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ARCHITECTURE IN THE AGE OF INFORMATION TECHNOLOGY

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ABSTRACT

Digital technology is rapidly transforming the field of architecture. Architecture design concepts start to be based on computational methods, which make a radical change in architectural forms, from simple platonic ornamental or maybe fragmented disassociated manually generated forms through physical models or sketches, to unexpected extraordinary forms computationally generated.

Digital technology brought to architectural design various types of devices which support architect in his design studio. This support a basic level (digital design media), an intermediate level (geometric modeling and rendering), or an advanced level (performance simulation,…etc.).

The previous levels of support to the architectural design studio change the ordinary studio a radical change, from a studio of ordinary methods in design, to a new digitally based studio. This new digitally based studio could be classified to; CAD studio, CAD-plus studio, Virtual studio, cyber design studio …..etc.

The new types of design studios start to create, and shape new concepts in architecture based on computational methods generated from the previous studios. These concepts are Parametric, Topological, Animate, Isomorphic, Metamorphic, Performance, and Evolutionary architecture.

The aim of this thesis is to study in an analytical comparative method the radical change brought by the information technology to the architectural concept.

Masters of contemporary architecture, there concepts, there architecture and its classifications will be presented at the end of the thesis.

LIST OF CONTENTS

Abstract

Introduction

List of figures

Part I: Architecture before the Information Technology.

Part II: The Interfere between Information Technology and architecture.

Part III: The change of Architectural design as affected by Information Technology.

LIST OF FIGURES

INTRODUCTION

At the end of the Nineteenth century, it is the information revolution that is metamorphosing architecture. Digital technologies are transforming the nature and the target of architectural think and creativity, blurring the relationships between matter and data, between the real and the virtual and between the organic and the inorganic and leading us to an unstable territory from which rich, innovative forms are emerging.

New types of mysterious forms, characterized by smooth, digitally rendered surfaces, complex curvilinear forms, blob-like objects, shells and skins stretched over wire-frame structures which lead to an already recognizable computer style, starts to attack the contemporary architecture through the work of the students, architectural firms, and the architectural competitions. Despite these new forms in contemporary architecture are recognized from the first sight that it is generated by a computer, its concepts, its methods of creation, its basis, and its ideology stills shows for many architects, a great confusion, an ambiguous and unclear atmosphere.

Through an analytical study this research tries to disclose this architecture with its great difference from the previous architectural movements, and this is done by studying its tools, its design studios, and its concepts with an application on the masters of architecture in this field.

FIELD OF STUDY

The field of study for the thesis is studying the fascinating changes brought by the Information Technology to architecture, and this will be done through studying the following field :-

- Architectural movements before information technology.
- New design studios.
- New concepts in architecture.

- Masters of digital architecture, with their concepts, and their ideology.

RESEARCH OBJECTIVES

Research objective can be explained the following points;-

Objective 1:-

The aim is to study how has been architecture changed by the Information Technology ?

Objective 2:-

The architecture concepts of architecture in the age of information technology with its classifications, its concepts, and what are the most concept used in design.

METHODOLOGY

The methodology of the study will follow the Analytical methodology in order to show how the information technology affects architecture.

Part I: Architecture before the Information Technology.

Chapter 1
Architectural Movements

Chapter 1: Architectural Movements.

1-1 Modern architecture

Modern architectural movement reflected clearly social, economical, political, cultural changes in the 20th century, by using; all possible technological means, all new materials (glass, iron, and concrete).

This architecture was actually a moral force and a philosophical investigation. It represented the strongest form of protest against the past (with its ordinary architecture) by breaking down the old traditional styles with its restrictions, its decorations, and its old mentality. Walter Gropius (famous architect of modern architecture) summed up his own insight about this architecture as follows, "We have had enough of the arbitrary imitation of historical styles. In a continuous development away from architectural caprices and whimsy and toward the dictates of a constructive logic, we have learned to express the life of our epoch in pure, simplified forms." [1]

Modernism, as a movement gained its basis from economic necessity. After the end of the world war, vast areas of Europe and Asia lied in ruins, this made the economic necessity could no longer be ignored (particularly in the area of housing) by making the priority to find a way of putting a roof over the heads of millions of people, as quickly as possible. Many architects and town planners regarded -with a concealed joy- the destruction left by the war, and the need of rebuilding there cities economically as a good atmosphere to start a new architectural movement free form the old constrains. [2]

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1   Heinrich Klotz, <u>The history of postmodern architecture</u>, the MIT Press Cambridge, London, England, 1988. p.8.
2   Jan Gympel, <u>The story of architecture form antiquity to the present,</u> Kőnemann, 1996.

Later on, the functionalism that developed after the second war in response to the rebuilding of economy, had turned against the aesthetic aspect of the Modernism movement.

1-1-2 Ideological:

The ideology of modern architecture can be explained as follows:

- **Modern architecture was not simply a style, but more of an attitude.** A determination to break the past and free the architect from the stifling rules of convention and etiquette.
- **Buildings were functional machines for performing various programs**. One of the principal ideas driving modern architecture was that building should be first and foremost functional machines.
- **The modern architecture showed a great contradictions between various styles of its architects, but all of them reflected the protest against the old (but with different mentalities).**
  Architects like Mies Van Der Roche, created new forms of architecture to represent the new age of machine, by selecting the most primitive forms (machine like aesthetic that brooked no decoration). He thought that an architect could create and shape an aesthetic from the minimal form, aiming to find a new kind of aesthetic.
   Others, like Le Corbusier saw in modernism a new form of lyrical expression, where the potentials of new materials like concrete could create new forms.
  As the century progressed this contradiction and division in the ranks became increasingly clear.

1-1-3 Stylistic:

- **Straight forward.** The rational ideology of modernism architects reflected on there work to produce a straight forward architectural style.
- **Simplicity.** The use of the simplest kinds of forms appeared clearly by using structural elements without any contradictions or verbosity.
- **Isotropic space.** The appearance of new structural systems facilitated existence of large universal spaces, which was divided with temporary partitions.
- **Abstract form.** Primitive shapes were used as forms.
- **Purist.** The style of modernism architect was clear and pure; it was not affected with any other kind of previous architecture neither in general forms nor in details.
- **Anti-ornament.** There was no sign anywhere of the heaviness of monumental architecture. neither the bottom-heavy pedestals nor the cornices. There were no pilasters, colonnades, and even no slight piece of an ornament that might evoke the memory of classical architecture. Modernism architects regarded empty white walls as walls richer in content than the vast use of ornaments in the old walls.
- **Anti-representational.** Modern architect inspired his concept from rationality.
- **Anti-Metaphor.**
- **Anti-historical memory.** New materials like steel and transparent glass were used with a great accuracy, to emphasize the rejection of the historical memory.

1-1-3 Design ideas:

- **Transparency and lightness**. Light and shadow were used as an essential basis to provide expressive terms for modernism

- **Creating aesthetic from the structure**. Despite of the contradiction between the two aspects (aesthetic and structure), aesthetics was created from structural systems. This was clear in buildings of Mies Van Der Roche, especially in his skyscrapers where the grid in his elevations was constructed with load-bearing skeleton.
- **Appearance of endless façade**. The horizontal extension in skyscrapers was emphasized by horizontal marble stripes.
- **Asymmetrical elevation**. This was clear in the works of Le Corbusier, where the balanced asymmetry replaced the ordinary classical symmetry.
- **Gardens augmented buildings.** Ideas like roof gardens, gardens instead of ground floor, were created by architects like Le Corbusier.
- **Harmonious integration with surroundings**. Architects like Frank Lloyd Wright, thought that a building should integrate with the surrounding, by using natural materials like, stones, and wood.
- **Open ground floor plan.**

1-2 Late-Modernism:

The 1960's saw the emergence of the idea "building as a technically organized work of art". [1] This movement so-called "high-tech architecture".
"Late-Modernism takes Modern architecture to an extreme in order to overcome its monotony and the public's boredom with it: in this it is like other late styles coping with aesthetic fatigue".[1]

It was historically rooted in Joseph Paxton's Crystal palace of 1851 (an industrial building) and other industrial buildings of the 19th century. However, the former approach of deriving the form from the fulfillment of structural requirements and accentuation of character was continued only by a few architects after the Second World War, until this movement started. [2] Since the construction of Crystal palace, the maximum realization of the external wall as a glass skin remained the dominant topic in high-tech architecture.

Late-modernism main concern was using structural requirements, and new high tech materials, as a source for aesthetic. This architecture reflected mainly the potentials of the new technology in creating prefabricated, light weighted materials with great potentials in structure (like tension cables, and new kinds of steel with new cross sections).

This movement tended only to be applied in office blocks, large halls and similar structures, due to the high costs arising from such extreme designs. It was architecture for the elite, professional, and hardly to spread due to its highly cost, its need to sophisticated technology, sophisticated designs (structure), fabrication, and well trained workers.

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1   Charles Jencks, <u>Architecture today</u>, Abrams, 1982.
2   Jan Gympel, <u>The story of architecture form antiquity to the present,</u> Kőnemann, 1996.

1-2-1 Ideological:

- **Unconscious style.** The ideology of this movement appeared, to reflect the new potentials of the new technology.
- **Old elements of modernism were taken to an extreme**. This elements was logic, technique, circulation, repetition mechanical services, structure, and construction.
- **Loose fit.**
- **Late-Capitalist.** This movement reflected the progression in the west countries with its capitalist, its progression in technology, its potentials in industry.
- **Suppressed artist.** It reflected the ideology of a hesitated artist. It was modern architecture, with an overlap of the modern technology.
- **Elitist Professional.** it was architecture for the elite.

1-2-2 Stylistic:

- **Slick tech.** There was an exaggeration of technological image toward the glossy and ultra smooth, by the use of steel Sheets, polished Aluminum, glistening plastic, bright enamel and mirror-plate glass. Late-modernism buildings often achieve an oily wet- look, smoky mixture in which highlights and darkness blend into each other without distinct transition. In short, Slick Tech style of Late-modernism replaced the straightforward expression of modern architecture. [1]
- **Complex Simplicity and ambiguous references.** The style of this movement reflected the celebration of structural engineering as seen through the eyes of architects. They used steel works columns, beams, pipes, and ducts as a form of decoration .
- **Extreme isotropic space & flatness.**

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1 Jonathan Glance, 20<u>th</u> Century Architecture, Carlton Publisher, 1998.

- **Simple forms were used.** The forms were mainly the primitive shapes, such as cubes, boxes, and spheres, without any extensions.
- **Extreme repetition & purist.** The repetition was clear in this movement, because it depended mainly on the structural appearance, by showing its polished columns, and beams.
- **Extreme Articulation.** The articulation of the surface into "skin and bones", repeated joints, and the complex details, was clear.

1-2-3 Design ideas

- **Emphasizing the structural concept as a major design concept.** The structural concept became a piece of sculptural, in the form of machine.
- **Irrational Grid.**
- **Architecture became like clothing, or like a responsive robot fulfilling every individual wish.**
- **Enclosed skin volumes**.
- **Extruded building.**
- **Literal transparency & Multi layer.**
- **Tends to symmetry& formal rotation, mirroring& series.**
- **Forced harmonization.**

1-3 Post-modernism

The "post-modern" architecture had its roots in the 1960's It tried to breathe a new life into the modern language of modern architecture, a language which many people found it monotonous. Postmodernism was response to the lack of inherent meaning in the abstract forms of the Modernists.

"The pioneers of post-modern architecture dismissed their predecessors to the same extents as modernists rejected theirs". [1] Clearly, the Postmodernists retained many of the ideas of the Modernists but they supposed an identity, where the Modernists rejected history the Postmodernists reinterpreted the works of the past.

Robert Venturi (Post-Modernism architect) summarized Postmodernism movement as follows, "If there was one point that was emphasized in Postmodernism, it was that a building must fit in with its surrounding and enter into a dialogue with it. Modern architecture, it was generally opinioned, had nothing to say and thus remained silent." [1] Post-Modernism reacted against the visual dullness of modernism, by combining the modern language with another one, one-half Modern and one-half something else (often traditional building), in an attempt to communicate with both the public and a concerned minority (usually architects).[2]

Generally, Balanced asymmetry was replaced with a return to classical symmetry; the transparent wall was replaced with a return to the traditional small windows. The absence of decoration was replaced with a return to applied ornament. *Mies van Der Rohe*'s "less is more" was no longer applied, and was replaced instead with *Robert Venturi*'s pronouncement that "less is a bore".

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1   Jan Gympel, <u>The story of architecture form antiquity to the present,</u> Kőnemann, 1996.
2   Charles Jencks, <u>Architecture today</u>, Abrams, 1982.

Venturi expressed his general criticism of modernist architecture in his book "complexity and contradiction in architecture".

1-3-1 Ideological

- **Double-coding of Design.** "part Modern and part something else: vernacular, revivalist, local, commercial, metaphorical, or contextual. In several important instances it was also doubly coded in the sense that it used to speak on two levels at once : to a concerned minority of architects, an elite who recognized the distinction of a fast changing language, and to the inhabitants, users, or passersby, who wanted only to understand it and to enjoy it." [1]
- **"Popular" and pluralist**. Its ideology was for the popular; the style which evoked the memory of the classical architecture. The classical architecture which the popular missed it, now appeared again in a new appearance (to reflect the new potentials).
- **Artist/client.**   Post modernism style was for the satisfaction of the architects, artists, and the client all of them was satisfied with this style, in contradictory with the modern architecture which was for architects only.
- **Semiotic form,** its form was a combination of the modernism style with motifs from other architecture, maybe Roman, Gothic or any other historical architecture.
- **Elitist and participative.**

1-3-2 Stylistic

- **Hybrid expression.** This style was mainly a hybridization between different, or similar styles maybe in motifs, colors, or ornaments

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1   Charles Jencks, <u>Architecture today</u>, Abrams, 1982. P. 111.

- **Complexity.** Since this architecture was a combination and a collage, between different types of architecture, the resultant style appeared a very complex style.
- **Variable space surprises.** Architects increasingly indulged in more and more bizarre and senseless games; false walls on top of residential building, staircases leading nowhere, arches which could be neither walked nor driven through, living spaces with slanting walls, or completely complex plans which was forced into deep structures. [1]
- **Eclectic.**
- **Semiotic articulation.**
- **Variable mixed aesthetic depending on context**. Expression of content and semantic appropriateness toward function.
- **Pro-organic and applied ornament.**
- **Pro-representation.** The desire to win the approval of the observer led the post-modern architects to produce increasingly showy designs, so they started to design functionless parts, and individual vanity was prized above functional fulfillment.
- **Pro-metaphor.**
- **Pro-historical reference.**
- **Conventional and abstract form.**
- **Pro-symbolic.**

1-3-3 Design Ideas

- **Skew space and extensions,**
- **Tends to asymmetrical symmetry.**
- **Collage/collision.**
- **Large icons,** the use of large icons on the façade even if it was useless.
- **False facades.** The use of successive false useless facades.

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1   Jan Gympel, <u>The story of architecture form antiquity to the present,</u> Kőnemann, 1996. P. 106.

1-4 Deconstruction

Around 1990, post-modern architecture was replaced as a focus of media attention by "deconstruction". This style was named after an exhibition entitled "denconstructivist architecture" organized in New York, which aimed to establish this new style.

Presentatives of this new style developed an elite formal language based on the philosophy of *Jacques Derridas* (A French philosopher, searched for the "ultimate truths of human existence", and he was influenced by the ideas of *Friedrich Nietzsche* and *Martin Heiddegger*). This took the abstraction of modernism to the extreme and mainly worked on the principle of exaggeration of familiar motifs. The movement was assigned by its interpreters to the intellectual context of modernism, and was thus also known as the New Modernism.

However, like the post-modernists the Deconstructionists also searched for prominent, spectacular from, which expressed their opposition to structural and decorative norms and does not take into account the fulfillment of functional requirements. The mentality for deconstruction was "from follows a fantasy", which was said by *Bernhard Tschumi* and derived from *Mies Van Der Roche* famous maxim "from follows function". [1]

The most important concept of Deconstructivism, was the concept of "disturbed perfection". The buildings of Deconstructivism "often looked like somebody was playing with building bricks, using an extremely varied model construction kit or match sticks and accidentally bumped into the table. This caused everything to slip and shift, and the resulting form was then used as a model. Linear and small elements are often found next to monstrous oversized elements, with the result that the structure appears weak. As if it was liable to collapse at any

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1   Jan Gympel, The story of architecture form antiquity to the present, Kőnemann, 1996.

minute. The architecture of deconstruction tries to use all these means to upset the unquestioning daily perception of architecture, and through this alienation make architecture capable of being experienced in a new and more direct way as an art."[1]

In short, New Modernism architecture (Deconstruction) was the Deconstructive of modern forms and ideas, often fragmented and dissonant in form, self-contradictory by intention, anti- humanist and spatially explosive. Often the intention was to weave opposites together and deconstruct traditions from the inside, in order to highlight difference, and the alienation from the cosmos. [2]

1-4-1 Ideological

- **Revolutionary Challenging.** "Deconstructionists can be defined as a group of architects who challenge every fixed notion. They have revolutionary ideas and try to test new boundaries and possibilities."[1]
- **Digging in the Unconscious.** Architects tried to represent what was hidden in their conscience through their designs.
- **Complexity between order and chaos.**
- **Anti-Humanist.** The deconstruction architecture was Anti-Humanist which is against the basic function of architecture. Deconstructionists did not believe in the humanism, they generally presented there own work to justify their own self-desires and ideas away form architectural fixed constraints.
- **Opposition.** Architects played with oppositions in their conceptual ideas for their projects. (Memory/anti-memory, inside/outside, place of no place).

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1 Jan Gympel, <u>The story of architecture form antiquity to the present,</u> Kőnemann, 1996. p.108.
2 Charles Jencks & Karl Kropf, <u>Theories and Manifestoes of Contemporary Architecture</u>, op.cit.
3 Zeinab Abd El-Ghaffar, <u>The Meaning of Deconstruction in Architecture,</u> Master of Science Degree in Architecture, Ain Shams University.

- **Hidden concept.** Most of the architects of this approach believed that there buildings must reflect a hidden concept,
- or must narrate a certain story.
- **Poly-functionality, or had no function.** Architects designed a functionless buildings, or a multifunctional buildings.
- **Design idea more important than form, and function.**
- **Meaningless volumes.** Incomplete forms were used in the projects of Deconstruction.

1-4-2 Stylistic

- **Fragmentation, disassociation, and layering.** The style of this architectural approach resembled ruins, due to the use of linear objects, with planar objects, in a disassociated fragmented way.
- **New Deco Elements.** Deconstructionists used new elements in their designs.
- **Superimposition.** the use of overlapped elements which showed a great complexity.
- **Juxtaposition.** the use of different materials, elements, contradictions, beside each other.
- **Clashing style, explosive forms.**
- **Reflected Anti-gravity,** the architects used elements like cut-out columns, beams, and slabs.

1-4-3 Design Ideas

- **Abstraction-Representation**.
- **Presence/Absence-Anti-memory.** Architects tried to find something that was no longer found.
- **Texts-Scene-Experience and Events.** Deconstructionists tended to make a story of their designs and buildings.

- **Anti-form/Hierarchy/Structure.** In modern architecture (Modernism) form followed function, but in the Deconstruction form followed fantasy.
- **Shocking/Unpredictability.**
- **Disorientation out of location.** Jewish Deconstructionists used ideas like disorientation out of location as concepts in their designs.
- **Presence and absence.** Architects used present objects or symbols in their projects to remind people with absent events, or things.
- **Text, and events.** Architects used concepts derived from poems, events.

PART II
The Intertwinement between Information Technology and architecture.

Chapter 2
An Interface about the Information Technology.

Chapter 2: An Interface about the Information Technology.

2-1 Historical background

The telephone was invented by Bell in 1876, the radio by Marconi in 1898, the first programmable computer and transistor invented in 1974. This invention enabled the processing of electric impulses in a binary mode at a fast pace. later on, further development of processing of electric devices in semiconductors and cheap occurred. In 1971, Intel's breakthrough with a computer on a chip or a microprocessor increased both the capability and portability of information processing power. The computer, as the mother of all technologies since the Second World War, was firmly and irrevocably established.

The timeline for information technology industry describes a four-phase evolution [1] :

  i.   A systems-centric system between 1964 and 1981,
  ii. A personal computer-centric system between 1981 and 1994,
  iii. a network-centric system between 1994 and 2005.
  iv. A projected content-centric system between 2005 and 2015,

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1   David Moschella, Waves of Power: Dynamics of Global Technological Leadership 1964-2010, New York AMACON, a division of American Management Associates, 1997.

	Systems-centric 1964–1981	PC-centric 1981–1994	Network-centric 1994–2005	Content-centric 2005–2015
Users	Business	Professional	Consumer	Individual
Technology	Transistor	Microprocessor	Communications bandwidth	Software
Law	Grosch	Moore	Metcalfe	Transformation
Network focus	Data centre	LANs	Public networks	Transparency
Supplier structure	Vertical integration	Horizontal integration	Converged horizontal	Embedded
Supplier leadership	US systems	US components	National carriers	Content providers

Fig 2. 1   A timeline for the information technology industry
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2-3 Describing the phenomenon of IT

The IT is now almost everywhere, it is at hand and in sight. It is used, it is seen, and everybody rely on it for many of his daily activities. Yet, what is 'it' that is in sight and at hand?

The first answer to the question of 'What is IT?', IT is computers. "Today IT is the computer" [1]. In order to capture the common and most acceptable contemporary meaning of the word IT, rely is going to be on a sample of widely accepted definitions, particularly in respected dictionaries.
IT is said to be "the technology in the recording, storage, processing, communicating and spreading of information, using computers, microelectronics and telecommunications." [2] and the study or "the use of processes, computers and other electronic means for storing, and sending information." [3]
In general, IT is the "practical applications of computer systems" [4]

1   Albert Borgmann, Holding on to reality: The nature of information at the turn of the Millenium, the university of Chicago press: Chicago and London, 1999. P.166.
2   OERD, The Oxford English Reference Dictionary, Oxford University Press, UK, 1996.
3   OPDT, Edited by Julia Elliot, Oxford Paperback Dictionary & Thesaurus, Oxford University Press: Oxford, New York, 1997. P.388.
4   OPE, Oxford Paperback Dictionary, Oxford University Press: Oxford, New York, 1998.

Many items either devices or services keep on appearing can be called IT: Television, video, DVD, high-definition TV, VHS devices, videotext, Internet, electronic mail, servers, mainframes, desktop, and laptop computers, disks, phones and mobile phones, mobile data, text, sound, and video, paging, video conference, fax, electronic communications gear, copying and printing machines, photo apparatus hardware infrastructures , software applications peripherals for all of these devices. In short, IT is described as the kind of technology that acts on information (Borgman 1999, Castells 2000) through devices which capture, store, process, and distribute text, numbers, sounds, images, and any combination of these.

IT mainly shows (physically) "up as a multitude of physical devices. IT shows up as a material object mostly made of metal and plastic. Inside their surfaces, where buttons and a diverse set of commands show up in order for us to push them as appropriate, there lie complex pieces of electronic engineering, which powered by electricity make the machines run. Noetically, each device belongs to its own place, which is in accordance with referential whole. Within the referential whole the device gains its meaning, as something. Bearing this in mind, we now refer to key aspects of descriptions of three of the most IT devices: the PC, the television set, and the mobile phone."

So far, the definitions and the appearance of IT were described, but not yet what IT is. IT appears as a collection of devices united by the fact that they are all IT, which is a concept independent of any particular IT device. "IT is an open collection of physical devices situated at appropriated contexts because they already presuppose a form of life in which they are meaningful."

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1   Albert Borgmann, Holding on to reality: The nature of information at the turn of the Millenium, the university of Chicago press: Chicago and London, 1999. P.166.
2   OERD, The Oxford English Reference Dictionary, Oxford University Press, UK, 1996.

Considering a PC, TV, or mobile phone as an IT device implies a previous idea of IT itself. Thus, the concept of IT is the first mode in which the phenomenon appears. "IT devices are united in a synthesis of identification" (Husserl 1995:39-41) that shows them in their togetherness. IT is therefore more than only IT devices.
IT is the precisely that which characterizes those devices as IT devices. This makes a step closer to the essence of the IT, which might sound rather paradoxical at this descriptive phase.

Do IT devices imply in their appearances anything that is common, defining to all of them, which would be essential to IT? As the description of IT have yet penetrated the realm of essences, the logic answer at this stage would be NO.
The real answer to the above question is actually YES, there is something common and to some extent fundamental, about the computer, TV, mobile, phone, and too many other IT devices: the screen. The immersion of screens in IT, the screen might be closely related to the essential nature of the phenomenon of IT.
People act on, and with, most information technologies by observing and touching screens. The screen is the typical interface of IT. The screen shows and informs the people what is going on, it shows the actual situation, and the options for action.
"This means that the screen might be closely related to the essential nature of the phenomenon of IT. Their monumental presence of the screen in the modern life shows that the screen has much the meaning of being the skin of IT."

IT devices attract attention and physical presence as well. They provide relevance for everybody. Their mode of being is ready-to-hand, as they are in a world in always-already-are.

IT devices gather the people that surround them, and shape their actions. For example, the people all over the country, or the world, are watching the same TV program (McLuhan 1994).

Actions of these persons are shaped by the PC or TV, by the conversation that is going on the phone, by the kind of data presented, by the different understanding of the data, all of which affects the attitudes.

These initial lines have touched on an obvious feature of the phenomenon under investigation: IT is not an object, but many objects. IT always appears as IT-and-something-else: experiencing a computer is experiencing IT, watching TV, is feeling of what IT is; in using a mobile phone, IT is being used, and so forth.

2-4 Investigating the essence of IT

The investigation opened the contours of the essence of IT: the entanglement between IT and being-in-the-world.

The content of IT is evidently information and technology. Either IT refers to technologies as they are related to information as it is related to technologies, or, indeed, to both of the aspects. How do these two phenomena merge in a new one? Is there any supremacy of one phenomenon over the other? Does IT refer to information through technology or to technology through information?

A cross checking what was found in the analysis of technology and information. Some questions were done to check the phenomenon of information and the description of the IT:

- Does IT, or do IT devices, involve or refer to meaning? Do IT devices inform us? Do they present us differences that guide and influence us?
- Is IT included in a worldly unfolding in which the people face distinctions and perturbations?
- Does IT mediate data?
- Is IT related to people's activities in the world?

The answers to all these questions are yes.

Other questions were done to check enframing and the findings of the description of IT:

- Is IT based upon the revealing of the real?
- Do IT devices suggest some kind of a framework for the matters to which it relates?
- Does IT refer to the real?
- Does IT participate in some kind of an ordering process of our activities in the world?
- Does IT support efficiency?
- Does IT help beings to be addressed within a stand-by-ness?

- Can beings be called by IT?

Again, the answer to all of these questions is yes. IT is related both to the essence of technology and to the essence of information. Yet, IT does not show itself as two phenomena, but rather as one. IT is IT. In itself, IT is not only or essentially either information or technology but something different. Acting on information IT technologies information. In/With IT information becomes technological "*technological information could simply be defined as the object of information technology*" (Borgmann 1999:166

The meaning of the real, in the sense of the world in which people always already find themselves, is identifiable as to remain orderable. It keeps the essential revealing of enframing. As a systematic way of making present meaning- as a system of information – IT changes the perception of the real, which is equal to say that it changes reality. Everything said, observed, perceived, is always said, observed, perceived, by someone (Maturing and Varela 1980, 1992).

"*Reality, as experienced, has always been virtual because it is always perceived through symbols that frame practice with some meaning that escapes their strict semantic definition*"(Castells 2000:403). "*Thus there is no separation between reality and symbolic representation*" (ibid.).

The perception of reality depends upon the structure of information, which is substantively affected by IT.

It must be noted that as the IT phenomenon is absorbed in the world and its name has been changing from IT, information technology, to IS, information systems. This change of name points to a deeper engagement of us in the phenomenon of IT.

This change of the name points to a progressive and deeper absorption of the ontological revealing that IT is. It opens up a specific direction in which the appropriation of IT is to unfold: its systematic and systemic character.

These standard notion of IT and IS (many others would serve as well) show how the notion of system addresses the way in which IT is penetrating not only the assumed external and objective world but rather the very phenomenon of the in-the-world , of our lives as we live them. In short, IS is how with IT. IS is IT in the world.

Within a system of information being is revealed. Being is bound together constructively in a system, presenting itself as something 'clear', and thus requiring no further justification (Heidegger 1962:60). IT is receiving the name of IS because as an ontological revealing IT is essentially a background against which that which IS appears. IT grounds what appears as a system of information:

IT	IS	Words pointing to the engagement of IT in the world
The enabling mechanism which facilitates the processing and flow of information. (Peppard 1993:5)	The flow of information in an organisation and between organisations (Peppard 1993:4)	... in an organisation... ... between organisations...
Computers, computers software, files, database management, communications. (Lucas 1990:109 ffs.)	A set of organized procedures that, when executed, provides information to support the organization. (Lucas 1990:15)	...organized procedures... ...when executed... ...support the organization...
Processing information technology, system software and programming language, data storage and processing, database management systems, communications and distributed processing. (Hicks 1993:215 ffs.)	A formalized computer information system that can collect, store, process, and report data from various sources to provide the information necessary for management decision making (Hicks 1993:2)	... formalized ... ... to provide ... ... necessary for ... ... management ... ... decision makings ...
Comprises, besides all shapes and sizes of computers, automation technologies and communications. (Earl 1989:ix)	IS strategy is defined as the long-term directional plan which decides what to do with IT. (Earl 1989:67)	... long-term... directional plan ... ... what to do ...

Fig. 2.2 IS is IT –in- the- world

"It is a system in which reality itself (that is, people's material symbolic existence) is entirely captured, fully immersed in a virtual image setting, in the world of make believe, in which appearances are not just on the screen through which experience is communicated, but they become the experience. All messages of all kinds become enclosed in the medium because the medium has become so comprehensive , so diversified , so malleable that it adsorbs in the same multimedia the whole of human experience, past, present, and future, as in that unique point of the universe that Jorge Luis Borges called "Aleph" (Castells 2000:404 from the original).

The ITised background discloses the real because every real is disclosed against a background. As a substituting background IT replaces reality- essentially IT is this ontological replacement. "*Information gets more and more detached from reality and in the end is offered as something that rivals and replaces reality*" (Borgmann 1999:182). "*The new media – that IT is – are bridges between man and nature; they are nature*" (…) they "*are not ways of relating us to the old "real" world; they are the real world*" (Mcluhan 1995:272). This detachment of information from, so to speak, natural nature, is achieved in that technological "information holds on its own its self-realising" (Borgmann 1999:182), by referring and being referred to signs within the technological information situation.

2-5 Watching modes in which the essence of IT appears:

Firstly, let's think, how would life survive without IT?

A formally correct answer is that, that world would indeed be another world, which means that IT replaces reality. For example, without IT nobody would ever have seen images of the earth taken from the moon, because man would never have gone there. The moon would still stand in the sky above us, as a mystery. The possibilities for being that IT has brought to us, and the way in which these possibilities address the whole earth and the all of human activities, is the dominating character of IT ness. It is in accordance with the possibilities revealed by IT ness as background that the real is being experienced by man.

Revealing the real IT determines the relation of man to that which exists.

"*Through technology the entire globe is today embraced and held fast in a kind of being experienced in western fashion and represented on the epistemological models of European metaphysics and science*" (Heidegger 1984:175).

Replacement is achieved by the gathering of all information about reality in one well-ordered information space (ibid). The prototype of this space, an appearance of the essence of IT, is today the internet and its logic of navigation, hypertext, and search engines (ibid).

This replacing power concealed in modern technology "rules the whole earth" (Heidegger 1966:50). Ruling the whole earth, it reveals what is the earth as such. The earth, our world, is now united in the globe. The answer is everywhere, not only as a present-at-hand entity, but already as a ready-to-hand being. Replacement reveals the earth as a globe.

As the earth is ITised it becomes global. By making the global, IT makes all human activities globalised. The Globalised world is that on the basis of which the possibilities for being are now revealed in our lives.

The essence of IT is clear by the transformation of earth to the globe.

The globe hanging suspended in space is nowadays the most common and ready-to-hand equipment of our daily coping. The globe is now part, a constitutive element, of being-in-the-world. Wherever anyone looks the picture of this age become clear for him: on the TV channels' logos and news bulletins (e.g., CNN, BBC, CBS, ABC, TVE, TF1), on a significant percentage of the advertising material that runs in magazines and newspapers, in the material of international organizations (e.g., UN, OECD, WB, IMF, Greenpeace). This is the appearance of the essence of IT.

Due to the essence of IT the globe is formed, and this globe is a background of our action in-the-world. What is seen is not a picture, which, paradoxically, was only seen by a very few men, but the collective appropriation of the meaning of that image and perspective in human activities. This human embodiment of the globe hanging suspended in space is what is ordinarily called globalization.

In globalization the essence of IT addresses the real. Replacement unfolds in globalization. Thus, globalization is not a phenomenon of the economy, of the markets, of politics, of culture, or of any other kind of human activity.

Globalization is an aspect of the essence of IT, which as ontological has primacy over all the other aspects characteristic of the present epoch, it is how man is making sense of the world today.

For example, the recent events of September 11, 2001, in the USA, are another example of the unfolding of this globalization of everything. The underlying logic of that new kind terror is nearly global. Its global operational reach is just a corollary of something more important and previous to it: the global perspective.

The common representation of
the phenomenon of the globe
hanging suspended in space

The representation of the
phenomenon of the globe hanging
suspended in space as it is

The world is the globe, an object in space, an object identified, delimited, and isolated. The globe is the object, man is the subject. This can be verified by a closer look at an icon of the epoch. Let refer to CNN's Globe (CNN 2001).

The globe for example, appears in CNN's homepage and its TV channel's programs, contextualized by other type of signs. While many signs disclose the subjects in which CNN is involved, the globe provides the perspective in which those subjects are addressed: globally. To address an issue globally is to cover it anywhere on earth; it is to consider the whole earth as the relevant arena. CNN surveys the whole world as if from outer space and offers us the latest and the relevant news. Headline news, political news, financial news, sports news, cultural news, and so forth, are the issues that matter; global, is the perspective, in which all of them matter. The global perspective under which CNN makes sense, turns the words into an object, and reveals itself as an always running information system.

The global perspective means an addressing of the world from space, that is, man's activities in the world disclose their meaning

while addressed, so to speak, from outside the world . Yet, as it is obvious that man is not in outer space, he is in the world, that picture of the globe might point to other matters as well. The out of the world perspective is a main, statement of the totality in which reality makes sense today. The world is the globe. A globe is a "spherical object" (OPDT:319), as such it is something delimited- it is spherical- and objectified.

Within the essence of IT, that is, as replacement unfolds, the world is turned into an object surveyed, monitored, controlled, dominated by man. This is a fundamental appearance of the essence of IT. The totalizing rationale of IT is fully disclosed in the global perspective.

| Millions of years ago | 100,000 | 0 | today |
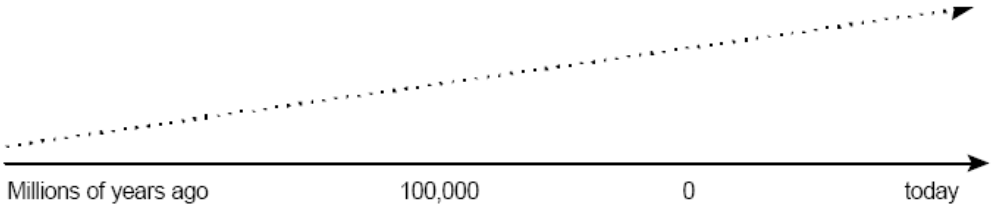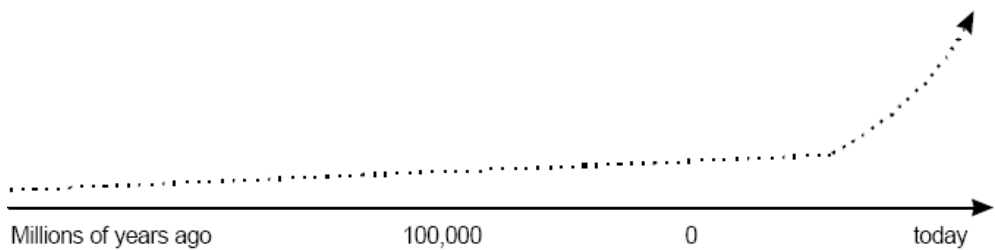
Usually everyone think of the history of man, of his evolution in the last few hundreds of thousand years, as something represented in figure .

