3D Visualization of Building Services in Virtual Environment, Phase 2

Abstract

In 2000 a one-year project called BS-CAVE was started. The results from that project were successful, and this paper describes the plans for a new project (phase 2) in which the research is continued as already planned in the original project (phase 1) proposal. The research is conducted at Helsinki University of Technology utilizing the experimental virtual environment EVE. The main objectives of phase 2 include integration of spatial audio to models, further development of interaction techniques and transmission paths, and visualization of non-visual building services information.

Background

Helsinki University of Technology has since 1997 had a virtual room called EVE. Currently the EVE has stereo projection on three walls. In addition it has state of the art 3D-audio system. The EVE offers possibilities to present and study different models and rooms. Research affiliated to this virtual environment has been conducted on virtual acoustics, scientific visualization, and animation.

Virtual environments are extremely well suited for presenting architectural models and spaces. Studying different construction possibilities in a virtual environment (VE) will be both faster and cheaper than building a model room or a mock-up. Most of the existing international VE setups in the building sector are used for architectural models. Visualization of the building services systems in virtual environment is less usual.

The project phase 1 lasted one-year, and used 30 man months to achieve following results. The main results from project phase 1 were:

1. Transmission path of lighting visualization models to virtual room has been specified

2. Successful integration of flow data and photorealistic models

3. The navigation methods adopted in the project are clearly better than those used previously.

These results have been presented at Nordisk Belysning 2000, and The Engineering Reality of Virtual Reality 2001 conferences. In addition the project phase 1 has been presented in VR-SIG Finland seminar (November 2000). Several participants of Healthy Building 2000 conference visited the EVE in August 2000.

Objectives for the project phase 2

In project phase 2 the main objective is to further develop methods and techniques for visualizing building services in 3D virtual reality environment. This will both accelerate the visualization of data and offer possibilities to study information in many ways that has not been possible before.

The project phase 2 is divided into following partial objectives:

1. Integration of photorealistic models and spatial audio, i.e. increasing the plausibility of virtual environment by adding arbitrary sound sources and room acoustic modeling to the models.

2. Development of new interaction techniques appropriate for visualization of building services in virtual environment.

3. Visualization of varied non-visual building service information in photorealistic room.

4. Further exploration and development of transmission paths.

Integration of spatial audio

Integration of spatial audio will enhance the sense of presence and realism of the model. The main development in spatial audio is to represent the noise generated by ventilation. Also other sources of noise (for example computers or other machinery) are studied.

This work is based on previous research made at Helsinki University of Technology (HUT). In this project our goal is to study how arbitrary sound sources, such as ventilation noise, can be positioned in arbitrary locations in a virtual environment, and how it affects the plausibility of the system. This is enabled by our high quality audio reproduction system containing 15 loudspeakers and a subwoofer positioned around the virtual room.

At HUT we have made lots of research on room acoustics modeling and real-time auralization. By auralization we mean making the room acoustics audible. In BS-VE we study integration of basic room acoustic modeling and auralization to these models. In the project we are not going to develop the acoustic modeling itself, only integration of the existing techniques to the cases in BS-VE.

Interaction

During the phase 1 of the project it was found that in addition to navigation there is also need for another kind of interaction with the model. Foe example, it was found, that there is a great need for easy comparison of different lighting solution visualizations. As another example, at the moment the flow visualization methods are controlled by keyboard, and it was found to be impractical. The basic interaction tasks we are dealing with are (1) navigation, i.e. moving around the model, and (2) manipulation, i.e. affecting the model itself. In BS-VE project we are going to research both of these.

In our work we are going to concentrate on finding novel ways to apply existing devices instead of developing own hardware. In phase 1, work with navigation was started and new techniques were found, and preliminary user tests were done. In phase 2, this work should be finalized.

During the project phase 2 we will develop methods, which allow users inside the virtual room to control the visualization using proper interaction devices and methods. In addition we will investigate possibilities to provide accurate numerical values of interesting variables (such as lighting solution data and building services' product information) during the model exploration.

