Spaces Meet Users in Virtual Reality

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ABSTRACT: In this paper, we present outcomes from Finnish HospiTool project that introduces an interactive user-oriented approach to health facility planning, construction and renovation. Tools were developed that enable end user participation in the planning through evaluation of hospital spaces in order to match the spaces with user needs and requirements. The plans were first presented by making use of new visualization technologies. Solution for 3D model embodies two virtual reality environments - Computer Aided Virtual Environment (CAVE) and in VTT's Lumeviewer, a lightweight visualization client for personal computers. Then the user feedback was developed to be user requirements in EcoProP systematic requirements management tool. The feedback from Virtual reality was also compared to interviews in existing hospitals. Evidence Based Design (EBD) has considered in this research.

1 INTRODUCTION

The project started after a roadmap that clearly showed a need to take end-user opinions into account as early as possible when designing hospitals and its processes. Also tool supporting decision-making was as well among money decision makers as well among other stakeholders involved in planning spaces and processes.

In conventional design process the goal of a designer is to satisfy paying client. In other words, the designers take into account owner perception and match end-user needs complied with orders from authorities. Therefore, relatively clear relationship exists between designers and paying clients, but this can leave important gaps in understanding between the clients and the end-users and between the designers and users (Barrett and Stanley 1999, page 60). Regarding this gap, bulk of the research in construction industry is allocated to design process but true interaction towards end-users has remained as a rather unexplored research domain.

User-centric approach has gained more emphasis in the academia during the last decades. Especially in hospital environments, user feedback has indicated that physical environment has a lot to be improved to be a healing environment for patients and a motivating work place to staff.

Great potential exists in user-centric approach. In Finnish hospitals the experiences have showed that three-year period of hospital use equals facility construction costs. Therefore, it is justified to argue that end-user viewpoint should be recognized comprehensively in the design process.

User-Oriented Hospital Space (HospiTool) project is a joint project by the Technical Research Centre of Finland (VTT) and the National Research and Development Centre for Welfare and Health (STAKES). A parallel project is run by Finpro. The project involves the hospital districts of Southwest Finland and South Ostrobothnia, and currently also three companies: Abloy Oy, Väinö Korpinen Oy and Pöyry CM Oy. In addition, the project is also closely connected to educative purposes, and collaborates with North Karelia university in Seinäjoki and Turku University of Applied Sciences.

Project is carried out within FinnWell program of Tekes (Finnish Funding agency for Technology and Innovation). The program lasts until end of year 2008, and has an emerging objective to developing operational processes of healthcare. There is clearly a need to take end-user opinions into account as early as possible when designing hospitals to support better the related processes.

2 OBJECTIVE

How well do spaces support processes within the spaces like patient room in hospital? We have explored answers to earlier question in HospiTool project. We started to find new concepts for end-user participation using state of the art visualization technology, virtual reality (VR), and compare created

virtual model to real environment experiences through interviews. We have developed virtual reality solution from three-dimensional architectural information. Solution provides as natural as possible feeling for communication process with end-users.

3 APPROACH AND METHODS

This paper introduces an interactive user-oriented approach to health facility planning, construction and renovation. The results are outcomes from HospiTool project, where tools were developed that enabled end-user participation in the planning and evaluation of hospital spaces in order to match the spaces with user needs. Then, user needs were formulated to user requirements and outcomes have been managed in VTT's EcoProP software for systematic requirements management (Fig1). Defined set of user requirements were evaluated in virtual reality by making use of new visualization technologies.

