ABSTRACT

The notion of seriality describes such relations where each element has a processor. It could be also understood as a condition of sequential translation and transformation. This thesis investigates "seriality" in the relationship to architecture and landscape. I begin my investigation with a criticism of the conventional relationship between architecture and landscape. This relationship is often static and inert while it should be more dynamic and interactive within the design process. Reconsidering the relationship between "research" and "design," my attempt to connect the two using algorithmic design was instrumental in formulating a new design process.

In this thesis, a new design process has been developed and examined in three different sections: 1) "Theoretical Approach," 2) "Technical Approach" and 3) "Case Study."

In the theoretical section, I investigate "rhythm," which is an underlying series of movements affecting on architecture physically and fundamentally, in both architecture and landscape. In response to this theory, I propose a method known as the "Genetic Grid" to manage grid flexibly by receiving its new identities from "natural conditions."

In the technical approach, I introduce methods in algorithmic design to manage grid flexibly. The basic method is called the 'UVN generator' which is based on the algorithmic process combining the scripting potentiality and flexibility of traditional 3D surface modeling. This technique contributes to a method to generate the "Genetic Grid."

In the third section, I examine this "Genetic grid" more closely throughout a proposed design process called "Condition Linkage." By embedding "Gene of Place" into architectural elements, I hope to show an underlying harmonious relationship between architecture and landscape.
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1 INTRODUCTION: Seriality and Translation

1.1 Research Background

"Architectural form" is determined by various conditions. "Landscape" is one of the most important conditions which affects architectural morphology. The word "landscape" includes not only natural conditions but also artificial conditions. According to a dictionary definition, the word "landscape" is "everything you can see when you look across an area of land, including hills, rivers, buildings, trees, and plants." For the purposes of this paper, I will define "landscape" as the "existing site conditions," and I will use the term "natural conditions" when referring to nature in the notion of "landscape."

Among examples where architectural form is affected by "natural conditions," there are two main patterns which have serial similarity:

1. Serial similarity between a complex of architecture and natural conditions.
2. Serial similarity between an architectural form and natural conditions.

The first example is a condition where the city-scape has a continuous relationship in its form towards natural conditions. The second example is the effect of natural conditions on an architectural form itself. Both conditions visually provide us with the smooth seriality. Regarding the second pattern, there is a systematized design tactic using seriality from land-form which was first done by Foreign Office Architects and written in their book called Phylogenesis. Besides seriality from land-forms as a design tactic, there are only a few systemized design processes using seriality from natural conditions. There is still room for reconsidering this process.

This paper focuses on seriality in the relationship between architecture and landscape, especially in natural conditions. Through the paper, I will propose an original design process to define an architectural form, and develop algorithmic design tools to make it possible. Lastly, I will examine possibilities of the design process through case studies.

1.2 Research Position

There are two main types of research that deal with translation from nature into architecture:
1. Translate natural shapes directory into architectural morphology.

2. Translate algorithms or systems under natural shapes into a design strategy.

Although studies have been made on morphological possibilities, what seems to be common of those research is that those natural shapes are separated from their landscape.

In response to the precedent work, my design process will have three main features to make a tight relationship between architecture and landscape physically and fundamentally:

1. Seriality: I will focus not only a morphological seriality but also a fundamental seriality between architecture and landscape.

2. Translation: I will translate rhythm, which is an underlying series of movements affecting on landscape, into architecture.

3. I will propose a design process allows to treat rhythm of natural conditions which are not separated from their landscape.

1.3 Research Composition

The first chapter describes a research on rhythm in both architectural form and natural shape. In response to the first chapter, I will propose and define ‘Genetic Grid’ which will connect both architecture and landscape in the second chapter. In the third chapter, I will examine and consider the potentiality of the design process throughout the case studies.

Notes


2 THEORY

2.1 Rhythm in Architecture

In music, "rhythm" is the pattern of regular or irregular pulses caused in music by the occurrence of strong and weak melodic and harmonic beats. In architecture, "rhythm" is the pattern of regular or irregular pulses affecting on architecture, both physically and fundamentally. In order to consider seriality in the relationship between architecture and landscape, I will discuss how rhythm takes shape in both architecture and landscape.