However when one considers the kind of events that marked and shaped human evolution, taking into account what counts in drawing the picture above, we would rather consider a curve such as the following:
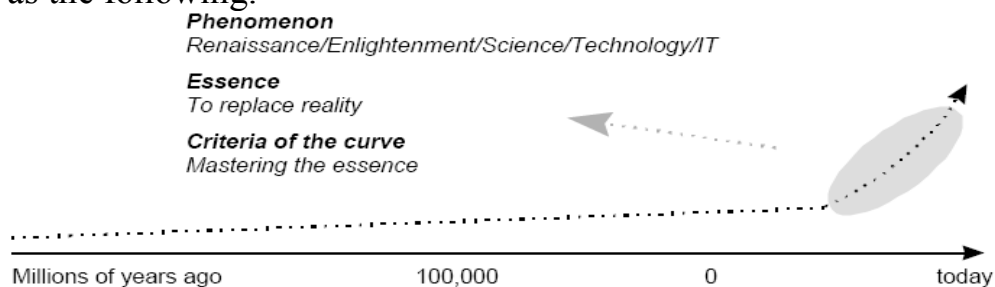
Thus, the way to understand fully the chart is an investigation into the essence of the phenomenon that establishes the rising slope of the curve. The interpretation is that that essence is replacement.

IT and globalization go hand in hand. In some cases IT is pointed out as an enabler or as a promoter of globalization. In other cases it is just indicated as a result of the spreading of IT. This investigation aims at uncovering a deeper relation that links both phenomena. Essentially IT and globalization are the same phenomenon: replacement. "*Information is globalization*" (Anderson 2001:205) Let 's address this observation with an example.

"*Our daily lives are performed within an encompassing information technological milieu*" (Cooper 1991:27). People are

awakened by a digital clock radio, they check the email or read the news on the computer, while driving to the office they phone to clients, partners, and so on. At the office the matters in which they are involved come forward on screens. Action is taken by email, over the phone by video conferencing, on account of previously monitored computerized charts and tables. How the company is going on a symbol stock exchange data shown on TVs and computers all over the place. As the manager withdraws from action he thinks IT: new ITized products, new ITized clients, and new ITized competition.

An obvious appearance of the essence of IT is the emergence of a whole new sector of economic activity. IT appears not as a new activity, or business, as it were, as a vast set of newer and new activities. Chakravathy (1997) calls Infocom to this phenomenon that united industries related to information and communication. He claims that Infocom is organized around many clusters: Information providers (media, film, music, publishing), information processors (computer and office equipment and services), communication support (telecommunication equipment and consumer electronic manufacturers) (ibid.). These activities in establishing a whole new realm of human contemporary action in the world, that adds and to a great extent substitutes agriculture, industry, and services, are in themselves an evident appearance of the replacement under way .

Chapter 3: New design tools in the age of Information Technology and its applications in the design studio.

Chapter 3: New design tools in the age Information Technology.

3-1 Introduction

Information technology is the set of tools used by an information system or its participants to perform work; it is the hardware and software used by information systems. It is important to understand that information technology has no effect unless it is used within an information process. To be effective, the information technology must be able to support the information process.

3-2 Computers

Hardware is the physical equipment involved in processing information, such as a computer, network cables and data storage devices. It refers to objects that you can see and hold. Computers often form the basic hardware of an information system. **Computers** are electronic devices that can process data according to stored sequences of instructions. They have five basic functions: input, processing, storage, control and output.

- **Input** involves entering data into the computer. A device designed to assist the entry of data is called an input device. Input devices include the keyboard, mouse, scanner, digital camera, video camera and microphone.
- **Processing** changes data to produce information by following a series of instructions. Processing is performed by the computer's central processing unit (CPU). The CPU is the 'brain' of the computer. It takes the data from an input device, changes it to produce information and sends it to an output device to be displayed to the user.

Storage involves retaining data over a period of time. Before, during and after processing, data and programs are held temporarily in memory. To retain data more permanently, storage

devices such as magnetic disks, magnetic tape, optical disks and flash memory are used.
- **Control** coordinates the operations of input, processing, output and storage. The control unit is part of the CPU. The control unit is the 'organiser' that directs the flow of data in the computer in the same way as traffic lights.

All the functions of computer hardware work together. Data is entered using
 input device and is processed in some way before being presented using an output device. The computer's power comes from its ability to perform these functions with speed, accuracy and reliability.

3-2 Networking
Networking: is the ability to exchange information electronically from one computer user to another, there are many kinds of networking: Local Area Networks, Internet.

3-3-1 Applications of computers & networking in design studio

The applications of computers in design studio can be classified into three main levels:

3-2-1-1 Basic Level
- **Digital Design Media** This level covers a broad set of computer based design applications at an introductory level, including interactive communications (web page development), basic geometrical modeling, digital image processing, and mixed media productions that involve the use of digital video, scanning and output media. Universal principles and basic concepts serve as the design process.

3-2-1-2 Intermediate Level
- **Geometrical Modeling and Rendering** This subject area examines the full spectrum of three dimensional modeling

33

and rendering applications from a beginning to an advanced level, including color theory, image processing, digital modeling, and basic animation. It includes the handling of file management (intelligent naming convention etc.) and data conversion (import and export).

- **Digital Media and Drawing** This subject area explores the relationship between photography, two-dimensional drawing and digital media, including technical issues of scanning, image resolution, color models, and file formats.
- **Structural Analysis** This subject area examines the full spectrum of structural analysis tools, including Finite Element Modeling and other advanced simulation techniques.
- **Digital Moviemaking and Animation** This subject area explores moviemaking as a way to critique or forward design propositions. The use of a narrative or storytelling is considered. Special attention is given to panoramic projections.
- **Computable of Design** This subject area explores the quantitative basis and invisible geometrical order of shapes found in nature and architecture as explored through writing computer programs. The use of (evolutionary) algorithms within a morphological context is treated as a powerful input towards the digital generation of form.
- **Spatial Simulation Techniques** This subject area considers the appropriate use of digital verses analog techniques, which can enhance the depth of evidence and the realistic content of a design "under construction" by simulation.

3-2-1-3 Advanced Level
- **Computer Aided Manufacturing** This subject area considers the possibilities of numerical control processing, rapid prototyping and building component manufacturing.

Developments of (digital) form generation find their completion in physical products.

- **Digitalization of the Third Dimension** This subject area focuses on three-dimensional scanning of physical models, which leads to an accurate three-dimensional digital source for the creation and further development of complex geometry.
- **Laser Surveying** This subject area explores the range of computer applications that provide photo-realistic and accurate three-dimensional models to be constructed from field data and sites.
- **Performance Simulation: Energy** This subject area examines the use of particle flow analysis and energy simulation software, HVAC design software, and other computer applications used to evaluate, analyze and solve the heating, cooling and air handling needs of buildings.
- **Performance Simulation: Digital Acoustics and Synthesis** This subject area examines topics in digital acoustical analysis and simulation as a specialized area within the design disciplines.
- **Performance Simulation: Artificial and Daylight Representation** This subject area examines light analysis in different stages of the design process. Specialized lab installations such as an artificial sky are also examined.
- **Digital Technology and Communications Media** - This subject area explores communications based on a dynamic mix of digital design media. Collaborative teamwork with remote participants within a Virtual Design Studio serves as a basis for testing design alternatives. Communication relies on video conferencing.
- **Computation of Construction** This subject area explores the computational relationship between structural engineering and architectural design. The use of infinite elements is a topic that could be explored at an advanced level.

- **Geographic Information Systems** – This subject area examines the use of polygon overlay technologies for site analysis and area information management, possibly extended to space planning and facilities management.
- **Spatial and Data Analysis Methods**– This subject area explores the setup and implementation of relational databases as a design aid. Cost estimations serve in this context as a case study.

Chapter 4
The applications of Information Technology in the design studio.

Chapter 4: The influence of Information Technology devices on the design studio.

This chapter discusses integrating digital media and computation into design studios. This integration is clear by appearing new kinds of design studios. These studios depend mainly on applications of information technology, such as computers with its different software, networking, and video conference. Each studio addresses a different application of computing in studio.

Each studio will be described as a distinct paradigm, but in real practice, these studios usually integrate together to create projects. These studios are as follows [1]:

i. **The CAD Studio** is a computer augmented design studio. Up-to-date software is used to aid the conventional design studio.
ii. **The CAD-Plus Studio** addresses the integration of knowledge in design.
iii. **The Virtual and Web Design studio** explores new opportunities for collaboration using the Internet or networking.
iv. **The Cyberspace Design Studio** addresses the design of virtual communities.
v. **The Intelligent Buildings Studio** explores embedding computation and smart materials into the built environment.
vi. **The Tools and Toys studio** employs experimental digital design media that may become future tools of practice. (It explores next generation software and its effects on architecture).

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1 Mark D. GROSS, Ellen YI-Leun DO, <u>Integrating Digital Media in Design Studio: Six Paradigms,</u> Proc. ACSA (American Collegiate Schools of Architecture) National Conference '99 (Minneapolis, Minn), 1999.

Part III
The change of Architecture design as affected by IT.

Chapter 5
The new tools change the concepts of design

Chapter 5: The new tools change the concepts of design.

In contemporary architectural design, the information technology tools (especially computer) are increasingly used not only as a tool for presentation, but also as a generative tool for the derivation of forms and its transformations to fulfill the concept of design. In a radical change from the old and traditional norms of architectural design, new forms and concepts are not generated or drawn by the conventional ways, but they are calculated by chosen generative computational methods.

The digital generative processes are opening up new kinds of concepts, forms, and explorations. Generally, what will be discussed in this chapter is using Computers to ''find the form'' as a fulfillment of a concept, with various digitally based generative techniques.

5-1 Algorithmic form generation

Powerful three-dimensional modeling software makes it easy for architects to shape and sculpt three dimensional material and space using direct manipulation operations. Architects find that computer aided design modelers can help them generate radically new forms for there buildings, Gehry's forms in the Guggenheim museum in Bilbao and at the Experience Music Project in Seattle, all show radical departures from conventional forms enabled by computer aided design software.

The previous interesting forms were created using modeling software, later on another way of creating forms appears which can be called, " *generating form algorithmically, that is, writing computer programs whose execution results in three-dimensional*

geometry, and using this computational medium to explore architectural form. Generative systems are a well-established theme in computer-aided architectural design, including the approaches of shape grammar[1], genetic algorithms[2], and parametric[3] variation. However, algorithmic form generation has largely remained the province of academic investigation, perhaps because of the level of technical expertise it has required." [4]

Generally, creating a from using digital processes depends mainly, on two types of software, a previously designed software for modeling forms, or writing an algorithm using programming languages (a small design program that executes forms). This variety of software will be explained later on in this chapter.

Visual arts and music have a long history in exploring algorithmic form generation, by using algorithms that translate music or arts into forms. Although algorithmic form generation has a large presence in computer-aided architectural design, it is fair to say that other interests starts to take a more prominent position.

The use of algorithms creates new forms for buildings, free from the constraints of conventional building materials and techniques. Architects begin to create algorithms that can be used to generate complex three-dimensional curves, arrangements, and folding of space. Algorithmic generation can produce significantly different and more complex forms than conventional CAD.

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1   Shape grammars are concerned with the development and application of rules that operate on shapes to generate compositions, Many design decisions can be expressed in the form of: IF, THEN such - pairs can be viewed as guiding principles or rules to develop a design composition. In a broad sense, these design principles or rules are similar to the use of grammar rules in natural languages.
2   Definition at p.   .
3   Definition at p….
4   Mark D. Gross, FormWriter *A Little Programming Language for Generating Three-Dimensional Form Algorithmically*, CAAD futures 2001.p.578

Despite the power of industrial strength 3D modelers such as CATIA and Maya, many things are difficult to accomplish, and some just can't be done. It remains difficult to use most CAD modelers to generate three-dimensional forms through parameterizations. Algorithmic form generation is familiar in the engineering design disciplines: civil and aeronautical engineering and naval architecture, where three-dimensional shapes are more strictly dictated by functional requirements expressed as mathematical equations.

If one wants to generate three-dimensional forms algorithmically, one must decide between two main alternatives [1]:
- Macro facilities and scripting languages [2] within CAD modelers are relatively easy to learn, but they inherently limit the programs one can write (and hence the forms one can generate).
- Programs created by programming languages such as C and Java are powerful but they require more effort to learn, and generating 3D geometry also requires attention to many language features that have no direct bearing on form.

5-1-1 Support for algorithmic form generation.[3]

The following table (Fig. 5.1) distinguishes five levels of support for algorithmic form generation provided by CAD modelers. The simplest modelers provide no support at all for algorithmic generation: models can be constructed directly using the geometric primitives and operations provided on the CAD modeler's menus. Most CAD modeling programs offer macro facilities or scripting language.

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1   ibid.
2   Definition for Macro Facilities, and scripting language at P. 73.
3   Mark D. Gross, FormWriter *A Little Programming Language for Generating Three-Dimensional Form Algorithmically*, op.cip.

1	None	the designer may use only the geometric primitives and operations built in to the modeller.
2	Macros	frequently used sequences of operations can be recorded and replayed, in some cases allowing parameters to be supplied at replay time.
3	Scripting languages	more control over the modeller than recorded macros but which fall short of a full-fledged programming language.
4	Embedded programming language	e.g., AutoCAD's AutoLisp or ArchiCAD's GDL. Access to the modeller's library via a language within the modeller.
5	External programming language	programs typically written in C or Java communicate with and control the modeller. Bentley Microsystem/J

Fig. 5.1 Support for algorithmic form generation. [1]

- Although a macro facility serves simple tasks well (such as repetitive window patterns or stairs), it is difficult to program more complex operations using only macros. Scripting languages, which have gained wide acceptance in other domains (witness JavaScript and Flash), provide considerably more power than macros but coding more sophisticated tasks becomes quite complex, requiring a specialist programmer.

- An embedded programming language, like a scripting language, enables the programmer to control and command the modeler from an environment within the CAD program, and allows more powerful constructs than the typical scripting language. Many CAD programs now include an embedded language, and advanced users of these CAD

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1   ibid.

programs use it. AutoLisp [1] is the best known example. Although the underlying Lisp language is extremely elegant and powerful, Autodesk's implementation was a weak one and the programming environment for developing AutoLisp routines is weak by the modern standards.

- Programming languages such as C or Java can be used to write complex form-generating algorithms but it requires more expertise than most designers need to commit to acquiring, but with these languages architects could design an algorithm that transforms any kind of information into a form, this information maybe driven form arts, music, text, etc. (according to the concept).

What designers need is a simple way to explore and generate forms algorithmically, without the complexities of a professional programming language.

One of the most famous software is Mathematica, which is good at describing three-dimensional surfaces by parameterised functions. This software is used by famous architects such as Marcos Novak.[2]

FormWriter is another example of algorithm, which is an easy-to-use programming language, designed especially to allow architects and architecture students to explore algorithmic form generation. The idea of FormWriter is to eliminate complexity without sacrificing the power of programming. FormWriter offers a simple syntax, a unified development environment, and easy access to three-dimensional libraries.

With only a few lines of codes, a designer can generate three-dimensional graphics immediately, and within minutes, a designer

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1   A language for programming more commands embedded in the AutoCAD software.
2   Branko Kolarevic, <u>Architecture in the digital age. Digital design and manufacturing</u>, op. cip.

can explore parameterized and conditional construction to generate complex combinations of forms. The graphics environment is integrated with the code editor and programming environment, allowing a designer to explore forms fluidly without the complex knowledge of programming.

The figures 5.2, 5.3, 5.4 (a-d) show the FormWriter working environment: at left a window into a 3D space with browsing controls; at right an editor window for writing code.
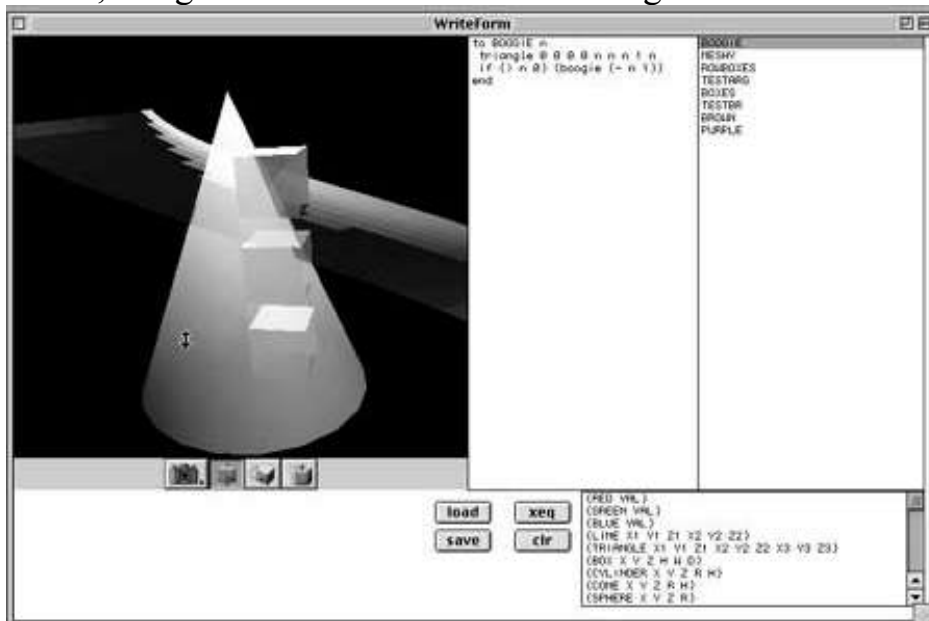
Fig. 5.2 FormWriter design enviroment.[1]
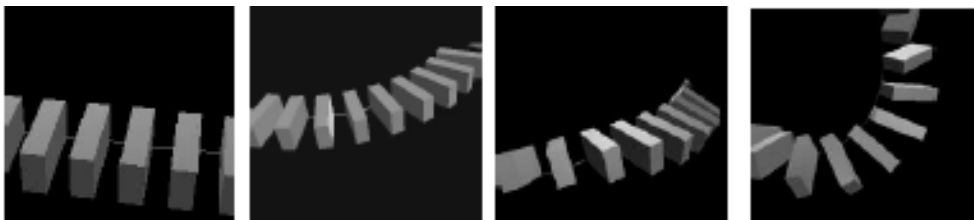
Fig. 5.3   (a) A row of boxes; (b) turning boxes; (c) twisting boxes; (d) boxes helix, created using FormWriter

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1   Mark D. Gross, FormWriter A Little Programming Language for Generating Three-Dimensional Form Algorithmically, op.cip. p.581.

5-1-3 Examples for Algorithmic forms created by architects:

1- Data driven Forms created by Arch Marcos Novak .
– The algorithm used for creating these forms was time-based, as well as data-driven algorithm. "*In cyberspace, these forms are generated in real-time at the point of transition from one information node to another*"[1]. (Fig. 5.4). Figures 5.5, 5.6, are forms created by the architect.
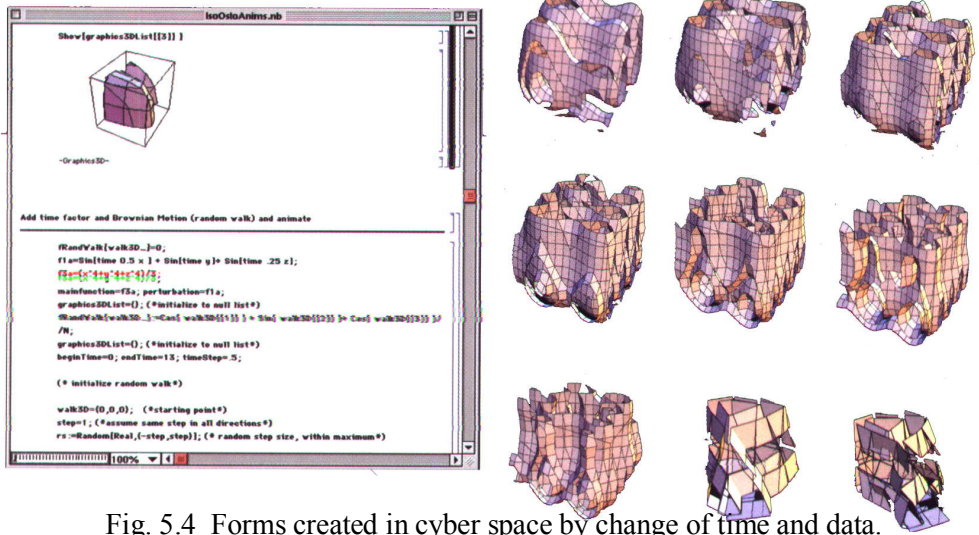
Fig. 5.4 Forms created in cyber space by change of time and data.
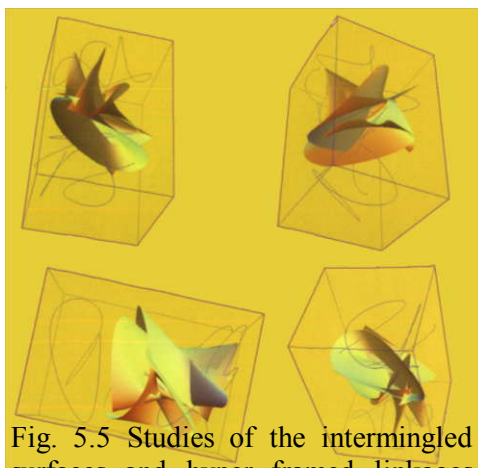
Fig. 5.5 Studies of the intermingled surfaces and hyper framed linkages created by another algorithm.
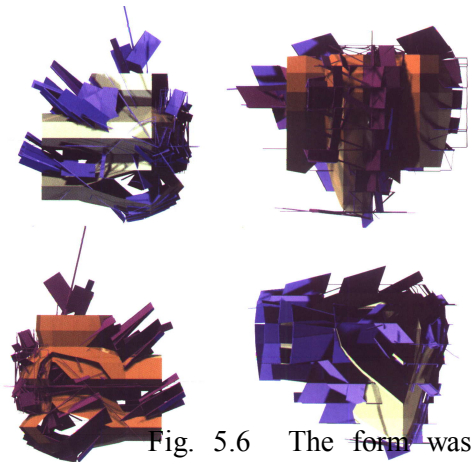
Fig. 5.6   The form was created by an algorithmic function extracted from linked web pages.

1   Peter Zellner, Hybrid space: New forms in digital architecture, Rizzoli international publications, 1999. p.131
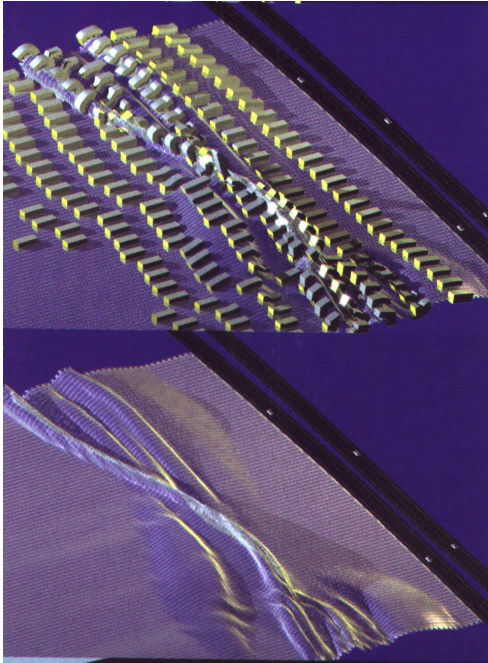
Fig. 5.7 the aerial sequence of traffic-generated wave diagram shows the site transformed into a sonic landscape.

2-"Off-the-Road" housing and noise barrier, Netherlands, by NOX Architect [1].

Eindhoven in the Netherlands exemplifies the split of two zones by a noise barrier: on one side of the city lays a highway; on the other side the Blixembosch residential quarter, NOX attempted to reconcile this disjunction with a project that builds out a sound model of the site as it is experienced. Using animation software, the existing sound barrier of the passing traffic was translated into a system of "string" (to be used as data for an algorithm). The wave patterns in the strings were recorded at intervals and then transferred into a sonic landscape. The form of every 208 houses was inflected by these sound waves patterns.[2]

Fig. 5.8 Details of housing forms.

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1   A famous Dutch architecture firm founded and directed by Lars Spuybroek.
2   Peter Zellner, Hybrid space: New forms in digital architecture, Rizzoli international publications, op.cip.

5-2 Digital Morphogenesis

Computational, digital architectures are defined by computationally-based processes of form origination and transformations, so, the processes of digital morphogenesis, such as topological geometries, isomorphic polysurfaces, motion kinematics and dynamics, keyshape animation (metamorphosis), parametric design, genetic algorithms, and performance, will be discussed in the following sections.[1]

5-2-1 Parametric Architectures

5-2-1-1 Definition

Parametrics can provide a powerful conception of architectural form by describing a range of possibilities. Using parametrics, designers could create "*an infinite number of similar objects, geometric manifestations of a previously articulated schema of variable dimensional, relational, or operative dependencies. When those variables are assigned specific values, particular instances are created from a potentially infinite range of possibilities.*"[2]

In parametric design, the parameters of a particular design are declared, and not its shape. By assigning different values to the parameters, different objects or configurations can be created. Equations can be used to describe the relationships between objects, thus defining an associative geometry-the "*constituent geometry that is mutually linked*" [3]. That way, interdependency between objects and objects' behavior under transformation can be established. As observed by Mark Burry, "*the ability to define*

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1   Branko Kolarevic, Architecture in the digital age. Digital design and manufacturing, op. cip.
2   Ibid. p.13.
3   Mark Burry, 1999 Paramorph, in S. Perrella (ed.), AD Profile 139: Hypersurface Architecture II, Academy Editions, London, pp. 78-83.

, determine, and reconfigure geometrical relationships is of a particular value". [1]

The term "parametric design" is probably the most suitable term for this kind of design, by changing any parameter in the equation new forms, and new shapes, could be created. The parameters are not just numbers relating to Cartesian geometry-they could be performance-based criteria such as light levels or structural load resistance, or even a set of aesthetic principles.

When someone refers to parametric design, he usually refers to Cartesian geometry and the ability to modify the geometry by means other than erasure and decomposition. Parametric design is more accurately referred to as "associative geometry".

5-2-1-2 Description
- Parametric design often needs a procedural, algorithmic description of geometry.

- Parametrics are particularly useful for the modeling of complex building forms. Their successful application requires careful articulation of a clear strategy of finding relationships between the units of each project, such that a sufficiently clear description of interdependences can be achieved. In other words, a well-defined design strategy is essential for the effective application of parametrics.

- For the first time in history, architects are designing not the specific shape of the building but a set of principles encoded as a sequence of parametric equations by which specific instances of the design can be generated and varied in time as needed. Parametric design calls for the rejection of fixed solutions and for an exploration of infinitely variable potentialities.

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1   ibid.

– Parametrics approach to design, if consistently applied from its conceptual phase to its materialization, changes radically the entire nature and the established hierarchies of the building industry, as well as the role of the architect in the processes of building.

Parametric design as an associative geometry process;
– As shown in the figure (5.9) the non-associative geometry, example of a sphere and a box in space with a line a1-a2 connecting the center of the sphere to defined corner of the box. If the sphere is translated, the line a1-a2 remains in place referencing the center of the sphere where it once was.

Explicit geometry modeling.
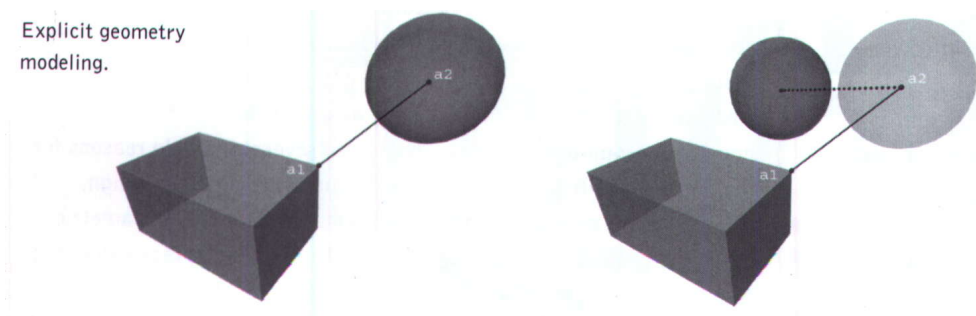
Fig. 5.9 Non-associative geometry.

– Figure (5.10) shows the parametric design equivalent of the case in the previous figure, where there is now a relationship between the sphere and the box, such that translation of the sphere drags the line with it as it maintains the relationship between the two geometries. If the length of the line changes, the sphere moves with it, as indicated. Beyond these apparently easy concept there rests an important implication: if geometry can be associated, the associations   can   be   associated   as   well.
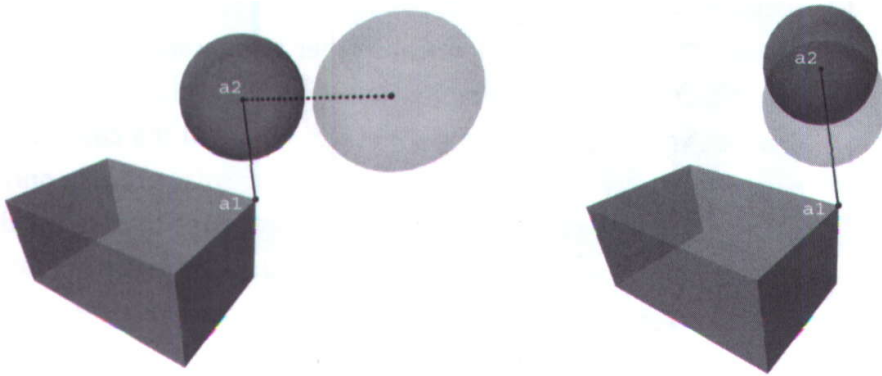
Fig. 5.10 Parametric modeling.

- In the examples shown at Fig. 5.11, the side of the box "x" is expressed as the same size of the sphere, and the sphere is connected with the box through line a1-a2. By increasing the size of the box (and with it the size "x") the sphere increases in size while the line a1-a2 shortens in length. Associations can be made between geometries of figures whose only relationship is sharing Cartesian space. In Fig. 5.11 the parameters governing the size, shape and position of the cone can also be tied directly to the activities, which inform the change in relationship between the sphere and the box.
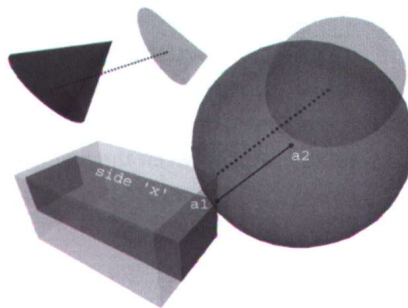
Fig. 5.12 Associative geometry modeling.

This ability to form associations between entities has especially useful opportunities for formalizing design, as these relationships can be changed and revised during the design process itself. Each time a value for any parameter changes, the model simply regenerates to reflect the new values.

In general terms, all parametric operations are linked to each other in clear explicit or implicitly declared relationship. Maximum dimensions for a certain object can be declared. So, If the model suffers from over-constraint in relationships that was declared early in the design process, subsequent design decisions might be invalidated simply through the inability of the regeneration process to comply with conditions set by the designer earlier on.

5-2-1-3 Examples for the Parametric architecture.

1- Paracube by Arch. Marcos Novak.

Using Mathematica software, Marcos Novak constructs "*mathematical models and generative procedures that are constrained by numerous variables initially unrelated to any pragmatic concerns   Each variable or process is a' slot' into which an external influence can be mapped, either statically or dynamically".* In his explorations, Novak is "*concerned less with the manipulation of objects and more with the manipulation of relations, fields, higher dimensions, and eventually the curvature of space itself*" [1].

This project was defined by six parametric surfaces, each with its own coordinate system. Fig. (5.13, 5.14).
- The parametric equations governing each surface were arranged so that a variation on a particular surface would cause reactions or permutations on adjoining surfaces, effectively creating a topological cube.

- The parametric equations governing the cuboid, was manipulated to create two forms: a skeletal frame and a smooth skin. Parameterization allowed the smoothness of

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1   Marcos Novak. Transarchitectures and Hypersurfaces in Stephen Perrella (ed.), Hypersurface Architecture, London Academy Editions, 1998.

each element to be defined and manipulated through computational formulas.

Fig. 5.13 Paracube.   Fig. 5.14 Interior picture for the project.

2- Park city, Reitdiep, Holland, 1996. by Oosterhuis Associates. [1]

The "Park city" of Reitdiep in Groningen, Holland, is torn between being a city and an international ecological center for migrating birds.
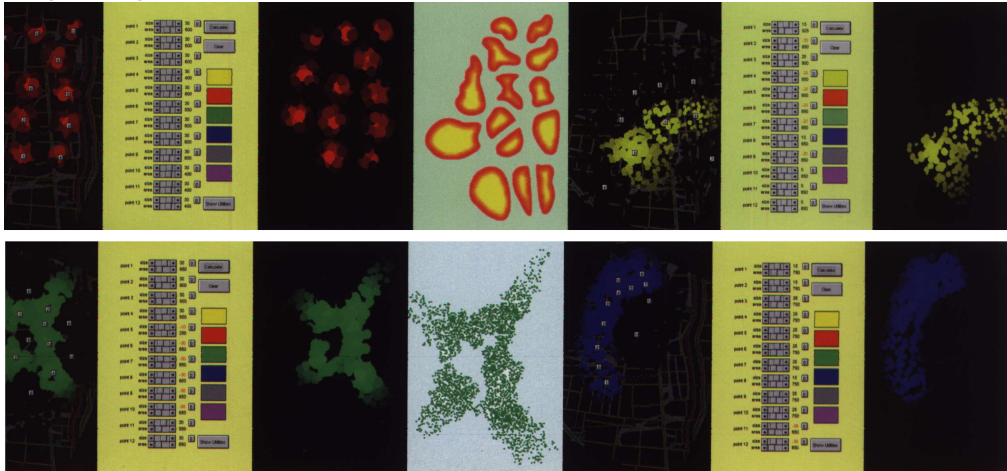
Fig .5 15 the parameters used to create the layout.

The plan proposed by Oosterhuis is conceived as a large sponge that absorbs and discharges liquid, matter, people, impulses and

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1   Oosterhuis associates is a Dutch disciplinary design studio, where architects, visual artists, web designers and programmers work together and join forces. It is an office where reality and virtuality meet, founded by Kas Oosterhuis.

information (data). The existing site forms the breeding ground for the park city that will be designed, to create the layout, a new design tool is developed depending on the parametric concept in design. It is called the Attractor Game, in which attracting aspects are placed in the landscape and each aspect is given a parameter (as shown in the above figures), by changing the parameters the layout changes, and so the designer could select the most suitable layout. (Fig. 5.15, 5.16).
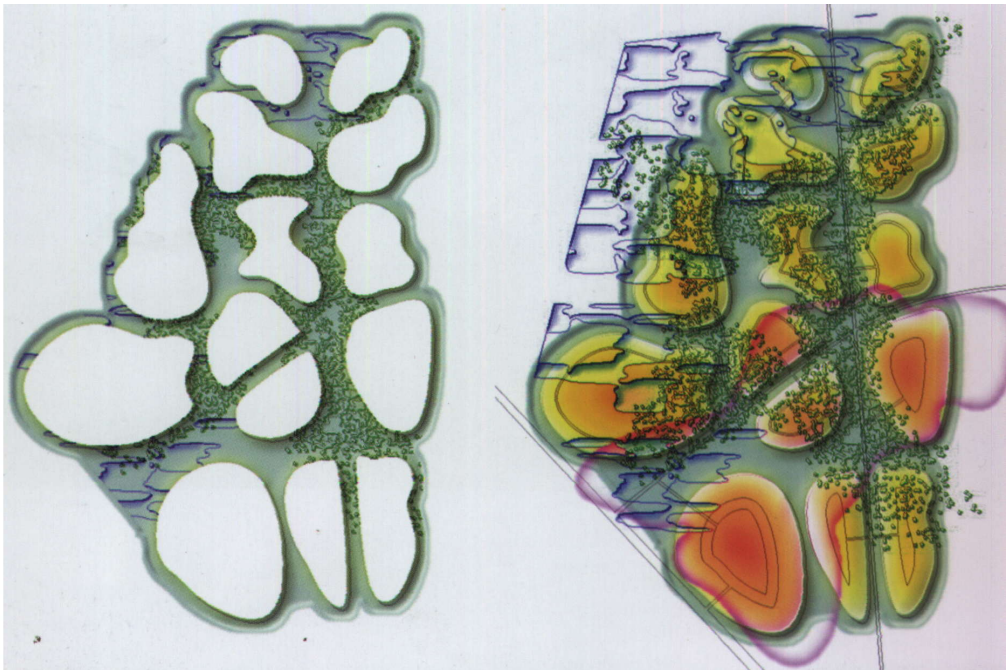
Fig .5 16 Park City layout.

5-2-2 Topology architecture

5-2-2-1 **Definition.**

It is the approaches to design that move away from deconstructivism's "logic of conflict and contradiction" to develop a "more fluid logic of connectivity." [1]

This new fluidity of connectivity is manifested through "folding", "*a design strategy that departs from Euclidean geometry of discrete volumes represented in Cartesian space, and employs, "rubber-sheet" geometry of continuous curves and surfaces mathematically described as NURBS – "Non-Uniform Rational B-Splines*". [2] What makes NURBS curves and surfaces particularly appealing is the ability to control their shape easily by manipulating the control points, weights, and knots. NURBS make the heterogeneous and coherent forms of the topological space computationally possible.

5-2-2-2 **Explanation**.

Architectural thinking throughout centuries was based mainly on Euclidean Geometry with its platonic solids, such as the cylinder, pyramid, cube, prism, and sphere. However, due to the appearance of digital technology (Information technology) with its great potentials in drawing and modeling using the NURBS, architecture has started to use forms and ideas based on the topological structures, and Non-Euclidean geometries that depart away form the Euclidean geometry with its platonic forms. Topology, Euclidean and Non-Euclidean geometries, and NURBS, will be mentioned in details.

