Virtual information representation

Daniel Skog[a] & Markus Söderlund[b]
dskog@informatik.umu.se[a] and markus.soderlund@enator.se[b]

[a] Department of Informatics, University of Umeå, Sweden
[b] Enator Medical, Malmö, Sweden

Abstract

Modern information technology provides new techniques for information visualization and communication. These new advanced visualization techniques make it possible to present large amounts of information by using virtual models.

The purpose of this paper is to study virtual information representation and its consequences. This is done through an experiment in which the use of a traditional visualization technique is compared with the use of an advanced technique. A house was described to different persons either by drawings or by a desktop VR-model. Depending on which technique that was being used to present the house to a single person, he or she later described the house in a certain way, pointing out specific aspects of the house and its appearance. The different techniques obviously gave rise to different experiences and these differences could be categorized under the four headings; Language, Aesthetics, Spatial perception and Functionality. The VR-model generated strong emotions within the users and as a result they described the house using an artistic language, mentioning aspects of the house that had more to do with its aesthetic features than with its functionality. The users of the VR-model also demonstrated an incomplete spatial perception whereas the users of the drawings showed a very accurate knowledge.

We find these results important since the use of advanced visualization techniques is likely to increase. More studies are needed in order to achieve a greater understanding of these new techniques and the consequences of using virtual information representations.

Keywords: information representation, information visualization, virtual models, virtual reality, virtual representation

BRT Keywords: HA, HC, HD

Introduction

Every day we use different techniques to visualize information. Signs, symbols and models are only a few examples of common techniques used to describe and communicate information. Modern information technology provides us with new *advanced visualization techniques*, enabling virtual modeling of large information spheres.

Virtual modeling can be understood as the formation of three-dimensional virtual models. Furthermore, a virtual model should in this connection be viewed as the “gestalt” of a specific information sphere, a kind of a visual information representation. These models can help users to access information and also facilitates a correct understanding

of the information.

Casti (1997) compares this technique with laboratories where the information structure of complex systems can be studied. By making virtual models of information spheres it's possible to examine the "real thing" in a way that is similar to the way in which laboratory studies are performed in traditional natural sciences. A real situation can be modeled virtually and in that virtual reality different "what-if" scenarios can be tested by changing certain parameters and factors in the virtual environment (Casti, 1997). Furthermore, since our visual organ can handle information faster than our logical-mathematical intelligence, a visual information representation will make it easier to detect and understand certain connections, deviations and changes (Kalawsky, 1993; Walker, 1995).

The application areas for this technique are almost unlimited. Geographical information systems can give us the possibility to travel through three-dimensional models of our world. Different torrents of data, for example share prices and other economical relationships, can be viewed in real time. Architects and city planners can study a virtual model of the end product before the building process begins.

The purpose of this paper is to study virtual information representation and its consequences. This is done through a small experiment in which the use of a virtual model is compared to the use of a more traditional visualization technique. The experiment aims to show the characteristics and functions of the different techniques. On the basis of the results we then try to conclude some of the consequences of using virtual models as information representations. The experiment should be regarded as a small pilot-study not sufficient to reveal all the characteristics of these virtual representations. Still, it can give us a notion of some of the most crucial characteristics and serve as a basis for further discussion and studies of virtual information representation.

Computers and modern information technology is becoming more and more common in society. The social change of the last few years also involves a greater use of new advanced visualization techniques among companies and organizations, by that means giving techniques such as virtual modeling a greater degree of significance in society. As every other visualization technique, these new advanced techniques have their own specific characteristics, and because of the big difference between the new techniques and the traditional, there is an uncertainty regarding the consequences of their use. For that reason it is important to study the function of the advanced visualization techniques and see how they might change the user's possibilities to receive and understand visualized information. Perhaps they can act as intermediaries of information that earlier have been hard to communicate, or maybe there is a risk of loosing important parts of the information sphere being communicated.

Virtual representation

To visualize is to describe and reproduce something. The aim is to communicate a meaning and a content, and to enable an understanding of the visualized object. As long as there have been humans wanting to communicate with each other there also have existed different techniques and tools to visualize information. The written language may be the most common and widespread technique. Letters form words that communicate a meaning. But visual communication using characters and symbols is older than the written language. Since time immemorial, messages and events have been reproduced with various tools. Modern information technology provides new advanced visualization

techniques. Complex information that earlier have been represented by large amounts of characters, numbers or pictures can now be represented virtually. Through virtual modeling the information sphere is being represented by a virtual model, making it easier for the user to access the information.

Depending on context, the word *virtual* has been given many different meanings. Usually, however, the word is defined as *apparent* or *illusory*. A *virtual reality* then, can be described as a computer generated illusory, interactive world, in which the user can have a feeling of being present (Heim, 1998; Wong, 1996). In order to experience the virtual reality as real its characteristics and features have to be similar to those found in the physical reality. For example our laws of nature must also apply to the virtual world.