2.1.1 Strong Order in Architecture

We can see various types of rhythms in architectural morphology. Among those rhythms, strongly ordered ones such as straight lines, right angles and equal distances are discriminative and often used in architectural morphology. These symbolic rhythms, which are found in artificial materials, are not often seen in natural conditions. In fact, there is interesting research to determine the distinction between artificial and natural materials for artificial intelligence. In this research, artificial materials are characterized by their strong order which in turn is represented by a long distance order, a same direction order and so on.

In addition, these primary shapes have an important role in the early stages of the architectural design process. Several architects have mentioned their importance:

- Marcus Vitruvius Pollio: "The very basic model of architecture is a square roof and four columns."

- Louis Kahn: "I always start with squares no matter what the problem is."

- Le Corbusier: "Cubes, cones, spheres, cylinders or pyramids are the great primary forms that light revels to advantage, the image of these are distinct and without ambiguity. It is for this reason that these are beautiful forms."

As stated above, high ordered shapes are notable features of architectural forms and it is essential to figure out space volume, as well as module and proportion in the early stages of architectural the design process. In the above views, the coordinates system is a simplified and organized
tool. Tokyo architect Jun Aoki mentioned in his book, “...a grid is a tool to describe ‘space’ which one is unable to see.” Further, he pointed out “...a grid is a useful tool nothing can replace for a long time.”

Let's review a brief history of the grid.

2.1.2 Grid History

The grid can be traced back over 2000 years where we see tight connections between primary geometry and architectural morphology; the definition of grid and coordinate systems, however, are not such old concepts. The Cartesian Coordinate System which forms the backbone of every CAD program is only a few hundred years old. Descartes introduced his coordinate system in his book, Discourse on the Method in 1637. The word ‘grid’ was defined as “something which is in a pattern of straight lines that cross over each other,” in the middle of the 19th century.

Here I can also mention how the history of the grid city had a strong effect on the relationship between architecture and landscape. It was over 2000 years ago when the grid city was initially applied. Hippodamus, the father of city planners, proposed the grid city which later became known as the “Hippodamian Grid” in the fifth century BC. It was an innovative plan as complex city plans were popular at that time. Over the last 2000 years, it remained popular for two main reasons:

1. It is flexible even if the city’s context changes because there is no centeredness.
2. It is easy to extend.

2.1.3 Fragment City

At the present time, the structure of grid cities has a strong influence on the relationship between architecture and landscape in many urban areas. Rem Koolhass expressed the effect caused by a grid city “The grid – or any other subdivision of the metropolitan territory into maximum increments of control – describes an archipelago of Cities within Cities.” Each block surrounded on all four sides by roads separated from other blocks seems like an island on the sea. As a result, the landscape is also subdivided to create an island within the grid city. This tendency can be also seen here in a suburb of Vancouver, British Columbia. The relationship here between architecture and
landscape has become fragmentary through its separation.

This is one of the reasons that it has been difficult to find projects which has seriality translation from landscape.

Notes

3 Marcus Vitruvius Pollio, De Architectura.


2.2 Rhythm in Landscape

In comparison to artificial materials, nature has complex and diverse shapes. The reason why these shapes appeal to us is that their complexity comes from many underlying layers of order. In addition, these shapes are not static, but have various time lines, appearing as different shapes continuously. The purpose of this chapter is to find the main characteristics of rhythm contained within natural shapes. It is rather difficult, however, to observe them from even a vast number of examples. The strategy to find these features is to observe how to analyze characteristics of nature in other areas of research.

2.2.1 Sense of Nature on the Edge of Chaos

"Chaos Theory" is a scientific theory describing the erratic behavior in certain nonlinear dynamic systems. In this theory, there is a certain state called the "Edge of Chaos," considered to be similar to a sense of nature. The "Edge of Chaos" is the region between order and chaos, where the complexity is maximal.

The state, "edge of chaos," was proven by Christopher G. Langton, impressed by research done by Stephen Wolfram using a cellular automaton (cf. p15). Wolfram pointed out that those patterns made by a cellular automaton could be categorized into four classes of behavior listed below (see Figure 1. Between order and disorder).

