VR for Decision Support in Urban Planning

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Abstract

The idea of VR and visualization in general and in urban planning has been discussed for decades and a lot of work has been put into that area. Many different visualization techniques have been presented. The visualization techniques still being developed reach higher and better realism for each step, but what about changing the display system and use real VR.

This paper describes the possibilities of moving around in a modelled world with total freedom of where to move and what to see in a scale that is very close to realism. Together with the Danish consulting company COWI a new town district placed in an area of natural beauty has been modelled and then presented before the town council of the municipality of Kjellerup. The presentation was done on a panoramic screen of the size 10m x 3.5m and 160° of field view at VR Media Lab, Aalborg University (www.vrmedialab.dk).

The paper will describe the process of modelling in order to present real-time presentation on a large screen facility, discuss the effect of using large scale display systems due to a questionnaire that has been handed out to the local council members and present generalized guidelines for using large display systems with VR.

Project description and object

According to the Danish Planning Act a district plan has to be made, no matter what kind of construction is in question. The municipality of Kjellerup and Cowi (Consulting Engineers and Planners AS) prepared a preliminary district plan for a housing district in the outskirts of Ans, a town in the municipality of Kjellerup. This district plan was to form the basis for a pilot project about site development as the price often determines whether a municipality wants to stake their means on preparing an area for a housing district.

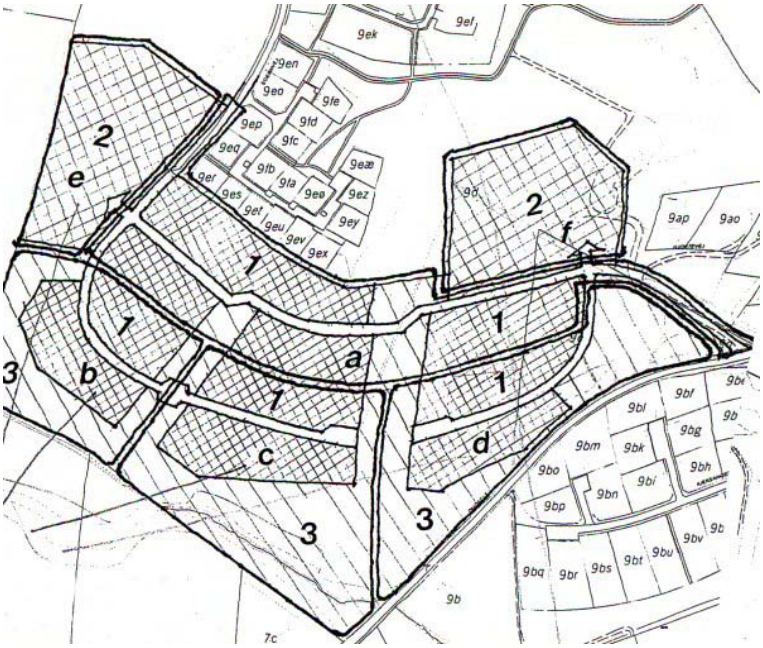

Figure 1: The district plan

The following questions arise:

Is the area so attractive that it can attract new citizens to the town? Is the price of the sites too expensive in the existing district plan? Are the road junctions and the road courses appropriate or do they actually worsen the conditions of the existing neighbouring districts or other parts of the town? How will the new neighbourhood influence the neighbouring districts? Not only with regards to view and access, but also very much with regards to the value of property.

Thus the project originated from the wish of the municipality of Kjellerup to be able to make a better evaluation of this intervention in the area in question. Therefore Cowi offered the municipality of Kjellerup an examination of the possibilities of creating an actual visualisation of the existing district plan. Cowi contacted VR Media Lab at Aalborg University, Denmark. VR Media Lab estimated that it was a relatively easy task to make a model and a presentation of the area.

The object was to model the existing district plan. The model was intended to support the decision that was going to be made by the municipality; a decision where they had to decide whether the project was to start and what alterations had to be made.

The modeling

Compared with general models of town and landscape areas this area has undergone an actual engineering project work. Alterations of the ground have been made, especially in connection with the local roads which are part of the project and which are cut into the ground.

