POLITECNICO DI MILANO - FACULTY OF ARCHITECTURE AND SOCIETY
MASTER OF SCIENCE IN ARCHITECTURE - LANDSCAPE

THESIS WRITTEN REPORT:

TRANSPLANTING ARCHITECTURE
PARAMETRIC DESIGN FOR KAOHSIUNG MARITIME CULTURAL AND POPULAR MUSIC CENTER

THESIS SUPERVISOR: ANDREA ROLANDO, Prof.
STUDENT: TRAN QUANG HIEU - MATRICOLA: 734447
ACADEMIC YEAR :   2008-2010

transplanting architecture

PARAMETRIC DESIGN FOR KAOHSIUNG MARITIME CULTURAL & POPULAR MUSIC CENTER

The gate of Castello Sforzesco, Milan, see interpretation of the gate part 3.1.1 p23

content

A short introduction of the thesis

The chapter explains how the topic (the competition in Kaohsiung, TW as the project brief and parametric design as the approach) was chosen. The goal of the thesis is finding the potentialities of the approach results from the research and the project to apply to real world.

The research firstly studies the brief to understand the context and the theme of the project. The second part studies the approach by analysing the goal, the method and lessons from casestudies. The result of this research becomes guidelines for the project design.

The chapter starts with the interpretation drawn from the research part to create a framework for designing the project, then after mapping the constraints and variables, the parameters are defined and applied to the design, then the process restarts the next loop to refine itself.

The conclusions are: parametric design has immediate applications and could be developed to become a more powerful design approach. The project has not been completed although it shows fundamental rules and direction to continue for the promising outcome.

0   abstract

In the 11th Architecture Biennale in Venice 2008, *"Parametricism"*[1] was first claimed to be a new style, and about a year later it was slightly adjusted to "a global new style"-after modernism. In fact, parametric design has been discussed, researched, taught in numbers of institutions, practiced and manifested in from students' works to numbers of recently built constructions around the globe. But architects has been dealing with design parameters eversince the primitive hut was built. What is the difference then?

This three part thesis starts with a research which focus on studying parametric design by quickly scanning from historical context to the recent digital environment. In second part, the thesis takes the on-going design competition named "Kaohsiung Maritime Cultural and Popular Music Center" (KMCPMC) in Taiwan as a brief to do the project. Finally a self- critic conlusion summarizes the work. The three parts run almost parallel instead of one after another.

1   introduction

The chapter explains how the topic (the competition in Kaohsiung, TW as the project brief and parametric design as the approach) was chosen. The goal of the thesis is finding the potentialities of the approach results from the research and the project to apply to real world. The main points are :

- the demand of growing fast and the problem of complexity are typical in recent projects in south east asia, the challenge of time pressure and instable context asks for actions

- parametric design has capacity to deal with complexity because it utilizes advanced mathematic to process data, operates in a collective way and builds up multiple relationships between different systems which reflexes the complexity as the design requires

- The goal of the thesis is taking the approach from the research to look at the problem in a different perspective, experimenting with the project to see the applicable possibilities to real world projects.
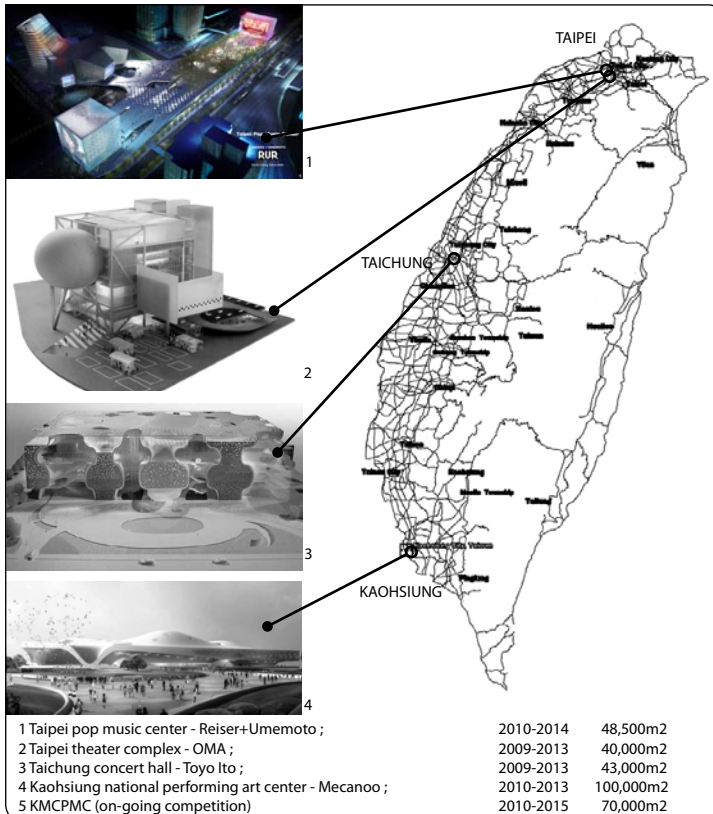
fig 1.1   New projects for performing art in Taiwan

1 Taipei pop music center - Reiser+Umemoto ;	2010-2014	48,500m2
2 Taipei theater complex - OMA ;	2009-2013	40,000m2
3 Taichung concert hall - Toyo Ito ;	2009-2013	43,000m2
4 Kaohsiung national performing art center - Mecanoo ;	2010-2013	100,000m2
5 KMCPMC (on-going competition)	2010-2015	70,000m2

fig 1.2   New projects for performing art around Taiwan

6 Chengdu contemporary art center - Zaha Hadid	2010-TBC	200,000m2
7 Guangzhou opera house- Zaha Hadid	2007-2010	70,000m2(site)
8 National performing art center (Beijing) - Paul Andreu	2001-2007	-m2
9 Thang Long theater(Hanoi) - Renzo Piano	2010- TBC	-m2

1.1. why KMCPMC

1.1.1.   *"go east"* [1] - the demand

Kaohsiung Maritime Cultural and Popular Music Center" (KMCPMC) is an on-going international competition, the site of which is located in the port city named Kaohsiung, in southern Taiwan. *"The project is part of the "i Taiwan 12 infrastructure projects" and "new 10 construction projects" which has a budget of 500 billionNT over five years."*[2]

In fact, within the years of 2009 and 2010 Taiwan started 5 new major constructions dedicated to performing art (fig. 1.1). These projects are scheduled to complete in 3-4 years. Zooming out, in the South East Asia , particularly the area around the Pearl river delta (Hongkong, Shenzen) also has similar projects (fig.1.2).

Refer to the rate of economical growth, one could see the living standard in developing countries is relatively improved, as a consequence people here are willing to have more entertaining places. In other words, the demand for more buildings, specially pop-culture facilities is getting higher.

1.1.2.   the problem

"Any architectural project we do takes at least four or five years, so increasingly there is a discrepancy between the acceleration of culture and the continuing slowness of architecture."[3]

The problem is not new: complexity. Buildings have to be complex, have to be iconic, original therefore specific, and at the same time be flexible, adaptive therefore generic. They have to be members of different plannings, contain different functions, serve different roles, operate by different systems and benefit from different sources. An example of mix progam: the contemporary art center in Chengdu(fig1.2 img.6) has 200,000m2 (about 4 times larger than other projects in the list) of three auditoria, an art museum, exhibition space and conference centre, plus restaurants, bars and shops.

The challenge is time pressure and the increasing instability of the context. An example is: the National performing art center in Beijing (fig1.2 img.7) has a 2400 seat opera hall, a 2000 seat
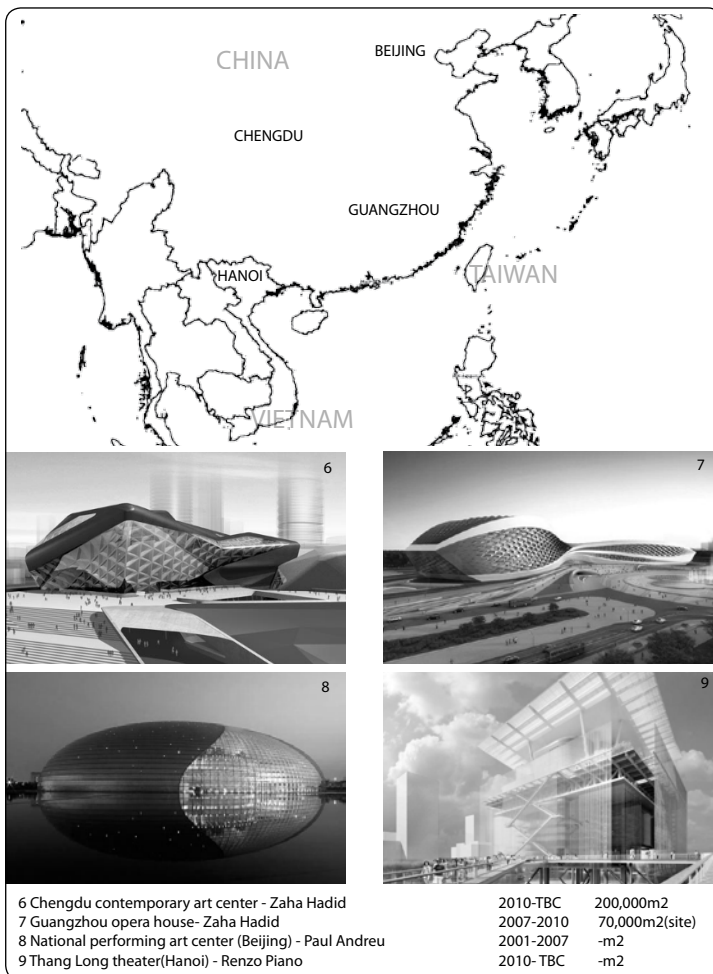
---

1   Theme of the book entitled Content by OMA-AMO, 2004 Taschen.
2   Extract from the competition brief
3   interview Rem Koolhaas by Marcus Fairs, http://www.iconeye. com/index.php?option=com_content&view=article&id=2715:rem-koolhaas--icon-013--june-2004

music hall and a 1040 seat theater , took 7 years to construct, while the Kaohsiung center for performing arts (fig1.1 img.4) has a similar program of a 2300 seat concert hall , an 2000 seat opera house, a 1000 seat theatre hall and an 500 seat experimental Black Box, but schedule to complete in 3 years. The cost of the building in Bejing increased 20% compare to estimation. *"The major cause of the cost increase was a delay for re-evaluation and subsequent minor changes as a precaution after a Paris airport terminal building collapsed."* [4]

The demand is there, the challenge is there, should architects take it and do like what they used to do, or find another way or leave it?
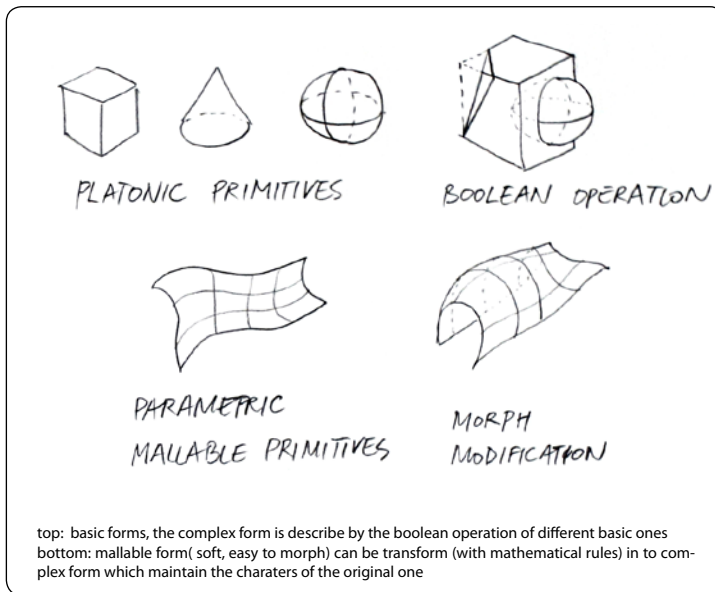
4   from wikipedia

top: basic forms, the complex form is describe by the boolean operation of different basic ones
bottom: mallable form(soft, easy to morph) can be transform (with mathematical rules) in to complex form which maintain the charaters of the original one

fig 1.3 primitive geometries

left: conventional form finding process
right: parametric form finding process

the codes/rules in parametric design are interconnected, have affection on each other through a multi-system network. The snowflake forms are always different but they base the hexagon shape
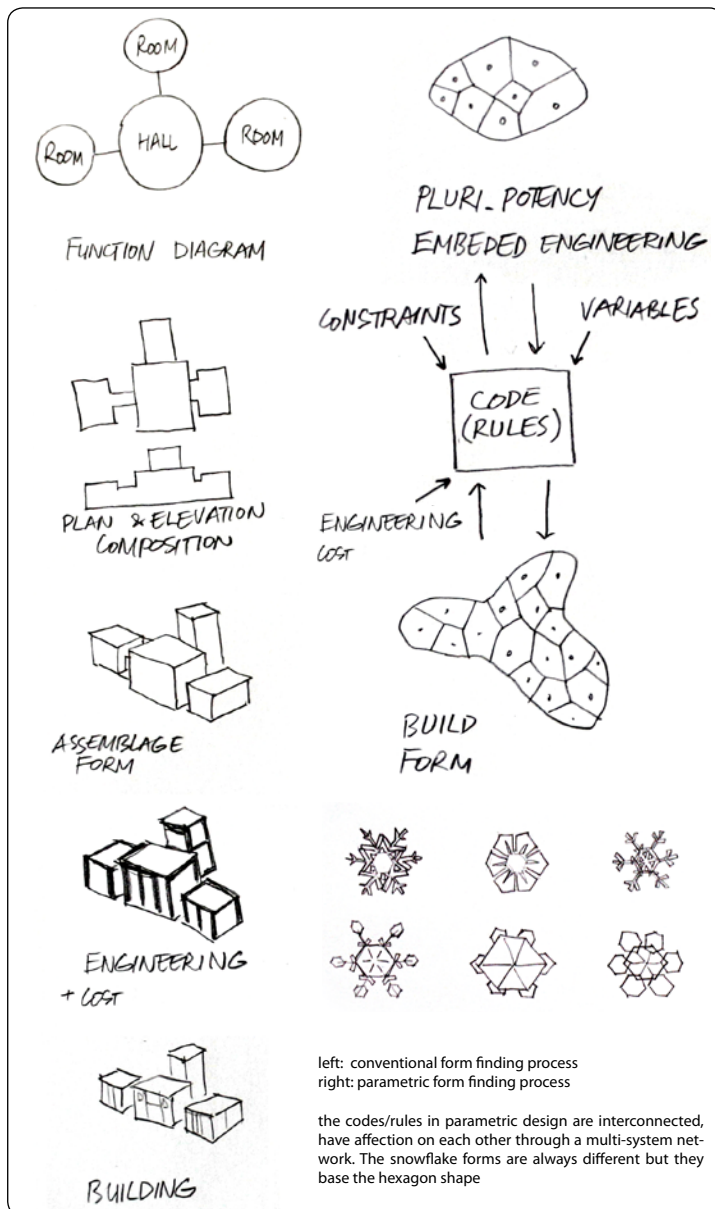
fig 1.4 form finding processes