A. Limit point: Patterns disappear with time or become fixed.
B. Limit cycle: Patterns evolve to a fixed size with periodic structures cycling through a fixed number of states.
C. Chaotic: Patterns become chaotic.
D. Patterns grow into complex forms, exhibiting localized structures moving both spatially and temporally. This type is a behavior not cyclic and not chaotic.

Impressed by the research of these four categorized classes, Langton tried to test these patterns from different perception using λ (lambda) parameter to be clear, and in 1986, he expressed those four types clearly using the parameter. Above all, the area called "complexity" otherwise known as "edge of chaos" had attracted attention. The word is now used in diverse fields with the definition
"as a region between order and complete randomness or chaos, where the complexity is maximal."\textsuperscript{10}

The point we can depart from is the state called "edge of chaos." Even though its basic structure is simple, its overall behavior can be as complex as in any system. Furthermore, it must be noted that Wolfram assumed "edge of chaos" would be a clue to understanding the beginning of life and system in nature. We might say complexity can have order and disorder, and there is a sense of nature in "edge of chaos."

There is a similar way to define states between order and disorder parametrically. In crystallography, the length of order is one of the elements to classify crystal structure into three categories. The first category, "quasi-crystal" has a high order defined by its "long order." While "amorphous," the second category, is defined by its "short order," and has a very complex shape. Between this "long order" and "short order," there is a state called "crystal," which is the third category.

*cf. Cellular automaton: Consists of a grid of cells that usually appear in black and white using 0 and 1 on the computer. Every cell has the same rule for updating, based on the state in the neigh-
borhood. Each time the rules are applied to the whole grid a new generation is created.

2.2.2 Unit of 'Complexity'

In the area of thermodynamics, there is a unit to measure a degree of order. It is called "entropy." The word is now used in a wide range of areas such as biology, statistical mechanics, economics and so on.

The history of entropy began with the work of physicist Rudolf Clausius who defined entropy in his paper in 1865. The word named from the Greek "τροπή" means "transformation," symbolized by S, formally symbolized by \( \int Q / T \) using heat quantity \( Q \) and temperature \( T \). A common example used to understand the increase of entropy in physics is the conditional transformation from ice and hot water to lukewarm water.

2.2.3 Existence of Order Under the Heading of 'Complexity'

In addition to those examples from physics and biology, there are other examples which take "natural shape" parametrically.

My starting point of looking into the word of "complexity" was when I tried to understand "sense of nature" instead of simply translating natural shapes staunchly. When people describe nature, such as color, shape and state, using the term "complexity," they often imply a meaning of "richness" and "aesthetics".

The word "complexity" is defined as "the state or quality of being intricate or complicated," and "consisting of many different and connected parts." In the 17th century, the word had the meaning of "to combine, entangle and intertwine," and originates from the Latin "complexus" which is the past participle of "complectere" meaning "to embrace and comprise." At the same time, "plexus" in Latin means "braided and plaited," thus "com" plus "plexus" has a sense of plaited with number of strings together.

The word "disorder" is sometimes used as a synonym of complexity, and is defined as "a state of confusion." The word "confusion" comes from the Latin word, "confusio," and "confundere" in verb form, which means "mingle together."
The word “complexity” is difficult to define because it depends on a person’s sensibility, but if we refer to the word’s original meaning of “plait,” we can say people tend to use the word when describing a state having a system difficult to read, which means there is an underlying, somewhat entangled system. It will be clear when we see both “complexity,” “disorder” and “confusion” in the diagram that follows. The word “complexity” is a state having range between order and disorder.

There is a rather interesting description related to “plait” in Japanese traditional bamboo work. There is a way to plait called “yatara-ami” which is similar to the meaning of “complexity.” This word derives its meaning from how it looks to the observer, but for its creators, there is a simple order to its weave. The relationship between the creator and the observer is reminiscent of the relationship between nature and humans.

Having clarified the meaning of the word “complexity” in a relationship between nature and order, I will now look a relationship between “complexity” and art.

