

論文の内容の要旨

論文題目

**Remote Collaboration of Designers:**

**Adaptable Networks for Unpredictable Environments.**

デザイナーによるリモート・コラボレーション

ー環境の変化に適応可能なネットワークの構築に関する研究

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### **Purpose**

The purpose of this research is to construct new tools, both practical and theoretical, to support remote collaboration. Existing tools are focused in the exchange of information; however, the collaboration of designers includes as well the debate of ideas. The target of this research is to build the instruments towards the necessary synthesis between the exchange of information and the debate of ideas.

### **Research Organization and Research Interests**

This dissertation is structured in three parts:

- 1) The Theoretical Framework explains the characteristics of the design process, and the way design ideas are constructed and discussed.
- 2) The Field Studies explore the state of the art in Internet tools for remote collaboration, identifying areas for research and development.
- 3) Finally, System Design and Evaluation presents the new computational instruments constructed and tested to support the remote collaboration of designers.

### **Theoretical Framework**

The theoretical framework presents the advances in the fields of Management of Projects, Design Methodology and Activity Theory, and also Dynamic System Theory as a metaphoric resource.

The systematic approach to the design process provided by the Management of Projects regulates the design activity without constraining innovation in design or construction. Management of Projects suggests the setting of a series of reviews with the all the stakeholders where the design objectives and future steps are discussed and agreed. It is important to notice that this system does not intervene at all in the creative design periods between reviews, liberating the participants from the necessity of adopting any structured approach. Considering the structure of remote collaboration, real time communication tools support the exchanges during reviews, while non-real time (asynchronous) tools support the whole process.

Those periods between reviews are studied from the point of view of Design Methodology. Here, three approaches to the method of architectural design are presented regarding their objective of stimulating innovation.

Christopher Alexander (Alexander and Poyner 1966) and Rodolfo Livingston (Livingston 1999) develop different views of the design, but converge in the idea that there is not one perfect solution for a design, but many. Instead of demonstrating one infallible path to the true design, they center in how to produce alternatives.

In another view focused in collaboration, Dana Buntrock (Buntrock 2001) explains how Japanese make construction a collaborative process sustained by tacit knowledge and tacit organization: Teams do not rely on clearly specified roles, but in a more lax organization where the overlapping of responsibilities reinforces the idea of shared design objectives.

The specific characteristics of Design are better understood when identifying that process as an activity, following the approach of Activity Theory. When several designers collaborate, the communication between them plays an important role. It is a tool used by the subjects that perform the design activity towards a shared objective. Communication is not a complement for the activity: it is a structural part of it.

Another point is that the shared object of the design, the target, is not a static element: it evolves through time. When designers agree that an object is reached, it usually becomes a tool towards the next step, a new tool for a new object or objective. This is clearly understood for example when the Outline Design (the object of the first stage of the activity) is finished and architects face the Detail Design. In this case that Outline becomes a reference tool for the new object.

That implied instability of the Design Activity allows us to metaphorically assimilate it to a dynamic system. In this study, we will not try to apply the conclusions and the predictive character of the mathematical Theory of Dynamic Systems. However, this assumption does not prevent us from having a creative approach: I will propose a model of architectural design activity based in a metaphoric understanding of Dynamic System concepts. The system must

be understood under the following terms:

- What are the elements of the system?
- Is it a fluid or a discrete system?
- How is the time evolution of the system?
- Are there any concepts like sensitivity to initial conditions, instable trajectories or bifurcations that may be recognized?

### **Field Studies**

For understanding how the collaboration of designers works nowadays, five workshops were conducted: 3+1plateaus, Arrecife, Paperegg and 2RIOS as professional design activities, and ViReTi, an academic exercise of distant teaching. For the sake of clarity, in this dissertation only the last two professional activities and the academic exercise will be presented in detail. Paperegg was carried out using a Project Specific Web Page, 2RIOS was e-mail based, and ViReTi was a distant teaching project where real-time tools were used.

10 points can be summarized from the outcome of the field studies:

- 1) A specific system is needed to foster remote collaboration.
- 2) Instead of reinventing existing tools we should focus on the deficient ones.
- 3) It must have a clear browser for the information.
- 4) The connection has to be fast.
- 5) Provide minutes and on line discussions.
- 6) E-mail did not encourage collaboration.
- 7) It is useful a web based repository for design data and communication.
- 8) In the first stages of design, images were the main support for concepts.
- 9) Images need to be complemented with immediate comments on the subject (speaking images)
- 10) Focus in non real time tools, in order to complement and improve the present-day schema.

### **System Development**

The main feature to support collaboration in architecture is to know *who* is doing *what*, and *when*. Remote collaboration has to be supported by understanding teammates actions, by having immediate access to the information, and also by the discussion of ideas.

