation

Technological tools: smart materials and robotics

3- Spatial sharing and control

Enhance spatial organization, creating environments that act as mediating devices for a social statement. Personalization the space

The ways of implementing such application are:

First through:

Ideological concept: intelligent environments or artificial intelligence

Design process:

Tangible and kinetic human computer interaction

Haptic and gesture user interfaces.

Automation or external communication embedded computation

Technological tools: soft spaces and robotics

Second through:

Ideological concept: virtual reality model

Design process:

Surface based sensing and response human computer interaction

Haptic user interfaces.

Automation embedded computation

Technological tools: sensors and smart materials

4- Increase sense of space

Sensing and controlling the surrounding space through communication. Challenging the senses guiding the users to new potentials

The ways of implementing such application are:

First through:

Ideological concept: responsive or kinetic

Design process:

Tangible or kinetic human computer interaction

Haptic and gesture user interfaces.

Active control or automation embedded computation

Technological tools: sensors, microcontroller and smart materials

Second through:

Ideological concept: virtual reality or intelligent environments.

Design process:

Surface based sensing and response and kinematic human computer interaction

Haptic and gesture user interfaces.

Adaptive control and automation embedded computation

Technological tools: robotics and soft space

5- Allow communication and information flow

Responding to real time information

The ways of implementing such application are:

Ideological concept: virtual reality model or intelligent environment

Design process:

Tangible or Kinematic human computer interaction

Cognitive control user interfaces.

External communication embedded computation

Technological tools: soft spaces and CNC

6- Spatial reconfiguration

Responding to exterior and interior environment conditions in a kinetic manner

The ways of implementing such application are:

Ideological concept: artificial intelligence

Design process:

Tangible and kinetic human computer interaction

Gesture and haptic user interfaces.

Adaptive control or home automation embedded computation

Technological tools: robotics or smart materials

7- Environment optimizing

Interacting with environmental conditions

The ways of implementing such application are:

Ideological concept: responsive

Design process:

Surface based sensing and response human computer interaction

Haptic user interfaces.

Adaptive control embedded computation

Technological tools: sensors, and smart materials

From the previous applications the distinguishing features of interactive applications properties are:

- afford responsive behaviors with respect to changing needs of:

Individuals

Social

Environmental

- provide level of interactions between:

The user and built environment

The users and Exterior Environment

Between the users and each other

- allowing for the flow of information and communication

- Serving Humanistic needs of: sensing of place, understanding of space, control and attachment to space

This will be used in the development of the characteristic model to analyzing the use of interactive applications in public buildings.







						Exmple																												
Tower of Winds	Dune	Light Scraper	Connection	Volume at the V&A	EnterActive																													
combining reality and virtual	combining reality and virtual	combining reality and virtual	combining reality and virtual	combining reality and virtual	combining reality and virtual	interactive level																												
describe environment	describe environment	communicate with users	communicate with users	communicate with users	communicate with users	interactive system																												
changing its surface according to the noise and the speed of wind	sensing the users movement enhancing their sense of place	interacting with built environments through sensing the visitors motions	context awareness of the built environment	it constantly reacts to environmental shifts, and reflects these change	reflecting the users movement	application description																												
context awarness				Combining the ideas of video games and surveillance		type of application																												
						<table border="1"> <tr> <td>responsive</td> <td rowspan="5">ideological concepts</td> <td rowspan="15">interactive design method</td> </tr> <tr> <td>kinetic</td> </tr> <tr> <td>virtual reality</td> </tr> <tr> <td>intelligent environment</td> </tr> <tr> <td>artificial intelligence</td> </tr> <tr> <td>Tangible</td> <td rowspan="4">Human computer interaction</td> </tr> <tr> <td>Surface based</td> </tr> <tr> <td>Kinematic</td> </tr> <tr> <td>Kinetic</td> </tr> <tr> <td>Haptic</td> <td rowspan="3">user interface design</td> </tr> <tr> <td>gesture</td> </tr> <tr> <td>Cognitive</td> </tr> <tr> <td>Active</td> <td rowspan="4">Embedded Computation</td> </tr> <tr> <td>Adaptive</td> </tr> <tr> <td>automation</td> </tr> <tr> <td>External Communication</td> </tr> <tr> <td>sensors</td> <td rowspan="6">technological tools</td> </tr> <tr> <td>microcontrollers</td> </tr> <tr> <td>robotics</td> </tr> <tr> <td>hypersurface</td> </tr> <tr> <td>(CNC)/smart materials</td> </tr> <tr> <td>soft spaces</td> </tr> </table>	responsive	ideological concepts	interactive design method	kinetic	virtual reality	intelligent environment	artificial intelligence	Tangible	Human computer interaction	Surface based	Kinematic	Kinetic	Haptic	user interface design	gesture	Cognitive	Active	Embedded Computation	Adaptive	automation	External Communication	sensors	technological tools	microcontrollers	robotics	hypersurface	(CNC)/smart materials	soft spaces
responsive	ideological concepts	interactive design method																																
kinetic																																		
virtual reality																																		
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Tangible	Human computer interaction																																	
Surface based																																		
Kinematic																																		
Kinetic																																		
Haptic	user interface design																																	
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Active	Embedded Computation																																	
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automation																																		
External Communication																																		
sensors	technological tools																																	
microcontrollers																																		
robotics																																		
hypersurface																																		
(CNC)/smart materials																																		
soft spaces																																		

Table (3.2) interactive applications of combining the ideas of video games and surveillance and context awareness analysis






					Exmple	
Ada	From dust till dawn	NoRA	The Bamboostic	Constellation		
combining reality and virtual	combining reality and virtual	combining reality and virtual	physically shape shift	combining reality and virtual	interactive level	
communicate with users	describe environment	communicate with users	alter space	communicate with users	interactive system	
reconfigurable space through challenging the senses guiding the users to new potentials	built environment interaction by sensing and controlling of space	enhance the perception of place	sensing the users movement	allowing for the communication between the audience and the installation	application description	
increase sence of space					type of application	
					responsive	ideological concepts
					kinetic	
					virtual reality	
					intelligent environment	
					artificial intelligence	
					Tangible	Human computer interaction
					Surface based	
					Kinematic	
					Kinetic	
					Haptic	user interface design
					gesture	
					Cognitive	
					Active	Embedded Computation
					Adaptive	
					automation	
					External Communication	
					sensors	technological tools
					microcontrollers	
					robotics	
					hypersurface	
					(CNC)/smart materials	
					soft spaces	

Table (3.3) interactive application of increase sense of space analysis





				Exmple	
Warm and cold	Blurring Space:	Remote Home	Ispa		
combining reality and virtual	combining reality and virtual	physically shape shift	combining reality and virtual	interactive level	
communicate with users	communicate with users	communicate with users	communicate with users	interactive system	
provide control of the physical space and making new relations between space and image	personalizati on the space and allowing for spatial sharing	Creating environments that act as mediating devices for a social statement.	changing in response to users conditions	application description	
spaital sharing and control				type of application	
				responsive	ideological concepts
				kinetic	
				virtual reality	
				intelligent environment	
				artificial intelligence	
				Tangible	Human computer interaction
				Surface based	
				Kinematic	
				Kinetic	
				Haptic	user interface design
				gesture	
				Cognitive	
				Active	Embedded Computation
				Adaptive	
				automation	
				External Communication	
				sensors	design process
				microcontrollers	
				robotics	
				hypersurface	
				(CNC)/smart materials	
				soft spaces	
					technological tools
					interactive design method

Table (3.4) interactive application of spatial sharing and control analysis





				Exmple	
Body Movies	Vital Signs	No place	D-tower		
combining reality and virtual	combining reality and virtual	combining reality and virtual	combining reality and virtual	interactive level	
communicate with users	communicate with users	communicate with users	describe environment	interactive system	
enhancing the sense of space and encourage the interaction between the users	responding to real time information	responding to the users views and allow for charring this with different people's cluture.	responding to the users emotions, showing the social current status, through communication.	application description	
allow communication and information flow				type of application	
				responsive	ideological concepts
				kinetic	
				virtual reality	
				intelligent environment	
				artificial intelligence	
				Tangible	Human computer interaction
				Surface based	
				Kinematic	
				Kinetic	
				Haptic	user interface design
				gesture	
				Cognitive	
				Active	Embedded Computation
				Adaptive	
				automation	
				External Communication	
				sensors	technological tools
				microcontrollers	
				robotics	
				hypersurface	
				(CNC)/smart materials	
				soft spaces	

Table (3.5) interactive application of allow of information and communication analysis






					Exmple	
Smart Wrap Pavilion	The Muscle Body	Muscle Tower 2	Muscle Tower 1	Aegis		
combining reality and virtual	physically shape shift	physically shape shift	physically shape shift	physically shape shift	interactive level	
describe environment	alter space	alter space	alter space	alter space	interactive system	
interacting with environmental conditions	responding to exterior and interior environment conditions	responding to exterior environment conditions . As madia installation	responding to exterior and interior environment conditions	It can be used in a kinetic environment al responsive architectural surfaces.	application description	
environment optimazion	spaital reconfiguration				type of application	
					responsive	ideological concepts
					kinetic	
					virtual reality	
					intelligent environment	
					artificial intelligence	
					Tangible	Human computer interaction
					Surface based	
					Kinematic	
					Kinetic	
					Haptic	user interface design
					gesture	
					Cognitive	
					Active	Embedded Computation
					Adaptive	
					automation	
					External Communication	
					sensors	technological tools
					microcontrollers	
					robotics	
					hypersurface	
					(CNC)/smart materials	
					soft spaces	

Table (3.6) analysis of , spatial reconfiguration and environment optimization interactive systems.

3/3 Public Building Design Requirements

This section discusses the general requirements in designing public buildings. For public building to increase its efficiency it should restrict the use of energy; buildings should maximize passive design which means taking advantage of natural lighting, heating and cooling. This reduces energy consumption and also provides a healthy and pleasant environment for the users. Public buildings also require to be designed in an adaptable flexible way, to meet the different needs of the users and the likely future needs without major alterations.⁸⁵

3/3/1 Indoor Environment Requirements

Optimizing the amount of natural light entering the working environment while minimizing glare, and ensuring employees have access to views. Also providing an adequate artificial lighting for the tasks the users inside the buildings need to perform. Design interior spaces to provide day lighting and views for the occupants. Day lighting is the practice to supplement or replace a portion of the building's internal artificial lighting (Fig. 3.53). Views of the exterior environment give building occupants visual comfort along with physiological and psychological benefits. Day lighting design must mitigate the adverse effects of glare and solar heat gain.⁸⁶



(Fig. 3.53) Wayne Lyman Morse United States Courthouse Eugene, Oregon, Natural light pours in through glass walls, clerestories, and skylights, to animate the curving white walls of the public spaces.

Artificial lighting design is a careful integration of daylight and artificial lighting to enhance the appearance of the space, saving energy, and support the performance of the occupants. Lighting design uses a combination of ambient and task lighting to provide light levels that support

⁸⁵Better public building Published in 2006 for HM Government by the Commission for Architecture and the Built Environment and the Department for Culture, Media and Sport. London. PP. 21-30

⁸⁶according to ,The impact of office design on business performance, CABA and BCO, 2005. Research shows that Good lighting design and adequate daylight in particular have been linked to 15 per cent reductions in absenteeism and increases of between 3 per cent and 20 per cent in productivity.

occupant productivity. Brightness and glare must be balanced from both natural and artificial lighting sources.

Optimizing the amount of ventilation and fresh air provision to ensure air change effectiveness, for example no sections of the building to have stale air build up because of inadequate air flow.⁸⁷

Considering the concept of adaptive thermal comfort measures including radiant temperature, internal air temperature ranges related to external ambient conditions, air movement and activity levels. Providing individual controls to allow building users to tailor the environmental conditions of their working space.⁸⁸

3/3/2 Pragmatic Design Requirements

Public buildings shall incorporate universal design to enhance accessibility for all. This approach to architecture and project development assures accessibility by all people equally, even as their needs change with age, ability, or condition during an entire lifetime.⁸⁹

Integrating Art into Public Buildings and Spaces, this expands the public experience with art and adds to the building's identity and enhances the human experience of the facility (Fig. 3.54).



(Fig. 3.54) Cris Bruch, Artist, Shortest Distance, for Wayne Lyman Morse United States Courthouse Eugene, Oregon is installed on the front plaza.

Equitable design for the workplace; to meet the functional needs of the users by accommodating the tasks to be undertaken without compromising individual access to privacy, daylight, outside views, and aesthetics.⁹⁰

⁸⁷ Design guide office and public buildings edition 3 Australian government –department of the environment and water resources, ISBN 0 642 553 491- 2007.PP.15-18

⁸⁸ According to the International standard for thermal comfort is ISO 7730.

⁸⁹ Excellence in Public Buildings: A Guide for Stakeholders the Department of General Services (DGS) California USA has launched the Excellence in Public Buildings (EIPB) program. This program encompasses all new design, construction, and major renovation or modernization work on buildings under the preview of DGS.

⁹⁰ Facilities Standards for the Public Buildings Service, (P100) U.S. GENERAL SERVICES ADMINISTRATION, November 2010.

Flexible design for workplace components; so it can easily adapted to organizational or work process and functional changes and readily restructured with a minimum of time, effort, and waste.

Provide workplace services, systems, and components that allow occupants to adjust thermal, lighting, acoustic, and furnishing systems to meet personal and group comfort levels.

Allow for connection between the users and the building components. Enable access for necessary information among users also provide full communication and simultaneous data access among distributed coworkers.

Providing reliable design; supporting the workplace with efficient, heating, ventilating, air conditioning (HVAC), lighting, power, security, and telecommunications systems and equipment that require little maintenance and are designed with backup capabilities to ensure minimal loss of service or downtime.

Making the public building Identifiable; the workplace with a unique familiarity, character, image, and business identity or “sense of place” enables and convey a sense of pride, purpose, and dedication in both the individual and the workplace community.

Provide workplaces that are healthful, free from hazards, and safe from fire. Public spaces should be safe and secure, accessible, welcoming, and effective. Site and landscape design must address building and personal security while enhancing the pedestrian experience and fully engaging the surrounding context.

Exterior elements of the public buildings may be individual materials, assemblies of materials, equipment, or assemblies of materials and equipment. Selection of construction materials should regards factors like being lasting, provide enduring quality, and are maintainable. The building enclosure is an environmental separator for thermal, moisture, air, acoustic, and day lighting properties, and also provides structural protection for blast, seismic, wind, and other hazards. Exterior wall assemblies must be designed to work in concert with HVAC systems to optimize energy performance (Fig. 3.56).



(Fig. 3.56)- United States Courthouse, Fresno, California, A system of distinctive precast concrete wall panels form an irregular pattern of folds, extrusions and corrugations across the building’s buff-colored surface.

In general by providing buildings and spaces that are fit for its purpose, built to lift the user's spirits, creates places that are safe, healthy and sustainable. The evidence reveals about making the users more involved where everyone can participate equally, confidently and independently in everyday activities, improves public services. It make services easier to deliver, also improving productivity and it can help reach out to sectors of society who may previously have been excluded. People are drawn to and tend to stay longer in public spaces that offer interest and stimulation or a degree of comfort. A good-quality public realm can benefit local economies.⁹¹

3/4 The Development of The Characteristic Model

From the following requirements explored through the research the characteristic model can be developed to evaluate the interactive application used on the case study project of public buildings in chapter four, where these requirements are according to:

Types of the interactive application:

- Combining the ideas of video games and surveillance
- Context awareness
- Spatial sharing and control
- Increase sense of space
- Allow communication and information flow
- Spatial reconfiguration
- Environment optimizing

Design procedure includes:

Ideological concepts include:

- Kinetic
- Responsive
- Intelligent environments
- Artificial intelligence
- Virtual reality

Design process:

- human computer interaction include trends of (tangible typologies, surface based, kinematic surface respond, kinetic typologies)

⁹¹Caroline Holland, Andrew Clark, Jeanne Katz and Sheila Peace, "Social interactions in urban public places." published by The Policy Press 2007.P.16

- user interface design trends of (haptic interfaces, gesture, cognitive control)
- embedded computation include trends of (active control, adaptive control, automation, external communication)

Technological tools:

- sensors and microcontrollers
- robotics
- CNC and smart materials
- Hyper surfaces
- Soft spaces

Interactive applications properties:

- afford responsive behaviors with respect to changing needs of:
 - Individuals
 - Social
 - Environmental
- provide level of interactions between:
 - The user and built environment
 - The users and Exterior Environment
 - Between the users and each other
- allowing for the flow of information and communication
- Serving Humanistic needs of: sensing of place, understanding of space, control and attachment to space

Public buildings requirements:

Ecological needs

- Artificial Light optimization
- Natural light articulation
- Ventilation
- Thermal comfort

Pragmatic needs

- Spatial Sharing and Optimization
- Flexibility & comfortable
- Safety
- Security

From the following the “characteristic model” is according to the following chart.

Concluding summary:

The tools used for acting in interactive environments in a physical matter are sensors, microcontrollers, robotics and CNC materials. Interactive applications also relied on the technological techniques of hyper surfaces that integrate information with the space physical typologies and soft space that increase the participation of space through challenging the user's senses.

From analyzing the interactive applications it was found that they fall into seven main types. The applications were categorized according to their effect on space performance, the way of involving the users and their design method of implementation, these types are;

- Combining the ideas of video games and surveillance
- Context awareness
- Spatial sharing and control
- Increase sense of space
- Allow communication and information flow
- Spatial reconfiguration
- Environment optimizing

From analyzing the previous interactive applications it was concluded that; installing interactive applications that involved the users and let them take decisions about their surrounding spaces has increased the number of audience and enhanced the overall experience. Architecture can benefit from implementing the interactive applications to improve its performance.

To determine the way of implementing interactive applications and its effect on architecture performance the research proposed a “Characteristic Model” to assess the fulfillment of the interactive applications in response to the requirements of public buildings. Such model depends in its assessment on the following:

- The type of the interactive application; each application is specified by its way of implementation and function.
- The design method; it involves the identification of the ideological concepts, the design process and tools used for implementing the applications.
- The requirements of public buildings; it involves the identification of the ecological and pragmatic requirements of public buildings. Also the requirements of identifying the interactive properties.

Chapter 4

Use of Characteristic Model: Assessing the Interactive Applications in Public Buildings

Introduction

A characteristic model was developed to assess interactive applications after exploring the requirement of public buildings and the interactive systems in chapter three with relevance to the ideological concepts, design process and tools discussed in chapter two.

The Proposed characteristic model is applied on case study contemporary projects, to investigate the influence of interactive applications on the design requirements of public buildings. After evaluating each project a comparative analysis methodology will be applied for all the case study projects.

The case study projects selected include existing buildings that shows a sense of intelligence in acting in an interactive way to either environmental or user's stimuli , award winning competition projects that shows new potentials in using interactive applications and research projects that shows the possibilities of making physically shape shifting architecture acting according to the user's needs.