When the word virtual is being used in everyday language, it is very often in the context of Virtual Reality (VR). The reason for this is probably that other phenomenons than VR not have been considered being virtual. However, nowadays there is a common understanding that virtuality is something closely related to computer-manipulated data and information in all different forms. The purpose do not have to be the making of an immersive virtual world, the advanced visualization techniques renders possible virtual visualization in various forms.

The development within the area of information technology has furthermore expanded the definition of virtual objects. The new meaning of the concept involves partly erasing the distinction between the virtual and the physical world by letting virtual objects influence the physical world (Lévy, 1998). Internet, World Wide Web, cellular telephones and teleconferences have caused such a dramatic change in the way work is being done throughout companies, that it is now legitimate to talk about virtual companies. A virtual company can for instance be a union of freelances and entrepreneurs that together sell products and services. The company has no office and can not be found on any map but their products are real and can be used in the physical world.

However, in the context of this study, the earlier, common used and accepted definition of virtual objects will be adequate. Nevertheless it is important to bear in mind this expanded definition since it indicates the position of the information technology of today which is of great importance for the development of new visualization techniques.

The characteristics of visual information representations

Traditional visualization techniques such as text, sketches and maps are static and abstract to their nature. They are static because they can not visualize dynamic processes and abstract because they can not capture all the aspects of the reality needed to get a full and correct understanding. This implies the need for an intellectual interpretation of the visualized information before it can be understood and experienced (Stolterman, 1997).

The new techniques are fundamentally different than the traditional, visualizing information virtually and by that means making it dynamic and concrete. The concrete does not have to be interpreted or transformed but is directly available to our senses. This brings forth a completely new way of interacting with visualized information. Instead of only being able to view static models of reality it is now possible to interact with, and with all senses experience, a three dimensional virtual model which to a greater extent helps the user to comprehend the information sphere being visualized. (Kalawsky, 1993; Spring, 1991; Stolterman, 1997; Waterworth, 1996.)

In our experiment we used two different techniques for information visualization, drawings of a house and a desktop VR-model of a house. The VR-model is the result of a new advanced visualization technique whereas the drawings are the product of a traditional technique. In this case, you might wonder which of the two representations being the most concrete?

Ågren (1998), actually uses the example of representing a house using drawings and a VR-model when discussing different visualization models and their level of abstraction and information substance. At the construction of a drawing, certain aspects of the building are chosen to be reproduced in the drawing. Suppose afterwards a VR-model is being made on the basis of the information put in the drawing. Then it is hard to argue that the VR-model contains more information than the drawing. Nevertheless Ågren argues that the VR-model is likely to cause a stronger experience than the drawing and that it will be easier to comprehend for a layman. The reason for this, according to Ågren, is that the experience caused by the VR-model, is a synthesis of the visualization of the drawing in the VR-model and the layman's earlier experiences of having been in other houses. Thus it is this synthesis that becomes more concrete and that can be regarded as containing more information than the abstract drawing. A layman watching a drawing is not likely to be capable to add anything from his/her own experience of that which the drawing describes (in this case a house), and since the drawing itself is rather abstract it does not to the same extent as the VR-model succeed in giving rise to an experience of the house. (Ågren, 1998.)

On the basis of this discussion the critical question would not be in what way the house is being visualized or modeled but which amount of information the different representations can contain. However, since the conditions for visualization of large amounts of information changes depending on which technique is being used, in the end this approach also leads to regarding the choice of visualization technique as being most crucial (Stolterman, 1997). The form and the content of the visualized model are obviously hard to separate.

To reproduce always involves abstraction. Irrespective of how much information that is being put into a model it can not be regarded as containing as much information as the reality it describes, thus it becomes more or less abstract. However, depending on the purpose of the model the requirements regarding its content vary. For example must a map used at orienteering be very detailed and show where woodland paths and hills are located, whereas a roadmap covering the same area does not have to meet the same requirements regarding levels of detail and information substance. Thus, when something is to be modeled a selection is made, choosing the aspects that are relevant according to the purpose of the model. These aspects of the total information sphere are than being reproduced in the model. Although the reality is one and the same it can consequently be reproduced in several different ways depending on which aspects being brought out. This also implies that it is possible to put subjective values about reality in the model representing that reality. It is important to bear in mind that models are being used to communicate a message. By reproducing an object or a process the *right* way the model can than be used to promote certain interests and to communicate certain values (Ågren, 1998). Even though this always is the case when making models and representations, the advanced visualization techniques provides new sophisticated tools for manipulation and modification of reality.

The use of the advanced visualization techniques dramatically changes the possibilities to describe and communicate different kinds of information. For that reason it is of great interest and importance to study how these new techniques function and

what the consequences are of using them.

The experiment

One common application area for advanced visualization techniques is the building process. The techniques can be used in several stages of the process, in the initial stage of planning as well as in the final stage of evaluating the end product.

