SKETCHING TECHNIQUES IN VIRTUAL REALITY: EVALUATION OF TEXTURING STYLES IN AN URBAN PLANNING MODEL

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ABSTRACT:

Today's design processes involve many participants and demand new methods of communication for designers, developers and users. Using Virtual Reality (VR) as a design tool has become increasingly common. Regarding visual expression, photorealism is often strived for, even though this might not always be in accordance with the main purpose of the visualization-project. The research behind this paper regards the development of VR as an architectural design tool that can be used throughout the entire design process, from sketch to final presentation. Here we present results from a comparison between different sketching styles and photorealism in the texturing of an urban planning model. The aim is to show how sketch-like expressions in the texturing of a model can clarify and simplify the understanding of a building project (area plan, housing area, road design). The target group is located within municipalities (architects, planners) and the consultant industry (road designers/engineers, landscape architects). Data was collected from questionnaires answered by 20 participants, all of them professional users of VR. They assessed the experience of the texturing styles in the test model on desktop-PCs. The results revealed important differences and similarities in the perception of the sketching styles vs. the photorealistic style. The evaluation revealed a desire for more sketch-like expressions supporting conceptual design thinking. Even so, models should provide a high level of detail and good spatial experience. Aesthetic factors are considered important. The results contribute to a better understanding of technical and aesthetic limitations of photo-realism in VR.

1. INTRODUCTION

Using Virtual Reality (VR) as a tool for visualization in the design process is becoming increasingly common, and the advantages of using this new medium for communicating ideas are many. However, computer generated visualizations can in some ways also increase the distance between the designer and the representation of the design ideas (Brown, 2003). Visualizations in the early stages of the design process which aim to look as finished and realistic as possible may limit creative thinking, since the flexibility for the final representation is settled too early (Oh, 2006). Using photorealism as a standard representational style in visualizations raises issues concerning the visual expression. In today's VR-visualizations photorealism appears to be the standard representational style, irrespective of what the visualization is intended to show. It can also be discussed if a photorealistic expression in the visualizations can be misleading regarding how finished the depicted design plans are, when on the other hand, the photorealistic level in interactive architectural models is often unsatisfactorily low.

For the design, communication and criticism of architecture, architects depend on representations (Bermudez, 1995). Traditionally, sketches have been used by architects to form and convey their ideas throughout the design process. The value of sketches in the development of a design project lies in the intent to illustrate an idea or a concept that should support creative thinking and conceptual design processes. What is important in a sketch is to show the focus of the idea, i.e. to illustrate the different levels of relevance in accordance with the concept. Another advantage of using sketching is that this technique can pedagogically express how developed the ideas are, i.e. how far in the design process the project plans have come. By using sketching the architect has the ability to visualize information in the project that is not yet fully decided or thought through, as well as to visually enhance aspects of the design which it is important to focus on. For VR to be a useful design tool throughout the whole design process, these values need to be considered. The design process is a wide concept with many interpretations. We consider it to be roughly divided into the early design phases of pre-conception (e.g. associative imagery) and sketching/design, and the later phases of presentation and management.

Our research deals with developing VR as an architectural design tool through visual expression, throughout the entire design process. This paper is based on the research project *Sketching Techniques in Virtual Environments (STIVE)* The problems addressed are connected to 1) how a VR-visualization can convey the different levels of information in an idea under development, throughout the whole design process, and 2) how the creative characteristics of an architectural sketch can be conveyed into a VR-visualization and adjusted to the specific pre-requisites of this technique. The aim with this paper is to evaluate how different alternative sketching styles in the texturing of an interactive virtual model can clarify and simplify the understanding of a building project (area plan, housing area, road design) during different stages in the

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planning- and design process, from initial sketches to final presentation. The motive for focusing on textures in the visualizations is to enable users to get better control of the visual expression. The questions we will discuss in this paper concern both visualization techniques and the experience of a visualization. By analyzing the results from the study we wish to answer the following questions: 1) Which advantages and problems do the participants relate to VR? 2) Is there a need for different texturing styles to better support the different stages of the design process? 3) To what extent are parameters such as colour, details, and aesthetic values of importance in the interpretation of visualization? These questions will form a part of a more general discussion on representational issues of visualization. In this paper these issues will be discussed from the perspective of architectural research and in relation to current research. Target groups are architects, landscape architects, planners, road designers and others interested in representational issues in VR.

