Arrangement of Product Data in CAVE systems

Elisabeth Dittrich* and Johann H. Israel**

*research training group prometei at University of Technology of Berlin, **Fraunhofer IPK

ABSTRACT

It is industrial practice to conduct Design Reviews of product models by means of Virtual Reality (VR) systems. Especially in the car industry CAVEs are mandatory tools to visualize the current state of product models (digital prototypes). However such systems usually display only the geometric product structure as it is imported from CAD systems. Other information which are of prime importance for the decision making are usually not visualized, e.g. requirements, documents, regulations, non-visual relations between parts and function etc. Such information have to be looked up in external systems, e.g. product data management systems. In order to improve the utility and efficiency of VR-based Design Reviews, such media breaks should be prevented and all necessary data should be available in the immersive environment. The present work provides an explorative study on possible visualization techniques for combined graphical and textual information within a CAVE. 21 subjects were asked to arrange product structures of a given product in 3d space. The resulting product structures were analyzed by means of a category system. The results vary among others in terms of the visualizations of the product structure, the relations between words and the product model and the use of depth. Future research questions are derived from the results which take user experience and perceptual issues into account.

Keywords: Product data management, 3D interaction, CAVE, spatial arrangement, Virtual Reality.

1 INTRODUCTION

CAVE systems are among the most immersive output-media for information visualization, used in many disciplines like engineering or architecture [1]. For example, in automotive industry CAVE systems are used to support the decision-process (e.g. the decision between two designed alternatives) during virtual Design Reviews. Mainly the visualization in real size and from the users' perspective (in the automotive industry sometimes combined with a real driver-chair) is generally considered to be advantageous.

Currently it is common practice in the industry to visualize geometrical CAD-model within CAVE system during Design Review. However, the decision process in a Design Review is also affected by more information than the geometrical model: meta-data (e.g. material properties of product-parts, thickness of the housing or moments of inertia), functional parameters (e.g. links to other parts and their influence on the total system) and further documents (e.g. results from user studies or technical tests or regulations). Additionally, during the decisions process the members of the decision committee make comments, sketches and markings [2] that influence the decision, too. A typical order in a Design Review is to first discuss the problem using a document on a screen (usually big screens or projection), second to go into the CAVE and have a short look on the design alternatives, and last to discuss again (in the CAVE or in front of it) and to make the decision. The visualized product models and variants are usually prepared before the Design Review starts and the participants have only limited means to interact with it or to spontaneously create other variants.

To sum up, the information that are needed for a decision during a Design Review are distributed in the CAVE, on a screen, on printed documents or on other mobile devices. Hence, not all information is visualized in the CAVE at the same time or place.

One way to improve the decision-process is to visualize all information on one output-medium. Due to the fact that the geometrical model can only be shown in the CAVE, other data must be visualized in it, too. Therefore, the goal of our work is to visualize meta-data and documents within the CAVE. In doing so it is necessary to preserve the structure of the data also in the immersive visualization. The common way to visualize meta-data in current product data management systems (PDM) is a vertical tree. Some other approaches use object-related visualizations (annotations) [2][3].

This paper shows a first explorative step to understand how users would intuitively arrange and structure product-data and related documents during a Design Review in a CAVE. The goal of this experiment is to generate hypotheses for following studies and to find appropriate visualization techniques. The materials used in the experiment are product-data from automobile manufacturing.

2 TECHNICAL ENVIRONMENT AND PERCEPTUAL ISSUES

The study was conducted in an immersive VR environment (CAVE [4]) in the Virtual Reality (VR) Lab at Fraunhofer IPK Berlin. This CAVE consists of five back projected walls of 2.5 m edge length each, employing an optical tracking system by Advanced Realtime Tracking ART and active stereo vision.

The VR application used during the study is an immersive modelling application which enables to draw free-hand sketches and to manipulate virtual objects. The system employs various tangible interaction tools of which a stylus and a gripper were used in this study (fig. 1).

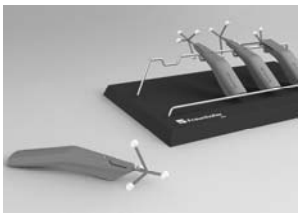

Figure 1: Interaction tools [cf. 5].

