A CAVE-interface in CAAD-education

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The so called ”CAVE-interface” is a very interesting and thrilling development for architects! It supports a better illusion of space by exposing almost a 270° view of a computer model than the 60° which can be viewed on an ordinary computer screen. At the Lund University we have got the possibility to experiment with a CAVE-installation, using it in research and the education of CAAD. The technique and two experiments are discribed. The possibilities are discussed and some problems and questions are put forward.

What is a CAVE-interface?

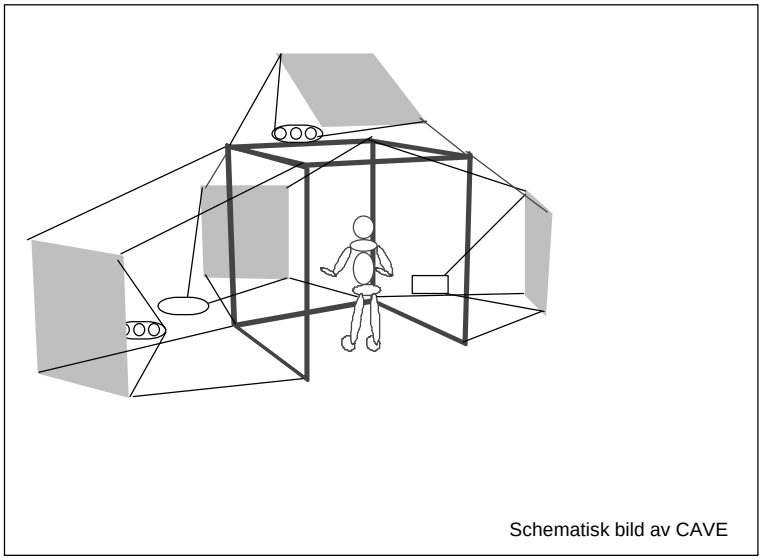

Fig.1. Schematic image of the CAVE-installation.

In 1992 the ”CAVE” was presented at the Electronic Visualization Laboratory at the University of Illinois in Chicago, USA. The name "CAVE" is both a recursive acronym (CAVE Automatic Virtual Environment) and a reference to "The Simile of the Cave" found in Plato's Republic, in which the philosopher explores the ideas of perception, reality, and illusion. Plato used the analogy of a person facing the back of a cave alive with shadows that are his/her only basis for ideas of what real objects are.

It is used by high-tech industries for defence, space, oil, cars etc. There are about a dussin labs today and the number is rapidly increasing. The installation consists of a cubic room with the sides of 3 meters. Three walls are used for backside and the floor for direct projectionscreens. The projections of images are produced by a Silicon Graphics ONYX Infinite Reality (MIPS R10000) computer and the images are stereoscopic, that is one image for each eye which is syncronised by special spectacles which the spectators are to ware. The computer strives to do 24 imagesets per second to achieve realtime movement.

A positioner for the eyes of one of the spectators makes registrations for the calculation of the projections. This means that you can move around within the area of the cub for ”minor motions”. You can then move the position of the whole cub within the model using any kind of ”joystick”. You can ”walk” and the computer calculates your eye-position over the surface you are standing on. You can turn the model around, pull your way through and fly. Persons can stay beside the positionbearer and get a slightly disfigured perspective but still a satisfactory experience.

There are some producers of software for Virtual Reality aplications and they have ajusted some of their products to be run on a CAVE. One of them, Prosolvia-Clarus, is Swedish which might make it possible for closer colaboration.

The CAVE-installation in Helsingborg

In Helsingborg, a city at a distance of about 40 minutes journey from Lund, the Lund Institute of Technology (LTH) has established a local department for certain engineering courses. Some of the courses are focusing on IT and Multimedia and in this context representatives from the city and the LTH have agreed to buy and run a CAVE-installation for joint use. The installation was officially opened in September 1997.

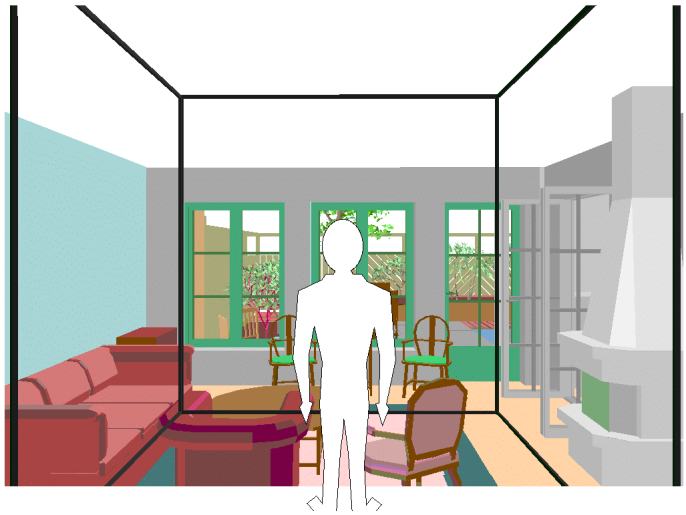

Fig.2. The CAVE is positioned in the model which gives you the illusion of being inside.