– **Topology:**
According to its mathematical definition, "*it is the study of intrinsic, qualitative prosperities of geometric forms that are not*

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1   Branko Kolarevic, <u>Designing and ManufacturingArchitecture in the Digital Age</u>, Architectural Information Management[19th eCAADeConference Proceedings] Helsinki (Finland) 29-31 August 2001.

2   Ibid. p.118.

normally affected by changes in size or in shape, which remain invariant through continuous one-to-one transformations or elastic deformations, such as stretching or twisting" [1]. A circle and an ellipse, for example, or a square and a rectangle, can be considered topologically equivalent, as both circle and square could be deformed by stretching them into an ellipsoid or rectangle, respectively. A square and a rectangle have the same number of edges and the same number of vertices, and are, therefore, topologically identical. See the example in Figure. 5.17.
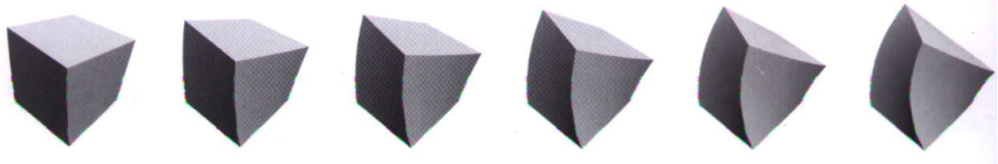
Fig. 5.17 Homemorphic (topologically equivalent) figures.

This quality of homeomorphism is particularly interesting, as the focus is on the relational structure of an object and not on its geometry, the same topological structure could be geometrically manifested in an infinite number of forms. Topological transformations, first and foremost, affect the relational structure, and, thus, the resulting forms. For example, a rectangle could be transformed into a triangle with a single topological operation of deleting one of its vertices.

New forms based on topological structures were added to architecture. For example, Mobius strip [2], and klien bottle [3] (Fig. 5.18, 5.19) with their intrinsic property of one-sidedness, which breaks the boundaries between what is interior and what is exterior. While the conceptual possibilities of these topological

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1   Branko Kolarevic, Architecture in the digital age. Digital design and manufacturing, op. cip. P.13.
2   The Klein bottle is a closed nonorientable surface that has no inside or outside. It can be constructed by gluing both pairs of opposite edges of a rectangle together giving one pair a half-twist.
3   The Möbius strip (also called the twisted cylinder) is a one-sided nonorientable surface obtained by cutting a closed band into a single strip, giving one of the two ends thus produced a half twist, and then reattaching the two ends .

geometries are important, their inherent, conceptual qualities are often difficult to truly manifest tectonically.

Fig. 5.18 Mobius strip   Fig. 5.19 Klien bottle

– **Euclidean and Non-Euclidean geometries** [1]

Euclidean geometry is the geometry based on five postulates, of which all are considered self-evident except the fifth postulate of "parallelism". This postulate asserts that two lines are parallel, (non-intersecting) if there is a third line that intersects both perpendicularly. The consequence of this postulate in Euclidean geometry is that through every point there is one and only one line parallel to any other line. The first four postulates are considered as the postulates of the absolute geometry, while the fifth postulate is the postulate that opened the realm of non-Euclidean geometries.

Non-Euclidean geometry is the geometry based on postulates different from Euclid's. The term non-Euclidean geometry (also spelled: non-Euclidian geometry) describes both hyperbolic and elliptic geometry, which are contrasted with Euclidean geometry. The essential difference between Euclidean and non-Euclidean geometry is the nature of parallel lines. In Euclidean geometry, if

---

1   In three dimensions, there are three classes of constant curvature geometries. All are based on the first four of Euclid's postulates, but each uses its own version of the parallel postulate. The "flat" geometry of everyday intuition is called Euclidean geometry (or parabolic geometry), and the non-Euclidean geometries are called hyperbolic geometry (or Lobachevsky-Bolyai-Gauss geometry) and elliptic geometry (or Riemannian geometry). Spherical geometry is a non-Euclidean two-dimensional geometry.

we start with a point A and a line l, then we can only draw one line through A that is parallel to l. In hyperbolic geometry, by contrast, there are infinitely many lines through A parallel to l, and in elliptic geometry, parallel lines do not exist. (Fig. 5.20)
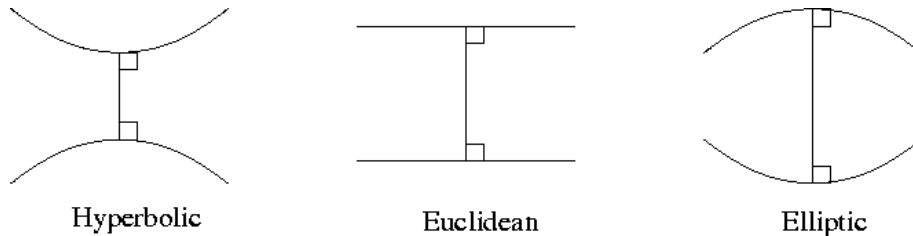
Fig. 5.20 Behavior of lines with a common perpendicular in each of the three types of geometry.

Ideas based on the consequences of non-Euclidean geometry;

i.   In <u>Riemannian geometry</u>, (which is also known as "spherical" geometry); the "plane" is situated on the surface of a sphere, and the "line" is a circle that has the same radius as the sphere, there are no parallel "lines" exist in this geometry. The distance between two points is always a curved distance, i.e. not a "flat" distance. Another interesting concept in this geometry is the concept of curvature of space and that the spaces maybe of positive or negative curvature.

ii.   In <u>Poincare geometry</u>; "lines" are hyperbolas on a Cartesian plane, there is an infinite number of "lines" through a chosen point that are parallel to another "line".

Each of these Non-Euclidean geometries has a particular application. Riemannian geometry is used in Navigation, and Poincare geometry is used in ballistics and for the representation of electromagnetic forces.

"What makes these and other non-Euclidean geometries interesting from an architectural point of view is the possibility of

mapping objects between them, thus providing for us a radically different conceptualization of space" [1].(new forms, new ideas).

The following example will show how it is very interesting for the architects, to shift from one geometry to another to explore new forms, which are all topologically homemorphic. (need NURBS to be drawn in the Cartesian geometry).
Spaces in this example were constructed based on non-Euclidean axioms. This sketch investigates how computers and new media may extend the designer's perception and imagination, and how designer can use these new forms of the project in Non-Euclidean spaces to give him new forms.

On the assumption that visual space is hyperbolic and physical space is Euclidean, it is possible to derive computational numerical models (or mappings) between the two spaces (depending on Non-Euclidean geometry). From a study of these models, one can get a good visual sense how the objects of the physical space (Euclidean) will be different if it is seen in the space of Non-Euclidean Geometry. [1] (The computer system used in this example is called "zhapes" and it is a Java-based algorithm.)Fig. (5.21- 5.24).
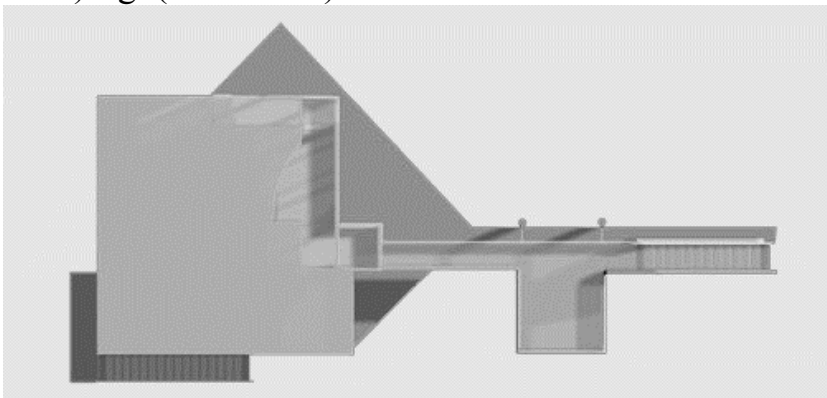
Fig. 5.21 Orthographic View (layout).

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1   Terzidis, Kostas, Experiments on Animated Visual Forms, Proceedings of the Eighth International Conference on Computer-Aided Architectural Design Futures Atlanta, 7-8 June 1999, pp. 335-350.
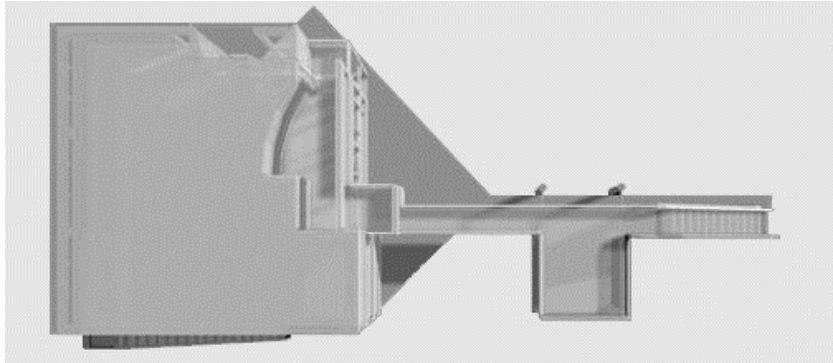
Fig. 5.22. Perspective View:
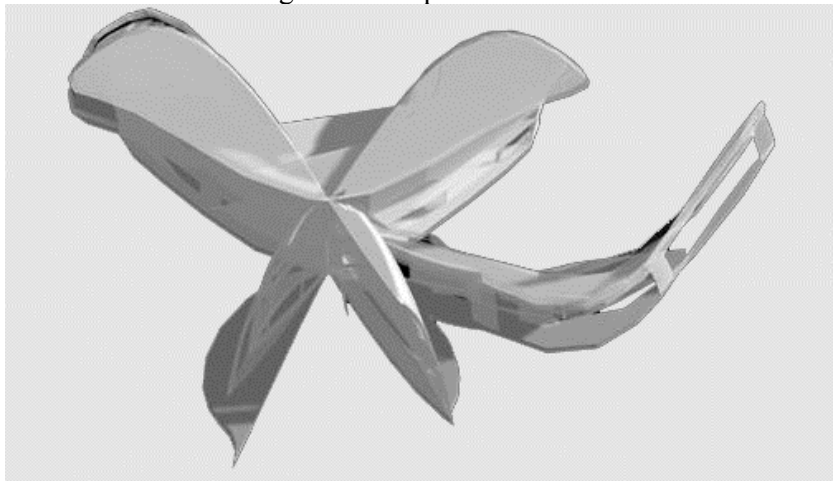
Fig.5.23 Hyperbolic projection.
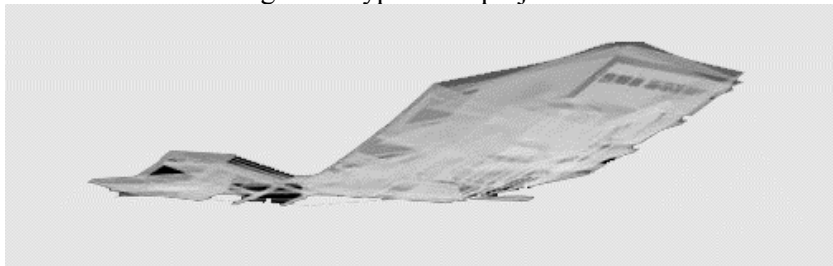
5.24 spherical projection.

It is important to know the following points form the previous example:-

- The previous pictures are for the same object but they are seen through the rules of different non Euclidean geometries.
- All the objects in the previous pictures are Homemorphic.

− The objects as seen through the Non-Euclidean geometries can be drawn and created in the Cartesian space, using NURBS, to be constructed.

NURBS:

In pre-digital architecture, whose formal potentiality was, in large part, a direct extension of the limits of Euclidean geometry (lines, circles, quadrilaterals, etc.), the description and, consequently, the construction of compound, complex curves was accomplished through an approximation by concatenating tangent circular arcs and straight line segments, which could be delineated with ease on paper and on the building site. (Fig. 5.25)
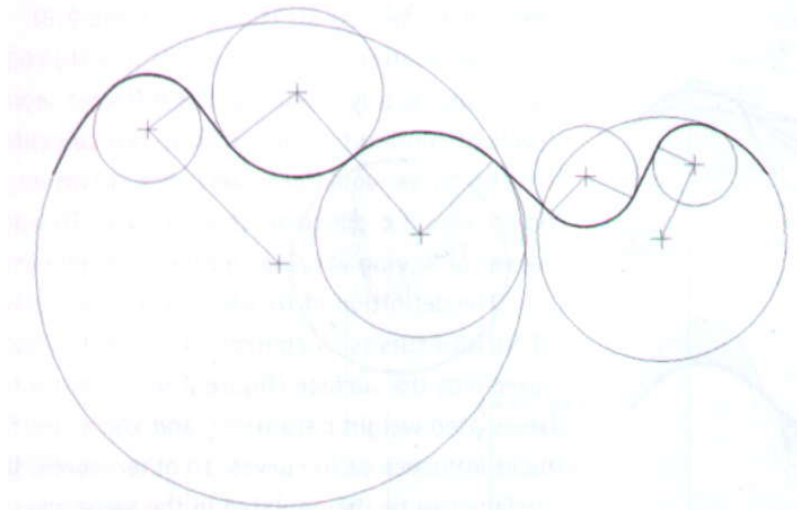
Fig. 5.25 Ordinary method of identifying a curve

The introduction of digital modeling software into architectural design provided a departure from the Euclidean geometry of discrete volumes represented in Cartesian space, and made the present use of "topological", "rubber-sheet" geometry continuous curves and surfaces that feature prominently in contemporary architecture possible. The highly curvilinear surfaces in the architecture of the digital avant-garde are described mathematically as NURBS, which is an acronym that stands for

Non-Uniform Rational B-splines. NURBS. It can be described as follows :

  i.   NURBS are a digital equivalent of drafting splines used to draw the complex curves.

  ii. NURBS make the heterogeneous, yet coherent, complex forms of the digital architectures computationally possible. NURBS make the construction of these forms attainable by means of computer numerically controlled (CNC) machinery.

  iii. The widespread of NURBS is due to its ability to construct a broad range of geometric forms, from straight lines and platonic solids to highly complex sculptured surfaces.

  iv. From a computational method point of view, NURBS provide an efficient data representation of geometric forms, using the minimum amount of data for shape computation. For this reason, most of today's digital modeling programs rely on NURBS as a computational method for constructing complex surface models.

  v.   The NURBS curves can be changed by manipulating its control points and associated weights and knots, as well as the degree of the curve itself. The NURBS curves are shaped primarily by changing the location of control points, which do not have to lie on the curve itself, except for the endpoints. Each control point has an associated weight, which determines the extent of its influence over the curve. Increasing the weight of a control point pulls the corresponding curve or surface toward that control point and vice versa. (Fig. 5.26, 5.27).
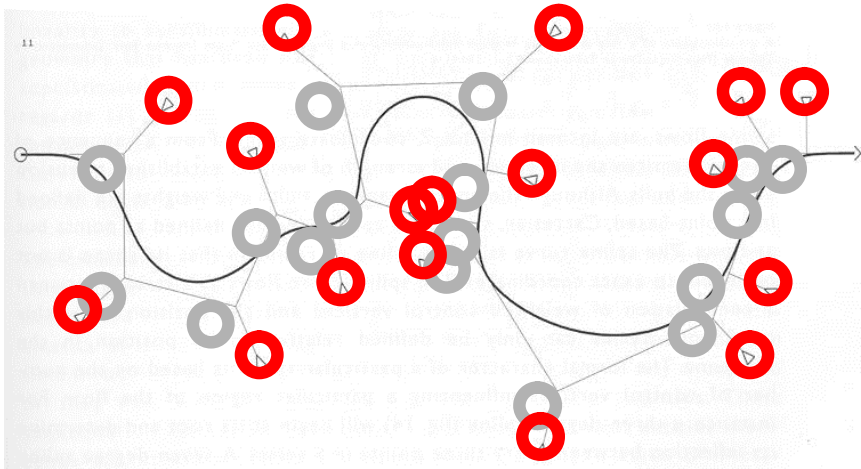
Fig. 5.26 When a spline is constructed, the line is not drawn by itself (curved line in image), but rather by the control points (grey circles) that influence the spline. The curve in the figure is modified by the forces exerted on each control point. (second dark red circles).
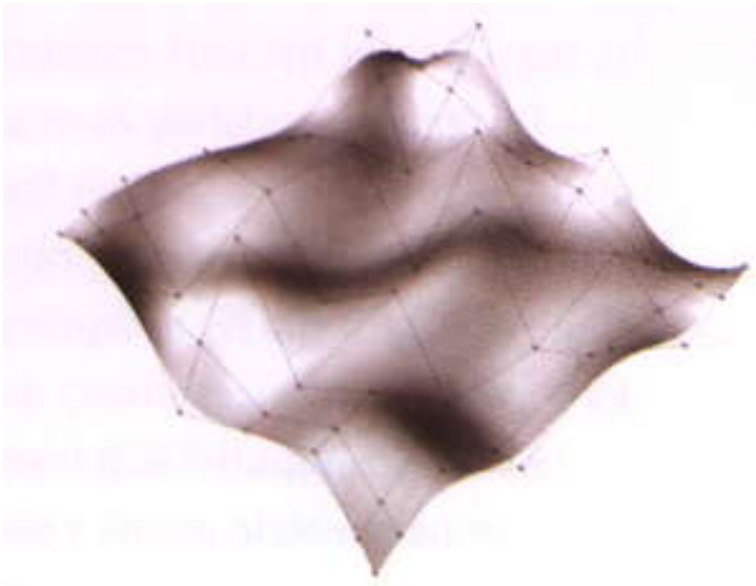
Fig. 5.27 The control lattice for a NURBS surface

5-2-2-3 Examples for Topological architecture:

1- Mobius house, Amsterdam, Holland, 1998. by Architect Van Berkel.[1]

The concept of this project is based upon the Mobius strip, which is derived from the topological forms.

The concept of this project can be explained in the following steps:-

Fig. 5.29 The embodiment of the concept.
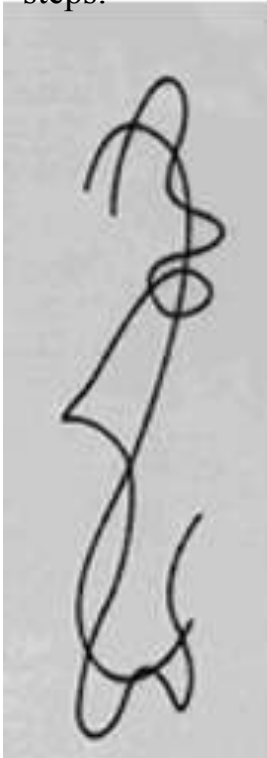
Fig. 5.28 Main diagram of the concept Interconnection between two people living in the same house.
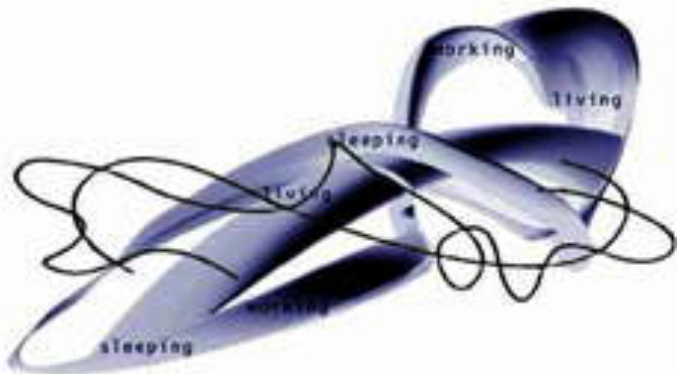
. Fig. 5.30 The zonning of the form according to the function.

-Step 1; Creating the main diagram as the concept of design. It describes the existence and interconnection between two people living in the same house. (Fig. 5.28).

-Step 2; The concept of the project was embodied in the Moebius band. (Fig. 5.29).

-Step 3; Analysis and zonning of the form took into consideration the function. (Fig. 5.30)

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1 A famous Dutch Architect, and the founder of the famous Architectural Firm UN studio.

Ground floor plan   Second floor plan   Roof plan

The designed project was not the same form as seen in the previous figures, but it was constructed as a folded sheet, developed from the previous Mobuis band (which is topologically equivalent with the previous form.
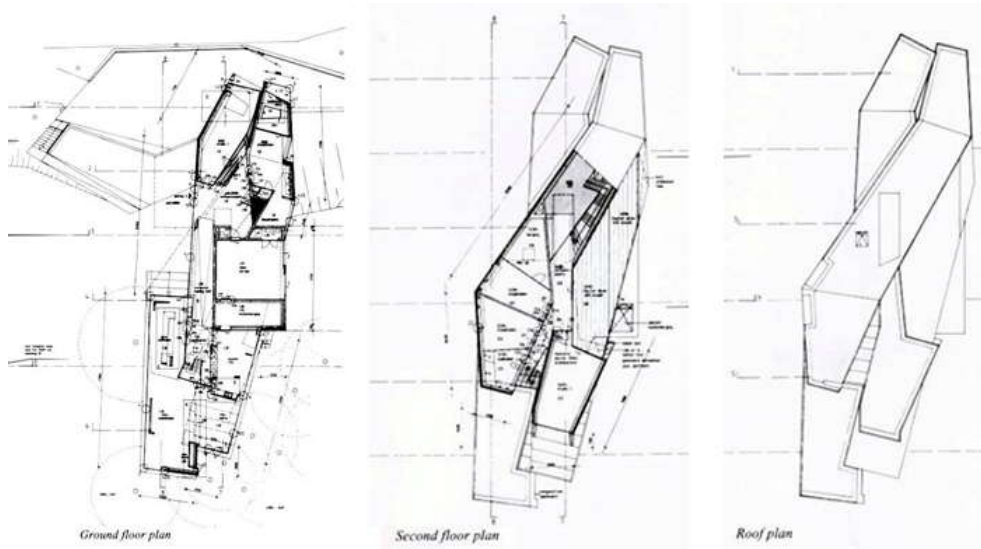
Fig. 5.31- 5.33 Plans of the project.

Fig. 5.34, 5.35 Post nature of the project.

The application of the Mobuis strip as a concept fulfills the following points in the design :
• Creation of shared and separate spaces that intertwine. (Fig. 5.31-5.33).
• Linking the internal spaces with the external landscape surroundings.

• Transformation of the interior and exterior structures. Many parts of the building flow into or issue out of each other; Concrete structure becomes furniture, Glass facades turn into inside partition walls. (Fig. 5.34-5.35).

2- Yokohama Ocean Liner Terminal [1], by Winka Dubbeldam.
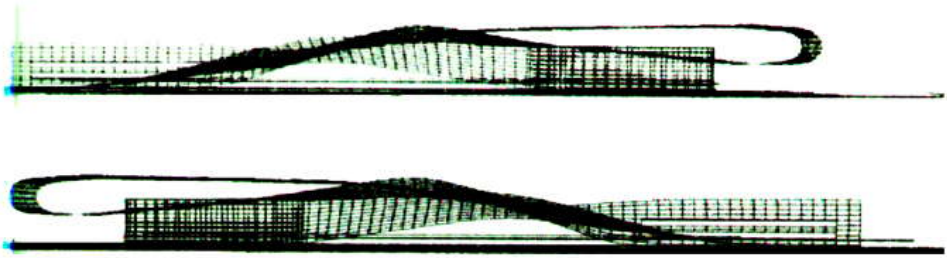
Fig. 5.36 Elevetions of Yokohama Terminal.

A topological project, in which two twisted rubber bands "*gives a sense of delay, is the main basis for the project*" [2]

It is actually composed of four spaces: the auditorium, the exhibition gallery, the outdoor exhibition space and the studios. (Fig 5.36-5.38).

Fig. 5.37 Sequential studies of the twisting ribbons that shows the steps of design and describes the form.
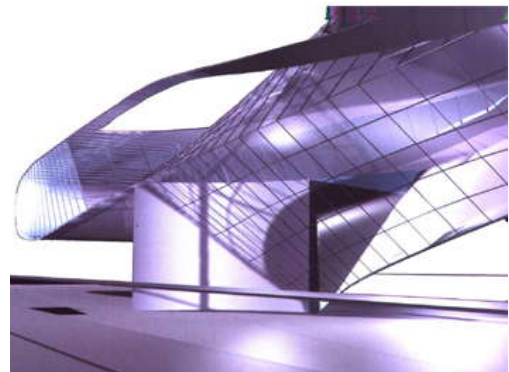
Fig 5.38 .Exterior view shows the aluminum frame enclosed by the warping glass planes.

1   "Yokohama Ocean Liner Terminal" (concours), Japon ; 1995.
2   Peter Zellner, Hybrid space: New forms in digital architecture, op. cip. p.93.

5-2-3 Animate architecture.

5-2-3-1 Definition:

  "*Animation is a term that differs from, but is often confused with, motion. While motion implies movement and action, animation implies the evolution of a form and its shaping forces; it suggests;   growth, actuation, vitality and virtuality.*" [1]

  Animate design "*is defined by the co-presence of motion and force at the moment of formal conception. Force as an initial condition, changes the atmosphere, which effects both motion and particular inflections of form.*" [2] Architecture can be modeled as a participant immersed within the dynamical flows. Instead of a neutral abstract space for design (neutral space vacuumed from forces), "*the context for design becomes an active abstract space that directs form within a current of forces that can be stored as information in the shape of the form*". [3]

  Animate design is widely used in aeronautical design, naval design, and automobile design by employing this animate approach to model form in a space that is a medium of movement and force. In naval design, for example, the abstract space of design is created with the properties of flow, turbulence, viscosity, and drag. So, the form of a ship can be conceived by studying the motion through water.

5-2-3-2 Explanation.

 − Traditionally, in architecture, the abstract space of design is conceived as an ideal neutral space of Cartesian coordinates. However, in animate architecture design space is conceived as an environment of force anti-motion rather than as a neutral vacuum.

Generally, space in animate architecture is not a neutral container that is uniform in all three dimensions of the Cartesian coordinate system, but it has densities, speed, and direction. Furthermore, architectural objects are not neutral separate objects from space, but space influences the object and the object influences space. (Fig. 5.39-5.41).
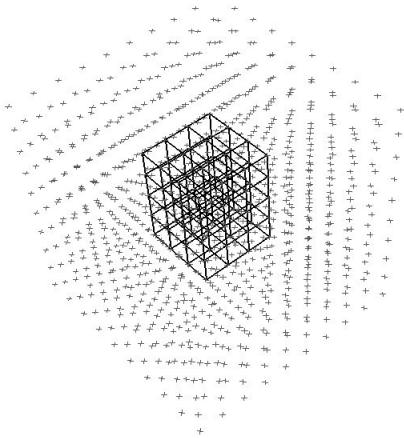
Fig. 5.39 Space of conventional architecture (vacuumed from forces.
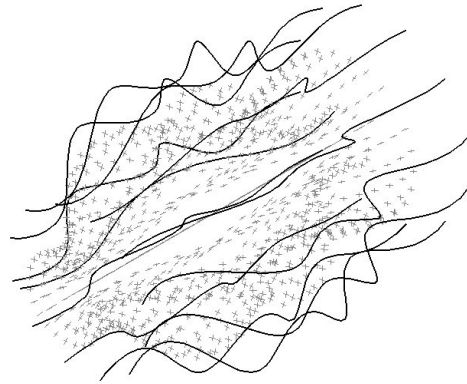
Fig. 5.40 Space of Animate architecture (atmosphere contains forces).
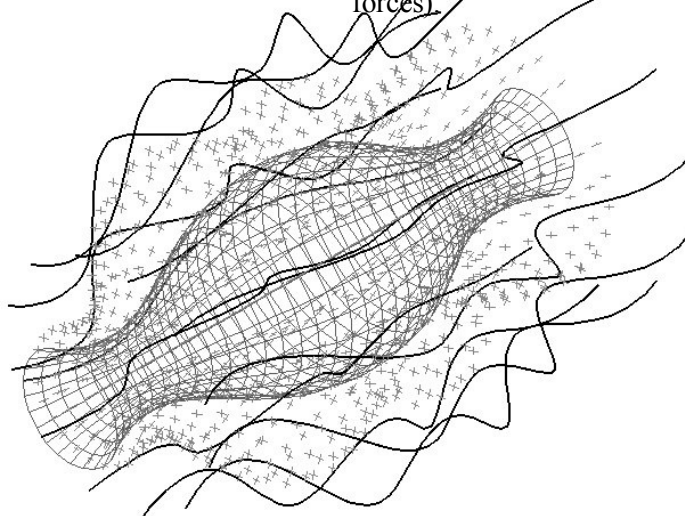
Fig. 5.40 Space of Animate architecture influences, and creates the architectural form.

- Architectural form is not designed in a fixed, and stable space, but as a participant in a dynamically moving space. Therefore, architecture and space have to be conceived of as dynamic elements, and this dynamics has to be captured and expressed. In the animate design, any object (architectural form, or any other objects) is defined as a vector whose trajectory is relative to other objects, forces, fields, and flows and these objects define the form. This shift from a passive space of static coordinates to an active space of interactions implies a move from autonomous purity to contextual specificity.

- The main step in the design process is creating the suitable virtual atmosphere (forces, densities, and other objects) according to the main concept and the idea of the project. This means that the designer is not designing the form its-self by modeling, but he designs the virtual atmosphere of the project, and then by animating the scene the form is created automatically. This form can be changed if the designer changes the atmosphere of design (intensity of forces, directions of forces, densities, .etc.).

- The modeling of architecture in a conceptual field populated by forces and motion contradicts with the previous paradigms and technologies of formal stasis in architecture. *"Stasis is a concept which has been intimately linked with architecture in at least five important ways, including 1) permanence, 2) usefulness, 3) typology, 4) procession, and 5) verticality."* [1]

- Types of animation used in animate architecture [2]:-
1-**Dynamic simulation**: It takes into consideration the effect of forces on the motion of an object or a system of objects, in

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1   Ibid. p. 13.
2   Branko Kolarevic, <u>Architecture in the digital age: Design and manufacturing,</u> op.cip.

creating the project form. Physical properties of objects, such as mass (density), elasticity, static and kinetic friction (or roughness), are defined.

Forces of gravity, wind, or vortex are applied, collision detection and obstacles (deflectors) are specified, and dynamic simulated computed. (Fig. 5.41, 5.42)

Fig. 5.41, 5.42   The "Dynaform", BMW pavilion, Auto show in Frankfurt, Germany, 2001. architects Bernhard Franken and ABB Architekten (will be mentioned in detail later on in this chapter).

2- **kinematics**; In its true mechanical meaning, is used to study the motion of an object or a hierarchical system of objects without consideration given to its mass or the forces acting on it. Hierarchical constructs, such as "skeletons" made of "bones" and "joints", which can have various associated constraints, allow designers to create an infrastructure of relations that determine the complex behavior of the model under transformations. A "global skin" assigned to such "skeletal" hierarchical organizations makes the deformations formally manifest able. As motion or external influences are applied, transformations are propagated down the hierarchy in forward kinematics, and upwards in inverse kinematics. For example, in the project "House Prototype in Long Island" by Gerg Lynn, skeletons with an envelope are deformed using inverse kinematics under the influence of various site-induced forces. (Fig. 5.43, 5.44).
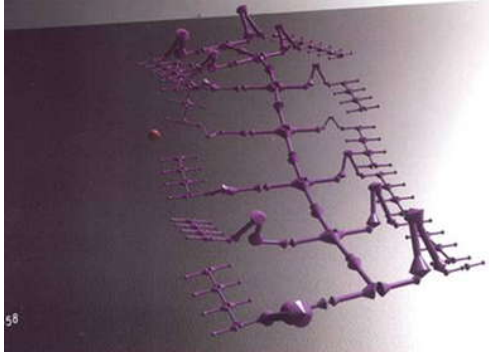
Fig. 5.43 The skeleton of the project with its joints, with the skin. (the form of the project).

Fig. 5.44 The project (skeleton covered with the skin) during the design process and it deform due to external forces

3- Particle emission: This system is done by emission of particles in the virtual atmosphere, and this emission is used for studying the forces in atmosphere to decide the kind of forces, its direction, and its intensity. The collision of the particles, or the union of them, can create a basic concept for the creation of a project. For example, Project "port authority gateway", by Greg Lynn. (Fig. 5.44).
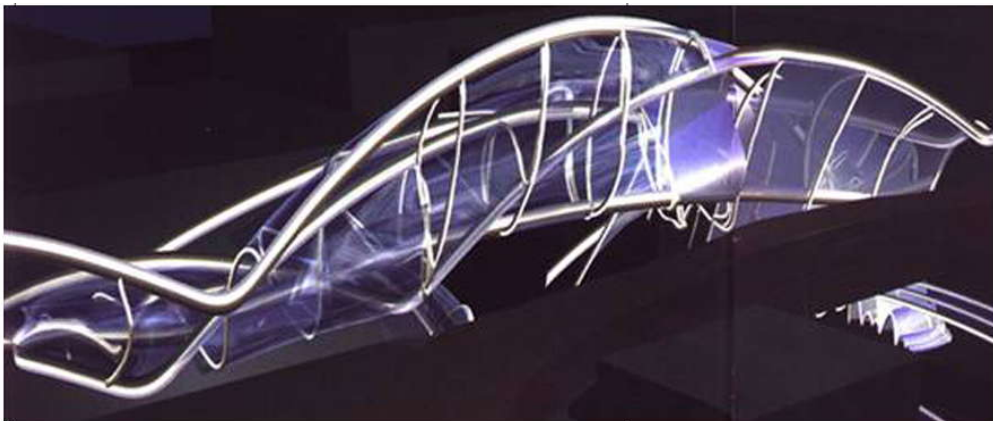
Fig. 5.44 Port Authority gateway a project designed by Greg Lynn using particle emission (it will mentioned in detail in this chapter).

5-2-3-3 Examples for animate architecture.

1- Dynaform   by architect Bernhard Franken.

The new BMW exhibition pavilion was designed to express the marketing core philosophy of BMW, which is driving enjoyment. The idea in designing this pavilion is to give the sense that the displayed automobiles are in motion; however, they are presented and displayed at a standstill.

The previous concept of design was fulfilled by inspiring the idea from the Doppler effect[1] . The architect made simulation for the displacement of air done by moving the car in a vacuum atmosphere, and then the resultant of this curvature of space was translated into the building form.

- **Step I** creating the main forces used to create the form
− Forces created by the moving car due to air displacement.Fig.5.45
− Atmosphere vacuumed from forces. (Fig. 5.45-5.48)
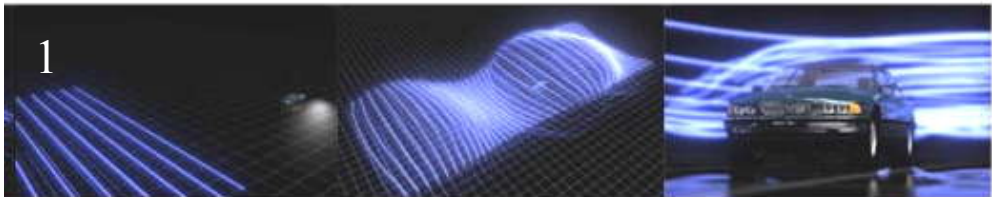
Fig 5.45 the displacement of air due to the car movement.
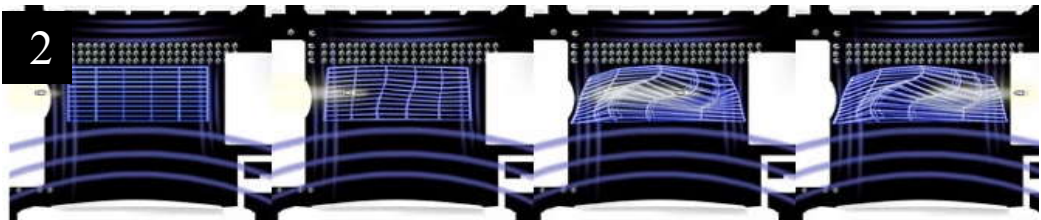
Fig.5.45-5.48 the atmosphere vacuumed form forces, deformed due to car displacement

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1   Doppler effect:: the apparent change in wavelength of sound or light caused by the motion of the source, observer or both. Waves emitted by a moving object as received by an observer will be blue shifted (compressed) if approaching, red shifted (elongated) if receding. It occurs both in sound and light. How much the frequency changes depends on how fast the object is moving toward or away from the receiver.