The article is structured as follows: Chapter 2 draws a concise picture of research using VR models and different sketching techniques in architectural planning processes. Chapter 3 presents methodological considerations and the experimental project behind this paper. Chapter 4 includes qualitative and quantitative results from a questionnaire completed by 20 professional users of VR in architecture. Chapter 5 discusses these results from the viewpoint of discovering how different texturing styles and sketching techniques better support design processes. The last section presents conclusions and future work. The term VR-visualization refers in this context to a computer generated architectural 3D-model, which can be used as a base for rendered images, for animations or for an interactive visualization and in which a user can move around in real time.

1.1 Problem Area and Relevant Research

The field of visual representation in VR is broad and includes many disciplines, from imaging and technical areas of expertise to cognitive science and art. Unwin (2007) refers to the literature of architecture when distinguishing three main uses for architectural drawing, that is: as a medium for *communication* (with clients, builders etc), as a medium for *design* (private 'play') and as a medium for *analysis* (to acquire knowledge and understanding). Among architects VR as a tool for visualization is above all used in order to communicate ideas (Setareh et al. 2005). In this paper we will mainly focus on visualizations as a means of *communication*.

As mentioned in the introduction, the value of sketches in the development of a design project lies in the intent to illustrate a design idea or a concept rather than showing the real world setting as it is. However, two dimensional drawings can sometimes be hard for laymen to interpret, and thus are not optimal for architects as a means of communication. For example they have difficulty providing a correct impression of scale as well as perspectives of every space from all angles, which is something that VR-visualizations facilitates (Savioja et al. 2003). Communication to non-specialists seems thus to be made clearer and easier through the use of computer visualizations, i.e. both interactive representations and rendered realism. (Neto, 2003) It is however still difficult to design and implement a trustworthy virtual environment, even with today's progressive technology. The traditional assumption has been that by making interactive models look as visually realistic as possible, more believable virtual experiences have been created (Drettakis et al, 2007). But still, visual realism is hard to obtain, mainly due to the complexity and richness of the real world. Neto (2003) stresses the importance of putting great care and critical information into the creation of visual computer technologies. He states that interactive models used in planning and design practice, due to still being too artificial looking, mostly lack the necessary believability to be accepted as reliable tools for evaluating the proposed urban or architectural space (Neto, 2003).

It appears that the research area of architectural representation in VR needs to be further studied in order for VR models to be used to correctly convey ideas throughout the design process. Kwee (2007) notes that the area of digital architectural presentations focuses on the technology's provision for speed and ease of information retrieval. In the meantime, the quantity and presentation of information in these visualizations are assumed, without proof, to be currently adequate for mediating correct understanding. He states that there still needs to be much rethinking and improvement to consider in order to understand the potential of digital visualization for architectural presentations. (Kwee, 2007) Although exploratory usability-oriented studies involving VR-programs have been carried out (e.g. Panagiotis et al, 2006), very few studies have been reported on the role that VR plays, and could play, in ongoing environmental planning contexts (e.g. Heldal et al. 2005). Balakrishnan et al. (2007) observe that physical objects rather than the spatial experience are emphasized in common digital tools for design visualization. In current rendering technologies great achievements are made in representational similarity through increased photorealism. Accordingly the challenge lies in the experimental concordance with a corresponding real space. Balakrishnan et al. state that more work needs to be done exploring current tools of digital representation, in order to improve aspects related to the experience of a simulation (Balakrishnan et al. 2007).

In relation to the technical development for visual rendering, there are new techniques that support non photorealistic rendering (NPR), e.g. by generating textures with boundary effects (Ritter et al, 2006) and creating 3D shapes from 2D contour sketches (Karpenko et al, 2006). These works use *given* background information (e.g. from topology databases) where the naturalism of certain features (e.g. boundaries, volumes – provided by the databases) are important. Thus the form of final products can be predicted. Contrary to this, our project aims to find the necessary information (e.g. simple lines and shapes) that supports creativity to obtain new solutions. Here the new forms should support conceptual design thinking and not be limited by predefined structures. Bermudez (1995) encourages us not to concentrate our investigations on the computer's power to do what we already know how to do, but instead to focus on the distinctive features and uniqueness of digital media. He states that the unique ways in which electronic representations address architectural issues, elements, ideas and design problems need to be dealt with. (Bermudez, 1995)