In this experiment a house was described using two different techniques for information visualization. The traditional techniques were represented by drawings of the house and the advanced techniques were represented by a desktop VR-model of the house. The subjects were divided into two groups and the participants in one group used the drawings to study the house whereas the other group used the VR-model.

Method

Because of our lacking ability to make an acceptable desktop VR-model, a model found on the Internet was used in the experiment. The model is made without any commercial interests, using VRML 1, by a student at the School of Engineering of the Cantone Ticino in Switzerland (Scholer, 1996). The VR-model was studied using the VRML-viewer blaxxun CC3D version 3.07 as a plug-in application to Netscape Navigator version 4.04.

The drawings were then made by hand on the basis of the VR-model. Totally, six drawings were used of which four showed the outside of the house. The drawings contained some written text explaining the functions of the different rooms, for example were the bedrooms marked with the text “bedroom”. In the VR-model some of the rooms were furnished, however, these pieces of furniture were not present in the drawings. The house had two floors including the attic, which had a low ceiling height and were intended to be a storage room. The ground floor had three rooms, a kitchen and a smaller storage space. There was no bathroom. The house had two entrances, one on the front and one on the back of the house at the storage space.

The subjects were eight students at the University of Umeå, aged 20-30, four men and four women. The subjects were chosen mainly because of their availability. They were not to have any experience from the application area. People that are used to make and interpret drawings have a trained ability to “see” the information put in a drawing. That means that a drawing becomes much more useful for such people than it is for a layman who does not have the same knowledge and experience. Since the experiment did not aim to study how professionals could use the new visualization techniques, people with such prior experience were excluded.

The subjects were divided into two groups, each consisting of two men and two women. They were given the task of examining the house with the main purpose of creating a personal opinion of the house and its features. One of the groups performed the examination using the drawings and the other group used the desktop VR-model. The experiment was performed individually.

The part of the experiment where the VR-model was being used was carried out in a computer laboratory at the Department of Informatics at the University of Umeå. By way of introduction, the subject was allowed to get acquainted with the software and its functions by navigating through two smaller models representing an office and a market place. Then he/she were given time to examine the VR-model of the house. Most of the subjects needed 10-15 minutes before they said that they had got a satisfactory

understanding of the house and its features. Afterwards they were given questions about the house and they were being asked to describe it and to reveal their opinion of the house. The subject was free to mention any aspect or feature of the house that he/she had been taking notice of during the examination. Since we wanted them to reveal their spontaneous impression of the house we tried not to control or lead the conversation in any direction. The conversations were being taped in order to enable later compilation and analysis. To get a complete picture of how the different subjects had experienced the house they were finally asked to make a sketch of the design of the house as they remembered it.

Since no computer were needed for the second part of the experiment it was performed in an ordinary classroom. The subjects in the second group were given the very same task as had been given to the subjects in the first group, only this time the examination of the house were performed using the six drawings each presenting the house from different perspectives. After 5-10 minutes the subjects regarded themselves as being done with their task and afterwards they too were asked to describe the house and to make a sketch of its design.

Results

The results of the experiment show that the participants in the two separate groups experienced the house in different ways. The differences can be categorized under the four headings; *Language*, *Aesthetics*, *Spatial perception* and *Functionality*. These headings are not chosen according to any specific purpose, but only because they reflect the received results.

The experiment was performed individually but since we want to point out tendencies in the two groups, when describing and discussing the results we will refer to the groups as a whole. We will refer to the groups as the *VR-group* and the *drawings-group*.

Language

Under this heading the linguistic differences between the groups are being discussed. The intention is not to look for different words that are being used by the participants, but to compare the groups' different way of expressing their opinions about the house.

When the participants in the drawings-group were to describe the house they started by describing the location and the estimated sizes of the rooms. Their description reminded of a travel instruction; "*…the kitchen lies straight ahead, on the right there is … a big bedroom*". The participants in the VR-group were instead describing the house by giving more of a graphical description. According to them the house was "*cozy*", "*angular*" and "*airy*". They used words and expressions that showed that they have had a stronger feeling of being present in the house, than had the subjects of the drawings-group. When the groups were to reveal their opinion of the house, the drawings-group said that the house appeared to be "*rather OK*", and "*bad planned*" whereas the VR-group referred to the house as "*angular*", "*nice design but to stiff*", "*a small cozy cottage*". Thus, using a more expressive language was a typical characteristic of the VR-group.

One of the reasons for the more graphical description of the VR-group can be that the VR-model, to a greater extent than the drawings, gives rise to a strong sense of presence. The subjects given the possibility to examine and to walk through the VR-model of the house noticed details that are hard to discern with just the aid of two-

dimensional drawings. For a person without prior experience of interpreting drawings it is hard to for instance notice the relation between ceiling height, window size and room size. By "*walking through*" the model of the house the VR-group have received a better apprehension which have led them to describe the house as "*airy*", "*harmonious*", "*narrow*" and "*tight*".