1.2. Why parametric

1.2.1. Mathematic and form description

In order to build, architects have to describe the form by geometrical language : distance(length), angle, area, volume, weight... mostly "devisible measurements"[5]. Boolean operations (adding, substracting, dividing, multiplying) which base on simple algebra, are used to make assemblage forms(fig1.3). The problem of assemblage form often appears at the junctures between elements. The more complex the form is, the more description needed, that costs more time and money to produce and that is not what contemporary pharaohs want.

Parametric forms bases on contiuous tranformation which can be described through calculus[6], and that results in the seamlessness[7] of the form (fig1.3). Therefore when cooperate with engineering process, the forms can be treated as a whole logical system instead of an assemblage of different parts with diffent logic. This also means the final outcome can avoid the problem of connecting different components of different systems. So firstly, parametric design employs advanced mathematic to help explaining the complexity of architectural forms.

1.2.2. Form finding and design process

"Architecture is a fuzzy amalgamation of ancient knowledge and contemporary practice, an awkward way to look at the world and an inadequate medium to operate on it."[8]

Conventional form finding process(fig1.4): follows strict order , that limits the ability to modify (with major changes) due to cost of resources to coordinate between stages, specially when form is being engineered. This process reduces the capablity of handling the complex project in which forms have to be refine many times

"Pluri-potency is a term in biology used to define the ability of a single cell to develop in several configuration"[9].

Parametric form finding process(fig1.4): Parametric modelling describes form as sets of rules, which have embedded engineering information.

5　　　　compare to non-divisible measurements: temperature, pressure...
6　　　　Calculus can solve problems for which algebra alone is insufficient.
7　　　　this character might cause misunderstanding that parametric design is limited to blobs and nurbs.
8　　　　Rem Koolhaas, Content. Taschen 2004, p20
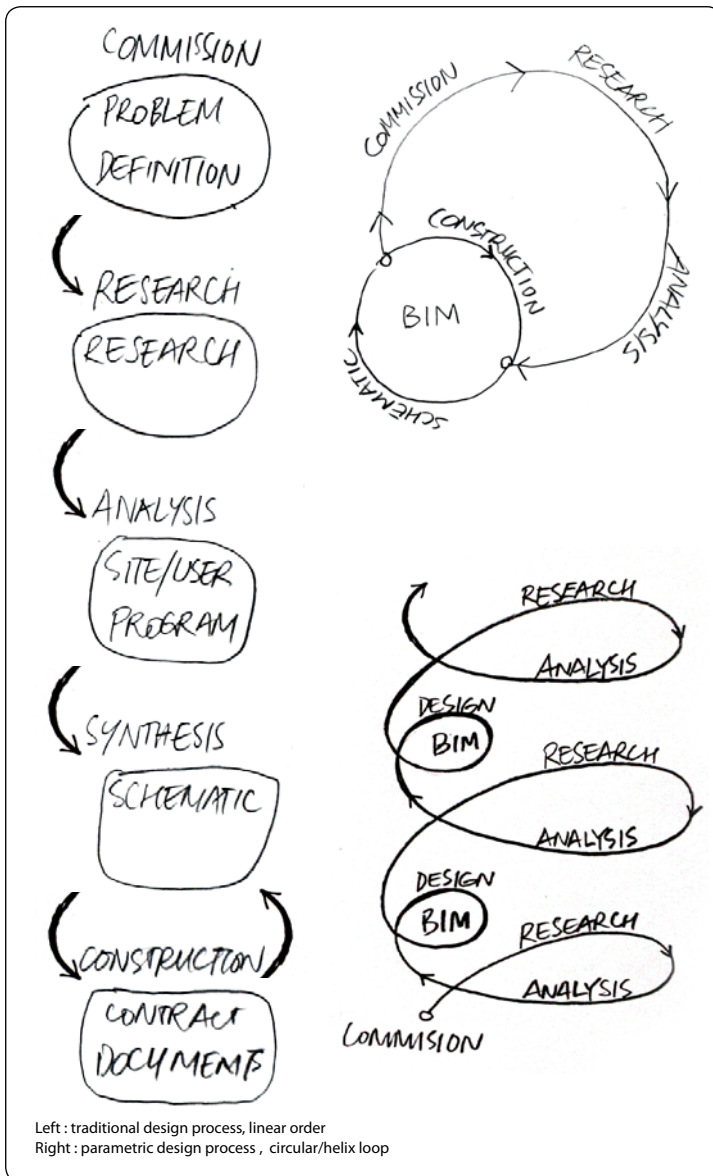9　　　　P,Angius, Innovative design and construction technology, 2009, Politecnico di Milano, Maggioli editore, p63

fig1.5 design processes

Left : traditional design process, linear order
Right : parametric design process , circular/helix loop

These rules are recorded, the information is kept through any transformation which means any modification can always go back and forth without having to re-model the form. This also means a family of radically different variations can be produced from the same "gene", that make themselves more adaptive to different context.

The conventional design process(fig1.5) : similar to the form finding process, the conventional approach bases on a sequence of steps which allow to go back only for minor changes. To address the sophistication of the contemporary design problems, the avantgarde practices are moving toward the design process which involves most of the consultants in a loop from the early stage(fig1.5). The building information model (BIM) is the common language between parties. Parametric scripting give instruction to process or sub-proccess in which repetitive refinement can be made as many times as needed.

The computers can not keep up with the brain but the good thing is they are not tired. They can help but they need training. Starting from form finding, describing, and transfering (between stages of the design process), parametric design techniques shows the potential capability of dealing with complexity. But architecture is more than form, it has many non-geometrical measurements such like: light, heat, noise, privacy... How should parametric design address this issues?
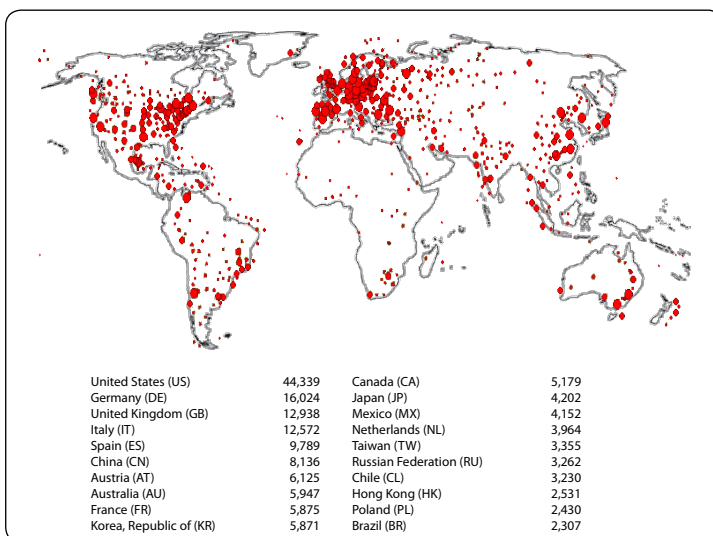
1.2.3.   is it a fashion ?

"parametric design is universal" [10]
The approach is collectively developed by a global comunity. What can be read from the map of users login Grasshopper[11] website(fig1.6) is a well connected network of actors actively participate in the field: users and software developers response to each other instantly, users sharing codes, parameter definitions, compete each other with more refined algorithms... This is the difference from the previous generation of digital tools in which users just take what is avalable from the providers.

United States (US)	44,339	Canada (CA)	5,179
Germany (DE)	16,024	Japan (JP)	4,202
United Kingdom (GB)	12,938	Mexico (MX)	4,152
Italy (IT)	12,572	Netherlands (NL)	3,964
Spain (ES)	9,789	Taiwan (TW)	3,355
China (CN)	8,136	Russian Federation (RU)	3,262
Austria (AT)	6,125	Chile (CL)	3,230
Australia (AU)	5,947	Hong Kong (HK)	2,531
France (FR)	5,875	Poland (PL)	2,430
Korea, Republic of (KR)	5,871	Brazil (BR)	2,307

fig 1.6 Map of Grasshopper users and top 20 countries have visited the site on day Nov.2010

10   Patrik Schumacher,lecture : experimenta, AA london 2009
11   Name of the parametric design software by R. Mcneel

Digital project(Gehry Tech)　　Grasshopper(R.McNeel)　　Generative component(Bentley)
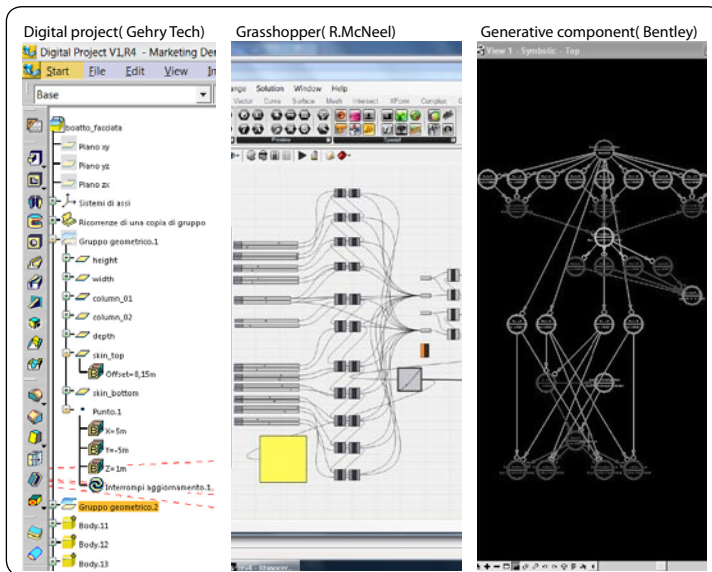
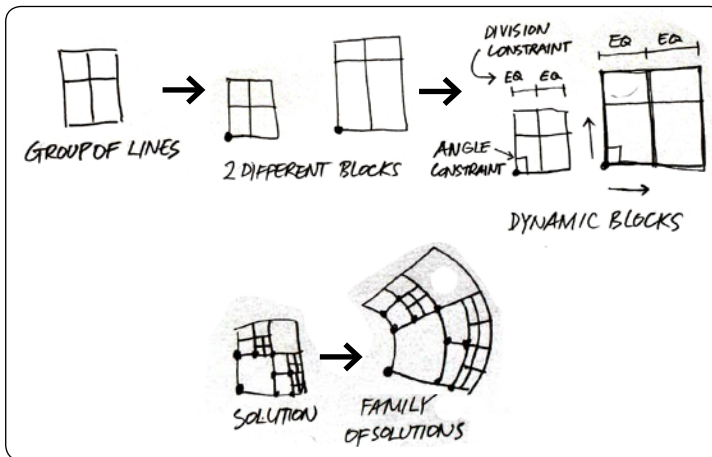fig 1.7 graphic user interfaces (GUI) of parametric modelling software

fig 1.8 software development toward parametrical description of form

fig 1.9 parametric design outcomes

The *actors*[12], among many others, should be mentioned are:

actors in institutional research
- AA DRL(London,UK)
- Havard GSD(MA,US)
- SCIArc(LA, US)
- TAC Polimi (Milan, IT)
- TU Delft(Delft, Ne)
- TU Innsbruck (Innsbruck, Au)
- TU Berlin(Berlin, Ge)
- UCLA(US)
- Vienna University of applied arts(Au)

actors in theory:
- Ben Van Berkel (Academy of Fine Arts Städel-schule in Frankfurt am Main)
- Greg Lynn (UCLA+ Vienna)
- Hani Rashid(GSAPP)
- Lars Spuybroek(TU Delft)
- Manuel Delanda. (European graduate school, Columbia)
- Patrik Schumacher+Zaha Hadid(AADRL+TU Innsbruck+Vienna)

actors in infrastructure(softwares)
- Digital project-Gehry Techonologies
- Paracloud-GEM
- Revit architecture-Autodesk
- Maya(melscript)-Autodesk
- 3DSMax(Maxscript)-Autodesk
- Rhino +Grasshopper-Robert Mcneel
- Generative components-Bentley

Graphic user interface of parametric modelling softwares (fig 1.7) often visualize the complex relationship between design parameters in a form of network diagram. Basic CAD softwares are also developing parametrical geometries(fig1.8).

actors in practice
- Aranda/Larsch(US)
- Asymtote(Hani Rashid,US)
- FORM(Greg Lynn, US)
- NOX(Lars Spuybroek, Netherland)
- Morphosis(US)
- Zaha Hadid architects (UK)
- UNstudio(BVBerkel,Netherland)

The outcomes(fig1.9) ranges broadly from urban design and architecture to interiors and products design.