4/1 Case Studies

The selection of the case study projects relies on analysing existing projects that interact to the users or its surrounding environments. Due to the fact that interactive architecture is a field that is still under research, there is limited number of existing projects that benefited from using interactive applications. Relevant to that the research also analyse international competition winning projects and research projects that show the potential of expanding the usage of interactive applications.

4/1/1 Water pavilion

The project was collaboration between different designers from different disciplines including architecture, the pavilion was divided into two themes the Freshwater pavilion designed by NOX, Lars Spuybroek and Saltwater pavilion designed by Oosterhuis associates (Fig. 4.1). The generative composition and spatialization concept was designed by Edwin van der Heide. Music composed by Edwin van der Heide and Victor Wentink. Software development by, Arjen van der Schoot and Edwin van der Heide. It was for the 2001 expo in Venice, Italy.¹



(Fig. 4.1) water pavilion layout and the two pavilions salt water and fresh water with its non-Euclidian form shaped as a sculpture. The pavilion has evolved from a three-dimensional computer model.

4/1/1/1 Project Explanation

The concept of the water pavilion is based on the idea of creating a communicating architectural environment. It's an environment where the building, light, projected images and sound form one complete experience. The behaviour of the environment is based on literal processes and metaphors

¹ Studio Edwin van der Heide. http://www.evdh.net/water_pavilion/ (Accessed 9 June 2011)

about water. The fluid structure of the inside of the building is a shell for a continuously flowing and transforming world of water realized both with real water and virtual environments.

The pavilion crates an immersive virtual environment acting as sensorium acting according to real time behaviour. The sensorium offers numerous kinds of virtual representations experience of virtual water. The curved lines that stretch from one pole to the other correspond to the outer lines of the building body; multi-coloured fibre optic cables following these lines illuminate the sensorium from behind the polycarbonate interior skin. In the poles there is a set of red lights which are controlled by the public through immersed sensor board. By pressing the interface the user can activate the poles and make them glow in bright red colours. The colour and dimming sequences of the fibres are controlled by a series of sensorial parameters (Fig. 4.2-4.3).



(Fig. 4.2) on the left the embedded touch sensors in the walls and floors
(Fig. 4.3) on the right shows the wave-shaped interior of the sound and light variations

The data feedback is from maritime board unit; the raw data is digested and converted to midi-driven impulses which conduct the mixing tables of both the light and sound environments. The pavilion displays a real-time behaviour, calculating with the speed of light its personal emotive factor. This emotive factor is translated into a responsive biorhythm. The ever changing colour conditions from behind the transparent inner skin are experienced as a form of light massage, simultaneously an immersive soundscape is experienced by the public. The amplifiers are absorbed in the skin of the body and of the floor membrane, it feels as if the building itself makes the sounds.²

² Lars Spuybroek, NOX Machining Architecture, Published by Thames & Hudson, 2004. PP.18-39

There are 60 speakers distributed over the whole building. Each individual sound has its own character of movement and speed over the speakers so the same speaker performs differently for each viewer. Each pavilion has its own sound environment. The sound environment of the freshwater pavilion is based on metaphors of a river, a water source and a darker underwater space. The saltwater pavilion is inspired by virtual sounding sky, the water surface of the sea and a hydra traversing these. It's presenting metaphors of different weather conditions. The music in the two different spaces is not a fixed composition but has a generative approach to it and is therefore composed on the moment itself. The rules for how sounds can be combined are predefined; the actual decision of what sounds is made in real-time. This way the music will always be different. Partly the visitors can influence the processes via sensor based interfaces in the building. Furthermore the weather conditions outside of the building are used to control part of the compositional parameters.

While a traditional concert often aims for a uniform experience of the audience, the Water pavilion has the opposite approach. It's part of the concept to promote individual experiences. Two persons visiting the building can have different experiences and when visiting the Water Pavilion a second time this can lead to again another experience.

H₂O worlds diving into virtual extension, on both the surface of the wave-floor and the interior polycarbonate skin of the sensorium the users are immersed in the projections of a series of virtual worlds. They all describe different perceptions of water and fluidity. The worlds are generated by two computers and projected by high-resolution data projectors through small openings in the transparent skin, the worlds are navigated by the public through an interface which is merged into one the six worlds are:³

Ice, the navigator moves slowly in between even slower sliding icy masses. H₂O, swarms of H₂O molecules at three different speeds, the navigator travels with the swarm and try to ride on one of the molecules. Life, intelligent sea creatures float in a virtual sea. Blob, fluid mass elastic like chewing-gum is constantly deforming while the navigator floats around and through it. Flow, the navigator is captured in the flow of a whirlpool; the only way is to go with the flow. Morphe, two slowly shaping skyscapes capture the navigator, because of the extreme wide-angle view the clouds seem to rush by. The virtual worlds are direct extensions of the physical building.

³ ONL office website. <http://www.oosterhuis.nl/quickstart/index.php?id=saltwater-pavillion>. (Accessed 15 June 2012)

4/1/1/2 Project Analysis

Type of applications used:

Increase Sense of Space

Through, the pavilion crates an immersive virtual environment acting as sensorium acting according to real time behaviour.

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: Artificial Light optimization.
 - b- Pragmatic needs provided: spatial sharing and optimization, Flexibility.
- Design procedure:
 - a- Ideological concept: virtual reality model.
 - b- Design process:
 - Surface based sensing and response and kinematic human computer interaction.
 - Haptic and gesture user interfaces.
 - Adaptive control embedded computation.
 - c- Technological tools: robotics and soft space.

Interactive Applications Properties:

- The responsive behaviours with respect to: individuals.
- Level of interactions between: The users and built Environment.
- Allowing for the flow of information and communication.
- Serving Humanistic needs of: sensing of place, understanding of space, and attachment to space.

4/1/2 Blur Building

The Blur Building was built for the Swiss Expo 2002 on Lake Neuchatel by Diller Scofidio and Renfro. The project program is creating immersive environments. The building mass definition is not constant it changes describing the level of moist and pressure of its surrounding environment.⁴

4/1/2/1 Project Explanation

It is architecture of atmosphere, the lightweight tensegrity structure measures 300 feet wide by 200 feet deep by 75 feet high. The primary building material is related to the site, water. Water is pumped from the lake, filtered, and shot as a fine mist through 31,500 high-pressure mist nozzles. A

⁴ Diller & Scofidio. <http://www.dillerscofidio.com>. (Accessed 3 April 2012)

smart weather system reads the shifting climactic conditions of temperature, humidity, wind speed and direction, and processes the data in a central computer that regulates water pressure. Upon entering the fog mass, visual and acoustic references are erased, leaving only an optical "white-out" and the "white-noise" of pulsing nozzles.⁵

The pavilion resembled a cloud built using artificially generated fog. As the visitors entered the building all their visual and acoustical references were erased and replaced instead by a white foggy atmosphere and the white noise generated by the fog nozzles (Fig. 4.4-4.5). The public can approach Blur via a ramped bridge. The 400 foot long ramp deposits visitors at the centre of the fog mass onto a large open-air platform where movement is unregulated. Visual and acoustical references are erased along the journey toward the fog leaving only an optical "white-out" and the "white-noise" of pulsing water nozzles.



(Fig. 4.4-4.5) the mist is the main theme of the building creating a new experience to the users

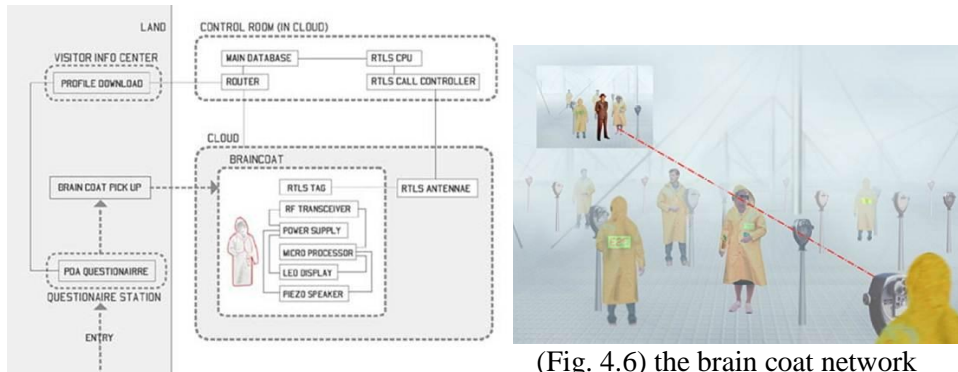
Before entering the building the visitors were prompted to answer a questionnaire referred to their personality. The information of their responses was stored in a raincoat embedded that each user would wear while inside the building (brain coat) that host an interactive media project featuring wearable, wireless technology.⁶ A central network would track the position of each brain coat and compare their profile with other users'. When two users approach each other, the brain coats would compare their users' profiles and indicate the degree of attraction or repulsion of their users. This would be made explicit by colour light and sounds. Red would indicate affinity and green antipathy. There could be up to 400 visitors at the same time, but when the pavilion was actually built for the Expo, the brain coats' project was not implemented due to cost reduction (Fig. 4.6).

⁵ Arc. Space, blur building.

http://www.arcspace.com/architects/DillerScofidio/blur_building/. (Accessed 3April 2012)

⁶ Blur Building_Braincoats.

http://realtimocities.wikispaces.com/BlurBuilding_Braincoats. (Accessed 3April 2012)



(Fig. 4.6) the brain coat network

4/1/2/2 Project Analysis

Type of applications used:

Increase Sense of Space

Through, the artificial fog atmosphere

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: artificial light articulation.
 - b- Pragmatic needs provided: spatial sharing and optimization.
- Design procedure:
 - a- Ideological concept: virtual reality model.
 - b- Design process:
 - Surface based sensing and response human computer interaction.
 - Gesture user interfaces.
 - Adaptive control embedded computation.
- c- Technological tools: sensors, and soft space.

Interactive Applications Properties:

- The responsive behaviours with respect to: the environment.
- level of interactions between:
 - The users and built Environment for the pavilion
 - The users and each other for the rain coat
- Allowing for the flow of information and communication.
- Serving Humanistic needs of: sensing of place, understanding of space.

4/1/3 Kunsthaus Graz

The Kunsthaus Graz opened its doors in 2003, the architectural "pièce de résistance" of Graz's year as European Capital of Culture. The biomorphic building designed by Peter Cook and Colin Fournier, it's known locally as the Friendly Alien, it has become an essential landmark in the urban identity of the city of Graz in Austria. Its BIX media façade constitutes a unique fusion of architecture and media technology. Effectively it is a large screen in the middle of the city; it acts as an instrument of art and communication.⁷

4/1/3/1 Project Explanation

The designers of this project created an impressive structure which unites their innovative design language with the historic setting of this urban district. The aesthetic dialogue between the new biomorphic structure on the bank of the Mur and the old clock tower on Graz's famous Castle Hill, is the trade-mark of a city aiming to create a productive tension between tradition and avant-garde. In this content as well as from an urbanistic point of view, the new Kunsthaus Graz acts as an interface between past and future (Fig. 4.7).



(Fig. 4.7) the location of the biomorphic building in a historical setting

Functionally and technically, the Kunsthaus meets the most up to-date requirements for museums on the international level. The building has an area of 11,100m² of usable space that provides a global level of participation in the exhibition business. It has a cost-effective air conditioning system that meets all the demands of the most important art owners. The building's interior is meant to inspire its curators as black box of hidden tricks; its outer skin is a media façade which can be changed electronically (Fig. 4.8). The building also consists of a delivery area, depots and workshops. Modern lighting and security systems are available to ensure the professional handling of exhibition projects.

⁷ ibid P.177



(Fig. 4.8) the façades works as a giant instrument of communication placed right in the middle of the city. It is a composition between the urban style, the technology and the historic setting around the building.

The designers used a low resolution application of programmable skin technology called BIX. The skin wrapped around the entire body of the building displaying constantly changing images designed by artist and curators. ‘BIX enables the institution to present a transparency of information and content and to further develop methods for dynamic communication between buildings and their surroundings, between internal content and outside perception. The structure of the walls here is not only acting as a separator between the inside and the outside but instead becomes a mediator to the public. The skins and surface envelope of buildings become programmable surfaces photo sensitive membranes that narrate design and inform the spatial organization of the volumes and interpret their functions.

4/1/3/2 Project Analysis

Type of applications used:

Allow for Communication Flow

Through the rapped BIX skin rapped around the building

- Fulfilment of Public buildings requirements:
 - a- Pragmatic needs provided: spatial sharing, safety .
- Design procedure:
 - a- Ideological concept: virtual reality.
 - b- Design process:
 - Kinematic human computer interaction.
 - Cognitive control user interfaces.
 - External communication embedded computation.
 - c- Technological tools: hyper surface.

Interactive Applications Properties:

- The responsive behaviours with respect to: Social.
- Level of interactions between: The users and built environment.
- Allow for communication flow.
- Serving Humanistic needs of: sensing of place , understanding of space.

4/4/1 San Francisco Federal Building

The building was designed by Thom Mayne of Morphosis office. It was commissioned by the State of California, to design the San Francisco Federal Building (Fig. 4.9). The total building area is 1,200,000 sq. ft. The completion date was 2004. It was the first building in California to be commissioned under the Design Excellence Program. It consists of two distinguishable masses creating an L-shaped plan which opens the architecture to the street, making an access to the public plaza. The larger of the two volumes is of thirteen stories, while the smaller is a four story volume.⁸ The building is covered with elevations that respond to environmental and context stimuli.

4/1/4/1 Project Explanation

The project has developed around three primary objectives: the establishment of a benchmark for sustainable building design through the efficient use of natural energy sources; the redefinition of the culture of the workplace through office environments that boost workers' health, productivity, and creativity, and the creation of an urban landmark that engages with the community.⁹

The building borrowed some of its designing elements from its existence location on the high way where a lot of cars pass all the time. The building double façade was designed in a kinetic manner where its characteristic animation function like the car body to protect and shield its inhabitants. The mechanical nature of the skins reacts in an intelligent way to its environment as it opens and closes depending on the temperature and the sunlight conditions. This creates a constantly shifting façade that is closed and therefore more private during the light of the day and becomes open and transparent during the night.



(Fig. 4.9)The new San Francisco Federal Building, designed by Thom Mayne: The exterior includes a screen that curls just over the top of the building.

⁸ architecture daily on line magazine.

<http://www.archdaily.com/tag/morphosis/>. (Accessed 15 Feb.2012)

⁹ morphopedia San Francisco Federal Building.

<http://morphopedia.com/projects/san-francisco-federal-building#>. (Accessed 19 April 2012)

The south façade of the building is cover with Photovoltaic cells that shield the facade from direct sunlight during peak hours while generating 5% of the building’s energy. Movable skin system is used over the courtyard at south elevation, to establish a canopy and to create a transition space where building meets the plaza (Fig. 4.10 & 4.11). The skin system made of aluminium panels cover a double skin layer of glass.



(Fig. 4.10) on the left shows a detail of the panel motion.

(Fig. 4.11) on the right the south façade canopy that spreads open over the courtyard and the Photovoltaic cells covering the façade.

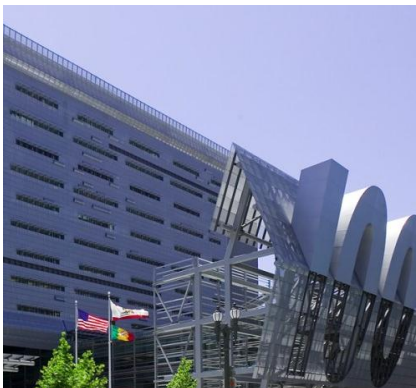
The research done for the San Francisco Federal Building project to improve the worker comfort and increase environmental efficiency led to; designing non-hierarchical floor planes with open and light-exposed workspaces for all workers regardless of rank. All window shades on exterior windows are manually operable to ensure that employees have a sense of control over their own work environments with respect to the amount of light and air that they require (Fig. 4.12 & 4.13). Elevators operate on a “skip-stop” basis; opening onto centrally located stairwell lobby gathering places on every third floor. This “skip-stop” scheme intensifies circulation and encourages productive social exchange.



(Fig. 4.12) left ,San Francisco Federal Building At Seventh and Mission Streets, a new structure tries to balance security and transparency

(Fig. 4.13) right, The lobby of the new San Francisco Federal Building uses leaning columns to help create a sense of airiness.

A graphic sign marks the building as 100 South Main Street where, layers of opacity and transparency as well as 2D and 3D typography act together to specify the space to the public (Fig. 4.14). The public plaza is distinguished by a constantly shifting building skin denotes an urban landmark. The public spaces are located on ground level and include an exhibition gallery, a large public art piece, retail stores and a cafeteria.



(Fig. 4.14) The large cantilevered light-bar connects the structure to First Street, and the forty-foot, forward-canted super-graphic “100” marks the South Main Street entrance. This layered sign, with its nod to L.A.’s Hollywood sign, denotes the building as an urban landmark.

The public art was invested in one installation (Fig. 4.15) that, designed in collaboration with artist Keith Sonnier that integrates with the architecture. Horizontal bands of red neon and blue argon light tubes cycle

through light pattern sequences mimicking the ribbons of headlights on California's freeways.¹⁰



(Fig. 4.15), the carefully arranged horizontal tubes are reminiscent of the streaks of headlights on California freeways.

4/1/4/2 Project Analysis

Type of applications used:

First application used Environment Optimization

Through the constantly shifting building skin

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: natural light, Ventilation, Thermal comfort.
 - b- Pragmatic needs provided: Flexibility, comfortable, security
- Design procedure:
 - a- Ideological concept: responsive.
 - b- Design process:
 - Kinetic human computer interaction.
 - Active control embedded computation.
 - c- Technological tools: sensors, and smart materials.

Second application used Context Awareness

Through the use of the installation that is made of mimicking light tubes to the headlights on California's freeways.

- Fulfilment of Public buildings requirements:
 - b- Pragmatic needs provided: spatial sharing.
- Design procedure:
 - a- Ideological concept: responsive environments

¹⁰ Caltrans District 7 Headquarters.

<http://morphopedia.com/projects/caltrans-district-7-headquarters#>(Accessed 5 April 2012)

- b- Design process:
 - Tangible human computer interaction.
 - Active control embedded computation.
- c- Technological tools: sensors, smart materials.

Interactive Applications Properties:

- The responsive behaviours with respect to: the environment.
- Level of interactions between: the users and exterior environment.