To sum up, the subjects in the VR-group seemed to use more adjectives when describing the house. The drawings-group described the house mainly with concern to its structure, the number of rooms and the sizes of the rooms.

Aesthetics

Apart from the linguistic differences between the groups there was a difference regarding their opinion about the aesthetic features of the house. Subjects in the VR-group showed a greater ability to view the house out of an aesthetic perspective. They often commented on aesthetic features, for instance saying that the house had "*a funny roof*", "*nice pillars*" and "*a nice porch*". The drawings-group never really mentioned the aesthetic features of the house, instead describing the house regarding to its functionality, saying that an inner wall should be removed or that two rooms should switch places to improve functionality.

In the very same way that the language used by the two groups were affected by the ability of the VR-model to give rise to strong feelings of being present, this also influenced the ability of the groups to view the house out of an aesthetic perspective. The higher "level of presence" within the VR-model seemed to cause the VR-group to notice more of the aesthetic features of the house than did the drawings-group.

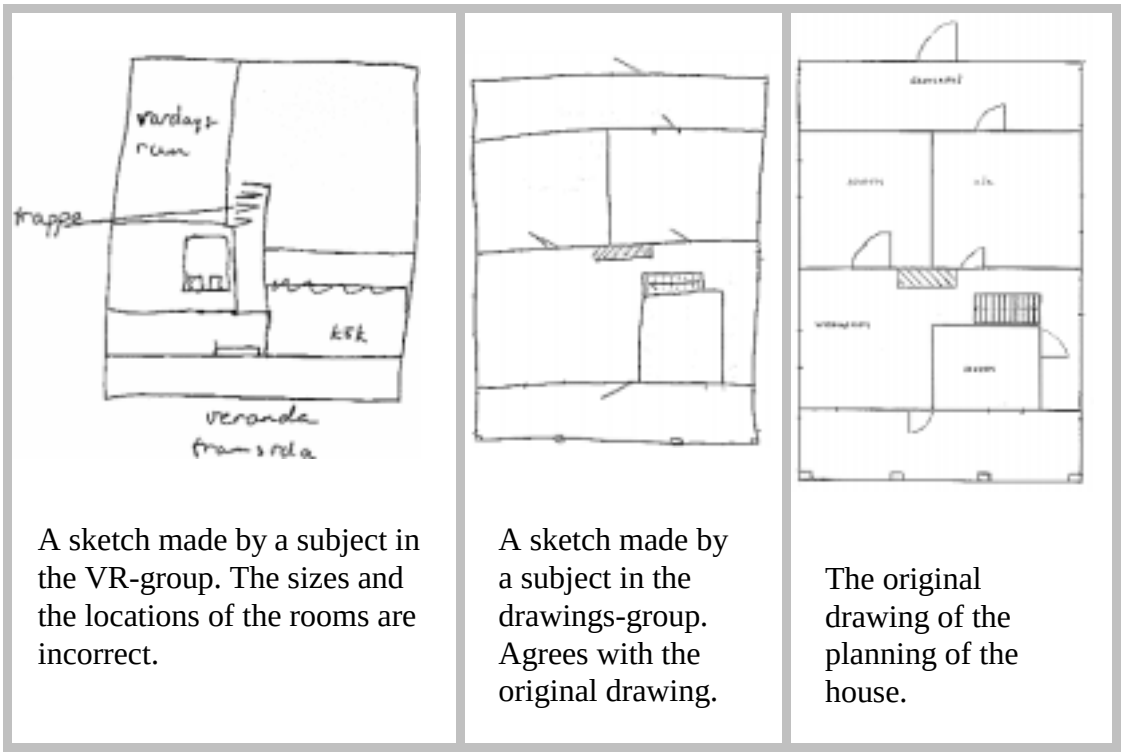
The subjects in the drawings-group tended to spend a lot of time on studying the planning of the house, while only rapidly looking over the drawings presenting the outside of the house. This can be one of the reasons to why they did not have anything to say about the aesthetic features of the house. On the basis of only the planning it is hard to comment on the aesthetics. To do that it is necessary to also study the drawings presenting the house from other angels than from above.

Spatial perception

The spatial perception involves understanding the size of the house, the sizes and the locations of the rooms and the overall planning of the house. The VR-group described the house as small with narrow corridors combining the rooms. They also agreed about the windows being large. The drawings-group had a different opinion. No one in the drawings-group thought that the house was small and someone said, referring to the kitchen, that it was "*very big*".

All subjects in both of the groups thought that they, after having examined their model of the house, had a good and fairly correct image of the "real" house. Nevertheless, when they later were asked to draw a sketch of the house it was evident that the subjects in the VR-group did not have a correct understanding of how the planning of the house really looked like. In figure 1 examples of sketches made by subjects in the different groups are showed together with the original drawing of the planning of the house.