In the following other conditions will be described more thoroughly. One of these is the requirement of presenting the area using real-time graphics on large display systems. I.e.; that the model is not presented as an animation but is being generated while moving through the model, thus enabling the viewer to look at a specific part of the model. It is possible to stop and turn and to look in any direction. It is also possible to go back to the starting point, or rise above the buildings to view the area from above, or to imagine oneself as a small child sitting on a tricycle at street level.

This requires that the number of polygons must be seen simultaneously in the model with the equipment and software and must not exceed 80,000 polygons. If the number of polygons is lower the system is able to generate a maximum of 120 images per second per projector. 120 images equal 60 images per second per eye, if the model is shown in active stereo. The high number of images is required especially in connection with the panning situation in order to present a flowing model without a low frame rate in the graphics.

Theoretically both eyes perceive approx. 40-50 images per second, as they are not able to perceive the single image by themselves, but can perceive that an image is missing. The change in image during the panning is seen much more clearly than a forward movement in the image, which is a far larger alteration in the image. To achieve flowing graphics it is necessary to obtain a high image frequency. The television media cheats by using 50 fields pr. sec, showing only every second field per second, thus actually showing only 25 fields per second (interlaced). (Watkinson 1996)

The ground

The model has to be divided into several pieces, and different methods known especially from the game industry are used to meet these very high requirements of the image frequency. The largest geographic division is made on the ground itself, as it is divided into a large number of coherent squares. This means that the software used in this model does not have to memorize the entire ground at all times. Thus the software needs only to input and output a specific part of the model. The ground is the largest single object, making this particular work a very important part of the project. In this example a qualitative selection of the ground description will be made, as the need of an accurate description of the ground varies a lot. The large open spaces surrounding the area need only very little information in contrast to the model of the district plan. To a very large extent a number of polygons is needed along the roads as both kerb and ditch constructions a cut into the terrain model. Often the curved road alignment need a large number of polygons as well. Nevertheless the numbers of polygons were reduced with a dedicated soft-

ware package, which then reduces the number of polygons. In this way even complex models can reduce their number of polygons considerably. We used the software “Rational Reducer” which uses the algorithms built on the "edge collapse" technique (www.sim.no). Depending on the model it is possible to decrease the numbers of polygons down to 10% from the original number.

When presenting landscape models on large display systems the horizon is very noticeable. At a model presentation on a 21” screen it is relatively easy to ignore the edge of the model as the whole situation itself is very artificial, and the focus area is very narrow in the human field of vision. If one is seated in front of a 160° Panorama screen one also views the model using one’s peripheral vision; which causes cyber sickness when moving too fast in the model. If one has to look at the model in a realistic large size with the peripheral vision a number of serious requirements needs to be fulfilled concerning the area surrounding the fairly accurately defined district plan. Thus the entire view of the neighbouring meadow is of great interest to the modelling work. Various methods have been tested. The best method involved fixed billboards, where textures from bushes, fringes of a wood, and a couple of trees were draped on. This created a very lifelike vision of the horizon, gave very fine depth to the model, and at the same time the edge of the model disappeared.

The housing area

The model looks like a typically Danish housing area around the Millennium. Textures were photographed and mounted on simple model boxes. Trees, hedges and bushes were placed casually in the area. Here the billboard technique was used. I.e.; the facings always turn towards the viewer. Trees look like trees, but they are merely a transparent image placed on a surface consisting of two polygons (two triangles). Concerning street lamps and other elements like cars similar techniques have been used.