12　　　　Research method of studying "the actors" taken from the book "Forma, geometria, struttura"
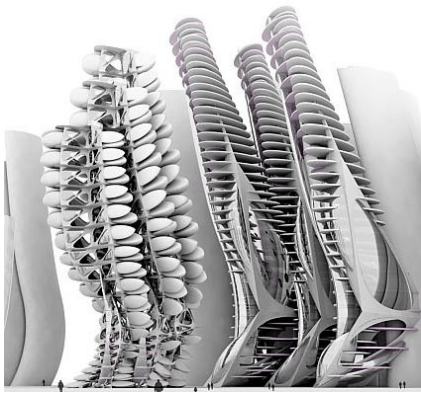
Left: Student's work from AAschool
Right: MAD's new design

1.3. the aim

In academic research, there are many good ideas but they have difficulty in applying to the real world condition, specially at the detailing process where many subsystems are taken into account which violate the main conceptual rules. As a result, what we see now, the average outcomes, due to intellectual poverty, may stand around superficial use of parametric modelling technique. In other words, the application stays at the playful skin or envelope of the building but not involves deeply with the complex program.

The thesis, by studying the brief, the goal of the approach, how design parameters (both formal and functional parameters[13]) evolve from the historical values to the latest built work of the masters, learning the lessons, then look at the problem of the project in a different perspective, experiments with the project to see the applicable possibilities to real world projects.

---

13   formal parameters: geometries/shapes ; functional parameters: uses of spaces, privacy(from public to private), cultural identity, symbolic meanings...

The research firstly studies the brief to understand the context and the theme of the project. The second part studies the approach by analysing the goal, the method and lessons from casestudies. The result of this research becomes guidelines for the project design. The main points are:

- the vision of the city and the context show the project can be interpreted as a "gateway", this will become the principal parameter of the project. The changes in pop music industries, the meaningful history of navigation in seafaring people, and the changes in business model suggest the sub parameter in the project design which organizes spaces with the degree of privacy

- the study of the approach with the modern philosophy of Gilles Deleuze, helps constructing the goal of parametric design. The goal is to show positive difference which helps people navigating through spaces. The examples from the past to the present give lessons about how to achieve that goal.
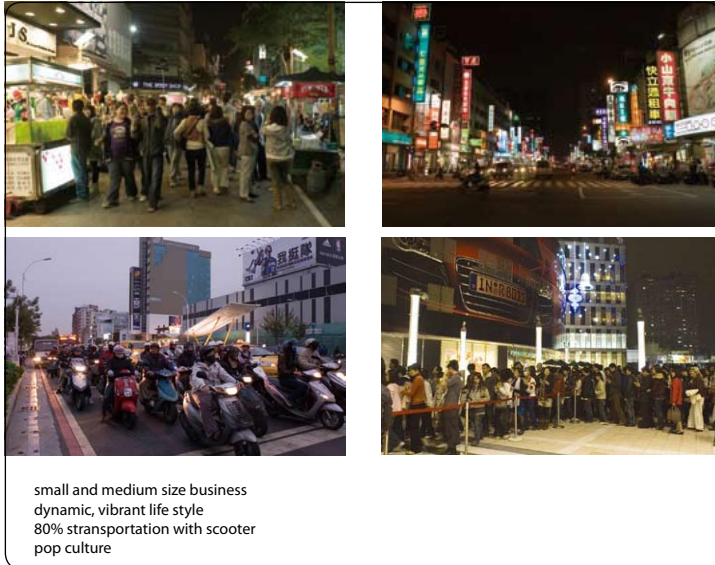
small and medium size business
dynamic, vibrant life style
80% stransportation with scooter
pop culture

fig 2.1 Kaohsiung lifestyle

fig 2.2 Kaohsiung architectures

The plan for Kaohsiung port is converting parts of the old industrial port facilities to new cultural, commercial faciilities. The site of the project locates in Designed cultural and recreational district(A)
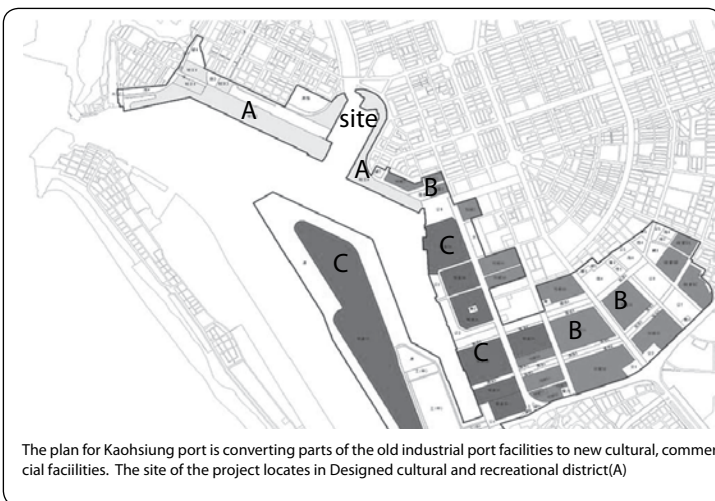
fig 2.3 Urban planning of Kaohsiung port

north gate   south gate   east gate ; west gate(demolished)
The old city wall was built in1825 with the donation from peasants and government, at the time was the most advanced city wall in Taiwan. The meaning of the four gateways along this wall should be reflected on the interpretation of the design as a new gateway to the city.
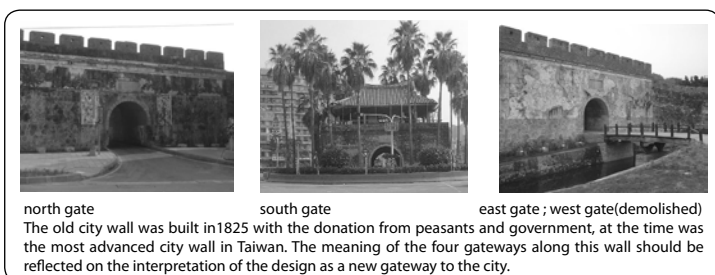
fig 2.4 the old city gates

2.1. the brief

2.1.1. client vision [1]

- *Kaohsiung as a fulcrum for Asia-Pacific pop music production and performance and an international exchange platform for maritime culture*
- *the biggest international commercial port in Taiwan, is in a prime position to become a **symbolic gateway** to this maritime city*
- *a city that prides itself as the "maritime capital", should be distinct from other maritime museums on the island and showcase unique characteristics in the development of the Port of Kaohsiung.*
- ***pluralistic culture(fig 2.1)***
- *focus on the **commercial and entertainment** functions intrinsic to pop music*
- *In particular, the architecture of the main performance hall and the maritime culture center should take on a youthful, energetic, cheerful and yet artistic personality.*
- *waterfront green belt*
- ***large volumes should be avoided***
- *energy saving*
- *extensive shaded areas*
- *night time use*
- ***minimize crowded and noise impact***
- *public art coordination*

 "The core idea for the Project is to integrate the city infrastructure, waterfront green arcade together with pop music perwformance venues to create a unique culture and harbor music city. "

Kaohsiung architecture(fig 2.2)
Buildings in the city have various architectural styles from vernacular to contemporary outlooks. There are several historical construction, besides that most of the urban areas are constructed after WWII(after Janapese colonial preriod).

Urban planning of port Kaohsiung (fig2.3)
A. Designed Cultural & Recreational District
B. Designed Warehousing & Transshipment Dist.
C. Designed Commercial & Trading District
 Program requirement(see appendix 1)
By studying the brief and the context, the project 's main theme can be suggested as a new "gateway" to the city (compare to the old ones fig2.4). This principal parameter shall be used as a frame to analyse the problem, to shape and correlate the other rules, to evaluate the result and refine the whole process.
See the interpretation of the gateway to the project in chapter 3.1.1 on p.23

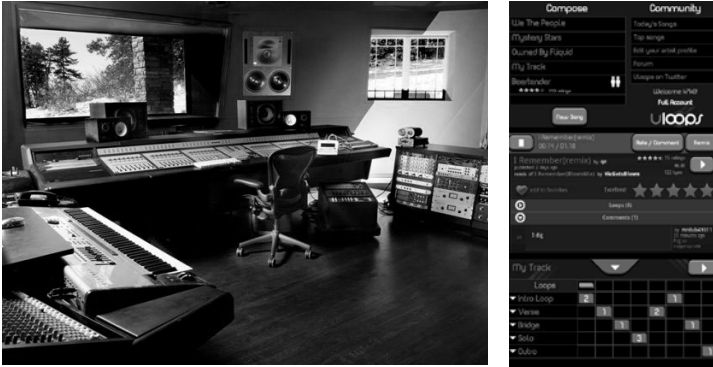1   Extract from the KMCPMC competition documents

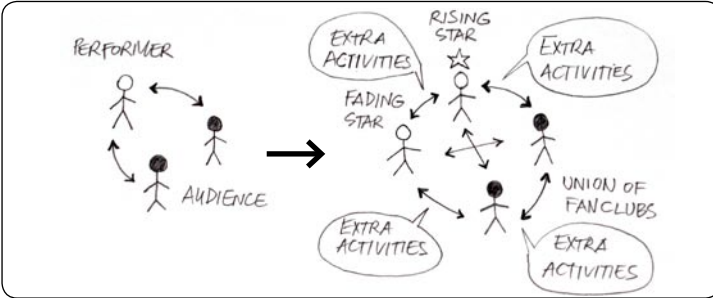fig 2.5 changes in composing and recording spaces
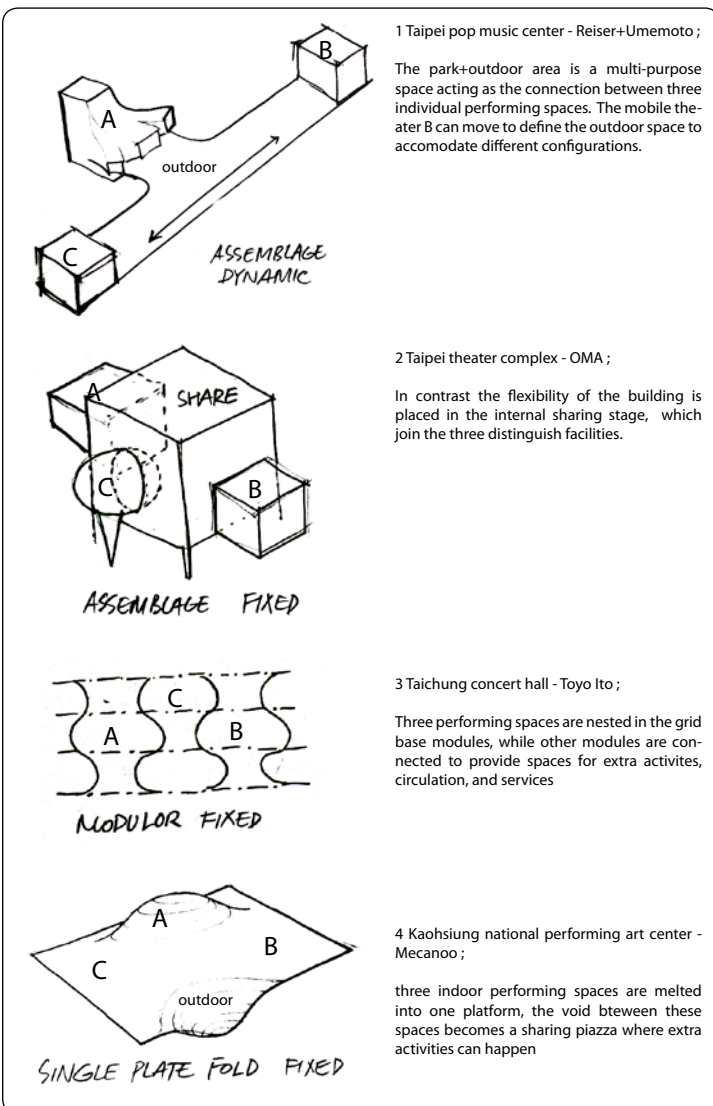

fig 2.6 changes in performing spaces

1 Taipei pop music center - Reiser+Umemoto ;

The park+outdoor area is a multi-purpose space acting as the connection between three individual performing spaces. The mobile theater B can move to define the outdoor space to accomodate different configurations.

2 Taipei theater complex - OMA ;

In contrast the flexibility of the building is placed in the internal sharing stage, which join the three distinguish facilities.