Step II: Form follows force: By overlapping the environment the forces (vacuumed forces, and forces due to air displacement) to create the Dynaform.
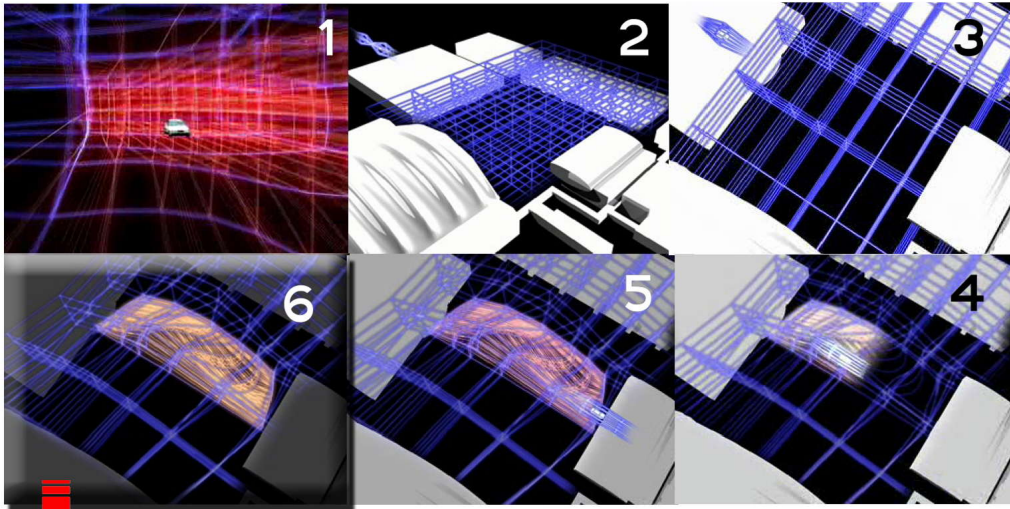
Fig. 5.49-5.54 shows a sequence of frames from the animation, of a BMW car penetrating an environment vacuumed from forces. The forces appeared due to the car movement, and the atmosphere vacuumed from forces shape the main form of the building.
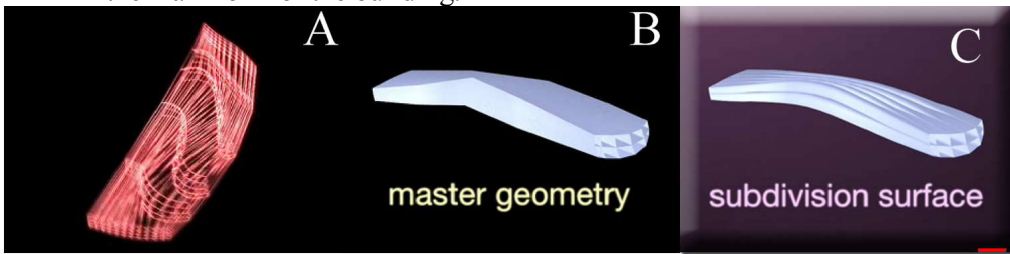
Fig. 5.55-5.57 The form arising from previous simulation process became the master geometry, and then this master geometry was subdivided to be more smooth, and thus creating the final from.

Fig.-5.59 shows the post nature   Fig.-5.58 shows the final form..
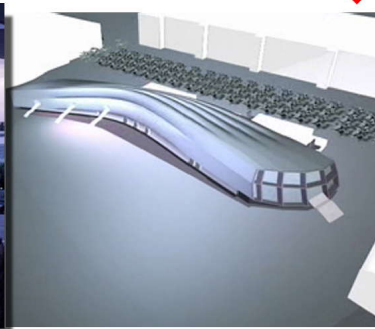
2- Port Authority Gateway [1]. by Architect: Greg Lynn.

This project involved the design of a protective roof and a lighting scheme for the underside of the bus ramps leading into the Port Authority Bus Terminal, located near a series of massive steel bridges that connect the Lincoln tunnel (running under the Hudson river between New Jersey with midtown Manhattan) to upper decks of the Port Authority Bus Terminal along Ninth Avenue, 42nd and 43rd streets.

The site was modeled using forces that represent the intensity of the movement along Ninth Avenue, 42nd and 43rd streets, and the four elevated bus ramps emerging from below the Hudson River. These various forces of movement established a gradient field of attraction across the site. To discover the shape of this invisible field of attraction, they introduced geometric particles that change their position according to the influence of the forces. From the particle studies, they captured a series of phase portraits of the cycles of movement over a period of time. These phase portraits are swept with a secondary structure of tubular frames linking the ramps, existing buildings and the Port Authority Bus Terminal. Eleven tensile surfaces are stretched across-these tubes as an enclosure and projection surface.

Step I creating the atmosphere forces
The dynamic setting of the site –cars and buses, pedestrians and vehicles, underground and over ground, land, and water– was initially simulated as a set of forces and geometric particle systems of varying physical weights and velocities. Using an animation and modeling software the intensities of forces and its gradient were studied by animating vaporous and light material emanating form all directions. (Fig. 5.60-5.62).

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1   Greg Lynn, Animate form, op.cip.
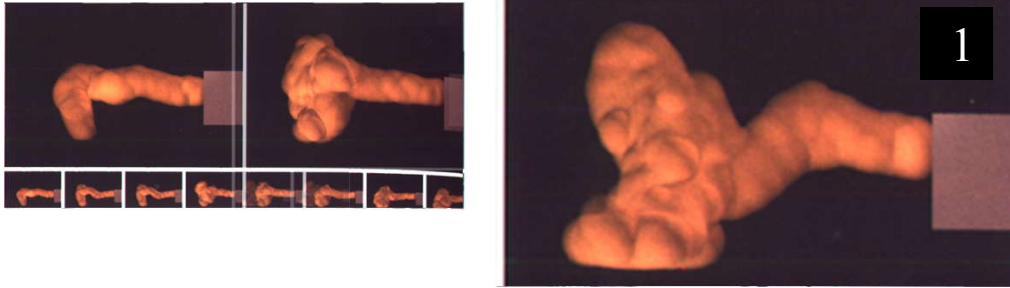
Fig. 5.60-5.62 Represent frames from the animation of vaporous material, which was used to study the forces created in the site

Step II creating the form Gradually the vaporous material used in studying the site forces was exchanged with very heavy particles. This particle material, translated visually into a collection of gravitationally weighted balls emitted from all the directions of the site (Fig 5.63-5.71), these balls were then amalgamated to create the building's main tubular components (main structural units).

Fig. 5.63-5.65 (frames from the animation) Particle study of the Ninth Avenue motion forces.
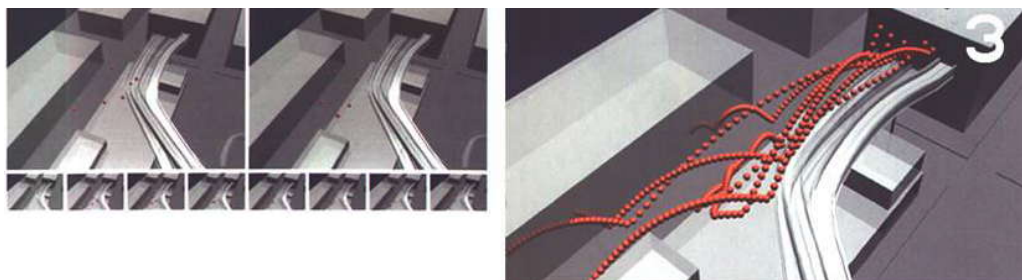
Fig. 5.66-5.68 (frames from the animation)   Particle study of the west side motion forces.
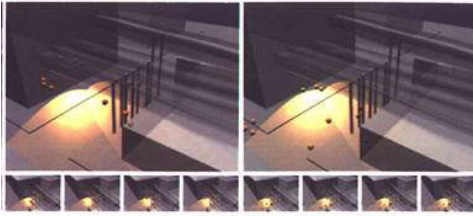
Fig. 5.69-5.71 (frames from the animation) Extra Particle study of the Ninth Avenue motion forces.
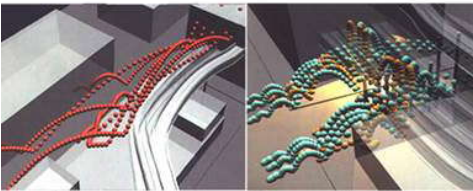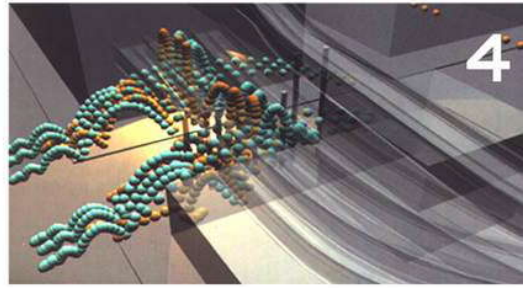
Fig. 5.72-5.74 Collecting the previous Steps together to form the main structure.
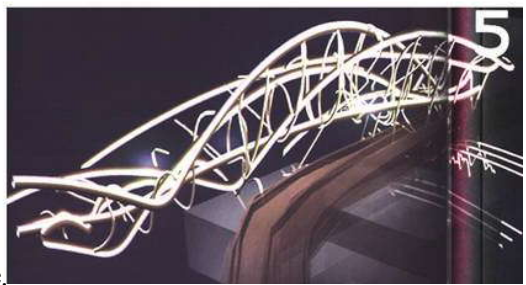
…The collaboration of figures 2,3,4 of the particle study, and the amalgamation of these particles were used to create the main tubular beams in figure 5. (These vectors became the center lines for the tubular beams). Because the dynamic movements were animated within a system of gravities (simulated forces), the tubes have ideal ballistic forms, critical for further static assumptions and calculations.
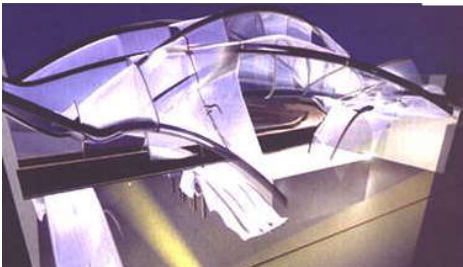
Fig. 5.75-5.76 represent the final form after adding the tensile fabric bands on the structural tubes

The previous tubular beams support a series of tensile fabric bands. The tensile surfaces provide a screen for the projection of transportation information visible to pedestrians and passengers as well as providing a surface for the diffusion of light from below

5-2-4 **Metamorphic architecture.**

5-2-4-1 Definition.

  Metamorphic architecture represents the concept of creating a simple form, and then   selecting the suitable transformation modifier, such as bending, torsion, lattice box, morphing, etc, to change the form. This modifier is selected according to the concept. By adding a fourth, temporal dimension (time) to the deformation processes, animation software adds a possibility to literally express the space and form of an object's metamorphosis, and then select the best frame during the animation. [1]

5-2-4-2 Explanation.

i. Digital modeling software offers wide varieties of transformations a designer could use to explore more formal potentialities.

   Simple modifiers, such as twisting and bending, are particularly effective means for creating alternatives. For instance, Gehry's Ostra Office Building in Hanover, Germany has a simple

prismatic form, which twists in the direction of the nearby open park area. (Fig. 5.77)

Fig. 5.77 Gehry's Ostra Office Building in Hanover, Germany (1999)

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1   Branko Kolarevic, Designing and ManufacturingArchitecture in the Digital Age, op.cip.

ii. By adding the fourth dimension to the metamorphosis of an object in keyframe[1] (keyshape) animation, different states of an object (i.e. keyshapes or keyframes) are located at discrete points in time, and the software then computes through interpolation a smooth, animated, time-encoded transition between them.

A designer could choose one of the interpolated states for further development, or could use the interpolation as an iterative modeling technique to produce instances of the object as it transforms, i.e. morphs from one state another. The example shown in figures 5.78-5.81 shows frames from the animation of a metamorphosis process for a project designed by Peter Eisenman.
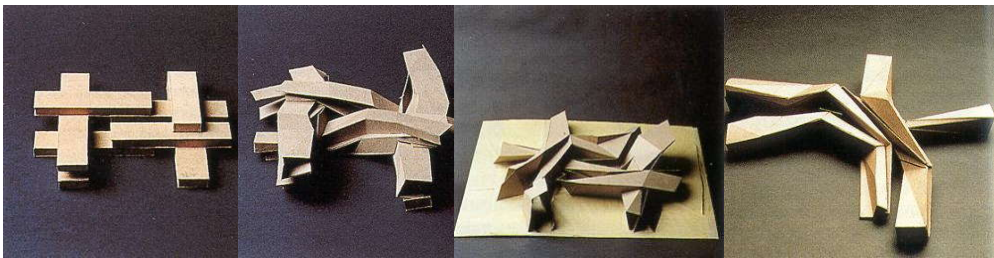
Fig. 5.78-5.81 Offices of BFL Software ltd. by Peter Eisenman

iii. Metamorphic architecture represents the most suitable concept for creating a form, which is hybridization between two distinct forms, by using the technique of morphing between these two forms.

iv. Metamorphic generation of form includes several techniques for deformation, such as modeling space around the model using a bounding box, a spline curve, or one of

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1   keyframe animation is a technique that works a little like storyboarding (a comic strip series of images illustrating a sequence of events). It enables us to choreograph and build an animation by arranging objects and taking snapshots of them at key moments during a sequence of movement or change. These key moments or keyframes become the fixed points in time through which the animation passes.

the coordinate system axis or planes, and path animation, which deforms an object as it moves along a selected path.

Examples of different types of Metamorphing objects with different modifiers ;

1-Morphing: Dissimilar forms are blended to produce hybrid forms that combine formal attributes of the "base" and "target" objects. As shown in the figure the frames of transforming a box to sphere. (Fig. 5.82)
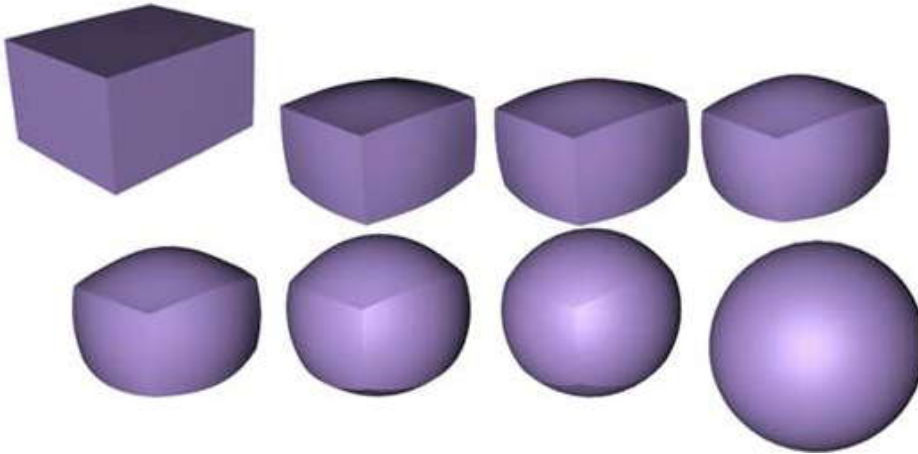
Fig. 5.82 A process of morphing a box into a sphere.

2- Patch deform: A process of deforming an object, by making it moves on a surface of another object. The deformation of the first object depends on the topological surface of the other one. As shown in the figure a torus moves on surface of a plane. (Fig. 5.83)
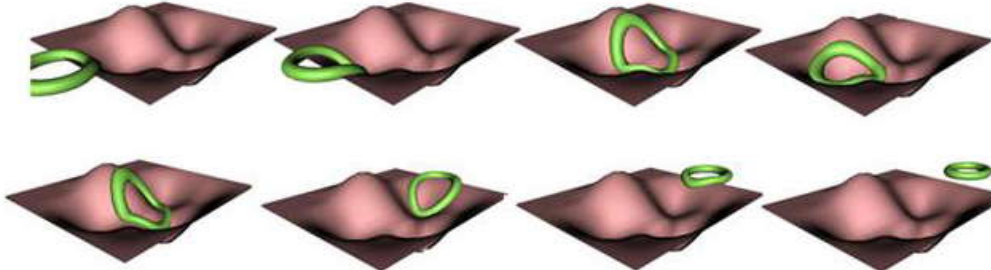
Fig. 5.83 A torus deforms due to its movement on a surface of a plane

3- Path deform: it is a process of deforming an object by making it moves along path. As shown in the figure an object moving along a spline. (Fig. 5.84)
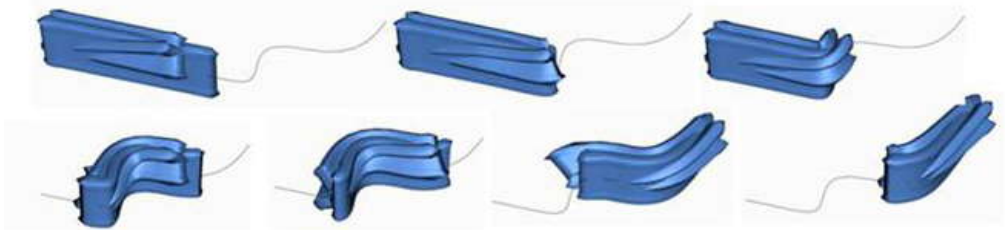
Fig. 5.84 An object is deformed by making it moves on a path.

4- Lattice Box: The main form is surrounded by a virtual box, which is represented as points, by moving these points the main form is modified. As shown in the figures 5.85-5.88 a process of deforming a sphere using virtual lattice box.
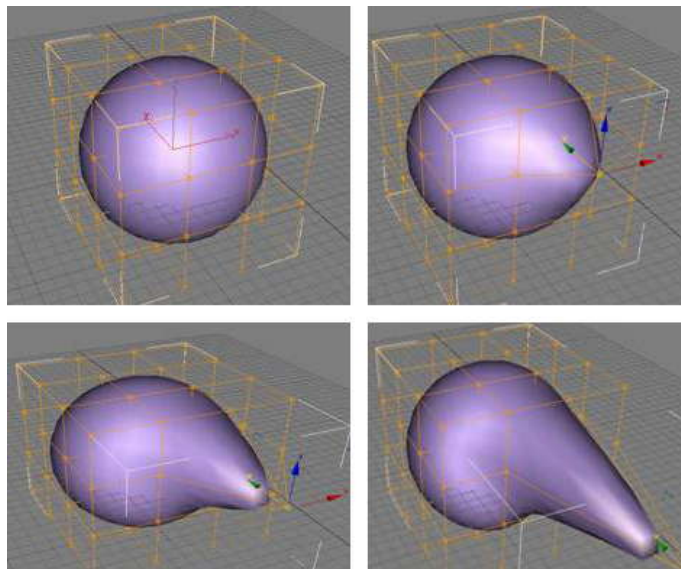
Fig. 5.85-5.88 A process of deforming a sphere by lattice box modifier.

5-2-4-3 Example;

1- Aronoff center for design and art, by Peter Eisenman.
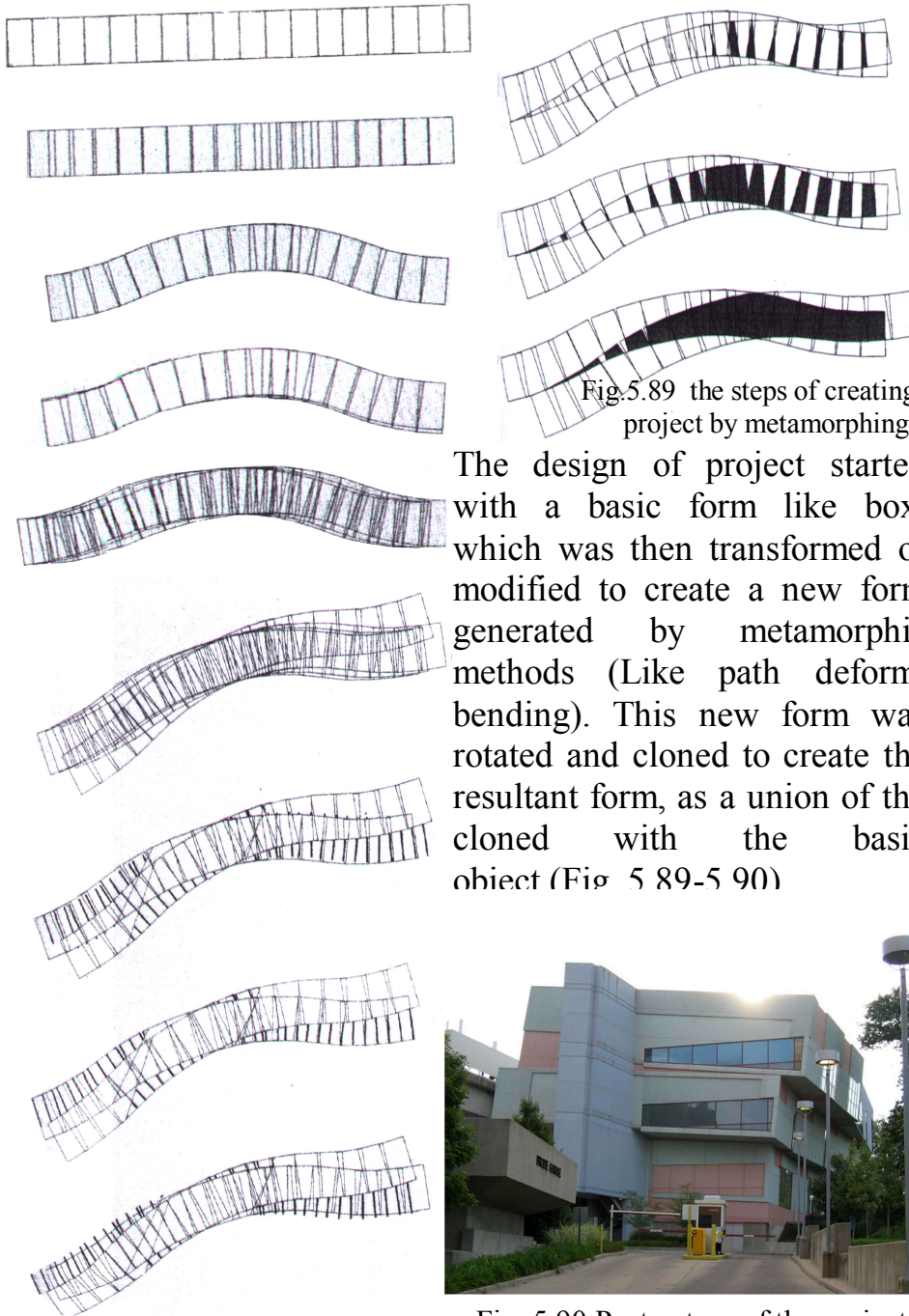
Fig.5.89 the steps of creating the project by metamorphing.

The design of project started with a basic form like box, which was then transformed or modified to create a new form generated by metamorphic methods (Like path deform, bending). This new form was rotated and cloned to create the resultant form, as a union of the cloned with the basic object (Fig. 5.89-5.90)

Fig. 5.90 Post nature of the project.

2-Ost/Kuttner Appartments[1] by, Kolatan and Mac Donald
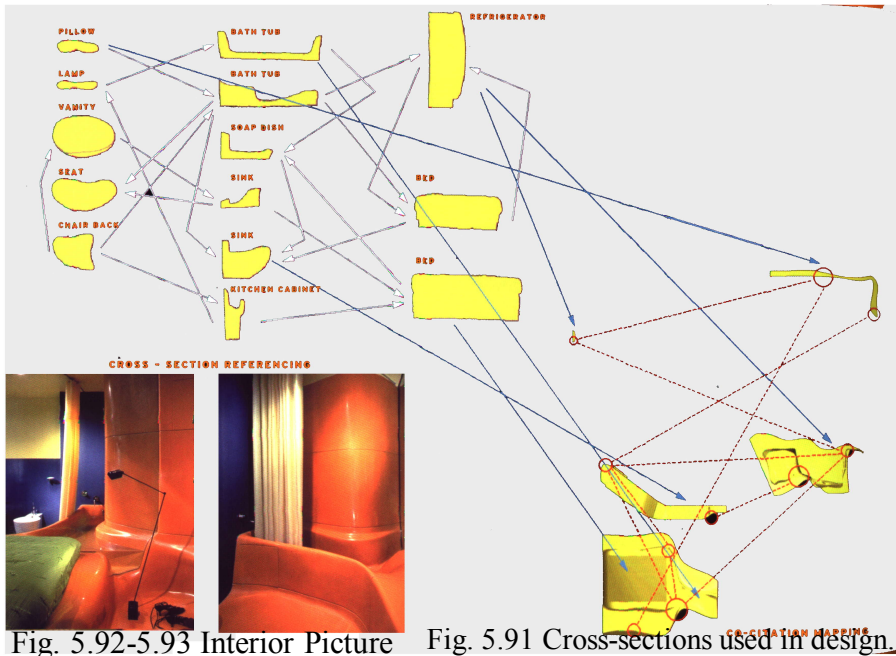
Fig. 5.92-5.93 Interior Picture

Fig. 5.91 Cross-sections used in design.
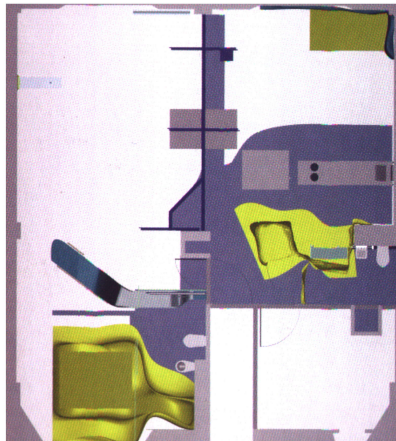
Fig. 5.94 Plan of the apartment

Fig. 5.95 Bedroom of the apartment

In the Ost/Kuttner Apartments, the architect digitally blended cross-referenced sectional profiles of common household furniture, such as a bed, sink/ sofa, etc. Fig. 5.91, to generate new hybrid forms that establish a "chimerical condition between furniture, space, and surface Fig. 5.92-5.95. Kolatan and Mac Donald intentionally employed digital generative processes whose outcomes were unknown and impossible to preconceive or predict,"- i.e. they relied on metamorphic concept such as morphing which is characterized by non-linearity, indeterminacy and emergence.

1   Ost/ Kuttner Apartments New York City, 1996.
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111

5-2-5 Isomorphic architecture.

5-2-5-1 Definitions.

   Isomorphic architecture is based on isomorphic polysurface or what in special effects and animation industries commonly refer to as "meta-clay", "meta-ball", or "blob models". It was originally developed for the study of complex molecules, and Greg Lynn popularized it architecturally.

   The geometric objects of the isomorphic architecture are defined as monad-like primitives with internal forces of attraction and mass. A blob is defined with a center, a surface area, a mass relative to other objects, and a field of influence. The field of influence defines a relational zone within the blob will fuse with, or will be inflected by other blobs. When two or more linked blob objects are proximate, they will either [1];

   i.   Mutually redefine their own surfaces based on their particular gravitational properties. (Fig.5.96).
   ii. Actually fuse into one adjoining surface defined by the interactions of their own centers and zones of inflection and fusion.
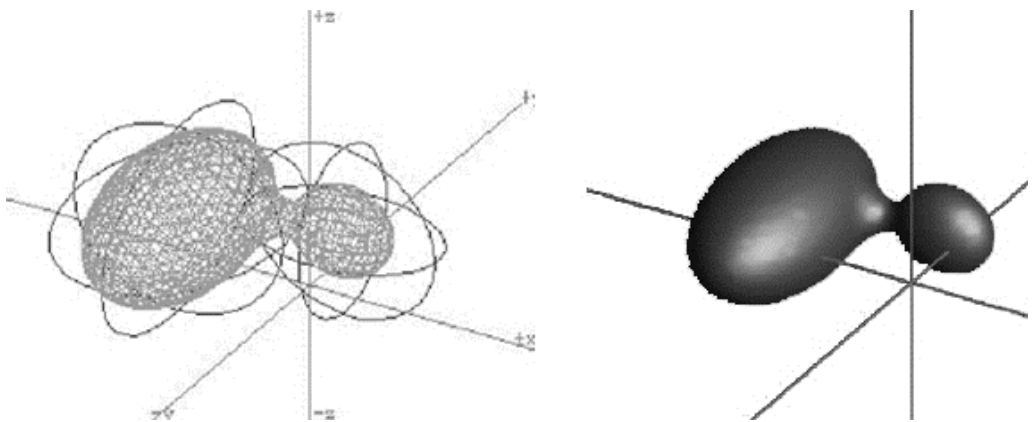
Fig.5.96 Mutual forces between two blobs.

There is no essential difference between a spherical form and a blob. The sphere with its symmetry is merely the index of a rather low level of interactions, while the blob is an index of a high degree of information, where information is equated with difference. Thus, even what seems to be a sphere is actually a blob without influence because it is isolated from adjacent forces.

Blobs or metaballs[1], as isomorphic polysurfaces are sometimes called amorphous objects constructed as composite assemblages of mutually inflecting parametric objects with internal forces of mass and attraction. They exercise fields or regions of influence, which could be additive (positive) or subtractive (negative). *"The geometry is constructed by computing surface at which the composite field has the same intensity – hence the name- isomorphic polysurfaces"*[2]. The surface boundary of the whole (the isomorphic polysurface) shifts or moves as fields of influence vary in their location and intensity.

5-2-5-2 Description.

The parameters that define blobs are such things as mutual extent of influence (threshold), gravity (weight), and form type (ellipsoid, sphere, etc). At the level of imagination, these

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1 Meta Objects are defined by a *directing structure*, which can be seen as the source of a static field. The field can be either positive or negative and hence the field generated by neighboring directing structures can attract or repel. For example a Meta Ball, whose directing structure is a point, generates an isotropic field around it and the surfaces at constant field value are spheres centered at the directing point. Two neighboring Meta balls interact and, if they are close enough, the two implicit surfaces merge into a single surface. In fact, Meta Objects are nothing more than mathematical formulas that perform logical operations on one another (AND, OR), and that can be added and subtracted from each other. This method is also called CSG, Constructive Solid Geometry.

2 Branko Kolarevic, <u>Designing and ManufacturingArchitecture in the Digital Age</u>, op.cip. p.21.

modalities of definition lead to works that are distinctly different from solids or surfaces.
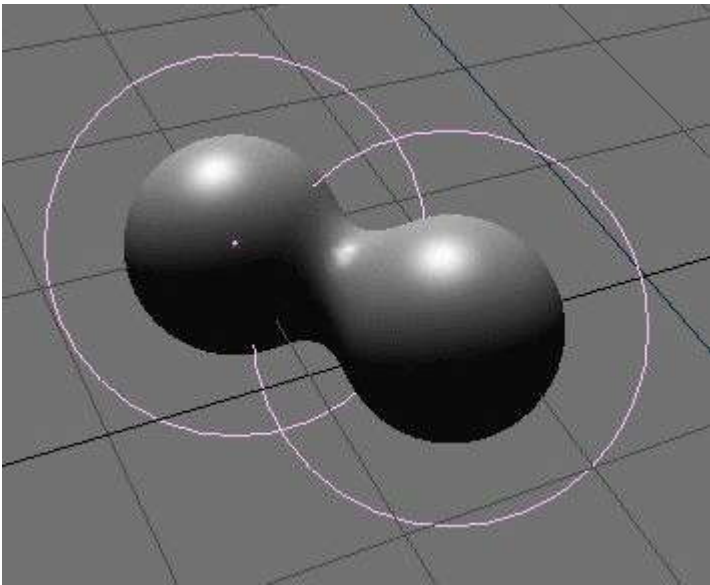
Fig. 5.97 The extent of influence of each blob..

– **Weight and Threshold.**

LEFT OBJECT WEIGHT = +1   LEFT OBJECT WEIGHT = +3   LEFT OBJECT WEIGHT = -4
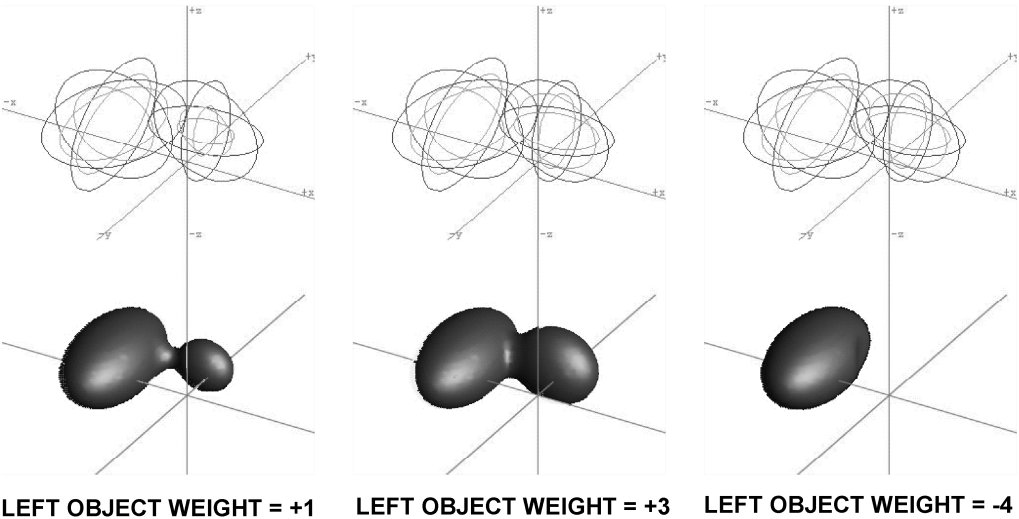
Fig. 5.98 The weight of each object changes its ability to attract other objects

The weight of a "blob" can simply be perceived as its energy or force. If a weight of the "blob" is a positive force, then it will morph with an adjacent blob provided that the other object is within its threshold (shown in gray in the wireframe diagrams). And if its weight is a negative force, then it will "indent" the adjacent object within its threshold. (Fig.5.98)

– **Main types of blobs**. (fig. 5.99)

SPHERE OR
STRETCHED SPHERE

ELLIPSOID OR
STRETCHED ELLIPSOID
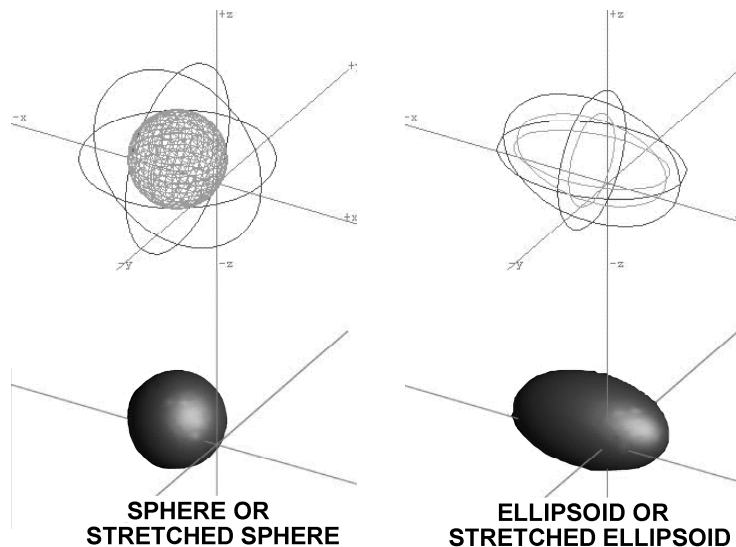
Fig. 5.99 Main types of blobs.

– **The Biosphere**

Biosphere is a group of blobs attracted together.The amount a BioSphere attracts or repels other BioSpheres is determined by its Energy value.

The larger the Energy value, the more powerful the BioSphere becomes, the smaller the value, the less powerful, until it does not attract other BioSpheres at 0. If a BioSphere's Energy value is less than 0, then BioSphere repels other BioSpheres. (the same ideology of interaction between two blobs). (Fig. 5.100)

ENERGY =100   0   -100
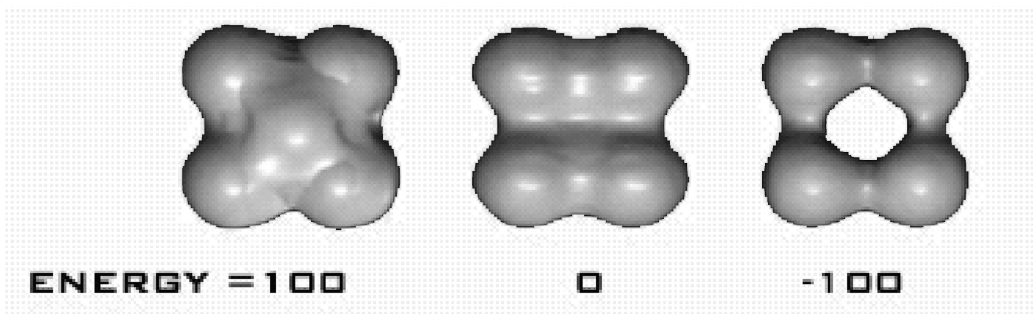
Fig. 5.100 Biosphere with different energy contents.

5-2-5-3 Examples for Isomorphic architecture

1- The "bubble", BMW's exhibition Pavilion, Frankfurt, Germany, 1999.   by Architect Bernhard Franken.

Clean Energy driving with hydro and solar energy and the aid of hydrogen is thematically presented in the form of a water drop (the main concept of the project).

Fig. 5.101-102 water with its two drops as the main concept for the pavilion.