Our current system includes a magnetic tracking device, two datagloves, and a radio mouse. During phase 1, we noticed that in typical cases use is inconvenient due to the large number of wires (each dataglove and sensor has its own cabling). In phase 2, we try to find reasonable solutions for this problem.

Visualization of non-visual information

In addition to flow visualization there is a lot of other non-visual information included in building services models and databases such as photometric values, indoor air quality indices, visual field parameters and magnetic fields. Integration of this information with photorealistic model is one interesting research area. In phase 1, we applied VTK toolkit in visualization, which was found suitable for the task, and it provides excellent tools also for visualizing wide variety of other kind of datasets.

In phase 2 we have two research aims in this area. First, the amount of data in a typical model is very large. Therefore we need tools for reducing that, thus enabling more accurate exploration of data under interest. For exploring these multivariate models, we will investigate

the usage of Magic lenses. The preliminary research of this tool has been presented in Hannu Naparis Master's Theses.

The second aim is finding new visualization techniques for the non-visual information obtained from the models. This can also include sonification, i.e., making the dataset audible. Researcher Matti Gröhn has worked several years in this area.

Transmission paths

During the phase 1 of the project we have determined transmission paths for lighting solutions, and flow data. There is also other information that need own transmission path. Unfortunately each new data needs its own path. On the other hand current transmission path from photorealistic 3D-models to virtual room is far away from optimal, and automatic. These both aspects need further development to ensure more effective and practical virtual tool for building services industry.

At the moment it takes roughly from one day to one week to import a new model into our environment. This time should be reduced such that in a typical case model import should take two hours, and it maximally takes one day supposing the model fulfills our specification of the data format.

Exploitation of results

The participating companies can present the results of the project to their customers in HUT virtual room during project (max. 5 projects/company and 20 presentations/company during the project). The new visualization techniques developed in this project offer new possibilities for the building services industry in marketing, product development and design.

The research results will be presented in international conferences. Conferences of both research areas: construction and computer science will be covered.

At the end of the project we should have a system in which a partner can bring his own model to our virtual environment, such as CFD data. The model can also include arbitrary sound sources that can be located in the virtual environment. For all these we provide usable navigation and interaction tools, and finally we should be able to make all this with reasonable costs, such that importing a new model takes only a couple of hours.

The organization

Associated to the project from HUT are the following people:

Lauri Savioja (responsible director)
Markku Mantere (project manager)
Matti Gröhn, researcher
Iikka Olli, research assistant
Jukka Rönkkö, researcher
Seppo Äyräväinen, researcher

The company parties and contact persons are following:

1. Oy Halton Group Ltd. / Kim Hagström
2. Insinööritoimisto Olof Granlund Oy / Tuomas Laine
3. Lighting manufacturers / Sanna Forsman
4. YIT / Jarmo Laitinen
5. Senaattikiinteistöt / Auli Karjalainen

Lighting manufacturers consists following partners:

Fagerhult / Markku Varsila, and Luxo Finland / Mikael Åkers.

The budget and schedule

The project phase 2 begins at 1.3.2001 and ends 28.02.2003 (2 years)

Estimated total costs (in 1000 FIMs)

	First year of phase 2 (1.3.2002 – 28.02.2003)	**Second year of phase 2** (1.3.2002 – 28.02.2003)
salaries, 42 man month x 13	= 546	546
side costs 88%	= 481	481
traveling	= 38	68
equipment (EVE)	= 60	30
Sum	**= 1125**	**1125**
Total		**2250**

Financing plan for whole project:

Oy Halton Group Ltd	= 100
Ins.tsto Olof Granlund Oy	= 100
Lighting manufacturers	= 50
Senaattikiinteistöt	= 100
YIT	= 100
Money from companies (20%)	= 450
Money requested from Tekes (80%)	= 1800
Total	**= 2250**