The developed system is an asynchronic communication device. Specifically speaking, it is an Internet accessible relational database where you can navigate through a three-dimensional environment. It was developed in three stages: 3DCDVisual as pre-alpha version, and MultiDCD<sup>+</sup>Visual as alpha and the current beta versions.

The software is an interface for a relational database accessible

through Internet. The application was entirely built in Java programming language (Java Development Kits 1.4 and 1.5 and also the 3 dimensional plug in Java3D 1.3). The software is a standalone application, but it supports the possibility of being embedded in a Web page (html file) as an Applet.

The relational database used for this research was an Oracle9i Database, programmed using SQL language inside the Java code, with the use of the Thin driver for the Java - Oracle communication. Oracle Database manages the Internet traffic through the Oracle Net utility, as part of the package of the database management system.

The main purpose of the software is to serve as the main communication device during the design process. It acts as a centralized warehouse for the files and images produced, and at the same time it manages in a flexible fashion the flow of information.

The information and its changes during time are arranged in a three-dimensional environment. The location of files is a semi automatic process, where the user has a great degree of flexibility. For this reason, the system is able to support diverse approaches to the design, without imposing any constraints for the development.

The information produced during the design activity is displayed following a sorting method based in a genetic algorithm. The purpose of the arrangement is not to search for the data by names or key words, but to be able to look immediately into the images. This is inspired in the way students hold their drawings in the walls during studio review sessions, and in the way professional practices were arranged in the past, where the main architect used to walk by the drawing tables looking directly into the working process without mediation.

The project is presented with images (speaking images) and users (spheres as speaking entities as well). This is, as entities able to show comments and messages when picked. They are arranged in the project universe showing the history of the process, conforming a 3D model of the design activity.

The navigation system allows users to approach to the design process from multiple perspectives. 3 main scales can be recognized:

Whole project level: In a panoramic of the whole project, the main trend of the design process with the number of users, ideas and the discussion of them can be recognized.

Local area interaction: A closer look into idea lines or groups of 4 or 5 ArchiPacks show the evolution of a proposed idea in the short range.

Image level: The closest approach to an image. At this range, is possible to navigate each file by clicking the colored covers of discussion and also commented areas inside the image, retrieving all the information available in an ArchiPack.

MultiDCD<sup>+</sup>Visual is the final name of the tested version of the system. It contains all the features introduced in the previous release, but includes several radical improvements that projected the possibilities of use of this system beyond expected requirements. The formal complete name changed to Multi-dimensional Communication Debate Visualizer.

The new configuration allows the introduction of new dimensions to the project, besides the 3 default ones (Ideas, Level Of Detail and Timestamp). A new dimension can be created at any time during the project. The multiplicity of dimensions ensures the possibilities of the system to foster the design process over all the stages of the project, until its finalization.

### **System Evaluation**

For the evaluation of the system, a design exercise was proposed in two different environments. First in a professional workshop and then in a distant teaching activity.

Cyber-Contemplation pavilion was the selected theme to foster imaginative projects. For the first proposal, the same professional team of 2RIOS was gathered again for a professional design activity. The second workshop was conducted as a continuation of the ViReTi project, a distant teaching activity.

The general evaluation of the performance of the system was very positive. The system supported the collaboration of designers as a professional activity, and also as a teaching activity. The proposed tool supported the activity under an easy-to-understand, friendly three-dimensional environment that fostered the exchange of ideas and information through the World Wide Web.

Filter utilities and the aspects related to speed connection can be pointed as features for redevelopment or redesign, depending on the final object of the system. In a similar direction, the possibility of implementing real-time contacts may be targeted in future developments.

### **Conclusions**

From those results it is possible to conclude that this investigation, based in a constructive research for system design, provided an innovative instrument in the field of architectural design. This instrument supports remote design through Internet, managing and facilitating the design activity, and capable of supporting it in all scales and stages of design. Based in the accountability of the process at a glance, the system interface provides a good understanding of the designers' interest or preoccupations, fostering the communication between participants. At the same time, it alleviates the searching of information, through a sorting algorithm that results in an easy to understand interface.

Regarding future research, the 3D model of the design activity that the software produces could be analyzed. From there, the laws that rule the architectural design could be inferred. Those rules would be the basis for a solid structure that will reinforce the management of projects and the teaching /

learning activity in the architecture field.

Following a similar line, another course for future research is the construction of a network of design. This network should be organized as a distant teaching project based in the use of the MultiDCD<sup>+</sup>Visual among several universities. By these means, professors can be able of leading studio-type courses abroad without being obliged to travel continuously. And conversely, students can experience new didactics in their home universities.

This dissertation pretended to construct new tools, both practical and theoretical, for the developing of design methodologies in general, and for remote collaboration of designers in particular. More than a final treatise on the subject, it must be considered as a stepping-stone.