2.2.4 A Need for Complexity in Art

In his book Entropy and Art Rudolf Arnheim reuses some of the concepts from physics in order to understand and to evaluate art. Based on a discussion that “order is a necessary condition for anything the human mind is to understand,” he explains a connection between aesthetics and entropy by distinguishing between order and orderliness. He suggested that the level of ordered complexity is the level of order. Here is a quote from his chapter “A need for complexity”:

“Orderliness comes in degrees; order comes in levels. A structure can be more or less orderly at any level of complexity. The level of ordered complexity is the level of order. The “aesthetic measure” at which George Birkhoff (cf. p17) aimed was merely a measure of order, derived from the relation between orderliness and complexity. Order, I shall suggest, is a necessary although not a sufficient condition of aesthetic excellence.”

Notes

10 http://en.wikipedia.org/


3 PROPOSAL

3.1 Characters of Forms

Based on the first chapter, here is a summary of the main features of rhythm in terms of architectural morphology and natural shape.

1. Rhythm is the pattern of regular or irregular pulses affecting on architecture and landscape both physically and fundamentally.
2. High ordered rhythm is a feature of architectural morphology.
3. The grid and the coordinates system are necessary to grasp spatial sense, module and proportion in the early stages of the design process.
4. The grid city fractures elements in a city to destroy the relationship between architecture and landscape.
5. There is both high order and low order in natural shapes.
6. Those states can be analyzed parametrically.
7. The state between order and complexity is defined as well balanced states.
8. We, as humans, tend to think the state of ordered complexity is essential attribute of beauty.

Reflecting on the above mentioned characteristics of rhythm, the three main possibilities come to mind with the potential to use seriality in architecture from landscape:

1. Can the grid be managed flexibly in the design process?
2. Is the grid feasible in the parametric design process?
3. How can we insert rhythm derived from natural conditions into a grid?

3.1.1 Architectural Precedents

At the architectural scale, the proposal takes inspiration from a number of precedents that explore the manipulation of a grid as a design process for finding architectural form.

3.1.1.1 Emerging Grid / Toyo Ito

Seeking to transcend the uniform grid aesthetics of Modernist architecture that pared diversity
down to rational abstract order, Toyo Ito proclaimed the “emerging grid” concept that embraced richer complexities and transformed standardized rigidity into fluid organic space, a more natural twenty-first century grid scheme that signaled endless new possibilities interrelating architecture and people.

Here is the process of making an emerging grid.
1. Place two types of zones alternately in a regular grid.
2. Transform each volume of zones to fit to the provided program.
3. An “emerging grid” is made floor to floor by connecting top and bottom, and the grid “emerges” as a continuous curved surface.

3.1.1.2 Transforming Grid / Cecil Balmond

As with Toyo Ito, Cecil Balmond aimed to connect landscape and architecture by breaking out of the rigidity of the grid. In his book, Informal, he mentioned his idea as below:

"Landscape, urbanscape, building scapes can all be thought as "infoscape"... Once those connections are made, it becomes evident to me that what is possible is a much broader coalition, of generic processes that involve the same layer of information, working at different scales, connected by inner hierarchies of logic. Ultimately it is about the serial orders of pattern."^{13}

"Trapped by a Cartesian cage I wanted to break out. [...] The formal marches to strict rhythms. Why the necessity of structure equally, like soldiers marching on a parade ground? [...] Let the informal in. Have a syncopation - a rat-ta-tat-tat – instead of dull metronomic one ..."^{14}

His strategy for making the grid was “to translate the idea of forest as an externalisation.” He tried to make a state of randomness by duplicating and rotating over the first grid to make a scatter of points comes into play.

Toyo Ito transformed the grid with his own perception of organic forms, while Cecil Balmond took a system of randomness which is a system translated from a forest. The difference is clearly shown in the outcome that Toyo’s idea remained in geometric forms, while Cecil’s idea showed us something in the rhythm of architectural forms.
3.1.2 Genetic Grid

3.1.2.1 What is the Genetic Grid?

In response to the previous presented questions and precedents work, I proposed the “Genetic Grid.” The Genetic Grid has two main features:

1. Genetic grid is an advanced grid from a regular grid.
2. Genetic grid can merge architecture and landscape fundamentally or directory, to become a new order/module which is essential in the new architectural design process.