The sketches clearly show that the subjects in the VR-group were not capable of placing the rooms in their right places neither could they determine their sizes. The subjects in the drawings-group could, however, make a correct and detailed sketch showing the planning of the house. All of them could describe the location of the rooms and in most cases they could also tell the location of the windows.



A sketch made by a subject in the VR-group. The sizes and the locations of the rooms are incorrect.

A sketch made by a subject in the drawings-group. Agrees with the original drawing.

The original drawing of the planning of the house.

Figure 1. The ground floor of the house. Sketches from subjects in the different groups and the original drawing of the planning of the house.

The reason for these differences between the groups has probably to do with the VR-group lacking the overview of the house and its planning which were available to the drawings-group. It proved to be very hard to get a correct understanding of the planning of the house using only the VR-model. The drawings-group that had examined the correct drawing could, however, without any difficulties reproduce that very same drawing.

The VR-group also experienced the house being small and some of the rooms being very small. This can partly be explained by the way in which the navigation occurred. The subjects examined the house by "walking" through the rooms similar to the way in which one would do in a real house. However, because of certain features in the software being used, the field of vision is quite large, which can lead to the feeling of having an extremely large body. Since the spatial perception is created on the basis of how one's body is being experienced, consequentially the VR-model can be understood as being smaller than it is intended to be.

The VR-model did also, unlike the drawings, contain some pieces of furniture. Thus, when the subjects in the VR-group were to determine the sizes of the rooms it could have been by judging the relation in size between a piece of furniture and the room. This means that the correctness of the scale and the limitations of the software could have influenced the total spatial perception in some way.

Functionality

The functionality of a house has to do with its practical use, if it is appropriate and suitable to the persons living in the house. Crucial to the functionality is the size and the planning of the house. How the subjects experienced those factors have already been discussed but the link to the functionality of the house shows additional differences between the groups.

When the subjects described their understanding of the house it became evident that they had experienced its functionality in different ways. The subjects in the VR-group described the house as small with restricted space, ”*to small to live in*”. Someone called it a ”*cottage*” and another one compared it to a ”*luxurious cabin in the mountains*”. No one in the drawings-group mentioned anything about the house being to small, instead there was a common opinion that the available space was enough, even though it maybe could be used in another way by rearranging the location of the rooms.

The VR-group also had comments concerning the planning of the house and in which way the available space had been used. The kitchen was too small and too isolated. Furthermore, they thought there were too many corridors in the house and due to these corridors there were unnecessary spaces between the rooms. However, the subjects in the drawings-group actually were the ones with the strongest opinions regarding the existing planning of the house and how it could be rearranged to improve functionality. Foremost they commented on the main entrance being located at the living room. This was regarded as inappropriate and they felt that a better solution would be to use some of the space to create a hall at the entrance. This group also mentioned the location of the kitchen and there were many suggestions regarding changing the location of the kitchen and the other rooms. The storage space in the far end of the house was considered too big and that space should instead be given to other rooms. Other suggestions mentioned were for example to change the location of the stairs (leading to the attic), change the location of the windows, create more open spaces by removing inner walls, and building a larger porch on the front or on other sides of the house.

Only four of the eight subjects mentioned that the house was without a bathroom. Foremost, it was the female subjects who did mention it and they of course wanted to have a bathroom in the house.

To sum up, the drawings-group had more opinions regarding the functionality of the house than had the VR-group. Furthermore, they had many proposals for changes and these proposals were of a different nature than those given by the VR-group. The subjects in the drawings-group used expressions like “*rebuild*”, “*rearrange*” and “*remove walls*” whereas the VR-group seemed to focus on minor adjustments of the exterior of the house. The VR-model of the house seemed to be experienced more as a finished product whose form, appearance and features already were determined. The drawings-group wanted to rearrange things and told spontaneously of all the things they thought could be improved if the house were to be built different. The VR-group, on the other hand, seemed to be more reserved and to view the model with respect. It was obviously regarded as a description of an already built house on which rearrangements where hard to perform. The drawings, however, gave rise to a feeling of freedom regarding rearranging the plans for the house.

Comments about the results

It is evident that the subjects have experienced the house in different ways depending on weather they have studied the VR-model or the drawings. Although they have examined the same house, the subjects then describes it using different perspectives and expressing different aspects of the house. Furthermore, the subjects of the two groups have used different formulations and different ways of expressing themselves when describing the house.

The VR-group noticed more details than did the drawings-group and consequentially the VR-model caused a more detailed description of the house. The VR-

group commented on the color and the shape of the house whereas the drawings-group commented more on the location and the function of the different rooms. The drawings-group also commented on hidden factors such as the building material and the insulation of the house, factors that can be of great importance when trying to get a correct total impression of the house.

