Systemization of Architectural Design through Advancement of Information and Communication Technology: Possibilities of a Life-theory Approach

Naomi Matsunaga[1], Tomohiro Fukuda[2], Atsuko Kaga[2]
[1]Lemon Gasui Co.,Ltd., Japan,
[2]Osaka University, Japan
http://www.interlab.jp/

The design and implementation processes of architecture changed radically in the late 20th century. Architects began to apply computer programs to design and conceptualise processes. This study classifies and analyzes some of these techniques, and demonstrates processes by which architecture came to establish an organic relationship with the environment while being influenced by the theories of life.

***Keywords**: Induction Design; Mathematics-based Structural Design; Ubiquitous Computing.*

Introduction

The relationship between architecture and the environment has been perceived as separate since the beginning of modern era. Architecture's purpose is to secure a space for humans to enjoy safe and comfortable living and work in that space while sheltering them from the external environment. The image of architecture is "box-shaped" with a contribution to a clear division between interior and exterior. However, because of rapid advancement of information and communication technology (ICT), changes have become apparent in architectural design and design processes applying computers. Since the mid-1990s, groups of architects began to use computers not only as tools, but also as highly functional aids for creative work. Consequently, changes have come in the relationship between architecture and the environment, which had been previously dissociated formally. Whereas the past relationship between architecture and environment was inorganic, separated, and starkly different, architecture designed using ICT has begun to have lively function and format at various levels. For that reason, a new relationship has formed between architecture and environment. The possibility of a life-theory analogical approach is open for present architecture and that of the future. This study is an attempt to provide these predictions with reasonable groundings. This study attempts to demonstrate these hypotheses through analyses of realized works.

Theory of Life

Living things are constantly undergoing all of the following processes: (1) growing themselves through replication of cells based on certain phylogenetic gene information (growth of life); (2) homeostatically self-adjusting and maintaining systems as individuals while accommodating information from the

outer environment (self-preservation of life) and also redefining themselves by processing information that is provided from outer environment (auto-poietic function). These functions and characteristics create a so-called co-creative relationship between life and the environment. Life and environment create a reality while serving as mutual causes and results. We will prove these concepts with actual works in the following section.

Analysis with Actual Examples

New forms of architecture appeared in the late 20th century; digital architecture, blob architecture, and others utilizing ubiquitous computing technology can be regarded as analogous processes of those two characteristics of life. For example, regarding (1) above, phylogenetic gene information (growth of life) is a natural condition to generate conformation and can be regarded as prototype information. Greg Lynn is among those who developed a digital esquisse technique to run these programs on a computer. The Korean Presbyterian Church in New York (1999) was planned through reconstruction of an old dry-cleaning facility to renew it as a church building. Water drops were inspired by "cleaning" in the choice of that prototype.

The BMW Pavilion Dynaform (2001) by ABB Architect and Bernhard Franken is an example of using conformation occurrences as natural phenomena that are not necessarily limited to life. As Franken wrote in his essay entitled *"The Joy of Driving"*, he has applied the Doppler effect for the form to recreate a sensation that a person has when driving an automobile. Semantically, it is possible to say that he uses the "play of force" in nature as a given parametric design process to create a new form.

The most state-of-the-art example of the concept is by Makoto Sei Watanabe in Japan, who embedded programs that are close to artificial life into the design creation process itself. His project "The Induction Cities" is a creation of conformation using an algorithmic program while matching urban conformation and the environment. It is an attempt to replicate creative phenomena of life, so to speak. We can see architecture as an attempt to repeat life's emergent phenomena. The experimental version of "The Induction Cities" is a WEB FRAME of "Subway Station Iidabashi" (2001). Computer Program-Generated Architecture (CPGA) was realized for the first time. The "Creation by programming" that is used here does not mean merely creating shapes and plans using given program rules; rather it means "solving required conditions" and "automatically" creating space and conformation while reflecting "the designer intent." In addition, for the station's "WIND WINGS," the WEB FRAME programming is further expanded, developing programming that is embedded with structural mechanics. It creates a variety of forms from simple rules, similar to plant structures.

Furthermore, Mutsuro Sasaki, a Japanese structural engineer, is attempting to construct a Sensitivity Analysis method and Extended Evolutionary structure optimization method, which are mathematics-based structural design methods that unify mechanics and aesthetics. These create rational structural conformation using computers while regarding principles of evolution and self organization of life from an engineering perspective. Attempts at new architectural design methods began in the competition idea of "Firenze New Station" (2002), a collaboration with Arata Isozaki. Using structural optimization methods such as evolution theory, a structure similar to the roots of tropical plants was created. Not only did they use computers as conformation creation tools but there was an attempt. They attempted to utilize them to make the most effective dynamics while minimizing the costs of materials used. These structures, which have organic, curved shapes that exist in nature as building materials, are becoming more advanced. Architecture is thereby becoming transformed from "box-shaped" into natural shapes such as cells and water drops.

Kas Oosterhuis from Holland provides examples of environmentally compatible auto-poetic architecture. The body-like architecture that he suggests

aims for an architecture that resembles the human body in responding actively to information from the outside environment. Such architecture is realizable through the development of real-time sensors that act similarly to sensory organs of living organisms as well as the advent of the Internet for mass-information sharing.