In the process of forming a design idea there is a need for different expressions and levels of representation. The visualizations also have to interpret some issues exactly (e.g. Drettakis et al, 2007), while just sketching others (Lange, 2005). The precision of representation can differ from one user group to another or from one design phase to another (Al-Kodmany, 2002). According to Brown (2003), in different phases of the design process different types of representations appear to serve well, and one challenge lies in how best to

integrate the different computer generated representations into the design process. Too much detail and visual realism in representations at the initial stages of the design process is often not necessary and can even be misguiding, since that information will not be decided on until later on in the process (Neto, 2003). Several experiments have been conducted on comparisons with the human vision response to computer generated architectural images with a conventional expression of hard edges and straight lines to a hand drawn expression, with wobbly lines (Van Bakergem and Obata, 1991; Brown and Nahab, 1996; Bassanino, 1999). Results from these studies showed that the images with a hand drawn expression, depicting the same building and containing the same data as the hard edged images, were rated higher on qualitative factors such as stimulation and interest (Brown, 2003). Brown notes that "Such images, whether produced manually or via computer hardware and software appear to have more worth attached to them and are regarded more highly as stimulating and pleasing architectural objects." (Brown, 2003)

2. EXPERIMENTAL PROCEDURE

The research project STIVE was conducted between 2007-08 and is a collaboration between the Dept. of Architecture at Chalmers University of Technology and the software developer Vianova Systems Sweden AB. The target group for the study was located within the municipality (architects, planners) as well as within the consultant industry (engineers, landscape architects). The research approach is primarily design-based (Groat and Wang, 2002; Billger and Dyrssen, 2005) focusing on elaborations with texturing in an interactive visualization. A selection of textures were applied in an environmental interactive test model, which was designed to present the different texturing styles from various distances and in varying environmental contexts (housing area, roads and nature). Together with a questionnaire and a user manual, the test model was distributed to the selected group of participants for evaluation. The results were then compiled and analyzed.

2.1 Set-Up

The test model was designed in the infrastructure design software Novapoint Virtual Map[**], which is an add-on modeling and visualisation application on the AutoCAD platform. The choice of software was connected to the need for the participants to be able to switch between the texture styles in a simple way, though they were restricted from changing the actual structure of the model. The participants assessed the task on desktop PCs. As part of the set-up, the participants were required to download the model from the Vianova ftp site and install the accompanying Style-library, which contained the seven different texture styles. Before beginning with the actual evaluation, they were asked to get acquainted with the model for a few minutes. When evaluating the model the participants were asked to go through different viewpoints in each texture style, before answering the questions in the accompanying questionnaire.

In the study, 20 participants took part, both architects and civil engineers, all of them professional users of VR in environmental and architectural contexts. Since the participants were located all over Sweden, the questionnaire and accompanying information had to be sent to them by mail and the other correspondence was handled via e-mail and phone. In order to ease the set-up and the viewing of the model for the participants, one important condition was that they would already be familiar with Novapoint Virtual Map and have access to this software.

[**] http://www.novapoint.se/produkter.asp/id/30/LID/12627

2.2 The Demonstration Model

The study was based on a VR model containing built environment, infrastructure and landscape (see Figure 1). A selection of textures in different artistic styles was applied in the model and shown to the participants. The virtual setting which the model displayed consisted of different environmental contexts in a typically Swedish landscape in summer time. Since the context was to be usable for both landscape architects, architects and planners the virtual setting included parts relevant for each profession. One part of the model showed a housing estate, consisting of both single houses and blocks of flats of different sizes, detail and expression. Another part described different types of roads, while the third part described countryside displaying various trees, bushes, flowers and ground materials. In order to simplify the task for the participants, a selection of different view points, showing what was relevant in the model, had been preset. One important criterion was that the model should contain common types of objects that a VR-visualization consists of. These objects include *billboards* (i.e. trees, bushes, people), *buildings* (i.e. facades of a selection of different building types), *ground material* (i.e. gardens, meadows, fields, farmland, woodland etc), *roads* (i.e. paving, slopes, ditches) and *back-drops* (i.e. the edge of a forest, wood fences etc). Another basic criterion was that the model should be equally well represented in all of the included texture styles.