Animation and virtual reality in the model

The model looks very much like the real thing, which will be documented later, but one misses some kind of dynamic features in the model for instance small animations to put some live into it. Light and shadow are factors, which have not been dealt with in the first phase of the project. However, these functionalities do not work so well on large display systems, where the real-time graphics are used. Proper light calculations require lots of processing power and are therefore difficult to implement as dynamic factors. VR Media Lab has found a sustainable method, where complicated light calculations are done in a specified light calculation programme like “Light Scape”. The texture-surfaces calculated for a specific light scenario on a PC are than assembled on the model in the presentation programme, in e.g.; the Panorama facility. However, the problem is not entirely solved by doing this, because large display systems with this specific technique find it difficult to reproduce the colour depth satisfactorily and at the same time the use of the stereo technique converts a beautiful summer day into a grey and sad day. The biggest

problem is due to lack of texture memory, because it is not possible to use the same texture information several times in the same model. Every little surface must have its own texture due to special light conditions. In this project only a few simple light conditions were used. No shadows were used because the model got very dark and at several occasions when walking towards these dark areas, it didn't look right.

Figure 2: Example of the model

Panorama

To understand what makes a presentation in the Panorama facility so unique a short description of the physical surroundings is given:

The Panorama facility is situated at VR Media Lab, Aalborg University, Denmark. Several VR-facilities are gathered here. Besides the Panorama facility VR Media Lab has a Power Wall where passive stereo is presented for a maximum of 80 people simultaneously; and a 6-sided Cave which gives the ultimate experience in a virtual model and in which there is full immersive environment. VR Media Lab has a staff of technicians who maintain every installation and network, develops new VR-techniques, and teach in the use of the VR-facilities, especially students and researchers at the university. A number of students are employed at VR Media Lab as guides and VR-pilots at presentations of the facilities. Other students are involved in student projects or involved in developing e.g.; interaction devices for later use in the laboratories and facilities.

The Panorama facility

The facility looks like a small cinema. A maximum of 28 people in four rows can be seated in the facility. The floor in the Panorama slopes, so that the back row is a somewhat higher than the front row.

The screen is approx. 10 metres long and 3.5 metres high with a 160 degrees field of view, which means that if one is seated in the middle of the front row looking straight ahead the screen covers one's field of vision totally. This is the ultimate experience where the immersiveness of the model is felt in the whole body, especially in the stomach. But the other seats in the facility also allow a reasonable experience.

