Experimental study in inter-University collaboration

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1. Introduction

The architectural design requires collaboration among various participants, such as architects, clients, engineers in the stages of the design process. The Sasada laboratory has been involved in the various collaborative architectural design projects. The authors found several important issues in the process of those projects. Firstly, the presentation data is composed of different kinds of data such as documents, computer generated still images, movies and 3D objects. The participants involved in those projects need to access these data as necessary. Secondly, it is virtually impossible for all participants to attend at the same time and place. Therefore, computer networked collaborative design work is essential, in particular, for an international project and for a complex architectural design project.

CSCW (Computer Supported Collaborative Work) and the Internet technologies enable remote participants to collaborate seamlessly. As Internet and the World Wide Web have given a new dimension for global communication recently, now it is possible to easily use a hypermedia system that can be accessible from anywhere by just point-and-click. The participants can access design information of the hypermedia which links to texts, images, movie, VRML, and review the design while communicating with other participants using hyper-linked communication tools. Computer networking allows convenient share and exchange of data between distant machines.

The paper describes the recent research on hypermedia in collaborative design. The research is conducted in the form of inter-University collaboration, participating Osaka University in Japan and Kyung-Hee University in Korea.

2. Project

Kyung-Hee University in Korea is in the process of establishing a new graduate school of design for training the design professionals. As the current education system is given too much emphasis on the logical reasoning and theory, they are going to build a new curriculum and new building for the graduate students who want to have practical experience. The planned building should be composed of CAD rooms, design critics rooms, lecture room equipped with slide, audio and video facilities and so on. To design the building, an Inter-University project between Kyung-Hee University in Korea and Osaka University in Japan has been initiated. In the early stage of the project, both of the universities set up their project home pages and shared the project data. Kyung-Hee University is in charge of providing the topographical map of the University, pictures and the drawings of the buildings around the planned site. The Osaka University is in charge of providing various tools such as electronic calendar system, bulletin board and web robots database. The project is proceeded using various media that is hyper-linked between each other, i.e. hypermedia on network.

Several different kinds of modelers, such as ArchiCAD, formZ and AutoCAD are used; therefore model data is shared through the neutral data exchange format, such as the DXF and VRML format. In the early stage of project, Kyung-Hee University made the 3D models and Osaka University made the 3D models into VRML: Kyung-Hee University produced 3D models of the buildings around the site, and presented those images and the DXF files to their home page; Osaka University downloaded the DXF files from the Kyung-Hee home page on the Internet and converted them into VRML for the design review and presented them to the Osaka University home page.

2.1 Internet and Network status of both sites

Almost all of the computers used for the project at both labs in Japan and Korea have been connected to the Internet: the Sasada Lab at Osaka University in Japan is networked through ODINS (Osaka Daigaku Information Network System) with direct connection to the Internet and CAD lab at Kyung-Hee University in Korea is networked, although not all machines used for the project are directly connected to the Internet. Therefore, some members of Kyung-Hee University have experienced some difficulties in direct and seamless data communication with the Osaka University.

From the view of machine environment, Osaka University has various kinds of machine including Macintosh, PC and Workstation. However, Kyung-Hee University mainly used Window 95/NT on PC for the project. Therefore, the project team experienced some difficulties in constructing the
seamless project modeling environment when they need to run platform independent applications to generate computer models.

2.2 Main Design Concepts
There were several main programming and design concepts as follows:
1. The planned building should have the image of architecture and design.
2. Future extensions of the building should be considered.
3. The planning building should not destroy the natural landscape of the campus and should be in harmony with the other buildings in the campus.
4. The height of the planned building should be lower than the library building that is located in the opposite side.
5. The shape and color of the building must be in harmony with the surrounding buildings, such as the library building, the school of social science building and the school of natural science building.

2.3 The Project Team
The project team, which consists of graduate students at both universities, is divided into two design teams. The design team A consists of two Kyung-Hee University graduate students and one Osaka University graduate student, used a virtual space, and the design team B consists of two Kyung-Hee University graduate students and one Osaka University graduate student, used VRML model in the stage of design review. The computer models which surround the planned building site was constructed by the under-graduate students at Kyung-Hee University.

3. The process of the Project
3.1 Project schedule of each team

![Calendar](http://10.130.10.2/ecaade1997/lee/lee.htm)

Fig.1 Calendar
As the computer systems used for the project at both universities were different, platform independent calendar should be constructed. The calendar server which uses TCP/IP has been set up in Osaka University to share the project scheduling information. The members of each team proceeded the project according to the schedule in the calendar server and posted a message on the network, for example, suggesting a virtual meeting when they need to communicate. If the time
for a virtual meeting on the network is agreed, the participants discuss about the design in a virtual space or on BBS.

3.2 Communication
Communication necessary during the design process was performed using BBS on the project homepages. BBS records the contents of communication such as problems, questions and answers in the form of multimedia data including text, image, movie and 3D object. The participants can post a message with an attached data, such as image, VRML and movie.