The definition of Genetic Grid:

This type of grid has continuous rhythms with surroundings. The concept for the “Genetic Grid” is clear from the combination of words in its name. It contains identities from surroundings as well as from the grid which is its architectural identity. To put it simply, the “Genetic Grid” has the gene of its “site.”

3.1.2.2 How to generate the Genetic grid?

Here is a proposed process of making the Genetic Grid (see Figure.2):

![figure 2: How to make the genetic grid?](image)
1. First step is to research existing conditions of a site which we usually do in our research process.

2. Translate those data of real conditions into an abstract data to capture and emphasize the feature of the data in order to see the unique condition of the site.

3. Respond to the translated data, make a unique grid which has site identity.

Notes


3.2 Grid Possibility in Algorithmic Design

In order to manage grid flexibly in the design process, I need to customize my computer tool which is greatly influenced by the Cartesian grid. This is one of the reasons why I step into an algorithmic design. Japanese carpenters, known as Miyadaiku, are specialized in constructing traditional temples, and have over 30 types of "hand planes" customized for responding to various uses. It is time for us to question our digital design tools and expand their possibilities.

3.2.1 Algorithmic Design Possibilities?

The introduction of the algorithmic design process into architecture continues to produce interesting results. This type of architectural design "might be aligned with neither formalism nor rationalism, but with intelligent form and traceable creativity." Algorithm is generally understood as a sequence of exact instructions proceeding from an initial state, through a successive transformation, up to its termination. Due to its prescriptive character, some find that the algorithmic method restricts the design creativity. However, the algorithmic design process is not necessarily predictable, or deterministic. Through the deployment of variables, algorithm offers an explosion of possibilities, while the explorations of randomness, or "fuzzy logic" can contribute to the new, unpredictable and rich design conditions. "The intellectual power of an algorithm lies in its ability to infer new knowledge and to extend certain limits of human intellect."

Design tools, which will be introduced later, build on the initial premise of Kostas Terzidis who said that algorithmic design radically differs from the conventional design. "The human designer may be constrained by quantitative complexity and may be unable to construct unpredictability since that would negate a designer's intellectual control." By reconsidering, challenging and extending the algorithmically conceived grid in architecture, I hope to contribute to the emergence of an "advanced grid" notion in new, algorithmic design.

Based on a discussion of the "UVN generator" that facilitates running given scripts on any selected objects, I will introduce the "Genetic Grid" which can insert the rhythm from a given landscape into architecture to make harmonious relationships between architecture and landscape. The technique for the "UVN generator" will be quoted from my recent paper presented at the "Critical
3.2.2 The UVN Grid

"The need for architects to develop their own tools is increasingly evident. For those who translate design ideas into precise geometric forms using traditional modeling applications, there is a growing operational ease, but "behind the scenes" there are always a series of scripts making it all possible. Scripts can easily repeat dynamics that compiles many components and complex relationships. However, when architectural form is generated with scripts, it is necessary to write complicated algorithms using exact mathematical formulas. (see Figure 3. Forms from mathematical formulas) Sooner or later, without a broad understanding and engagement of algebraic or mathematical disciplines, the designer confronts his or her limitations in drawing the imagined, complex form. Apart from the possible "generate and test" strategy, to enter critical design loops one needs to apply digital tools more simply and immediately.

Is there any way that we can use both the application flexibility of making complex shapes and utilize potential of scripting? How could these two be combined in the design process?

In response to those questions we proposed the idea of the “UVN Generator.” We named it for
its main task of shape translation—from the XYZ the coordinate system into our UVN coordinate system. This is very important, as it facilitates running given scripts on the selected object using the UVN coordinate system.

With this hybrid approach, it is possible to generate extremely complex shapes in a familiar way without the previous constraints. We can now construct complex geometric relationships and parameter values on the object using scripts. Our assumption is that we can broaden shape possibilities by running scripts on the UVN coordinates usually running on XYZ coordinates (see Figure 4. A script running on XYZ coordinates and UVN coordinates). In other words, running scripts on the space edge allows us to give new expressions. Furthermore, we can design space-edge as a "space design," not just simply as "surface design" by adding the N coordinate to the UV coordinates."18

3.2.3 Technique for UVN Generator

"The UVN coordinates are based on UV coordinates generated by a perspective projection system, where we applied the N coordinates as the normal direction from an arbitrary point on the UV surface. Using this notion, we developed the script for the purpose of translation from XYZ coord-
dinates to UVN coordinates, and called it the “UVN generator.” This is illustrated in the alignment of the cubes script that is running initially on XYZ coordinates and then translated to UVN coordinates. (see Figure 5. A script running on XYZ coordinates and UVN coordinates) We explored the three types of processes applied to space-edge, a basic process of “on a surface” and “between surfaces”.