Figure 1: The demonstration model, showing 1) built environment, 2) landscape and 3) infrastructure

2.3 The Textures

Different artistic texture styles were developed and applied in the model. The starting point for the elaborations was the original photorealistic textures in the model. Important in the elaborations was that the textures should work in different stages of the design process. Variations in detail, expression and abstraction were considered. For example, textures containing only outlines or coloured surfaces were assumed to work better in the beginning of the design process, where the concept rather than the details is most important, while the textures containing more details should

be suitable for later stages. The general aesthetic expression of the textures was considered more important than, for example, correct colour reproduction in each texture, and a certain amount of artistic freedom was allowed. The elaborations concerned both colours and greyscale. A large part of the elaborations consisted of finding a suitable balance between textures on vertical and horizontal objects in the model. The final selection of texture styles was to include a variety ranging from less to more detailing, more abstract and artistically free styles to realistic ones, and monochromatic to polychromatic ones.

The final selection of texture styles came to include *Realism, Colour, Greyscale, Contour (Colour)*, *Contour (Black and White), Graphical* and *Sketch* (see Figure 2a and 2b). The styles were defined as the most relevant by two experts in the STIVE-project. The textures of *Colour* and *Greyscale* were poly- respectively monochromatic surfaces and contained the fewest details, followed by *Contour (Colour)* and *Contour (Black and White),* which were surrounded by black borders. *Contour (Colour)* contained slight variations in colouring while *Contour (Black and White)* was purely black and white, imitating pen and paper. We thought these styles suitable for the early stages of the design process. The textures *Graphical* and *Sketch* were more sketch-like and artistic, and contained more detailing. They were assumed to be more suitable for presentational use in later stages of the design process. *Realism,* containing most detailing, was the default photorealistic texture from which we started the elaborations.

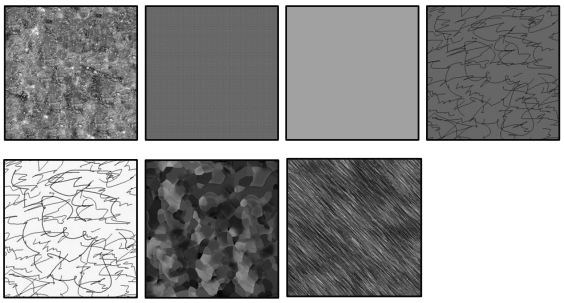

Figure 2a: Ground textures. From top left: *Realism, Colour, Greyscale, Contour (Colour), Contour (Black and White), Graphical* and *Sketch*

Figure 2b: The texture styles on billboards. From top left: *Realism, Colour, Greyscale, Contour (Colour), Contour (Black* and *White), Graphical and Sketch*

Most of the chosen final textures were designed in Adobe Photoshop, apart from the *Graphical* style and the *Sketch* style which were drawn by hand and then manipulated in Photoshop.

2.4 The Questionnaire

The questionnaire was divided into four sections. The first section concerned the professional profile of the participants, while the second focused on their use and experience of working with computers in general. Their experience of working with 3D-visualizations and which software they used was encircled. The third section concerned their experience of VR-visualizations. The participants were asked to give their views and comments on the general advantages and problems of today's VR-visualizations, and how they might be improved. They were also asked to comment on how well their companies' VR-visualizations fulfilled their purpose. In section 2-3 free descriptions were used to a large extent, sometimes as a supplement to encircled answers of a yes/no/don't know-character. The fourth and biggest section of the questionnaire concerned the evaluation of the experience of textures in the accompanying test-model. In this section a few more evaluation techniques were added:

1. Free description of each style. The participants were asked to describe, with one or two words, the experience of each texture style.

2. Motivated semantic differential scaling. The participants were asked to mark the importance of different characteristics (colour appearance, detailing and aesthetics) for the textures on an open 7-grade scale and to motivate the markings.

3. Visual evaluation of the model. The participants were asked to encircle the texture style best suited for each component in the model (ground, billboards, buildings, road, and side-scenes).

The questionnaire was composed of both qualitative and quantitative questions, which were important complements to each other.

3. RESULTS

Here we will present the results from the different parts of the questionnaire.

3.1 Part 1 and 2 of the Questionnaire: Target Group and Computer Usage

Part 1 of the questionnaire concerned the professional profile of the participants, while Part 2 concerned their usage and experience of working with computers. The questionnaire was sent to 34 participants, from among whom 20 answered and returned it. All of the participants were occupied within the municipalities or the consulting industry, with work concerning planning and design of architecture and infrastructure. The group of participants came to consist of 10 architects (5 female and 5 male) and 10 engineers (4 female and 6 male). The age of the participants varied from 28 to 57 years, with an average of 37, 5 years. The participants were all used to working with computers, with an average experience of 15, 5 years and 30-40 working hours per week in front of a computer. They were all familiar with AutoCAD and most of them also with other 3D-visualization software. On the question of how often they worked with 3D, 10% answered "frequently", 60 % answered "sometimes" and 25 % answered "seldom". On the question of who made the visualizations that they used, all of the participants answered that their own companies created them.