One of the differences between the groups was the things they wanted to change about the house, when imagining the situation of buying and living in the house. The VR-group tended to mention things that in a real situation could be described as not so important for a decision. The tendency of focusing on details seemed to influence their way of thinking about the house, the details became more important than the whole. The drawings-group, however, had in this respect much more relevant comments about changes that would be necessary if they were about to buy the house. They viewed the house out of a total impression, which also led them to demand changes that were of another kind than those mentioned by the VR-group. A characteristic comment from the VR-group was; "*I would like to repaint…*" whereas the comments from the drawings-group were like this; "*I would like to remove this wall to gain space…*". On the whole the drawings-group had much more comments concerning necessary changes in the house.

The high level of details in the VR-model gave rise to a stronger feeling of being present than did the drawings. The subjects that examined the VR-model could *experience* the house rather than only *view* it, which was the opportunity left for the drawings-group. By walking through the house the subjects could experience aesthetic features as for instance that a room was airy and that the porch was nice. On the other hand, subjects examining the drawings got a better spatial perception, that is to say a better understanding of the sizes and the locations of the rooms. The reason for this was probably that they during the examination of the house had received a better overview of the house. The VR-group thought that they had a good and correct understanding of the sizes and the locations of the rooms in the house, but it became evident that they were mistaken. They had the false impression of knowing how the planning of the house looked like. On the sketches made by the VR-group, the rooms are dislocated and either to small or to big. The drawings-group managed well with their sketches.

All these differences that arose between the two groups leads to the conclusion that the different representations communicated certain aspects and parts of the information sphere unequally good. The VR-model offered details and communicated a feeling of presence, whereas the drawings offered a better overview and a good spatial perception. These differences led to different opinions about the house and also to the usage of different linguistics when describing those opinions. Of course, since this pilot-study only comprises eight persons divided into two groups it is hard to draw any general conclusions on the basis of the result. What *can* be seen are tendencies that it seems to happen in a certain way.

The use of an already existing VR-model also meant not having a perfect model. Maybe if we had made a model with concern to the purpose of our experiment it could have been better. Still, the model used did function well. The drawings were made by us, and since we do not have that much experience in the area of making drawings of buildings, they probably also could have been better made. Before making the drawings, however, we studied other construction drawings and gained an understanding of how we should do. During the experiment the subjects had the opportunity of asking for help when feeling uncertain about anything in the drawings, this, however, were rarely the case.

Our experiment could have been performed in other ways. For example by

including subjects with professional experience from the application area and study how they can use advanced visualization techniques. However, since the purpose of the experiment was to focus on the different abilities of the representations to communicate information, rather than studying the abilities of the subjects to understand the representations, we used only laymen. The different character of the two representations should reasonably appear more clearly when using subjects without prior experience.

The reason for using a house as the object being represented was simply that VR-models of houses already existed on the Internet, ready to use. Furthermore, we knew that we had the ability of making a correct representation of the house using a traditional visualization technique. Still, it would be interesting using other objects and information spheres. Then maybe more tendencies could have been detected.

Consequences of using virtual models as information representations

On the basis of the results of the experiment, let us consider some of the apparent consequences of using virtual models as information representations. When doing so we must bear in mind that the small pilot-study performed not allows us to draw any final conclusions. Still, although the pilot-study does not offer a solid foundation for final conclusions, it can serve as a basis for a discussion of the consequences of virtual information representation.

The discussion is divided into three parts, each concerning a specific feature of virtual representations, *the dynamics*, *the content*, and *the power* of virtual models.

The dynamics of virtual models

One of the most significant features of advanced visualization techniques is its ability to make dynamic representations. Processes and courses of events can not easily be visualized using traditional static visualization techniques. Advanced techniques, however, can capture and visualize the dynamics. By representing a process with a dynamic model, reasonably a correct understanding of that which is being visualized will be made easier. That means that information spheres that earlier were very hard to comprehend without professional skills now can be made legible to a layman.

Virtual models can be understood as dynamic also in the sense of offering opportunities of interaction. The user can actually change and manipulate the presented information. In the dynamic models describing a process it may be possible to see how the process is affected by the changing of different variables. Objects which to their nature are static can also benefit from being described virtually since the dynamic and interactive character of the description makes it possible for the user to examine the object from certain angels and different perspectives.

The VR-model used in the experiment was dynamic, letting the user walk through the model and rotating it to examine it from different angels. However, the user could not change the model. A higher level of interactivity could have meant giving the user the possibilities of changing the colors of the house and also changing other things about its appearance. By letting the user “repaint” the house he/she could have viewed the house in his/her favorite color and in that way a possible decision of buying the house could have been made easier. It could also have been possible for the user to change colors and

textures on the wallpapers and the floors, or maybe to remove or add walls. That kind of scenarios can not be described using static visualization techniques.