3.2.4 Running Scripts

3.2.4.1 Case one: Running on a Surface

- Proceeding with Script

After a space is formed, the algorithmic process starts with the “UVN Generator” working to translate points on the drawn space to points on the UVN coordinates. Once this data has been stored in the point-cloud database, the programming can then begin with the “Points relations and Unit design” for running scripts on a UVN surface.

- How do scripts work on a surface?

The “Point Relations and Unit Design” step offers many components and complex relationships to a surface by adding selected “unit function” codes. “Unit functions” in turn can store any of the 2D/3D unit drawings based on a point “Pt” value that comes from the point-cloud database.

3.2.4.2 Case two: Running Between Surfaces

The main difference between “Running on a Surface” and “Running Between Surfaces” is the location where scripts are run (see Figure 6. A script running on UVB coordinates). In Case One, scripts run directly on a single surface, while in Case Two, series of scripts run between two or more surfaces which are not necessarily identical, as they can have distinct shapes. The field where scripts run is defined by UV coordinates and new B coordinates that are directed between surfaces, instead of N coordinates. The second hypothetical case fosters communications and interactions between surfaces in design to create expressive surface behavior.

This investigation of “between surfaces” starts with a criticism of conventional surface design that proposes static relationships between architectural elements such as “wall”, “floor”, “ceiling”,...
“window” and etc.

A concept for the technique was inspired by the integumentary system which is one that protects the body. It is not just one surface, rather it is comprised of many layers including the Epidermis, the Dermis and the Subcutaneous layer. The integumentary system has a variety of functions - it may serve to waterproof, cushion and protect the deeper tissues of the body, excrete wastes, breath and regulate temperature. It can serve as the location of sensory receptors for pain, pressure

figure 5. A script running on UVR coordinates

figure 6. Combined structures with inner and outer surfaces
and temperature. The name derives from the Latin integumentum, which means “a covering.” Our biologically inspired concept proposes to adopt this notion in exploring the potential of the algorithmically designed surfaces of architectural forms.

The results were explored through a project for a stadium design. In this study, a ‘composite component’ has been designed to integrate and combine structures with inner and outer surfaces in the algorithmic design process (see Figure 6. Combined structures with inner and outer surfaces). The space between outside and inside was designed with ring shaped “structural elements” and both inner and outer surface elements were designed using human scale components. The overall structure is continuous and self supporting at all points. Unlike conventional stadium structures, which employ hugely scaled structural elements, the stadium structure combines structure, outer surface, inner surface and space into one, “composite component.” Therefore, the surface is not divided by various functions, and “form possibilities” increase.

The results were explored also through a physical model using a 3D printer. The model revealed to us the possibility for a new surface geometry. The final model was a combination of rapid prototyping and hand-crafting. It prompted us to change the notion of a “surface” as “wall,” “floor” and “ceiling” to that of a surface as a single element that was inspired from an integumen-
tary system. As a result, we can now see the change from the static relationship between architectural elements resulting from this altered notion (see Figure 7, 8. The physical model produced on 3D printer).

3.2.5 The Genetic Grid

I would like to list the tool possibilities introduced so far:

1. Besides the traditional XYZ grid, objects can have their own grid called either the UVN grid or UVB grid.

2. These grids can be applied to any of the selected objects.

3. Grid modules can be adjusted to one’s own purpose.

4. One can apply expressions to selected objects using the unit design scripts.

Based on those introduced techniques, the technique to make “Genetic Grid” has been developed.