The city of Helsingborg intend to use the CAVE as a high-tech attraction to inspire the local industry to develop techniques for the future. The other goal is to use the CAVE as an interface for the participation of the citizens in different planning situations. A third goal is to give some time to artists to experiment with the medium.

The LTH will share its use of the CAVE between research and education. At the moment five partners are forming an interest groupe - departments of Work Environment, Robotics, Cognitive Science, LTH-Helsingborg and The CAAD-lab. As university departments are slow starters the CAAD-lab being on its feet at this stage has got as much time as we can possibly use. One essential thing is that we have found that you can save ArchiCad models in a format which is directly readable by the CAVE-software! This means that we just have to transport the models by the Internet and go to Helsingborg to have a look.

CAVE-interface for compact spaces.

The students of the 3:rd and 4:th year working in a half-year project on ”Compact living” researched exsisting examples. After having critisized them the students made up their own ideas and designed the same spaces to make them more practical and pleasent. As an excersis in client-relations the students of the corresponding ”CAAD-project” were engaged as computer modellers using ArchiCad. Within a week the models were ready and sent to the CAVE computer. The models were then evaluated by students and teachers together in the CAVE.

The models were:

the living quaters of a submarine,

the 6 m2 for spending the holidays in a caravan,

a sleeping compartment in a railway wagon,

an airplane cabin for tourist passenger on long charter tours,

a passenger cabin in a cruising vessel

the living quarters of a spacestation

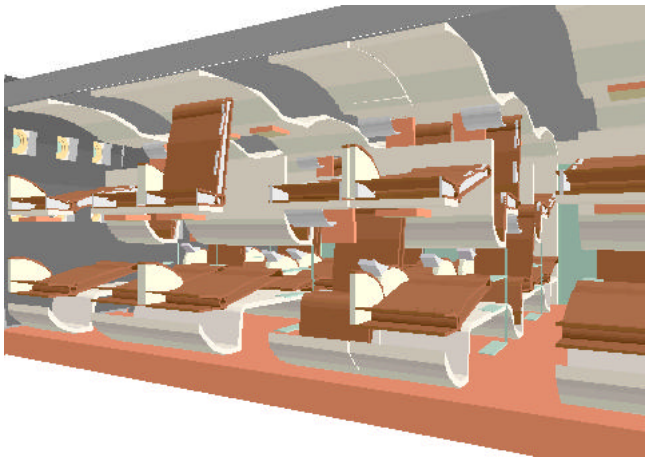

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Fig.3. The cut interios of an airplane cabin for tourist class passengers on long charter tours .

It is obvious that the three dimensional impression is impossible to show in a 2D image!

Even if the physical space would not have allowed it, in the CAVE it was possible for up to five persons to stand ”in the model” and discuss the different details of the proposed solutions. The possibilities of moving about within the limited space of the CAVE were very useful and some design solutions were inspected kneeling to look underneath for example a table

It would have been impossible to make a pespective view by computer or manually of these narrow spaces. So, what would be the alternative except making a big physical model? Both students and teachers were quite impressed by the models and that they were consistant enough after such a short time to be inspected from all unexpected angles.

All participants agreed that this was a success!

CAVE-interface for Architects own understanding of space.

The same students of the ”CAAD-project” then undertook a new task. This time each of them modelled and visualized a project which has been designed by one of their teachers. The idea for the teachers was to get an experience of CAAD modelling using a project which really were of their interest. Eight projects were modelled and only two exist as physical objects. So the impact of their three dimensions had not been experienced before. Existing drawings etc on paper were presented by the teachers and the modelling started. Spontanious contacts were taken from modellers as well as ”clients”. The information of the traditional media was not as informative as was expected by their authors, so the students had to ask for more details. The curiosity of what the building was going to look like in the computer was attractive for the ”clients” to sneak in to the CAAD-lab.