In the introduction to this paper we compared the computers and the advanced visualization techniques of today with laboratories for performing studies on complex systems. Casti (1997) argues that courses of action and processes that earlier have been impossible to visualize now can be made accessible thanks to the new techniques. One example of such a dynamic process is the traffic situation in a large city. Traffic engineers spend lots of time planning and constructing roads, creating traffic light patterns and place traffic signs etc, trying to make the traffic run smoothly and trying to minimize the negative effects on the environment caused by the traffic. However, since a traffic system is dynamic and living, there is no way of knowing the effects of changing it. For that reason, a research team at the Santa Fe Institute in New Mexico has made a model which can simulate the road-traffic situation in Albuguerque, a city of about half a million people. The model includes 200 000 households and 400 000 daily travelers moving around on 30 000 different road segments. Every actor in the model makes rational decisions based on population statistics. Parents take their children to school in the morning, continue driving to work and maybe go shopping in the afternoon, etc. The actors make their traveling plans on the basis of the information available and thus can also change plans when receiving new information. In this way the effects of changing the traffic net can be studied and different future scenarios can be examined before any real action are being taken. (Casti, 1997.)

If this information sphere would have been represented with the aid of traditional visualization techniques, the result had probably been lots of maps containing lines and arrows in different colors. The dynamic aspect of the traffic would have been lost. Due to its dynamics the virtual model contains information that would be impossible to detect and interpret from a static description. It is obvious that the study of the total traffic situation is made easier with the virtual model and advantages similar to this can probably be reached within other research fields were dynamic processes are being studied.

The dynamic character of virtual representations is also associated with its possibilities of interaction, and there are many examples of virtual models far more interactive than the VR-model used in the experiment. The Swedish company *Reachin Technologies* has developed a new technique for interacting with virtual objects. To the visual and the audible impression, this technique adds the feeling of touching the virtual object. The hardware consists of a screen, a mirror, 3D-glasses and a “robot-arm”. The robot-arm is a kind of a dataglove that can transmit a sense of contact, which causes the user to feel he/she actually touches the objects seen on the screen. (Johansson, 1998.) With such a technique it is possible to feel the texture and the shape of the real object being represented virtually and assuming a high level of detail in the representation, a realistic feeling can occur. In a not so far future maybe studying biology can involve the possibilities of stroking the back of a an animal and maybe the consequences of the natural laws can be experienced by examining the weight and shape of a virtual object during physics class.

The extension of this means understanding the virtual model as something that can be experienced rather than only viewed. In the experiment this became evident. The VR-group, unlike the drawings-group, described the house as if had they experienced it. The expressive language used by the subjects in the VR-group speaks of a strong experience of the house, although the VR-model used only offered limited possibilities of interaction.

The content of virtual models

Compared to traditional visualization techniques, the advanced techniques can handle larger amounts of information in a way that better facilitates understanding (Spring 1991; Stolterman, 1997). The results of the experiment also indicate that the traditional and the advanced techniques seem to differ in the way they communicate different types of information. This explains why the two groups in the experiment paid attention to different features of the house. The VR-group seemed to be focusing on details and the reason for this was probably simply because the VR-model offered more details than did the drawings.

Focusing too much on details can, however, cause a loss of the whole. This was probably the case with the VR-group showing a defective total impression. Thus, the many details can cause the loss of the bigger perspective, which badly influences a complete understanding of the information being represented.

As previously stated, an abstract model demands interpretation whereas a concrete model to a great extent can be experienced. Since the VR-group, unlike the drawings-group, seemed to have experienced the house, consequentially the VR-model should be regarded as being more concrete than the drawings. Still, is this always the case? Are virtual models always more concrete than those made by a traditional visualization technique and do the virtual models always give rise to strong emotional experiences?

Let us return to the discussion initiated by Ågren (1998). He argued that the VR-model of a house would cause stronger emotions within the user than would drawings of the same house. The reason for this was that the user, to his/her experience of the model also adds his/her own experiences of other houses. This means that the previous experience of the user is important for the successful communication of information.

If for example a person without any earlier experience from engines intends to learn about car engines by examining a VR-model of a car engine, he/she might understand how the oil runs through the engine and how the fan belt gets the fan to function. But he/she will *not* know anything about *why* the engine needs oil or *why* there is a need for a fan in the engine. Thus, in order to use the advantages of virtual models, a certain amount of experience is needed, so that the user can connect the model to reality. In the same way that it is good to learn about the basics in mechanics before you try to fix your broken car engine in real life, it is a good thing to do before examining a VR-model of an engine.

The virtual model is not used unconditionally, but demands, similar to the traditional models, a certain amount of prior knowledge. This also implies that the virtual representation not always has to be more concrete than the traditional equivalent and furthermore that both representations sometimes demand an intellectual interpretation before they can be experienced.

The power of virtual models

When creating models there is always the possibility of inserting subjective values into the models. This is true regardless which visualization technique is being used. Compared with the traditional techniques, however, the possibilities of sophisticated manipulation of models are greater when using advanced techniques. A model can be modified and rearranged so that certain aspects emerge and in that way a specific message can be communicated. This means that it is even more important to consider the

values behind the model and the purpose of the model when using a virtual one. It also seems like the virtual representation, by generating strong emotions within the user, in a very powerful way manages to communicate the message being inserted in the model. This implies that one should consider virtual models as being very powerful in that sense that they successfully can be used to communicate a desired message.