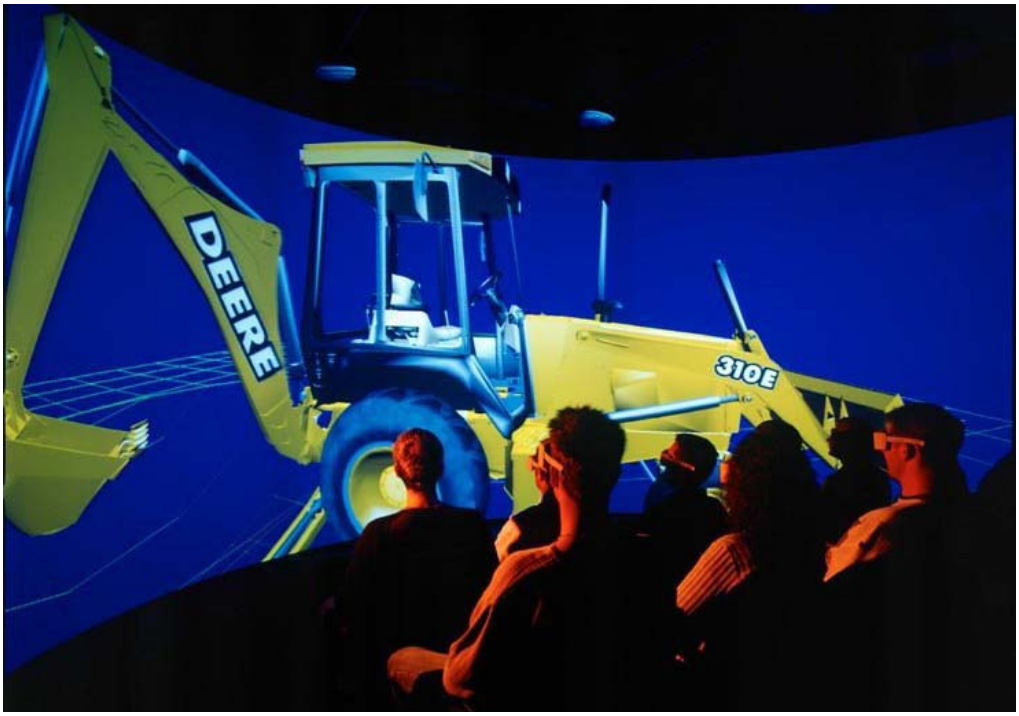

Figure 3: Photography of the Panorama facility

Mono versus stereo

In the Panorama it is possible to present both mono and active stereo. A presentation in mono is very common, but a presentation in active stereo will be a new experience to most people. The active stereo makes it possible for people to perceive the depth in the facility as the left and right eye each receive an image that is proportionally shifted. By using active stereo two images are generated simultaneously - one image for the left eye and one for the right eye. At that point when the screen presents an image to the left eye the special glasses (shutter glasses) close the right eye and vice versa. As mentioned earlier this is done be a frequency of 120 images per second. The shutter glasses take a part of the field of view and are not suitable for all kinds of presentations. In general, when presenting models of large buildings or landscape, a mono presentation is preferred as the effect of stereo is lost and advantages are less than the disadvantage of using glasses, which diminish the field of view and darkens the model. (Edelman et. al 1992)

The Panorama facility is very good at a large number of presentations as the immersiveness in the presentation technique is something between a presentation on a large flat screen and a presentation in the Cave. VR Media Lab

benefits a lot from presenting models in industrial design, simulation, bio informatics, data-mining, and not at least town and landscape architecture. This is also the reason why VR Media Lab chose the Panorama facility as the presentation technique in connection with the Ans district plan project.

The Panorama facility holds a very important element that is practically unattainable in other display systems. When 10, 15, or 20 persons are seated in front of the Panorama screen, looking at the exact same model something inexplicable happens. VR Media Lab has presentations, including graduations and Ph.D. defences where the viewers almost forget why they are gathered, and animatedly discuss the model. Engineering detail solutions, the form of the design element, or the possibilities of interaction with the virtual media. The reasons for the success of the Panorama facility are the possibility of interacting with the model, having animated discussions when seated in a comfortable chair, and from a visual input reach essential decisions on the same basis and within the same frame of understanding. Comparing the presentations of Ans in the Panorama facility with the basis material as shown in Figure 1, it is obvious why the Panorama facility is preferred. Often it is only experts who are able to perceive a plan as a spatial model. The transmission from two-dimensional to a spatial understanding has some elements of uncertainty. The multiple possibilities are how a rough, often engineering or architectural plan is perceived as a spatial model. It is just like reading a book. Everybody who reads the same book has different experiences when reading the book. The same aspect exists when describing a plan. The below figure tries to illustrate levels of abstraction that surround us in daily life.

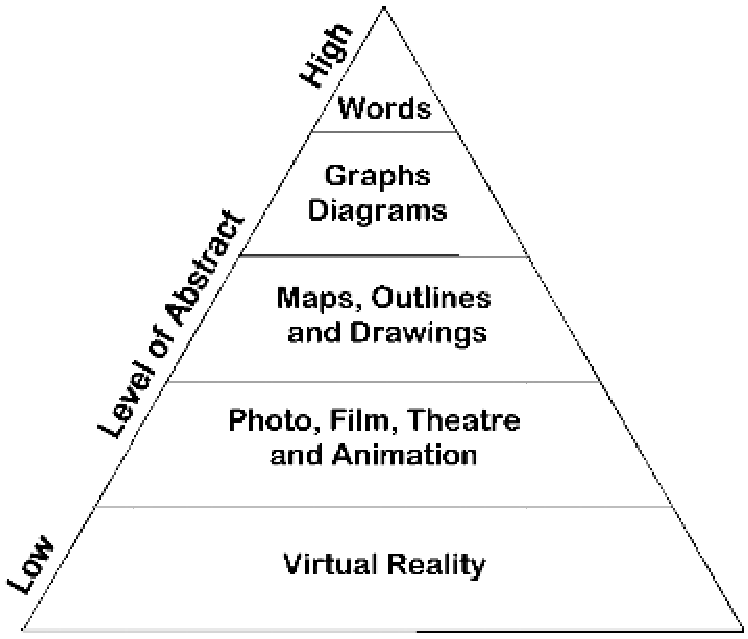

Figure 4: The pyramid of abstraction.