20% also used external visualization consultants. It is important to note that all of the participants in the study were working with visualizations in addition to their ordinary work tasks and that the visualizations were to be an aid for them in their work.

3.2 Part 3 of the Questionnaire: Visualization Technique

Part 3 of the questionnaire concerned the participants' opinions on visualization techniques, focusing on the advantages and disadvantages of VR-visualizations. The answers were all qualitative. The main advantage of using VR-visualizations was considered by most (70 %) to be increased understanding of a project. Many of the participants defined this to be the advantage of being able to mediate ideas to clients or the public. 30 % considered the capacity and content of the visualizations to be other advantages. Many also mentioned the ease of orientation and getting a general view of a VR-visualization compared to 2D. Some comments read: "Inexperienced map readers get a clearer picture of the area, heights, layers etc.", "It is easier to mediate an idea to a client by using 3D-views." and "The whole; that it is all there." The main disadvantages of using VR-visualizations were related to the representation of realism (43 %), the technology (31%), the basic data (16%) and the work effort (10%). Many of the participants commented on the representation of realism as a problem. Some of them specified this to regard *the level* of realism in the visualizations. One wrote: "Some users get more annoyed that everything does not look exactly as it does in reality, instead of seeing the purpose of the model." Another one noted that: "Those who see the model often expect it to be more accurate than it actually is." Other participants commented on wrong interpretations of realistic looking visualizations. One remarked: "A too realistic looking visualization can lock the opinion of what an area / a building can become." Another comment read: "It can be a risk that the public believes that it will become exactly as it is shown – which is not always the case." One wrote: "It [the visualization] is not always regarded as a sketch, but is experienced as more fixed." Regarding the technology and the work effort, time-consumption was mentioned by many as one of the biggest problems. One participant wrote: "Too much energy is taken from the "real" design in order to do a good-looking VR-model." Other problems included the size of the visualizations and usability issues, i.e. difficulties in learning new software, and also that visualizations sometimes are too complicated to make. One participant remarked: "[The visualizations are] difficult to run in real time. I wish they worked more like well-made computer games." Difficulties in finding good basic data (orthophotos, terrain data etc) for the visualizations were also mentioned as a problem.

3.3 Part 4 of the Questionnaire: Evaluation of the Texture Styles in the Demonstration Model

The fourth part of the questionnaire contained both main questions with sub questions and groups of questions. Some participants did not answer one or more of the questions, and therefore the numbers of answers which are accounted for in this paper vary between 16 and 20. Important to consider is the qualitative follow up to each quantitative answer. Also important to note is that participants sometimes stated more than one alternative in their answers. For the analysis we have considered this, and chosen to calculate each answer as 1. If the participant stated two styles as answer to a question that demanded only one alternative, we calculated on 0,5 for each stated style. If they stated three styles we calculated on 0,33 for each etc. This procedure has been consistent throughout the analysis. On the question of which texture style they would most likely consider using as a work tool in all stages of the planning and projection-process (see Figure 3a), the participants answered that they would chose *Sketch* (21%), *Realism* (20 %), *Contour (Colour)* (16%), *Colour* (15%), *Graphical* (13%), *Contour (Black and White)* (11%) and *Greyscale* (4%). Comments revealed that the sketch styles were considered good in order to simplify or distinguish objects in a model, as well as for adjusting and varying the model for a specific need or stage. Realism was commented on as being useful in the latter stages of the design process. On the question of which texture style they would most likely consider using as a tool for presentation (see Figure 3b), the participants answered that they would chose *Sketch* (27%), *Contour (Colour)* (24%), *Graphical* (16%), *Realism* (15 %), *Contour (Black and White)* (13%), *Greyscale* (3%) and *Colour* (2%). When analyzing the accompanying comments, it is apparent that the sketch styles were considered more usable as a presentational tool than as a work tool. A mix between some of the sketch styles was asked for by some, as well as the ability to combine sketch style objects in an otherwise realistic looking model to enhance new additions to a plan. One participant remarked "Often it is desirable to be able to decrease the realism in a model. If the realism is too high, smaller details with not so much significance get too much attention."