3 Taichung concert hall - Toyo Ito ;

Three performing spaces are nested in the grid base modules, while other modules are connected to provide spaces for extra activites, circulation, and services

4 Kaohsiung national performing art center - Mecanoo ;

three indoor performing spaces are melted into one platform, the void btween these spaces becomes a sharing piazza where extra activities can happen

fig 2.7 contemporary performing art spaces in Taiwan, more images in page 6

2.1.2. pop music culture

Rapid changes in technologies and entertaining market have transformed performing spaces, manufacturing and the relationships between the participants in pop music industry. Composers, editors, producers, publishers... of pop music are now have more options to choose between the traditional studios filled with complicated equipments, and the mobile application runs on any smartphone(fig 2.5). The performing spaces used to host the relationship between performers and audiences, now co-host many extra activities of a networking relationships (fig2.6): products promotion, artist promotion, new releases signing ceremonies, old stars and new stars duets, joined events, fan clubs meetings...

The above tendency can be understood by looking at general pop music characteristics:
- *a focus on the individual song or singles, rather than on extended works or albums*
- *an aim of appealing to a general audience, rather than to a particular sub-culture or ideology*
- *an emphasis on craftsmanship rather than formal "artistic" qualities*
- *an emphasis on recording, production, and technology, over live performance*
- *a tendency to reflect existing trends rather than progressive developments*
- *much pop music is intended to encourage dancing, or it uses dance-oriented beats or rhythms* [2]

Recently built performing art centers in Taiwan (fig 2.7) show the spatial organization responses to the fact that more and more activities a join together, and flexible public spaces are crucial in the design.

Refer to the gateway: the building can be seen as a gateway that enhances the accessibility of the makers to the users and vice versa, between the makers, and between the users. This perspective suggest the sub-parameter of privacy that will control the transformation from private spaces to public spaces.
Refer to the project: see chapter 3.1.2 on p.23

---

2   Pop music, wikipedia
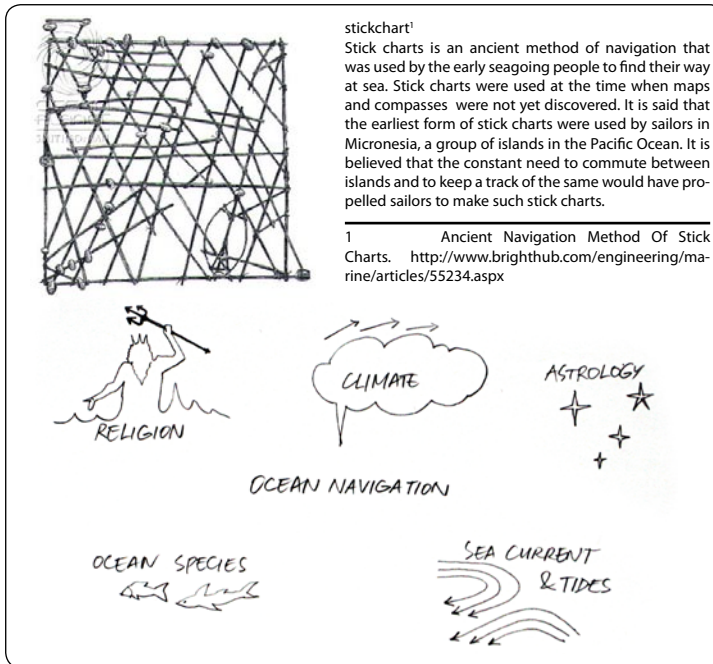
stickchart[1]

Stick charts is an ancient method of navigation that was used by the early seagoing people to find their way at sea. Stick charts were used at the time when maps and compasses were not yet discovered. It is said that the earliest form of stick charts were used by sailors in Micronesia, a group of islands in the Pacific Ocean. It is believed that the constant need to commute between islands and to keep a track of the same would have propelled sailors to make such stick charts.

---

1   Ancient Navigation Method Of Stick Charts.   http://www.brighthub.com/engineering/marine/articles/55234.aspx

fig 2.8 maritime culture and ocean navigation in the past

from a simple ticket to Elvis's show in 1956, today a Megadeth fan package includes : fan club shirt, band photo, guitar picks, laminate, sticker, logo magnet, metal keychain, welcome letter , one year access to the MFC website with exclusive media, private forums and chat room, live chats with the band, meet 'n greet opportunities, fan club store, auctions, contests, blogs, giveaways, news and photos, pre-sale concert tickets.

fig2.9 music product bundles

The first Adobe Creative Suite in 2003 has 6 applications, while the 5th version today has intergrated and subdivided into more than 30 applications

fig2.10 Software bundles

from one studio IMP in 1911 , Universal in 1996 becomes a giantic corporation of which complicated organization problem did prevent the design of the headquarter from being built

Fig 2.11 problem bundles in architecture

2.1.3. Maritime culture

"Taiwan's geographic position, geographic factors, the rise and fall of the tides, seaports, business and trade, and the immigration of peoples from across the ocean are all intimately tied to the sea and are some of the characteristics of Taiwan's culture." [3]

Ocean navigation(fig 2.8) has strong influences on the seafaring people's lives: religion and belief, knowledge and skills, traditions and habits... also on their openminded personality because of culture exchange with oversea countries mainly through trading .

Refer to the gateway: the gateway between local and global that suggest the subparameter of diversity, which control the differences in patterns, in forms to accomodate variety of functions. Refer to the project: see chapter 3.1.2 on p.23

2.1.4. Business model

in music:
- genres: pop, blues, RnB...
- version: radio, unplugged, collectors...
- product bundles(fig 2.9): ticket +merchandise +meeting +subscription

in software[4] :
- *license products, intellectual capital*
- *version: autocad 2009, 2010, 2011*
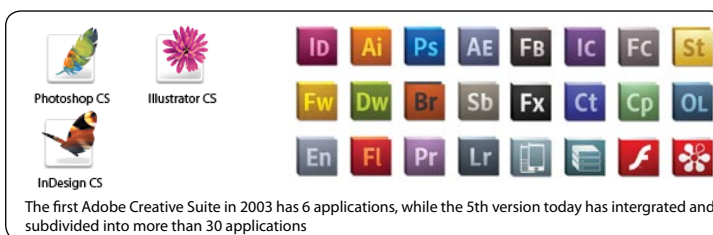- *software bundles(fig 2.10): Adobe CS*

in architecture:
- *specialized domain knowledge: experts in office buildings/hospital/hotels &resorts*
- *version: bilbao 101, bilbao 102*
- *consultant bundles: S.O.M= Architecture + Engineering +Digital +Graphics +Industrial + Interior +Structural & Civil Engineering + Sustainable +Urban Design & Planning*

"The Universal project would be put on hold, indefinitely - final confirmation, it seemed, of architecture's incapacity to respond to the new pressures of organization and instability"[5]OMA1996 (fig 2.11) Whether it is software or music or architecture, the business models are moving from singularity to multiplicity which is developed after each new versions.

Refer to the gateway: this is the sub-parameter that control the transition between permanent functions(fixed) and the instable functions(flexible), which also implies the affects on privacy. Refer to the project: see chapter 3.1.2 on p.23

---
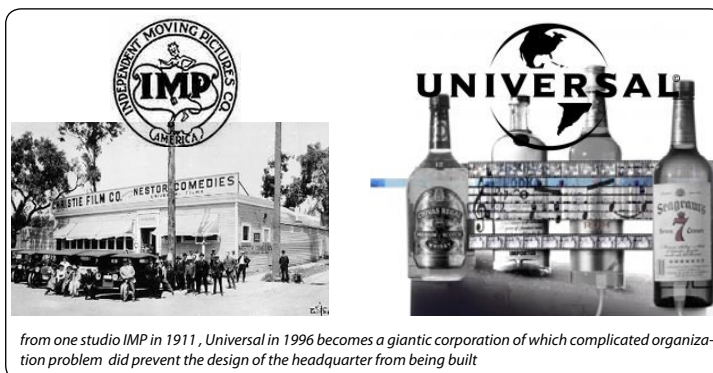
3   from The Government Information Office, Executive Yuan, R.O.C. http://culture.teldap.tw/culture/index.php?option=com_content&view=article&id=313
4   Paul Nakazawa, lecture: next and again, 2010, AA London
5   Rem Koolhaas, 2004, Almost famous, Content, Taschen p125

three dimensional view of space-time patterns of tourist. [1]
This patterns of density derived from GPS data show the intensity of use(number of people using the path) and pattern of time(how long people stay) . The result look like a landscape with mountains. , but it is produced by infrastructures(both hardwares and softwares)

1   Steffen Nijhuis, Jeroen Van Schaick (ed) Stefan Van Der Spek(ed). Urbanism on track, 2008 IOS press. p44

fig 2.12 nature as information
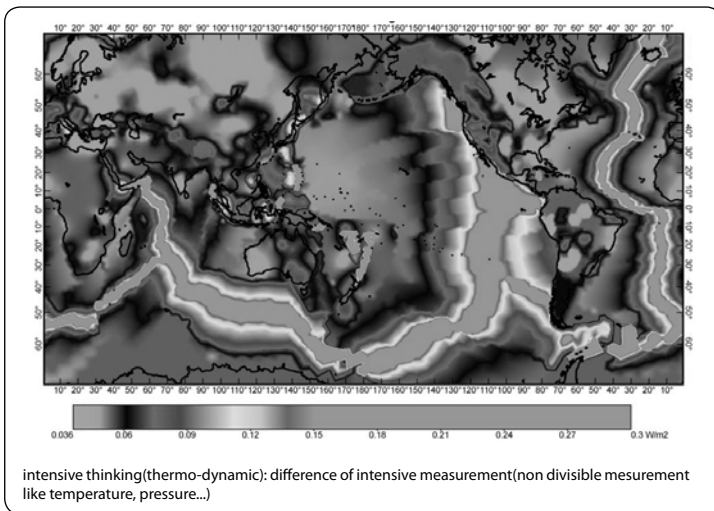
intensive thinking(thermo-dynamic): difference of intensive measurement(non divisible mesurement like temperature, pressure...)

fig 2.13 intensive thinking in thermo-dynamic

population thinking(biology): difference includes imperfection, variations, heterogeneity

fig 2.14 polulation thinking in biology : evolution

2.2. the approach

2.2.1.   the goal = navigation/orientation

"A man raised in one part of the desert would know its flora and fauna backwards. He knew which plant attracted game. He knew his water. He knew where there were tubers underground. In other world, by naming all the 'things' in his territory, he could always count on survival." [6]

In the past, human navigated through spaces by learning the changes in nature: the movement of stars, the wind direction, the location of plants, the behaviour of animals... Today in the city, we can also look at nature but another kind of nature. "*Nature in the information age = information (fig 2.12) = occurrents = events =facts which happens and be supported by infrastructure = scenarios* " [7]

In fact, looking at a scenario, one could get a sense of direction by reading how an event in one place happens differently from another place. To give a strong indication for navigation /orientation, this difference should be *positive difference*[8] : *a difference of intensity spontaneously tends to cancel itself out and in the process, it drives fluxes of matter and energy. In other words, differences of intensity are productive differences since they drive processes in which the diversity of actual forms is produced.* An example could be borrowed from thermo dynamic physics: The direction of the wind(=process) can be drawn from the difference of the temperature(=intensity) measured from different points (fig2.13).

The more events are counted, the more precise the direction becomes. But if the events happens in a high contrast or even controversal way, the direction can be seen only by going up to a higher level of logical relationship between events. An example can be borrowed from biology(fig 2.14): one can not see the direction how fishes evolve to become human by looking at millions of fishes and millions of people, even fishes are different from each other. The direction can be seen when looking at fishes and human as species then in that level, fishes evolve to reptiles...to mamals to human.
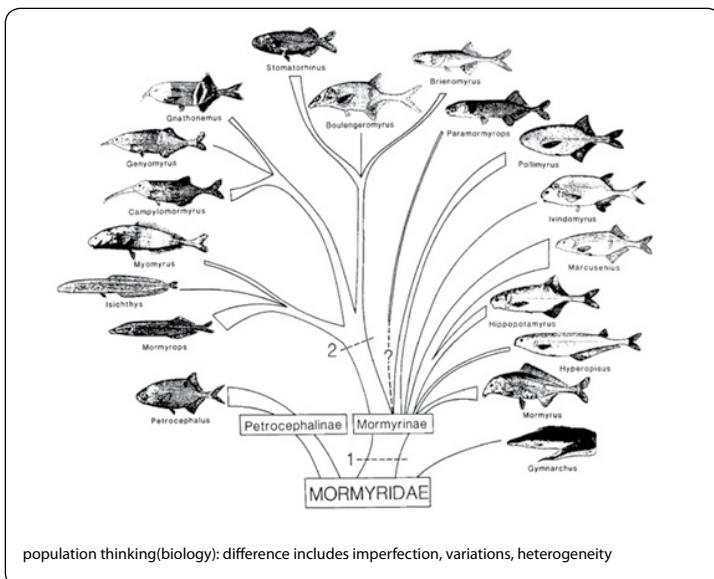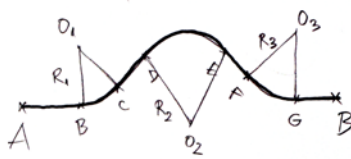
This method works but it is not practical when thinking about time consuming to get the direction , one has to see that much of series of

6   Bruce Chatwin , The songlines 1996 Penguin Publisher
7   Antoine Picon, lecture : nature of information ,GSD 2010
8   Manuel Delanda, lecture : Deleuze and the use of genetic algorithm in art, Columbia center for new media teaching and learning2004

topological thinking(mathematic): the difference in calculation between algebra and differential calculus

Curve description in Euclidean geometry and Cartesian coodination :
Points A,B,C,D,E,F,G,O1,O2 are defined by coodination x,y,z

In construction, to build this curve , one needs to locate all points with x,y,z, then build the component AB, BC... then assemble them. Since the components have different sizes and different embeded engineering(AB is a line, BC is a curve) there can be problem at the joints B, C,D...

