

Developing a Digital Form Generating Process for User-Participated Space Design

- Focused on extracting of the User Behavioral Data -

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Abstract : Digital design process has become a major technology in contemporary space design through analyzing information-oriented society conditions. In the sense of human interactivity, the outputs of many works have some limitations, mostly depending on insufficient data which are not fully reflected user behavior.

The objective of this study is to suggest a new digital form generating process on which the user behavior data are reflected, and it will be meaningful to attempt interactive method through user direct participation and approach humanization of space design. For this, researching about the examples of digital space design were executed to find out the trend of existing digital form generating process, and a prototype of '*Liquid human Flow*', for '*Force Field Simulation*' by the user behavioral data, that detected the actions and reactions between user and the experimental space into digital data was developed and proposed as a solution. In this process, Optical Motion Capture System and Virtual Reality with HMD(Head Mounted Display) were used in order to capture and to record the responses of user data.

As a result, the digital space form generating process for user-participated method which has user behavioral data about internal space contents was obtained as a better solution in the side of delicacy and accuracy. And it will allow more participation and satisfaction of users in digital space design form generating process.

Key words : *Digital Space Design, Interaction, User-Participated Design, User Behavioral Data*

1. Introduction

In the 21st century, modern society has faced radical computer technology and development of information telecommunication . They brought us to the middle of information revolution that called The Third Wave. William J. Mitchell said in his book 'City of Bits' that an information-oriented society appeared with electronic equipment like new-media, computer and networks, would be controlled by them. He also foresaw that architecture would face the epoch-making changes. These kinds of changes will influence on designing and studying a space. We can see some differences between the past and present, such as, digital space design.

Design using CAAD(Computer Aided Architectural Design/Drafting), keeping pace with IT(Information Technology), showed new possibilities from 1990 to new millennium. In the early days, digital methods are used mostly for

cutting down expenses or for its convenience. However, in 1990s', digital methods are considered as a creative change that can be never done with the existing. Environmental changes including that offered a turning point in space design. Especially, designers changed their point of view for space and approached to ideal space by widening their sensibility. But in actual works and studies, quite a few example of digital space have being approached by user side and that induces lots of dehumanized space. The ideal space can be formed only when the nature of space is regarded as an environmental interaction between space and human being. User of a space pursue tends to various needs according to his own personality. Therefore, it is said that designing has a digital space to reflect the needs of the user and the design process should include the user-participated method of space form generating. The objective of this study is to suggest a new digital form generating process that is reflected user behavior data in order to create an interactive method through user direct participation and to approach humanization of space design.

2. The change of the organization of user society in information-oriented society

2.1 Decentralization of Authority

Information-oriented society made it possible for user to automate collecting, storing, controlling, expressing and exchanging information. A new way of flowing of goods and services was introduced by the use of database or network. Also a series of economic activity such as producing, marketing and distributing has been done in more flexible way. In office area, a working space is not occupied by one person at all times and 'hot cubicle' is used for whoever feels to need it, instead. Also a typical conference room was changed to a cyber conference room. Using network system and sharing information in common converted a centralized and vertical structure of user to a flexible and horizontal one.

2.2 Secession from Organization

Modern society brought dramatic changes in the scales of each society besides in using time and space. Because of telecommunication on network. Information revolution made information itself be regarded as a main part of social power. That is, the strength of social power depended on the position of information giver and taker. On the other side, the way of accessing information became more various and convenient. Being free from existing large-scaled structure, the organization of user society has a new power structure.

2.3 Individualization of Economic Activity

After the industrial revolution, the paradigm of standardization and mass manufacturing made the supplier as the main group economically and brought supplier-centered production system. But information with its economic value in information-oriented society changed the previous production system to user-centered one. We can participated in economic life easily through the network whenever and wherever we desire. Also, selling goods as well as buying became more convenient by easier information acquisition.

2.4 Chapter Summary

With the networking information technology, life were changed to a new territory. One's life has been influenced by his complex environment and also headed toward decentralization, flexible horizontal structure of social organization, de-organization and individualization. It is no more available that explains an individual by his environmental structure. New recognition that environmental structure can be explained by an individual is

coming up to the world as an epistemological change. That the networking information technology decides the structure of user behavior and experience. And that explains epistemological change of thought through inductive reasoning in digital era. In other words, It is enlarging that user participation territory through user needs and his environmental system, too.

