PARTICIPATORY DESIGN IN COLLABORATIVE VIRTUAL ENVIRONMENTS

Jelena Petric, Giuliana Ucelli, Giuseppe Conti
ABACUS, Department of Architecture, University of Strathclyde, Glasgow, UK
j.petric@strath.ac.uk , giuliana.ucelli@strath.ac.uk ,
giuseppe.conti@strath.ac.uk

Abstract

This paper re-establishes the theoretical framework for participatory design evolved in the late sixties and early seventies as part of the movement towards a more explicit design methodology and attempts an explanation of why the concept failed to gain commitment from the architectural and urban design professionals. The issue of user participation in the processes of building and urban design is enjoying renewed attention following its relative neglect over the last 20 years due, in large measure, to significant advances in emerging information technologies, particularly multimedia, virtual reality and internet technologies.

This paper then gives an account of two significant and relevant developments in the evolution of the application of information technologies with which the authors have been engaged. These are:

a responsive and interactive interface to wholly immersive and realistic virtual reality representations of proposed buildings and urban neighbourhoods.

an intuitive and platform-independent VR modelling environment allowing collaborative evolution of the scheme from within the virtual world.

The efficacy of these IT developments is tested in the context of a design exercise in which three designers, from distributed locations and using different computer platforms, collaboratively design an Information Centre from within the virtual world.

Resumo

Este trabalho restabelece uma estrutura teórica de projeto participativo originado no final dos anos 60 e início dos anos 70, como parte de um movimento direcionado a uma metodologia mais explícita de projeto e busca uma resposta para as razões do seu fracasso para a obtenção de um envolvimento maior dos profissionais das áreas de arquitetura e desenho urbano. A questão da participação do usuário nos processos projetuais arquitetônicos e urbanísticos está tendo uma renovada atenção após a relativa rejeição dos últimos 20 anos. Este fato deve-se, em grande parte, a avanços significativos em tecnologias da informação emergentes, particularmente multimídia, realidade virtual e tecnologias ligadas à Internet.

Assim, este trabalho pretende demonstrar dois desenvolvimentos significativos na aplicação da tecnologia da informação nos quais os autores estão envolvidos:

uma interface sensível e interativa, completamente imersiva e representações realísticas de realidade virtual de edifícios e áreas urbanas.

um ambiente de modelagem de Realidade Virtual, intuitivo e para múltiplas plataformas, permitindo a evolução colaborativa de um projeto a partir de um mundo virtual.

O impacto destes desenvolvimentos de TI é demonstrado a partir da realização de um projeto de uma estrutura de lazer para uma comunidade de usuários com deficiências físicas.

Design Decision Making

Architectural design is a multi-faceted occupation which requires, for its successful performance, a mixture of intuition, craft skills and detailed knowledge of a wide range of practical and theoretical matters. It is a cyclical process in which groups of people work towards a somewhat ill-defined goal in a series of successive approximations. There is no 'correct' method of designing and, although it is recognised that the process can be divided into separate phases, there is no generally accepted sequence of work that might guide design teams in the direction of achieving a satisfactory solution. Indeed, there are no solutions to design problems in the way that there are solutions to mathematical problems: the best that can be hoped for is an outcome which satisfies the maximum number of constraints which bound the area of concern. Furthermore, design is not an algorithmic process in which the desired conclusion can be reached by the application of step-by-step procedures - first finalising this aspect, then that. It is a fluid, holistic process wherein at any stage all the major parts have to be manipulated at once. In this sense, it is less like solving a logical puzzle and more like riding a bicycle, blindfold, whilst juggling.

Despite the complexity of the design decision-making process the emerging new generation of computer-based models is already having an impact on how design is performed and, hence, on the quality of design. The impact stems from the fact that the new models, as opposed to paper-based plans and elevations or other

conventional forms, are predictive rather than descriptive; dynamic rather than static; explicit rather than implicit and, above all, permit a more-or-less continuous and interactive assessment of a developing design on cost and performance.

Evidence is growing of the advantages offered by the application of computers in design, and these can be summarised as follows:

Widening the Search for Solutions

Access to programs which dynamically predict the cost and performances characteristics of optional design proposals can increase the scope of search for good solutions by as much as ten-fold. Not only is the search coverage extended, it is also more purposefully directed because designers are able to compare the quality of any one tentative solution against the quality of all previous solutions.