Curve description in Gaussian geometry :
The curve is defined by start point A , end point B and speed of the tangent t

To build this curve, locates point A, then one can use software to divide the curve into equal segments with ID in an order, sends data to CNC milling machine to produce the components (the segments are all treated the same way), then connects the components in the given order. Since the components have the same engineering treatment, problem of joining them can be avoided.

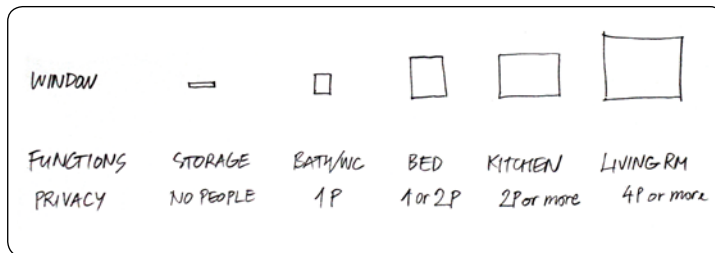fig 2.15 topological thinking in mathematic

fig 2.16 reading architectural information

events. So another example to solve the complexity of information can be borrowed from mathemactic: learning from differential calculus, the basic idea is to describe a complexity by look at instantaneous behavior of an event to speculate the behavior of the whole series. To describe a curve, in Cartesian coordination system , it has to be segmented into smaller division or series of points with x,y,z distances from the original axes. In Gaussian geometry a curve can be described with the tangent value right at the point which is calculated.(fig2.15)

Unfortunately too often, many scenarios are overlayed, and the overall direction is still hard to read and that is the situation where people look at architectures today and get lost. The three modes of thinking developed in three distinguished domains of knowledge all suggest the differences shall be compatible or based on higher level of logical relation. That means one can only find the overall direction by correlating the scenarios and reading the information at higher process which affect all scenarios. And that should also be the goal of parametric design, which promotes differentiation but maintains the strong coherence between variations and between systems of variations by a complex logic.

An interpretation of the approach to architecture can be proposed as follow: in a unfurnished house, one can read the functions of the spaces by its openess-the windows(fig2.16). The larger the windows the more public the space shall be. The size of the windows is a parameter. The window is one subsystem and privacy is another which are not compatible in unit or measurements but associated in functional order. If the size is contrained, meaning windows have same size, another parameter can be added is the opacity of the glass in the window, which also associates with privacy. To provide this information in large complex building, all subsystems and systems should be correlated in a *complex variegated order*[9]

- *Inter-articulation of sub-systems*
- *Parametric Accentuation*
- *Parametric Figuration*
- *Parametric Responsiveness*
- *Parametric Urbanism*

9   Patrik Schumacher, 2008 parametricism the global new style

top left: Housing in Hongkong(photo by michael-wolf) ; top right : Ho chi Minh city(photo by John Young)
bottom: hyperphotorealistic painting by Chuck Close

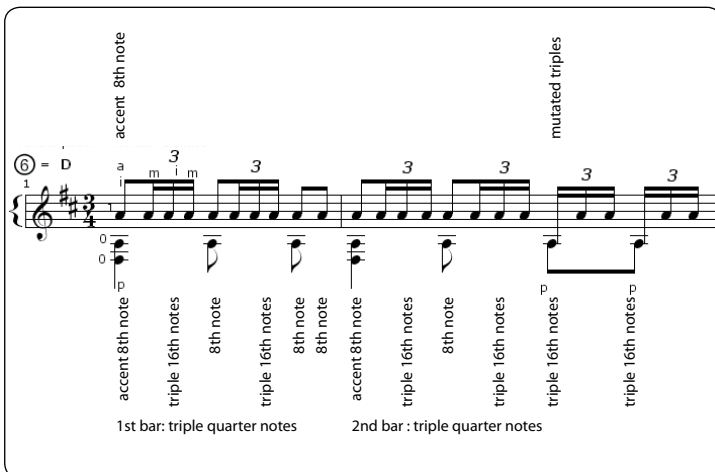fig 2.17 interarticulation subsystems

fig 2.18 accentuation

An example of interarticulation subsystem and urbanism (fig 2.17):
The apartments are absolute repetitive therefore all flats are the same, no sense of orientation, identity. The rowhouses are absolutely different therefore no sense of direction(urban), nor identity. In the painting of Chuck Close, the individual cells are different and absolutely abstract, they share a form of colored circle. When the cells are put together in an given order (in this case a gray tone is a parameter which relates the cells) they produce a specific meaning. Back to the rowhouses, an sense of urban direction can be read when a new parameter of the houses is added, such as color code, same width...

An example of accentuation (fig 2.18)
In the classical music piece " Bolero" by Maurice Ravel, the triple 16th notes together with the 8th note are nested in the quarter note which make the pattern sounds random (on top), while the bottom beats play simple 1,2,3 quarter notes. The randomness is reset after two bars which put the accentuation on the first note. The melody is beautifully composed on top of the ramdom pattern, but it does not "run out of" the composition thanks to the accentuation which keep the randomness in harmony with the steady quarter notes at bottom line.

Back to the rowhouses, the sense of direction can be read also by put height control parameter in each row, so that the houses can be varied in architectural styles but maintain a logic such as higher toward the city perimeter, and lower toward historical center.

In reality, one could see the approach has been naturally applied in historical cities by chronoligal order. But in emerging cities or within new large building complexes, or in new buildings in a historical context, the sense of direction is reduced due to the lack of interrelations between architectural components, and between architectures. Parametric design approach therefore shall emphasize on building relationships not just on geometrical component(results in forms) but also on non geometrical components(results in functions - in broad sense) and in between the two systems.

The following part is a quick scan of works which achieved the goal mention above in different level, starting from the Rennaisance and Baroques masters in Italy to contemporary starchitects around the globe.
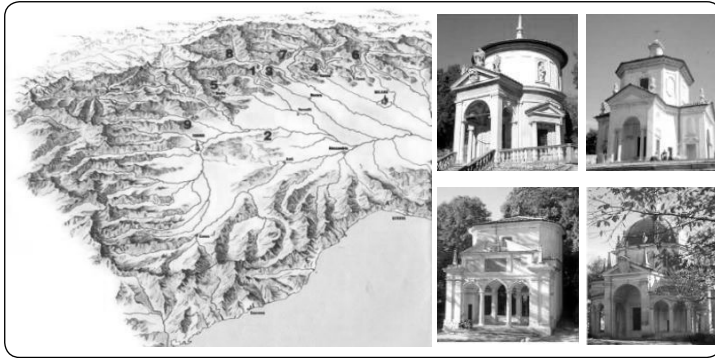
fig 2.19 in urban design and architecture: The Sacri Monti are shining examples of buildings that combine the natural environment and the hand of man to achieve religious aims and form a new cultural landscape.

fig 2.20 the increasing intensity in the fusion of urban design to architecture and to art

entrance

entrance

left : the Borromini's dome (San Carlo alle Quattro Fontane)

right : Berini's dome (Sant'Andrea al Quirinale)

fig 2.21 Comparison between the geometry of the Borromini's dome(San Carlo alle Quattro Fontane) and Berini's dome(Sant'Andrea al Quirinale)

2.2.2.   the past

• **Sacri Monti of Piedmont and Lombardy**
a series of nine groups of chapels and other architectural features.(fig 2.19)
Lesson: The complexity of system (groups of chapels) to sub-systems (chapels within a group) and smaller sub-divisions (architectural components of a chapel, to the artworks on an architectural component) all contribute to the multi purposes function (religious, religious educational, defensive) and well supported by the context(nature).
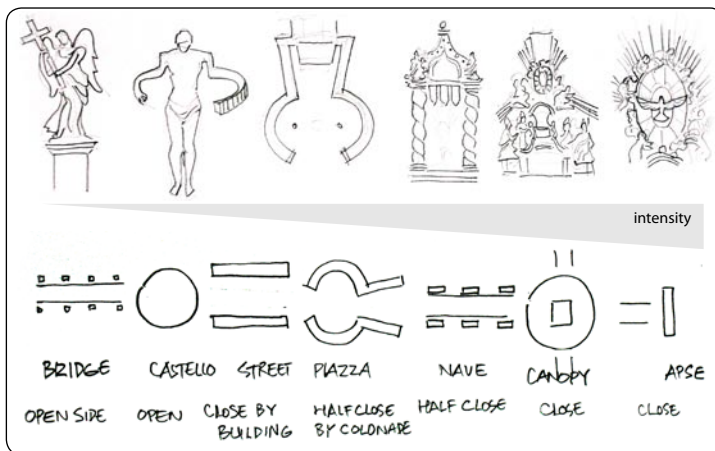
• **Bernini and St.Peter**
the fusion of urban design to architecture and to art(fig 2.20)
"The visitor was beckoned forward by the angels on the bridge, embraced by the arms of the oval, directed to the facade by the trapezoidal shape of the space before it, drawn to the main portal by its emphatic centrality. Inside the building, the dynamic sequences increased in intensity: the awesome nave, the gigantic canopy marking the saint's tomb and the papal altar, the message of the reliquary program of the crossing, and -visible all along the great length of the nave through the spiral columns of the Badalcchino- a shining object fixed against the farthest apse. This gilt-bronze reliquary enclosing the original Bishop's chair of St. Peter- the Cathedra Petri carried by the Fathers of the church-was the visual and the spiritual climax of the pilgrim's journey"[10]
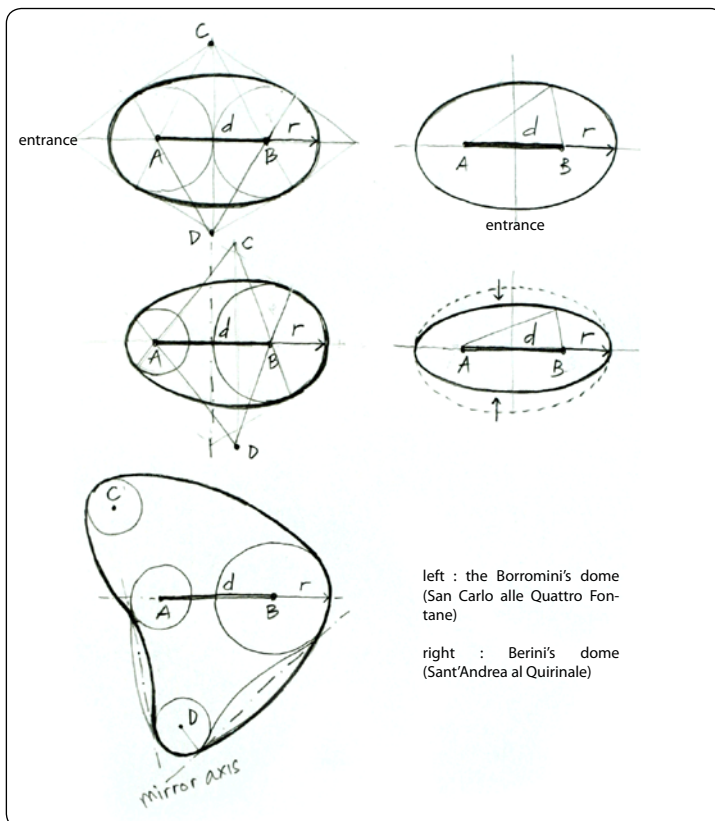
Lesson: Similar to the previous example but with a radical increase of intensity of richness in details

• **Borromini and the oval**
The dome of San Carlo alle Quattro Fontane has an oval shape which composed by 4 arcs. (fig 2.21)
Lesson: Not only because the 4- arc-oval more mallable make it easier to adapt to different context, but also the geometrical composition is developed from the combination of 2 circles inscribed in 2 equilateral triangles, which are the two important symbolic shapes in Christianity.
Moreover, the viewing parameter of observer has been changed when the entrance is placed at the longer axis of the oval, which makes the space seems to be larger, deeper to what it really is.