4/1/5 La Defense Offices

La Defense is a medium-size low-rise office complex in Almere, Netherlands, completed in 2004 and designed by UN Studio. The plan shows a neutral rational organization with four separate bands of different lengths and heights covering an irregular plot. The proposal links these bands to some extent in a more integrated urban solution which ties in with the new, larger-scale center development of Almere Town.¹¹

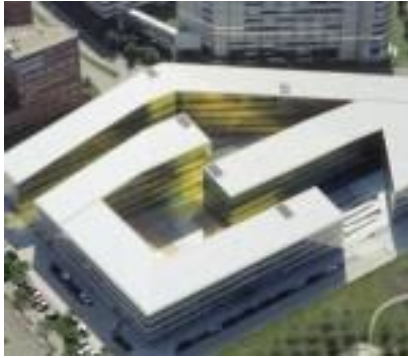
4/1/5/1 Project Explanation

La Defense office complex is well integrated with the larger urban plan. Both its height and the entrances into the inner courtyards tie in with the larger site. The exterior façade reflects the larger urban condition reflecting the direct surroundings in its metallic façade finishing (Fig. 4.16). The outer skin expresses urbanity and a degree of closeness of the unit. From the exterior the complex is generally unremarkable but its facades facing its interior courts are so different.¹² The facade adjacent to the courtyard is built up of glass panels in which a multicoloured dichroide foil, also called “Radiant Colour Film”, is integrated. Depending on the time and the day and the angle of incidence of light, the facade changes from yellow to blue to red or from purple to green and back again (Fig. 4.17), also depend on the position of the viewer, the court has benches allowing for people to set and meet while enjoying the view.¹³

¹¹ Archi central. <http://www.archicentral.com/la-defense-offices-almere-the-netherlands-unstudio-8443/>. (Accessed 16 march 2012)

¹² UN studio website . www.unstudio.com . (Accessed. 31 july 2012)

¹³ mies architecture. <http://www.miesarch.com/> (Accessed. 31 july 2012)



(Fig. 4.16) La Defense office complex consist of low rise units integrated together to create interior courts the outer volume is integrated with the surrounding urban context



(Fig. 4.17) the interior facades with various light patterns organization

4/1/5/2 Project Analysis

Type of Applications Used:

Context Awareness

Through the interior façade colour changing glass panels

- Fulfilment of Public buildings requirements:
 - b- Pragmatic needs provided: spatial sharing .
- Design procedure:
 - a- Ideological concept: responsive.
 - b- Design process:
 - Tangible human computer interaction.
 - Haptic interface.
 - Active control embedded computation.
 - c- Technological tools: sensors, and smart materials.

Interactive Applications Properties:

- The responsive behaviours with respect to: the environment.
- Serving Humanistic needs of: Sensing of the space.

4/1/6 Son O House

Designed by Lars Spuybroek located in a large industrial park in Breugel, The Netherlands opened in 2004, the Son-O-House is a public pavilion where visitors can sit around, eat their lunch and have meetings. The Son-O-house is 'a house where sounds live', not being a real house, but an artwork that creates different sound patterns with relevance to the different movement of its visitors. In the Son-O-house a sound work composed and designed by Edwin van der Heide (Fig.4.18). The structure is both an architectural and a sound installation that allows people to not just hear sound in a musical structure, but also to participate in the composition of the sound.¹⁴



(Fig.4.18) the distinguished mass of the son o house showing non uniform computer generated form through using interactivity in the design process

4/1/6/1 Project Explanation

The Son-O-House's has a generative and reactive sound environment. The aim of this environment is to create a permanent interaction between the sound, the architecture and the visitors.¹⁵ The sound influence and interfere with the perception and the movements of the visitors. The presence activity and the approximate location of the visitors are being detected by sensors placed in the building. This information is continuously analysed and quantified. The output of the analysis is used to control the nature of the sound and therefore challenges the visitors to re-interpret their relationship with the environment. The result is a complex feedback system in which the visitor becomes a participant.

Twenty three sensors are positioned at strategic spots to indirectly influence the music. The sound generation system is based on spatial interferences and dynamic standing wave patterns resulting from the

¹⁴ Studio Edwin van der Heide. <http://www.evdh.net/sonohouse/>. (accessed 6 June 2012)

¹⁵ Lars Spuybroek, NOX Machining Architecture, Published by Thames & Hudson, 2004. PP. 174-181

combination of speakers. The visitors influence the landscape itself that generates the sounds. The score is an evolutionary memory scape that develops with the traced behaviour of the actual bodies in the space (Fig.4.19).



(Fig.4.19) an arabesque of complex intertwining lines that is both a reading of movements on various bodily scales and a material structure

The Son-O-House is equipped with 20 speakers, they can be used with two different approaches. First they can all be used individually; the sounds will be clearly perceived from the direction of the corresponding speaker. With the second approach the 20 speakers are divided in five overlapping 'sound fields'; each field consists of 4 individual speakers. The sounds produced by the speakers are designed in such a way that they interfere with each other in the space, therefore the sounds are not perceived from the location of the individual speakers but surround the visitors in the space. The interferences of the sounds produced by the speakers in one field can either be static or dynamic resulting in movement in the space. All of the sound is synthesized in real-time.

The sound environment of the Son-O-House is not a musical composition in the traditional sense. The goal is to have a continuous developing environment that challenges the visitors to come back, perceive the new musical state and then relate and interact themselves with it again. For the opening of the building the sound environment doesn't contain any prepared sounds. The system consists of rules and conditions that produce parameters of the sounds. The system is therefore generating its own sounds in real-time. The sound fields transform within themselves depending on the activity of the visitors inside the field. On a higher level of composition the sounds fields can be swapped with each other in space and time. The effect of a current sound can be measured by using the sensor input and analyse the relation of one location to another location. The results are stored in a growing data base. Previously generated sounds can be re-used in the future in new combinations.

The visitors leave their traces in the building because of their interaction with the architecture and the sound. The nature of the sound is based on interference. The sound environment as a whole attempts to interfere with the architecture.

4/1/6/2 Project Analysis

Type of applications used:

Increase Sense of Place

Through the different sound installation.

- Fulfilment of Public buildings requirements:
 - a- Pragmatic needs provided: spatial sharing and optimization
- Design procedure:
 - a- Ideological concept: responsive environments
 - b- Design process:
 - Tangible human computer interaction
 - Gesture user interfaces
 - Adaptive control embedded computation
 - c- Technological tools: sensors, microcontroller

Interactive applications properties:

- The responsive behaviours with respect to: individuals
- Level of interactions between: The users and built Environment
- Allowing for the flow of information and communication
- Serving Humanistic needs of: sensing of place and attachment of space.

4/1/7 GreenPix - Zero Energy Media Wall

The GreenPix Zero Energy Media Wall placed at Xicui entertainment complex in Beijing near the Olympic complex. Designed by architect Simone Giostra & partners, it is a New York-based office designs that innovative curtain walls in Europe and the US. The project opened in June 2008 (Fig. 4.20). It is Self-sustaining media façade generates double the energy needed to power its LEDs.¹⁶

¹⁶ Media architecture group. <http://black2.fri.uni-lj.si/humbug/files/doktorat-vaupotic/zotero/storage/ZUCVHBEE/2.html>. (Accessed 28 Oct. 2012)

4/1/7/1 Project Explanation

The building opaque box-like facade gains the ability to communicate with the surrounding urban environments through a new kind of digital transparency. It is an intelligent skin that interacts with the building interiors and the outer public spaces using embedded, custom-designed software, transforming the building façade into a responsive environment for entertainment and public engagement (Fig. 4.21).



(Fig. 4.20) The GreenPix Zero Energy Media Wall makes the Xicui entertainment complex in Beijing an artistic medium with a social conscience, using photovoltaics to generate energy.



(Fig. 4.21) Some of the glass panels tilt outward, adding to the aesthetic effect of GreenPix.

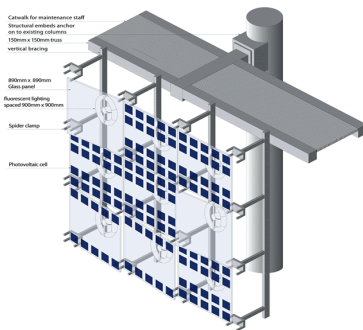
The project applies sustainable and digital media technology to the curtain wall of the façade, featuring coloured LED display and polycrystalline photovoltaic cells system integrated into a glass curtain wall. The building performs as a self-sufficient organic system, storing solar energy by day and using it to illuminate the screen after dark, mirroring a day's climatic cycle (Fig. 4.22); the wall would therefore perform differently on cloudy days than sunny days, mimicking the patterns of nature.¹⁷

¹⁷ Article originally published in Archi-Tech magazine By John Gregerson. 10 Jan. 2008



(Fig.4.22) the greenpix façade with deferent representations according to the weather conditions and the solar density gained during the day

The curtain wall tempered glass is about 8 millimetres each contain a series of interlayers that provide various degrees of transparency. The solar cells are laminated within the outer glass layer, which is also waterproof, LEDs sit 2 feet behind the glass panels (Fig.4.23). The polycrystalline photovoltaic cells are placed with changing density on the entire building's skin. The density pattern increases building's performance, allowing natural light when required by interior program, while reducing heat gain and transforming excessive solar radiation into energy for the media wall.



(Fig.4.23) The systems, materials, and structure shown in this model were used in the installation.

Showing the catwalk for maintenance, the glass panel of 89x89 cm grid, the LED lightening and photovoltaic cell

GreenPix is a large-scale display comprising of 2,292 colours (RGB) LED's light points comparable to 2.200 m². Monitor screen for dynamic content display. The very large scale and the characteristic low resolution of the screen enhances the abstract visual qualities of the medium, providing an art-specific communication form in contrast to commercial applications of high resolution screens in conventional media façades.

The grid-connected system does not require batteries. Instead of feeding power to a battery, the PVs feed power to the grid - wires take DC

voltage from the solar cells to an inverter, where it is converted to AC power, fed into the building's transformer, and to the city's power grid, the same power source the LEDs draw from at night. To collect enough energy to compensate for the LEDs, the solar cells did not need to cover the entire surface of the wall. Certain areas of the building required visibility to the outside; others required neither visibility nor light of any kind. The density and pattern of solar cells varies for artistic effect, making the façade appear organic.¹⁸

The full integration of media information technology with architecture in an urban context represents a new kind of communication surface devoted to unprecedented forms of art, while projecting information about the behaviour and activity of the building to a wide range of distances and engaging vast. The innovative use of technology and experimental approach to communication and social interaction defines new standards in the context of urban interventions worldwide, raising global interest in the integration of digital technology with architecture.

4/1/7/2 Project Analysis

Type of applications used:

First application used Context Awareness

Through intelligent skin that interacts with the building interiors and the outer public spaces.

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: Natural light , Thermal comfort
 - b- Pragmatic needs provided: spatial sharing.
- Design procedure:
 - a- Ideological concept: responsive environments
 - b- Design process:
 - Tangible human computer interaction
 - Gesture user interfaces
 - adaptive control embedded computation
 - c- Technological tools: robotics

Second application used Environment Optimizing

Through the polycrystalline photovoltaic cells used behind the glass panels.

¹⁸ dezeen magazine, greenpix media wall . <http://www.dezeen.com/2008/05/07/greenpix-media-wall-by-simone-giostra-partners/>. (Accessed 7 May 2012)

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: Ventilation, Thermal comfort
- Design procedure:
 - a- Ideological concept: responsive environments
 - b- Design process:
 - Surface based human computer interaction.
 - haptic user interfaces.
 - Active control embedded computation.
 - d- Technological tools: sensors, and smart materials.

Interactive Applications Properties:

- The responsive behaviours with respect to: The environment.
- Level of interactions between: The users and exterior Environment.
- Allowing for the flow of information and communication.
- Serving Humanistic needs of: understanding of space, control and attachment to space.

4/1/8 FLARE - Kinetic Membrane Facade

Flare is an interactive skin that can be installed over any building façade. It is designed by whitevoid an office based in Germany for designing interactive art installations. The first mockup was on a building designed by Staab architects, Berlin in 2008.¹⁹ It is an example of how by adding an application can enhance the building performance to be more interacting to its surrounding conditions. FLARE is a modular system to create a dynamic hull for facades or any building or wall surface (Fig.4.24).

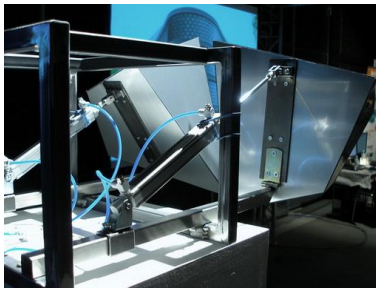


(Fig.4.24) The flare installed on a mock up building in berlin originally designed by Staab architects making the building more interactive to their surrounding environment

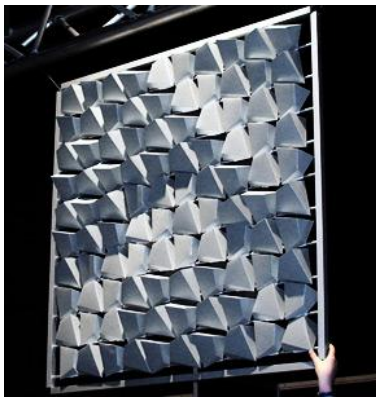
¹⁹ Media architecture group. <http://black2.fri.uni-lj.si/humbug/files/doktorat-vaupotic/zotero/storage/ZUCVHBEE/2.html>. (Accessed 21 Oct. 2012)

4/1/8/1Project Explanation

The system act like a living skin, it allows a building to express, communicate and interact with its environment. It turns the building facade into a penetrable kinetic membrane instead of a static one. The system consists of a number of tiltable metal flake bodies or units supplemented by individually controllable pneumatic cylinders (Fig.4.25-4.26). The developed pattern can perform an infinite number of array patterns, various surface animations can be programmed into the system. It can be mounted on any building or wall surface in a modular system of multiplied Flare units.²⁰



(Fig.4.25) The flare unit controlled by a pneumatic cylinder. A mock up for the tiltable flake units controlled by a computer connected to sensors to give information about the surrounding environment



(Fig. 4.26) The prototype of the system consists of a number of tilting metal flake bodies which reflect light and act like pixels.

Each stainless steel flake reflects the sunlight when in vertical standby position. When the flake is tilted downwards by a computer controlled pneumatic piston, its face is shaded from the sky light and this way appears as a dark pixel. By reflecting ambient or direct sunlight, the individual flakes of the Flare system act like pixels formed by natural light. The system is controlled by a computer to form any kind of surface animation. Sensor systems inside and outside the building communicate the buildings activity directly to the Flare system which acts as the buildings lateral line.²¹

²⁰ flare, kinetic ambient reflection membrane.
<http://www.flare-facade.com/>. (Accessed 28 Aug. 2012)

²¹ Flare Facades: Modular Kinetic Membranes. <http://www.architerials.com/2010/03/flare-facades-modular-kinetic-membranes/>. (Accessed 28 Aug. 2012)

4/1/8/2 Project Analysis

Type of applications used:

Context Awareness

Through the pneumatic flake acting like a building skin

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: Natural light, Thermal comfort .
 - b- Pragmatic needs provided: Flexibility and comfortable, safety.
- Design procedure:
 - a- Ideological concept: responsive environments
 - b- Design process:
 - Kinetic human computer interaction.
 - Gesture user interfaces
 - Adaptive control embedded computation
 - c-Technological tools: robotics

Interactive Applications Properties:

- The responsive behaviours with respect to: The environment.
- Level of interactions between: The users and exterior Environment
- allowing for the flow of information and communication
- Serving Humanistic needs of: understanding of space, control and attachment to space

4/1/9 Iluma in Singapore

“Iluma” Singapore is a complete entertainment district incorporating theatres, clubs, bars, shopping and public space stacked opened in 2009. It is the result of collaboration between WOHA architects, Singapore and media architecture “specialist’s realities: united”, Berlin.²²

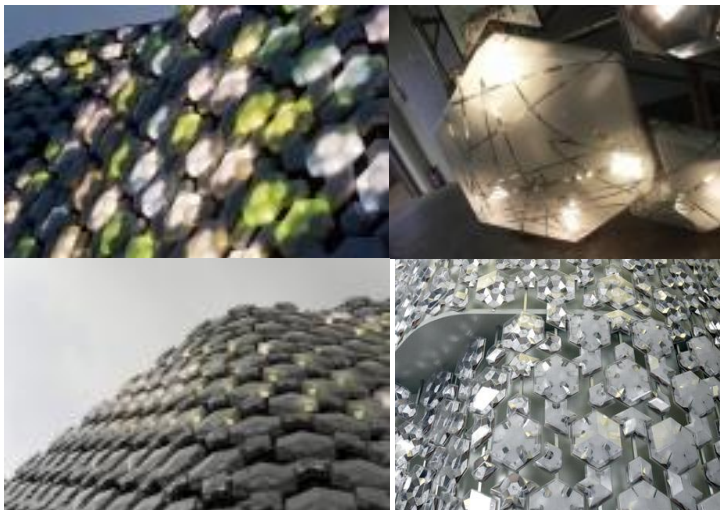
4/1/9/1 Project Explanation

The building incorporates an interactive façade, where visitors can use mobile phone technology to send messages, images and graphics onto the building. An electronic version of the concrete and glass pixels of the Duxton Plain façade Crystal Mesh is made for the façade of the building complex “ILUMA”. It combines aspects of a conventional curtain façade with those of a light installation or monitor-façade. Crystal Mesh forms the building’s

²² Ibid P.177

visual hull while the construction-physical functions are carried out by another exterior wall deeper inside.²³

Crystal Mesh consists of a tessellated pattern made of 3,000 modules of deep-drawn polycarbonate covering a façade area of more than 5,000 m². About 1,900 of these modules contain a regular matrix of compact fluorescent light tubes forming “active patches” within the façade. At night the light matrix superimposes the physical structure of the white crystalline daytime façade. The irregular arrangement of the crystalline patches divide the façade into areas with different resolutions, that does not create a large homogeneous screen in front of the building but instead forms a more general impression of the building’s “medianess” as a whole and act as an essential ingredient of its architecture. In various ways this concept blurs boundaries as it actively merges the concept of a media screen with an ornamental architectural screen filtering air and light (Fig. 4.27).



(Fig. 4.27) the crystal mesh producing the media façade of Iluma these modules contain a regular matrix of compact fluorescent light tubes forming “active patches” within the façade.

The original idea of the façade is acting as monitor simultaneously realized and obstructed by the crystalline façade system. The façade is perforated as the polycarbonate crystals cover only 75 percent of the underlying matrix. Therefore there is no central, high-resolution monitor; instead the active light elements are distributed in coherent groups across the entire surface, sometimes at small, sometimes at large intervals. A normal

²³ Artistic Ornamental Granulated light and media Façade.
<http://golnazebrahimi.com/research/1%20research.html>. (Accessed_15 July 2012)

depiction of high-resolution motifs cannot provide coherent results in this way. This eschewal of the characteristics of a monitor is balanced by the complex overall effect on the scale of the city. Because the focus of the efforts is not an individual motif in digital staging, but being able to alter the character of the building's skin and thereby to achieve a dynamic expression of the entire architecture (Fig. 4.28).

The central idea of the design is not that of a monitor, but of a façade with changeable expression. Accordingly the active (night) appearance and the (day) appearance have equal rights in the design. The façade sends light signals during the day as well; reflections of sunlight in the folded aluminium reflectors of the polycarbonate modules. Crystal Mesh eludes the problem of competition with better and less expensive LED façades, which will appear in the future as a part of the city zoned as a new nightlife district.



(Fig. 4.28) the exterior view of Iluma, at night the light matrix superimposes the idiosyncratic physical structure of the white, crystalline daytime façade.

4/1/9/2 Project Analysis

Type of applications used:

Allow for Communication Flow:

Through the rapped BIX skin rapped around the building

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: Natural light articulation, Ventilation.
 - b- Pragmatic needs provided: spatial sharing, safety.