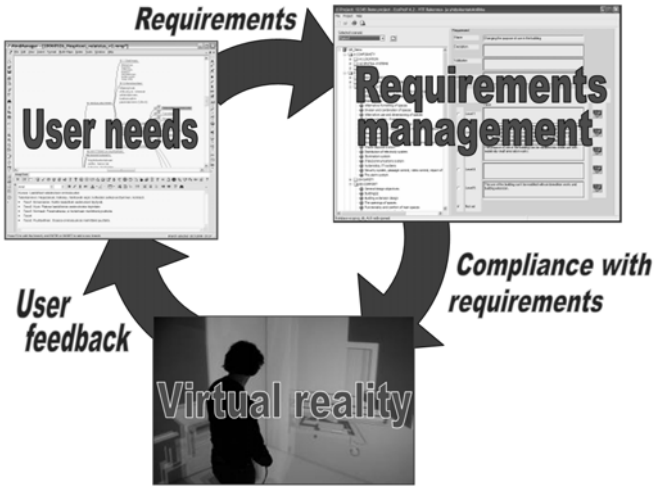

Fig 1: Research approach consisting from capturing user needs, managing user requirements and evaluating compliance of requirements in virtual reality.

We used EcoProP software to capture the requirements systematically. Software is designed for developers, owners and consultants, to help capture needs at the early stage of project. Typically tool is utilized in team sessions for developing common targets to design team. EcoProP comprises standalone application to database, and provides an easy-to-use user interface to information. It can be used for both new construction and renovation projects, and also for benchmarking purposes.

Realistic surface materials and lighting were simulated using texture mapping and radiosity methods. This was done to catch the most natural feeling in the 3D model. The developed 3D model was used both in the Computer Aided Virtual Environment (CAVE), see Fig2, and in VTT's Lumeviewer.

The CAVE was in the facilities of the School of Information and Communication Technology at the Seinäjoki University of Applied Sciences (SeAMK).

The CAVE is based on a cluster of computers. It had five rear-projected walls in a cubic arrangement, covering the user's entire field of view. Digital light processing (DLP) projectors were used to display a stereo image on each wall, giving a three-dimensional view through shutter glasses. The user was tracked by the Flock of Birds magnetic tracking system from Ascension Technology, allowing them to move around in the model (within the physical bounds of the CAVE room). In addition to this, a joystick-like wand could be used for moving longer distances.

Fig 2: View from patient tool in CAVE.

The Lumeviewer is 3d "lightweight 3D visualization Client" for personal computers developed in VTT (Rönkkö and Markkanen, 2007). The software is coded on the top of the OSG (open scene graph) core, and system consists of pc with dual graphics card, stereo projector, shutter glasses with IR synchronization and a semi-transparent screen. When person stands about 1 m away of the screen, the view is almost 1:1 scale trough shutter glasses (Fig3).

Six patients from a rehabilitation ward and an acute ward of the Health Centre of Seinäjoki and from a neurological rehabilitation ward of the Seinäjoki Central Hospital were interviewed in the CAVE. They were aged from 56 to 83 years (mean age being 76 years). Four of them were women and two men. Patients were selected by nurses of those wards to ensure that they would be fit enough and capable to communicate in a new environment.

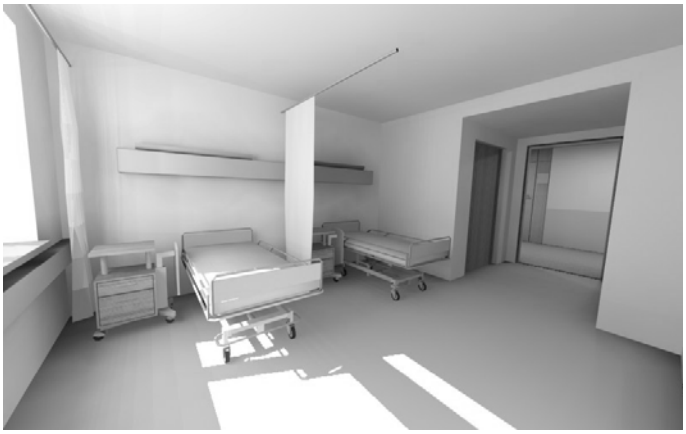

Fig 3: Rendered 3D view from screen view in Lumeviewer.

Also six nurses were interviewed in the CAVE. Their mean age was 38 years. They were all women. Most of them had work experience of nearly 20 years, only one had been working in hospitals three years (average 10 years).