10   Marvin Trachtenberg, Isabelle Hyman. Architecture from prehistory to post modernity, Prentice hall Inc, 2003. p336-337
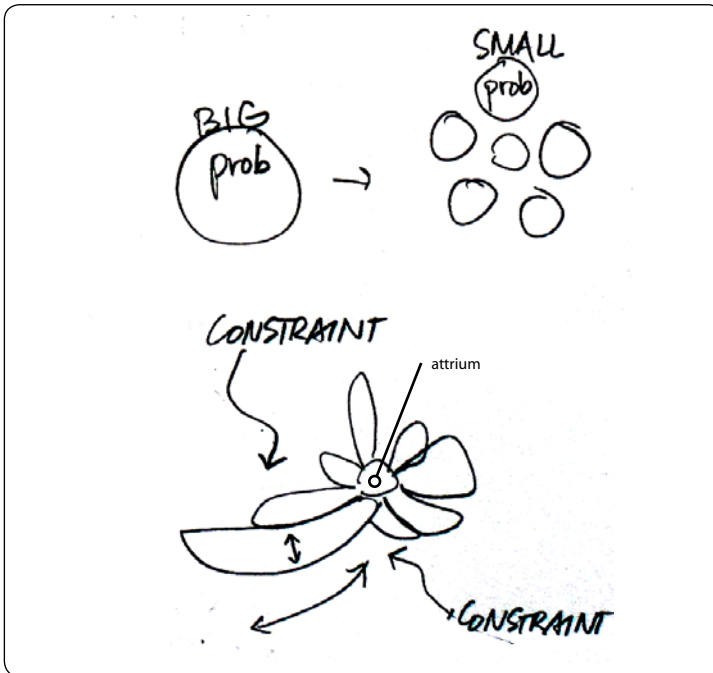
fig 2.22 Bilbao Guggenheim museum

fig 2.23 the four cable railway stations, Innsbruck

fig 2.24 Doha library

2.2.3.   the present

• **Frank O Gehry and Bilbao Guggenheim**

In Bilbao(fig 2.22), what we can see is that Gehry break down the main design problem into smaller ones(different functions) then assemblage them around the main central atrium. Each function grows with its own constraints from the context(location, orientation, internal program...) to reach its form(subsystem) but maintain a coherence with the whole(system) by intergrating its configuration to the other functions via the connection of the atrium.

Lesson: Circular spatial organization with privacy parameter change from private to public toward the center

• **ZHA and Nordpark Cable Railway stations**

site adaptation and visual relationship between variations(fig 2.23)

Lesson: the station "typology" is composed by 2 main elements: a fiberglass roof and a concrete platform. These elements varies their shape at each station regarding the ground interface (site condition parameter) but they can still be easily recognized by the similarity in form and material.

• **OMA and Doha library**

In Doha library(fig 2.24) , OMA starts with the convinience of book searching, the user can see the whole book stacks at once when standing in the center of the library, which help themselves to easily and quickly navigate to the section they need.

Lesson: main viewing parameter drives the form to maintain visual connection between users and the book shelves, at the same time this parameter control the visual connection between inside and outside spaces of the library.

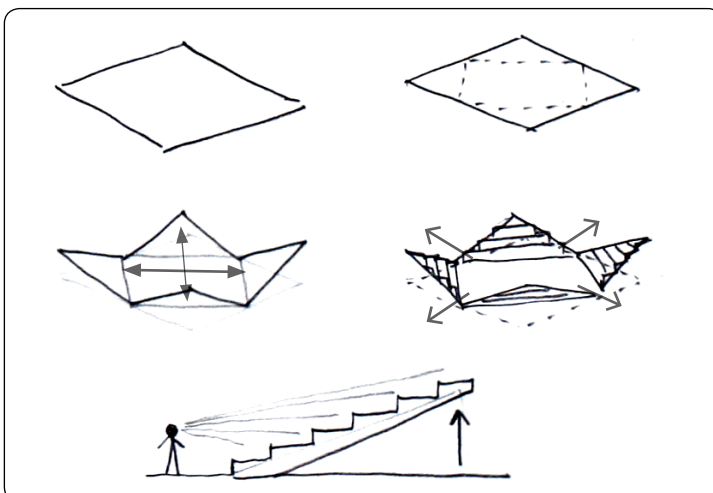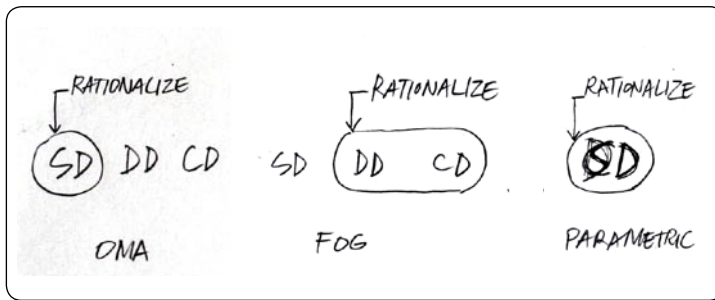Fig 2.25 Processes of form rationalization applies in different stages result in the final outcomes

2.2.3. the future

From the lessons of the masters, what we can do can be gerenalized in-but not limited to the following experimental actions:

formal heuristics[11] : *principles that delimit the formal repertoire and guide the formal elaboration of the design*

- *Negative heuristics (taboos): no rigid forms, no repetition, no pure difference*
- *Positive heuristics (dogmas): soft forms +intelligence, differentiation +intelligence, correlation*

functional heuristics: pricipals that guides the interpretation of the brief and the functional elaboration of the design

- *Negative : avoid typological reduction to generic or essentializing functional designations, avoid discrete function zones*
- *Positive : variable social scenarios, calibrated via multiple event parameters, actor-artifect networks.*

Looking at the design process of contemporary practices OMA and Gehry Partners, one could see the the outcome designs are affected by how forms are rationalized in the process. Parametric design should inherit the advantages from both of them.(fig 2.25)

11   Patrik Schumacher, lecture: Parametricism and the Autopoiesis of Architecture. Southern California Institute of Architecture 2010

The chapter starts with the interpretation drawn from the research part to create a framework for designing the project, then after mapping the constraints and variables, the parameters are defined and applied to the design, then the process restarts the next loop to refine itself. . The main actions includes:

- interpretation of the approach to architecture, and to the project as system of "walls" and "slabs"[1] that control the accessibility of any spaces, then the sub parameters define the privacy of the spaces . The interpretation can be continued to detailed level and be applied to the design

- the constraints and variables which are derived from the research of the brief and the site context are mapped .They creates the field condition in which forces(influences) from attactors transform the geometries and the function mixtures

- the principal parameter "gateway" controls the accessibility to the space, defined by the transformation from the "wall" events to the "slab" events. The following parameters are defined more detailed elements

- the parameters are correlated then driven by constraints and variables to build the form. finally the form is refined and start the next loop.

---

1   walls and slabs to be seen as events, not the physical wall and slab in construction definitions
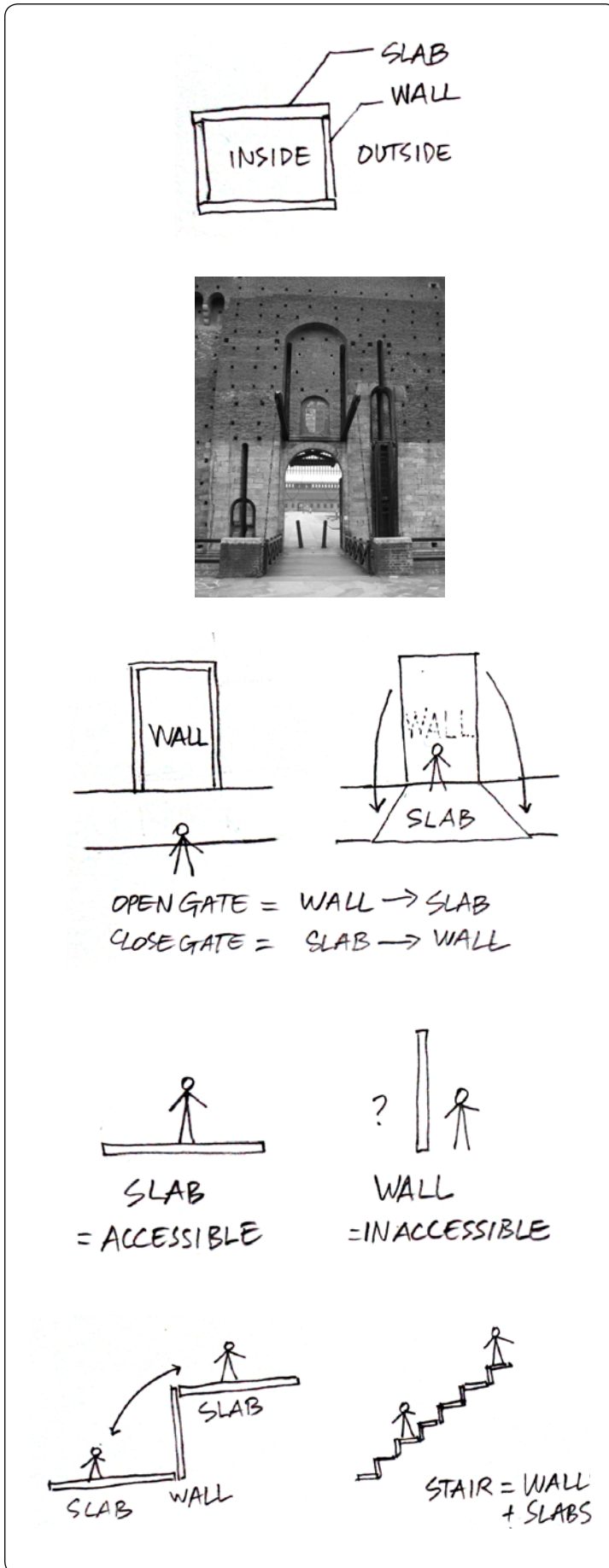
fig 3.1 primary parameter

3.1. interpretation of the research

3.1.1 interpretation of the approach to architectural system

The research in chapter 2.1.1 suggests to see the complexity problem from the relationship between systems and subsystems. Thesis suggest an interpretation of primary system form (formal parameter) of architecture is the boundary condition where the state of being inside and outside is defined by wall and slab components.

The interpretation of the gateway can be the space accessibility (functional parameter), also becomes the "information". In this information or scenario, there are two events: "wall"[1] = inaccessible and "slab" = accessible. When there are two slab similar in form but different in function, the direction can be read as a stair. This means to transform from one function to another , the events shall be divided into smaller divisions (not nessessarily be equal) (fig3.1). This primary parameter will affects on all the subsystems or secondary parameters.

3.1.2. interpretation of the subsystems

With the same infomation of accessibility, when there are more events the direction can be read easier. In between "wall" and "slab" there are endless numbers of "slope" events which can accomodate endless numbers of sub-parameters. (fig3.2). Formal subparameters then read "wall " as the vertical system and divided into subsystem of rooms which have smaller divisions of walls and slabs.

The interpretation of pop music characters in part 2.1.2 could be the functional sub-parameter of privacy which defines relation of private spaces for the performers, staff, operators...to the semi public of the auditorium, stage...then to the public space like foyer, lobby. This matches with the business model: toward the public spaces ,there will be more connection between participants, more extra activities. Similarly, the privacy parameter for maritime culture in part 2.1.3 will define the private space of staff, labs, workshops...to the semipublic spaces for special exhibition, permanent exhibition, to public lobby, outdoor exhibition. The "slope" then can be read as semi-public zone(fig 3.2) . From here one more sub parameter can be added is the densi-

---

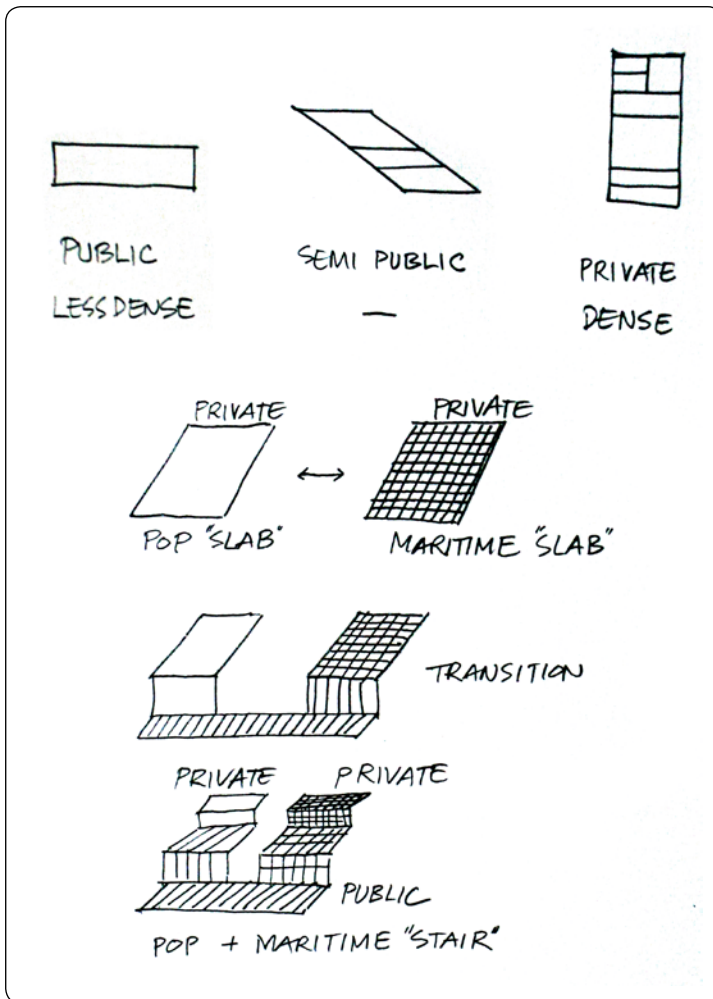1   the two term "wall"and "slab" shall be read as events

fig 3.2 sub parameter

ty: the "wall" event due to privacy shall be more dense, while the "slab" is less dense. This means toward "wall" event, the space are divided in smaller room, in reverse way toward the "slab" event, smaller spaces join together to become large sharing spaces.