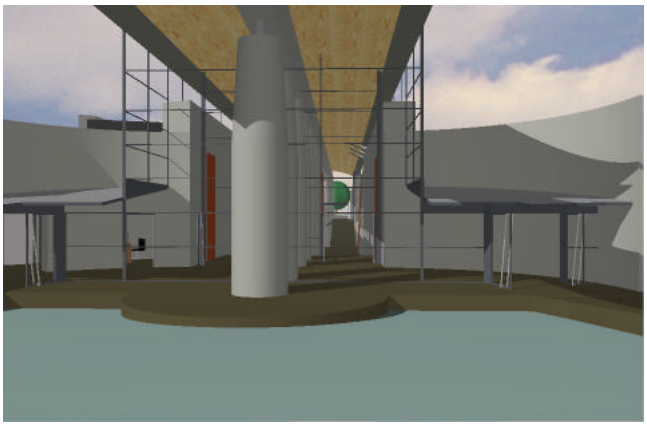

Fig.4. Contribution to a architecht´s competition of a crematory by professor Anders Holst, computermodel and rendered image by arch. stud. Niklas Dahlman.

The rumour of the first CAVE-experiment made the ”clients” interested in taking a look for themselves. It was then quite natural to let students and their clients study the models in the CAVE as well as on the computer screen. As this is written before the whole process is finished it is not evaluated properly. One conclussion is that you have a tendecy of getting lost as you would in any new building! An overview like a paln on a paper would help. Except for all other spontanious comments the indication of one of the more sceptical professors is positive. He quickly learned how to manouver the movements of the CAVE and spent almost an hour strolling about his design!

A student´s comment afterwards is, that after having seen the full model it would be quite enough to be able to use the VR on just one screen. The interactivity is for him the most important facility. It is also noticed that people after a while can let go of the stereoscopic spectacles and use the ”double imaged” views quite efficiently.

For the rest of the term the students of the CAAD-project are going to make a design of their own and present it with computer media. The plans are to do the presentation partly in the CAVE.

CAVE-interface for client´s understanding of space.

The CAAD establishment has used the illiteracy of the public to interprete drawings as an argument for visualization on the computer screen. Interaction with the clients is one of the great advantages of CAAD. Having tried this for a couple of years we might have experienced that understanding the impact of 3D is much better but still not entirely easy. Personally I have found it time-consuming to ”scan” around the whole ”visual dome” of a room on the screen to put the total experience of it together. In the CAVE it is much quicker, and I think it is because you can use your indirect viewing to support memorizing what you just have seen - in spite of the stereoscopic glases covering part of it.

The experience of the ”whole environment” is also one of the comments we get from the visitors that the representatives from the City of Helsingborg have been bringing about. There have been all sorts of people so they represent the ordinary user or city member in for instance a city-planning project.

Together the representatives of the city of Helsingborg and the CAAD-lab of the School of Architecture at Lund University are presenting the CAVE for people from different sectors of the building and facility management in the region to find suitable projects to test how to use the CAVE for marketing of new facilities. Also the use of the CAVE at exhibitions of the new generation of living environments in Helsingborg 1999 and Malmö 2001 are discussed. One of the ideas is that projects which are situated outside the exhibition area could be presented and experienced ”Virtually” in the CAVE.

One of the teachers of the CAAD-lab who is a practising architect and myself have made private experiments with clients in real projects. We are very content with the result as we found it possible to be sure that we agree on the same solution on the same interpretation of the real thing! The client also seams even more active.

Enthusiasts will not admit it, but ordinary people will - there is something like a CAVE-sickness. It emerges from the way the ”driver” handles the ”travelling” of the CAVE. We have found that the driver has to be seated on a high chair to avoid unnecessary moving around. The driver ought to excersise by himself to find out how the

joystick works. Even with an experienced ”driver” most participants get exhausted after an hour. We think that this is because of the concentration and allertness to access all the information.

CAVE and dynamic facilities

The CAVE software technique was to a great extent developed for different branches of defence and other hightech purposes. A nessecary facility then is the use of changing conditions dynamically. For housing this might mean simple things like the possibility to open closed doors, move furniture and other objects interactively or by programmed routines.

It is a quite revoloutionary possibility to make visualisations of building and plan-projects ”alive”. Architects' photos of buildings are usually concentrated on the architectonic expressions and other ”objects” like people are looked upon as ”distractions”. Non-architects though tend to prefere looking at each others rather than on the built environment. So this is something which has to be looked deeper into. Also the possibility to change the environment dynamically while staying in a model is something thrilling but also mentally problematic.