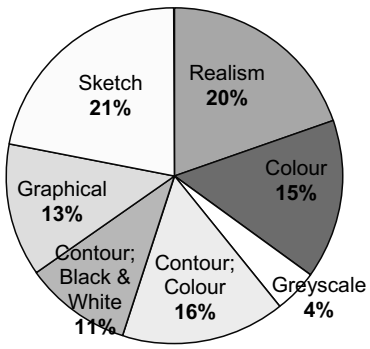

Figure 3a: The texture style best suited as a tool for sketches and projections

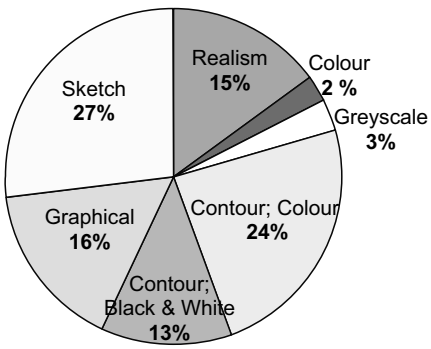

Figure 3b: The texture style best suited as a tool for presentation

The participants were also asked which texture style they considered to work best on each object type (ground, billboards, buildings, road and background) in the model. In their answers *Sketch* was considered to be the best working style for billboards (39,5%), buildings (39,5%) and background (42%).

For roads *Graphical* was most popular (28%) and for ground textures the *Contour (Colour)* (45%) (see Figure 4).

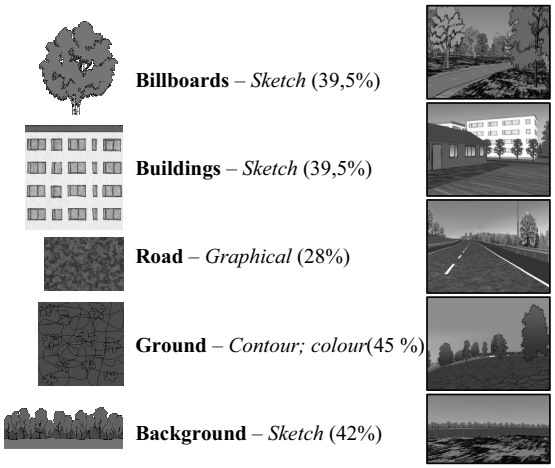

Figure 4: The best working texture style for each object type in the model

The participants were asked to mark the importance that the different characteristics *colour appearance*, *detailing* and *aesthetics* have for the textures on an open 7-grade scale and to motivate the markings (see Table 5).

	Colour appearance	Aesthetics	Detailing
Sum	36	34	19
Mean value	2	1,9	1,1
Modal value	2	2	2
Non-response	2	2	3

Table 5: The importance of colour appearance, aesthetics and detailing for the visual expression of a VR-visualization

The scaling stretched from 3 to -3, where 3 was considered the most affirmative and -3 the most negative. 0 was neutral, but considered in the calculation. The mean value for the importance of *colour appearance* for the experience of the visualization was 2. The modal value (i.e. the highest number of participants marking the same number) was also 2. The mean value for the answers to the importance of *aesthetics* was 1,9. The modal value was 2. The mean value for the importance of *detailing* was 1,1. Here, too, the modal value was 2.

The textures which the participants generally preferred were *Sketch* (41%), *Contour (Colour)* (20%), *Realism* (19%), *Graphical* (11%), *Contour (Black and White)* (7%), *Colour* (2%) and *Greyscale* (0%) (see Figure 6). Evident when analyzing the comments is that the different styles would sometimes benefit from borrowing some of each other's features. One participant remarked for example that *Contour (Colour)* had better textures for buildings and ground, but that the trees and other billboards looked better in the *Sketch* style. *Contour (Colour)* was described as good in being distinctly visible at both long and short distances. *Graphical, Sketch* and *Contour (Colour)* were regarded by some as good in their ability to depict reality in a non-realistic manner. Among the architects 8 out of 10 preferred the sketch styles and 2 preferred realism. Among the engineers 7 preferred the sketch styles and 3 preferred realism.