The term is clearly seen as the highest level of abstraction. No matter how many words are used to describe the new housing area in the town of Ans, a fast visual tour of the area would provide even more information and insight in

this plan. One often uses graphs to describe complicated coherences. This simplifies any explanation. When a town presents a new urban plan project today the best tool is a two-dimensional plan with suitable colours. Such a plan can be of great value to architects and engineers especially, as it is often at a fixed scale and can be used for the actual planning of the area, but to a novice the plan would be difficult to interpret. Lately the use of photomontage has risen, but also the use of spatial modelling is increasing in order to illustrate the extent and the content of the plan. The increased illustration level has been very well received among politicians and entrepreneurs, and the basis of decision has improved. Architects have only reluctantly accepted this; probably because they are not willing to present too much, as a rough plan can always be alternated along the way whereas a model looking like the real thing is very difficult to deny. Fortunately spatial models are required even more nowadays. Lately in Aalborg requirements have been made regarding a new Music House. Project suggestions have to be delivered electronically in order for all projects to be presented and compared in e.g.; the Panorama facility.

To finish the pyramid of abstraction the ultimate experience in the VR-environment is the Cave. When using the cave the viewer becomes part of the model. VR Media Lab has only recently started using these facilities and possibilities, but things are progressing. Especially the lack of haptic sensation of the objects is a problem. But the first solutions are on their way. (VR-IEEE 2001)

Principally there could be a level below VR, as a direct connection to the human brain would blur the difference between the virtuality and the reality. The first interactions with brainwave are for real, so it is not to be excluded in the future.

Presentation of the Ans district plan for the municipality of Kjellerup

The first presentation was held on 23rd August 2000. Unfortunately not every member of the Town Council was able to attend the presentation, but some political representatives and some municipal officers from Department of Technical Administration found their way to Aalborg and VR Media Lab.

Prior to the presentation VR Media Lab and council engineer Bendt Bjergaard discussed the presentation in order to explain what was going to take place and to enquire if it would be possible to hand out a questionnaire to the participants from Kjellerup. It was essential to the questionnaire that it was completed right before and right after the presentation of the project. VR Media Lab and Bendt Bjergaard agreed to have two presentations of 45 minutes each; one in mono and one in stereo (see above). A 30-minute-coffeebreak was held between the presentations. The presentations each started with a short and traditional two-dimensional presentation in a meeting room.

The breaks and the course of the presentation are not without interest to the final result. Whether the presentation was in mono or in stereo was rather based on internal discussion in VR Media Lab. Experience shows that if the presentations in the Panorama facility last too long the viewer normally feel

nausea because of navigating in e.g.; a town and landscape model, where the visual input does not apply to the physical surroundings of the body. Moving very fast in the panning the phenomena increases. Moving forward in the model does not create any problems, but moving from side to side may cause nausea. If one tends to get carsick, flight- or seasick it is relatively easy to become cyber-sick in e.g.; the Panorama facility. Experience also show that one does not feel nausea in the same way when working with the head-mounted display (HMD) systems, as there is no peripheral vision to create confusion in the human brain. So the very large immersive images have both positive and negative sides. (Hodges 2001) (Howarth 1994)

By clever navigation in the model and exact planning of the presentation programme the nausea problem should not be an issue. The presentation normally starts with a "guided" tour. This means that a walking path has been predefined before the actual presentation is given. This gives a very smooth kick off for the first about 10 minutes passing all the nice spots and maybe even the bad ones. After that the "VR-pilot" strolls very smoothly around in the model waiting for somebody from the audience to ask for a special view or path to go. So it is the audience in front of the screen who decides where to go. It would be possible to let the audience navigate by them selves, but it is not easy to handle with 15 or more people. In addition it takes some time to get used to the pointing device, so it is better for everyone to let a trained VR-pilot handle the navigation.

Alterations of the model can be programmed into the presentation. This has been done on several other occasions with minor projects for instance deciding on different architectural proposals. In this project only one plan was for discussion and no alternatives prepared nor desired.