Fig. 2 BBS

3.3 Data Sharing and Management
The Web Database is constructed to handle image data and 3D object data during the design process. The Web Database is composed of a search engine and CGI (Common Gateway Interface), and enables the project members to effectively search needed data. Figure 3 shows the search page and Figure 4 shows the search result page.
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Fig. 3 Search Page

**LAST UPDATE**: November 3, 1996. Unless otherwise noted, all material accessed from this server is a 1983-1996 Eddie Lab, the Department of Environmental Engineering, the Faculty of Engineering, Osaka University.
3.4 Design tasks for Team A and B
The Design Team A focus on designing building plan concentrating on effective space zoning. It consists of 3 zones including lecture zone, research zone and administration zone.
Team B focus on designing building plan concentrating on educational exchange among undergraduate students, graduate students and professors.
3.5 Design Review
3.5.1 Design Review in Virtual Space

Fig. 7 Design Review in Virtual Space Team A reviewed the design in the virtual space after completion of design. The DXF or VRML formatted 3D model data produced by various modelers are finally converted to the RWX(Renderware) format. The RWX formatted data is stored in the project server, so that the participants can view it via their own browser. They could re-arrange, move, and transform the objects in the virtual space. Also, the participants could recognize avatar as a remote representation of human identity and existence, and express the emotion through avatar. It is possible to communicate precisely through the synchronous communication.

3.5.2 Design Review using VRML
Fig. 8 Design Review using VRML Team B reviewed the design using VRML. The 3D model data was converted into VRML model, which was presented on the project homepage. Team members schedule a certain time to review the design on the group-ware calendar. On the scheduled day, each member opens two browsers, one for posting their opinions about the design on BBS, and the other for browsing VRML formatted model. It is virtually impossible to make a VRML model which includes all detailed surrounding data such as topological data and 3D model data around the planned site due to the limit of computer power and software browsing speed. Therefore when the team B reviews the design, they only used partial data within the small range of the site. It takes much time for deciding the eye point to each member. They communicated on BBS, the time lag resulted in the problem of efficiency.

3.6 The Final Design Proposal
The final design proposal was selected within the virtual space. Team A and B reviews the two alternative design proposals made by each team in the virtual space. The environmental data, such as topological data and 3D model data surrounding the site was all located in the virtual space. The members of the each team enter in the virtual space simultaneously, and discuss about the two design alternatives. Finally, the design made by the team B, which complies with design criteria and concepts, was accepted as the final design proposal. When they review the final design proposal, if necessary, the participants might discuss on BBS. The Team B chose the virtual space as a proper reviewing tool rather than utilizing VRML. Figure 9 shows the final design proposal.
4. Analysis of Project
Both universities established their project homepage to share the design information. BBS is used for uploading the project data and FTP is used for direct transmission of data that does not need to be stored on the project homepages. For the management of design process, a group-ware calendar has been established. Also, the web database enables remote participants to search and retrieve data what they need.

4.1 Communication
The remote participants can navigate through the various type of design information interactively which was hyper-linked on the project homepage. In addition, the group-ware calendar and BBS were hyper-linked from the each home page. Due to the nature of the international project, it is very difficult to be present at the same place and time. Therefore most of the problems occurred during the design process must be solved on the network. Due to this reason, the network facilities are critical factors in the success of this project. In the daytime, team members use chat communication program when they need to discuss about the design while proceeding the design work individually. At night, team members download the revised data from the opposite project homepage and post the progress of the design during the daytime on BBS. From the view point of speed, although communicating using chat is faster then BBS, it has several disadvantages as follows:

- Normally the contents of communication information are not saved.
- It is difficult to exchange graphic data

4.2 Process Management
Because the data of the project is increased as the design evolves, proper project management is required. For an effective collaborative design work, it's important to formalize how to proceed the work and to identify what kind of process is needed. To perform an effective data management, a web database has been built to store image data and 3D object data. Each member of the team can upload the data on the homepage. The data was saved in the database automatically. Physically, team A and team B proceeded their work separately. However, when they need to exchange their opinions about the schedule and details about their design, all of members discuss in a virtual space for the making of design, modeling and presentation.

4.3 Design Collaboration
If necessary, the participants can access to the design information and communicate interactively. The members of each team can exchange their new ideas and refine the design using various design tools. They could represent their new idea easily to the other members of the design team who are geographically remotely located. In addition, they could use various digital media to present their ideas. If required, they could attach photos or images which could illustrate their concepts more easily. In a virtual space, people take their partners to another virtual space where they presented their idea.

5. Conclusion
The teamwork of the mullet-disciplinary groups is an integral part of the architectural design. The design process includes the exchange of information between individuals and organizations, and requires discussions among professionals of the team. The hyper-linked communication tools enable the participants to communicate virtually beyond the barrier of time and space.

Several important finding by performing this experimental study are as follows:
(1) In the stage of design review, using the virtual space is better than the VRML model from the view of speed and manageable amount of data. Moreover, avatar as a human embodiment was recognized as remote participants. The design reviewing process in the virtual space had a reality like a real space.
(2) Design review using VRML model has some operational problems as the environmental data such as topography data and surrounding building data is too huge to easily manage under the currently available computer power. However, VRML model is very effective when there is just single building model to review. To sum up, it is necessary to develop an effective software tool which is easy to operate, can store huge 3D data and fast enough to deal with complex 3D models.
(3) In the near future, various communication tools, which can help to exchange design ideas in remote, are required.

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