Spatial Configuration Data Model For Inter-Applicational Collaborative Design

Takeshi Kimura
Kiichiro Komatsu
Hitoshi Watanabe

Department of Architecture
School of Science and Engineering, Waseda University
3-4-1 Ohkubo, Shinjuku-ku, 169
Tokyo Graduate School of Socio-Economic Planning,
University of Tsukuba
1-1-1 Ten-ou-dai, Tsukuba, Ibaraki
JAPAN

In this paper, a new design method is proposed which will enable the designer to predict and control the flow of pedestrians acting inside the designed building. Watanabe laboratory has been working on human behavioral research, and referring to the results of these studies, the authors pointing out the requirements for a tool supporting the new design method. Later on, a data model and a loosely integrated system intended to match the needs will be proposed.

Keywords: human behavior, design method, design process, integrated cad system

1 Introduction

According to the rapid growth of computer technologies, Watanabe laboratory has been depending more research and development on computers [1]. Not just the technical growth brought this situation, but it is because that the members continuously have been seeking for new ways of utilizing these technologies [2,3].

On the other hand, analysis of design process, particularly of those under collaborative situation, has been studied as a basic research, and computational method is also adopted in this area. As a matter of course, the software used in the laboratory tends to vary, and a framework for seamless interchange of information among the members using different softwares has become a critical issue.

Product models are the first nominee of a solution to this issue, but those like STEP seems to be getting over speced though lacking the ability to handle information of our needs. In this paper the authors will begin the discussion with pointing out the requirements for a new data model, while introducing the activities of the laboratory. Later on, a data model and a loosely integrated system intended to match the needs will be proposed. Finally the application of this system and problems remaining to be solved will be discussed.

2 Pedestrian flow and human conscious design

Watanabe laboratory is a laboratory of planning and design at the department of architecture in Waseda University. One of the main theme of this laboratory is to create a architecture and design method based on human behaviors. The most important and interesting an behavior in architectural space is the movement of people inside. We summarize this movement as pedestrian flow and have been studying this subject since the election of the laboratory [4,5]. How people evacuate in emergency, how commuters walk in stations or how people get out from a large space like a stadium; these are some of the examples of what we call pedestrian flow.

Our future goal is to develop an architectural designing method which will enable the designer to predict and control the flow of pedestrians acting inside the designed building. This method can be said that it is human conscious, since the designed building will be the result of considerations on human behavior.

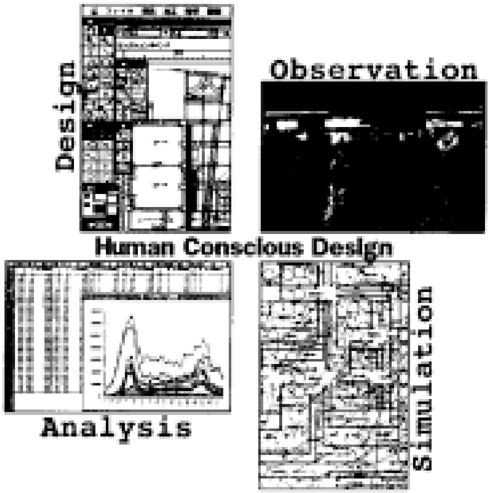

Figure 1: Previous Researches and Human Conscious Design

2.1 Approaching the goal

As a step towards the goal, many methods for evaluating spatial configuration of buildings and facilities has been proposed. Each of the methods adopts some aspects of human behavior, especially those of pedestrian flow, as a criteria of evaluation. The criteria are derived from the result of intense observation and analysis on human behavior.

The evaluation process and the analysis process has much in common. In both processes computational simulations and visualization techniques are introduced. The most essential part of these processes is the making of computational model for simulating the behavior of people inside. Aesthetic evaluation of architectural environments is another important evaluation which is supported by computer-graphics simulations [6]. The modeling process is the most important in this case, also.

There is another approach toward the new design method. With the currently available technologies, we are studying designers design process, especially those under collaborative circumstances. The main object here is how to share adequate information via network among designers using different softwares. The following sections will illustrate some of the studies mentioned above.