- Design procedure:
 - a- Ideological concept: virtual reality.
 - b- Design process:
 - Tangible human computer interaction.
 - Cognitive control user interfaces.
 - External communication embedded computation.
 - c- Technological tools: hyper surface and smart materials.

Interactive applications properties:

- The responsive behaviours with respect to: Social.
- Level of interactions between: The users and built environment.
- Allow for communication flow.
- Serving Humanistic needs of: sensing of place, understanding of space.

4/1/10 Media-TIC

The Media-TIC building in Barcelona is an information and communication technology hub designed to incubate, generate, exhibit and invite new ideas and developments in information communication technology. It is designed by Barcelona-based architects Cloud 9 founded by Enric Ruiz Geli and opened in 2010. Media –TIC is eight-level, 38m-high building separated into three sections of varying density, offering a total floor space of 23,104m² and occupancy capacity for 2,418 people, with an exhibition area, office spaces and auditorium.

The Media-ICT has been awarded recently with the WAF Award, for the World's Best Building of the Year, 2011. It was also Special mention at FAD Awards, 2011. Investigation Prize at XI Spanish Biennial of Architecture and Urbanism, 2011 and Steel Design Awards ECCS, European Convention for Constructional Steelwork, 2009.²⁴

4/1/10/1 Project Explanation:

The designers worked at the interface between architecture and art, digital processes and technological material development. The theme of the Media-TIC building is how architecture creates a new balance with the digital use of energy. It is designed with the concept of "performative architecture", where the structure itself performs other functions. The 'performative' elements in the Media-TIC building are found in two of the four façades, which are made of the eco-efficient material ethylene tetrafluoroethylene (ETFE) cladding, to enhance energy efficiency.²⁵

The concepts involved are: digital manufacturing processes, ubiquitous technology, computing, off grid, self-sufficient energy and

²⁴ World architecture news.

http://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=19128. (Accessed 25 Feb 2012)

²⁵ Design build, media-TIC, Barcelona, Spain. <http://www.designbuild-network.com/projects/media-tic/>. (Accessed 21 Aug. 2012)

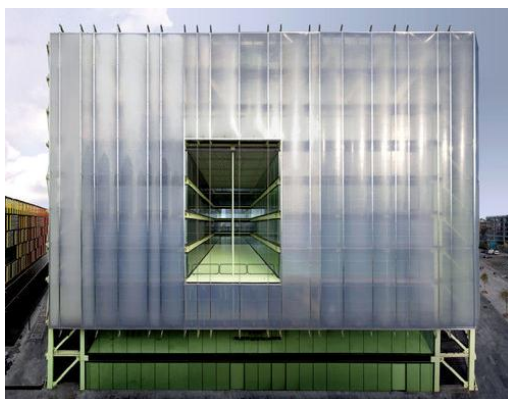
distributed intelligence. The designers main aim is to reduce the carbon emission of the building as minimum as possible.

The south-east façade absorb six hours of sunlight a day. The ETFE cladding surface appears as a mosaic of concave and convex triangles, to depict the merging of atoms or elements to make meaningful information, while also representing the process of digital construction (Fig. 4.29). The protection from the outside heat will be achieved using 'diaphragm' configuration of ETFE cladding whereby three layers of the plastic are fixed within the triangular frame and inflated like a pillow. The resulting bubble contains up to three air chambers that together create a shade-effect and provide thermal insulation for the building.



(Fig. 4.29) The Media-TIC façades are made of the eco-efficient material ethylene tetrafluoroethylene (ETFE) cladding.

ETFE cladding is used for the south-west-facing façade, also exposed to six hours of sunlight daily. A different application of ETFE will be used known as the 'lenticular' solution, where two layers of the plastic are inflated and filled with nitrogen. In this method, the air density of the particles creates a cloud-like solar filter (Fig. 4.30). The remaining façades receive only three hours of sunlight a day and will use internal screen-type blinds for sun protection.



(Fig. 4.30) the ETFE cladding of the south-west façade Nitrogen based fog

Unlike most of the buildings, which consume huge amounts of energy, the Media-ICT is designed to be a great generator and optimizes energy use through:²⁶

Simulation Energy; the energy simulation of the building the demands of heat and cold are adjusted accordingly minimizing the dimensioning of installations.

Enclosed Building; The façade, made of inflatable ETFE cushions oriented south, act as a variable sunscreen, opening in winter to gain solar energy, and closing in summer to protect and shade. In the south west façade, Nitrogen based fog is introduced in the cushions, that by increasing its particles greater opacity is produced, thereby protecting users.

Monitoring; Both the façades and offices have been equipped with multiple temperature sensors, humidity or pressure that collect exterior information to adjust the interior conditions.

4/1/10/2 Project Analysis:

Type of applications used:

Environment Optimization

Through the ETFE facades of the buildings

- Fulfilment of Public buildings requirements:
 - c- Energy efficiency provided: Artificial Light optimization, Natural light articulation, Ventilation, Thermal comfort.
 - d- Pragmatic needs provided: Flexibility , comfortable, safety, security.
- Design procedure:
 - a- Ideological concept: responsive
 - b- Design process:
 - Surface based sensing and response human computer interaction.
 - Haptic interface.
 - Adaptive control embedded computation.
 - c- Technological tools: sensors, and smart materials.

Interactive Applications Properties:

- The responsive behaviours with respect to: the environment.
- Level of interactions between: The users and exterior Environment.

²⁶ media- ICT ,2011 World Building of The Year.

<http://europaconcorsi.com/projects/194744-Media-ICT>. (Accessed 21 Aug. 2012)

4/1/11 Kinetic Façade Brisbane Domestic Terminal Car Park

Its 5000 sqm kinetic façade ripple according to the wind direction was installed for the eight story car park of Brisbane's Domestic Terminal completed in 2011. The façade was designed by Urban Art Projects (UAP) is collaborating with established American artist Ned Kahn, Hassell Architecture (Sydney) and the Brisbane Airport Corporation.²⁷

4/1/11/1 Project Explanation

Viewed from the exterior, the car park's eastern elevation has an appearance of a ripple which is fluid to the wind as it activates 250,000 suspended aluminium panels. It responds to the ever-changing patterns of the wind, the façade create a direct interface between the built and natural environments. It is further embellished with rippling lines from the surface of the Brisbane River, a site-specific reference to the city's most iconic natural feature (Fig. 4.31).

Inside the car park complex patterns of light and shadow will be projected onto the walls and floor as sunlight passes through the kinetic façade. The design also provides practical environmental benefits such as shade and natural ventilation for the interior (Fig. 4.32). This large-scale work creates a mesmerizing impression for passengers emerging from the terminal arriving by car or on the elevated Air train platform. It is expected to become a memorable icon for the city of Brisbane.



(Fig. 4.31) The most well-known natural feature of the city is the Brisbane River. The building was embellished with rippling lines from the river's surface.



(Fig. 4.32) the ripples of the panels

²⁷ Great Examples of Interactive Architecture for Your Inspiration by Christian Vasile.
<http://www.1stwebdesigner.com/inspiration/great-interactive-architecture-examples/>
(Accessed. 12 may 2012)

4/1/11/2 Project Analysis

Type of applications used:

Spatial Reconfiguration

Through the unpredicted ripples of panels

- Fulfilment of Public buildings requirements:
 - a- Energy efficiency provided: natural light, ventilation.
 - b- Pragmatic needs provided: spatial sharing, Flexibility, safety.
- Design procedure:
 - a- Ideological concept: responsive.
 - b- Design process:
 - Kinetic human computer interaction.
 - Adaptive control embedded computation.
 - c- Technological tools: hyper surface.

Interactive Applications Properties:

- The responsive behaviours with respect to: the environment.
- Level of interactions between: The users and Exterior Environment.
- Serving Humanistic needs of: sensing of place.

4/1/12 Trans-ports

Kas Oosterhuis' designed an interactive architecture project the Trans-ports , for the Vienna exhibition in 2001. The object acts like a muscle, connected to data (input-output devices) in real-time. It uses three main elements: electronic interior skin, pneumatic muscles and flexible exterior skin. Instead of being static, it is rather like a lean device, which relaxes or tightens upon different forces.²⁸

4/1/12/1 Project Explanation

The complete trans-ports network consists of a series of active structures around the world crating a virtual environment through using an Internet website "www.trans-ports.com" that allow navigating and manipulating the virtual structures, by playing the real time trans-ports game. Visitors played a collective game to explore the different modes of trans-ports, the data-driven pavilion changes shape and content in real time. One can seamlessly jump from real to virtual and back again. Changes in the real

²⁸ "Motion as modern way of expressing architecture." paper by Adam Gorczica, Studio Architektury Format, Warszawa, Poland. 2005

influence the content of the virtual and vice versa. In this way the complex of real and virtual structures is experienced as one consistent hyperbody.²⁹

The active structure trans-ports digests fresh data in real time. It is not like the traditional static architecture which is calculated to resist the biggest possible forces, on the contrary the trans-ports structure is a lean device which relaxes when external or internal forces are modest, and tightens when the forces are fierce acting like a muscle. In the trans-ports concept the data representing external forces come from the Internet and the physical visitors who produce the data which act as the parameters for changes in the physical shape of the active structures (Fig.4.33).



(Fig.4.33) the shape transform according to the acted forces

The interior skin is a giant virtual window to a variety of global information sources like websites or webcams. The public is no longer looking at information, they are immersed inside information. Information is transported to the fully programmable interior skin. Through sensors the local public activates remote cameras and enters linked websites. The interior skin shapes and folds itself keeping track of the changes of the physical shape of the pavilion (Fig.4.34).



(Fig.4.34) the skin is activated according to the user's manipulation being immersed in information.

The

²⁹ ONL(Oosterhuis Lenard) <http://www.oosterhuis.nl/quickstart/index.php?id=167>. (accessed Aug. 2012)

physical structure of Pneumatic muscles trans-ports adjusts its shape according to the data received from the real time trans-ports game. A definite possibility is to build a space frame completely composed of pneumatic bars. All bars can adjust their length; they all will work together like a flocking swarm of filaments in a muscular bundle. All bars are individually controlled by structural engineering software, this programme analyses the changes in shape and calculates in real time the actual lengths of all cooperating pneumatic bars.

Both the flexible inner skin and the outer skin of trans-ports follow the changes of the data-driven pneumatic structure. The waterproof exterior skin must be flexible in two directions. A new type of membrane must be developed to meet these demands, primary research focuses on the concept of a three-dimensional moulded rubber sheet .Smaller sheets of rubber are vulcanized together to form one continuous skin. The most important feature of the trans-ports pavilion is that architecture for is no longer fixed and static.

Due to its full programmability of both form and information content the construct becomes a lean and flexible vehicle for a variety of usage. The designer has conceived six different modes performed by the installation: Art mode; the construct is a true piece of art, content and shape programmed by visual artist Ilona Lénárd. Office mode; the construct being the vehicle for showing projects by the architectural office oosterhuis.nl. Network mode; links the vehicle to the work of other designers. Info mode; exploits the trans-ports vehicle for broadcasting news from the architectural frontline. Commercial mode; where sponsors feed the cave space with their commercial content. Dance mode; trans-ports transforms into a multimedia party zone.

It is an immerse projection in the cave evokes the feeling of being inside the active structure of the trans-ports pavilion. The public feels the presence of the global public playing the real time trans-ports game at the same time. The public is represented in the installation as brightly coloured light beams projected from the ceiling. The array of sensors functions like the mouse of the computer. Through internet computers outside the cave the public can locally access the game and change the shape and content of trans-ports in the way the global visitors do.

4/1/12/2 Project Analysis

Type of applications used:

First application used Spatial Reconfiguration

Through the structure of the pneumatic muscles.

- Fulfilment of Public buildings requirements:
 - a-Energy efficiency provided: Artificial Light optimization, Natural light articulation, Ventilation, Thermal comfort.
 - b-Pragmatic needs provided: spatial sharing and optimization, Flexibility and comfortable, security, safety.
- Design procedure:
 - a- Ideological concept: artificial intelligence.
 - b- Design process:
 - Tangible and kinetic human computer interaction.
 - Cognitive user interfaces.
 - Automation control embedded computation .
 - c-Technological tools: robotics.

Second application used Combining the Ideas of Video Games and Surveillance

Through the website to control the interior and exterior skin.

- Fulfilment of Public buildings requirements:
 - a-Pragmatic needs provided: spatial sharing and optimization, Flexibility.
- Design procedure:
 - a- Ideological concept: intelligent environment.
 - b- Design process:
 - Tangible human computer interaction.
 - Haptic user interfaces.
 - Adaptive control embedded computation.
 - c-Technological tools: sensors and hyper surface.

Interactive Applications Properties:

- The responsive behaviours with respect to: individuals.
- Level of interactions between: The users and built Environment.
- Allowing for the flow of information and communication.
- Serving Humanistic needs of: sensing of place , understanding of space, control and attachment to space.

4/1/13 Guggenheim Virtual Museum

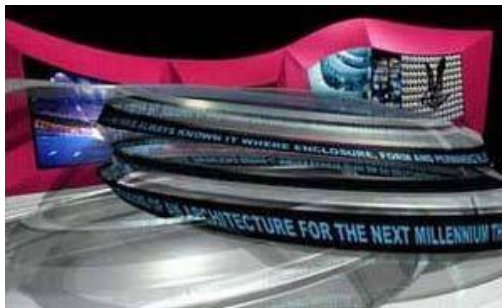
Guggenheim Museum has commissioned the New York firm Asymptote Architects to design and implement a new Guggenheim Museum in cyberspace. This is the first phase of a three-year initiative to construct an

entirely new museum facility.³⁰ The structure will be an ongoing work in process, with new sections added as older sections are renovated. The project will consist of navigable three-dimensional spatial entities accessible on the Internet as well as real-time interactive components installed at the various Guggenheim locations. *"The architecture of the GVM is an interactive and fully navigable real time three dimensional entity"*. Asymptote Architects.

4/1/13/1 Project Explanation

The Guggenheim Virtual Museum will emerge from the fusion of information space, art, commerce, and architecture depending on virtual reality techniques. The Atrium Objects, spaces, buildings and institutions can be constructed, navigated, comprehended, experienced and manipulated across a global network.³¹ The main aim of the design is to create architecture of liquidity, flux and mutability predicated on technological advances and fuelled by a basic human desire to realize the unknown.

The Guggenheim Virtual Museum will not only provide global access to all Guggenheim Museums and their services, amenities, archives and collections but will also provide a unique and compelling spatial environment to be experienced by the virtual visitor. The virtual museum is an ideal space for the deployment and experience of art and events created specifically for the interactive digital medium where simultaneous participation, as well as viewing is made possible for an audience distributed around the globe (Fig. 4.35).



(Fig. 4.35) the atrium with fully immersive information environment

Interactivity coupled with 3D modelling and the effects of image, sound, movement and light achieve a fluid and fluctuating environment that unlike physical space can respond to the navigation path of the user as well as adapt continually to its changing contents. The museum not only houses art

³⁰ Guggenheim Virtual Museum. <http://openbuildings.com/buildings/guggenheim-virtual-museum-profile-2437>. (Accessed June 2012)

³¹ Asymptote Architects, Guggenheim Virtual Museum Cyberspace. <http://www.arcspace.com/architects/asymptote/Guggenheim/index.html>. (Accessed June 2012)

but allows the user to simultaneously navigate the web as well as experience real-time collective events (Fig. 4.36).



(Fig. 4.36) interactive 3D modeling achieving a fluid and fluctuating environment

4/1/13/2 Project Analysis:

Type of applications used:

Allow Communication and Information Flow

Through the immersive environment.

- Fulfilment of Public buildings requirements:
 - b- Pragmatic needs provided: spatial sharing and optimization
Flexibility and comfortable.
- Design procedure:
 - a- Ideological concept: virtual reality.
 - b- Design process:
 - Kinematic human computer interaction.
 - Cognitive control user interfaces.
 - External communication embedded computation.
 - c- Technological tools: hyper surface.

Interactive applications properties:

- The responsive behaviours with respect to: individuals.
- Level of interactions between: The users and build Environment.
- Allowing for the flow of information and communication.

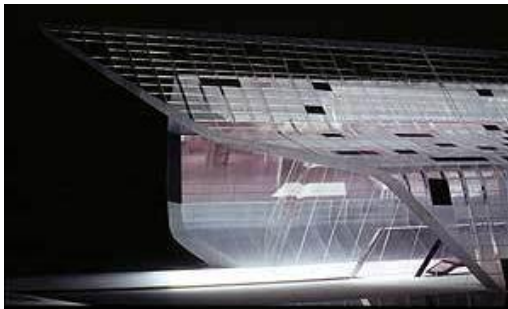
4/1/14 Tokyo Guggenheim Art Gallery

Zaha Hadid Architects were selected to design the new temporary Guggenheim Museum in Tokyo in 2001. The 116 square meter structure will be a ten-year intervention into a dynamic area of Odasiba Island. This site of cultural experimentation and dynamic urban space is characterized by rapid development. The temporary Guggenheim will be a trend setter in terms of the architectural identity of the area.

4/1/14/1 Project Explanation

The museum is created as two folded planes lean against each other and encapsulates a generous space. The light weight wrapping seems an appropriate response here where a space for changing exhibitions needs to be receptive to constant internal redefinition.³² the spatial concept is simple in effect the parallel extrusion of three simple sections , the size, level of abstraction and dynamic profile of the folded planes insures an exhilarating spatial sensation (Fig. 4.37).

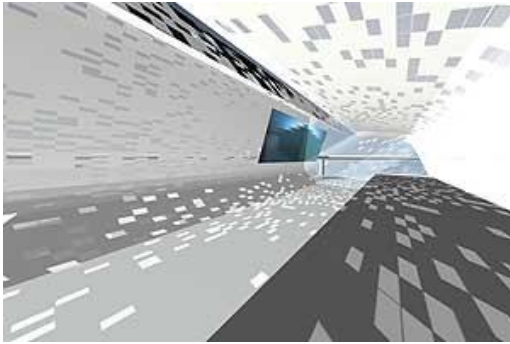
The proposal offers a big single space wrapped by a snakeskin like envelope which is animated by a large integrated media-screen (Fig. 4.38). The skin has pixillation that allows the integration of various surface performances. This is represented by light-boxes which allow further daylight to penetrate the space as well as acting as artificial light source at night. Further panels would be photovoltaic elements. The gallery has an embedded large media screen in the form of honeycomb based "smart slabs"³³. The media screen would nearly be camouflaged into the overall animation of the skin. Internally the skin operates according to the same concept. Here light, ventilation and heating are incorporated within the pixel logic.