To correlate the funtional subsystems , the two functions of pop music and maritime culture can be subdivided into series of "walls" and "slabs" and connect to each other thus become a "stair", in which functions aslo range from private to public then private.

This interpretation can be developed more and more to fully connect all functions and forms as required , at the same time the correlation between subsystems and sub-subsystems...can be added up to the create a complex logic. When applying this interpretation to design process, the constraints and variables are taken into account will start making the spaces varied their forms and mixed functions, but keep logic so the final outcome will have positive difference to help users orient themselves to the right space they want.

The following part will show the detailed sub processes to "transplant" the concept to the design.
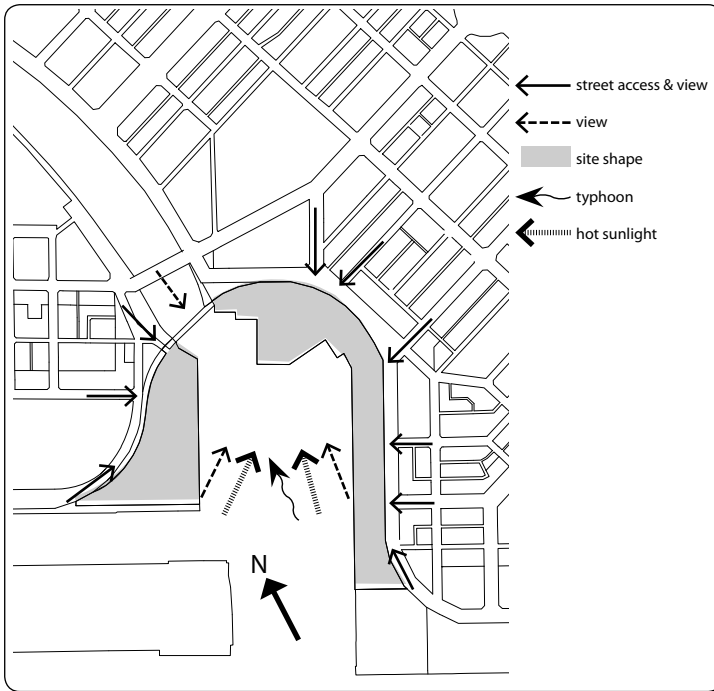
fig 3.3 map of constraints

3.2. constraints+variables

3.2.1. constraints (fig 3.3)

from the program
- geometrical: gateway, avoid large volume, reserved area for expansion
- non-geometrical: gateway, pluralism culture,

from the site
- geometrical: gateway, urban plan, street pattern, transportation connection, functions zones, waterfront, site shape, adjacent buildings, street view
- non geometrical: gateway, climate, user habit, traditions
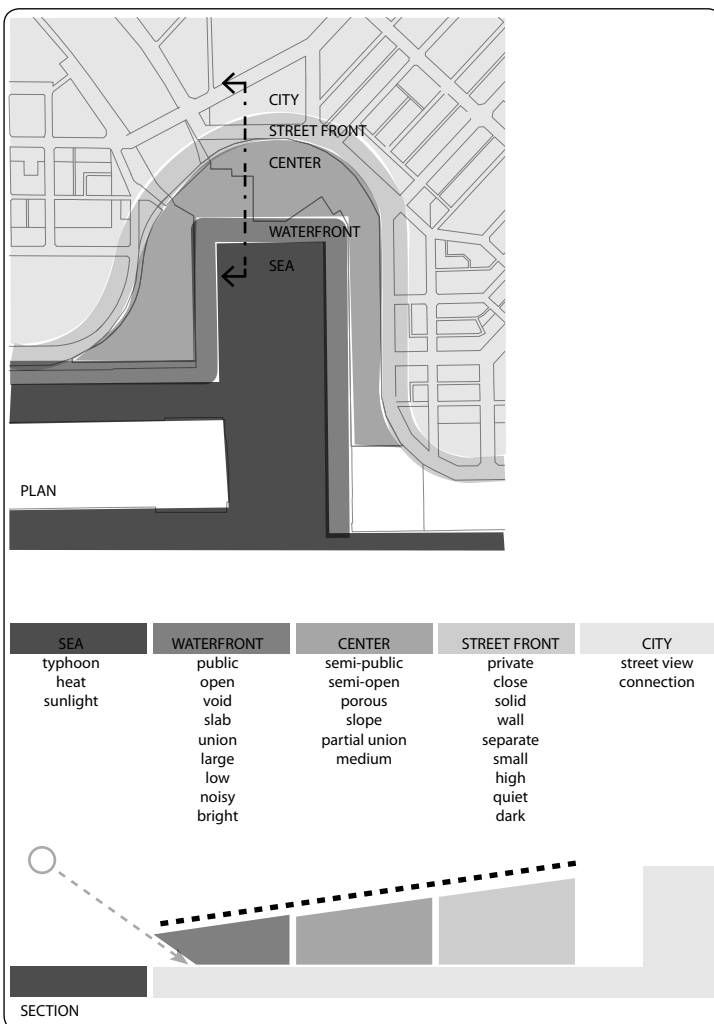
fig 3.4 diagram of attractors

3.2.2. variables (fig 3.4)

input variables
- extensive differences : program area
- intensive differences: noise, privacy

output variables
- extensive differences: location, size, shape, structure,
- intensive differences: privacy, noise, orientation, porosity

SEA	WATERFRONT	CENTER	STREET FRONT	CITY
typhoon	public	semi-public	private	street view
heat	open	semi-open	close	connection
sunlight	void	porous	solid	
	slab	slope	wall	
	union	partial union	separate	
	large	medium	small	
	low		high	
	noisy		quiet	
	bright		dark	

3.2.3. setting up attractors (fig 3.4)

the design can be seen as a field condition, in which particles(the buildings) are transformed by the forces coming from different attractors
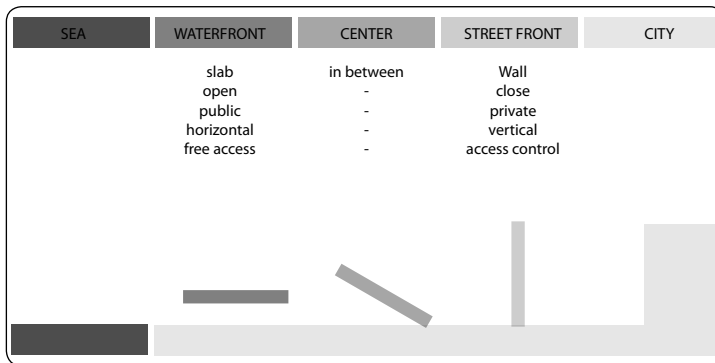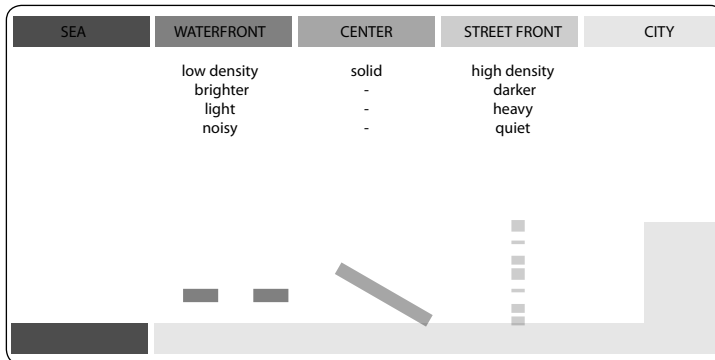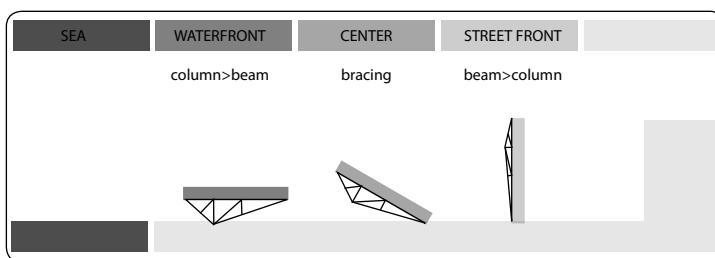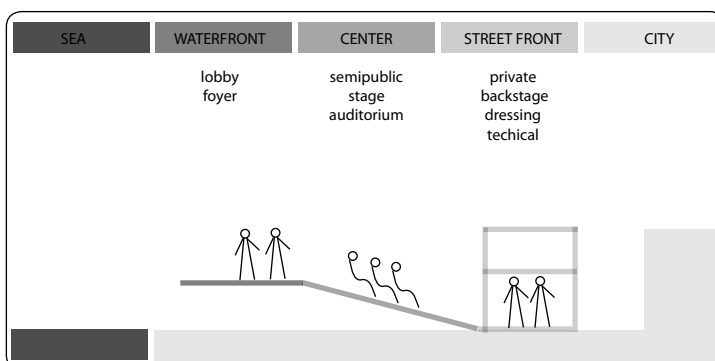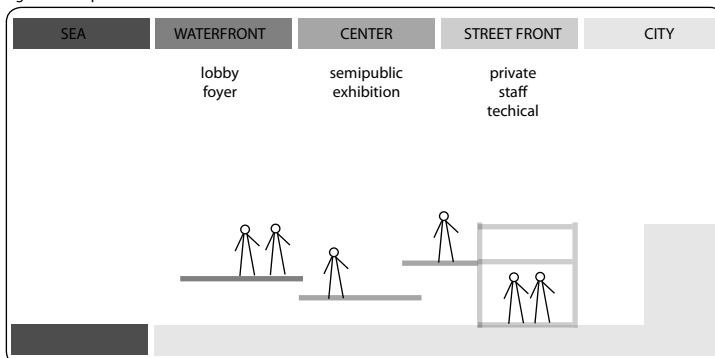
3.3. parameters definition

3.3.1. system : wall - slab(fig 3.5)

Refer to the gateway: the primary architectural components wall-floor can be seen as the degree of accesibility and privacy. The transformation between these two components defines the opening of the gate. This parameter acts like a new zoning tool to organize spaces in groups sharing similar form and function, the zones are graduallly blended from one to another

3.3.2. subsystem 1 : porosity(fig 3.6)

the sub-systems of openings, windows and doors can be seen as degree of porosity on the main system of wall-floor. this parameter is driven by the variables: lighting(natural) requirement, the user's vision, the vertical connection(stairs, floor openings), noise insulation.

3.3.3 subsystem 2 : structure (fig3.7)

the subsystem of structural member is intergrated with the main wall-slab. The transformation of wall to floor also deforms the columns into beams and vice versa. To do that the structural member shall be a 3D frame which contain predefined elements with the ability to function as both beam and column.

3.4. application + tuning solution

3.4.1 Apply to performance halls

Typical section will have private spaces at street front includes : dressing rooms, backstage and techincal areas, offices, rehearsal studios. Then the slope become the auditorium , and lobby will be public space connecto to the others functions(fig 3.8)

3.4.2 Apply to maritime exhibition

Conceptual section of the maritime exhibition also has private spaces toward the city, the semi-public area is the exhibition hall which is fragmented in multilevel exhibition spaces, larger ones will orient toward the lobby to join with the performance hall's lobby. (fig3.9)

see project drawings

SEA	WATERFRONT	CENTER	STREET FRONT	CITY
	slab	in between	Wall	
	open	-	close	
	public	-	private	
	horizontal	-	vertical	
	free access	-	access control	

fig 3.5 section system

SEA	WATERFRONT	CENTER	STREET FRONT	CITY
	low density	solid	high density	
	brighter	-	darker	
	light	-	heavy	
	noisy	-	quiet	

fig 3.6 section subsystems

SEA	WATERFRONT	CENTER	STREET FRONT
	column>beam	bracing	beam>column

fig 3.7 section subsystems

SEA	WATERFRONT	CENTER	STREET FRONT	CITY
	lobby	semipublic	private	
	foyer	stage	backstage	
		auditorium	dressing	
			techical	

fig 3.8 conceptual section auditorium

SEA	WATERFRONT	CENTER	STREET FRONT	CITY
	lobby	semipublic	private	
	foyer	exhibition	staff	
			techical	

fig 3.9 conceptual section maritime exhibition

4 conclusion

The conclusions are: parametric design has immediate applications and could be developed to become a more powerful design approach. The project has not been completed although it shows fundamental rules and direction to continue for the promising outcome. The main points are:

- the immediate application has already been used in parametric modelling . the thesis suggests parametric design shall be developed as an approach, not just a technique of modelling as it started in the 90s. By doing so, parametric design can be practiced by different techniques, not limited to scripting or coding, and it can also create a healthy educational environment. the research has certain limits of resources therefore some speculations are left without reliable evidences.