4 USERS VISIT THE VIRTUAL REALITY

The term Virtual Reality is used to describe applications in which we can interact with spatial data in real-time (Whyte 2002, page 3). VR is an experience in which a person is "surrounded by a three dimensional computer-generated representation, and is able to move around in the virtual world and see it from different angles, to reach into it, grab it, and reshape it (Cruz-Neira et al. 1993). However, in the design process it is important to distinct the term from structural building models, such as models developed with CAD tools, containing also parametric information about the actual building components.

Virtual Reality, as a medium, has three defining characteristics: it is interactive and users can interact with models, the models are represented in three spatial dimensions, and feedback from actions is given in real-time (Whyte 2002, page 3). Systems are supporting this interactive, spatial, real-time medium with the computer hardware and software through interaction devices. At high level those systems may be classified as immersive, non-immersive and augmenter reality systems (Whyte 2002, page 4).

We used CAVE based virtual reality for user visits, nurses and patients, together with a designer or an interviewer. The nurses performed a detailed walkthrough in 4 different patient room concepts and discussed with a hospital design nurse (Fig4).

The discussions with nurses focused both work processes and space related matters. The visit took typically about one hour. Only a few nurses did have mild simulator sickness day after the session.

The Patients were in this case very old, almost all of them sitting on a wheel chair or ordinary chair during the visit. The pre design interview was done by social psychologist repeating the same pattern every time. Because the age (about 80 years median) of the patients in the interview was high, psychologist was prepared to stop in case patient request. Only one of the interviewed patients was not visiting all of the 4 rooms. Most of the patients were happily commenting the virtual rooms like being in one even trying to "knock on the table".

Fig 4: The Patient interview in the CAVE.

5 REQUIREMENTS MANAGEMENT

Descriptions of technical solutions are currently guiding the design phase and space layout is often fixed too early in many cases. Architects first space layout proposal often leads to alternative design solutions whereas they should be inherited from activities taking place in the building, especially in hospitals. Therefore, aforementioned process ends up to lost value for user, although turnover improves when customer expectations are fulfilled (Lindkvist 1996; Smith et al. 1998).

Requirements management tools aim to provide applicable and updatable information for following project phases. In order to attain this, the user requirements need to be captured as a first target of requirements management. Since it is impossible to satisfy all needs of all stakeholders for various reasons, the second target is putting the separate user requirements together. Compliance of design with the requirements should be verified constantly during the project, in particular to eliminate contradicting requirements. It is difficult to judge the relative importance between the requirements. The last target of requirements management is to ensure that results lead to desired results.

One of the drivers for the performance approach implementation in Finland has been EcoProP soft-

ware in Fig5 (EcoProP 2008). Tool is used to create design brief that includes set of objectives how the building should perform in use – defined as requirements. Theoretical framework in EcoProP software leans on hierarchical management of requirements. Individual requirements are described with the help of five pre-set target levels that can be expanded to cover also comments from design session where requirements are set.

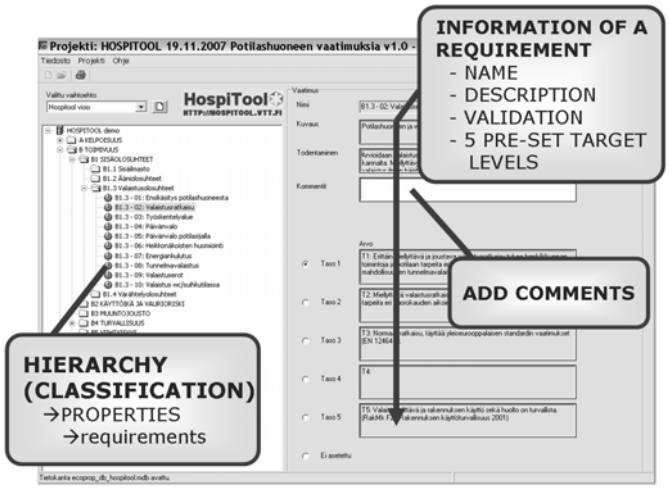

Fig 5: User Interface of EcoProP systematic requirements management tool.