The following figures illustrate the steps for creating the form of the project with isomorphic concept.
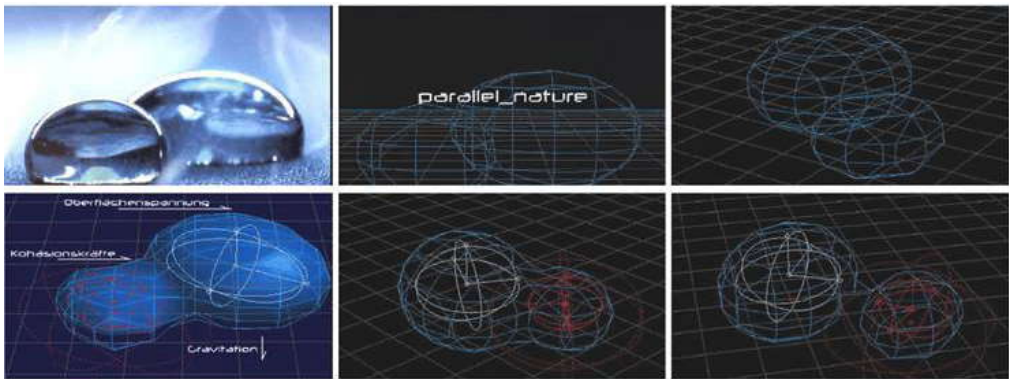
Fig.5.103-108 show the steps for simulating the water drop as an isomorphic surface. The architect studied the mutual forces between the two drops and there resultant form, which was later on his main form.
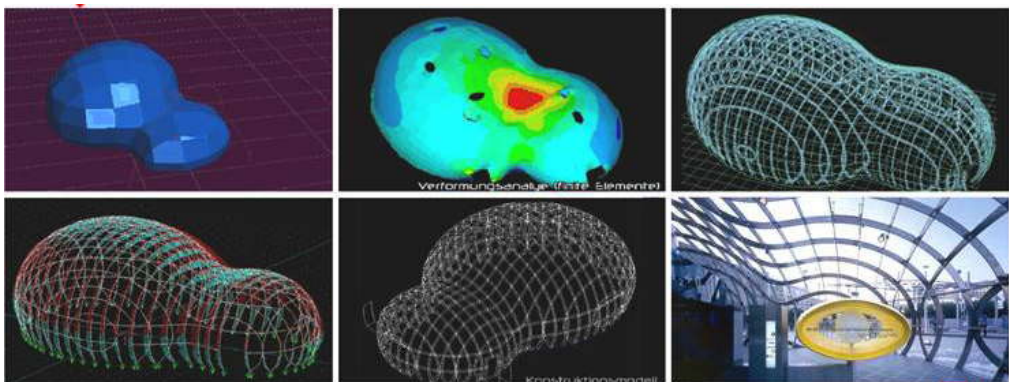
Fig. 5.109-114 Show post studies complex studies for the form created, and the studying of the structural system used, which is based on the same idea of polysurface.

Fig.5 115,5-117 shows the post nature of the project.

2-Korean Presbyterian Church, New York, 1999[1].

The new church structure emerges from within an abandoned factory building, formerly known as the "Knickerbocker Laundry", built by Irving Fenichel in 1932 in the "streamline modern" style.

The new church was built within the extension of the old factory, and it contained new spaces such as classrooms, rehearsal room, a cafeteria, a library, and a daycare center.

Generally, using Meta blobs is the main process used in creating the form. Fig.5.118 ("Meta Blobs" are specifically located nodes that interact according to their zones of assigned gravitational force. As the computer calculates the conditions of balance, the nodes grow and fuse into new nodes until they achieve a state of equilibrium.) The steps of creating form can be explained as follows;
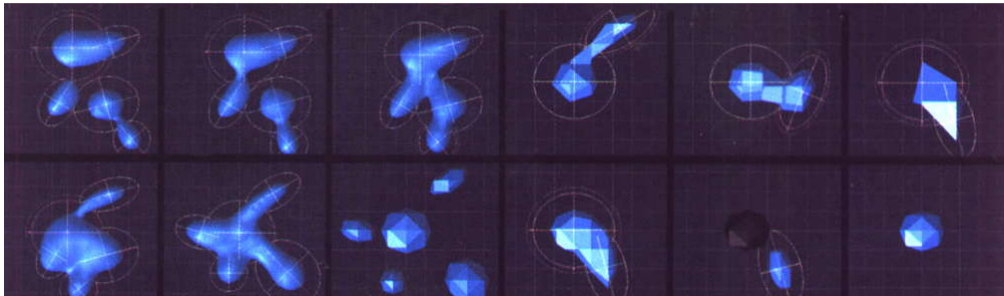
Fig. 5.118 The interaction of Meta-blobs

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1   The new Korean Presbyterian Church of New York in Sunnyside, Queens, is the result of a lengthy collaborative effort by three teams working in three cities: Garofalo Architects in Chicago, Illinois, Greg LynnFORM in Venice, California and Michael McInturf Architects in Cincinnati, Ohio. Shared digital technologies and web connections allow the seven person team to exchange CAD files, model photos and other project information day or night. By distributing the work load between offices and by tapping into the experience and expertise of each office, the consortium is able to oversee a project that would have been too large and complex for any one of them to manage individually.

Step 1 The "blob" strategy is used to generate a single volume that results from the growth and fusion process of separate programmatic nodes. What begins as a collection of single rooms (nodes), ends as a single surface that incorporates the entire program.Fig. 5.119.
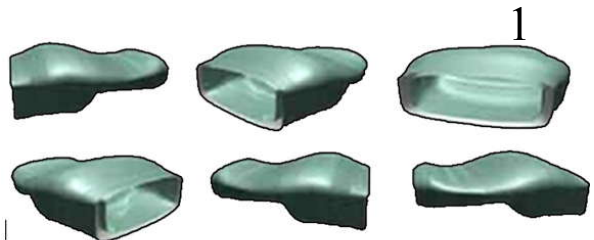
Fig. 5.119   Step1.

Step 2 A parallel alignment of nodes is chosen and allows a different manipulation of the growth and fusion process. The shaped form of the single volume is then arrested after the separate nodes reach their equilibrium. .Fig. 5.120
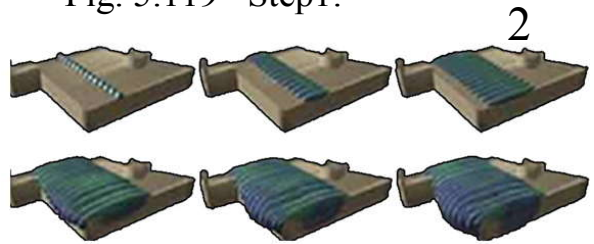
Fig. 5.120   Step2

Step3 A single shell is offset to generate a double-wall. The inner surface follows this offset, and each surface rib flares until it connects back to the outer skin, creating a stiff, three-dimensional structure needing no additional columns and an intricate interior volume of louvered-hung ceiling panels and facetted walls. .Fig. 5.121.
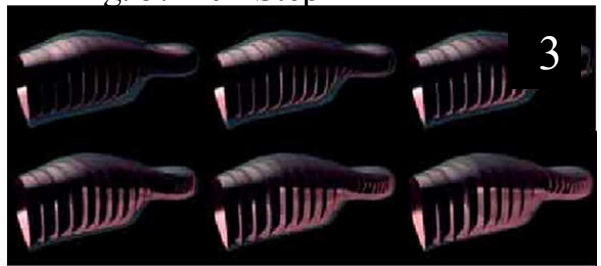
Fig. 5.121   Step3

Step4   Collaborating the previous steps (1,2, and3). Fig. 5.122, 5.123.
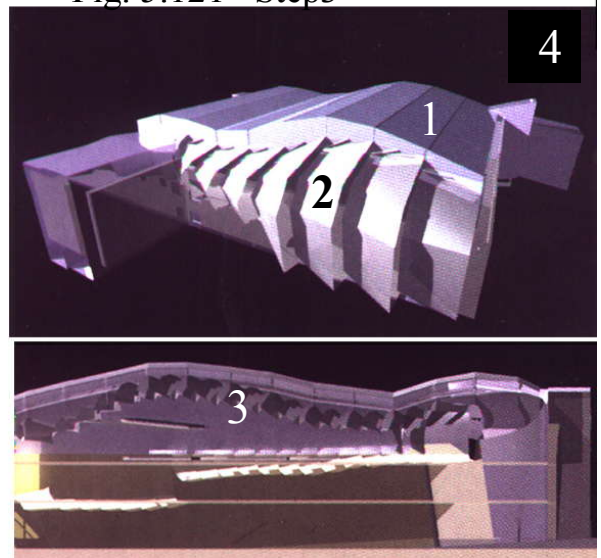
Fig.5.122,5.123 Step 4

5-2-6-1 Definition:

It is the architecture, which uses building performance as a guiding design principle and adopting a new list of performance-based priorities for the design of cities, buildings, landscapes and infrastructures. This new kind of architecture places broadly defined performance above form-making; it utilizes the digital technologies of quantitative and qualitative performance-based simulation to offer a comprehensive new approach to the design of the built environment. Performative design may be based on, financial (the owner perspective), spatial, social and cultural to purely technical (structural, thermal, acoustical, ecological, etc.). (Fig. 5.126). The emphasis on building performance (again, broadly understood from the financial, spatial, social, cultural, ecological and technical perspective) is redefining expectations of the building design, its processes and practices. [1]
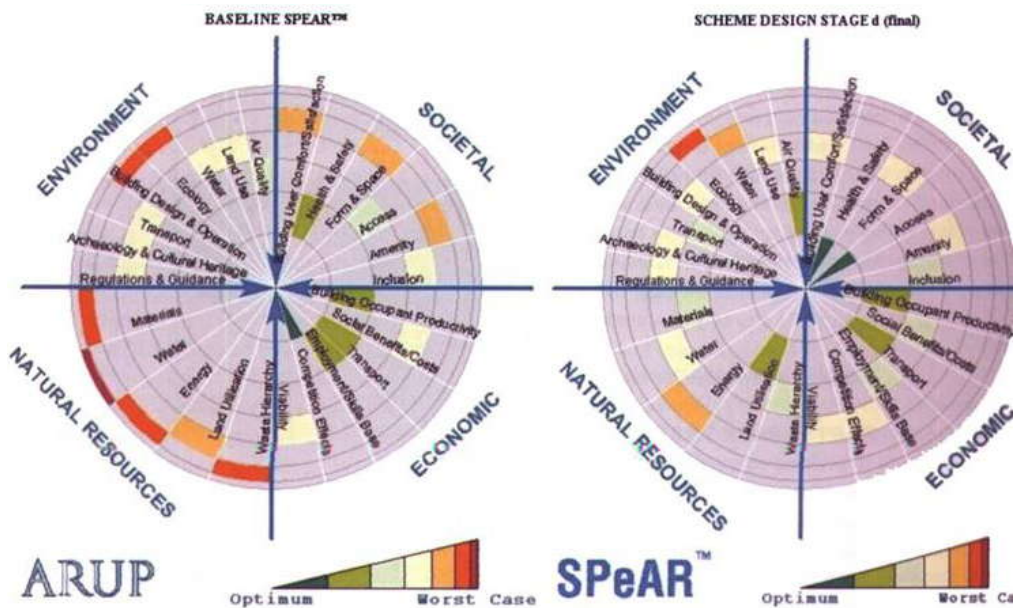
Fig. 5.126 Aspects of building performance.

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1   ibid. p.26.

5-2-6-2 Explanation.

i.   Performative approach to design of buildings could imply a significant shift in how free forms are perceived. The *" highly curvilinear forms could become not only an expression of new aesthetics, or a particular cultural and socio-economic moment that born out of the digital revolution, but also an optimal formal expression for the new ecological movements that calls for sustainable building "*[1].

ii. The design in the performative architecture uses the analytical computational techniques based on the Finite Element Method (FEM), in which the geometric model is divided into small, interconnected mesh elements. These mesh elements are used to study the structural perform, energy and fluid dynamics analyses for complex forms. These quantitative evaluations of specific design proposals can be qualitatively reached today due to the improvements in graphic output and visualization techniques, which explain the performance of every mesh element (Fig. 5.132, 5.133). By superposing various analytical evaluations, design alternatives could be compared with relative simplicity to select a solution that offers the optimum performance.

For example, The original form of Peter Cock's and Colin Fournier's competition winning entry for the Kunsthaus in Graz, Austria, was altered somewhat after the digital structural analysis, which revealed that its structural performance could be improved with minor adjustments in the overall form. (Fig. 5.127).

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1   Branko Kolarevic, <u>Architecture in the digital age. Digital design and manufacturing</u>, op. cip.
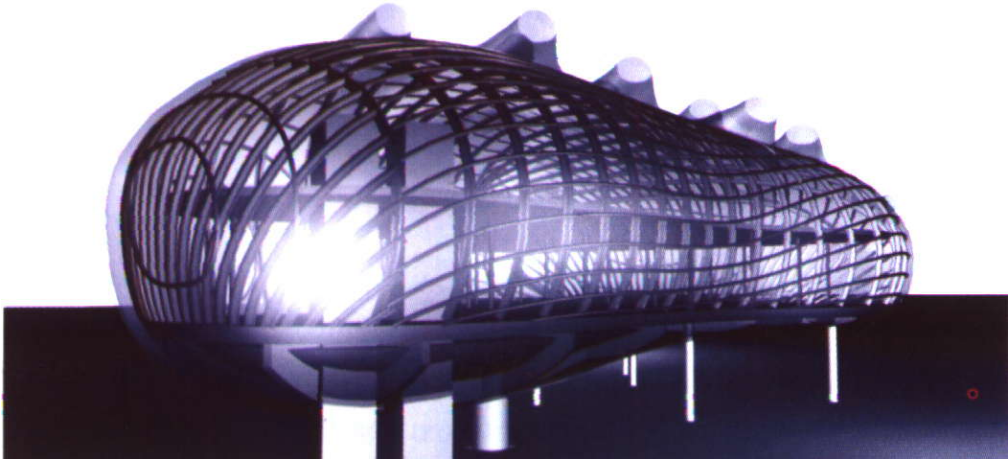
Fig. 5.127 Kunsthaus 2003, Graz, Austria, architects Peter Cock and Colin Fournier.

iii.   Analytical computation can be used in [1]:

–   Creating the main form: Analytical computation could be used to actively shape the buildings in a dynamic fashion, by adding a fourth dimension (time). An already-structured building topology, with a basic form, could be subjected to dynamic, metamorphic transformation, resulting from the computation of performance done with targets set at the start. (It is the same idea of metamorphic architecture, but the targets here are based on performance and not on modifiers). This dynamic range of performative possibilities would contain, at one end the unoptimized solution and, at the other end, the optimized condition, which might not be an acceptable proposition from an aesthetic or any other point of view. In that case, a sub-optimal solution could be selected from the in-between performative range, which could potentially satisfy other non-performative criteria.

–   Designing the details of the main form: Analytical software would preserve the topology of the proposed schematic design, but would change the geometry in response to optimizing particular performance criteria (acoustic, thermal, etc.). For example, if there is a

particular geometric configuration comprised of polygonal surfaces, the number of faces, edges, and vertices would remain unchanged (i.e. the topology does not change), but the shapes (i.e. the geometry) would be adjusted. The process of change could be animated i.e. from the given condition to the optimal condition, with the assumption that the designer could find one of the in-between conditions interesting.

5-2-6-3 Example:

1- City Hall, London, 1998.   by architect Norman Foster.

City hall in London houses the assembly chamber for 25 elected members of the London Assembly and the offices of 500 staff of the Greater London Authority (GLA). The main concept was to design the building as an iconic, signature building that would be sensitive to environmental issue.[1]

- **Creating the main form:**

i.   Originally, the concept was to create a large "lens" looking out over the river, but later on they attempted to create it as a "pebble", with mainly an integrated energy solution.

ii.   They started there design with a sphere, which has the minimum surface area for a certain volume. (The most suitable form from the energy point of view, because it will absorb the lowest amount of heat).

iii. To make the project form as a pebble-like form, many modifications were performed, which were done mainly to fulfill the ecological aspect (the main goal in design).

These modifications were as follows [1];

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1   ibid.

- Orienting the main axis towards the midday sun. This new orientation made the form of the project had the minimum surface area faced the sun. (Fig. 5.128)

- The side elevations also were curved, presenting a minimal area to the east and west, where the facades face a low sun angle. The resulting form, as seen from the north has an almost circular profile, exploiting views across the river.

- The planes which resulted from slicing of floor plates, were extracted to be used as the basis for space planning studies, by checking there areas, and computing there volumes. The resultant plans will be fed back to a parametric model to improve performance.
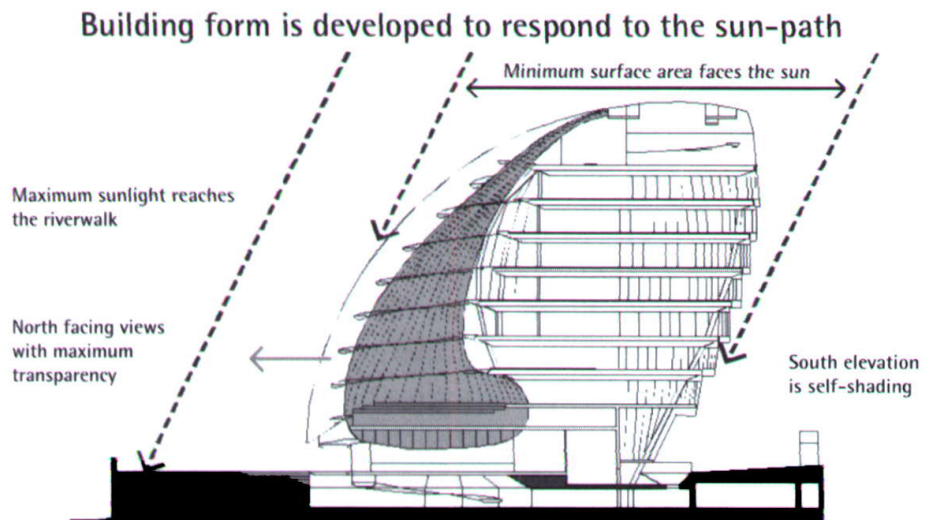
Fig. 5.128 The sun illumination diagram for the city hall.

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1   Hugh Whitehead, Laws of form, in Architecture in the digital age. Digital design and manufacturing, edited by Branko Kolarevic.

iv.   A number of detailed studies followed, with intense thought and effort were applied to study the glazing panels. These studies relied heavily on the CAD system and its link to the CNC (computer numerical controlled) machine. For example, by applying a diamond grid glazing system, the panels inherited different twist and different dimensions, which was going to make it more difficult to be fabricated. To eliminate the previous problems in the glazing system, the architect made the glazing system like cylinders (torus patches). (Fig. 5.129-5.131).

Fig. 5.129 Post nature of City Hall shows, how the glazing system was fabricated like cylinders.

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1   ibid.

Fig. 5.130 Flat-patterned drawing of the glazing solution for city hall.
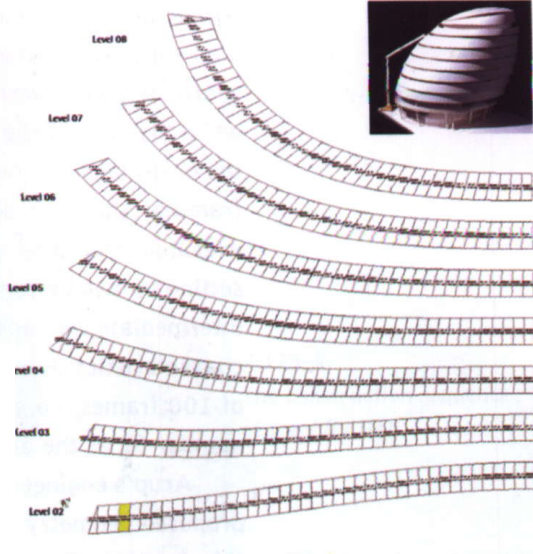
Fig. 5.131 A computer-generated spreadsheet with data for each glazing model.

Panel ID	Corner 1			Corner 2			Corner 3			Corner 4		
	X1	Y1	Z1	X2	Y2	Z2	X3	Y3	Z3	X4	Y4	Z4
P_002_001	38.526778	71.225110	15.700000	37.240670	70.447647	15.700000	37.187501	71.182021	11.900000	38.479968	71.962724	11.900000
P_002_002	37.240670	70.447647	15.700000	36.007043	69.589343	15.700000	35.948733	70.320140	11.900000	37.187501	71.182021	11.900000
P_002_003	36.007043	69.589343	15.700000	34.830971	68.653727	15.700000	34.767761	69.380625	11.900000	35.948733	70.320140	11.900000
P_002_004	34.830971	68.653727	15.700000	33.717292	67.644648	15.700000	33.649441	68.367342	11.900000	34.767761	69.380625	11.900000
P_002_005	33.717292	67.644648	15.700000	32.670585	66.566256	15.700000	32.598373	67.284456	11.900000	33.649441	68.367342	11.900000

- **Editing the form due to the energy studies:**

Arup[1]'s engineer did a solar study of the proposed design, and produced an image in which they color-coded the surface according to the total amount of energy that each cladding panel would receive during a year. (Fig. 5.132-5.133).

They provided figures in a spreadsheet format, so that the distribution of light could be analyzed in detail. (Fig. 5.130-5.131).
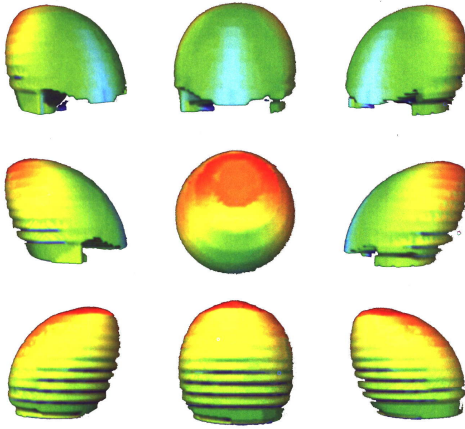
Fig. 5.132 Solar studies for the
City hall building.
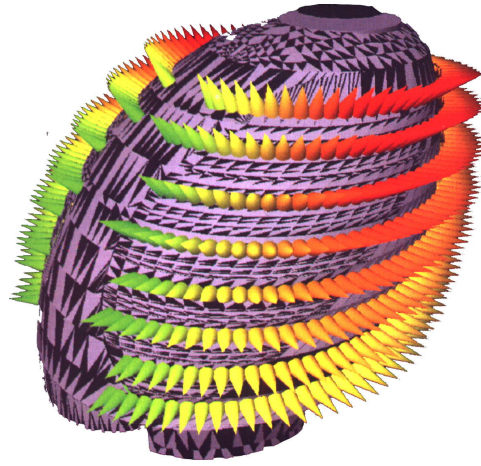
Fig. 5.133 Solar study for the City
hall building.

From these studies it was clear that:-

−   The south facade was performing as
    expected (it was self-shading as shown
    in Fig.5.134 by grey overhang areas).

−   The east and west surfaces were
    limiting solar gain as expected.

−   At the north surface, the protected area
    from solar gain was not large enough
    for the torus patches (cylindrical)
    cladding that has been envisioned
    (there was a conflict between the
    design and the outcome of the energy
    analysis). The solar studies showed
    them that the glazing system (the
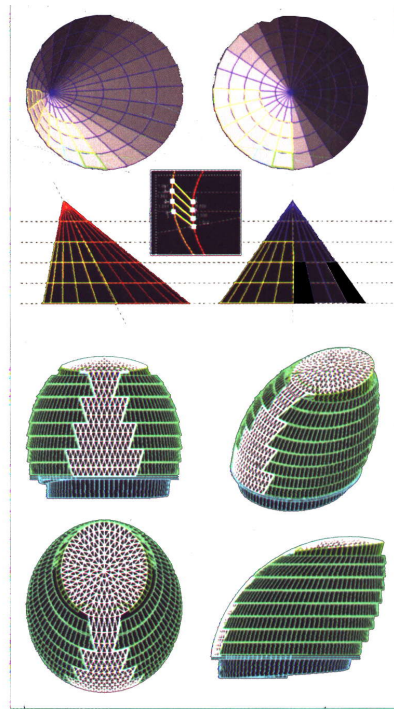
Fig. 5.134 The glazing solution
for the City hall based on a stack
of sheared cones.

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1   A professional firm providing technical solutions. Currently operating out of
    73 offices in 32 countries, with 7000 members of staff. Arup is made up of a
    number of inter-related practices, which combine nearly all fields of
    engineering.

torus glazing) had to be changed.   (Fig.5.134).

Due to the previous studies done by Arup, the architect changed the glazing system in the north elevetion, from a torus patch to sheared cones, and, so, in this case, the color-coded diagram actually led to the best glazing solution. (Fig. 5.134)

2- E-motive house, Rotterdam,Holland. 2002.   by Arch. Kas Oosterhuis.

The emotive house is fully industrial, flexible in programmability, demountable, and innovative. 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. [1]

The emotive house is a test case for extended reality. Traditional materials are augmented with a swarm of built-in technology. The construction of the house and the furniture becomes programmable. Everything changes, except the kitchen-area and the sanitary. The form of the emotive house is a long, movable space, with solid blocks in both ends (kitchen and bathroom). The space in between can be changed from workspace to eat place, to sleeping space ..etc. (Fig. 5.135)

Fig. 5.135 E-motive house 2002.
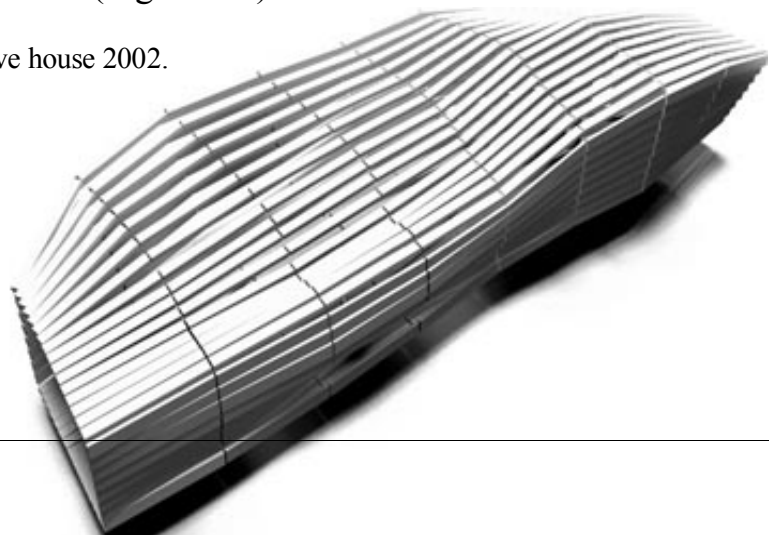
The structure consists of a combination between two types of elements; the hard massive wooden beams, and soft structures between the wooden beams. The form can be expanded or contracted to change the general form of the house by using pneumatic muscles which are connected to the wooden beams.

These pneumatic muscles are programmable and connected to sensors to deform the building according to the weather changes, or according to the user needs. In that way a user can perform changes to his house according to his needs, as if he is playing a virtual game, which is reflected on the form of his house. (This is due to the programmable muscles).

" *The E-motive house is a fully programmable muscle construct , designed to be able to change shape and content in real time. Responsive to the urgent needs and whimsical wishes of the inhabitants, they also act for themselves, they surprise their users, they are fooling them, and they play games with them. The E-motive house is programmed to behave within predefined emotional bandwidths of emotional modes. And within the modes (entertainment mode, relax mode, educational mode, commercial mode, and sports mode). The house is free to act and to develop a personal mood….In other words: the house is a social semi-independent extension of the human bodies of the inhabitants. The E-motive house is a complex adaptive system.*" [1] (Fig. 5.136, 5.137).
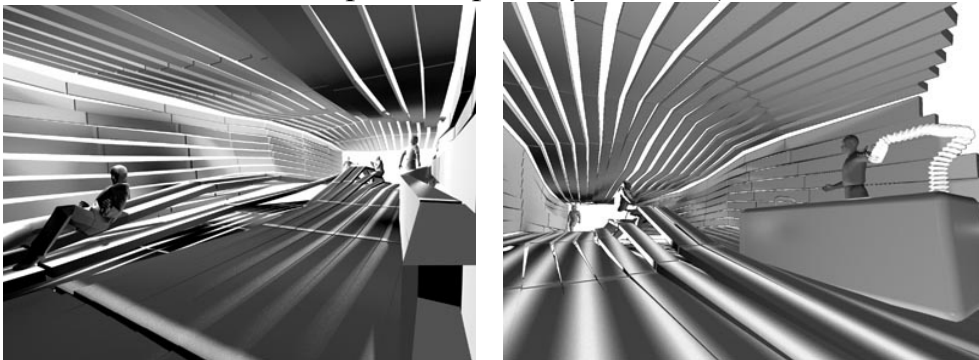
Fig. 5.136, 5.137 Different states for the project..

1   Peter Bentley (Ed.), Evolutionary design by computers, Morgan Kaufman publishers, 1999.

5-2-7 Genetic Algorithms (Evolutionary architecture).

Genetic Algorithm is an artificial intelligence procedure. It is based on the theory of natural selection and evolution. [1]

Genetic algorithms were developed in an attempt to explain the adaptive processes of natural systems and to design artificial systems based upon these natural systems. (Fig. 5.138)
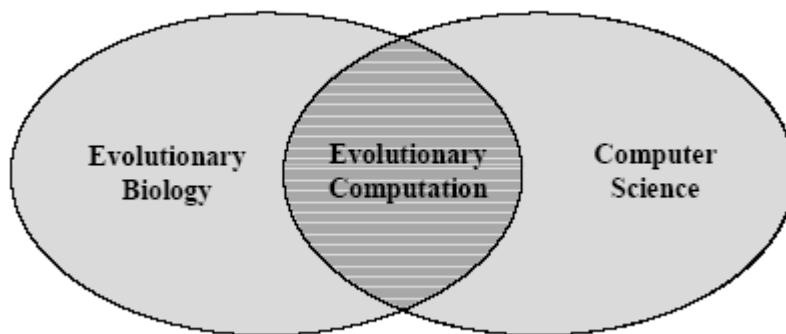
Fig. 5.138 Evolutionary computation has its roots in computer science and evolutionary biology.

The genetic algorithm (and enhanced versions of it) resembles natural evolution more closely than most other methods.

GAs are widely used in optimization of design in many engineering fields, to improve a previous design, or to create new design form scratch. GAs show great power in design fields due to its ability of creating a wide range of alternatives in design, in a very short time, which can help the designer in decision making. The idea of the GAs is based mainly on the genetic rules, similar to the genetic rules of the living creatures.

Genetic algorithms use two separate spaces: the search *space* and the *solution* space[2]:- (Fig. 5.139)

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1   Kas Oosterhuis, Hyper bodies: Towards an E-motive architecture, Birkhauser, 2003. P.54,55

i.   The search space is space of *coded* solutions to the problem.

ii. The solution space is the space of actual solutions.

Coded solutions, or *genotypes* must be mapped as actual solutions, or *phenotypes*, before the quality or *fitness* of each solution can be evaluated. (Fig. 5.139)
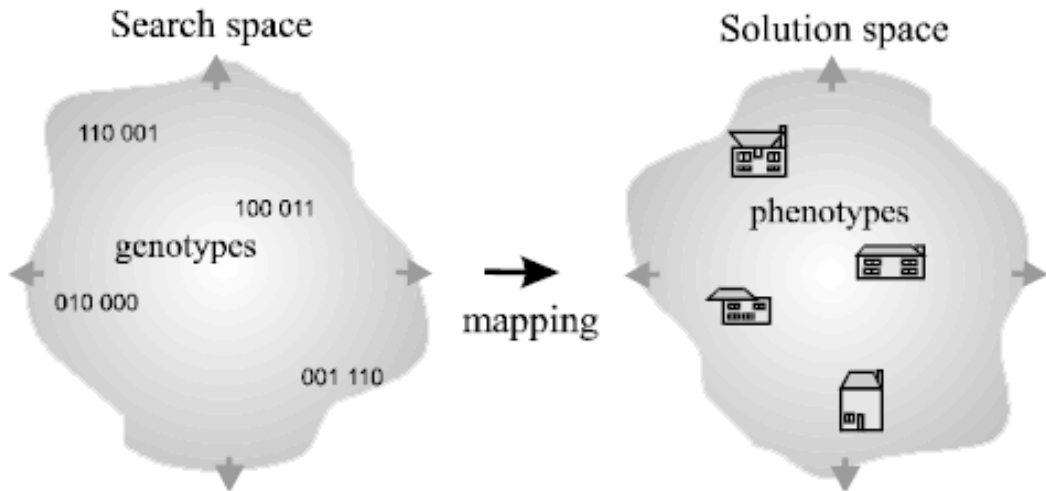
Fig. 5.139 Mapping genotypes in the search space to phenotypes in the solution space.

In GA each individual element (in the phenotype) in the solution space, takes a code (a binary code depends on its properties) in the search space (in the genotypes). Phenotypes usually consist of collections of parameters; Genotypes consist of coded versions of these parameters. A coded parameter is normally referred to as a *gene*, with the values a gene can take being known as *alleles*. A collection of genes in one genotype is often held internally as a string, and is known as a *chromosome*. (Fig. 5.140)

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1   Peter Bentley (Ed.), <u>Evolutionary design by computers</u>, Morgan Kaufman publishers, 1999.

2   ibid.
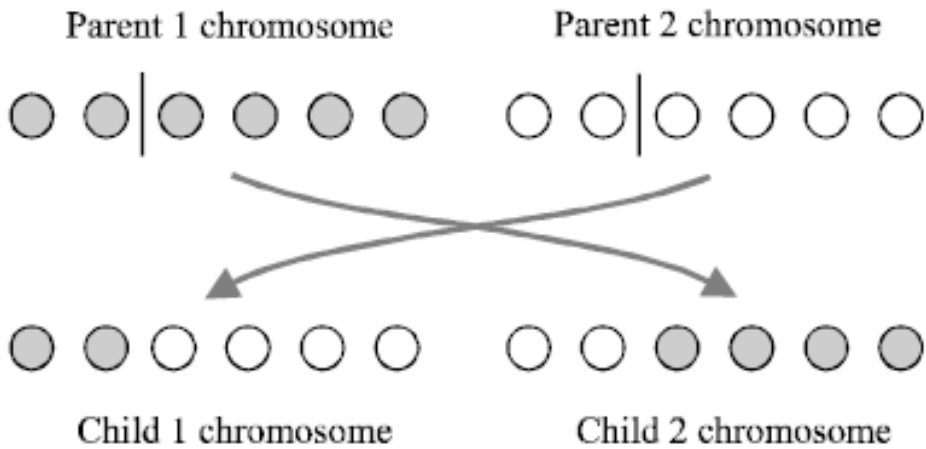
Fig. 5.140 The behaviour of the crossover operator. The vertical line shows the position of the random crossover point.
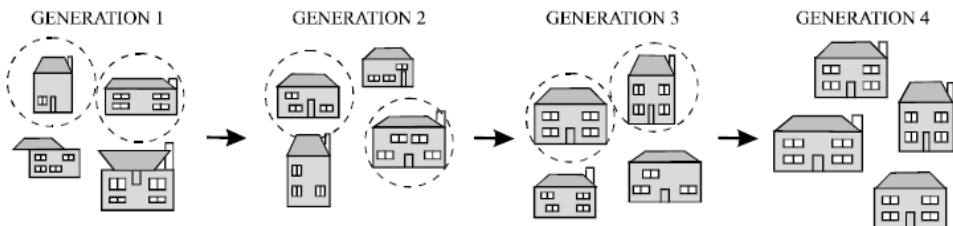
Fig. 5.141 Four generations of evolving house designs using a population size of four. Parents of the next generation are circled.

The simplest form of a GA is summarized in figure 5.142, this genetic algorithm can be explained in the following points [1]:-

i.   The genotype of every individual in the population is initialized with random alleles.

ii.   The main loop of the algorithm then begins, with the corresponding phenotype of every individual in the population being evaluated and given a fitness value according to how well it fulfils the problem objective or fitness function.

iii.   These scores are then used to determine how many copies of each individual are placed into a temporary area often termed the 'mating pool' (i.e. the higher the fitness, the more copies that are made of an individual).

iv.   Two parents are then randomly picked from this area.

v.   Offspring are generated by the use of the crossover operator, which randomly allocates genes from each parent's genotype to each offspring's genotype. For example, given two parents: 'ABCDEF' and 'abcdef', can create a new generation of 'ABcdef' and 'abCDEF', and another new generation can be created by 'ABcdef' and 'abCDEF', and so on…..

vi.   This entire process of evaluation and reproduction then continues until, either a satisfactory solution emerges or the GA will run for more generations.

INITIALISE POPULATION WITH RANDOM ALLELES

EVALUATE ALL INDIVIDUALS TO DETERMINE THEIR FITNESSES

REPRODUCE (COPY) INDIVIDUALS ACCORDING TO THEIR FITNESSES INTO 'MATING POOL' (HIGHER FITNESS = MORE COPIES OF AN INDIVIDUAL)

RANDOMLY TAKE TWO PARENTS FROM 'MATING POOL'

USE RANDOM CROSSOVER TO GENERATE TWO OFFSPRING

RANDOMLY MUTATE OFFSPRING

PLACE OFFSPRING INTO POPULATION

HAS POPULATION BEEN FILLED WITH NEW OFFSPRING?

YES   NO

IS THERE AN ACCEPTABLE SOLUTION YET? (OR HAVE x GENERATIONS BEEN PRODUCED?)

NO   YES

FINISHED

Fig.5.142   The simple genetic algorithm.

Genetic Algorithms in design.

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1   ibid.