2.2 Research on stations

Four years has passed since we have started researches on Yamanote Line [7] which is the main commuters' railway circulating central Tokyo. The target of the researches is to analyze the pedestrian flow in the concourse of the stations. Some of the researches were done with a contractor company for estimating how the pedestrian flow in a station will change in the coming 10 or 20 years [8]. This result is supposed to be used for future development of the station facilities and the area nearby.

The typical ways of observation are counting people passing a fixed region and recording the tracks of people passing the area. Enormous data will be collected and prepared for analysis in the later stage of research. With recent technologies, there are also researches using video cameras and computer based image analysis softwares. In these types of researches, many scenes of concourse are taken by video cameras and recorded on video tapes. Afterwards, the tapes will be digitalized into QuickTime movie files or sequential picture files and be prepared for analysis.

2.3 Simulation models

After observing pedestrian flow the results will be analyzed and, in turn, computational simulation model will be developed. The first of this series of research was a research on estimating evacuation time at emergency. This is the most crucial topic at planning considering human behavior, thus was the first to be studied. With new powerful computers, graphical simulation models are also developed [9].

Commuters behaviors at stations is another crucial subject in large cities. The scale of simulation models will vary from city planning to station planning. In larger scales, the simulation models will inherit a network model, while in smaller scale, transaction model will be inherited.

2.4 Experiment of an electronic collaborative design

Last year an experiment on electronic collaborative design was held between another laboratory on a remote site [10]. The designers (students of the two laboratories, in this case) were grouped in several teams each consisting of members from both laboratories, to make sure that each team were unable to have face-to-face communication inside their team. The experiment was a pseudo design competition. Each team were provided with same site information and subject. The difference between an ordinary design competition was that they were not allowed to have any contact beyond the Internet (thus have never met each other literally) and, most of all, there were no prizes.

At the beginning of this experiment, most of the teams had to struggle just to transfer DXF files. One team also had a trouble on using E-mail; they preferred a more direct communication method and finally start using phone-calls and facsimile. At the last stage of the experiment, which was two weeks after the beginning, all of the teams communicating via Internet became able to transfer information among them and finished their design.

From the designing point of view, the results were not satisfactory. One reason is that the students were not accustomed to the Internet technology, though they were almost professionals of stand alone applications. Another possible reason is the lack of communication. It can be assumed that the Internet technology (mainly E-mail and ftp at this time) could not offer enough capability for a dense communication which might have been necessary in this case.

2.5 Requirements

In this section the requirements for the new system will be described.

Above all, an integrated and feasible mechanism is required for transferring data between each process of research and design; starting with observation, analysis, deriving criteria, making simulation model and finally evaluating the design.

The mechanism should also support the analysis of collaborative design process. This will be realized by providing the analyst with means to share information and the process of design. Throughout the research and design process, interaction of information is likely to take place among remote sites, thus a network communication capability is required. The system expected to make use of existing resources of the laboratory; most of the computer resource, including hardware, softwares and data files, are supposing Macintosh systems. The overall view of the system can be seen as prototype of a tool suitable for the new design method, i.e. human conscious design.

In the following two chapters, a data model and an integrated design system fulfilling the requirements described in here will be proposed.

3 Spatial configuration data model (SCDM)

During research and design, the participants of the operation will interchange information in several file formats. For seamless and efficient transfer of information, SCDM is able to manage those file formats. It is desirable if SCDM also supports data translation between the file formats.

The result of observation and analysis of pedestrian flow will be passed to the participant constructing simulation models. The pedestrian flow is described with parameters, and, from previous researches, it is confirmed that the most explanative parameters of pedestrian flow are density and speed. Thus, these parameters necessary for representing pedestrian flow are adopted in SCDM.