System also has functionalities to evaluate rough life-cycle costs (LCC), and corresponding life-cycle analysis (LCA) impacts, based on requirement levels between to support decision making. Further, it is also possible to perform alternative design comparisons to compare various design options.

6 INTERVIEWS RESULTS IN VIRTUAL REALITY

During the interviews, patients were asked to express their opinion as freely as possible on following features of the patient rooms in the CAVE environment: colours, lighting, furnishing, surface materials, room size, placement of windows, and pleasantness, aesthetics and functionality of the room in general. They were also asked if they would like to change anything in the environment.

In the end of the interview the patients were asked how they felt about being in the CAVE, how real the experience of being inside a patient room or bathroom was, and did they have any unpleasant feelings whilst being inside the CAVE. The interviews were recorded and videotaped and analysed using Atlas.ti -programme.

Following subjects were discussed by patients in the CAVE:

- colours
- windows
- surface materials
- other patients (good company)
- furniture, paintings, TV etc. (size, form, placement)
- room size.

A few subjects were NOT discussed in the CAVE though they were discussed in the parallel study performed in the three wards. These subjects include:

- air conditioning
- temperature
- noise
- height of the thresholds
- thickness of the grab bars in bathrooms

The reason was that these issues did not 'exist' in the CAVE environment or they were stable. Interesting is that one of the patients reckoned that thicker grab bars would have been better in the bathroom, although it was not possible to feel the thickness. Another patient tried with his feet if the floor was slippery. A few of the patients found it difficult to evaluate the size of the room or to compare one room to another room.

It might not be possible to evaluate perfectly issues relating to room size, furniture and moving in the CAVE but on the basis of respondents' behaviour it can be estimated that the CAVE produced a strong illusion of being inside a modelled room. Clearly it was much easier for them to express their opinions during a visit in the CAVE than on the basis of reading documents such as architectural drawings.

Generally, all respondents expressed either that evaluating rooms in the CAVE was a positive experience or that at least it was not a negative experience.

7 DISCUSSION

Making use of virtual environments gives a possibility to provide planners and designers with increased understanding of user experiences. Systematic requirements management is enhanced by true dialogue and it is relatively easy to produce and compare various design options in an early planning phase.

The HospiTool process was successful in creating a platform for development of user-driven innovations in the operating environment: process innovations for healthcare and product innovations for industry. Ultimately, the main objective is to develop a generic concept for inclusive design: to make spaces support processes within the spaces. The evidence based design (EBD) is also taken into consideration in the concept.

Conventional construction process is mainly production driven although buildings should be made

for users. Requirements management is targeted to increase products value. It's obvious that human and organizational questions need more attention than technical aspects with the analysis of client's needs (Lindkvist 1996). Open and transparent communication amongst the parties involved is emphasized.

Construction and real estate industry is currently experiencing a paradigm change towards increased use of Information Technology. Building Information Modeling (BIM), that is one of the drives of the aforementioned paradigm change, is an approach to design, construction, and facility management in which a digital representation of the building process is used to facilitate the exchange and interoperability of information in a digital format. Further, this paradigm change is also an enabler for the next step that involves also taking users into the design process as active participants.

During last decades Evidence Based Design has challenged the conventional hospital design arguing that by improving physical environment hospital facilities would be healing environment for patients, better places to work for staff and attractive environments to visitors supporting patients to heal. Much of the EBD research is covering issues reducing stress induced by poor environment such as lack of natural light, lack of positive distractions and noise.

Especially the issues tested by interviewing patients in CAVE have been often rejected in conventional hospital design. Thus the findings of this research support the importance of development of methods for user involvement in hospital design process. Many of those features are not possible to experience through traditional design methods and processes. The CAVE environment is a useful tool for feedback from users and there is a great need for developing it further.

The project has already been creating a real feedback from end-users (both nurses and patients) to the new hospital building which is in the planning phase. The further project is starting and it is planned to support one hospital planning only. The different stakeholders (architect, bathrooms deliverer, door deliver etc) are participating the project as well as planning it.

8 ACKNOWLEDGEMENTS

One of the authors, Janne Porkka, is doctoral candidate in Helsinki University of Technology.

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