Dividing the presentation into two parts, the relatively long presentation of 1 ½ hours, including breaks also was used to introduce the participants to the technique used in the project and not at least the facilities of VR Media Lab. One of the big problems when we present our models with large display-facilities, as the Panorama, is what we call the "Wow-effect". In this case it would be of great importance whether the decisions are made on the basis of an impressing presentation or on the basis of the actual project. Some of the questions in the questionnaire were to uncover whether the "Wow-effect" would influence on the effect of the presentation. The basis of the participants was very alike. Nobody had visited VR Media Lab before though some participants had seen a film on a panorama screen. After the presentation the participants unanimously estimated VR Media Lab's facilities as being impressive and the presentation very good. Both estimations were the top answers on a scale from 1-5. Thus it is impossible to say if the surrounding has influenced the final result after all.

Immediate reactions during the presentation

When the participants sit in their chairs looking at the presentation they are quiet for some time, usually because it is difficult to breath evenly. The large screen right in front of the viewer gives some fantastic visual experiences, which take some time to perceive. After a few minutes through the area of the

model the questions pop up. At the beginning the questions are about the techniques used in the model, but after a while questions concerning the project itself and the form of the model are asked. The form of the roads, the size of the lots compared to the size of the whole area, or the architecture of the houses, including number of floors. These were some of the questions asked. While moving through the area, looking at the nice views from the houses it was an easy decision to make that through a careful placing, all houses was to be in one floor only. In this way all real estate owners would have a nice view from both their houses and their gardens. Other conditions like considerations to existing houses was also discussed. The model presents some black buildings, which mark where parts of the existing houses in the town are placed. During the presentations it was thus possible to estimate how the view from the existing houses would be like in the future. The general estimation was that it would be possible to place and form the new housing area in a way that it would only create a minor influence on the clear view of the existing houses, it would not totally block their view of the meadow area. Their clear view was highly rated to the form of the area. The municipality thought that it would be impossible to sell lots in this area if the clear view was blocked. In this connection the model assisted in solving various problems. An area in the north-western part of the areas was given up, as it was plain to see that the requirement of a clear view could not be met. At the same time the lots were enlarged, so that there would be more space between the houses and thus creating a better view for the houses placed further up on the slope. The above questions or problems were solved or discussed during the presentation and then decided in the Town Council of Kjellerup.

The road courses were briefly discussed, as everybody agreed that the curved road courses was very effective in connection with the traffic safety in the housing area, as limited vision would prevent drivers from speeding. Speed ramps or similar measures would also be drab elements in a whole new street.

Giving the area an image as a green area was of very high importance to the council. This could be confirmed or disconfirmed by the model. Thus the placing of the green “wedge” in the area was discussed during the presentation. The wedge was viewed from both within the area as well as from the meadow, at eye level in the street and from the air. It was very well received and the revised district plan contains two green wedges as illustrated in figure 1.

One of the participants knew the area very well as he grew up in the town of Ans. He confirmed that the reality of the model was striking and the view of the meadow very similar to the real meadow. Besides our own observations it was confirmed that the computer made model was of fine quality and high reality.

The survey

The main purpose of the survey was to measure the effect of a presentation of a development plan, which in Denmark usually is presented by means of

two-dimensional plans of written text with the newest existing VR-techniques. It is important to have a solid basis for others or similar models and to be able to document the effect of the performance or payment, especially, as the performance does not deliver a product but rather an impression.

The following chapter is a summary of the most important questions, which are obligatory in order to illustrate the problems described above. 14 questionnaires were handed out and 10 questionnaires returned. As a statistical basis this is hardly enough, but because of the homogeneity of the answers, it is clearly an excellent documentation of the use of VR in town planning.

Before visiting VR Media Lab

Before the town council arrived at VR Media Lab they were asked what their expectations to the presentation were. Some did not know how to answer, probably because they had not idea of what they were going to see or experience. Most of them had great expectations to the presentation.