Greater Integration in Decision-Making

In conventional working, a great deal of design time is lost as proposals are passed to and fro between the architect (who tends to be the originator) and the other specialist members of the design team (who tend to the "checkers"). Quite frequently the scheme on which the architect has lavished time and effort is found by one or other of the specialists to be infeasible. With access to appropriate appraisal techniques embodied in computer programs, it is possible to check a proposal against a wide range of criteria from the outset of the design activity. Moreover, it is entirely practical (though not yet a widespread working method) for all members of the design team to have access to, and operate on, the common design model whether or not they share a design office. The models, then, can provide a strong integrating force in design team working.

Improving Design Insights

Apart from the use of appraisal programs to search for better designs, the programs can be used in a research and development context to provide insights into the way in which particular design decisions affect cost and performance. Typically, a designer working in this mode would select an existing building for study, then, keeping all other design variables constant (insofar as this is possible), systematically vary one factor while recording the cost/ performance output from the program. In this manner, the architect can establish sets of causal relationships which provide powerful insights into structure of design decision-making.

Differentiation of Objective and Subjective Judgements

Contrary to the early fears of many architectural practitioners, the use of CAAD techniques focuses increased attention on subjective value judgements rather than less. As measurable attributes of optional designs are made more explicit, the necessary value judgements are forced to the surface of design activity and thereby, themselves become more explicit. The effect of this is to make it clear to designers and their clients, which judgements are based on quantifiable criteria and which on subjective and intuitive concepts.

Evidence of the degree to which computer-generated cost/ performance information promotes effective value judgement, throws into sharp focus the crucial question: **whose** value judgement? This question was, for the first time, seriously addressed in the Design Participation Conference in Manchester in 1971. At that time, however, the human-machine interface was too primitive for the concept of useful participation by the users of buildings to be achieved. The new technologies of VR and Multimedia give real prospects for participation.

Virtual Reality

The essence of Virtual RealiyÈ (VR) is that the user, instead of looking through the window of his/her computer screen at a virtual world, can in effect, step through the window and enter the virtual world itself. This enhances:

Immersion: Users are completely surrounded by the environment.
Presence: Being surrounded the participant has actually the sensation of being ***in*** the environment. The Virtual Environment becomes then a place on its own and its perception is similar to real environments.
Interactivity: This is surely the most important ***feature*** provided by VR: the environment allows the participant to be involved and the result of the actions done by the participant is visualized in the VE.
Autonomy: Participants are neither constrained in paths nor in views preset by others but have the freedom and autonomy to explore any single part of the environment.
Collaboration: Multiple users are able to take part and to interact in the same VE.

The effectiveness of VR for the ***presentation*** of design proposals is well established but its potential in the ***process*** of design has yet to be realized. However the speed at which technology is evolving is making the application of VR within the design professions a feasible approach. AEC companies have already started to evaluate how time consuming the traditional presentation path can be where animations or walkthroughs are used to show designs solutions to their clients. In fact traditional CAD/CAAD systems are used as rendering tools more than design tools. Any change on design solutions is subject to the inevitable delay of having to step back to the CAD/CAAD systems and then the result must be rendered again to be eventually visualized. This approach is obviously not only inconvenient but time consuming and therefore costly. The consequence of these issues is that some design and manufacturing companies have already started to investigate how VR can be used within the design process. The research and development reported in this paper hopefully makes a signal contribution to this investigation.

The JCAD-VR Concept

In the Department of Architecture and Building Science at the University of Strathclyde, the ABACUS group has been building a prototype design decision support system known as JCAD-VR.

The system can be initiated in single mode or multiple screen mode. Single mode is set for the display device which consists of a standard computer screen; the multiple screen option has been included to allow devices such as the multi-projector display system processing the visual output of a Reality Centre which was used for the experiments.

In this phase it is also possible to activate or de-activate video conferencing facilities for the session. In instances when video conferencing is activated, support for video capturing device recognition and checking is provided. JCAD-VR provides also a stand-alone option in case collaboration is not required.

Once the system is initialised every window disappears freeing the space for the 3D graphic user interface (GUI) of the system. A set of 3D menus and icons appear on the screen and through them each user can interact with the system and with the other participants. A number of functions can be accessed through these menus, such as navigation and creation of objects. A number of 3D shapes and 3D AEC objects can be created and shared with other participants. The objects created can be following: geometric primitives (cones, boxes, spheres etc.) and architectural entities (walls, doors, windows etc.). The system routinely checks for constrains and allows only the possible modifications; for example a door cannot be moved onto or too close to another door. A "3D ruler" and a 3D panel close to the object are constantly providing the user with feedback related to the parameters which can be edited such as size, materials and cost.