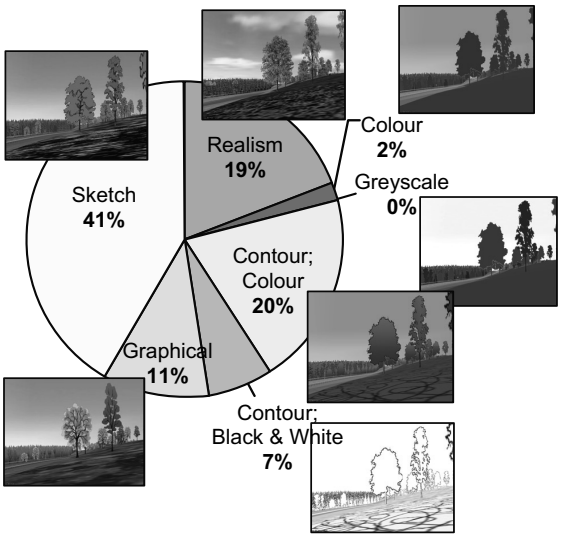

Figure 6: The generally best liked texture styles.

4. DISCUSSION

This discussion concerns the experience and evaluation of the test model in relation to current research on representational issues in interactive visualizations, from the viewpoint of architectural research. The questions we set up to answer were: 1) Which advantages and problems do the participants relate to VR? 2) Is there a need for different texturing styles to better support the different stages of the design process? 3) To what extent are parameters such as colour, details, and aesthetic values of importance in the interpretation of a VR-visualization?

The results gave us distinct answers to the first question. The participants confirmed what earlier studies have already acknowledged as advantages of using VR, such as an increased understanding of a project. Above all, the results point out the potential to mediate ideas to clients / the public. Other benefits of using VR were allowing dynamic content of the visualizations, understanding volumes, and better support for orientation. Regarding the problems of using VR, important results for this study include the representation of realism, which many participants considered a problem; above all the level of realism in the visualizations. The participants also considered it to be difficult to find good basic data (maps, orthophotos, terrain data etc) for the visualizations. A large part of what was considered problematic in using VR was related to technological issues, above all time-consumption and the overly large size of the visualizations. Usability issues and work effort were also pointed out as problems, i.e. difficulties in learning new software and visualizations being too complicated to make. This study also proved that more attention needs to be given to considering appropriate texturing styles in the different stages of the design process. The less complex styles were presumed to fit the early stages of the design process, while the more artistic and detailed ones were presumed to better suit the later stages. The results show that participants disliked certain styles, especially if they were not used to these in their everyday work. For example, the low ratings for the simplest styles (*Colour* and *Greyscale*) revealed that we misjudged these styles as fitting the early phases of the design process. The difference of the gradient, thus a more varied colour range, and the black borders were probably the

reasons for the otherwise similar *Contour (Colour)'s* much higher rating. The third stated question concerned the impact that the characteristics *colour*, *aesthetic values* and *detailing* have for the interpretation of visualizations. The high mean and modal values, in combination with the overall disregard for the monochromatic texture styles among the participants, shows the importance of *colour* in VR-visualizations during the whole design process. From the qualitative answers it generally appears to be of lesser significance that the colour appearance is correct, than that the over all impression of the total and combined colour appearance is satisfying and harmonious. Considering the impact that *aesthetics* have, the high mean and modal values indicate that this is very important. Some of the participants commented on the value of presenting a project using a VR-visualization in a non-realistic manner, demonstrating that it is a *proposal* instead of an attempt to visually imitate reality. One participant remarked: "I think a combination of different styles would be useful. Often you want to produce a sketchy expression, so that it does not look too finished. An even more sketchy appearance would be good." This comment may suggest that in some stages of the design process it would be valuable to use sketching tools with more naturalistic information obtained from predefined databases (e.g. Ritter, 2006; Karpenko, 2006). The slightly lower mean value and more scattered modal value of the relevance of *detailing* for a visualization indicates that this was not considered to be of equally high importance. These results are in line with the results from Oh et al (2006). The texture styles with the fewest details, i.e. *Colour*, *Greyscale* followed by *Contour;(Black & White)*, were generally the least popular ones, both as work tools and for presentational use. The exception was a slightly higher rating for *Colour* used as a work tool. This is somewhat surprising since the lack of details in those textures was an attempt to adjust them to fit the first stages in the design phase, where the forming of a concept rather than focusing on undecided details are relevant. One of the participants suggested adjustments for different contexts which would make the styles more applicable on different "zoom-levels".