In the CAVE at Helsingborg our intention is to share experiences and develop the facilities in close contact with other users. The other interested departments of the Institute of Technology are just starting to use the CAVE. The department of Work environment is going to research the use of ”maneqins” in evaluation of workplaces and the department of robotics are going to study robots at work in the virtual environment. So they are both going to develop the use of the dynamic facilities of the CAVE which the CAAD-lab with the less programming knowledge hope to gain from. On the other hand the knowledge of how to use and design space can be of use to them.

Lack of Megabytes in a ”Mega-computer”?

Even with a very powerful computer there is a lack of Megabytes. The Sillicon Onyx operates some 100.000 triangles for 8 images every 1/24:th second. This puts a limitation to the degree of detail and size of the models to be used. We have found that an ordinary villa-model with furniture and some trees and bushes in the garden is just what the computer can manage without starting to make the realtime in ”staccato”.

There are solutions to this and the usual one is to wait for a couple of years, when there will be more megabytes in all computers. As our experience is that you never tend to get enough other possibilities are still more interesting.

Designing the models with at least two ”levels of details” is the solution which has been tried already. It means that the program evaluates the distance between the viewer and the object and desides which representation to use. Another might be to divide a building in parts which you can move between. This has to be, when only a limited part of the whole buildning is visible at the same time, for instance when you exhibit the interior.

The computer engineers who are developing this technique have made hardware support for using texture mapping instead of geometric form to save memory. One of the problems then is to get the textures from the CAAD-programs to the mega plattform and apply it in the correct way. Another problerm is that the actual resolution used makes the textrues look like a ”bunch of pixels” rather than giving an impression of a three dimensional object. As far as our experiments have reached, we are quite content with the modells without textures, which makes it in a way clear that this is not the reality but a very good model of it.

Some conclusions on how a CAVE-interface can be used in the education of architects.

It has to be made clear that the real costs for establishing and running a CAVE-installation is at the moment nothing which an architects school can afford alone. So it has to be in conditions like ours when other parties pay the main part of the costs. Then there are three suggestions:

The first use of the CAVE-interface would be to make the students aware of the visual impact of computer modelling. This would mean to have students of the first year study some models made by themselves in the basic CAAD modelling course. There is a full scale laborarory at the school, and the students get some experience from working there. The problem then is that the model has to be built especially for the lab. - Then occaisionally some students might want to use the CAVE to convince a sceptical professor that his/her design is what he/she thinks it is and vice versa.

The second use is in interaction with the client or users. This ought to be experienced in practise and a simulation could be arranged in the CAVE. It is something quite different to be able to walk around and demonstrate your

design than make a presentation from drawings. This kind of exercise might also make a better awareness of how to demonstrate or ”tell the story” of a project with an ordinary computer screen.

The third use is more special. Professors of architecture seams to be thrilled by the unusual as for instance the Guggenheim museum in Bilbao by Frank Gehry. But in reality most of us have not the possibility to get efficient training using unusual forms like that. The CAVE offers a possibility to do some designs with unusual, primarely curved forms and evaluate their visual end cognitional effects. On this theme the next student CAAD-project is going to work in the spring term 1999.

Two critical questions to be researched.

Within the CAAD-lab in Lund and together with researchers of Cognitive science we have discussed the relation between the degree of naturalism and the human ability to make associations to ”inside images” with researchers in cognitive science and psychology. With the technique being havier, the limitations in memory and the costs for even more sofistication are running high this must be evaluated. What do the users want to see? What do they have to see?

Texture mapping techniques are developed but the computer´s understanding of what the texture is about is still too primitive. As architects we can use an image processing software in combination with our intelligence to for instance simplify the image of a painting and still get it recognizable. The computer cannot!

Some useful websites on CAVE:s.

http://evlweb.eecs.uic.edu/EVL/

The Hompage of the Electronic Visualization Laboratory at the University of Illinois in Chicago, USA. EVL has lot of useful information on CAVE technique, information of CAVE related research and information about CAVE-installations all over the world.

http://www.ncsa.uiuc.edu/VR/cavernus/

User Group for CAVE and Immersa Desks. Forum for discussion about CAVE and Immersa Desks, links to research Institutes, research projects using the technique etc.

http://main.tmgweb.com/psi/related_sites.html

Pyramid Systems Homepage - this is the producer of the CAVE in Helsingborg and the page holds information on the products.

http://www.caad.lth.se/research/visa/CAVE*lab.html

CAAD-lab at the Lund University decription of the CAVE and the work there.

http://www.hbg.lth.se/vr/links.html

The LTH-Helsingborg web-page.