- the project starts taking shape by organizing spaces in terms of form and function in to primary horizontal and vertical system. This way of zoning functions and forms are flexible yet logically order, provides a well structured framework for going to detailed process. The problem remains is many difficulties in that detailed process still have not yet discovered

The shape, size, stretch and hair type of the ink brush, the color, color density and water density of the ink, as well as the paper's water absorption speed and surface texture are the main physical parameters influencing the final result The calligrapher also influences the result by the quantity of ink/water he lets the brush take , then by the pressure, inclination, and direction he gives to the brush, producing thinner or bolder strokes, and smooth or toothed borders. Eventually, the speed, accelerations, decelerations of the writer's moves, turns, and crochets, and the stroke order give the "spirit" to the characters, by influencing greatly their final shapes

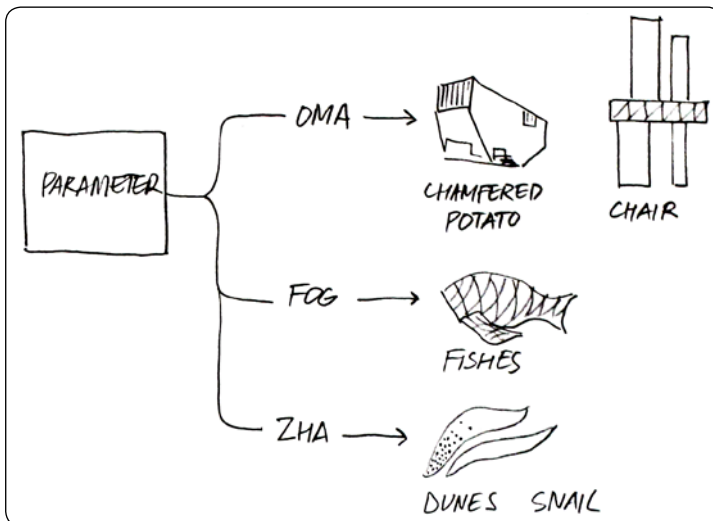fig 4.1 different versions of the word "wind" in Chinese

fig 4.2 architectures may look like nature but that is the end result, not the starting point

4.1. on parametricism

4.1.1. from techniques to methods to approach

Above all, math or the art of computing should be used as "*constructive medium*" for architects, not a "*representational one*"[1] for draftmen.

"*Parametricism roots in digital animation techniques of the mid-90s*"[2], but now it should be taken as an approach to address complexity in architecture design. An approach which has more than one methods, therefore is not limited in scripting and parametric modelling techniques. In Chinese calligraphy(fig 4.1) besides the careful preparation of the materials, the process of thinking may take much more time than the actual writing process which already takes a lot of time to practice. One of the reason is that the calligrapher has to think about what to write, or the meanings of the words. Calligraphy then can be taken as an approach to address a profound and complex issue by using writing techniques to see the hidden meanings/relations behind the words.

One more reason could be: to address a complex issue now requires knowledge from more than one scientific field. Since each of the field has its own methods and techniques, then the approach shall be carried out by certain skills which inflect and reflect(not merely adding but mutually influencing) all the fields where they come from.

Intuition of the masters is not easy to explain, thus more difficult to be taught and learned. But brain science is proving creativity is not only for the gifted people and it "*can be taught*"[3]. Perhaps exposing the creative brain through rules and logical relations is the first step, then not only people but also machines can learn to improve.

4.1.2. disambiguition
Architects have learned a lot from nature, and "*many algorithms are now written to produce complex forms*"[4] which look organic to avoid the boring boxes. Form and metaphor are clearly not the same: so biomimicry architectures, or

1   the two terms taken from Foreword by Detlef Mertins, p7 Architecture of continuity , NAi publisher 2009, described the way Lars Spuybroek works .
2   2009 Parametricism - A New Global Style for Architecture and Urban Design . London 2008. Published in: AD Architectural Design - Digital Cities, Vol 79, No 4, July/August 2009, guest editor: Neil Leach, general editor: Helen Castle
3   Brain series, Charlie Rose. www.charlierose.com
4   De-scripting the world: how new technologies are producing modifications in design processes, Seminar in Milano, Faculty of Architecture, may 18th, 2010
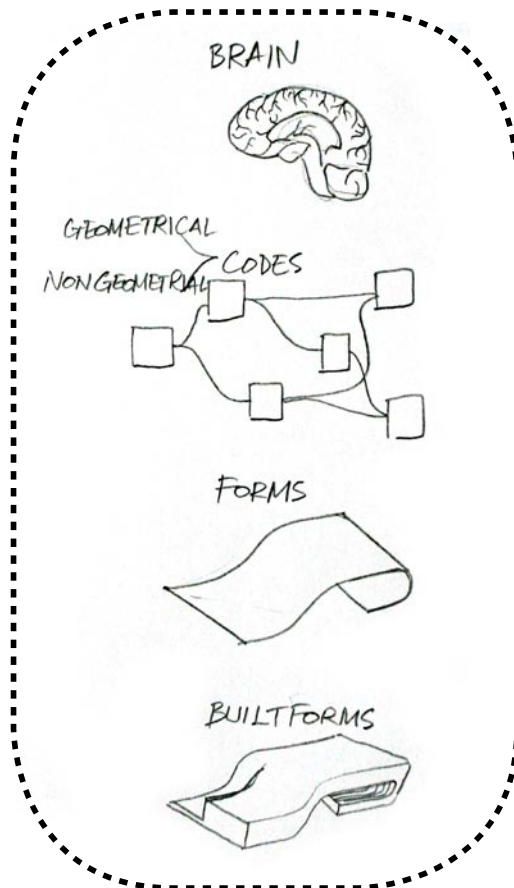
fig 4.3 transplanting thought from one's brain to a building

any attempts to make architecture look like nature, made like nature, work like nature shall be well considered, because *"architecture should not look like what it is not"*[5]. So, choosing what to script or to parameterize shall start normally with the brief more than a fancy idea.

Architecture may have multiple meanings in reading(fig 4.2), as in Venturi's ambiguity, but it should be clear in thinking and making.

4.1.3   transplant(v)[6]

1: to lift and reset (a plant) in another soil or situation
2: to remove from one place or context and settle or introduce elsewhere : relocate
3: to transfer (an organ or tissue) from one part or individual to another

the thesis borrows the term "transplant" to architecture to refer to the process of transfering thoughts from the mind to the machine with language of mathematical logic that makes the intuition of the mind explicit, then the logic can be collectively developed and refined before being transfered to the real world (fig4.3).

4.2. on the project

4.2.1.   pro

due to the limitation of time and knowledge, the project has not been developed to a complete design(even a schematic one) like the ambition at the beginning, but some potentialities can be recognized for further actions:

*   the primary parameter which control the accessibility from the city to the complex and within each parts of the complex, allows each part to operate inpendently but still well connected to each other via the 2 "public balconies" . This parameter is correlated with the structural definition.
*   the secondary parameter which defines the degree of enclosure of each part enable the forms to be varied
*   the structure definition support the primary system

In this basic level , terms should be taken in a very broad sense, which means they can be divided in to many subdivions, with that the complexity can be decoded without loosing any relations it may have. Conventional approach has a hierachical process, so does parametric approach, but the hierachy of parametric shall perform in a more flexible way, meaning crossing

5   Jorge Silvetti , lecture: nature of architecture, GSD 2010
6   definition from Merriam webster online dictionary

references between sub processes may changes the location or intensity of influence of those subprocesses.

4.2.2. cons
- many detailed parameters have not been defined : commercial, outdoor performing functions, materials, building services(MEP) The problem remains is many difficulties in that detailed process still have not yet discovered, therefore the question whether or not the approach can fully meet the demand is still openended.
- there are parameters have not been correlated

4.3. questions

why dont we stay with simplicity, minimalism? why curves? do architects have to be hardcore script writer? where is identity, humanity? where is the risk? can all design parameters be quantified and decoded?

these questions shall be discussed in the next research.

Manuel DeLanda.
- Video lecture: Deleuze and the use of genetic algorithm in architecture, GSAPP at Columbia university, 2004
- Video lecture: Intensive Thinking in Deleuze's Materialism, European graduate school, 2009

Antoine Picon
- Digital culture in architecture - an introduction for the design professions, Birkhauser 2010
- Video lecture: mathematics for sensible things , GSD 2010
- Video lecture: nature of information, GSD 2010

Greg lynn
- Folding In Architecture, Architectural Design. London, 1993
- Video lecture: The Future of Architecture and Philosophy. European graduate school, 2004
- Video lecture: Future of Design , University of Michigan Taubman College

Patrik Schumacher
- Parametricism - A New Global Style for Architecture and Urban Design . London 2008. Published in: AD Architectural Design - Digital Cities, Vol 79, No 4, July/August 2009, guest editor: Neil Leach, general editor: Helen Castle
- Arguing for Elegance, London 2006 Published in: Elegance, AD (Architectural Design), January/February 2007, Vol.77, No.1, Wiley – Academy, London, Editor: Helen Castle, Guest-edited by Ali Rahim & Hina Jamelle
- Video lecture : Experimenta ,Royal college of art, London 2009
- Video lecture : Parametric urbanism , AA, London 2009
- Video lecture : Intensive fields , USC, LA 2009
- Video lecture : Parametricism and the Autopoiesis of Architecture. SCIARC, CA 2010

Rem Koolhaas
- Content , Taschen 2004
- The Future of Information Modelling and the End of Theory, AD 79-2, John Wiley & Sons 2009
- Video lecture : what architecture can do, LKY school of public policy, Singapore

Andrea Rolando
- lectures and materials from the course "Theory and practice of representation", Politecnico di Milano, 2008
- Forma, geometria, struttura per il disegno dell'architettura, della città e del paesaggio, CittàStudiEdizioni 2008
- Definition and representation of complex architectural shapes(with D.D'uva, A.Janovitz, P.Piumatti, C.Zanchetta) published in "Innovative design and construction technology" Ingrid Paoletti (editor). 2009, Politecnico di Milano.
- Seminar discussion with Daniel Bosia, De-scripting the world: how new technologies are producing modifications in design processes, Politecnico di Milano, Faculty of Architecture, may 18th, 2010

Lars Spuybroek
- The architecture of continuity , NAi publisher 2009
- NOX: Machining Architecture, Thames & Hudson,2004
- Video lecture : Experimenta, Royal college of art,London 2009

Ingrid Paoletti (editor)
- Innovative design and construction technology . 2009, Politecnico di Milano, Maggioli editore

More references

- Jorge Silvetti , video lecture: nature of architecture, GSD 2010
- William J. Mitchell, Malcolm McCullough, Digital design media , Van Nostrand Reinhold, 1995
- Paul Nakazawa, video lecture: next and again, 2010, AA London
- Marvin Trachtenberg, Isabelle Hyman. Architecture from prehistory to post modernity, Prentice hall Inc, 2003.
- AD magazines series 76,77,78,79, John Wiley & Sons
- Jeroen Van Schaick (ed) Stefan Van Der Spek(ed). Urbanism on track, 2008 IOS press
- BURRY, M. (2003) Between Intuition and Process: Parametric Design and Rapid Prototyping, New York, NY, Spon Press
- MIGAYROU, F. & CENTRE GEORGES POMPIDOU. (2003) Architectures non standard : exposition presente au Centre Pompidou, galerie sud, 10 decembre 2003-1er mars 2004, Paris, Centre Pompidou.
- Neil Leach ed., Designing for a Digital World, Chicester, 2002
- Kostas Terzidis, Algorithmic Architecture, Elsevier, Oxford, 2006
- Michael Meredith (Au, Ed), Aranda-lasch (Ed), Mutsuro Sasaki (Ed) .From Control to Design: Parametric/Algorithmic Architecture .
- Branko Kolarevic(ed.) Architecture in the Digital Age: Design and Manufacturing, , New York, Spon Press, 2003,
- Kemp Martin, Science in culture: Algorithmic architecture, Nature, 8 August 2002
- Kemp Martin, Intuizioni strutturali e pensiero metamorfico nell'arte, architettura e scienza, in Metamorph Focus, catalogo della Biennale di Venezia, Marsilio, Venezia, 2004
- Kemp Martin, A sense of proportion , NATURE,Vol 446|26 April 2007

	m2
Pop Music Performance Area	
Large Performance hall	12000

      A-1 Auditorium
      A-2 Stage
      A-3 Dressing rooms and auxiliary spaces
      A-4 Backstage technical spaces
      A-5 Lobby and audience services
      A-6 Rehearsal studios
      A-7 Scene shops & storage
      A-8 Technical control rooms.

Small Performance Halls   6000

      B-1 Small performance hall (150 seats)
      B-2 Small performance hall (200 seats)
      B-3 Small performance hall (300 seats)
      B-4 Small performance hall (400 seats).

Outdoor Performance Area   9200

      C-1 Spectator area for at least 12,000 (seated)
      C-2 Stage
      C-3 Backstage & dressing rooms
      C-4 M&E & storage.

Pop Music Exhibit Area   3500

      D-1 Exhibit hall
      D-2 Interactive zone
      D-3 Shops
      D-4 Archives and workspace.

Cultural & Creative Industry Area
Pop Music Industry (Incubation) Center   4500

      E-1 Studio
      E-2 Large video recording studio
      E-3 Small video recording studio
      E-4 Large sound recording studio
      E-5 Multimedia production studio
      E-6 Conference room
      E-7 Workroom

Maritime Cultural Center
MarineCultureExhibitCenter   7000

      F-1 Permanent exhibit
      F-2 Special exhibit
      F-3 Archives and workspace
      F-4 Interactive zone
      F-5 Lecture hall.

Harbor Wharf and PassengerServiceCenter   500

      G-1 Concourse
      G-2 Ticketing center
      G-3 Tourism & passenger transit wharf.

Music and Marine Culture Commercial Area   6000

      H-1 Shops
      H-2 Restaurant and specialty food/drinks
      H-3 Small outdoor performance space.

Landscape & Others Facilities
Administration Area   1500

      I-1 Office
      I-2 Large meeting room
      I-3 Medium meeting room
      I-4 Small meeting room.

Connection Structure
Helipad
Scenic Landmark
Solar Energy Conversion System
YachtWharf