Evolutionary design has its roots in computer science, design, and evolutionary biology. It is a branch of evolutionary computation, which extends and combines CAD and analysis software, and borrows ideas from natural evolution. [1] (Fig. 5.143)
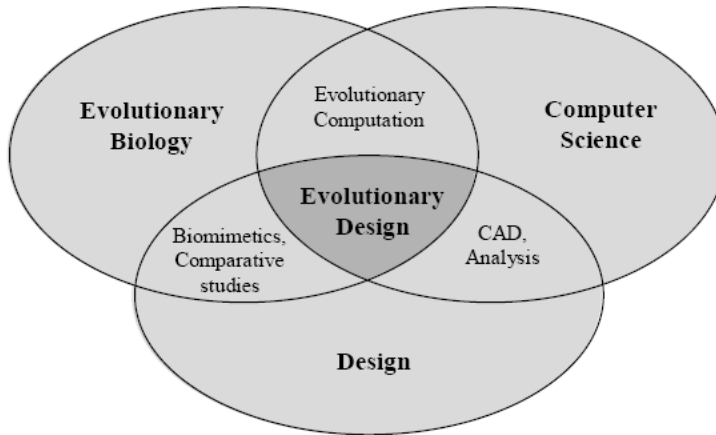
Fig. 5.143   Evolutionary design has its roots in computer science,
design, and evolutionary biology.

"The use of evolutionary computation to generate designs has taken place in many different fields over the last 10 or 15 years. Designers have optimized selected parts of their designs using evolution, artists have used evolution to generate aesthetically pleasing forms, architects have evolved new building plans from scratch, and computer scientists have evolved morphologies and control systems of artificial life." [2]
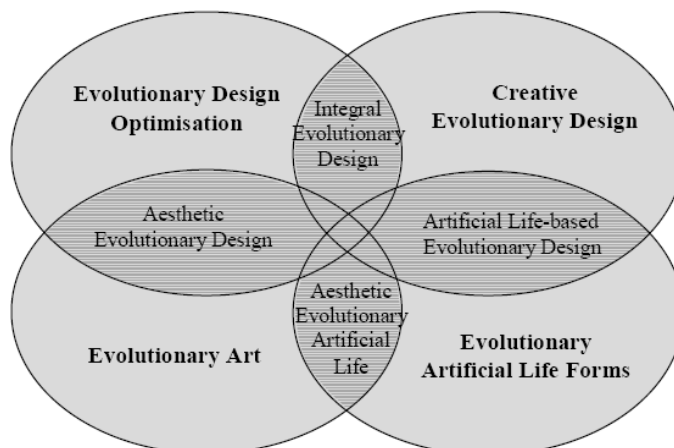
Fig. 5.144   Aspects of evolutionary design by GAs.

In general, these types of evolutionary design can be divided into many categories the most important are as follows [1]; *evolutionary design optimization*, *creative evolutionary design*, *evolutionary art*, and *evolutionary artificial life forms* see figure 5.144.

Examples of the four kinds:

i.   Evolutionary design optimisation.

For example, Evolutionary optimization of a table (Fig. 5.145).
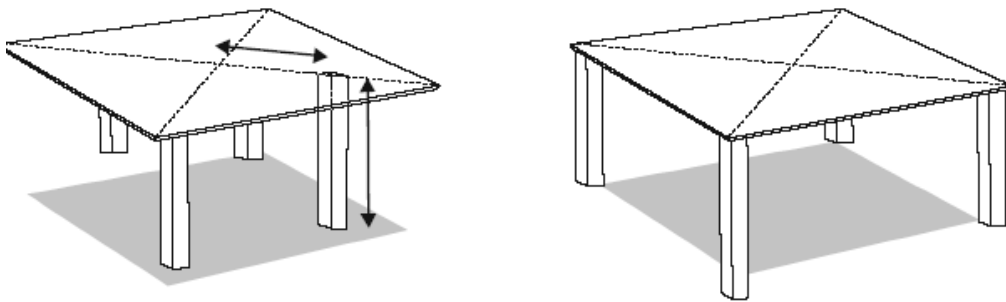
Phenotype:
Table consisting of fixed top and four legs defined by:
Length of leg 1, Distance of leg 1 from centre
Length of leg 2, Distance of leg 2 from centre
Length of leg 3, Distance of leg 3 from centre
Length of leg 4, Distance of leg 4 from centre

Genotype:

11010110	10101101	10101110	10011010	01101010	10001010	11110010	00101110
Length 1	*Distance 1*	*Length 2*	*Distance 2*	*Length 3*	*Distance 3*	*Length 4*	*Distance 4*

Fig. 5.145 Evolutionary optimization of a table.

ii.   Evolutionary art.

For example, Evolving 'artistic tables' Fig. (5.146)

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1   ibid.
2   ibid. p.35.
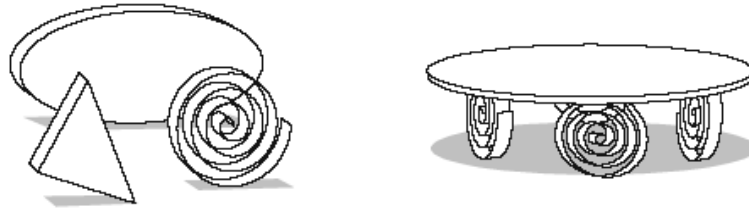
Phenotype:
Ellipse, width 80, height 50, depth 4, rotated by 90 degrees
Spiral, radius 40, curliness 4, depth 6, shifted horizontally by 50, vertically by -20
Spiral, radius 40, curliness 4, depth 6, shifted horizontally by 50, vertically by -20, rotated 90 degrees
Spiral, radius 40, curliness 4, depth 6, shifted horizontally by 50, vertically by -20, rotated 180 degrees
Spiral, radius 40, curliness 4, depth 6, shifted horizontally by 50, vertically by -20, rotated 270 degrees

Fixed structure (embryogeny)
using Shape Description Language:

Table =   { Ellipse (*width, height, depth*)
            YZ_Rotate (*angle*) }
          { Leg
            X_Shift (*distance*)
            Y_Shift (*distance*)
            Rotate & Duplicate (*angle, #duplicates*) }
Leg =   Spiral (*radius, curliness, depth*)

Genotype:

80	50	4	90	40	4	6	50	-20	90	4
width	height	depth	angle	radius	curliness	depth	distance	distance	angle	#duplicates

Fig. 5.146   Evolving 'artistic tables'.

iii.   Generative evolutionary design.

Generative evolutionary design of a table Fig. 5.147
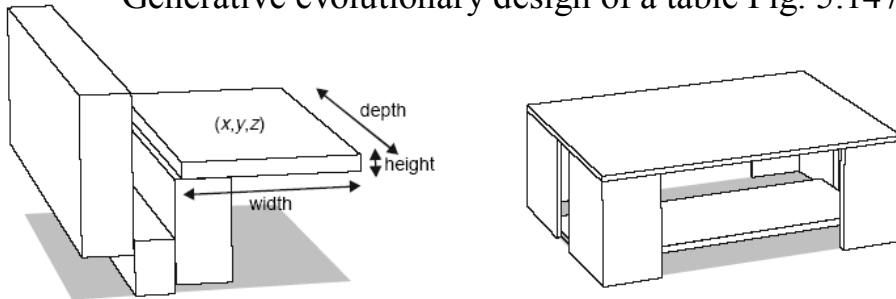
Phenotype:
x, y, z, width, height, depth of block 1   x, y, z, width, height, depth of block 2
x, y, z, width, height, depth of block 3   x, y, z, width, height, depth of block 4
x, y, z, width, height, depth of block 5   ...x, y, z, width, height, depth of block 16

Genotype:

11010110	10101101	10101110	10011010	01101010	01101010	...	10001010	10001010	10001010
desired xpos 1	desired ypos 1	desired zpos 1	desired width 1	desired height 1	desired height 1	...	desired width 4	desired height 4	desired depth 4

Fig 5.147 Generative evolutionary design of a table.

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1   ibid.

iv.   Conceptual evolutionary design.

For example, Conceptual evolutionary design of table. (Fig.5.148)

Conceptual Building Blocks:

Flat surface

function: supports objects, provides
a stable base, has negligible height

Leg

function: supports flat surfaces, three or
more provide stable base, has height

Phenotypes:

Flat surface

Leg   Leg
    Leg Leg

Flat surface

Leg

Flat surface

Genotype:

0000 1111	0001 0000	0001 0000	0001 0000	0001 0000
Concept1 Ptr1	Concept2 Ptr2	Concept3 Ptr3	Concept4 Ptr4	Concept5 Ptr5

Fig. 5.148 Conceptual evolutionary design of a table.

5-2-7-3 Genetic algorithm and architecture (Evolutionary Architecture)

The previous types of GA applications (*evolutionary design optimization*, *creative evolutionary design*, ..etc.), can be applied in simple design problems, but architectural problems still require more complicated computing power.

"In an attempt to achieve in the built environment the symbiotic behavior and metabolic balance that are characteristic of the natural environment, GA proposed the evolutionary model of nature as the generating process for architectural form. The

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1   John Frazer, Julia Frazer, Liu Xiyu, Tang Mingxi, Patrick Janssen, <u>Generative and Evolutionary Techniques for Building Envelope Design</u>, GA2002 (Generative Art and Design Conference, Politecnico di Milano University, Italy , Milan 11-12-13 December 2002)

2   Ibid.

creative power of natural evolution is done by generating virtual architectural models. Architecture by a GA is considered as a

form of artificial life, subject, like the natural world, to principles of morphogenesis, genetic coding, replication and selection."[1]

The use of genetic algorithms to manufacture forms and relationships is the main process in creating an evolutionary architecture. These genetic algorithms can be used to generate complex spatial models, which can then be filled, punched, and stretched to meet other functional or aesthetic criteria.

Architectural concepts in evolutionary architecture are expressed as[2];

i.   Generative rules, so that their evolution and development can be accelerated and tested by the use of computer models. Computer models are used to create the development of prototypical forms that are then evaluated on the basis of their performance in a simulated environment. The best models become (according to their performance) the parents, which are going to create better models in the new offspring. These new evolutionary steps (offspring) can be generated in a short pace of time and the emergent forms are often unexpected.

ii. Genetic language that produces a code script (Genotype at search space P.132) of instructions for form-generation (fig.5.139).

The architect must study the following points before he starts creating a form using a GA;
–   How structural form can be coded for the utilization of genetic algorithms?
–   How the conflicting criteria can be described?

– How these criteria operate for selection?
– How the morphological process is adapted for the interaction of built form and its environment?

Once these issues are resolved, the computer can be used not only as an aid to design in the usual sense, but also as an evolutionary accelerator and a generative force.

Generally, the evolutionary model requires that a design concept must be described in a genetic code. The code is then mutated and developed in a computer program into a series of models in response to a simulated environment. The models are then evaluated in the simulated environment and the code of successful models is selected. The selected code is then used to repeat the cycle until a particular stage of development is selected for prototyping in the real world.

In order to create a genetic description, it is first necessary to develop a design concept in a generative manner capable of being expressed in a variety of forms in response to different environments.

5-2-7-3 Examples,

1- Column museum[1]   by Dr. Haresh Lalvani[2].

The Column Museum is a prototype experiment with a simple goal, which is showing that using one algorithm (Genetic), one material, an infinite number of forms could be created.

This project mirrors nature's main theme "unity in diversity," and is enabled by the use of a morphologic coding similar in concept to the genetic code in biology. Constructed from a single sheet material (e.g. metal), these columns capture the variable

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1
3   John Frazer, Julia Frazer, Liu Xiyu, Tang Mingxi, Patrick Janssen, Generative and Evolutionary Techniques for Building Envelope Design, GA2002 (Generative Art and Design Conference, Politecnico di Milano University, Italy , Milan 11-12-13 December 2002). P.32

geometries of continuously curved and folded surfaces in nature (sand dunes, waves and ripples in nay medium, mountain folds, human skin, etc.).

The Column Museum, a universe of all possible architectural columns (past, present and future), is a meta-museum in virtual space through which a viewer (designer, client, visitor) can navigate via any chosen pathway. Any point within this space is an entrance or an exit to the museum. The museum is open-ended as new columns can be continually added to increase the repertory. (Fig. 5.149, 5.150).
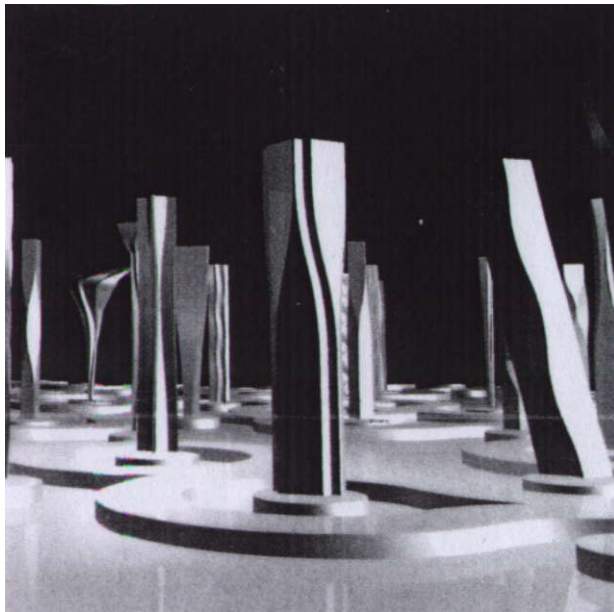
Fig. 5.149 Elevation of a column.

1   Dr. Lalvani is a tenured professor of architecture at Pratt Institute where he is also the co-director of the Center for Experimental Structures. In 2003 Dr. Lalvani received the Pioneers' Award from the Space Structures Research Center, University of Surrey, UK. He has worked at NASA-Langley Research Center on space applications and at Computer Graphics Laboratory, NYIT, on computer-animations.
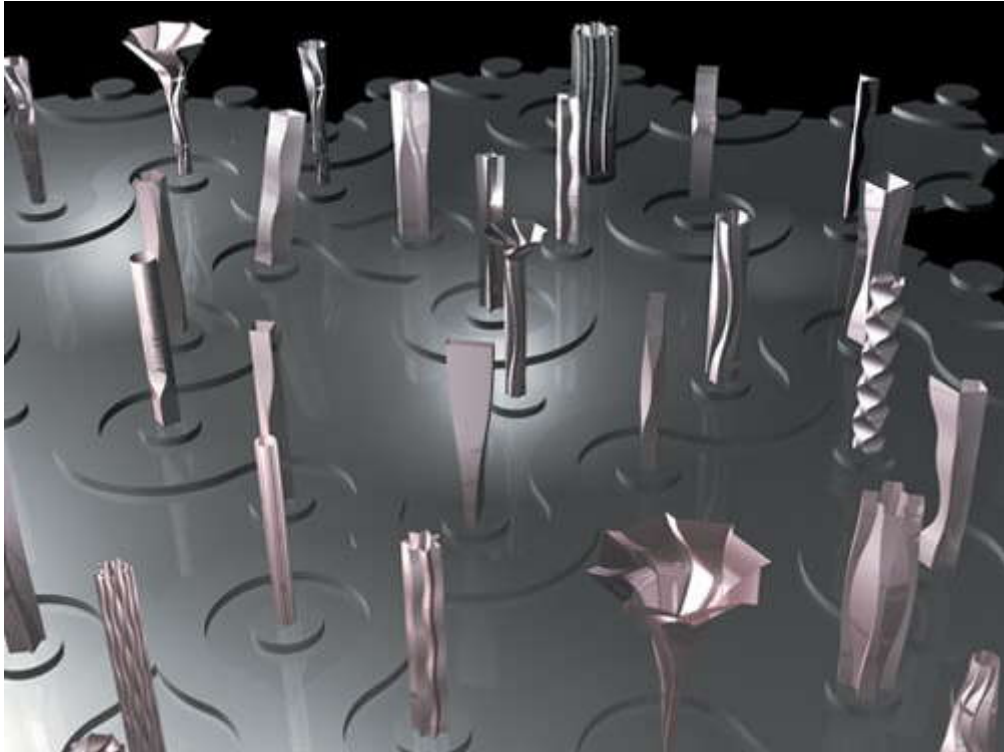
Fig. 5.150   Museum of columns

2- X-Phylum, Genetic space   by Karl.S. Chu. [1]

"Karl Chu works with the computational capacity of the computer to investigate a "genetic architecture". His emphasis is on the metaphysics of architecture and computation. Chu is involved with the creation of "generative surfaces." He begins by writing a simple algebraic formula that generates 6 primary combinations from three primary elements. He assigns each element a letter, "A", "B", or "C", and studies the continued development further generations." [1] (Fig. 5.151, 5.152).
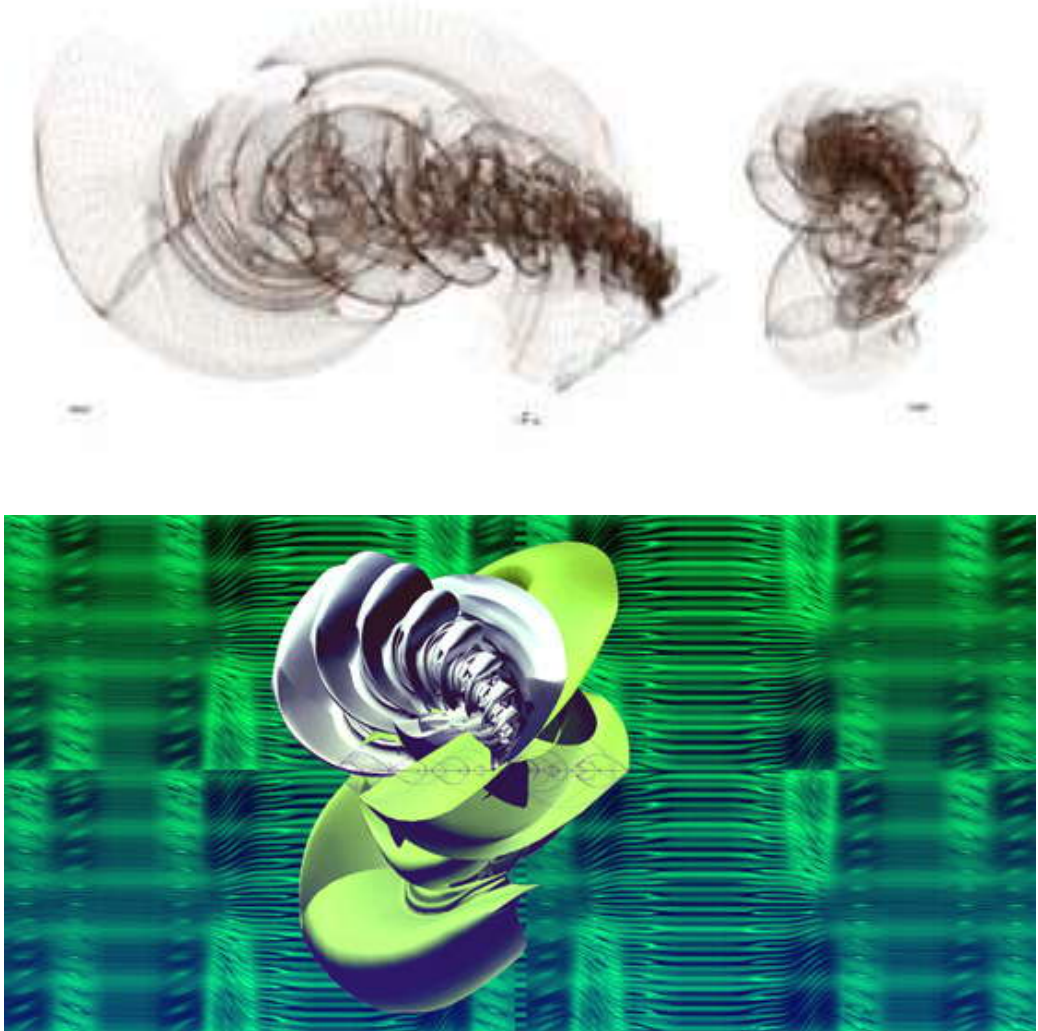
Fig. 5.151, 5.152 Various pictures for the X-Phylum genetic space.

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1   Architect and theoretician Karl Chu received his Master of Architecture from the Cranbrook Academy of Art, Michigan, in 1984. He has lectured all over the world and has been teaching at many famous architectural institutes. Karl Chu founded X Kavya, a research studio based in Los Angeles, which is dedicated to the re-conceptualization of architecture through the metaphysics of possible worlds.

142

Chapter 6
The Masters of architecture in the age of Information Technology.

Chapter 6: The Masters of architecture in the age of Information Technology.

The Information Technology starts to shape and influence the ideology of a new generation of architects. A radical change in there forms is clear due to their use of digital morphogenesis in there designs. The following chapter investigates the ideology, and the digital concepts of Bernhard Franken, Kolatan/MacDonald, Kas Oosterhuis, Greg Lynn, Ocean North, and Decoi, as masters of architecture in the age of information technology.

6-1 Bernhard Franken[1]:

Bernhard Franken is an architect and engineer following a medial concept featuring a coherent digital process from design to production. Starting out with a creative idea both form and realization are developed digitally.

6-1-1 Ideology:

i. Bernhard Franken's goal is the creation of buildings that produce and added value of communication, identity and site quality beyond the functional needs.

ii. "*If there is a sense of reality, there must be also a sense of possibility*"[2] said by Franken. What distinguishes Bernhard Franken and his team as the moderators of process is that they traverse between reality and possibility.

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1 German architect, born at 1965 in Neuss, Germany, His independent architectural language and philosophy has solicited broad interest in various international exhibitions, such as those held at the Bauhaus, Dessau and at the Netherlands Architecture Institute (NAI), Rotterdam. He has been Assistant Professor at TU Darmstadt and visiting Professor at Kassel University.

2 http://www.franken-architekt.de

iii.   Franken's work is distinguished by a transparency of process and communication. The firm is a research and experimental lab. Context, program and poetic elements by the parametric design are used during design. The resulting simplicity of the design stands in contradiction to the precision necessary to realize it.

iv.   A symbiosis is formed between the imaginary and the pragmatic. The results are unique, narrative and appeal to the senses.

v.   Many of his design have a certain similarity to the development of a racing yacht or airplane.

vi.   Franken finds in the internet an important field of architecture which he calls its architecture as "Hypertecture".

6-1-2 Digital conceptual projects of Bernhard during the period 1995-2003: (page 151 to 156).

1- Ribbons : BMWgroup Geneva international Motor show 2001.

Project type: Interior design. (Fig. 6.5).

Main concept: Architecture as communication. The design for the BMW group presented BMW and the Mini as two individual characters with different formal expression situated on a joint platform.

Digital form generation: Using a wind tunnel: An arrangement of various banners was subjected to the influence of a particle current during an animation process. The Banners were frozen in their waved and curved forms. (Fig. 6.1-6.4).

Digital concept used :

Animate architecture.

Fig. 6.1-6.4 Digital form generation.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			
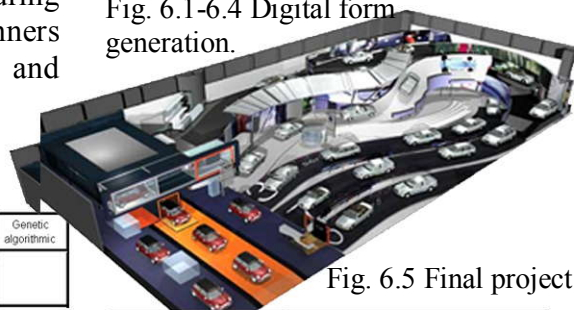
Fig. 6.5 Final project.

2- The wave Clean energy, Munich 2000.

Project type: Interior design of cars exhibition. (Fig. 6.8).

Main concept: Driving in the future: energy will come from the sun. However, energy is presented in various forms-it only becomes apparent by its effects. The wave serves as a metaphor for the dynamic form of energy.

Digital form generation: An impulse of light creates a wave. This wave as a force deforms the plane in a certain area. (to emphasize this area). (Fig. 6.6, 6.7).   The digital concept used :

Animate Architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			

Fig. 6.6 Light wave as an energy source
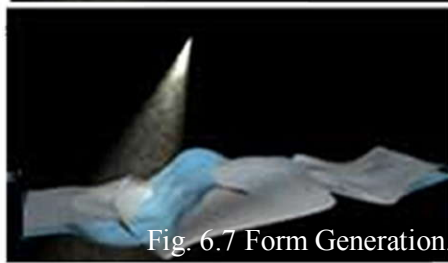
Fig. 6.7 Form Generation.

Fig. 6.8 Final project.

151
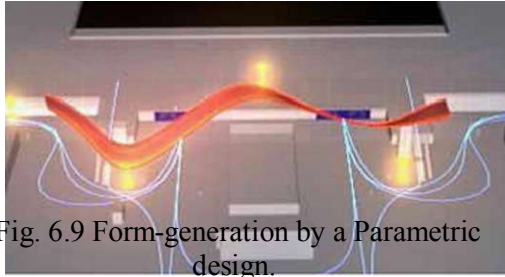
Fig. 6.9 Form-generation by a Parametric design.

Fig. 6.10-6.11 Final project.

3- Take off: BMWgroup Brand supersign TII, Munich, 2003.

Project type: Interior design. (Exhibition for BMW cars). (Fig.6.11)
Main concept: "*The movement of the observer produces the communicative, spatial effect, and gives rise to a visual kinetic interactivity.*"[1]
Digital form generation: A parametric design was chosen for the object, which is suspended in terminal II, in the interior design. [1] (Fig. 6.9-6.10).

The digital concept used :
Parametric Architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
■						

Fig. 6.12-6.15 Process of form-generation.

Fig. 6.16-6.17 Final form.

4- Light arc, Geneva international Motor show, 2002.

Project type: Interior design of an Exhibition for cars. (Fig. 6.16-6.17).
Main concept: Creating a light arc that spans the arch over the BMW product portfolio, from the smallest car to the 7 series.

Digital form generation: The form of the light arc was generated by spanning two poles as a source of forces in the atmosphere using a computer simulation. (Fig. 6.12-6.15).

The digital concept used :
Animate architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			

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1 ibid

5- Isbre : Concert Hall in Stavanger, Norway.

Project type: Music concert hall. (Fig. 6.20, 6.21).

Main concept: Glacier as a metaphor. *"The Norwegian fjord landscape is formed by the glacier of the last ice ages*"[1], and this project represents a part of ice left from the glacier ages. (Fig. 6.20)

Digital form generation: Music and the urban context are the parameters of the form-generation.[1] (Fig. 6.18-6.19).

The digital concept used :

Parametric Architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
■						
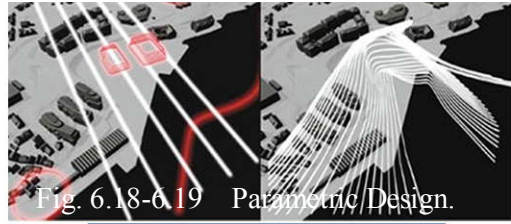
6- Cocoon : Fashion and design center, Busan.

Project type: Fashion and design center. (Fig. 6.26)

Main concept: An outer and inner cocoon defines the building, the outer and the inner façade are inspired by fabric, fibers and weaving techniques.

Digital form generation: *"The inner soft shape is generated in a computer simulation morphing the open atrium space.*"[1] (Fig. 6.22-6.25).

The digital concept used :
Metamorphic architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				■		

Fig. 6.18-6.19   Parametric Design.

Fig. 6.20 Final project.

Fig. 6.21 Layout

Fig. 6.22-6.25 Morphing the atruim

Fig. 6.26 The final form.

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1   ibid.
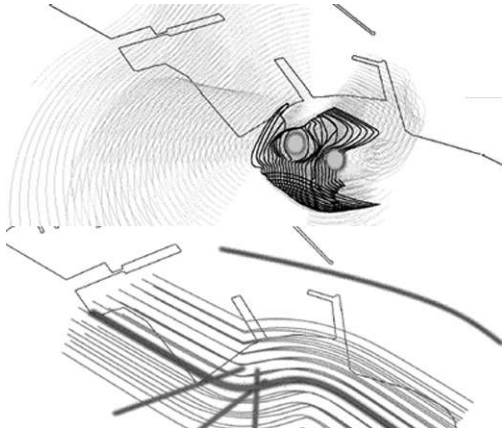
Fig. 6.27,6.28 Generating the main form.
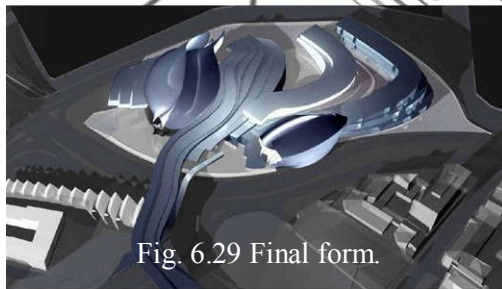
Fig. 6.29 Final form.
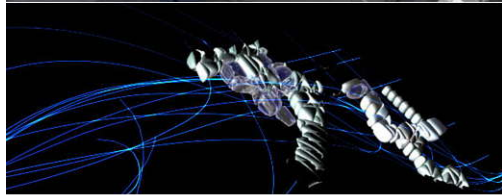
Fig.6.30, 6.31 Digital form generation.
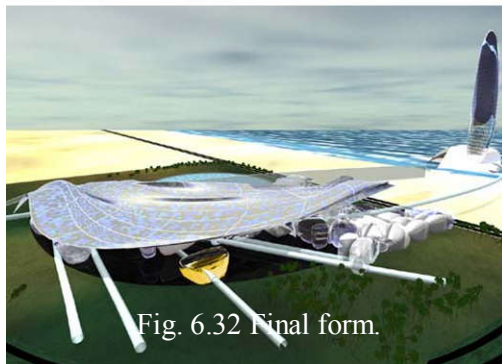
Fig. 6.32 Final form.

7- Concert hall, and Urban planning for the Harbour area, Reykjavik.

Project type: Concert hall, and urban planning for Harbor area. (Fig. 6.29).
Main concept: The concert hall is to be the new "icon of Reykjavik".
Digital form generation: Different kinds of parameters and forces were used in creating the main from. (Fig. 6.27-6.28)
The digital concept used :

Parametric architecture
and **Animate architecture.**

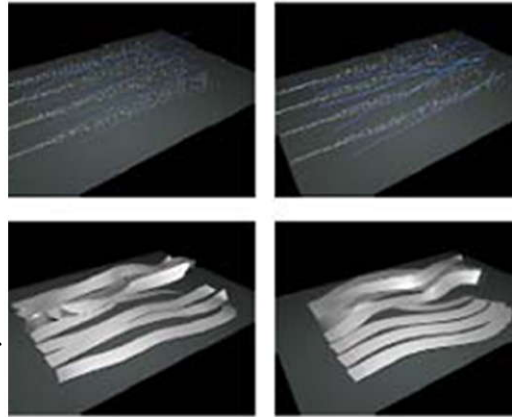| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
🟥			🟥			

8- Mediacity: Dubai city of millenuim.

Project type: Internet city. (Fig.6.32)
Main concept: Dubai has recently reconfirmed its status as the global city with the futuristic Burj Al Arab and the new Airport Terminal building. The project will reflect Dubai as a modern, creative, innovative and competitive commercial hub open to the world.[1]
Digital form generation: A tube structure is generated out of a simulation of the flow of visitors. This structure is the basis for every further design element. (particle animation). (Fig.6.30,6.31)
The digital concept: **Animate Archi.**

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			🟥			

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1 ibid..

9- Adidas : Adidas outlet arena.

Project type: Arena. (Fig. 6.36, 6.37)

Main concept: *"The Adidas outlet Arena combines the effectiveness of a competent brand-name with an emotionally charged shopping experience within a highly functional and efficient production atmosphere."* [1]

Fig. 6.33-6.35 Generating the main form.

Digital form generation: The fleeting motion characteristic of sports is rendered visible by Motion-tracking(Left part of fig. 6.33), which leave imprints in a spatial context. These imprints were used in the form generation. (Fig. to 6.33 Fig. 6.35)

Fig. 6.36 Final Form.

The digital concept used :
Animate architecture.
(kinematics animation)

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			

Fig. 6.37 Layout.

10- Dynaform: BMW exhibition.[2]
Animate architecture. (Fig. 6.38)

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			

Fig. 6.38 Post nature.

11- The bubble : BMW exhibition.[3]

Isomorphic architecture. (Fig. 6.39)

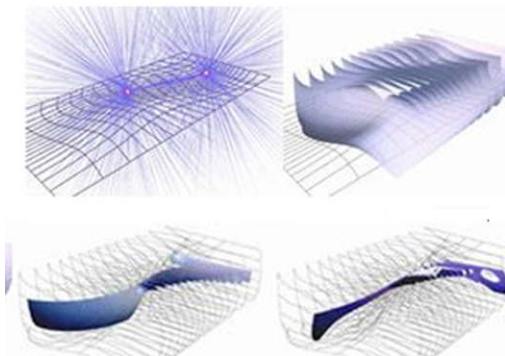| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
		■				

Fig. 6.39 Final form.

1   ibid.
2   More details at page 102.
3   More details at page 117.

Three Force Fields

Balance of inner Forces

Bubble Foam

Inversion of Volume
and Void
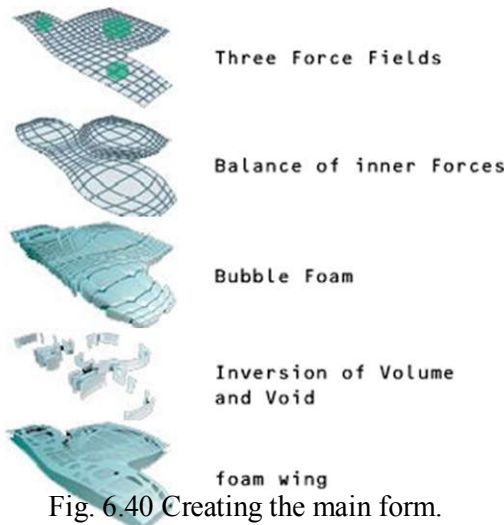
foam wing

Fig. 6.40 Creating the main form.

12- Foam wing: Maximilianeum-Plenar hall, Munich.

Project type: City Hall.(Fig. 6.41)

Digital form generation: Three main forces were put in the atmosphere to generate the main form. (Fig. 6.40).

The digital concept used :
Animate architecture.
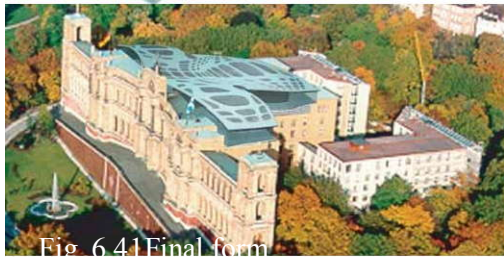
Fig. 6.41Final form.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			

13- Supercube: museo dell'audiovisio Mav, Rom.
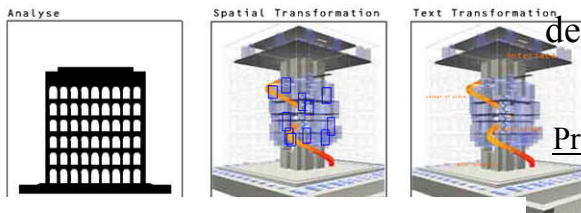
Project type: Museum.(Fig. 6.45).

Analyse   Spatial Transformation   Text Transformation

Fig. 6.42-6.44 Digital Form modifications.
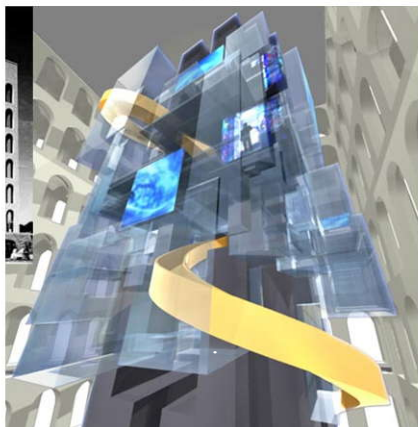
Digital form generation: The main form in figure 6.42 was transformed, using a group of modifiers to create the final form at Fig. 6.45. (Fig. 6.42-6.44).

The digital concept used :
Metamorphic architecture.

Fig. 6.45 Final form.

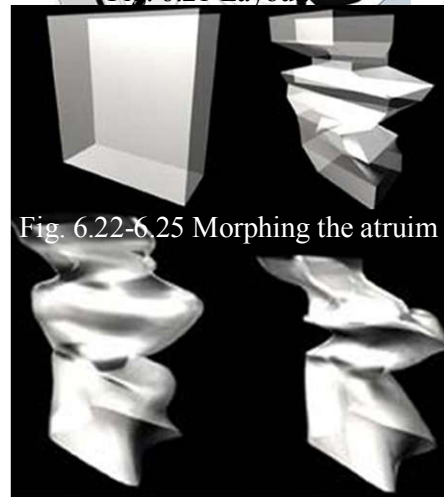| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				■		

6-1-3 Conclusion of Franken' s architecture movements during the period of (1995-2003):-

	Parametric architecture	Topological architecture	Isomophic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
1- Ribbons, 2001.				■			
2- The wave Clean energy, Munich.				■			
3- Take off, Munich, 2003.	■						
4- Light arc, Geneva , 2002.				■			
5- Isbre : Concert Hall in Norway.	■						
6- Cocoon Fashion center, Busan.					■		
7- Concert hall , Reykjavik.	■			■			
8- Mediacity: Dubai city of millenuim.				■			
9- Adidas outlet arena.				■			
10- Dynaform: BMW exhibition				■			
11- The bubble, BMW exhibition.			■				
12- Foam wing, Plenar hall, Munich.				■			
13- Supercube: Musuem in Rome.					■		
Architecture of Bernhaed Franken.	3		1	8	2		

Conclusion:
Bernhard Franken uses Parametric, Isomophic, Ainmate, and Metamorphic architecture as digital concepts, with an excess use of Animate, and Parametric architecture.