3. The trend of space form in digital space design

3.1 Information and Plato's Idea world

Information is recognized as an important thing that forms the one's values in digital era. In modern society, however information is described as a connection of binary digit which were combined bits, that is no more physical one. Also, information exists as a type of conversed bits in modern society. Information was considered as a basic substance rather than physical or psychological one. And also it explains physical and psychological phenomena through them. Through 'Allegory of the cave' in 'Ideal state', Plato explains that there are two worlds, the phenomenal world and the other is the idea world. In modern society, like Plato's Idea world, information is a subject which is something to think not only sensible experience but rational thought. Also, almost space designer who attempt to reflect digitalized information to create a digital space design, too.

3.2 Non-Euclidean, Complexity, Fractal, Chaos and Topological geometry

Human has produced space, either geometrical or non-geometrical from the primitive age to the present. Space designer has played a man who confine people to territory that has simple and flat ceiling and wall that is called as the Euclidean geometry. Unlike this, in 20th century, some space designers have tried to attempt a formative change from a simple thought to complex one by accepting a new concept. Far from the limitation of Euclidean geometry, It is considered that emphasizes the recognition of organic nature, and try to find the order in complexity of the form of the whole. Like those experimental space, they resist to make an order that has linear shape and rigidity through same patterns and structures. It means that the trends of decentralization, self-similarity from creation and transformation that have propensity of non-linear and rhizome were reflected on space form. Also, in processing of self-reproduction, it has the primitive shape of auto-production organization. In the shape of space, when transformation was impacted on surfaces, space has become elastically in organization, separation and application of space. Consecutive forces make a different dimension in time and space. Experimental digital space designers are utilizing these properties in part of spatial surface or conceptual method. That have the difficulties in expressing mechanism of form transformation by pure geometry, an extreme abstract of natural environments. From that reason, digital space designers try to make a form that contains state of flux and increases the safety of structure through 'Liquidizing Form' with metastability.

4. Classification of Space Form in digital space design

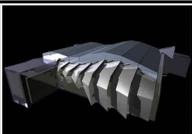
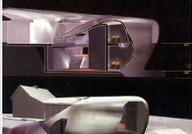
In using of digital technology, digital space design process is divided into two, a mean of thought and a tool of manufacturing. Including this classification, It could be analyzed, depending on whether they contains user data or not. And also the primitive concept related digital space design were investigated as follows.

4.1 Non-reflected user data in digital space design process

These cases with the major factors used in space form generating process were researched. In a sense of interactivity, those works depend on insufficient data which are not fully reflected user data. Like a city

organization, a flow through the surrounding and landscape and environmental information were affected digital design process.

Table1. Cases of non-reflected user data in digital space form generating process

Case	Architect	Concept of form	Form Generating Method	Trend of form
 Guggenheim Bilbao Museum	Frank O. Gehry	using digital instrument at molding step through the instantaneous fortuity with inspiration	using the definite numeric control with 3d scanner after making mock-up model with hands	non-Euclidean non-linear complexity
 The Tower of the Winds	Toyo Ito	Hypersurface System	expressing invisible environmental elements(wind, light, traffic noise) through media instruments	simplex geometry
 BMW Group 2001 Pavilion	ABB Architeckten, Bernhard Franken	Force Field Simulation	generating the dynaform and space shape through the Doppler effect	non-Euclidean topological shape
 New York Korean Presbyterian Church	Greg Lynn	Metaclay System	form generating through the meta blob which have cohesion which transform the form after selecting parametric data such as an altar, a choir, a nave, an aisle etc.	non-Euclidean fluid fractal shape topological shape
 Raybould House and Garden	Kolatan & McDonald Studio	Co-citation Mapping	chimera-like hybrid between the logic of the existing architecture and the of the surrounding landscape	non-Euclidean topological shape
 H2 House for the OMV	Greg Lynn	Force Field Simulation	the north facade's form was shaped by simulating of the movement of vehicles' motions in the adjacent highway	non-Euclidean topological shape
 100 WoZoCo's	MVRDV	Datascape	re-utilizing the concept through the limitation about conditions between landscape and architecture	instability fractal shape of transformed repetition

4.2 Reflected user data in digital space design process

In the side of enlarged user participation territory and system, it is required that digital space design is to meet the requirements of users and design process is to introduce in the method of user-participated space form generating at the same time. Therefore, user data should be use the effective factor for space form generating. Simultaneously, existing digital design process will be make up for limitations about dehumanization. For example, 'Fresh Water Pavilion', 'Aegis Hyposurface', 'Chamberworks Installation RAM Gallery'. Those works are

being process to apply the compromise between the change of social user organization and digital space form generating process.