The VR-model being used in our experiment describes a small house placed on a small green area that is supposed to represent a lawn. There are no trees or bushes or anything like a garden and there is no fence or road leading to the house. It is what you would call a Spartan environment, which certainly not contributes to a positive opinion of the house. It is not unlikely to believe that the opinion of the user would change if the house were to be placed in a beautiful surrounding with a blooming garden and singing birds. This way of influencing the viewer can obviously be used by estate agents, and probably is that already the case, agents using traditional visualization techniques trying to persuade presumptive buyers. The advanced visualization techniques, again, increase the possibilities. A client interested in building a house can choose among different alternate houses and then see how that house would look like when it was built, painted in a favorite color and placed in a nice surrounding. This would most likely communicate a flattering message influencing the client towards buying the house.

The experiment shows that subjects examining the VR-model thought they had a correct understanding of the house when actually having an incomplete understanding. All of them said that they thought themselves of having a rather clear picture of the house but when trying to draw a sketch of the house it became evident that they had been mistaken. The sense of understanding and almost having control, caused by the VR-model, was only illusive and misleading. It seems like the user risks to be deceived by the virtual model. Maybe the strong emotions caused by the virtual model create a feeling of having things under control when actually he/she has not correctly understood the information being represented in the model. If that is the case, that implies that virtual models, because of their ability to generate strong emotions within the user, always to some extent manipulate the users' perception of reality. Indeed, most models and representations are made with the intention of communicating an objective reality. This, however, does not change the fact that the virtual model by its nature seems to distract the user so that he/she risks getting an incomplete understanding of the modeled reality.

The power of virtual information representation should obviously not be underestimated and on the basis of this knowledge great efforts should be made on making virtual models correct and neutral, so that the negative effects of their influence are minimized.

Conclusions

The purpose of this paper was to study virtual information representation and its consequences. The experiment being performed was a pilot-study and obviously not sufficient to understand the true nature of virtual representations. However it gives us a notion of some of the most crucial characteristics of the virtual model, characteristics which give rise to certain consequences when using virtual representations.

In the experiment the different representations seemed to communicate information in different ways, causing the users to notice certain aspects of the information sphere being described. Based on the observations of the experiment, the virtual model should be understood as dynamic and interactive and by that means easily

accessible to the user. Unlike traditional static information representations, it can not only be viewed, but the user can also experience it with many senses. The emotions felt by the user can, however, apparently also distract the user and to some extent act deceiving.

As the information technology continues to develop, so will the advanced visualization techniques. If this pilot-study has proved anything it is the need for further studies and extensive research on how these techniques function and how information best can be represented virtually. Coming studies should include several different techniques and also different kind of information spheres. In that way even more characteristics of the virtual representations should emerge. Hopefully this research can keep pace with the technical development so that we not afterwards feel that the technique has led us in a not desirable direction where the consequences of using that technique come as an unpleasant surprise. We certainly need more knowledge of how to use these new powerful tools and with that knowledge the advanced visualization techniques probably can serve as vital tools for communication of different kinds of information.

References

Casti, J. L. (1997). Would-be worlds: how simulation is changing the frontiers of science. New York: Wiley & Sons.

Heim, M. (1998). Virtual realism. New York: Oxford University Press.

Johansson, J. (1998). Svenska *Reachin* har känsla för 3D-gränssnitt. [Swedish *Reachin* has got a sense for 3D-interfaces.] (In Swedish.) Computer Sweden, 1998:107.

Kalawsky, R.S. (1994). The science of virtual reality and virtual environments. Reading, Mass: Addison-Wesley.

Lévy, P. (1998). Becoming Virtual: reality in the Digital Age. New York: Plenum Press.

Scholer, A. (1996). Heinrich Tessenow - Casa unifamiliare (1911). (A VRML-object.) Available: http://www.trevano.ch/Public/progetti/maestri/casaht01.htm (1998-11-24)

Spring, M.B. (1991). Informating with Virtual Reality. In the compilation: Virtual Reality: theory, practice and promise, edited by Helsel, S.K. & Roth, J.P. (1991). London: Meckler Publishing.

Stolterman, E. (1997). Visualization Techniques in Societal Design. Department of Informatics, University of Umeå, Sweden.

Walker, G. (1995). Challenges of information visualisation. British Telecommunications Engineering, Vol. 14, 1995.

Waterworth, J.A. (1996). Proceedings of Ciber@RT'96, First International Conference on Virtual Reality. Valencia, Spain, November 1996.

Wong, G. (1996). The philosophy of Virtual Reality. A SURPRISE 96 survey. Department of Computing, Imperial College of Science Technology and Medicine, London, UK.

Ågren, P-O. (1998). Att förstå virtualisering. [On the Understanding of Virtualisation]. (In Swedish.) Licentiate thesis. Department of Informatics, University of Umeå, Sweden.