It is surprising to note that the participants generally considered aesthetic values in a visualization to be of higher importance than detailing. Aesthetic values have always been important in architectural visualizations and many of the participants from an architectural background also expressed a satisfaction with being able to work with aesthetic alternatives. One participant remarked that the sketch styles were good considering that "the architect will recognise himself". The lower ratings of detailing might be connected to Neto's (2003) assumption that too much detailing in the beginning of a design process is more of a hindrance than an aid to the correct perception of a project proposal. From the participant's answers we draw the conclusion that research on representational issues in VR is highly relevant and needs to be further looked into. Users have different purposes with their visualizations and use them in varied contexts, and therefore require different alternatives, which was also stated by Al-Kodmany (2002). Since, among the participants, there was an outspoken need for more sketch-like expressions and the option to choose the levels of detail in the visualizations, the question arises if the striving for photorealism and naturalism is just a current norm irrespective of what the visualization is intended to show. Many participants expressed dissatisfaction with the limited and conformist appearance of today's VR-visualizations. One participant wrote: "What we [in our company] miss in general is the ability to be able to soften the visualization. We liked the sketch style textures and want to see more of that." Another comment read: "These styles are a good step in the right direction. I believe it is beneficial to use a model in different stages and with different expressions." A photorealistic expression in interactive visualizations has sometimes caused clients to interpret the visualized project to be more finished than it actually is, which can thereby lead to unfulfilled expectations and disappointments. On the other hand, in VR-visualizations photorealistic textures in combination with a simplified geometry and lack of realistic interactive light also tends to create an imbalance in the visual expression. This sometimes unsettles users viewing the model, i.e. the model has the ambition to look realistic but does not look realistic enough. Many participants expressed a desire to be able to combine different styles in the same visualization (which was one of our original intentions). Finding a balance between horizontal and vertical textures in the model proved to be difficult, something that some of the participants also commented on. An important remark here is that it is easier to create a trustworthy appearance for textures on vertical objects than for the horizontal areas. This is connected to the lack of borders and the pattern of repetition in the horizontal areas, compared to the frames of single objects for the vertical textures.

In order to see what the two groups of architects and engineers preferred, we did a summary of preferences for the different styles vs. the realistic style. The differences in preference between the two groups were smaller than expected. The group of 10 architects and 10 engineers was however too small for any real conclusions to be drawn. Interesting to note is that the engineers in their qualitative answers were more positive towards the photorealistic texture style, and the architects were more dissatisfied with it. This tendency did not, however, show in any of the quantitative answers.

Considering the approach to this study it is relevant to note that design-based research is not a linear process. Instead it has been necessary to change perspective and go back and forth between theory and practice. The many hours of elaborations can be used to create better design, but above all to increase the understanding of VR's possibilities, as well as to answer questions on when and how we can use this relatively new medium and what the implications of it are for participants with different expertise. The number of participants in this study might be regarded as low. Regarding this, it is important to observe the set-up of the study. For the participants the study was demanding to partake in; both in time and in technological skill. It furthermore required that they would be familiar with and have access to the software as well as fit a specific professional profile. Above all the qualitative answers are very valuable, and through their combination the qualitative and quantitative answers did complement each other well. The variety of questions enables us to identify tendencies for users fitting our profile in their approach and experience of VR-visualizations.

5. CONCLUSIONS AND FUTURE WORK

This paper describes a comparison between different sketching styles and photorealism in the texturing of an interactive environmental planning model. Most current architectural VR-visualizations still struggle with problems related to an aspiration for a photorealistic expression. Models need to be better adjusted to the design phase they describe, and manageable in such a way that the user can modify the visual expression. The evaluation showed a need for greater variety of visual expressions in architectural models, as well as dissatisfaction among many users with the level of photorealism in the visualizations that is possible to obtain today. The results

confirm that further research on technological and usability aspects of VR-visualization is needed, e.g. avoiding time-consuming loading times and non-intuitive menus.

For future work there are many improvements and strategies to consider. With the results from the evaluation, we now have a base for further elaborations. More texture styles need to be developed and different levels of detail included in each style. In order to allow greater freedom in creating VR-visualizations that 1) correctly convey what is intended to be shown throughout the design process, and 2) have a varied and creative expression, it is important to be able to combine different styles. The differences and similarities in the approach towards visualizations between professional users with different backgrounds and/or different professional roles would be very interesting to study further. In this investigation we included architects and civil engineers, and found tendencies that we would like to investigate further with a larger number of participants. Since VR-visualizations are commonly used by city planners to communicate projects and proposals to the public, it would also be of great interest to include the general public as a new target group. Designing textures that will work in all the different stages of the design process is difficult, and this study must be considered as just a step in this process. To fully adjust and adapt the project to different design phases, a future aim is to incorporate it into a real design process, i.e. to follow a real planning project.

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