Table 2. Cases of reflected user data in digital space form generating process

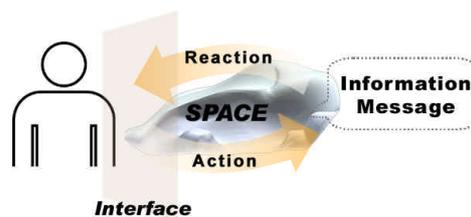
Case	Architect	Concept of form	Form Generating Method	Trend of form
 Fresh Water Pavilion	NOX	Liquidizing form	real-time form, lighting, sound changing through user action	non-Euclidean topological shape
 Aegis Hyposurface	dECOi	Hypersurface system	organized transformation of hyper surface through user activity, lighting and sound	non-Euclidean fluid fractal shape
 Chamberworks Installation RAM Gallery	OCEAN group	Particle animation	simulating with installation contents through the user traffic line	non-Euclidean fluid complexity curved trace shape

As is stated above, these space show user-participated space form generating. In 'Fresh Water Pavilion' and 'Aegis Hyposurface', user participate in temporary form transformation without interaction between user and internal contents. But, in 'Chamberworks Installation RAM Gallery', user interact with his internal elements during digital form generating process. The basis of space is formed when the purpose of space is regarded as interaction between space and human being. Because user pursues his own personality and has various needs in space. In this side of view, 'Chamberworks Installation RAM Gallery' also have some limitation that is restricted by linear curved shape of user movement. Actually, user behavioral movement is not the linear shape but the various volumes. Therefore, to supplement of the limitation, it should try to study lots of approach of methodology. Simultaneously, digital design process will be make up for limitations about dehumanization.

5. The Concept of User-Participated Digital Space Form Generating

5.1 Interaction between user and space

Fig. 2 Interaction between user and space



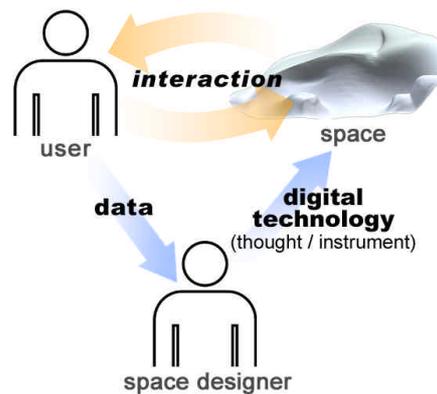
As rapid changing of information-oriented modern society, communication get changed into communication depending on interactivity. Interaction between 'user sensibility' and 'materialized world' shows great turn from supplier-centered design to user-centered one. Here, interaction means interactive relationship and it can be

utilized in overcoming dehumanization and improving comprehension for user needs. Nowadays, phenomenological space notion of ontology has changed into human-centered space concept freed from idealism or materialism in spatial recognition. Interaction in space and interface can be defined when the object of design is space which is reacted by user. Based on these ideas, the nature of space can have significance through user participation.

5.2 Concept establishment of digital space design

As previously stated, it is digital space design concept that a designer seeks for is established as follow.

Fig. 3 Digital space design concept



This figure stands for practical use of digital technology in space design. Space designer extracts proper data from user for harmonious interaction. The advent of digital area makes possible many processes which were impossible in the past. Digital technology is used not only for an instrument for creative space design but also a good way to overcome dehumanization.

6. Digital space design process reflected the volumetric trace of user behavior

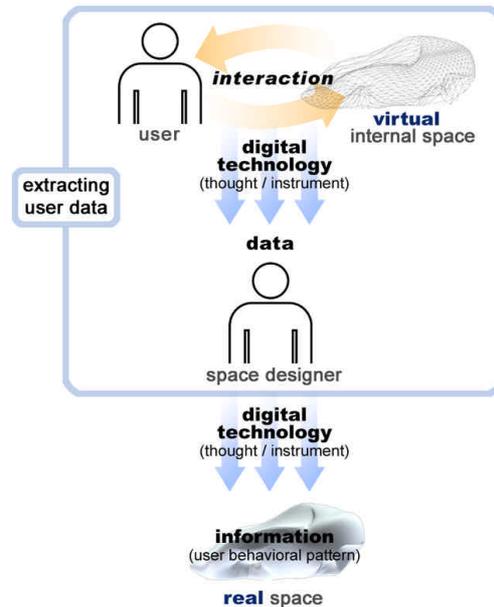
Usually, In the digital design process, digital design method exists in the middle of conceiving and actual reality. The significance of its position is meaningful in that the concepts and information about the conceiving can be worked out in the process of materializing. In this study, focused on the extracting user behavioral data was applied. It is the first step of digital space design process using user-participation.