The “Genetic Grid” is controlled by any rhythm running on a UVN grid or UVB grid by generation of deformation for each direction. In this step, interesting results can be clearly observed in the difference between a normal UVN grid and a Genetic Grid (see Figure 9. A UVN grid and a Genetic Grid). Even if the surface shapes and the script for running on those surfaces are the same,
different outcomes can be generated. Besides, this process can embed a new order on any selected surface not only on simple surfaces, but also on a very complex ones. This means we can ultimately generate new ordered surface behaviors beyond prediction.

figure 9. A UVN Grid and a Genetic Grid

Notes
3.3 Condition Linkage

Let us now return to the serial relationship between architecture and natural conditions. The question we have to consider next is “How to make interactions between architecture and landscape by using the Genetic Grid?” In response to the question, I propose a design process called “Condition Linkage.”

The definition of Condition Linkage:
Condition Linkage is the creation of a “link” between architectural elements and surrounding conditions in order to foster interactions between them. The linkage is created by selecting a natural condition which you want to insert into an architectural element. By combining various elements, variations will occur.

To systematize the process of making the linkage, five main elements were selected from both architectural elements and natural conditions:

1. **Surfaces**: walls, ceiling and floors, including anything attached to those elements such as windows, doors or ornamentation.
2. **Structure**
3. **Function**
4. **Sequence**: a series of related events, actions by people or transportation.
5. **Green**: Place for nature such as courtyards, roof gardens and so on.

The five main natural conditions are listed below.

1. **Sun**
2. **Air**
3. **Water**
4. **Land**
5. **Plants**

Figure 20 is a diagrammatic drawing of the Condition Linkage between selected architectural elements and natural conditions (see Figure 10. Condition linkage). An architecture will have various local interactions between an architectural element and a natural condition to be a complex of interactions to connect architecture, landscape and human.
Having proposed the design process and developed the techniques to make it possible, the potentiality of the design process has been examined throughout the case studies.
4 CASE STUDIES

4.1 Asrfl.plt - 001: Interactions Between a Roof and Plants

In botany, a leaf is an above-ground plant organ specialized for photosynthesis. For this purpose, a leaf adjusts its appearance to the environment, to allow light to penetrate fully into the tissues. As the results, there are various shapes, thicknesses, sizes and colors. In addition, leaves overlap each other to capture lights giving expressiveness to a space under the tree. In this linkage, I observe those rhythm and give it to a roof as a surface.

figure 11. The regular grid and the Genetic Grid

figure 12. The roof study with deformations
4.2 AsrfLplt - 002: Interactions Between an Enclosure and Plants

The process can be seen in a demonstration project, Studium-X where a script was run on the toroidal form of enclosure surface. By running the script, the surface will be a media, not only a wall function itself, reflecting the imagination of architects grasping from dynamic, energetic and clamor images of a stadium.

figure 13. Various expressions on the enclosure

figure 14. The studium enclosure study
4.3 AsrL.plt - 003: Interactions Between a Wall and Plants

Our intention was to make a curved wall surface into unpredictable and rich design condition using the simple unit. The unit is made by nine points connected by curves and surfaces. The result is repeating and aggregating order with complex geometric relationships of units. The wall character becomes unique. Its screen like perforated surface is expressive, yet with intuitive softness of transitions found only in nature. It is radically different from of conventional, inorganic forms produced with predictable logic of conventional design. This biologically inspired system suggests potential parallel between design creativities and creations in nature.

figure 15. The wall study with the unit “flower”
4.4 AsrfstrLInd - 001: Interactions Between a Roof and a Land

The study project for ‘Biennale Pavilion’ was to derive hidden rhythm from the landscape and embed it on the surface for tracing out by our unit script. It is of central significance for a sense of design process that this type of new ordered surfaces can respond to a rhythm from the site environment. This is particularly interesting point as outcome of design can have an underlying harmonious relationship to its site.

figure 16. Variations of the Genetic Grid

figure 17. The study for “Biennale Pavilion”
4.5 AsrfstrLplt - 001: Interactions Between a Roof and a Land

A concept for the technique was inspired by the integumentary system which is comprised of many layers. This type of process allows to integrate and combine structures with inner and outer facades. Since all elements and their relationships are determined by scripts, the rich and diverse range of possible structural solutions could be rapidly explored.
4.6 AsrfLnd - 001: Interactions Between a Roof and a Land

The roof geometry has been produced using the genetic grid which has an identity of land. The square roof was transformed by the identity and make a tight connection between the site and the architectural morphology. The flow of the plant was also produced using the genetic grid and give connection to the roof with the roof garden.