The elements of simulation model can be categorized as architectural entity, spatial entity, and human entity. Usually, the spatial model is a network of sub spaces and architectural entities. The people behave inside the architectural space are represented as flow or automata depending on scale and granularity of the simulation. As a general assumption, each entity mentioned above will have some kind of geometrical entity. Not to mention, in computer graphics evaluation, geometrical data is essential. SCDM is capable of handling these entities. Each element of SCDM holds a time stamp and a revision number which will be referred at analysis of collaborative design process. In SCDM the history of design process will be recorded as the history of alteration of data files. With process information stored, it is possible to share design experiences which are usually hard to be shared among a group of designers. In collaborative design, network communication capability is required. SCDM supports inter-network data transfer protocol.

4 Inter-applicational collaborative design system (ICDS)

The main concept of ICDS is to provide integrated environment with application softwares currently used in the laboratory. This environment is considered as the prototype of a tool suitable for the new design method, i.e. human conscious design. ICDS consists of application softwares and some glue routines for handling SCDM. The glue routines are attached to softwares which are extensible. Application essential for ICDS without such capability would depend the transfer/ translation of data on the data viewer.

The target applications are MiniCAD, form Z, Extend, HyperCard and Netscape; these are 2D drafting CAD, 3D geometrical modeler, simulation software package, hyper media database environment and a popular HTML viewer respectively. All of the software work on MacOS with a pseudo multitask environment.

4.1 SCDM file and the index stack

An SCDM file is implemented as a combination of a HyperCard stack, application specific format files and DXF files. This HyperCard stack is called index stack and manages a database of various files in one SCDM file, and holds the history of alteration. Revision management is realized with this history. The index stack also has an interface for storing and retrieving additional information which is in most of the case text based. With the index stack, users can attach comments and messages to SCDM file, or have access to any revision of the project.

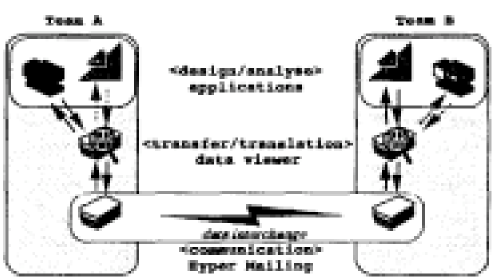

Figure 2: Inter-Applicational Collaborative Design System

4.2 Data viewer

Mini-CAD serves as a core of data transfer/translation [Figure 3] and supports other application which cannot directly handle SCDM files. It is called the data viewer and provides GUI for handling SCDM files. The data viewer is graphics oriented in comparison with the index stack. The data to be transferred from one application to another will first be sent to the data viewer, attached some additional information, integrated as SCDM file and prepared to be sent. The SCDM handling routines and interfaces are implemented as external commands; glue routines so called in MiniCAD. The role of MiniCAD here is to provide a platform and a function library effective for developing original CAD systems; not just a window /widget library, but a library which provides full functionality of standard CAD applications.

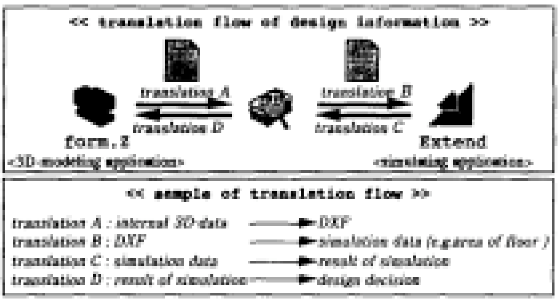

Figure 3: Data Translation

4.3 Hyper-Mail

For interchanging data files and information among designers and analysts on remote sites, a system named hyper-mail has been developed. HTTP is selected as the transfer protocol. The users just have to select what to send from the list shown by the index stack. The index stack is able to show any information related to the particular project, since once the data or information prepared as files, everything is registered on it. It is possible to create hyper links between a text in a message and any appropriate file. The interface is simple and the user can be unconscious of HTML specification.

4.4 form Z and Extend

form Z and Extend are the softwares actually used in planning and analysis. A designer will make a building model with form Z and decide to have the model evaluated by an analyst using Extend. He, then have to send the model to the data viewer in DXF format, add spatial configuration information and save it as a SCDM file. He will also invoke the index stack, add some hyper-messages and send it to the analyst with hyper-mail if the analyst is working on a different machine.