(Fig. 4.37) the exterior of the Guggenheim Art Gallery showing the rapping of the folded pixillation planes

³² Arcspace. http://www.arcspace.com/architects/hadid/Temp_Guggenheim_Museum/. (Accessed 17 July 2012)

³³ Smartslab is a patented interactive digital display technology invented by Tom Barker. The system allows entire buildings, floors or ceilings to become digital displays. SmartS lab uses a successful combination of aerospace materials, leading optical display technologies and established manufacturing techniques to produce a unique product. <http://epress.lib.uts.edu.au/research/handle/10453/12361>. (Accessed May 2012)



(Fig. 4.38) the interior with the animated smart slabs

The overall concept was to create a stable comfort environment and the system of both lighting and climate control are taken as open architecture, where in the future and adapting themselves to different exhibition requirements environmental plugins can be used to completely change the internal atmosphere of the building.

4/1/14/2 Project Analysis:

Type of applications used:

Allow Communication and Information Flow

Through the animated smart slab.

- Fulfilment of Public buildings requirements:
 - a-Energy efficiency provided: Artificial Light optimization, Natural light articulation.
 - b-Pragmatic needs provided: spatial sharing and optimization.
- Design procedure:
 - a- Ideological concept: virtual reality.
 - b- Design process:
 - Surface based sensing and response human computer interaction.
 - Haptic user interfaces.
 - Active embedded computation .
 - c-Technological tools: hyper surface.

Interactive applications properties:

- The responsive behaviours with respect to: social.
- Level of interactions between: The users and build Environment.
- Allowing for the flow of information and communication.

4/1/15 E-motive House

It's a Programmable structure changes shape in real time designed by Kas Oosterhuis in 2002 the it is a research project, experimenting on interacting spaces by extended reality as an attempt to make flexible innovative places with the potentials of being applicable in the near future.

4/1/15/1 Project Explanation

The house is considered as a lab that touches the emotional relationships between the house and the inhabitants, between the house and its guests and between the elements of the house itself.

Traditional materials are augmented with a swarm intelligence of built-in technology. The construction of the house and the furniture becomes programmable to changes, except the kitchen area and the sanitary. The changes depend on the weather and the movement of its inhabitants, changing the geometry and developing its own emotion. The form of the emotive house is a long movable space (Fig. 4.39), with on both ends the solid blocks of the kitchen and the sanitary. The space in between can be changed from workspace to eat place, to sleeping space and other reconfigurable spaces.³⁴



(Fig. 4.39) the exterior shape of e- motive house made of beams connected to each other with pneumatic muscles, which can be contracted and relaxed. Its form is a long movable space with two solid blocks on both ends

The space shape can be controlled as well as its information content. Every combination of real space with a virtual image and information can be made possible. In that way the house will develop an own emotion, it can be reactor as well as actor. The acting will be made possible by a cooperative swarm of actuators like pneumatic beams, contracting muscles and hydraulic cylinders. The movement of the users and the changes in the weather are registered by a diversity of sensors and are translated by the house main computer system into an action. In this way the inhabitants and the actuators

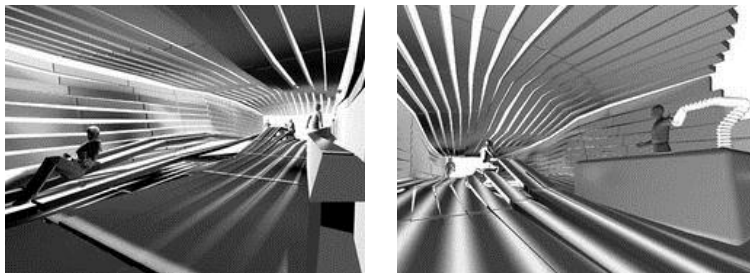
³⁴ digital technologies in architecture.

http://iaac-digitalarchitecture.blogspot.com/2007_10_07_archive.html. (Accessed March 2012)

of the house will develop a common language so that they can communicate with each other.

The Programmable structure is a weaving between a hard and a soft structure. The hard structure consists of massive wooden beams, and the soft structure is long-shaped inflatable chambers between the wooden beams. In this way the chambers can expand and shrink to give a global shape to the emotive house. The total construction is being shaped by a spatial structure of hydraulic cylinders which are cooperating to follow or cause shape-movements (Fig. 4.40). The hard structure on the exterior is covered with photovoltaic cells to generate electricity. The beams are connected with each other with pneumatic muscles, which can be contracted and relaxed.³⁵

The interaction here is build up by the game development program Virtools.³⁶Virtools has got a multi-player version which will be used here to play inside the house in real time. The players are the inhabitants, the guests and the actuators. There are also extern influences that can determine the interactivity. There is not always one solution when the extern and intern influences are written in real time into the brain of the house. The reaction will always be a complex consideration between lots of different factors. At the end the E-Motive House experience, gives to the inhabitants a feeling of a real time interaction, like learning to live in an environment with its own mind.



(Fig. 4.40) the interior of reconfigurable spaces using swarm intelligence except for the kitchen on the side of the house

³⁵ ONL(Oosterhuis Lenard) 2002, E-motive House.

<http://www.oosterhuis.nl/quickstart/index.php?id=348>. (Accessed March 2012)

³⁶ Virtools was a company founded 1993. They offered a development environment to create 3D real-time applications and related services. Virtools is a complete development and deployment platform with an innovative approach to interactive 3D content creation. The development platform is used in the industry for virtual reality applications, video game market (prototyping and rapid development), as well as for other highly interactive 3D experiences, in web marketing, virtual product maintenance.

4/1/15/2 Project Analysis

Type of applications used:

Spatial reconfiguration

Through reconfigurable structure

- Fulfilment of Public buildings requirements:
 - a-Energy efficiency provided: Artificial Light optimization, Natural light articulation, Ventilation, Thermal comfort.
 - b-Pragmatic needs provided: spatial sharing and optimization
Flexibility and comfortable, security, safety.
- Design procedure:
 - a- Ideological concept: artificial intelligence.
 - b- Design process:
 - Surface based and kinetic human computer interaction.
 - Haptic and gesture user interfaces.
 - Automation control embedded computation.
 - c-Technological tools: robotics and CNC.

Interactive Applications Properties:

- The responsive behaviours with respect to: Environments and individuals.
- Level of interactions between: The users and build Environment.
- Allowing for the flow of information and communication.
- Serving Humanistic needs of: sensing of place , understanding of space, control and attachment to space.

4/1/16 Fluidic muscle technology

The main objective of the project is to find real life applications for the Fluidic Muscle Technology developed by Festo and Kas Oosterhuis in 2003 to generate new concepts or to improve an existing situation.

4/1/16/1 Project Explanation

Unlike regular shading the facade works on having flexible solar shading that have the facility for individual and localized control to manipulate it. The regular systems can only be set fully open or fully closed, here the aim is to create a system that allows the user to have total control over the light levels in their immediate area, not to have an uncomfortable environment imposed on them by a centralized controller (Fig.4.41).



(Fig.4.41) shows the panels in unpredictable set of transformation

This system allows the building users in any part of a building to set their own preferred light levels. The structure is lightweight that can be attached to existing buildings with little effort.³⁷The muscles also involve no moving parts gears and motors to seize maintenance. It can also be used to enhance the aesthetics of an ordinary building as the facade brings attention to the building by the way it moves, it makes the building appear as if it's alive, as the skin pulsates and opens. Materials used are made of silicon coated polyamid rubber with steel valves at each end, the shades are inflatable cushions made of polyester coated with hypalon, the whole assembly is joined by steel fixings (Fig.4.42).



(Fig.4.42) the panels are arranged according to an individual desires

The way the Fluidic Muscle works is through the technology developed by Festo, utilises the contracting action of the rubber muscles to generate motion, a force of up to 6kN can be achieved .The rubber skins of the muscles have a lattice structure which when air is pumped into them expand laterally causing the muscle to contract along its length . The solar shades themselves are formed by inflatable cushions which are moved by the muscles. All the cushions and muscles in the facade are connected forming a single skin, the facade is programmed so that any muscle moving does not affect the rest of the façade.

³⁷ ONL(Oosterhuis Lenard) 2003 Adaptive Façade.
<http://www.oosterhuis.nl/quickstart/index.php?id=351>. (Accessed Aug. 2012)

4/1/16/2 Project Analysis

Type of applications used:

Spatial Sharing and Control

Through the reconfigurable shade.

- Fulfilment of Public buildings requirements:
 - a-Energy efficiency provided: Artificial Light optimization, Natural light articulation, Thermal comfort.
 - b-Pragmatic needs provided: Flexibility and comfortable, security, safety.
- Design procedure:
 - a- Ideological concept: artificial intelligence.
 - b- Design process:
 - Surface based and kinetic human computer interaction.
 - Haptic user interfaces.
 - Adaptive control embedded computation.
 - c-Technological tools: robotics and CNC.

Interactive Applications Properties:

- The responsive behaviours with respect to: Environments and individuals.
- Level of interactions between: The users and exterior Environment.
- Serving Humanistic needs of: control and attachment to space.

4/1/17 Souq Al-Hijaz, Jeddah

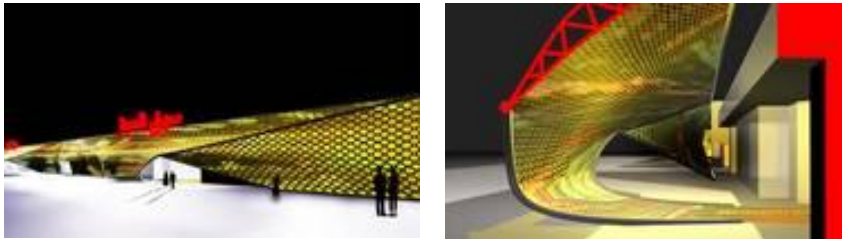
The following project shows the possibilities of installing interactive applications to upgrade an existing place to make it more interacting to the users and enhance the quality of space. The project was designed by ONL office by Kas Oosterhuis for the competition assigned by The Saudi Arabia government in 2005 to develop and upgraded the shopping mall, in order to attract new customers.

4/1/17/1 Project Explanation

The designer proposed the upgrading for the exterior elevations as well as the interior using the concepts of nonstandard architecture, using media installation informing and guiding the customers around the place.

The elevation upgrades tasks starts with the experience of the Souq from the Main Road ,by placing a second skin placed at a distance of some meters away from the old facade . This new skin is higher and built up like a

lightweight building kit (Fig. 4.43). The new loose skin will be designed using smooth lines folding back into the interior of the shopping centre. The entrances are limited in number and emphasized by LED lighting which is also visible in daylight like of electronic billboards (Fig. 4.44). The new skin contains in various densities arrays of LED lights, high density as to communicate words, symbols and images close to the entrances and transforming gradually into low density areas where the LED is used to form abstract patterns.³⁸



(Fig. 4.43) Left, the elevation of the shopping mall showing the rap of the new LED skin. (Fig. 4.44) Right, the entrance with emphasized by LED lighting.

Inside the shopping mall the upgrade include adding electronic surfaces scattered loosely around the whole interior. Electronic surfaces contain in a high density arrays of LED lights, communicating specific advertisements with the public. Electronic carpets on the floors lead customers through the shopping complex, as do the electronic piles and the electronic clouds attached to the ceilings (Fig. 4.45). Occasionally old surfaces may be removed and replaced by the new electronic surfaces. In this way the shopping centre can continue to function properly during the upgrading procedures.



(Fig. 4.45) shows the interior of high density arrays of LED lights

The structure of the new skin is designed according to the new File to factory process of mass-customization using parametric systematic technical

³⁸ ONL official website , Al-Hijaz | Jeddah
<http://www.oosterhuis.nl/quickstart/index.php?id=al-hijaz>. (Accessed May 2012)

design to be produced by CNC machines whereas the data feeding the CNC machines comes directly from the 3d model of the architect-engineer. The architecture which is possible applying the rules of mass-customization is labelled Non Standard Architecture, it allows for much greater visual complexity for greater and richer visual effects.

4/1/17/2 Project Analysis:

Type of applications used:

Allow For Communication and Information Flow

Through the media second skin of LED lights

- Fulfilment of Public buildings requirements:
 - a- Pragmatic needs provided: spatial sharing and optimization,
 - Design procedure:
 - a- Ideological concept: virtual reality
 - b- Design process:
 - Kinematic human computer interaction
 - Cognitive user interfaces
 - External communication embedded computation
 - c- Technological tools: hyper surface and CNC

Interactive applications properties:

- The responsive behaviours with respect to: Social
- Level of interactions between: The users and build Environment.
- Allowing for the flow of information and communication.

4/1/18 The Digital Pavilion

The project is an attempt by the South Korean government to produce a set of buildings to showcase the future of the country's new media, IT, software and electronics companies and its technological strategies and economic policies. The pavilion is intended to be a five-year installation with the possible replacement of old technology on remaining hardware. The project was designed by ONL office by Kas Oosterhuis and Ilona Lénárd in 2006 for the competition assigned by the Korean government.

4/1/18/1 Project Explanation

The Digital Pavilion is a complex adaptive robotic system of interacting installations. The environment is immersive to give the impression of navigating inside the technology through ubiquitous

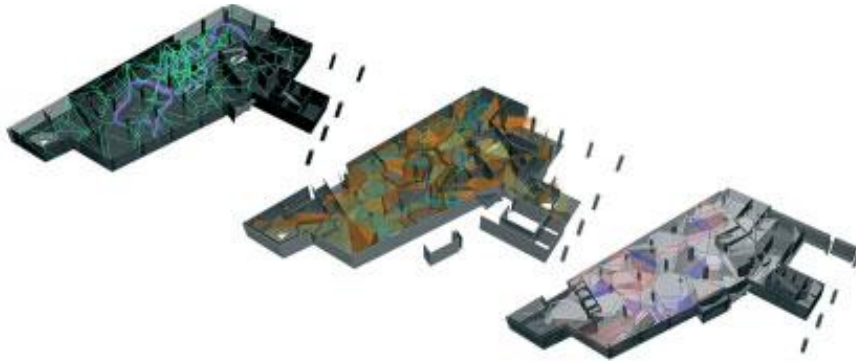
computation. Installations interact with the public but also with other installations. The output of one installation provides relevant data which are used as inputs for other installations.³⁹ The visitors are individually identified using RFID tracking and they build up their unique profiles while navigating through the floors of the pavilion with the interactive and interacting installations. Each visit will be a unique experience; the installation would never repeat its exact shape and content always being adjusted in real-time by the movements of the public and by the streaming content using the WiBro (Wireless Broadband) or WiMax technology embedded in their handheld devices.

The public interacts with the installations using a special 4G/WiBro handheld device. Thus the building as a living installation becomes a showcase for the technological priorities as set by the Korean government, it is a mix of real-life, augmented reality and online experience. The applications will be developed in close collaboration with South-Korean companies. The project main components are the 3d Voronoi diagram and handheld 4G/WiBro device. It acts as an essential tool in the discovery of the products and technologies displayed in the pavilion by the Korean authorities and exhibitors.

The spatial division of the pavilion interior is derived from a 3d Voronoi diagram algorithm.⁴⁰ The definition according of the Voronoi diagram according to Kas Oosterhuis is: *"the partitioning of a plane within points into convex polygons such that each polygon contains exactly one generating point and every point in a given polygon is closer to its generating point than to any other"*. The 3d Voronoi principle is translated in the design into beams of the Voronoi cell structure feature built-in linear actuators, able to alter the lengths of the beams in real time. Where the actuators controlled via the handheld devices given to visitors (Fig. 4.46).

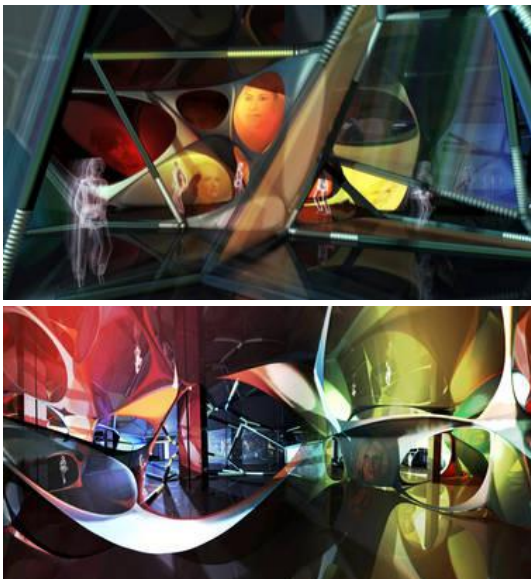
³⁹ ONL official website. <http://www.oosterhuis.nl/quickstart/index.php?id=digital-pavilion>. (Accessed May 2012)

⁴⁰ Voronoi diagram is a special kind of decomposition of a given space, a metric space, determined by distances to a specified family of objects (subsets) in the space. These objects are usually called the sites or the generators and to each such object one associates a corresponding Voronoi cell, namely the set of all points in the given space whose distance to the given object is not greater than their distance to the other objects. It is named after Georgy Voronoi. Voronoi diagrams can be found in a large number of fields in science and technology, even in art. It is the technique that enables the division of such multi-dimensional spaces into subspaces. http://en.wikipedia.org/wiki/Voronoi_diagram



(Fig. 4.46) Exploded axonometric of the three floor plans showing the Voronoi cell-like structure of the building's tectonic system across each of its three storeys.

This structure materialized the interior spatial structure creating a parametric system. By varying the density and position of the Voronoi generating point's variations of the resulting spatial division are achieved. The cell structure can be materialized in several ways depending on the situation. The sides can be constructed by structural beams and faces/planes can become walls, floors or ceilings. Faces can also be opened to provide for example passage form one cell to the other. All surfaces of the existing concrete structure will be covered with darkened glass. The glass is back-lit by LED-arrays, to give the impression of an infinite, media-rich or translucent space (Fig. 4.47).



(Fig. 4.47) Digital image of the interior. Made up of large, darkened, LED-backlit glass panels, the interiors provide the perception of an infinite, media-rich or translucent space. The space provides an experience of inhabiting an information rich play-shopping crystal, a showcase for the South Korean government and entertainment and IT companies.

Visitors interact with the installations and the personalized, virtual content by using a handheld 4G/WiBro device into which they program personal details which are then used to configure the content they are exposed to. By its camera lens on the back, acts like a viewer by revealing the virtual world from the viewer's perspective. It also serves as a communication device provide dynamic maps of the positions of visitors in real time and can be used to browse through lists of exhibitors, products and embedded information about the product or information being used, which can then deliver a real-time information feed as a guide to the items selected or being viewed/experienced at the time. RFID tracking of individual visitors throughout the building is also used to build up unique profiles of the interactions of people as they wander through the pavilion. The device then stores a record of the whole trip and all of the related media content, ready for remote retrieval, via the Internet, at a later date.

There is also social interaction between the users. The types of 'experiences', or 'game-play' offered in the interiors of the pavilion were derived from an analysis of Asian popular cultural entertainment and were selected to actively target different pavilion user groups. They are an action shoot-em-up game, a social chat game an adventure mystery game and a strategy/board game which are being developed with the help of Korean massively multiplayer, online role-playing games design companies to create dynamic and immersive team-based, as well as individual and social experiences. The success of such highly social and interactive computer games (the Second Life game now has more than 3.3 million international 'resident' players online) seems to offer a compelling popular precedent and model for spatially embedded and enabled social interaction, not just for the Digital Pavilion Korea but for social interactive space design as whole. The Digital Pavilion is an architectural hybrid between online multiplayer games and the new urban games that utilise GPS, GIS, RFID and wireless technologies.⁴¹

4/1/18/2 Project Analysis:

Type of applications used:

Spatial Sharing and Control

Through adjusted in real-time movements of the public and by the using the WiBro or WiMax technology embedded in their handheld devices.