Human goes through a complex process of space perception like the five senses. Among these senses, the sense of sight is most important sense to recognize space elements. Therefore, in this study, user data is limited in visual elements according to the trace of his visual experience for reflection in form decision. This experiment progressed as follows for the possibility to apply user behavior data to digital space design process.

6.1 Decision digital space design process reflected user behavioral data

User have special behavior to interacting with his environment. It may be a psychology thing or a physical one. As mentioned before, In this study, user movement is not the linear shape but the volumetric trace that contains vector values. This volumetric movement define as '*Liquid human Flow*' because that can be the shape of liquidity and vector values about the properties of the time and space. Also, that means not a 'personal space' but a visualized behavior between material environment and user through the time.

Fig. 4 Extracting user data in digital space design process

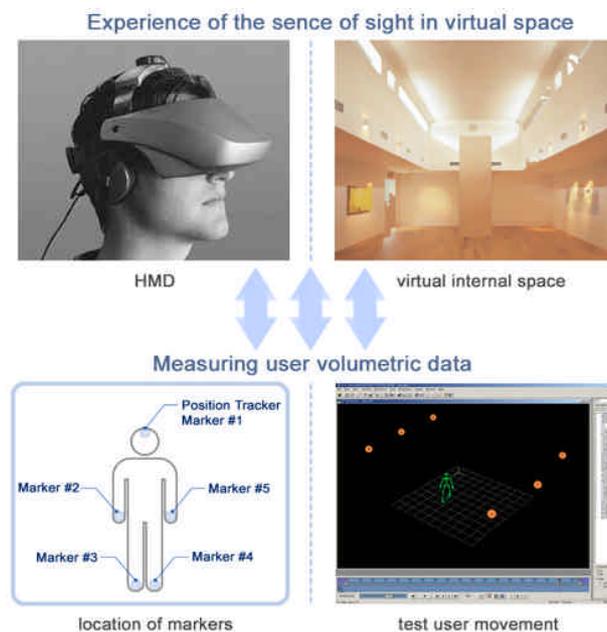


6.2 Experiment contents

This experimental process is for '*Force Field Simulation*' which is the way to transform the space shape through environmental movement such as a car, a river and so on. This study means the fundamental and methodological approach that apply to definite space with extracted user behavioral data. In order to extract '*Liquid human Flow*' elements, human behavioral movement, this experiment used Optical Motion Capture System because It can extract accurate data of user volumetric movement in real time. But, that have some spatial limitation to capture the human motion data in a real space. So, immersion type VR, HMD(Head Mounted Display) with Virtual Reality, was used to capture the reaction of user behavioral data.

According to the process, that virtual internal space made by 3-dimensional software was displayed to test user through HMD. The test user experience the internal space with 5 markers that are located in the user head, arms, legs. In the process, Motion Capture System extract data of each marker according to the its position through the time.

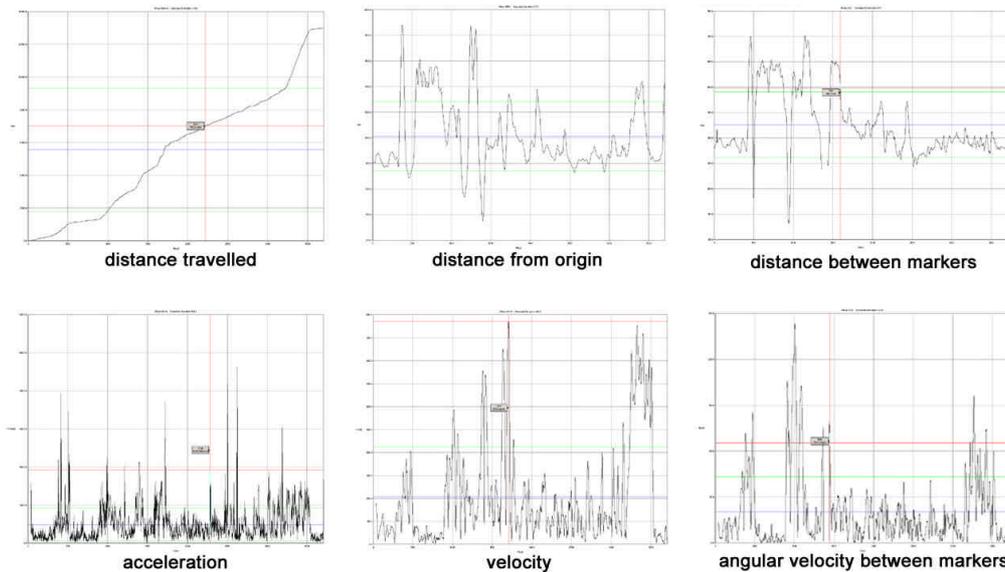
Fig. 5 Measuring user behavioral data in digital space design process