The analyst receives the hyper-mail and, in turn, will send back the designer the result of the analysis with some suggestion on the plan. The suggestion might say "extend the width of door A," and the word 'door A" is hyper-linked to a file in which the model of the door is described. The analyst can use the data viewer to retrieve the area of a room. Although the designer did not explicitly record the area of the room on the file, the data viewer can calculate and provide the user with the number. This is a typical case with ICDS. Plural softwares will kept invoked simultaneously; e.g. form Z, Netscape, the data viewer and the index stack, as the designer's case.

4.5 Revision management

For design process analysis the state of the project will be recorded when the index stack has changed or when the data is going to be transferred. This is how the history of the whole project would be maintained. The recorded states are called revisions. At a particular stage of the development, there will exist more than one revision of a same generation, especially when the project has been developed in plural sites simultaneously. To start a new stage, the designer have to decide whether to select one revision as the beginning point or to start with generating a new revision referring to elder revisions. The revisions of previous stage will be kept in the index stack whether referred or not.

4.6 Glue routines

In the current version of ICDS, most of the applications which consist the system requires glue routines to handle SCDM. These glue routines are called, external commands or plug-ins, according to the convention of each software. MiniCAD and HyperCard are also extend with external commands to serve as the data viewer and the index stack. ICDS can be expanded with any softwares extensible in this way.

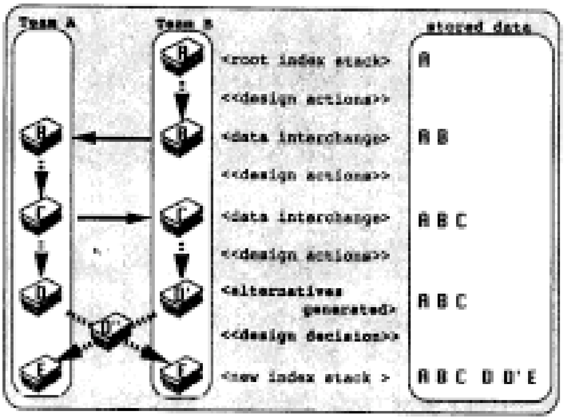

Figure 4: Revision Management and Sharing Information

5 ICDS environment and conventional design environment

In this chapter, we compare the ICDS environment and conventional design environment. An actual case under conventional environment has been taken as the subject of comparison.

The actual case was a re-development project of a station in Tokyo. The site was a 5 square kilometer area surrounding a terminal station of the Yamanote Line which has two train systems, a monorail system and a subway system. The main goal of the redevelopment is to estimate the future visiting demand of this area and re-design the station facilities to meet the demand. The demand was supposed to increase, and the shortage of the capacity of the station facilities were predictable. According to the increasing visiting and, the pedestrian flow was expected to change in its quantity and quality.

A platform (a pedestrian deck connected to the station concourse) was planned above the station to avoid overall heavy traffic of pedestrian. A sidewalk and an underground passage was planned to relieve the crossing of the pedestrian in particular regions. The participants of the project were classified into two teams, which are the planning team and the evaluation team, and the project developed through the interaction of both teams. The planning team were responsible for creating alternatives of spatial configuration, and the evaluation team evaluated the performance of those alternatives from human behavioral points of view.

The following sections describe the differences between collaborative design with and without ICDS environment.

5.1 *Sharing information*

In this project, designing and evaluating the station plan required enormous interchange of information; e.g. sequential human traffic, distance of human trip, results of simulations and so on. It became clear that, the decision on choosing when and how to interchange information highly affects the efficiency of design collaboration. Each team recorded information as paper documents or digital files, and transferred them via facsimile or directly by hand.

In an ICDS environment, besides conventional means, each team interchanges information by using hyper-mail system via computer network. The participants can retrieve essential spatial information from databases and interchange them with the structure of the information kept along [Figure 5]. For example, the planning team could transfer to the evaluation team, by hyper-mail in SCDM format, a zoning plan accompanied with other information such as alternatives of the spatial network model or comments related to the plan, in an appropriate structure. Interchanging information in this style has the following merits.