- Fulfilment of Public buildings requirements:

⁴¹ 4d social: Interactive design environments, guest edited by Lucy Bullivant published by Wiley academy, 2007.PP. 48-49

a-Pragmatic needs provided: spatial sharing & optimization,
Flexibility & comfortable, safety, security

- Design procedure:
 - a- Ideological concept: virtual reality
 - b- Design process:
 - Tangible and kinetic human computer interaction
 - Haptic and gesture user interfaces
 - External communication embedded computation
 - c-Technological tools: smart materials and robotics

Interactive Applications Properties:

- The responsive behaviours with respect to: Social and individuals.
- level of interactions between:
The users and build Environment, and between users and each other.
- Allowing for the flow of information and communication.
- Serving Humanistic needs of: sensing of place , understanding of space, control and attachment to space.

4/1/19 the Dynamic Tower

The Dynamic Tower is a residential hotel designed by David Fisher in the year 2008 to be constructed in Dubai. The Dynamic Tower offers infinite design possibilities, as each of the 80 floors rotates independently to create a building that constantly changes shape, resulting in a unique and ever evolving architectural structure.⁴²

4/1/19/1 Project Explanation

The Dynamic Tower will adjust itself to the sun, wind, weather and views by rotating each floor separately. The tower consists of a tubular concrete core, layered with smooth triangular floors which can move at varying speeds and so create a vast combination of different shapes. The floors will comprise more than 2,000 prefabricated steel and aluminium pods. The pods will then be lifted into place with between 30 and 42 per floor and will appear to cantilever out from the core.⁴³ Most of the floors will be

⁴² Tower that will change shape with motion, By Saifur Rahman, Published: 8 June 21, 2008. <http://gulfnews.com/business/construction/tower-that-will-change-shape-with-motion-1.112934>. (Accessed Aug. 2012)

⁴³ Institution of Civil Engineers. <http://www.ice.org.uk/About-civil-engineering/Big-civil-engineering-projects/The-Dynamic-Tower>. (Accessed Aug. 2012)

controlled from the architect's laptop so that they are synchronised to make undulating architectural forms.

The shape will be determined by each floor's direction of rotation, speed, acceleration and the timing; with timing meaning how each floor rotates compared to the other (Fig. 4.48). The rotation speed will be between 60 minutes and 24 hours for one revolution. Residents, if they own the entire floor are able to control the speed and direction of the rotation by voice command. The segmented tower design will allow each floor to turn independently using voice recognition technology and giving those inside an ever-changing view over the space of 1 to 3 hours. In the Dubai building the voice recognition will be able to interpret such instructions as 'left' or 'right'.⁴⁴



(Fig. 4.48) The 'tower in motion' - the world's first such building - is a revolutionary project based on Dynamic Architecture, creating unrepeated shapes

The buildings have to overcome several technical challenges such as connecting the plumbing with the same kind of shut off valves used when refuelling aircraft in flight. To take the lift residents have to step from the rotating floor into the stationary central core. The Dynamic Tower is environmentally friendly with the ability to generate electricity for itself as well as other buildings nearby making it the first building designed to be self-powered. It achieves this with wind turbines fitted between each rotating floor. Solar power will be provided by photovoltaic cells on the roof of each rotating floor, 15 per cent of which will be exposed to sunlight at any one time. (Fig. 4.49)



(Fig. 4.49) the turbines located between each floor and the photovoltaic cells on each roof

⁴⁴ World architecture news.

http://www.worldarchitecturenews.com/index.php?fuseaction=wanappln.projectview&upload_id=10026. (Accessed Aug. 2012)

4/1/19/2 Project Analysis

Type of applications used:

Spatial sharing and control

Through the rotating floors.

- Fulfilment of Public buildings requirements:
 - a-Energy efficiency provided: Artificial Light optimization, Natural light articulation, Ventilation, Thermal comfort.
 - b-Pragmatic needs provided: Flexibility and comfortable, security, safety.
- Design procedure:
 - a- Ideological concept: kinetic .
 - b- Design process:
 - Kinetic human computer interaction.
 - Haptic user interfaces.
 - Automation embedded computation .
 - c-Technological tools: sensors, microcontroller.

Interactive Applications Properties:

- The responsive behaviours with respect to: Environments and individuals.
- Level of interactions between: The users and exterior Environment.
- Serving Humanistic needs of: control and attachment to space.

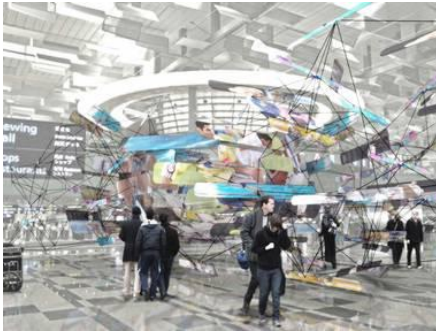
4/1/20 The Airport of Media Launchpad

The project is a research project design by ONL office by Kas Oosterhuis in 2011 it's an integration of social techniques and technical possibilities. The Airport of Media features a complete blend of the real and the virtual. The visitor is emerged in the content of a virtual environment, while experiencing the real physical environment as a virtual sensation.

4/1/20/1 Project Explanation

Information is the key factor to the design concept; Information is what connects the Launchpad with the users. Information is what connects one Launchpad in one airport to another Launchpads in other locations. Information is what connects people to people (Fig. 4.50). Information connects 216 reference points, slowly moving around in a designated space.

The users wait to be instructed by local and global information, as to stay calm or to unfold into high-definition images and movies.⁴⁵



(Fig. 4.50) shows the virtual of information flows imposed on the physical space defining its structure

The flow of information informs the structure to customize its physical shape and to unfold its content. The visitor navigates through information rather than to walk inside a physical structure. Information is tailored to the users inside the Launchpad. The built structure is only there to support the content. The building components is made of 216 small units form a loose swarm of low resolution pixels that transform into an organized herd of high definition displays. The visitor always enters into dynamic force, fields of low resolution information. Only after entering the pad excites the structure to locally enhance the information level. The information displays unfold and soundscapes comes alive.

The Launchpad can transform itself from one mode of operation into another. The different modes are triggered by the users. One single user triggers the unfolding of a limited area, locally pulling content based on their personal preferences. The other parts of the Launchpad remain unaffected by this single user; here the information is pushed from other sources of information bringing the Launchpad in a certain state of excitement (Fig. 4.51).



(Fig. 4.51) Different users in different locations according to their personal experience alter the space they occupy.

⁴⁵ ONL official website, 2011 Airport Of Media | Worldwide.
<http://www.oosterhuis.nl/quickstart/index.php?id=aom>. (Accessed May 2012)

The future of the Launchpad designed functions as a framework for future designs by a selected number of designers. They will base their designs on the internal logic of the 216 members of the swarm. On top of this internal logic they will impose their individual design concepts. Although based on the same conceptual idea each Launchpad will carry the signature of its designer in the end. To keep the network alive each year one-third of each Launchpad is substituted by an updated version. Technology changes fast and within three years each Launchpad will be completely renewed and equipped with the most recent technology.

4/1/20/2 Project Analysis:

Type of applications used:

Allow For Communication and Information Flow

Through the Information tailored to the users inside the Launchpad

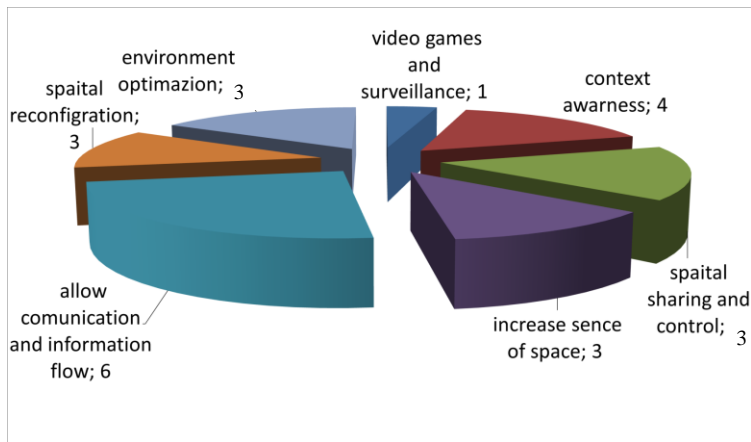
- Fulfilment of Public buildings requirements:
 - a- Pragmatic needs provided: spatial sharing and optimization, Flexibility and comfortable, safety.
- Design procedure:
 - a- Ideological concept: virtual reality .
 - b- Design process:
 - Tangible and kinetic human computer interaction.
 - Haptic and gesture user interfaces.
 - External communication embedded computation.
 - c- Technological tools: hyper surface and CNC.

Interactive applications properties:

- The responsive behaviours with respect to:
 - Social and individual.
- Level of interactions between:
 - The users and build Environment, and the user and each other.
- Allowing for the flow of information and communication.
- Serving Humanistic needs of: sensing of place , understanding of space, control and attachment to space.

4/2 Analysing the Case Study Projects

On the level of the existing projects they used the applications of: increase sense of space, environment optimizing, allow communication and information flow and context awareness. The other types of applications are used on the level of experimental projects which are, spatial sharing and control, spatial reconfiguration and combining the ideas of video games. According to the analysed case studies the influenced applications are:



The number of times of application usage in descending order:

- Allow communication and information flow number of usage 6
- Context awareness number of usage 4
- Environment optimizing number of usage 3
- Spatial sharing and control number of usage 3
- Increase sense of space number of usage 3
- Spatial reconfiguration number of usage 3
- Combining the ideas of video games and surveillance number of usage 1

4/2/1 Level of Fulfilment of Public Buildings Requirements

According to the analysed case studies the level of fulfilment of public building requirements is:

Type of Application		video games and surveillance	environment optimization	spatial reconfiguration	allow communication and information flow	spatial sharing and control	increase sense of space	context awareness	
public building requirements	ecological evaluation / energy efficiency	Artificial Light optimization	35%	65%	15%	65%	65%		
		Natural light articulation	100%	100%	30%	65%		25%	
		Ventilation	100%	100%	15%	35%			
		Thermal comfort	100%	65%		65%		25%	
	pragmatic evaluation	spatial sharing & optimization		35%	100%	100%	35%	100%	50%
		Flexibility & comfortable		65%	100%	30%	100%	35%	25%
		safety		65%	100%	45%	100%		25%
		security		35%	65%		100%		
interactive properties	responsive to changing needs of	Individuals		65%	30%	100%	65%		
		Social			85%	35%			
		environment		100%	65%		65%	35%	100%
	level of interactions	user and built environment		25%	35%	60%	35%	65%	25%
		users and Exterior Environment		35%	65%	30%	65%	35%	25%
		Between the users and each other					35%		
	information and communication flow			65%	100%	35%	100%	25%	
	sensing of place /control and attachment to space		35%	100%	65%	100%	100%	75%	

Table (5.1) analysing the degree of fulfilment to public buildings design requirements

Analysing the previous table the level of Fulfilment of the requirements for each of the used interactive applications is:

For the applications of combining the ideas of video games and surveillance; it was used in case study projects on the experimental level only. It supported the pragmatic needs of flexibility and the need of spatial sharing and optimization. As for the level of fulfilment of the interactive properties it supported the needs of information and communication flow and sensing of the place.

For the applications of environment optimizing; it was used in the existing case study projects. It supported the ecological needs of natural light articulation, ventilation, thermal comfort and artificial light optimization .It supported the pragmatic needs of flexibility, the need of spatial sharing and optimization, safety and security. As for the level of fulfilment of the interactive properties it supported the needs of sensing of the place, it responded to the environmental requirements and the interaction was between the user's and their built or exterior environment.

For the applications of spatial reconfiguration; it was used mainly on the level of experimental case study projects and showed a minor attempt on the level of existing projects. It supported all of the ecological needs and pragmatic needs on the experimental level while for the existing projects it supported the needs of; natural light articulation , ventilation ,flexibility and safety. As for the level of fulfilment of the interactive properties it supported the needs of controlling and sensing of the place and information and communication flow. It responded to the individuals and the environment and the interaction was between the users and their built or exterior environment.

For the applications of allow for communication and information flow; it was used both on the level of the existing and experimental case study projects. It barley showed fulfilment of ecological needs on both level of the existing and experimental case study projects it supported only the needs of light articulation and ventilation. For the pragmatic needs it supported spatial sharing and safety while for flexibility was on the level of experimental projects only. As for the level of fulfilment of the interactive properties it supported the needs of controlling and sensing of the place and information and communication flow. It responded to the individuals and social needs and the interaction was between the users and their built or exterior environment.

For the applications of spatial sharing and control; was used on the level of experimental case study projects only. It supported the ecological and pragmatic needs in various levels. As for the level of fulfilment of the interactive properties it supported the needs of controlling and sensing of the place and information and communication flow. It can respond to the individuals, the environment and social needs and allowed for the interaction between the users and their built environment or between the users and the exterior environment, as well as between the users and each other.

For the applications of increase sense of space; it was used in the existing case study projects. It supported the ecological needs of artificial light optimization and the pragmatic needs of spatial sharing and flexibility. As for the level of fulfilment of the interactive properties it supported the needs of controlling and sensing of the place and information and communication flow. It responded to the individuals and environment needs and the interaction was between the users and their built or exterior environment.

For the applications of context awareness; it was on the level of the case study projects. It supported the needs of natural light articulation and ventilation in one project only. For the pragmatic need it supported spatial sharing and optimization, flexibility and safety. It responded to the environment needs and the interaction was between the users and their built or exterior environment.

4/2/2 The Analysis of The Design Procedure

According to the analysed case studies the used applications whether on the existing or experimental level, showed a variation in one of its design procedures which affected the level of fulfilment of the public building requirement. The following analysis shows these variations:

		Type of Application		video games and surveillance	environment optimization	spatial reconfiguration	allow communication and information flow	spatial sharing and control	increase sense of space	context awareness	
interactive design method	ideological concepts	responsive			100%	35%			35%	100%	
		kinetic						33%			
		virtual reality					100%	33%	65%		
		intelligent environmen				65%					
		artificial intelligence						33%			
	design process	Human computer interaction	Tangible paradigms					30%	33%	35%	50%
			Surface based sensing and response			65%	35%	15%	33%	65%	
			Kinematic Surface-Response					45%			
			Kinetic Typologies			35%	100%	15%	33%		50%
		user interface design	Haptic interfaces			65%	35%	45%	100%	35%	25%
			gesture					15%	33%	100%	50%
			Cognitive control				65%	60%			
		Embedded Computation	Active control			65%		15%			70%
			Adaptive control			35%	35%		33%	100%	20%
			automation				65%		33%		
			External Communication					85%	33%		
		technological tools	sensors			100%			35%	65%	50%
	microcontrollers						35%				
	robotics				65%		65%		50%		
	hypersurface			35%	35%	100%					
soft space								65%	50%		
(CNC)/smart materials				65%	35%	45%	65%				

Table (5.2) analysis of the design method used for applying interactive applications in the design of public buildings

Analysing the used interactive applications according to the previous table:

For the applications combining the ideas of video games and surveillance it was used on the experimental level only, its design method is:

Ideological concepts

- Ideological concepts used only of intelligent environments.

Design process

- Tangible interactions.
- Haptic interfaces
- Adaptive control for embedded computation.

Technological tools

- Sensors and hyper surface techniques.

For the applications of environment optimizing it was used in the existing case study projects, its design method is:

Ideological concepts

- Ideological concepts used of responsive environments only.

Design process

- Surface based or kinetic HCI.
- 65% of the case study examples used haptic interfaces only.
- Active or adaptive embedded computation.

Technological tools

- Used technological tools of sensors , CNC materials and hyper surface.

For the applications of spatial reconfiguration; it was used mainly on the level of experimental case study projects. On the level of existing project the design method is:

Ideological concepts

- Ideological concepts used of responsive environments instead of artificial intelligence on the experimental level.

Design process

- Kinetic interaction with the exterior environment while on the experimental level it supported kinetic, tangible and surface based human computer interactions.
- Did not support user interfaces as the interaction was with the environment while on the experimental level it supported haptic interfaces.
- Adaptive embedded computation while on the experimental level it supported automation control as well.

Technological tools

- Used technological tools of hyper surface while on the experimental level it used robotics and CNC/smart materials as well.

For the applications of allow for communication and information flow it was used both on the level of the existing and experimental case study projects. On the level of existing project the design method is:

Ideological concepts

- Ideological concepts used of virtual reality on both levels, existing and experimental projects.

Design process

- Tangible and kinematic HCI on both levels, existing and experimental projects with more using of surface based interactions on the experimental level.
- Cognitive user interfaces on both levels, existing and experimental projects with more using of haptic interfaces on the experimental level.
- External communication e embedded computation on both levels, existing and experimental projects with more using of active control on the experimental level.

Technological tools

- Used technological tools of hyper surface and CNC/smart materials on both levels, existing and experimental projects.

For the applications of spatial sharing and control was used on the level of experimental case study projects only, the design method is:

Ideological concepts

- Ideological concepts used virtual reality, kinetic and artificial intelligence.

Design process

- Tangible and surfaces and kinetic based HCI.
- Haptic , gesture interfaces.
- External communication, adaptive and automation embedded computation.

Technological tools

- Used all technological tools used robotics and CNC/smart materials.

For the applications of increase sense of space it was used in the existing case study projects, the design method is:

Ideological concepts

- Ideological concepts used virtual reality and responsive environments

Design process

- Tangible and surfaces based HCI.
- Haptic and gesture interfaces.
- Adaptive embedded computation.

Technological tools

- Used all technological tools used robotics and soft spaces.

For the applications of context awareness it was used both on the level of case study projects, the design method is:

Ideological concepts

- Ideological concepts used of responsive environments.

Design process

- Tangible and kinetic interactions.
- Haptic and gesture interfaces, while not all the projects supported user interfaces as the interaction was between the environment only.
- Depends on active control and adaptive embedded computation.

Technological tools

- Used technological tools are sensors, robotics and soft spaces.

Concluding summary:

Interactive applications were able to fulfill most of the pragmatic needs or show the potential for it. While further development is needed to fulfill most of the Energy efficiency needs in public buildings.

For environment optimizing applications in existing projects it did not support public building requirement of spatial sharing and optimization. But it was supported on the experimental level as such projects used surface based sensing and response human computer interaction and gesture user interfaces.

For Allow for communication flow applications in existing projects it did not support public building requirement of artificial light optimization. But it was supported on the experimental level as such projects used surface based sensing and response human computer interaction, haptic user interfaces and active embedded computation. The public building requirement of flexibility and comfortable was supported on the experimental level as such projects used kinetic human computer interaction and gesture, haptic user interfaces.

For Increase sense of space support ecological needs of; artificial light optimization only and pragmatic needs of; spatial sharing and optimization flexibility and comfortable. But was not able to support the other requirements on both levels existing projects and experimental.