Richard Rogers and Norman Forster present architectural concepts that can accommodate environmental influences and thereby maintain so-called sustainability. In this case, the environment influences the conformation of the architecture just as it does the conformation of living things. The "Turbine Tower Project" (1993), a Tokyo office plan, is the first research example based on Rogers's ecology. Here, it was required that the building itself be energy self-sufficient as an office building research project. Ideas that Rogers et al. presented included the use of prevailing winds. The wind flow surrounding the building was modeled using dynamic computer programming; a method to improve the air vacuum from the building tower was considered. In addition, the building shape was adjusted so that the winds on the building surface, which were essential to realize the project goal, were accelerated. By changing the building shape, it is possible to increase the speed of prevailing winds that pass turbines that are located between the building and its annex tower. These turbines convert the wind power into electric power. Energy is used effectively with natural power. This idea illustrates how architectural conformation is influenced and changed by the environment in the process of realizing sustainable technology with computers. (Rogers,1997)

The Special Modeling Group, which consists of four members with different specialties ranging from aeronautical engineering to air-supported structure, conducts research using computers and miniatures in the Forster office on feasibilities of architectural conformation and mutual effects between architecture and environment. A team member, Whitehead, reported that, to determine the conformational possibility, it was effective to use a cut surface of a torus and a parabolic curve as solid curved surfaces. The attempt to run geometric conformation in the computer and determine an actual utility in architecture was carried out in planning of the "London City Hall" (1998). What was especially important was the relationship with sunlight for energy efficiency, which was sought using computers; the result was fed back. The research result on the environmental effects of conformation, therefore, became reflected in the architecturally feasible conformation.

The above-mentioned life auto-poetic function is expected to be utilized further for architecture, along with the progress of the so-called ubiquitous computing technology. Ken Sakamura is a Japanese professor in Information Science and the creator of the real-time operating system architecture, TRON. He designed and developed a new intelligent home based on TRON and other leading edge technologies. Called "TOYOYA Dream House PAPI," which is a house designed as a second version of TRON Cyber housing. This house has ubiquitous computing technology that simultaneously offers energy conservation, comfort, and improved function. It is designed to provide residents with various services through automatic optimal control with an inter-connected sensor net with air conditioning, lighting, security, disaster prevention systems, and audio equipment. Total control of support of "Time & Space" is conducted by the house, which learns a daily life rhythm of residents' rising from sleep in the morning to their sleep in the evening. Living sensors, which are banded on residents' arms, measure the degree of REM sleep; the house then reads the measurement and automatically adjusts the blinds and lighting (with music and sound of birds if preferred), thereby contributing to the comfortable awakening of residents so that they can start the new day refreshed. If these functions become more advanced, even architecture with automatic control of conformation will become possible.

Conclusion and Outlook

Schematic expression of the analogy with the biology described above can be compiled into a four-quadrant chart (Figure 1) that includes the design process, architectural form and function of each architect. The vertical axis shows the "Ontogeny", which is the process by which an individual organism reaches adulthood, and "Phylogeny", which signifies formative or genetic changes that a certain biotic community has undergone by the time of its formation or extinction. The "Emergence of form" and the "Homeostatic adaptation of the environment", which are related to existence of individuals, are put on the horizontal axis.

According to the above classification, for instance, Greg Lynn, who utilizes individual natural forms for the prototype, can be classified into the quadrant of the ontogeny. Meanwhile, Makoto Sei Watanabe and Mutsuro Sasaki, who employ an Artificial Life program and evolutionary optimum techniques, are classifiable into the quadrant of phylogeny because they repeat the evolutionary processes that take place inside a computer. Furthermore, challenges by Oosterhuis, who produces forms that possibly correspond to various information from the outside world, or those by Sakamura and others, who try to adapt them to information from natural environments, can be classified into the quadrant that emphasizes self-regulatory adaptability related to the existence of individuals.

As we have discussed, architecture that utilizes the effectiveness of ICT have functions that living organisms have within themselves. As Jakob Von Uexkull and many other biologists have stated, the relationship is not based on a subject-object dichotomy, but rather on co-existence as described in Buddhist philosophy, along with co-creation. Thus, it is considered that both make the creation of reality possible. Architecture that has outer environmental compatibility and prototype-based architecture will contribute to the creation of new relationships between the environment and architecture. In addition, buildings with functions to re-define themselves based on the information from the environment (including themselves) will effectively respond to issues of sustainability. This will provide an effective solution to the issue of sustainability.

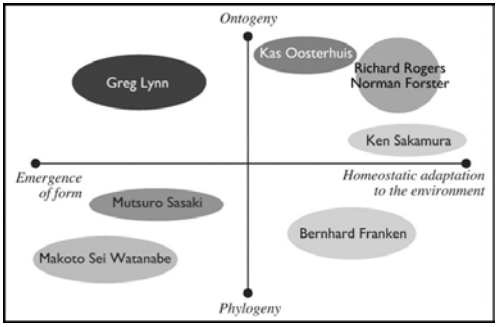

Figure 1
The possibility of a life-theory analogical approach

References

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