First of all, hyper-mail allows the participants to communicate in a mutual language. Naturally, the members of each team have their own way of thinking, solve the problems with domain specific models and represent their ideas in various forms. Hence, without ICDS, every information interchanged could be eccentric to the teams other than the creator. This situation might prevent the members from fluent and accurate communication. With a mutual language, this inefficiency can be avoided.

Secondly, hyper-mail enables the members to discuss on their project in a unified format. On the contrary, in conventional environment, the information would usually be interchanged in various formats and on different media such as computer file or facsimile. If the user wishes to incorporate an information on another format, he or she has to rearrange it in an appropriate style. Hyper-mail relieves the user from such an unnecessary rearrangement.

It is likely that the more information interchanged, the more severe the difference between two cases will be.

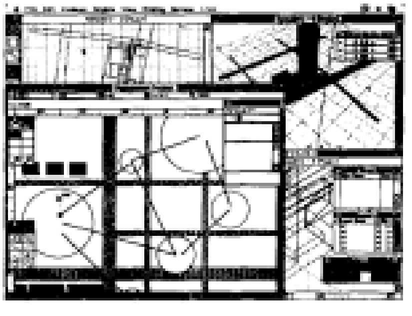

Figure 5: Operating ICDS

5.2 *Configuring simulation model*

Two different kinds of simulation models has been engaged in this project. One was network model used for evaluating human behavior in the surrounding area of the station, the other was transaction model used for evaluating human behavior inside the station. The network model was used to estimate the number of visitors to/from the station, and with the result, transaction model was used to evaluate the pedestrian flow inside the station.

In conventional environment, although there are many entities common in both models, the user had to build models of those entities on each simulation model. When the user decided to introduce into the model a criteria information which is the result of human behavior research, he had to translate them into an appropriate format. Furthermore, the user have to translate the result of the first simulation for the next simulation in which the result would be, in turn, used as preconditions. On the contrary, in ICDS environment, most of these translation would be done by the data viewer. With ICDS, even if these models tends to be updated frequently, and related materials keep on increasing, the operation of the user is kept minimal. Graphical interfaces are available for modeling and the data files will be managed by the software.

The advantages of ICDS environment are:

(a) Data interchange between teams or applications is easy. The user can be unconscious of the file formats.

(b) All the information is integrated and can easily be accessed. The throughput of modeling cycle will improve.

5.3 Face-to-face communication in collaboration

Throughout the project, face-to-face communications between teams and its members was essential. According to interviews to the members worked in the project [14,15], face-to-face communication, was indispensable for having better relationship with the members and making proper design decisions. Of course, ICDS environment does not prevent the user from face-to-face communication. No one denies the advantage of face-to-face communication in collaboration. It is because direct communication is supreme method of collaboration since ancient days. In practical case, we cannot communicate directly in anytime, and non-ICDS groups claim which require more direct communication also indicate that. With state of the art network technology, it is possible to offer more various method of communication such as computer based tele-conference. Although these new technology costs too much for everybody to use, it is certain that we are going to face a new phases of collaboration in the near future.

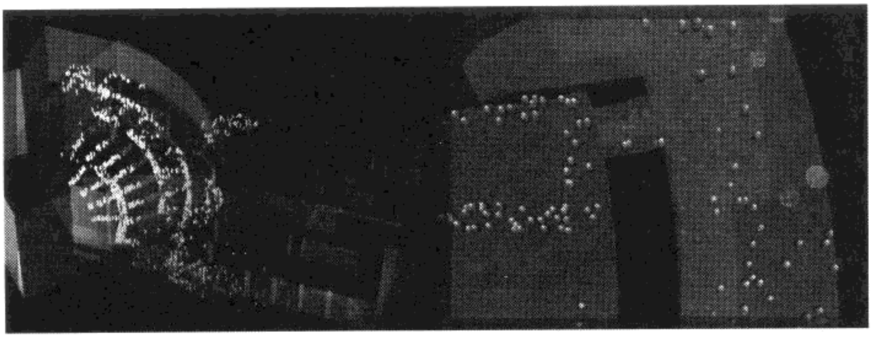

Figure 6: Scientific Visualization in Collaboration

6 Seeking the Future

6.1 Scientific visualization and ICDS

Sharing and transferring information and idea are essential for collaborative design. Communication between collaborating designer and analyst based on aural messages or documentation written with drawing tools on paper media. As approaching to the next century when requirements and value in design will be in great variety and the situation being more complicated, it is important to propose alternative method which supports the sharing of information and idea between collaborating members.