Everybody expected that the presentation was able to contribute with more information about the project, even though they knew that the model was based on existing plans and objectively not would hold any real new information.

At the same time most participants thought that the presentation would either definitively change their opinions of the project or only maybe. No one rejected that possibility.

To the question of what was expected regarding the realism of the computer model, the answers were medium. Maybe the participants would not have too high expectations to the technique.

Most of the participants were enthusiastic about the project in Ans and positive towards the implementation. The opponents either stayed at home or the town council was generally in favour of the project, but not convinced whether the lots were easy to sell.

After visiting VR Media Lab

Different questions were asked regarding the presentation itself. E.g.; whether the presentation has clarified the project. Almost everybody answered “a lot” which was the top answer on a scale from 1-5. In general the presentation was estimated as certainly meeting the expectations of the participants, also here on a scale from 1-5 in the top, which might be difficult to understand, as the expectations were already high before the presentation.

A very clear question of how important it is to be able to move perfectly freely in the model was asked. The answer was unambiguous, as everybody answered “great value”, again a top answer on a scale from 1-5. This unambiguous accept of the VR medium and its top force of free manoeuvring in the model was unmistakable. Many people have known this for quite some time, and even though it is in a small scale this questionnaire is a good documentation.

Another important issue was the question of how much this presentation influenced the perception of the project. The answers were that the presentation had only a small effect on this; approx. 50% answered that they had been influenced somewhat in their perception and others not at all. This matches the fact that everybody was positive towards the project. Thus their perceptions of the project were not changed that much.

Finances

The politicians were very clear in their answers that the costs of the presentation and the modelling were worth their money, and that they were likely to use these means in the future, depending on the project character and project size.

The most popular presentation form was the mono presentation. This has been explained in previous chapters. Altogether the presentation was seen as being very realistic, which is a compliment to the VR graphics designers. The most popular way to view the model was from the eye level. This is very interesting as most perspective reproductions today are presented from the bird's-eye view, which came in last from a scale of 1-5. To nobody's surprise it was a very positive reaction that the model could be made public on the Internet and used as a kind of sales material. It is possible to implement panoramic view from each house in order for buyers to check the view. Various complete animations were also a way of presenting the area.

At last the viewers were asked if the presentation was worth driving one and a half hours for. The answer was unanimously yes.

The future course of the project

Second phase of the project is started and the before-mentioned changes have been made. Two roundabouts in central junctions has been applied, some areas have been removed, another green wedge implemented, and several minor adjustments have been made. Some of these are based on the presentation at VR Media Lab.

On May 9th a new presentation will be made. This time the entire town council of Kjellerup and the neighbouring municipalities will be present. The final plan will be discussed here and probably decided. It is uncertain whether the site development will start this year, as a presentation in May is very late. Most house sales are done in early spring and are also the reason why the expectations are set for 2002.

Conclusions

This project has clearly shown that persons without any knowledge of VR-technology or of three-dimensional computer technology are very ignorant and insecure of the use and applications of these technologies. The project has shown that by demystifying the technology and by a thorough presentation it is possible to achieve the desired effects about the VR-applications.

Experts and technicians who have been working with these technologies for years and lately with the VR-media have always had the understanding that this was the correct tool to use in order to improve e.g.; planning. It is strange that most highly trained architects have not really adopted this technology. The reason should probably be found in traditions and cultural barriers rather than in a real resistance towards the technology itself.

By making a survey of how easy it is to use VR in a positive and inspiring way it is possible to convince everyone that VR is a fantastic technique that develops better projects. This particular project has shown that VR is the basis for and contribution to us to make important decisions. Of course, Acts of Law will follow, but the acts are based on the fact that a number of persons have seen and perceived the same thing. No one has been forced to imagine the spatial model, which in general is shown to be particularly difficult for women. (Pease 1999)

The project presentation is obvious. The immediate consequences of the district plan were defined and analysed. The influence on the traffic in the areas has not been presented, however this can be made possible as the traffic flow is easy to present in the area by the use of VR.

Through this project VR Media Lab has been able to present the possibilities and hopefully a lot of presentations of this kind will follow - as a benefit to all.

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