6-2 Kolatan/MacDonald [1]:

The Kolatan/MacDonald 's projects are produced entirely on the computer from early conceptual phase, through schematic design, design development and working drawings.

Generally, the forms of Kolatan/MacDonald are chimerical objects produced by hybridization, as a union between distinct elements produced through the logic of the digital machine.

6-2-1 Ideology:

The ideology of Kolatan/MacDonald can be explained as follows:

i.   Kolatan/MacDonald 's forms are generated as chimerical (by digital methods) object-spaces that challenge traditional architectural idioms and modes of production [2].

In a chimera the relationship between the parts is not one of interconnection or adjacency. The limits of the parts and the exact delineations of the thresholds between parts are not clearly identifiable. Rather, like the results of a successful attach, the border disappears. Locally the part that was different becomes bonded with the rest. Kolatan/MacDonald has two primary interests in there chimera:

–   "*One has to do with its seeming capability as a concept to help define existing phenomena of complex hybirdity in which categorically different somehow operate as a single identity.*"[3]

–   "*The second is based on the assumption that the ways in which the chimera are constituted and*

> *operate hold clues to a transformative aggregative model of construction/ production."[1]*
> The hybridization formed by Kolatan/MacDonald becomes more than the sum of its parts and therefore is not reducible to its constituent elements.

Thus, the chimerical has the potential to be both an analytical and methodological tool. (Check there projects at page 161 to notice there chimera).

ii.   Their exceptionally flexible and inventive design methodology uses the computer's ability to collect spatial data, which are tracked and organized in non-hierarchically cross linked informational indices. These indices are then transformed through a process of data-grafting, in which established spatial types are mapped across and through each other, producing new patterns for non-standard material constructions, moldings and castings. By inducing systematized fields of data into organized material and spatial relations with high-speed computation, kolatan/Mac Donald has developed the principles behind interlinked and cross-referenced networks into a tool for architectural production. (To notice the previous ideology, check the project of Yokohama Liner Terminal at page 162).

iii. The architects describe the transposition of data into form as co-citation mapping, an involved process that charts spatial information cross-sectional profiles, volumes and dimensions- onto catalogues or databases of dissimilar elements. As an index co-citation mapping works like any

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1   Kolatan/Mac Donald Studio was founded in 1988 as an architectural firm by its principals Sulatan and William J. Macdonald. Based in New York, it has strong connections to Europe and Turkey due to its principal's history, the firm has produced a series of projects of entirely different scales and situations with each one addressing a number of issues concerning architecture culture today.

2   Peter Zellner, <u>Hybrid space: New forms in digital architecture</u>, Op.cit.

Keyword based library search registering titles or papers related to the same term. Like such a search model this mapping technique reveals conceptual connections across categories that might not be immediately apparent. [1]

6-2-2 Digital conceptual projects of Kolatan/MacDonald during the period 1995-2003: (page 161 to 164).

1- Ost / Kuttner apartments, New York, USA, 1996.

Project type: Interior design of apartment. (Fig. 6.47-6.50)

Main concept: Creating a chimerical condition between furniture, space, and surface in the apartment.

Fig. 6.47-6.48 Bathroom pictures.

Digital form generation:
For more details check page 112.

The digital concept used :
  Metamorphic architecture.

Fig. 6.49 Bedroom

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				■		

2- Chimercal Housings: (six houses).

Project type: Houses.

Digital form generation: The six houses were selected from a series of digitally designed variants originated from the same 'Genetic pool". The previous variants were blended digitally between 'base' and a varying number of 'targets' to produce new digital forms[1].(Fig. 6.50).

The digital concept used :
Genetic algorithm architecture &
 Metamorphic architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				■		■

Fig. 6.50 Six chimerical houses.

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1   http://www.kolatanmacdonaldstudio.com

3- Resi-Rise skyscraper, Manhattan Columbus circle, New York.

<u>Project type:</u> High-Rise building.

<u>Main concept</u>: It is initially built-out to the maximum allowable zoning envelope with deformations accounting for site influences, such as views and adjacencies.

<u>Digital form generation</u>: The morphology, size, program, function, materials, and furnishing of the pods are customizable within parameters set by the architects. This strategy couples individual choice with the collective performance and identity of the rise-Rise.[1] <u>The digital concept used:</u> **Parametric architecture & Preformable architecture.**

Fig. 6.51 Prespective

Fig. 6.52-6.53 Details.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
■					■	

4- take 5 on Manhattan Horizontal, Manhattan, USA,1997.

<u>Project type:</u> Urban design proposal.

<u>Main concept:</u> Urban Layer above street level. (Fig. 6.54-6.55).

<u>Digital form generation:</u> The plan is a network based on the notions of hybrid identities (such as "co-citation").

<u>The digital concept used :</u>

Metamorphic architecture.

Fig. 6.54 Main form.

Fig. 6.55 Overall view of the midtown.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				■		

1   ibid.

5- Yokohama Liner Terminal.

Project type: Liner Terminal.
(Fig. 6.56-6.58).

Digital form generation:
The form was created through a series of operations, in which the local urban fabric was sampled, by a series of transformations method done a using digitally squeeze, fold, stretch….etc.

The digital concept used :
Metamorphic Architecture.
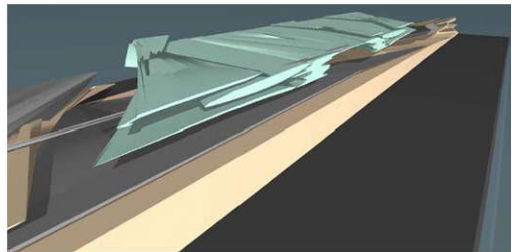
Fig. 6.56-6.57 Main form.
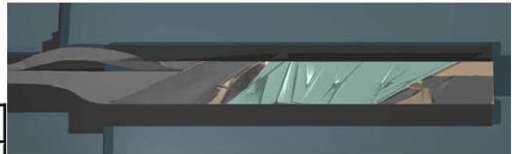
Fig. 6.58 Layout.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				■		

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1   Peter Zellner, Hybrid space: New forms in digital architecture, Op.cit.

6-2-3 Conclusion of Kolatan/MacDonald' s architecture movements during the period of (1995-2003):-

Kolatan/Mac. Projects.	Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
1- Ost / Kuttner apartments, 1996.					■		
2- Chimercal Housings: (six houses).					■		■
3- Resi-Rise skyscraper, New York.	■					■	
4- take 5 on Manhattan, USA,1997.					■		
5- Yokohama Liner Terminal.					■		
Architecture of Kolatan/MacDonald	1				4	1	1

Conclusion:

Kolatan/Madonald uses Parametric, Metamorphic, Preformable, and Genetic algorithm architectures as digital concepts, with an excess use of Metamorphic architecture.

6-3 Oosterhuis associates[1].

Oosterhuis holds that the invention of building forms can no longer follow the paradigms and norms of a classical discipline. Thus, he rejects the dominance of Platonic geometries forms as basic elements of architecture. He views architecture as an evolving technologically enhanced means of organizing sophisticated spatial data and programming information into structured mediums that synthesize complex geometries and aspects of human actions. These body buildings embody behavioral rules that are derived from the integration of form and information, to become environments that can develop their own intelligence[2].

6-3-1 ideology:

i. Architecture is bodies that are now the target of technological invasion. These bodies are a part of global networks, they are (linked by cables) wired. The bodies are connected to databases and their behaviors and (form) shape can be programmed. The body-specific scripts feed on data from databases that are upgrading themselves in real time. The architectural bodies can now be literally animated. Architecture no longer has a static final image;

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1 Kas Oosterhuis is the founder of Oosterhuis associates, he was born at 1951 in Amersfoort, Holland. He had his diploma in architecture from the university of Delft. Kas Oosterhuis found his multidisciplinary practice to look outside architectural circles and discourse for creative stimuli and procedural knowledge. As cofounder of the Attila Foundation a research institution for the electronic fusion of art and architecture he frequently collaborates with programmers and creative producers most notably with the Rotterdam based visual artist llona Lenard.

2 Peter Zellner, Hybrid space: New forms in digital architecture, Op.cit.

its visible form is becoming as unpredictable as the weather. Architecture is turning wild.

ii.   Buildings are becoming data structures that cannot totally controlled and that can influence their immediate (and perhaps global) contexts according to unpredictable and unknowable behavior.

iii. Constructing a building is like placing an attractor into the future. All information will head towards that attractor from then on. This particular stream of information through the attractor is thus energized and vectorized, and exerts them again in modified form. (Check his project at page 129).

iv.   Buildings, like other expressions of contemporary design -cars and electrical appliances, for example- contain ever growing amounts of data and are increasingly semi-autonomous.

v.   When a film is made of for example a house and speed it up a thousand times the house is acting like a living body. It absorbs all kinds of material including a liquid stream of humans pulsating in and out, it absorbs and it excretes them in a rhythmic pulsating manner. Who could tell the difference of the previous example from our biological life seen at the speed we are living at? Since we are captured in our arbitrary speed of life we are unable to experience the consistency of other life forms which are living at completely different pace. This notion of life as a specific configuration of information is important in developing ideas about the real-time behavior of the bodies, by feeding the electrified body, fueling it with a

wide variety of incoming matter and data. Ecological balance also includes people going in and out, and data being imported and exported, information flowing towards the body building (feeding), through it (digesting) and away from it (exerting). The most important thing is how to make things work. How we will involve ourselves in building greater complexities of meaning and establishing an increased exchange of information between human body and building body [1].

6-3-2 Digital conceptual projects of Oosterhuis associates during the period 1995-2003: (page 168 to 178).

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1   Kas Oosterhuis, <u>HyperBodies: Towards an E-motive architecture</u>, 2003, Op.cit.

1- Acoustic barrier and industrial building, Utrecht Leidsche rijn, Holland, 2003.

Project type: Acoustic barrier with an industrial building.(Fig. 6.59-6.60).

Main concept: The concept of the acoustic barrier including the Cockpit building was to design with the speed of passing traffic since the building is seen from the perspective of the driver[1]. Digital form generation Cockpit building as integral part of an acoustic barrier was based on a simple set of related curves, which were done by parametric relations between height, width and length. The digital concept used :

Parametric arch.
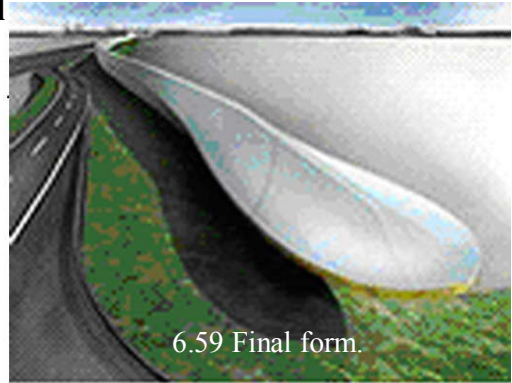
6.59 Final form.

Fig. 6.60 Final form.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
🟥						

2- Industrial building (Cockpit), Holland, 2003.

Project type: Sound barrier with an industrial building. (Fig. 6.61-6.63)

Main concept: They decided to design with a speed of 120 km/h, by making the building like a streamline.

Digital form generation: they studied the splines of cars, powerboats and jet planes which are streamlined to diminish drag. These studies with an animation studies were used in creating the main form. The digital concept used: :

Animation architecture, and Topological architecture.

Fig-6.61 General perspective.

Fig. 6.62 The perspective for the building as seen from a moving car.

Fig. 6.63 Interior picture for the project.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	🟥		🟥			

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1   http://www.oosterhuis.nl
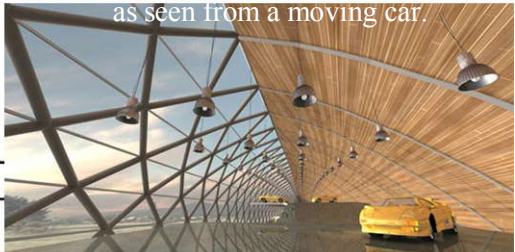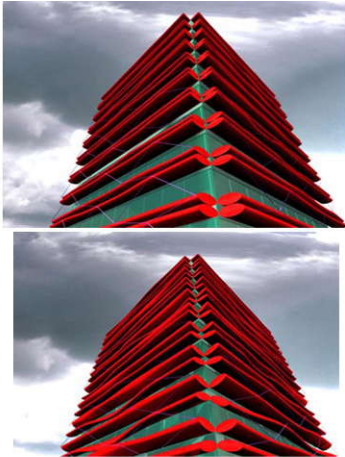
Fig-6.64-6.65 Deformation of the Facade.

6.66 Interior Picture.

Fig. 6.67 Hand Drawn 3d course of the structure.

Fig. 6.68 Final form.

3- Adaptable façade, 2003.

Project type: Façade. (Fig. 6.64-6.65)

Main concept: The aim of the architect was to create a system that allows the user to have total control over the light levels in their immediate area.

Digital form generation: The fluidic muscle technology, was used in the façade, this system allows the building users in any part of the building to set their own preferred light levels. (Fig. 6.64 to Fig. 6.66).

The digital concept used :
Performable architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
					■	

4- Open air meeting pavilion (Hand-draw space) Floriade, Haarlemmermeer, Holland, 2002.

Project type: Open air meeting space, pavilion (the visitors come to rest in the curved concrete bowls. from there they view 68 photographs depicting the province of North-Holland). Fig. 6.67

Digital form generation: The dynamic 3d course of the structure was derived from an impulsive intuitive hand-drawn sketch and then Splines were used to digitize the main form. (Fig. 6.67)

The digital concept used :
Topological architecture.

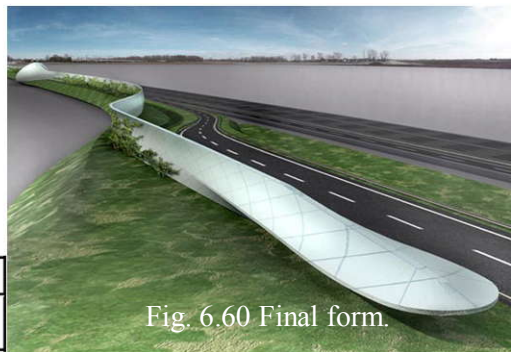| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

5- Programmable sliding volume, Budapest, Hungary, 2002.

Main concept: The architect must use the slider of the old crane which is available in the site to create a sliding building. (Fig 6.69-6.70).

Digital form generation: Moving and transforming complete building volumes, as a performable concept, with the use of blobs in the interior design were the main digital concepts used.

The digital concept used :

Isomorphic architecture, and Performable architecture

Fig-6.69 Final form showing the sliding volume.

6.70 Interior Design of the auditorium.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
		🟥			🟥	

6- Pavilion, (Web of North) Holland.haarlemmer-meer. 2002.

Project type: Exhibition halls.(Fig. 6.72).

Main concept: The WEB made a successful soft landing on the Floriade world Exhibition site in the Haarlemmermeerpolder in the Netherlands .

Digital form generation: The architect used the blobs (Digital clay) and the attraction forces between them as the main theme for creating the form.

The digital concept used :

Isomorphic architecture

Fig. 6.71 Cladding details.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
		🟥				

Fig. 6.72-6.73 digitally generated final form.

7- Music center, Helsinki, Finland, 2001.

Project type: Concert hall.(Fig. 6.74-6.76).

Main concept: The building was built on bedrock, and it was constructed right on top of the bedrock as a topological surface.

Digital form generation: Splines were used to form the shape.

The digital concept used :
Topological architecture
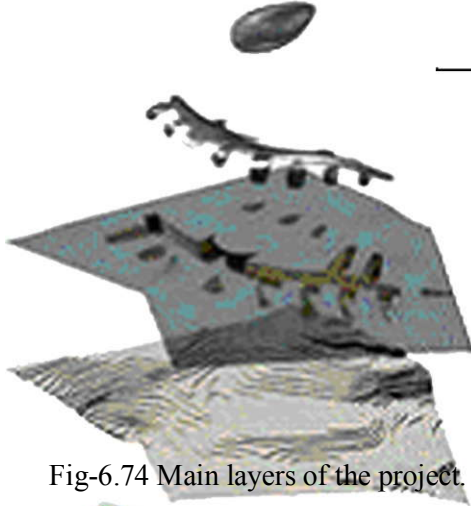
Fig-6.74 Main layers of the project.
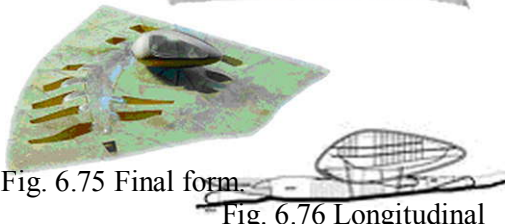
Fig. 6.75 Final form.
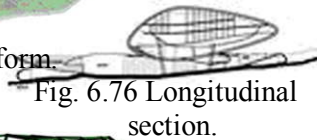
Fig. 6.76 Longitudinal section.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	🟥					

8- Saltwater Pavilion, Neeltje Jans Zeeland, 1997.

Project type: Water pavilion.
Main concept: The form is left for every to interpreter it in his own way.
Digital form generation: The first step was using the genetic idea, to create the form, and then this form was modified in many different ways to reach the final the form.

The digital concept used :**Metamorphic architecture and Genetic algorithm architecture**

Fig. 6.77 Main form.

Fig. 6.78 Interior Cladding.

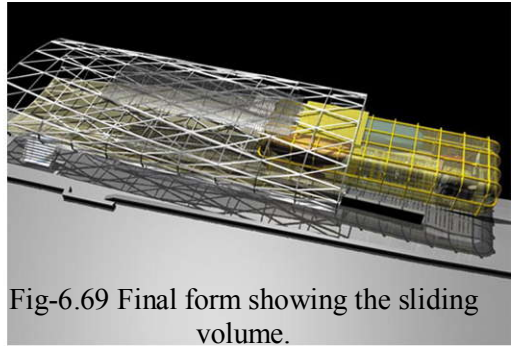| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				🟥		🟥

9- Office building, Kampen, Holland, 1996.

Project type: Office building.(Fig. 6.80)

Main concept: The office building must be merged with the landscape hill. (Fig. 6.78)

Digital form generation: Using a Boolean operation of intersection, the soft hill is crossed with a cruciform, as a regular office building.

The digital concept used :
Metamorphic architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				🟥		

10- Sculpture-building, Zenderen, Holland, 1995.

Project type: A large hall with an office building.
(Fig. 6.81-6.82)

Digital form generation: The design of the building body is entirely conceived in digital space, by 3d modeling and subsequent Boolean operations.

The digital concept used
Metamorphic architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				🟥		

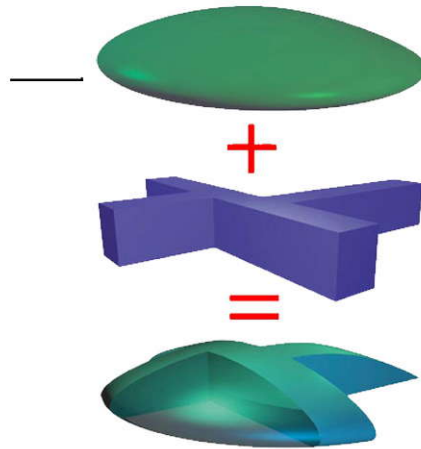

Fig-6.79 The process of Boolean used in creating the main form.
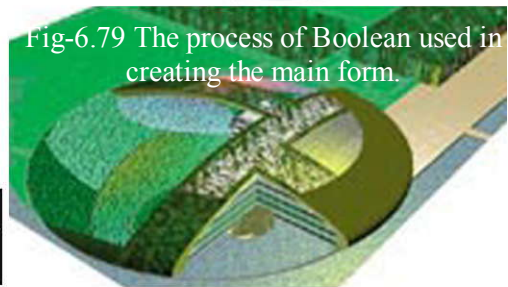
Fig. 6.80 Final form.

Fig. 6.81 Main form of the project.

Fig. 6.82 Interior view.

Fig-6.83 Parameters used in creating houses.

Fig. 6.84 Final form.

Fig. 6.85 Ephermeral Structures moves according to the atmospheric changes.

Fig. 6.86 Detail of the structure.

11- Variomatic US, USA, 2003.

<u>Project type</u>: Residential units.(Fig. 6.84).

<u>Main concept:</u> The house is the resultant of a collaborative design process of designer and a client, this concept involves the future client, who can on a website takes a sequence of personal choices by choosing values in the sliders to reach the design of his residential unit.

<u>Digital form generation</u>: The Variomatic_US is based on the principle of parametric design. One parametric method covers all possible variations. (Fig. 6.83)

<u>The digital concept</u> used :**Parametric architecture**

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
🟥						

12- Ephemeral Structures Urban game in real-time, Athens, Greece, 2002.

<u>Project type</u>: Landmark. (Fig. 6.85)

<u>Main concept:</u> The landmark is no longer just a tower, but an active and dynamic part of the Olympic game.

<u>Digital form generation</u>: The landmark is attracted by fields of activity. It collects information and reacts through the shape. The shape and the motion of the landmark is a real-time reaction with respect to the flux of people in the city. (Fig. 6.86)

<u>The digital concept</u> used :**Preformable architecture**

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
					🟥	

13- Energy cell, Harden, Holland, 2001.

Project type: Urban design. (Fig. 6.88)

Digital form generation: the liquid blobs are scattered on the site to represent the new habitable production domains. (Fig. 6.87)

The digital concept used: **Isomorphic architecture.**
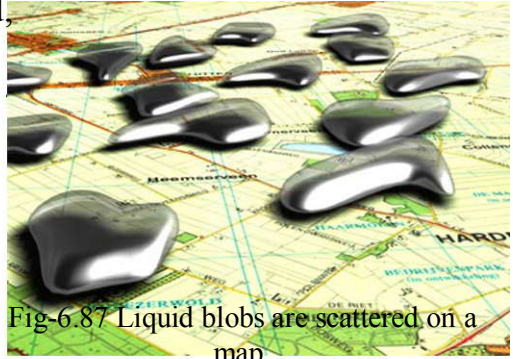
Fig-6.87 Liquid blobs are scattered on a map.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
		■				
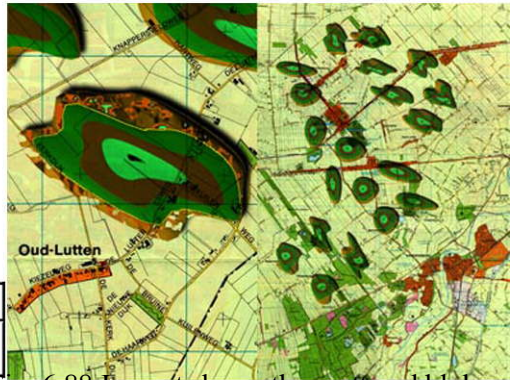
Fig. 6.88 Layout shows the scattered blobs.

14- Parkcity Reitdiep, groningen reitdiep, Holland, 1996.

Project type: Ecological Garden. (Fig. 6.90).

The main concept and the digital generation: check the previous chapter at page 84. (Fig. 6.89)
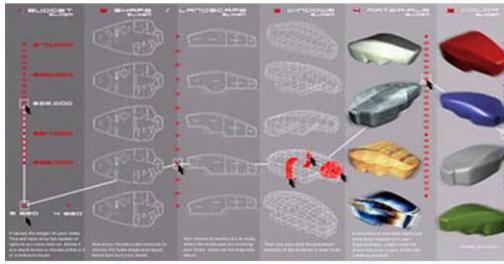
The digital concept :
　　　Parametric architecture.
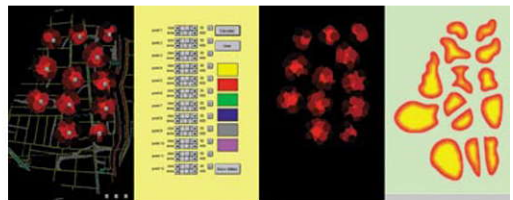
Fig. 6.89 Parameters used in creating the layout.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
■						
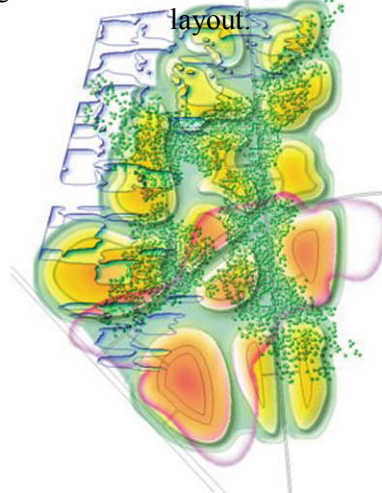
Fig. 6.90 Layer of studying the final layout.

15- Trans-ports muscle, Paris, France, 2003.
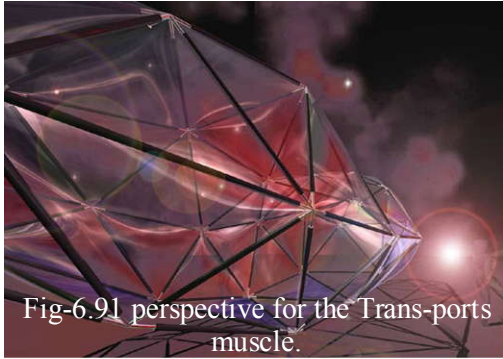
Fig-6.91 perspective for the Trans-ports muscle.
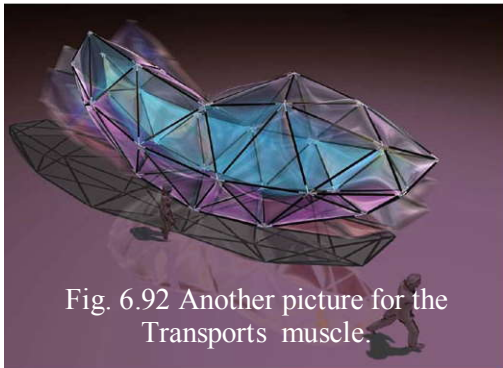
Fig. 6.92 Another picture for the Transports muscle.

Project type: Programmable pavilion. (Fig. 6.91-6.92)

Main concept: Architecture is no longer doomed to remain static after a dynamic design process.

Digital form generation: The form of the project is deformed when sliders on a computer screen is modified, or when any one comes closer to it. These are done through the programmable muscles which are connected to the main points that construct the form.
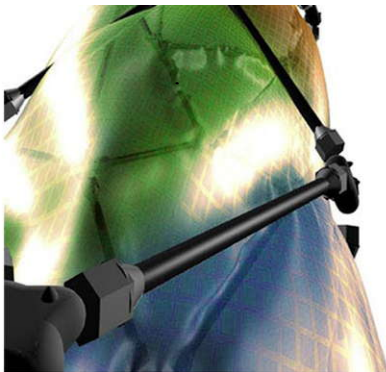
The digital concept used :
Performable architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
					🔴	

16- Parasacpe, Rotterdam kop van zuid, Holland, 1998.

Project type: Parascape is both landscape and sculpture.

Digital form generation: the main form was generated by "*two intuitive computer sketches which are projected towards each other following a twisted path and being scaled along that path (3d studio). then the 3d model is placed in the environment and adapted further by skewing, bending and scaling its endlessly elastic mass.*"[1]

The digital concept used
Metamorphic architecture.

Fig. 6.93 Perspective for the public instrument.

Fig. 6.94 Opposite picture for the public instrument.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				🔴		

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1   http://www.oosterhuis.nl

17- **Rettungszentrale**, **Vienna, Austria, 2000**.

<u>Digital form generation</u>: The design of the building body is entirely conceived in digital space by using the Splines, and NURBS in modeling.

Fig-6.95 Studying the main Elevation for the project.

<u>The digital concept</u> used :

Topological architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

Fig. 6.96 Final form..

18- **Residential unit Programm-able structure changes shape in real time, Holland, 1998.**

<u>Project type</u>:   Residential. Unit. (Fig. 6.97)

<u>Main concept and digital form generation</u>: check the previous chapter at page 129. (Fig. 6.98)

Fig. 6.97 Interior perspective.

<u>The digital concept</u> used :

Preformable architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
					■	

Fig. 6.98 General perspective for the project.

6-3-3 Conclusion of Oosterhuis' s architecture movements during the period of (1995-2003):-

Oosterhuis Projects.	Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
1- Acoustic barrier, Holland, 2003.	■						
2- Cockpit, Holland, 2003.		■		■			
3- Adaptable façade, 2003.						■	
4- Hand-draw space Floriade, Holland, 2002.		■					
5- Programmable sliding volume, 2002.			■			■	
6- Web of North Holland, 2002.			■				
7- Music center, Finland, 2001.		■					
8- Saltwater Pavilion, 1997.					■		■
9- Office building, Holland, 1996.					■		
10- Sculpture-building, Holland, 1995.					■		
11- Variomatic, USA, 2003.	■						
12- Ephemeral Structures, Greece, 2002.						■	
13- Energy cell, Holland, 2001.			■				
14- Parkcity Reitdiep, Holland, 1996.	■						
15- Trans-ports muscle, France, 2003.						■	
16- Smart public instrument, Holland, 1998.					■		

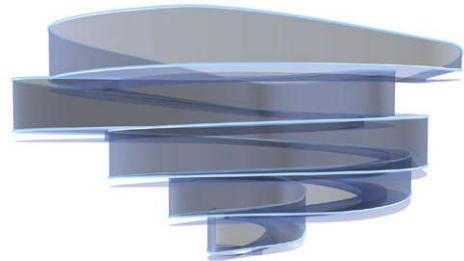|	Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
17- Rettungszentrale, Austria, 2000.		■					
18-Programmable structure, Holland, 1998.						■	
Architecture of Oosterhuis associates	3	4	3	1	4	5	1

Conclusion:

Oosterhuis uses all digital concepts with an excess use of preformable architecture.

6-4 Greg Lynn[1].

Greg Lynn is one of the fewest architects, who defined the use of computers as a design medium. His Projects, publications, research and exhibitions have shaped both the use of advanced technology in design and, accelerated its integration into the construction medium. In his projects, and publications he replaced architectural metaphors of stability and balance with more vital architectural processes, which are literally and conceptually animated.[2]

He was the first architect to discuss, and apply the concept of animate and isomorphic architecture, which have started to be familiar between architects.

6-4-1 Digital ideology:

i.   The forms of the buildings are evolved in a dynamic method which differs radically from the ordinary architecture.

   Lynn contends "*that the animate approach to architecture will reconstitute the inherited standard of stationary spatial description into a better expression of complex foundations and applications, to allow built form to be shaped virtual movement and potential".[3]*

ii. Lynn expressed in his ideas that a form that is created in architecture depends on :

   – Movement of the main form. Forms can be positioned as a trajectory, which has direction, velocity, and acceleration.

     – <u>Creating the virtual atmosphere of the form.</u> The buildings forms that are formed in computer-aided design are the results of decisions made using data, which describe characteristics of the virtual design environment such as temperature, gravity, and other gradient parameters of decay such as wave behavior, attraction, and density affect.

iii.   He was the first architect to discuss the idea of using software which is used in studying complex molecules, as a method of creating architectural forms known as isomorphic architecture.

iv.   In his essay on "Architectural Curvilinearity" published in 1993, Greg Lynn offers examples of new approaches to design. These approaches represent the initial ideas of the Topological architecture.

6-4-2 Digital conceptual projects of Greg Lynn during the period, 1995-2003: (page 211 to 217).

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1   Greg Lynn is an American architect, who was born in USA at 1954. He established his architectural office at 1994 in Hoboken, NJ. At 1998, he relocated his office to Venice, to take the advantage of the well-known techniques of design and manufacturing of aeronautic, automobile and film industries. His firm made many collaborations with fine artists, aerospace manufacturers, filmmakers and car prototype studios.

2   Peter Zellner, <u>Hybrid space: New forms in digital architecture</u>, Op.cit.

3   ibid, p.138.

1   http://www.glform.com

1- Interior deisgn of a shop, New York City, USA, 2002.

Project type: Interior design. A single wall continues vertically through three levels.
. (Fig. 6.100)

Main concept: The main idea was to create a wall with blebs. The blebs are three dimensionally curved volumes containing pockets, doors, shelving and lighting wells. (Fig. 6.99)

Digital form generation: The form was generated using the NURBS.

The digital concept used :
Topological Architecture
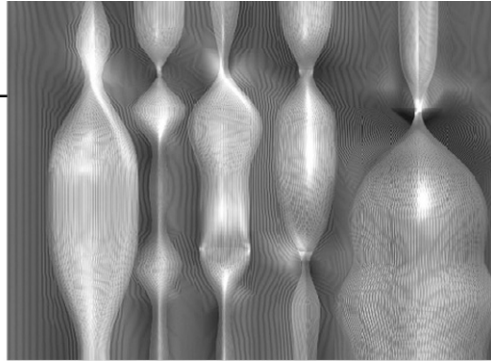
Fig-6.99 Elevation of the project of the New York shop..

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	🟥					
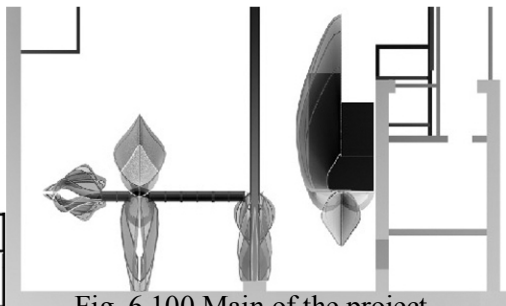
Fig. 6.100 Main of the project.

2- Housing units with a gallery space,(Sociopolis: Ciudad Del Habitat Solidario Generalitat) Valenciana,2003.

Project type: Apartments and a gallery space. (Fig. 6.102)

Main concept: Creating four towers of apartments, with a central social space. The open atrium core is like the root of an onion, that transforms in shape and size as it moves vertically through the building[1]. (Fig.6.101). Digital form generation: NURBS were used in generating the main form.

The digital concept used :
Topological Architecture

Fig. 6.101 A Section shows the Atrium.

| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	🟥					
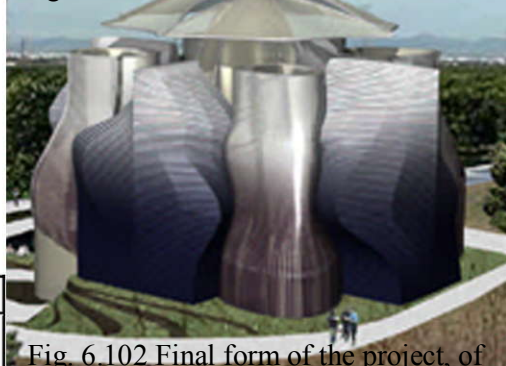
Fig. 6.102 Final form of the project, of Sociopolis.

Fig-6.103 Elevation of the Hydrogen House.
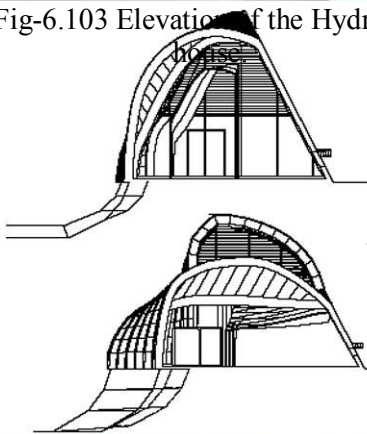
Fig. 6.104 Project Elevations

Fig. 6.105 **Final form after the** metamorphing process of the Natural museum.
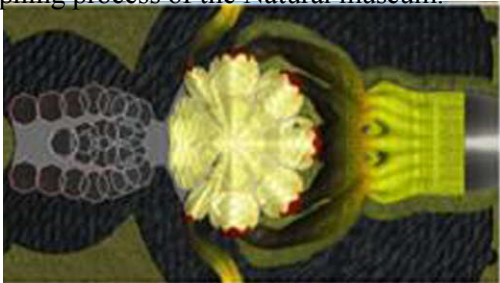
Fig. 6.106 Layout.

Fig 6.107 Main section.

3-Hydorgen House, visitors pavilion ,Austria,1996.

Project type: House for the display of new hydrogen, solar and low energy technologies[1]. (Fig. 6.103)

Digital form generation: *"The design used computer simulation software to model the solar vault and the alignment and shape of the building's shading devices and photovoltaic cells"*.[2] Forces exerted by moving cars around the project were translated to the external form of the project to reveal the interior as a sequence for anyone who uses the highway. (Fig. 6.104)

The digital concept used :

Preformable and Animate arch.

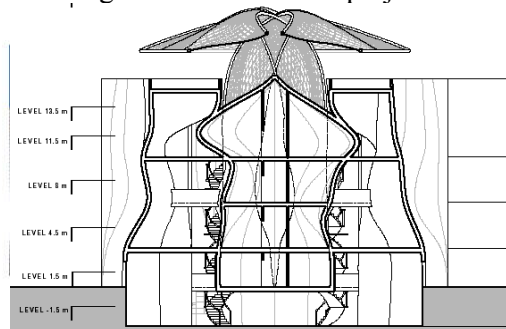| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			🟥		🟥	

4- Natural history museum, Costa Rica, 2002.