One alternative is a communication based on computer graphics called scientific visualization. We have noticed the possibility and importance of this communicating method, and have been researching on the application of this method for several years [Figure 6]. The research has just completed its first stage and has not yet been implemented on ICDS, but several experiment has already been practiced [16] and the efficiency in collaboration is confirmed. Thus, we conclude that visual approach of sharing information and idea will be an indispensable feature of ICDS in near future.

6.2 Collaborative design

The supporting of collaborative design, with integrated computer system such as ICDS, has a short history and the practical use has just begun. The methodology of collaborative design itself, regardless of computational support, is not well defined. There are many style of collaboration, and for the achievement of a better method the we must not devote ourselves only to the development of computer tools. It is necessary to accumulate design experiences and study on design process. ICDS might help the research.

7 References

[1] Watanabe H, Behavioral Simulation For Planning, JAPAN: Doctoral Thesis, 1975

[2] Iki K, Behavioral Model For Facility Planning, JAPAN: Doctoral Thesis, 1982

[3] Morozumi M, Studies on the Network Analysis for Locational Optimization and their Application t Locating Ambulance, JAPAN: Doctoral Thesis, 1984

[4] Watanabe H, New Architectural Systems 11 -environmental psychology, JAPAN: Shokoku-sya, 1982; p.l53-234

[5] Nakamura R, Human - Space system, JAPAN, Doctoral Thesis

[6] Kobayashi Y et al., Visualization of Architectural Design - Video -, JAPAN, Watanabe Laboratory, 1990-1994

[7] Kirishiki K, Designing Station Consideration of Transportation Poor, JAPAN, Mater Thesis, 1992

[8] Hayashi J, Estimate of Passengers by using the wicket partition model of the area affected by the station, JAPAN, Master Thesis, 1994

[9] Komatsu K, Visualization of Human Behavior, JAPAN, Master Thesis, 1993

[10] Hayashida K et al., Advanced Design Education Using Information and Network Technology, Proceedings of the seventeenth simposium on computer technology of information, systems and applications, japan, Architectural Institute of Japan, 1994; p.247252

[11] Sano T, A study on expression of human behavior, JAPAN, Master Thesis, 1992

[12] Kimura T, Intelligent CAD and Knowledge-base, JAPAN, Master Thesis, 1993

[13] Hayashida K et al., Selection in destination of passengers and users around Hamamatsu-cho, Summaries of technical papers of annual meeting, JAPAN, Architectural Institute of Japan, 1994; p.1031-1032

[14] Hayashi J et al., Network-flow-type Simulation in the Station and its Surroundings, Summaries of technical papers of annual meeting, JAPAN, Architectural Institute of Japan, 1994; p.1783-1784

[15] Sano T et al., Network-flow-type Simulation in the Station and its Surroundings, Summaries of technical papers of annual meeting, JAPAN, Architectural Institute of Japan, 1994; p.1785-1786

[16] Tatsuno H, & Komatsu K et al., The Study of Visualization of A Simulation of Human Behavior, Proceedings of the fifteenth simposium on computer technology of information, systems and applications, JAPAN, Architectural Institute of Japan, 1994;
p.125-130

8 Endnotes

The developer of application softwares

MiniCad	A CAD software developed by Graphisoft.
Extend	A simulation package software called EX-TD in Japan. Developed by Imagine that!
form-Z	3D geometrical modeler developed by Auto-des-sys, inc.
HyperCard	Hyper media database software developed by Apple inc.