For the spatial reconfiguration in fulfilled all of the requirements of public building but only on the experimental level as there was not any existing projects that support such application.

5/1 General Conclusion

The interactive trend in architecture has evolved due to the successive and intensive development of means and tools of digital technologies, media and communications, which constitute many domains of the social contemporary life. Architecture as a mirror of its age and culture always reflects the ideological movements of its era was affected to a greater extent by interactivity.

This research aimed generally to study and explore the meaning, theory, concepts, aspects and properties of the use of interactive architecture in public buildings. The research investigated the necessary design procedures and technological tools, used to produce interactive applications. In addition to the types of applications used so far and their ability to fulfil the public building requirements, were assessed, classified and determined.

Through this it was concluded that:

Starting from the second half of the last century architecture saw many shifts in its concept and approach according to the fast technological development influencing it. Interactivity was one of these shifts, practicing interactivity was limited to the technological tools developed radically over time.

Early attempts to practice interactivity in architecture set the main concepts of its applications. Cedric Price in the sixties influenced by the cybernetics theory was one of the first architects who used the concept of interactivity to create flexible spaces that are able to adapt. Buckminster Fuller in the post war era set the concepts of using technological advancement to limit recourse usage and enhance performance and his projects were one of the first attempts to use intelligence through home automation. Usman Haque also influenced by the cybernetics theory, considered interactivity through challenging the senses to control and manipulate spaces.

Trends development towards having spaces reconfiguring and communicating with its users, these trends set the main ideological concepts of interactive architecture; first kinetics, moving some parts of the architectural spaces in response to simple environmental or space alteration in one direct command line from its operator. Second responsive environment, which is reactive in nature mostly to environmental conditions. Third intelligent environments, providing intelligent technological interactions through a programmed system.

From cybernetics virtual reality and artificial intelligence were developed, these two also set the further ideological concepts of interactive applications. Virtual realities allowed for information and communication flow. Artificial intelligence introduced mechanical interaction solutions to reconfigure space through smart agents and robotics that mimic human actions.

Cybernetics theory constitutes the bases of interactivity; it is about crating two way stream and loops of communications. It creates the potential for the development of dynamic spaces that have an ability to interact and communicate with users. Cybernetics also constitutes the basic of contemporary technologies mainly computers that are used in interactive applications design process.

The design process used for interactive applications are:

- a- Interaction design through human computer interaction; It creates a frame work of relations between architecture and individuals. Recently human computer interaction provides the most common interactions in interactive architecture to explain the interaction between people and technology. Interaction trends are classified mainly to; tangible paradigm which gives physical form to digital information through sensing motion or gesturing. Surface based sensing and response for architecture attempting to incorporate forces, actions and activities to enhance spatial experience. Augment spatial performance this involves embedded sensors and infrared. Kinematic surface response represents the simulated action of visual response. Kinetic typologies represent the physical transformations of shapes.
- b- Interface design; Generally an interface is a two way device or group of devices, which facilitates the two-way process of interaction between the users and the surrounding technologies. Interface trends are classified into; Haptic interfaces, sensing and communicating with the surrounding environment through touch. Gesture interfaces, allow to directly control and interact with real objects in an environment through sensing the

motions or actions of the user. Cognitive interfaces, blurring the space between user control and digital information.

c- Embedded computation;

It is a system that is embedded into the building and has the ability to gather information, process it, and use it to control the behaviour of the actual physical architecture.

Trends in embedded computation are classified into;

Active control, depends on a decentralized system to modify the behaviour of a system in response to external stimuli. Adaptive control is a hybrid combination between active and passive systems using artificial intelligence to optimize performance. Automation control, it responds and adapts to human actions in terms of energy and power optimization. External communication, the main aim of such system is having the ability to monitor and physically control remote environments.

The design process techniques required technological tools and techniques to implement them in interactive applications which are; sensors, microcontroller, smart materials and robotics.

The techniques used in the development of the design process to have more dynamic and interactive spaces are: hyper surfaces techniques; it is the interaction between information and physical environment by streaming information to the built environments. Soft spaces techniques; were made to create space challenging the sensing to increase the sense and attachment of space.

Using an analytic methodology on interactive applications in different domains to determine properties and types of interactive systems.

a- Properties of interactive systems are:

Affording responsive behaviors with respect to changing needs of individuals, social and environmental conditions;

Providing level of interactions between, the user and built environment, the users and Exterior Environment and between the users and each other;

Allowing for the flow of information and communication
Serving Humanistic needs of, sensing of place,
understanding of space, control and attachment to space;

- b- Types of interactive systems:
 - Combining the ideas of video games and surveillance;
 - Context awareness;
 - Spatial sharing and control;
 - Increase sense of space;
 - Allow communication and information flow;
 - Spatial reconfiguration;
 - Environment optimizing;

Public building design requirements splits to two categories:

- a- Ecological needs
 - Artificial Light optimization
 - Natural light articulation
 - Ventilation
 - Thermal comfort
- b- Pragmatic needs
 - Spatial Sharing and Optimization
 - Flexibility & comfortable
 - Safety
 - Security

An analytic methodology was followed by using a proposed “characteristic model” to evaluate and determine the influence of interactive applications on public buildings. This model depends on three main effects in studying they are:

- Interactive systems: including the assessment of, the ideological concepts, design process and technological tools.
- Interactive properties.
- Public buildings design requirements.

Applying the proposed “characteristic model” on twenty international case studies to assess the uses of interactive application in public buildings

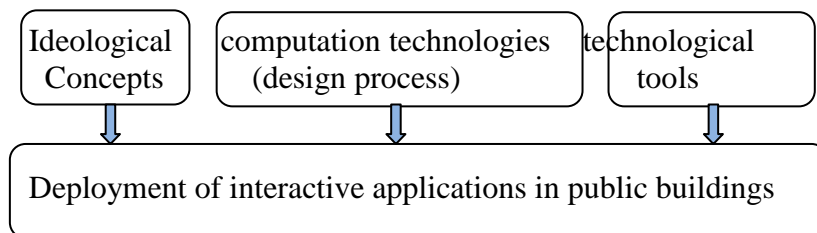
5/2 Results

We can classify the results of the research as follows:

From the previous conclusion it's deduce that the factors influencing the deployment of interactive architecture in public buildings depends on the following effects; ideological concepts of dynamic and flexibility. Computation technologies in interaction design, interface design and embedded computation. The development of technological tool and techniques like robotics and smart materials, hypersurfaces and soft spaces techniques.

Design process of interactive architecture has gone beyond just satisfying the pragmatic needs and specifications to enrich the senses and overall aesthetic qualities. It aimed to have spaces reconfiguring and communicating with its users through two way stream. With the help of ideological concepts driven from digital technologies development.

Due to the previous effects the architectural methodology to develop interactive architecture in building are as shown in (fig.5.1)



(fig.5.1) represents the factors of that constitute interactive applications

Each of the ideological concepts used in interactive applications has its own distinguished elements of concepts of application and mechanism. The ideological concepts are:

- **Kinetic typologies;**

Concept of application: Spatial Optimization System, It generally describe how systems can facilitate flexible spatial adaptability.

Multi-function Design System, It defines movable architectural objects that share a common physical space to provide multiple uses.

Contextual Adaptability System, It is kinetic structures that can be employed to dynamic or unknown contextual situations.

Mobility System, It is building or building component with variable constructability, location or geometry to physically adapt to change.

Mechanism: Embedded Kinetic structures control the larger architectural system or building in response to changing factors.

Deployable Kinetic structures, they exist in a temporary location and are easily transportable.

Dynamic Kinetic Structures, parts of the buildings that reconfigure themselves to adapt to needs acting independently with respect to control of the larger context.

- **Responsive environments;**

Concept of application: Altering weather condition, it is used to preserve a comfortable climatic environment

Preserving energy losses

Changing its architectural form, has the ability to change its architectural form according to environmental conditions, and user's needs.

Transporting the environmental conditions inside, using responsive building envelopes that mediate between users' needs and the natural environment conditions.

Mechanism: “A Discrete Model of Architecture”. It represents the integrating between needs and wants of users into architecture to reconfigure spaces.

“A Hybridized model of control”. It is used to control structural responses, and spatial responses, with respect to different user activities through feedback mechanism.

The deployment of actuated “tensigrity” structures. It’s the physical alteration of the envelope to give an interpretation of the environmental condition.

- **Intelligent environments;**

Concept of application: having the ability to respond on time according to processed information that is received from exterior and interior environments. Used in home automation and integrated building systems operating a single building or facility, where the systems can communicate and exchange information.

Mechanism: ubiquitous connectivity in sensor-rich environments; Context information, that can sense the current physical and computational environments, by using means of sensors to capturing information and Smart environment agents to act in in the environment.

- **Artificial intelligence;**

Concept of application: simulating any kind of intelligence already found in living creatures by having the ability to learn. Used in energy saving and serves as an integration element that provides communication between technology and individuals.

Mechanism:

- Intelligent agent; It is something that acts in a given environment. Categorized into two main types first, “Rational agent” that is capable of planning and executing the right task at the right time by having percept sequence. Second “An omniscient learning

and autonomous agent” which is intelligent enough to learn from its experience,

-The task environment; It is where the agent is functioned. It comprises a specified performance measure, an environment, and the agent's actuators and sensors.

- **Virtual reality;**

Concept of application: depends on immersion and presence where the user's point of view or some part of the user's body is contained within the computer-generated space where the user can watch and manipulate the simulated environment. Used in;_Data and architectural visualization. Modeling, designing and planning. Training and education. Telepresence and teleoperating. Cooperative working.

Mechanism: generally the virtual reality systems provide a simulated environment created by the computer or other media where the user feels present in it through means of:

- Immersive systems it involve computer interface devices.
- Augmented Reality techniques.
 - Through the Window, the user sees the 3D world through the window of the computer screen.
 - Mirror World, provide a second person experience in which the viewer stands outside the imaginary world, but communicates with characters or objects inside it.
 - Chamber World, is a small virtual reality projection theater.
 - The Vision Dome

The design process in interactive application which is based on computational technologies are classified into:

Human computer interaction: it provides an interaction loop concerning the relation between human and computers. It depends on; “modalities” it is used to differentiate between the different flows of information and to describe the interaction or communication. Defining the “Levels of interaction” as the presentation and feedback by the computer passes through several stages before presenting the final action. “Modes” those are classified into, symbolic or iconic which reflects the human output modalities where a person influences its environment and communicates with it.

Interface design: provides a medium where people can communicate and control their environments. It depends on; gather and analyze user information, and then design and constructing the user interface and finally validate the user interface.

Embedded computation: it provides a pragmatic system management having the ability to gather information, process it, and use it to control the behavior of the actual physical architecture. It depends on; mechanical means to respond and act to the changes

The technological tools and techniques used in interactive applications are classified according to their applications into:

Sensors: first Passive sensors: they act as observers of the environment and capture signals. Second Active sensors: such as sonar; they send energy into the environment.

Microcontrollers: functioned like a computer but they are programmed to perform a single task. Classified into “High-Level Microcontroller Modules”, “Mid-Level Microcontroller Modules” and “Low-Level Solutions” based on the level of difficulty of assembling their components and developing their programs.

Robotics: considered as an agent of artificial intelligence. Classified into; Manipulators, they are physically anchored to their workplace to perform a task. The mobile robots, they

move about their environment to carry out tasks in different places using locomotion. Mobile manipulator; that combines mobility with manipulation.

Smart materials: it changes one of its properties in response of environmental conditions. Or transform energy from one form to another to achieve the desired final state.

Hyper surface techniques: provide a stream of communication flow between the users and their environment using artificial intelligence concepts.

Soft spaces techniques: increases the sense of space through challenging the senses using virtual reality concepts.

Through analyzing interactive systems with respect to the previous effects their means of implementation falls mainly in to the following categories:

Combining the ideas of video games and surveillance

Implementing such application uses two main procedures:

-First through:

Ideological concept: virtual reality model

Design process:

Surface based sensing and response human computer interaction

Haptic user interfaces.

Active control embedded computation

Technological tools: sensors and hyper surface techniques

-Second through:

Ideological concept: intelligent environment

Design process:

Tangible human computer interaction

Haptic and gesture user interfaces.

Automation control embedded computation

Technological tools: sensors and soft space techniques

Context awareness

Implementing such application uses two main procedures:

-First through:

Ideological concept: virtual reality model or responsive environments

Design process:

Tangible human computer interaction

Haptic or gesture user interfaces.

Active control embedded computation

Technological tools: sensors, smart materials or soft surface techniques

-Second through:

Ideological concept: artificial intelligence

Design process:

Tangible human computer interaction

Adaptive control embedded computation

Technological tools: smart materials and robotics

Spatial sharing and control

Implementing such application uses two main procedures:

-First through:

Ideological concept: virtual reality model or artificial intelligence

Design process:

Tangible and kinetic human computer interaction

Haptic and gesture user interfaces.

Automation or external communication embedded computation

Technological tools: smart materials and robotics

-Second through:

Ideological concept: virtual reality model

Design process:

Surface based sensing and response human computer interaction

Haptic user interfaces.

Automation embedded computation

Technological tools: sensors, microcontroller and smart materials

Increase sense of space

Implementing such application uses three main procedures:

-First through:

Ideological concept: responsive or kinetic

Design process:

Tangible or kinetic human computer interaction

Gesture user interfaces.

Active control or automation embedded computation

Technological tools: sensors, microcontroller and smart materials

-Second through:

Ideological concept: virtual reality model

Design process:

Tangible human computer interaction

Haptic user interfaces.

Active control embedded computation

Technological tools: sensors, smart materials and soft space

-Third through:

Ideological concept: virtual reality model

Design process:

Surface based sensing and response and kinematic human computer interaction

Haptic and gesture user interfaces.

Adaptive control embedded computation

Technological tools: robotics and soft space

Allow communication and information flow

Implementing such application uses three main procedures:

-First through:

Ideological concept: virtual reality model

Design process:

Kinematic human computer interaction

Cognitive control user interfaces.

External communication embedded computation

Technological tools: hyper surface and CNC

-Second through:

Ideological concept: virtual reality model

Design process:

Tangible human computer interaction

Cognitive control user interfaces.

External communication embedded computation

Technological tools: soft space and CNC

-Third through:

Ideological concept: intelligent environment

Design process:

Tangible human computer interaction

Cognitive control user interfaces.

External communication embedded computation

Technological tools: robotics and soft space

Spatial reconfiguration

Implementing such application uses two main procedures:

-First through:

Ideological concept: artificial intelligence

Design process:

Tangible and kinetic human computer interaction

Gesture and haptic user interfaces.

Adaptive control embedded computation

Technological tools: robotics or hyper surface

-Second through:

Ideological concept: artificial intelligence

Design process:

Surface based and kinetic interaction human computer interaction

Haptic user interfaces.

Automation embedded computation

Technological tools: robotics and CNC

Environment optimizing

The ways of implementing such application are:

Ideological concept: responsive

Design process:

Surface based sensing and response human computer interaction

Gesture user interfaces.

Adaptive control embedded computation

Technological tools: sensors, and smart materials

- Interactive systems support the following public buildings ecological and Pragmatic needs requirements.

Combining the ideas of video games and surveillance;

Support ecological needs of:

Natural light articulation only

Pragmatic needs of:

Spatial sharing and optimization

Flexibility and comfortable

Security and safety

Context awareness;

- Support ecological needs of:
 - Natural light articulation
 - Ventilation
 - Thermal comfort
- Pragmatic needs of:
 - Spatial sharing and optimization
 - Flexibility and comfortable
 - Security and safety

Spatial sharing and control

- Support ecological needs of:
 - Artificial Light optimization
 - Natural light articulation
 - Ventilation
 - Thermal comfort
- Pragmatic needs of:
 - Spatial sharing and optimization
 - Flexibility and comfortable
 - Security and safety

Increase sense of space

- Support ecological needs of:
 - Artificial Light optimization only
- Pragmatic needs of:
 - Spatial sharing and optimization
 - Flexibility and comfortable

Allow communication and information flow

- Support ecological needs of:
 - Artificial Light optimization
 - Natural light articulation
 - Ventilation
- Pragmatic needs of:
 - Spatial sharing and optimization
 - Flexibility and comfortable
 - Security

Spatial reconfiguration

- Support ecological needs of:
 - Artificial Light optimization
 - Natural light articulation
 - Ventilation

Thermal comfort

Pragmatic needs of:

Spatial sharing and optimization

Flexibility and comfortable

Security and safety

Environment optimizing

Support ecological needs of:

Artificial Light optimization

Natural light articulation

Ventilation

Thermal comfort

Pragmatic needs of:

Spatial sharing and optimization

Flexibility and comfortable

Security and safety

Interactive applications were able to fulfill most of the pragmatic needs in the studied projects while further development is needed to fulfill most of the Energy efficiency needs in public buildings.

Each of the analyzed case study project in public buildings that are on the experimental level in chapter four; their design method and means of implementing were already explored before in other field whether in art or media as discussed before in chapter three. This gives the indications that interactive applications used so far has the potential to be developed to reach the desired goals of having a fully integrated building able to communicate and learn to meet all the required ecological, pragmatics and humanistic needs.

From analyzing the case study projects the lack of development of fully interactive systems where the architecture can physically reconfigured is due to the lack of having structures that can support the architecture and physically change in the same time. So the further research and study in pneumatic structures can open new possibilities in architecture.

5/3 Recommendation

Recommendation of the research could be classified into the following categories:

With regard to the future research in the same field

- Searching in the field of interactive applications and its technological tools and embedded computation especially in home automation and interface design to facilitate the wide spreading of the applications.
- Further development in the domain of ecological requirements and energy efficiency without neglecting the occupant's perspective and isolating them in a predefined set of conditions.
- Exploring more solutions in the domain of reducing the resource usage through using dynamic features optimizing the uses according to the desired needs.
- Searching in the field of interactive applications in the domain of creating spaces and buildings able to communicate and upgrade through its year of usage.

With regard to architectural research field

- investigating more solutions in improving the architectural built environment by means of artificial intelligence.
- Exploiting more of the design techniques of soft space and hyper surfaces which considered the tool for more revolutionary architecture that concern connectivity and flexibility.
- Searching in the field of interactive applications in the domain of development and upgrading existing places with installed applications especially in office and commercial buildings.

With regard to architectural education

- Teaching the new ideologies and techniques of interactive architecture.
- Spreading the computer science teaching in architectural education not only for drafting and presentation but in programming software's.
- Encouraging the collaboration in the design process between architectural design students and advanced design concepts.
- Design studios support it by means of new advanced design tools.

With regard to architectural practice in Egypt

- It is notable that the architectural situation in Egypt still falls behind in applying interactive architecture concepts with all of its effects in their design
- It is important for contemporary architects in Egypt to both study and practice the comprehensive concepts of interactive architecture concepts which will enhance their design concepts, techniques and tools to produce improved built environment and forms.
- The architectural situation in Egypt may not be able to benefit from all the applications types but can benefit from installing interactive applications on the level of preserving energy usage consumption.