The architecture of the system (Figure 1) has been developed to allow every object created in the system to be assigned with a unique id-number. The ID is a combination of local ID and a user ID assigned by the server. In this way each object is attributed a unique number consistent for all the users in the system. When any object is selected by the user, this object is ***locked*** and such event is sent through the network to other users. Every time the user is about to modify an object this is checked against a network lock mechanism. This mechanism controls that several participants are not editing the same object at the same time and is designed in order to ensure consistency throughout the system. The system notifies every user internal database of any creation or modification of geometric objects within the virtual scene and broadcasts their numerical information.

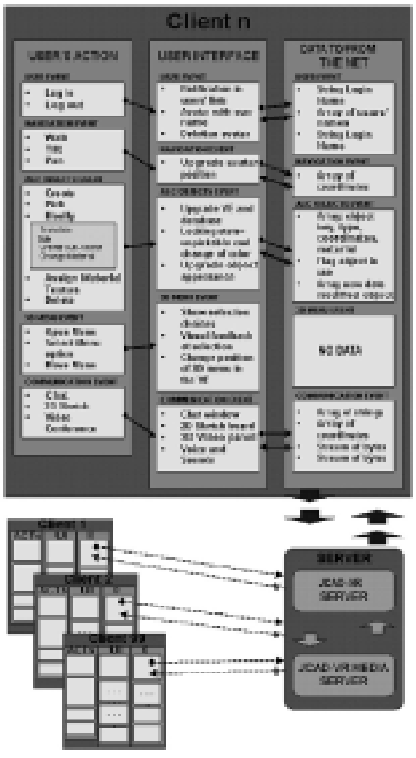

Fig 1 - Client/Server Architecture of JCAD-VR

To ensure communication between users, represented in the 3D world by avatars, different means are provided, from basic chat to voice and video conferencing. Freehand sketching in 2D is also possible through a shared electronic whiteboard. This architecture allows a real synchronous collaborative design making designing a true multi-user collaborative experience.

Fig 2 - An Image of JCAD-VR

Collaborative Experiment

The obvious first line of inquiry regarding the usability and usefulness of the emerging system was in the academic environment within which it had been created. For the past three years, the academic with overall responsibility for CAAD teaching had offered an optional class, to fourth year students (and to students from less senior years with exceptional commitment and skills in CAAD) in the design application of innovative VR technologies. In Session 2001/2 three of thebstudents taking the class were introduced to JCAD-VR and invited to put the system to its first serious test.

Students Christoph Ackermann, Ross Marshall and Edward Wright were located, each with an appropriate workstation, in three different areas within the Department of Architecture, with fixed and hand-held video cameras covering the actions and observations of the students. Over the two-hour design session, the three students were invited to design an information centre in a public square and in a given urban context of Glasgow. The introduction to the project and to the specifics of the interface to JCAD-VR lasted a mere 30 minutes. This meagre introduction was purposeful and intended to test how intuitive (or not) the system was.

The in-house experiment was a revelation to the authors of this paper. Over the two-hour design period there was:
Fast and furious interaction amongst the three design participants within the common design environment; some 60/70 design scenarios were commonly generated, modified and agreed.
Both satisfaction and frustration amongst the participants was noted regarding the high degree of mutuality in the interactive process.
A real sense of having experienced a wholly immersive and shared design experience which heralds a future way of exploring and determining the configuration of the built environment.
Screen shots from the experiment are shown in Figure 3 and a frame from the video is shown in Figure 4.

Fig 3 - Screenshots from the Experiment

Fig 4 - Pictures from the Experiment

Conclusions and Further Developments

The prototype JCAD-VR system makes some steps toward the change of VR usage from mere presentation medium to a more powerful and effective design tool, and establishes the feasibility of VR becoming the interface for the next generation of computer aided design (CAAD) applications for architecture. Several enhancements are being considered for further development if the system including:

A voice driven interface enhancing friendliness of the user interface

Support for driving devices such as 6-degrees of freedom virtual glove

Implementation of a multi-environments server capable of dealing with multiple VR environments simultaneously.

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