Project type: Natural history museum for ecological tourists. (Fig. 6.105-6.107)

Main concept: The museum is situated between two forests, so the form, and the color textured skin must be inspired by the local tropical flora and fauna.

Digital form generation: A process of morphing between a cathedral on one end and a museum in the other side was used to create the form.

The digital concept used :

Metamorphic Architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				🟥		

182

5- BMW Central building design Competition, Leipzig, Germany, 2002.

<u>Project type</u>: Central building for the BMW company. (Fig. 6.108)

<u>Digital form generation:</u> The BMW Group presents their cars and motorcycles in a clear fashion as "Ultimate Driving Machines." So too the design is first a high performance machine. The functional concerns of the design are centered on the functions of inspection, quality assurance, research, measurement and visualization.

<u>The digital concept used :</u>
Performable Architecture

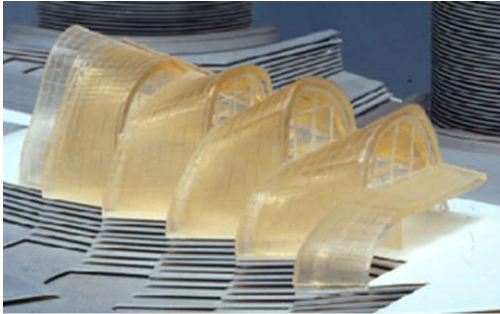| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
					▮	

Fig-6.108 Layers of creating the main form of the BMW building.

6- Artist space exhibition, New York, USA, 1995.

<u>Project type:</u> Interior design, and exhibition hall.

<u>Main concept:</u> "*Emphasizing virtual conception over actual end-product*"[1]. (The virtual conception is represented by the virtual Blobs used to create the main form of design, while the main exhibited elements represent the actual forms).

<u>Digital form generation:</u> Five blobs were used in generating the main form, by making it influences the external walls of the exhibition hall.(Fig. 6.109) <u>The digital concept used :</u> **Isomorphic Architecture**

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
		▮				

Fig. 6.109 Form generation using blobs.

Fig. 6.110 Final form generated using isomorphic architecture, of Artist space.
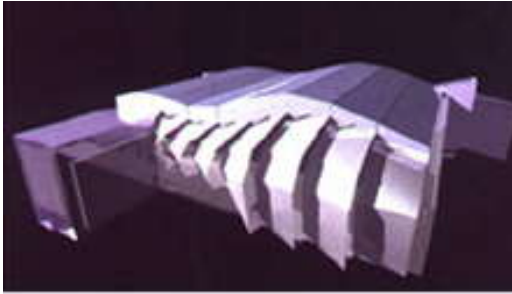
Fig. 6.111 Final form of the Presbyterian church

Fig. 6.112 Main section shows the interior design, which was designed using the blobs

7- Korean Presbyterian church, New York, USA, 1995.

Project type: Church, and lectures room. (Fig. 6.111- 6.112)

Main concept and Digital form generation: the outer and the inner forms were designed using blobs. More details about the project at page 119 in the previous chapter.

The digital concept used :
Isomorphic Architecture

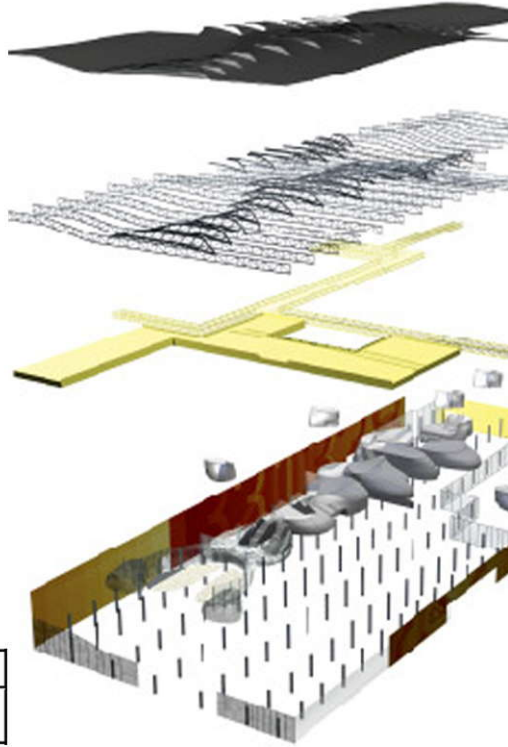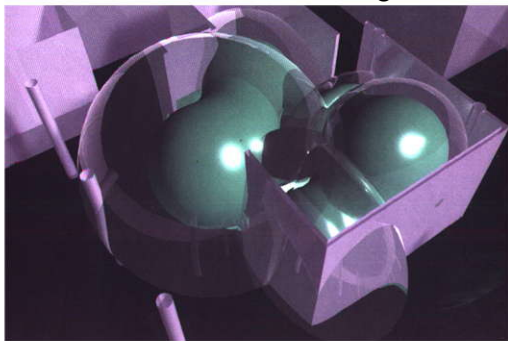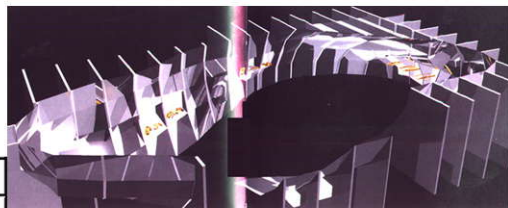| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
		■				

8- Port Authority Gateway competition, 1995.

Project type: Protective roof and a lighting theme. (Fig. 6.113)

The main concept and the digital form generation more at page 104 in the previous chapter. (Fig. 6.114)

The digital concept used :
Animate Architecture
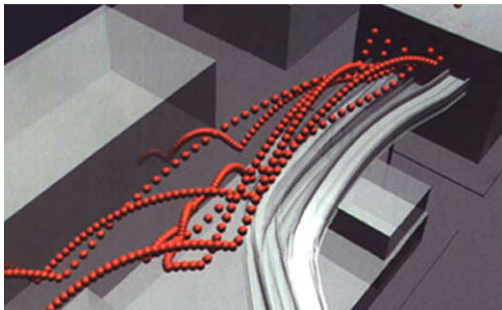
Fig. 6.113 Studying the forces in the environment..

Fig. 6.114 Final form..

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			

9- Interior design of "Lords on Sunset" store, West Holly-wood, USA , 2001.

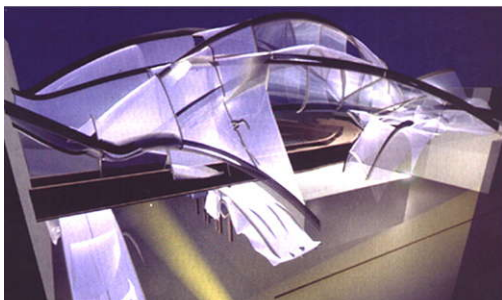Project type: Interior design of a store. (Fig. 6.115, 6.116).

Main concept: The design is organized as lavish surface that emerges form the floor and ceiling as display enclosure and furniture. (Fig. 6.117)

Digital form generation:
NURBS was to define and create the shapes.

The digital concept used :
Topological Architecture
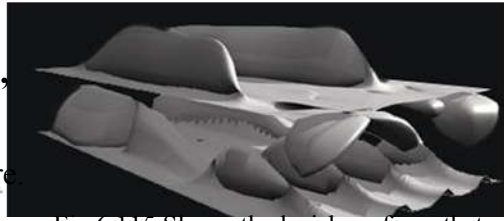
Fig 6.115 Shows the lavish surfaces that emerges form the ground of Lords store..
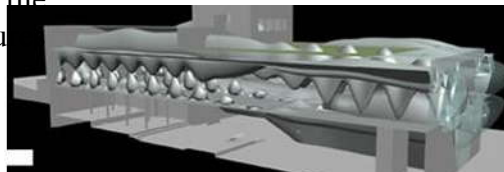
Fig 6.116 Final form.
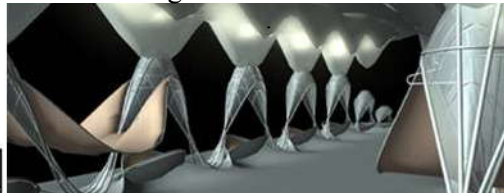
Fig. 6.117 Interior perspective for the store.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

10- Eyebeam museum of Art and Technology competition, New York, USA, 2001.

Project type: Museum. Main concept: The building is wrapped in a skin that acts as both a new media canvas and an electronic performance space. Fig. 6.118

Digital form generation: The building skin folds through itself which turns the interior of the galleries out to the street as electronic canvases for urban exhibition (6.119). These spatial loops creating pockets like rooms that act as black box galleries within an otherwise flexible museum interior.

Digital concept used :
Topological architecture

Fig. 6.118-6.119 Eyebeam museum.

Fig. 6.120 Electronic canvases.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

Fig. 6.121 Blobs used in creating design.

Fig. 6.122 Final Form.

11- Interior design of an exhibition (Henie Onstand Kunstsenter Installation Design), Oslo, Norway, 1995.

Project type: Interior design. (Fig. 6.120-6.122).

Digital form generation: the same technique which was used in project of Artist space exhibition (page 183), New York, USA, 1995, (Art-space New York).

The digital concept used :
Isomorphic Architecture

| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
		■				

Fig. 6.123 Another picture for the final form.

6-4-3 Conclusion of Lynn' s architecture movements during the period of (1995-2003):-

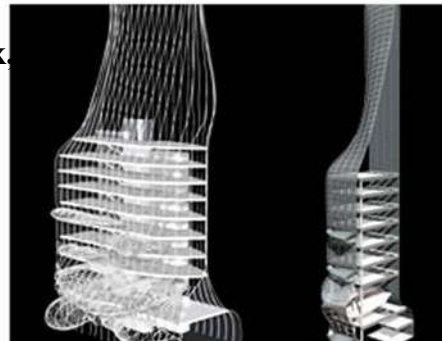| Projects of Lynn	Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
1-Imaginery Forces, USA, 2002.		■					
2-Sociopolis: Ciudad Del Habitat 2003.		■					
3-Hydorgen House, Austria,1999.				■		■	
4- Natural history museum Costa Rica, 2002.					■		
5- BMW Building, Germany, 2002.						■	
6- Artist space exhibition, USA, 1995.			■				
7- Korean Presbyterian church, USA, 1995.			■				
8- Port Authority Gateway competition.				■			
9- Yokohama port terminal competition.		■					
10- Lords , store, Hollywood,CA, 2001.		■					
12- museum of Art Technology, USA, 2001.			■				
Architecture of Lynn From 1995-2003	4	3	2	1	2		

Conclusion:

Greg Lynn uses Topology, Isomorphic, Animate, and Performable with an excess use of Topological architecture.

6-5 OCEAN[1].

OCEAN is an architectural firm consists of six departments in Boston, Cologne, Helsinki, Ljubljana, London, and Oslo.

"*Working sessions are carried out in extended conference mode as digital photographs, CAD models, drawings, and texts, for projects are electronically transferred between each node for editing or elaboration*"[2].

OCEAN 's dynamic and operative coherence is founded on a clear understanding of how digital technologies are dissolving and redistributing classically reinforced hierarchies, influences, and models of cultural production.

6-5-1 Digital ideology:

i. According to OCEAN, digital technology has shifted architecture from the production of singular, simplistic and fixed objects towards potentially dynamic and complex surfaces. By the time, computerized production has created technical and material conditions that demand the development of new strategic operations in the design process.

ii. All the parts of there architectural projects, from furniture to landscape design, are understood as extensions of urban topologies and thus, the architecture with the interior design, landscape and urban design are coherent

iii. Ocean's aim is to increase collaborative methods within the network by sharing resources and expertise, but the design network cultivates logic of minor incoherence, so that the probability of contradiction has become a fundamental creative aspect to the multi-linear organization. Indeed,

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1   ibid. p.153.

divergence and clash necessitate continual negotiations of basic operative and productive tasks, so that the work is in part the result of finding alternative ways of organizing its production and strategies.

iv. "*The theoretical commitment of OCEAN is to search for new and differential modes in urban thinking and space-making in particular toward fluid and topographical spatial organization and the invention of material effects Made possible through the vectorial logics in digital software and hardware, virtually all the group's work attempts to formulate a strategic urban architecture that validates and materializes contemporary culture and technology.*"[1]

6-5-2 Digital conceptual projects of OCEAN north during the period, 1995-2003:

The following projects represents the digital conceptual project of OCEAN north only, and not all OCEAN branches (page 190 to 193).

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1   Originally configured in London in 1995, OCEAN is an International and interactive network of some twenty architects designers and urbanists that operates across two continents, six countries and, three time zones. Composed of six "local nodes" in Europe and North America its organizational structure is collaborative inclusive multidisciplinary co-operative and decentralized -an active system of architectural conception and production. Although each nodal point is immersed in a "total condition" produced by interacting with the other centers and is therefore continuously acting and reacting to other operations each node maintains its independence by working on independent projects. The local points act as smaller-scale operations but can expand to suit larger project requirements.

2   Peter Zellner, Hybrid space: New forms in digital architecture, Op.cit. p.152.

1   http://www.ocean-north.net

1- Music and Arts Centre, Jyväskylä, Finland, 1997.

Project type: Music and art center. (Fig. 6.125)

Main concept: Integrating the cultural and public programs of the project with each other and with the urban setting of the town, Jyväskylä. The project is used to complete the historical grid and block structure of the site and extended the urban surface of the surroundings as the main formal and programmatic element of the project[1].

Digital form generation: Topological surface was used as the extension of the urban surface surrounding the site. (Fig. 6.124) The digital concept used :

Topological Architecture

Fig 6.124 Physical model for studying the form of Jyväskylä music center.

Fig. 6.125 Final form of the center

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

2- Finnish Embassy in Canberra, Australia. 1997.

Project type: Finnish embassy in Australia. (Fig. 6.126-6.127)

Main concept: The design for the Finnish Embassy in Canberra, Australia, results from a synthesis of folded topologies, program and function.

Digital form generation: Digital method was needed to identify and create the form.

The digital concept used :

Topological Architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

Fig. 6.126 Final layout of the Finnish embassy.

Fig. 6.127 Elevetion.

Fig 6.128 Creating the main form of the world trade center.
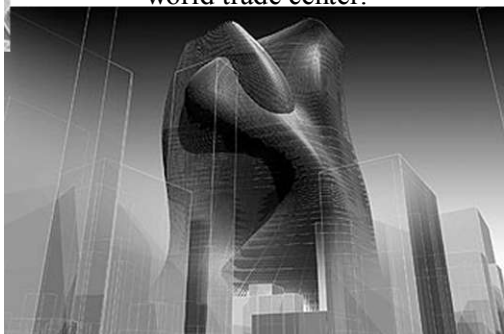
Fig. 6.129 Final form of the World trade center.

Fig. 6.130 The form of the open arena.

Fig. 6.131 Layout of the Töölö arena.

3- World Center for Human Concerns, USA, 2002.

Project type: High rise building. (Fig.6.128-6.129)

Main concept: The World Trade Center is a living symbol of man's dedication to the world peace.

Digital form generation: The World Center's spaces result from the draping and folding of the building skin around the volume of the twin towers.

The digital concept used :
Topological Architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

4- Open Arena, Töölö, Finnish, 1997.

Project type: Arena. (Fig.6.130-6.131)

Digital form generation: Three layered and continuous topological surfaces were used, to enable a free circulatory exchange between each other as well as with the existing surroundings.

The digital concept used :
Topological architecture

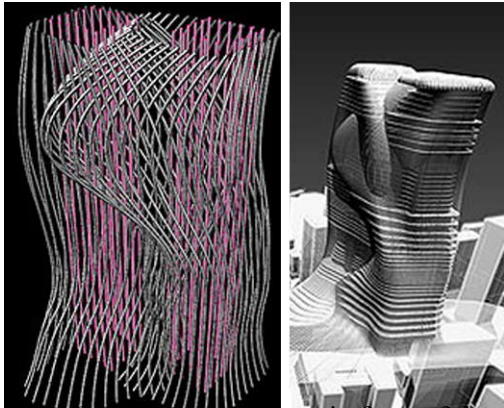| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

1   http://www.ocean-north.net
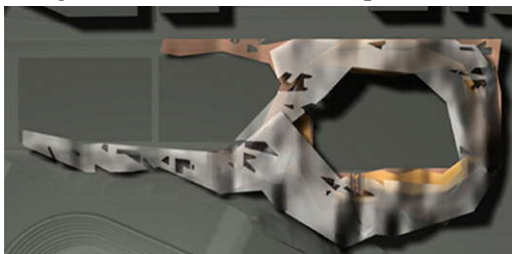
5- Ambient Amplifiers, Oslo, Norway, 2000.

Project type: a surface to provide shelter as fully developed pavilions. (Fig. 6.132-6.134).

Digital form generation: The animation methods, with a topological modifying. And this was based on the local landscape and design intentions.

The digital concept used :

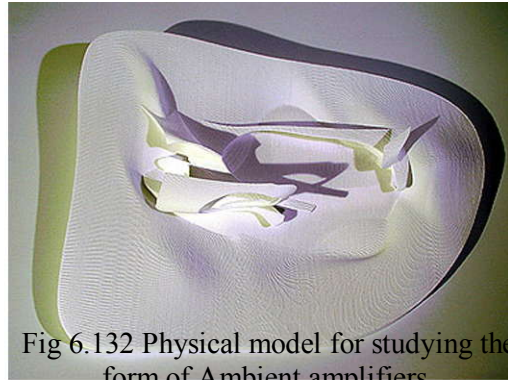**Animate Architecture and Topological architecture**.

Fig 6.132 Physical model for studying the form of Ambient amplifiers.

Fig. 6.133 Studying the skeleton of the form.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■		■			

Fig. 6.134 Final form of Ambient modifiers.

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1 ibid.

6-5-3 Conclusion of OCEAN North architectural movements during the period of (1995-2003):-

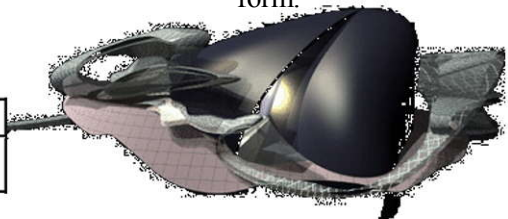| Projects of OCEAN North.	Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
1- Music Centre , Finland, 1997.		■					
2- Finnish Embassy, Australia. 1997.		■					
3- World trade center, USA, 2002.		■					
4- Open Arena, Töölö, Finnish, 1997.		■					
5- Ambient Amplifiers, Oslo, Norway, 2000.		■		■			
Architecture of OCEAN North From 1995-2003		**5**		**1**			

Conclusion:

OCEAN North uses Topology, and Animate architecture with an excess use of Topological architecture.

6-6 dECOi.[1]

dECOi has not been only influenced by the electronic revolution but rather radically formed the conceptual, poetic and technical possibilities enabled by the speed, and fluidity of the digital-technology paradigm shift. It organizes itself as a fundamentally loose (as it is found in three places) global practice to take advantage of the collaborative possibilities offered buy the speed of data transfer.

Embracing collaboration, technical innovation and experimental manufacturing processes, dECOi creates architecture that is light, mobile and elegant.

The aspect that is so deceiving and curious about the design processes of dECOi (as a computational invention and technical methods) is that the apparent mobility of the creative thinking and virtual technical applications have resulted in architectural works of great physical complexity.[1]

6-6-1 Digital ideology:

i.   dECOi has embraced the process of working " blindly" with the computer, by allowing the algorithms, and the animations create unpredictable forms .

ii. *"Goulthorpe suggests, "emphasizing the extent to which technology as an 'extension of man' is never simply an external prosthesis but actively infiltrates the human organism, certainly in a cognitive sense… it is*

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1   A famous architectural firm was founded by Mark Goulthorpe born at 1958 in Istanbul, Turkey. Goulthorpe was educated in the university of Liverpool, London. dECOi was Established in Paris in 1991 as a research-based design collaborative, Initially focused on competitions, theory, experimental installations and teaching. dECOi has evolved into a practice that now exists in somewhere between Paris, Kuala Lumpur, and London. Led by Mark Goulthorpe.

2   Peter Zellner, <u>Hybrid space: New forms in digital architecture</u>, Op.cit.

interesting to speculate not just on what technology my 'put' (or better perhaps 'leave') in our objects, but on the extent to which its general impact on patterns of cognition may intersect with such 'process-objects". The concealed potential for architecture is therefore more effective when it is liberated through an examination of social capacities and ways of thinking that are induced by the latest technologies advances."[1] dECOi's key operative aim has been to show how our desire for technical advancement might be manifested in architecture.

iii.   The powerful transformations registered in the work of dECOi reveal not only a change in the manner in which buildings will be conceived and constructed but a re-examination of the way architects will think and construct in order to achieve the elastic possibilities of the emergent techno-cultural paradigm.[2]

iv.   dECOi investigations suggest a slight and more fluid creative alternative to the aspect of function-to-form thinking that has hindered so much architectural reasoning in this Century.

6-6-2 Digital conceptual projects of dECOi during the period, 1995-2003: (page 196 to 201).

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1   1 ibid, p..56.

1- Dietrich house, London, UK, 2000.

Project type: An extension to an existing London townhouse. (fig. 6.136)

Main concept & Digital form generation: parametric architecture was used to create the main form. (Fig. 6.135).

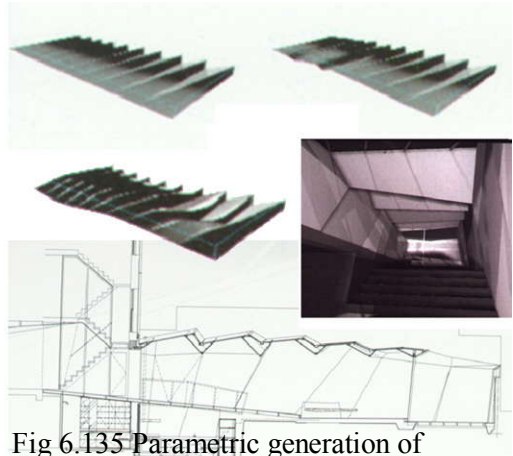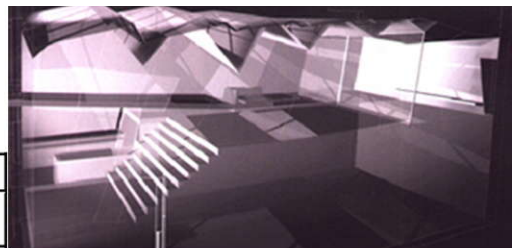The digital concept used :
Parametric Architecture

Fig 6.135 Parametric generation of Dietrich house.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
█						

Fig 6.136 Sectional perspective shows the final.

2- Formal research for a theater complex, Gateshead, London,1998

Project type: Formal research for a theater complex, undertaken for Foster&Partners. (Fig. 6.137- 6.138)

Main concept: The design can be used to design a complex curved skin that envelopes theaters of three different sizes in Gateshead, London[1].

Digital form generation: The form was generated by complex Splines, with a monolithic roof curving down to become a wall.

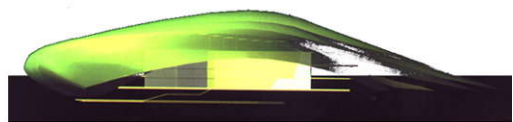The digital concept used :
Topological Architecture

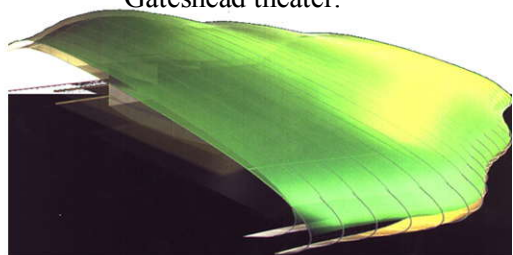Fig. 6.137 Main elevation of the Gateshead theater.

Fig. 6.138 Perspective shows the final form of the Gateshead theater.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	█					

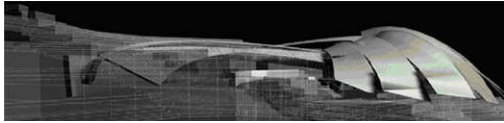1   www.newitalianblood.com/progetti/696.html
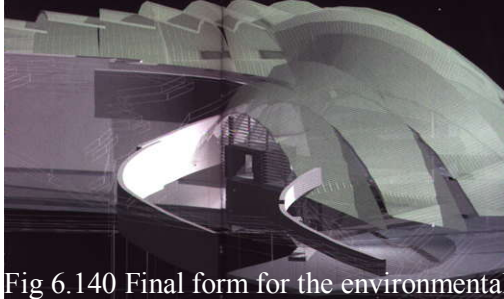
Fig 6.139 Main elevation of the Center.

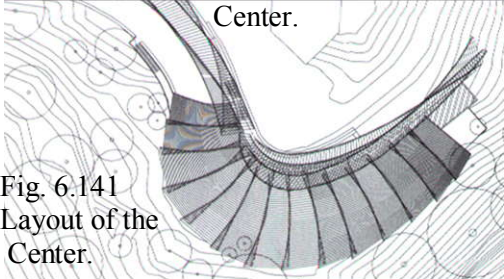Fig 6.140 Final form for the environmental Center.
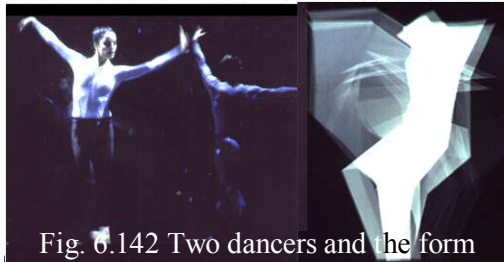

Fig. 6.141 Layout of the Center.

Fig. 6.142 Two dancers and the form derived from the tracing of there motion.

Fig. 6.143 Lines traced from the dancers

Fig. 6.144 Final form of the sculptural piece.

3- Eco Taal enviromental Center, Philippines, 1997.

Project type: Environmental center.(Fig. 6.139-6.141)

Main concept: the project responds to the challenge of creating a form that would disappear into the site but remain clear in the mind. By making the form like a carapace, a swelling of the surface that gives the slope, back its form.

Digital form generation: the form was generated by Splines.

The digital concept used :

Topological Architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

4- Ether/I Aniversary exhibition,Geneva, Swiss,1995.

Project type: sculptural piece for the 50th aniversary of the United Nations.(Fig. 6.44)

Main concept: Tracing of two dancers in space. (Fig. 6.142)

Digital form generation: Based on the negative trace of two dancers in space, captured on video. The ballet movement was broken down into graphs, which were transformed into the main form[1]. (Fig. 6.142-6.144)

The digital concept used :

Animate Architecture
(Kinematics animation)

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
			■			

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1   Peter Zellner, Hybrid space: New forms in digital architecture, Op.cit.

5- Blue Gallery, London, UK, 1999.

<u>Project type</u>: Gallery. (Fig. 6.145)

<u>Main concept</u>: The gallery surfaces are articulated as two shells. (Fig. 6.146)

<u>Digital form generation</u>: The gallery surfaces were created by the morphing of two shells contacts at a point of fusion occurs as a "dropping point" (where the ceiling surfaces gather and fall to earth, as if the gallery itself were liquefied, the surfaces was pulled to the ground).

<u>The digital concept</u> used :

Metamorphic Architecture

Fig 6.145 Form of the Gallery.

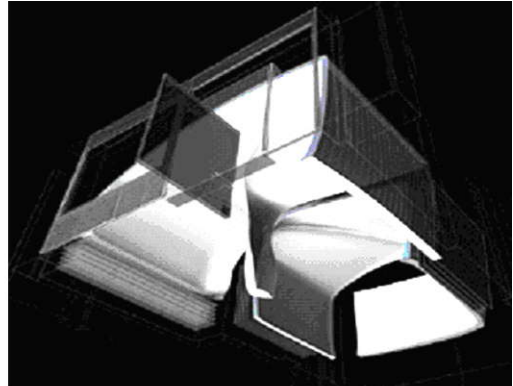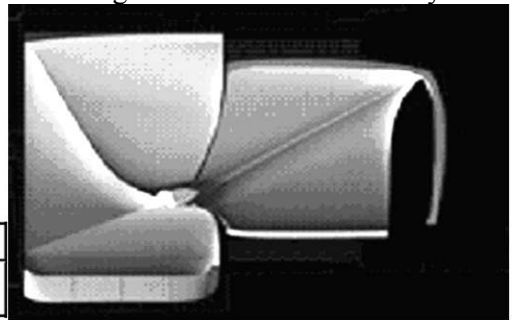| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
				🟥		

Fig. 6.146 Looking up plan for the gallery.

6- Agis Hyposurface, Birmingham Hippodom foyer, UK, 2002.

<u>Project type</u>: Interior Art piece.(Fig. 6.148)

<u>Main concept</u>: Reconfigurable surface capable of real-time responsiveness to the events in the theater.(Fig. 6.147)

<u>Digital form generation</u>: at Page 66.

<u>The digital concept</u> used :

Performative Architecture
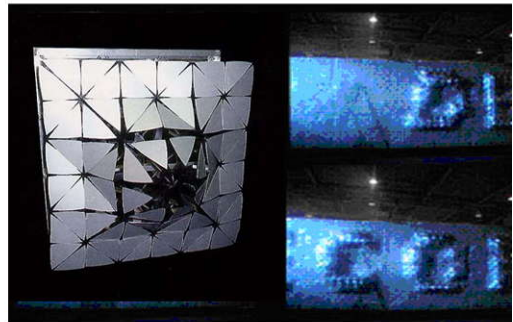
Fig. 6.147 On the left the unit used in creating the Agis surface.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
					🟥	
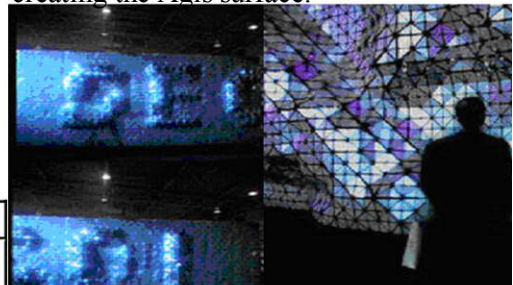
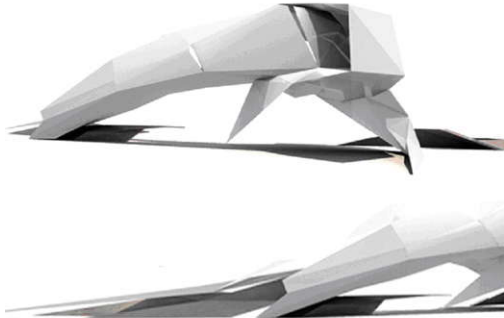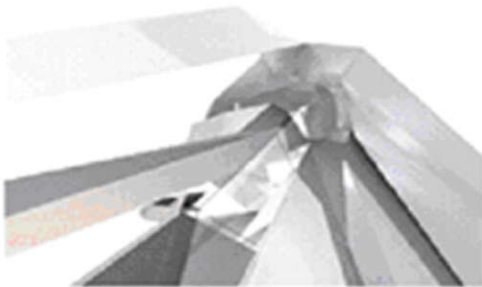Fig. 6.148 Upper right and bottom various forms for the same wall.

Fig 6.149 Form of the Excideul Folie.

Fig. 6.150 Detail in the form..

Fig. 6.151 Handlesman apartment.
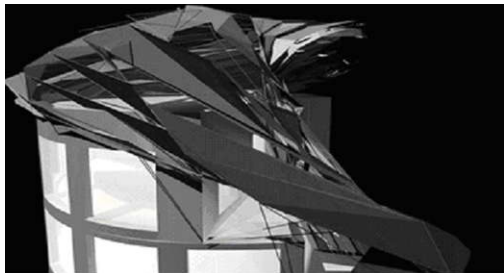
Fig. 6.152 Final form of Handlesman apartment.

7- Excideuil Folie, Excideul, Perigord, France, 2001.

Project type: -(Fig. 6.149,6.150)

Digital form generation: the form was created with five Splines, "primitives" of digital systems, twisting them serially to create notional shelter, and orienting it according to the parameters of exposure, view, traffic, etc.

The digital concept used :
Topological Architecture

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

8- Handlesman apartment, London, UK,002.

Project type: Apartment.
Main concept: The form resulted from a consideration of a range of contextual factors.(6.151,6.152)
Digital form generation: Using the parametric equations, the form resulted from certain factors: thermal laws governing the amount of glazing, planning restrictions as to the volume of any extension, structural and constructional factors demanding a rapid and a lightweight intervention.
.The digital concept used :
Performative Architecture, and Parametric Architecture.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
■					■	

9- Missoni Boutique, Paris, France, 1996.

Project type: Boutique.(6.153.6.154)

Main concept: This boutique is for the Italian Knitwear company, so the design is an architectural equivalent of the company's hallucinogenic textiles.

Digital form generation: The limited space suggested opening the entire floor as a slowly descending spiral (walls become floors become ceilings).

By using the Splines and NURBS to create the form.

The digital concept used :
Topological Architecture.

Fig 6.153 Form of the Boutique.

Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
	■					

Fig. 6.154 Two elevations of the project.

10- Paramorph,Gateway to the South bank competition, London, UK, 1999.

Project type: Gateway (entrance of a pedestrain route). (Fig. 6.155, 6.156)

Main concept: the form of the Paramorph is created from the movement of people through the space. Digital form generation: the gateway derived from a series of contextual mapping strategies, where sound and movement models were used with a parametric model to generate form.

The digital concept used :
Animate Architecture, and Parametric Architecture.

Fig. 6.155 Various pictures for the main form.

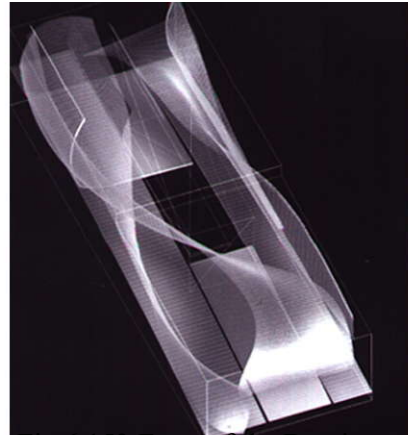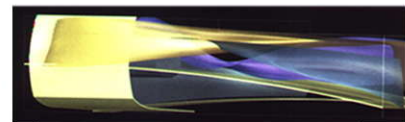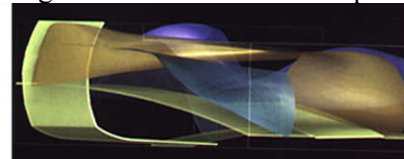| Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
■			■			

Fig. 6.156 Elevation for the Paramorph gate-way.

200

6-6-3 Conclusion of dECOi architectural movements during the period of (1995-2003):-

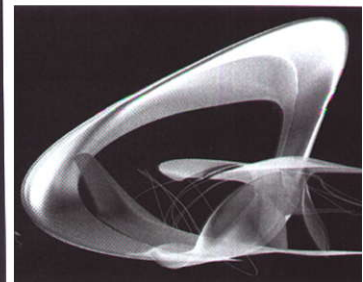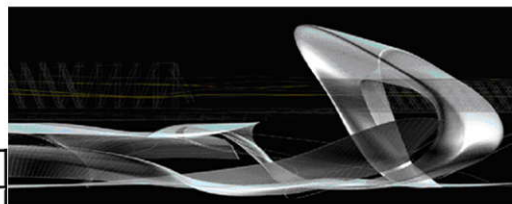| Projects of dECOi	Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
1- Dietrich house, London, UK, 2000.	■						
2- A theater complex, London, 1998.		■					
3- Enviromental Center, Philippines, 1997.		■					
4- Ether/I Aniversary exhibition, Swiss,1995.				■			
5- Blue Gallery, UK, 1999.					■		
6- Agis Hyposurface, UK, 2002.						■	
7- Excideuil Folie, Perigord, France, 2001.		■					
8- Handlesman apartment, UK,2002.	■					■	
9- Missoni Boutique, France, 1996.		■					
10- Paramorph Gateway, UK, 1999.	■			■			
Architecture of dECOi From 1995-2003	3	4		2	1	2	

Conclusion:

dECOi uses Parametric,Topology, and Animate architecture with an excess use of Topological architecture.

6-7 Conclusion :

The following table collabrates the architectural movements of the digital masters:

Architects	Parametric architecture	Topological architecture	Isomorphic architecture	Animate architecture	Metamorphic architecture	Preformable architecture	Genetic algorithmic
Architecture of Bernhaed Franken.	3		1	8	2		
Architecture of Kolatan/MacDonald	1				4	1	1
Architecture of Oosterhuis associates	3	4	3	1	4	5	1
Architecture of Lynn From 1995-2003		4	3	2	1	2	
Architecture of OCEAN North From 1995-2003		5		1			
Architecture of dECOi From 1995-2003	3	4		2	1	2	
Architecture from 1995-2003	13	17	7	14	12	10	2

Conclusions:

1. Topological architecture is most used concept during the period from 1995-2003.
2. Genetic algorithmic architecture is the least used concept during the same period.