The test user experienced virtual space and its contents by HMD. This virtual internal space has internal exhibit contents to interact with user. While user interact with internal exhibit contents which included the 2-dimensional image, the 3-dimensional objects and the animation movies in virtual environment, the marker's various data were saved to the computer through the Motion Capture System.

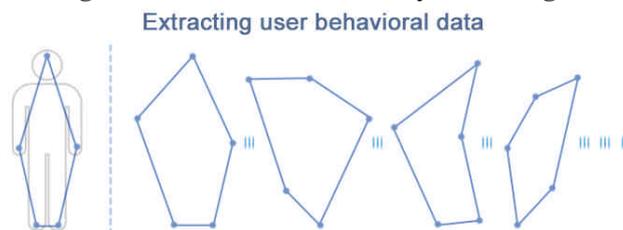
6.3 Experiment Conclusions

Fig. 6 Measured test user behavioral data through the Motion Capture System



User body change his motion during interacting with internal space exhibit contents in virtual environment. These changes bring on changes such as marker's position, angle, distance. User reaction is different from contents and his character. The data, measured by the motion capture system, was expressed such graphs as distance travelled, distance from origin, distance between markers, acceleration, velocity and angular velocity between markers. Thus, the visualized movements is offered to the data which recognize user reaction delicately and accurately.

Fig. 7 Changeable user reaction territory according to the time



User movement which is radical non-linear factor in '*Force Field Simulation*' is different from the factor as car in upper cases. It is so organic and not linear shape. The shape of attached each marker on the test user express the territory of differential user movement. These territory is expressed volumetric user behavioral trace by integration through the time. In this way, the process, reflected user factor in digital space design is transformed the method of digitalized data by analysing user volumetric trace. Also that is effective way to applying radical factor of user movement delicately in space form transformation. The experimental conclusion with these conceptual theory was as follows.

- 1) Each marker's numerical data such as X, Y, Z position and acceleration were extracted by the test user movement delicately and accurately.
- 2) These digital data were formed of ASC that can be saved CSV(Comma-Separated Values) file format. Therefore, it can use easily to convert data of database related applicable computer programs.

3) Visualized each marker's graph was expressed the possibility of presumption which have reaction about visual recognition.

4) That the shape of linked markers from #1 to #5 at the same time could convert to '*Liquid human Flow*' NURBS(Non-Uniform Rational B-Spline). These NURBS will be used for following studies which transform the space form through the '*Force Field Simulation*' by the user behavioral data.

7. Conclusions

The digital space design process has to be considered, rather than in the aspect of digital space design alone, in connection with the nature of, and the basis for, the digital culture that has spread into every part of our society in general. User participation inspired because of decentralization of authority, secession from organization, individualization with the networking information technology. Thus, user-participated design is the more available method in space design. In the side of enlarged user participation territory and system, it is required that digital space design is to include the user requirements and design process is to introduce in the method of user-participated space form generating at the same time. Therefore, radical user data should be use the effective factor for space form generation and transformation.

This study was suggested a new digital form generating process prototype that is reflected user behavioral data in order to create an interactive method through user direct participation and to approach humanization of space design. Through these analyses, an interactive method through direct user participation could be attempted and approach to humanization of space design and user-participated design became available. From this study, the digital space design process for user-participated method which has human motion data about internal space contents was obtained as a better solution in the side of delicacy and accuracy for digital space generating form by human factor. The possibilities of generation and transformation in either existing or ongoing real space that have various internal contents need to be researched for further studies.

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