![figure 20. The process of making a geometry](image)

![figure 21. The geometry for the roof study](image)
4.7 AsrfLsun - 001: Interactions Between a Roof and a Land

The genetic grid was derived rhythm from the sun after the simulation test to study the area where sun needs. The unit design was designed for the sun collecting function which collect sun light to give soft light into the interior space. The unit was designed with a combination of light wight structures and high tech skin.

figure 22. The unit design inspired from the light canon designed by Corbusier

figure 23. The outside view
4.8 AsrfLwrt - 001: Interactions Between a Roof and a Water

The unit was also designed for collecting water to give water to the plants on the roof garden. Rain will be collected inside of the unit, and flow through between the light canon and the skin for plant grow.

Figure 24. The diagram of the rain collecting

Figure 25. The outside view
figure 26. The perspective of the roof study as a complex of interactions

figure 27. The inside view
CONCLUSION

For many decades, human have attempted to control nature. Only recently, we have become aware that nature is being severely damaged and that the environment is being harmed by us. Gradually, we are attempting to shift our attitude towards nature from fighting against it to being wholly integrated within it.

The GENE/DNA of architecture, primitive geometries, grid systems and coordinates systems, which have lasted for more than 2000 years have not had enough flexibility for integrating with other rhythms. For this task, the GENE is one of the most important and necessary tools in the architectural design process, while it causes us to separate humans from nature as a whole. If the architecture of the city become part of its natural surroundings after it is built, there should be a strong interaction between those elements and those relationship should be described as serial.

Serialism in music can be defined as the structural principle according to which a recurring series of ordered elements are used in order, or manipulated in particular ways, to give a piece unity. In architecture, I see serialism as a principle of the design process according to which a recurring series of rhythm are continued from the landscape physically or fundamentally, to give interactions between architecture and landscape.

In this paper, I proposed the “Condition linkage” as a design process, and the “Genetic Grid” as a design tool which can have both an architectural gene and a gene of PLACE. Throughout this proposal, have sought to create a continuum between architecture and the landscape in which it resides.

In the near future, we might manage “natural” and “artificial” as two equal partners. If everything is made by layered orders, it might be possible. The only thing which can respond to this possibility is “technology”. I will keep investigating various technologies which have the infinite capabilities to connect architecture, human beings and their surroundings. Of course human creativity is truly where this infinite capability comes from.
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Physics and Mathematics

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APPENDIX

Appendix A: “Critical Digital Conference” submission (abstract)

Beyond Surface
Aspects of UVN world in Algorithmic Design

Aya Okabe, Tsukasa Takenaka, Jerzy Wojtowicz

The need for architects to develop their own computational tools is becoming increasingly evident. In this paper, we introduced our design tool named ‘UVN generator’ which is based on the algorithmic process combining scripting potentiality and flexibility of traditional 3D surface modeling. Our attempt on combining the two served us well to explore the new ground for design. New conditions were explored and observed in the three case studies which are named ‘on a surface’, ‘between surfaces’ and ‘on a new ordered surface’, referring to place where the scripts were run. In design projects presented in our case studies, we focus on the system behind the generation of complex, expressive, biomimetic, yet humanistic shape. This challenge to find a new ground for computational design enables us to pose our critical question ‘What could be algorithmic design potential may lay beyond basic surfaces?’.

The part of this thesis was presented at the “Critical Digital Conference,” April 18-19, 2008 at the Harvard University.
Appendix B: The script for forms from mathematical formulas (see Figure. 8)

Option Explicit

' Draw a sine wave using points

Call DrawCosWave()
Sub DrawCosWave()

Dim x, y, z
Dim arrPts()
Dim n : n = 0

For z = 0 To 5 Step 0.1
For x = 0 To 5 Step 0.1

    y = 1.2*Sin(x)*Cos(x)*Sin(z)

    ReDim Preserve arrPts(n)
    arrPts(n) = Array(x, z, y)
    Call Rhino.AddPoint(arrPts(n))

Next
Next

End Sub