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جامعة عين شمس
كلية الهندسة
قسم الهندسة المعمارية

استخدام تطبيقات العمارة التفاعلية فى تصميم المباني العامة

رساله مقدمه لنيل درجة الماجستير فى الهندسة المعمارية

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بكالوريوس الهندسه المعماريه ٢٠٠٦ - جامعة عين شمس

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رسالة بعنوان: استخدام تطبيقات العمارة التفاعلية فى تصميم المباني العامة
الدرجة العلمية: ماجستير فى التصميم المعماري

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تاريخ البحث

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الدراسات العليا:

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اجيزت الرسالة بتاريخ

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موافقة مجلس الجامعة

٢٠١٣ / /

موافقة مجلس الكلية

٢٠١٣ / /

إقرار

هذا البحث مقدم إلى جامعة عين شمس للحصول على درجة الماجستير في الهندسة المعمارية .

و قد تم اجراء العمل الذى تحتويه الرسالة بمعرفة الباحثة بقسم العمارة - كلية الهندسة - جامعة عين شمس فى الفترة الواقعة بين ٢٠٠٦-٢٠١٣ . هذا و لم يقدم اى جزء من هذا البحث لنيل مؤهل او درجة علمية من اى كلية او جامعة او معهد علمى اخر.

و هذا إقرار مني بذلك ،،،

التوقيع :

الاسم : دينا سليمان بغدادى

التاريخ : / / ٢٠١٣

ﺧﻠﻔﻴﺔ ﻋﻦ ﺑﺎﺣﺚ

ﺍﻻﺳﻢ :

- ﺩﻳﻨﺎ ﺳﻠﻴﻤﺎﻥ ﺑﻐﺪﺍﺩﻯ ﺳﻠﻴﻤﺎﻥ

ﺗﺎﺭﻳﺦ ﺍﻟﻤﻴﻼﺩ:

- ۱۹۸۴ / ۱ / ۱۱

ﺍﻟﺪﺭﺟﺔ ﺍﻟﻌﻠﻤﻴﺔ:

- ﺑﻜﺎﻟﻮﺭﻳﻮﺱ ﺍﻟﻬﻨﺪﺳﺔ ﻓﻰ ﺍﻟﺘﺼﻤﻴﻢ ﺍﻟﻤﻌﻤﺎﺭﻯ ، ﺑﺘﻘﺪﻳﺮ ﺟﻴﺪ ﺟﺪﺍ ﻣﻊ ﻣﺮﺗﺒﺔ ﺍﻟﺸﺮﻑ

ﺗﺎﺭﻳﺦ ﺍﻟﺘﺨﺮﻳﺞ:

- ﻳﻮﻧﻴﺔ ۲۰۰۶

ﺍﻟﻮﺯﻳﻔﺔ ﺍﻟﺤﺎﻟﻴﺔ:

- ﻣﻬﻨﺪﺳﺔ ﺑﺎﻟﻤﻜﺘﺐ ﺍﻟﻔﻨﻰ ﺑﺸﺮﻛﺔ ﻣﻘﺎﻭﻻﺕ

المستخلص

الطبيعة من حولنا في حالة تغير دائم من اجل ضمان استمرارها و بقائها و يتم ذلك من خلال التفاعل بين مكوناتها. من هنا يتضح ان مبدأ التفاعلية ليس بمستحدث علينا، لكن تم التعامل معه في الالونة الاخيرة فقط من خلال ابحاث ركزت على مفهوم التفاعلية كسمة أساسية لنظم الكمبيوتر التي تسمح بإمكانية عمل نظم معلومات مترابطة و تسمح بتغيرها و إعادة تكوينها بشكل مستمر. في مجال العمارة تم استخدام مبدأ التفاعلية في المجالات التالية: التفاعل من خلال التعرف على التغيرات المحيطة بالفراغ. التفاعل من خلال الوسائل الترفيهية و تنتج تغيرات بصرية و سمعية. التفاعل من خلال مشاطرة الفراغات و التحكم بها لاضفاء نوع من السمة الشخصية على الفراغ. استشعار الفراغات و التفاعل معها من خلال تحدى الحواس. التفاعل من خلال التواصل و مشاركة المعلومات. التفاعل من خلال اعادة تشكيل و تكوين الفراغ.

بناء على التطور التكنولوجى السريع ظهرت معه تغيرات على انماط الحياه اليومية و الثقافية التي تتسم بالتفاعلية . مما يتطلب حلول معمارية قادرة على صنع فراغات ديناميكية قادرة على التفاعل مع المجتمع الحالى و البيئة المحيطة، و اوجد ضرورة على وضع تصاميم تسمح باجراء حوار متبادل بين محتويات الفراغات المعمارية و تسمح بالمرونة وتأخذ في الاعتبار إمكانية ظهور متطلبات فراغية مع الاستخدام.

الهدف من البحث هو تحديد و تعريف مدى تأثير التطبيقات التفاعلية في تصميم المباني العامة و تكوين إطار تحليلى شامل لدراسة مدى استخدام و توظيف مبدأ التفاعلية فى العمارة و كيفية تأثير تلك التطبيقات على اداء المبنى مع بيئته المحيطة و احتياجات المستخدمين.

للوصل إلى ذلك فإن البحث يستهدف اكتشاف و تحديد اسس و مبادئ و ادوات العمارة التفاعلية و وسائل التصميم و التطبيق، بالتالى فان البحث يتناول بالدراسة ما يلى:

- بداية ظهور مبدا التفاعلية فى ستينات القرن الماضى و دراسة الانماط معمارية المصاحبة لذلك و هى الديناميكية و الاستجابة و البيئة الازكية (kinetics, responsive , intelligent environment). تمت دراسة ذلك لتحديد و تعريف المعانى و المفاهيم الأيديولوجية للعمارة التفاعلية و كيفية تطورها مع تطور التكنولوجيا.
- دراسة نظرية "السيبرنيتكس" التي اسست المفاهيم الأيديولوجية لمبدأ التفاعلية و ايضا كانت الاساس لتطور التكنولوجيا الرقمية المسؤولة عن تطوير التطبيقات التفاعلية. دراسة تطور الذكاء الاصطناعي و الواقع الافتراضي و الأدوات التكنولوجية و التي ساعدت على انتاج أنظمة قادرة على التفاعل. هذه الدراسة ساعدت في فهم سبل و إمكانيات استخدام التطبيقات التفاعلية فى المباني العامة.
- تحليل التطبيقات التفاعلية في جميع مجالات التطبيق سواء كانت في وسائل الإعلام أو الفن أو الهندسة المعمارية، لمعرفة المجالات الرئيسية لاستخدامات النظم التفاعلية و العناصر الاساسية للتطبيقات التفاعلية مع الاخذ فى الاعتبار المتطلبات الخاصة للمباني العامة.

- دراسة تأثير التطبيقات التفاعلية فى المباني العامة من خلال عمل دراسة تحليلية لمشاريع مباني عامة تم استخدام تلك التطبيقات بها ، وفقا لإطار تحليلي موضح به المفاهيم الابدولوجية و مبادئ التصميم و الادوات و العناصر الاساسية للتطبيقات التفاعلية و المتطلبات الخاصة للمباني العامة.

فى نهاية البحث تم استخلاص ان التطبيقات التفاعلية تعطى للعمارة فرصة للتعبير عن نفسها بعيدا عن المحددات التقليدية و تحسن من ادائها بالنسبة للبيئة المحيطة و المتطلبات الحديثة للمستخدمين لصنع امكانيات جديدة تلبى الاحتياجات المتغيرة.

كما تم التوصل إلى، حتى الان تقتصر التطبيقات التفاعلية فى المباني و الفراغات العامة على استجابات تكيفية بسيطة و تعديلات فراغية بسيطة ،مع الاخذ فى الاعتبار ان تم التوسع فى استخدام التطبيقات التفاعلية فى مجالات اخرى مثل الاعلام و الفن و كذلك على المستوى التجارب و المسابقات المعمارية مما يمكن استنتاج ان التطبيقات التفاعلية سيتم استخدامها بشكل اكبر قريبا .

نتائج هذا البحث تتلخص فى، أن تطوير التصميم التفاعلي، و تصميم الروابط و تصميم أنظمة الكمبيوتر المستترة فى الفراغ، جزءا لا يتجزأ من تقنيات التصميم الرئيسية التي توجه سلوك مستخدمي الفراغات العام و تؤسس نوع من الحوار معهم ليس فقط من أجل الاستجابة للمتطلبات المختلفة و لكن ايضا لاشراكهم فى جميع أنواع الأنشطة الفراغية.

استخدام تطبيقات العمارة التفاعلية في تصميم المباني العامة

المقدمة

اثر التغيرات التكنولوجية الحديثة على نمط الحياة اليومية حيث أصبحت جزءاً أساسياً من الأنشطة اليومية، فحصل كل فرد على نصيبه الخاص من التكنولوجيا التي منحتها خيارات أوسع لأداء مهمة معينة بسهولة أكثر. ذلك من خلال أجهزة تكنولوجية ظهرت مع عصر تكنولوجيا المعلومات وتطورات وسائل الإعلام والاتصالات الرقمية، مثل تلك الأجهزة هي: إى- باد و اكس- بوكس و تطبيقات الأندرويد و الوتساب، التي تعتمد على مبدأ التفاعل بين المستخدمين من خلال عمل نوع من الحوار لفتح تجارب جديدة للمستخدمين. هذا هو جوهر التفاعل، صنع حلقات تفاعلية تتوسع لصنع تجارب فراغية متنوعة أنت بنتائج مختلفة عن ما هو متوقع من مدخلاتها.

شهدت الأعمار القليلة الماضية تطور سريع في مجال الوسائل الرقمية التفاعلية وأجهزة الاتصالات، وهذا التطور التكنولوجي يهدف إلى كونه أكثر تفاعلاً مع مستخدميه. أثير ذلك على المفاهيم المعمارية لصنع فراغات ديناميكية و قادرة على التكيف و ذكية بقدر كافي لتكون أكثر تفاعلاً مع بيئتها. قد تم اعتبار تلك المفاهيم في العمارة من قبل لكن في الوقت الحالي فقط مع تطور التكنولوجيا الرقمية الحالية أصبحت العمارة قادرة على تحديد كيفية إنتاج تلك المتطلبات.

غالباً ما كان يتم تصميم المباني كاشكال ثابتة قادرة على استيعاب المستخدمين وتوفير فراغات مريحة من خلال التصميم والإضاءة و التحكم الحرارى و الراحة البصرية، و كانت تلك العناصر الشاغلة لتصميم الفراغات المختلفة. التحدى الآن هو كيفية تصميم فراغات قادرة على استيعاب الاحتياجات المتغيرة بشكل دائم من خلال إيجاد فراغات قادرة على التفاعل و التكيف مع الاحتياجات المختلفة.

الهدف الاساسى من العمارة التفاعلية هو صنع فراغات قادرة على تلبية الاحتياجات المتغيرة بناء على متطلبات المستخدمين و البيئة المحيطة. حيث ان العمارة التفاعلية لا تصنع حوار فقط بين المستخدمين بعضهم البعض، ولكن بناء حوار و علاقات بين الفراغات المختلفة للمبنى و المستخدمين.

العمارة التفاعلية هو مجال جديد للبحث و الاستكشاف، و يستخدم في مختلف الأوساط العلمية لتعريف الاساليب المختلفة للتفاعل بين الفراغات الرقمية و المادية. من الناحية التقنية العمارة التفاعلية تبحث في كيفية توفير المعلومات و البيانات عن الحالة الانشائية، و الأثر البيئي، و السلوك البشرى في الفراغات من خلال الحاسب الالى المحيط بالفراغ. بالنسبة للعمارة هذا المجال يظهر امكانيات جديدة لعلوم البناء و الانشآت و كذلك اظهر عناصر جمالية جديدة للفراغات و المباني. اما بالنسبة للمصممين العمارة التفاعلية تفتح افاق جديدة للتواصل مع المباني و البيئة المحيطة من خلال فراغات تسمح بالاستجابة لمتطلبات المستخدم و تسمح ايضا بالتعرف و التفاعل مع المستخدمين بصفة يومية. الهدف الاساسى هو دراسة الانظمة التي تحقق ذلك متمثلة في نظم الحاسب الالى المحيطة بالفراغ، و دراسة نظريات التطبيق و التقنيات التكنولوجية الجديدة التي تحفز النظم المعمارية على التكيف.

نتيجة التغيرات الحياتية و التطورات الثقافية التي تحدث بشكل سريع و متزامن اصبحت هناك ضرورة على تطوير معايير معمارية جديدة تواكب تلك التطورات. لذلك ظهرت ضرورة للفراغات المعمارية لتعزيز طرق من شأنها السماح بإجراء حوار فعال مع مكوناتها، للتعامل مع الاحتياجات المتغيرة للمجتمع بشكل ديناميكي، و القيام بتصميمات تتسم بالمرونة في حالة ظهور متطلبات فراغية جديدة لا يمكن التنبئ بها الا اثناء الاستخدام الفعلي للمبنى مع امكانية تعديل التصميم مع مرور الوقت.

المشكلة البحثية:

سمات وآليات وأدوات التصميم للتطبيقات التفاعلية في مجال العمارة في حاجة إلى الدراسة والبحث لتحديد المفهوم التقني والأدوات التكنولوجية المستخدمة لتطبيقها على نطاق أوسع.

اهداف البحث:

الهدف الرئيسي للبحث هو تحليل و تقييم النواحي المادية للتطبيقات التفاعلية في تصميم المباني العامة الاهداف الفرعية للبحث يمكن تلخيصها كالتالي:

- ١- معرفة الاسس والمفاهيم وراء تطور العمارة التفاعلية وتحديد معناها، من خلال دراسة الاتجاهات المعمارية التي ادت الى التفاعلية و الاعمال السابقة للرواد.
- ٢- دراسة النظريات والأدوات التكنولوجية اللازمة لتصميم التطبيقات التفاعلية في المباني العامة.
- ٣- إمكانية صنع عمارة تتسم بالمرونة وذكية بما فيه الكفاية لتتغير وفقا لمطالب البيئة المحيطة والمستخدمين.
- ٤- دراسة امكانيات التطبيقات التفاعلية المستخدمة مع مراعاة متطلبات تصميم المباني العامة لتحسين اداء الفراغ، و العناصر الجمالية، و التجارب الفراغية.
- ٥- تقييم التطبيقات التفاعلية بناءا على تصميم اطار تحليلي لتحديد معايير التقييم بناءا على متطلبات التصميم للعمارة التفاعلية و المباني العامة
- ٦- تطبيق نموذج التقييم المقترح (الاطار التحليلي) لتقييم المشاريع دراسة حالة بها امثلة لتطبيقات تفاعلية .

فرضيات البحث:

يعتمد البحث على فرضية رئيسية و هي: ان استخدام التطبيقات التفاعلية فى المباني العامة من شأنه تحسين اداء المبنى

محددات البحث:

- يعتمد البحث على دراسة الجوانب المادية فى استخدام التطبيقات التفاعلية لتصميم المباني العامة.
- دراسة و تحليل عينات دراسية لمباني تم استخدام مبادئ و اسس التفاعلية سواء كانت مشاريع قائمة او تحت الدراسة.
- يتأثر هذا البحث بنوعية البيانات ومصادر المعلومات المتاحة لهذا الموضوع، و يعتمد أساسا على الكتابات المنشورة، الأوراق العلمية والأبحاث والمؤتمرات ، وكذلك التجارب العملية وتطبيقات التصميم الدولية.

منهج البحث:

- البحث يعتمد على المنهج التحليلي فى الدراسة و التحليل بناء على الملاحظة و التفسير.
- تطوير نموذج لاطار تحليلي على حالات دراسية لتقييم استخدامات التطبيقات التفاعلية فى المباني العامة.

و قد تم الاستعانة بالعديد من المناهج العلمية موضحة كالاتي:

- الدراسة الاستنباطية فى الفصل الاول : حيث يبدأ البحث بملاحظات شاملة، للتجارب المعمارية السابقة و معرفة مبادئ الانماط المعمارية المؤدية الى مبدأ التفاعلية فى العمارة لمعرفة اسس و مبادئ العمارة التفاعلية.
- الدراسة النظرية فى الفصل الثانى: من خلال عرض و تحليل المفاهيم الايدولوجية و دراسة طرق التصميم و الادوات و التقنيات المستخدمة للتطبيقات التفاعلية .
- دراسة تحليلية / تحليلية مقارنة فى الفصل الثالث: استعراض متطلبات المباني العامة و تحليل و تقييم النظم التفاعلية و العناصر التصميمية اللازمة بهدف استكشاف مدى امكانية تلبية الاحتياجات الوظيفية و البيئية للمباني العامة.
- دراسة تحليلية مقارنة فى الفصل الرابع: من خلال الوصول الى الاطار التحليلي و تطبيقه على حالات دراسية لتقييم استخدامات التطبيقات التفاعلية فى المباني العامة و معرفة مدى تأثيرها

لتحسين اداء المبنى، و توقع ظهور امكانيات جديدة لتصميم المباني إذا ماتم الاستفادة من التجارب العالمية و مواكبة التطور التكنولوجي.

هيكل البحث:

يتكون البحث من خمسة فصول متمثلة في:

- الفصل الاول : اسس و تطور العمارة التفاعلية و يهدف هذا الفصل إلى استعراض بعض التعريفات الخاصة بالعمارة التفاعلية و مراحل تطورها. الممارسة الأولية التي ساعدت على ظهور و استخدام التطبيقات التفاعلية في الهندسة المعمارية و كذلك الانماط المعمارية التي ادت الى العمارة التفاعلية في ظل التطور السريع لوسائل الإعلام الرقمية والتكنولوجيا.
- الفصل الثاني : المفاهيم الايدولوجية و الادوات التقنية المؤثرة في العمارة التفاعلية يهدف هذا الفصل إلى طرح المفاهيم الايدولوجية و التصميمة الاساسية المستخدمة في التطبيقات التفاعلية، و كذلك خطوات و مراحل التصميم و الادوات المستخدمة.
- الفصل الثالث : تحليل استخدامات النظم التفاعلية. يستعرض هذا الفصل امثلة للتطبيقات التفاعلية المستخدمة سواء ان كانت في العمارة ، الفن ، او الاعلام و تحليلها من حيث المفاهيم الاساسية و مراحل التصميم و الادوات المستخدمة، التي تم طرحها في الجزء الاول لاستعراض النظم الرئيسية المستخدمة للتطبيقات التفاعلية و خصائصها مع مراعاة متطلبات المباني العامة.
- الفصل الرابع : استخدام الاطار التحليلي: لتقييم استخدامات التطبيقات التفاعلية في المباني العامة. يهدف هذا الفصل إلى تحليل حالات دراسية لتطبيقات تفاعلية في المباني العامة وقاء الضوء على مدى امكانية تحقيق الاحتياجات البيئية و الوظيفية للمبنى في ظل الخلفية النظرية و الدراسة التطبيقية للبحث.
- الفصل الخامس :الاستنتاجات والتوصيات يعرض هذا الفصل المخرجات البحثية والاستنتاجات المبنية عليها والتوصيات والأبحاث المقترحة في المستقبل .