The stylus allows for drawing virtual ink directly into the virtual environment, following the movements of the stylus tip. The gripper allows for grasping virtual objects by moving the tool to the relevant object and pressing the physical handles. The object is then attached to the position and orientation of the gripper and can be freely moved and rotated. When the user releases the handles the virtual object remains in its current position.

* elisabeth.dittrich@zmms.tu-berlin.de

3 METHOD

We conducted an explorative user-study with 21 participants in which the participants had to arrange car-related product data in three-dimensional space (fig. 2), using the interaction techniques described above. The product data was presented on paper and contained thirteen words (labels of product parts) that were structured in three hierarchical levels and a schematic representation of the car.

Figure 2: Participant interacting in the CAVE.

In the first task, all words were randomly located in the CAVE and participants had to order them to a consistent arrangement. Additionally, participants had the possibility to add drawings. This task was intended to explore possible arrangements of the same product structure. In the second task, participants had to highlight one specific word. They were provided with the possibilities to re-arrange words and to draw connecting lines or other objects. This task was intended to see which strategy users choose to emphasize elements. For both tasks neither time limits nor other restrictions were set. Due to the explorative character of the study no hypothesis were formulated.

4 RESULTS

For the analysis all generated scenes were sorted in a category system. The categories described visualization parameters such as visualization of hierarchies and relations, types of drawings and depth-usage. Then the scenes in every category were counted.

Three types emerged from the analysis of the different ways to visualize the product-related structure: 1) visualizations of the product structure as a tree (ten participants), 2) visualization of the relations between words and the car, like annotation (two participants) and 3) visualization of both, a product structure (tree) and the relations to the car (nine participants).

Two types of relations were found: links between words (e.g. to visualize different hierarchy levels between these words) and also links between one word and one part of the object (e.g. to point to the name of the part). Two participants choose only the latter option, all others draw both kinds of relationships.

To visualize relations of words that are in one hierarchy level, six participants arranged them closely together. Another four connected the words with lines. And one participant used the same color for the words. To visualize the link between a word (a part-name) and its corresponding part from the object, twelve participants arranged the word as near as possible to the corresponding part. Another seven connected the word and the part with a line or an arrow. And one participant used the same color for the word and the related part.

Finally a short analysis about the usage of depth was performed. In summary no participant actively used the third dimension to arrange the words or to visualize the object. The scenes itself were indeed three-dimensional, but the depth of the scenes was not used to encode information. Instead the depth was caused unintentionally by the behavior of the participants. For example, twelve participants ordered the elements in a semi-circle with the radius of their arm length. Some participants tried to arrange the elements in a plane without success. Instead they arranged them unintentionally at different depth levels.

5 DISCUSSION

In the present work, we explored new ways to arrange textual product data in addition to pure CAD-models in a CAVE system. This is an important issue, because in industrial practice the available information in a virtual Design Review does not differ significantly from traditional Design Reviews. Usually it is almost the same process but employing Virtual Reality technologies e.g. a CAVE or a Power Wall. This mixture of old methods and new presentation techniques does not maximize the efficiency of the working process. One reason is that traditional output media and new immersive media cannot show all types of data. Therefore this explorative user study provides options to visualize hierarchical trees and text in a CAVE. In general we want to visualize documents and their product-structures, in that the documents can be searched, in the CAVE. We think this integrative way of information visualization will optimize the working process in virtual Design Reviews.

In subsequent studies we plan to extend the presented results. For example, up to now we do know that participants arrange the words in classical data trees or annotations. But we do not know if experts prefer separate search structures or a search on the object. Following the general usability goal of being in line with expectations of the user, experts could prefer the separate tree over object-annotations because they know this kind of visualization from their product data management systems.

A second research question touches the kind of relation-visualization that users prefer. Following [6] and [7] laws the grouping by lines between elements should be the strongest one. Hence searching in a visualization that is based on the "grouping by lines"-law, users should be the fastest? Another interesting research question refers to the use of the third dimension. Will subjects make increased use of this dimension if the complexity of the products structure and the textual information increases?

It is to assume that in the future all necessary documents and information for a virtual Design Review will be available and visualized in the CAVE. It is to expect that working in such an environment will be much more efficient than today.

REFERENCES

[1] Fu, M. & East, E. The Virtual Design Review. *Computer-Aided Civil and Infrastructure Engineering*, 14: 25-35, 1999.

[2] Pick, S., Hentschel, B., Tedjo-Palczynski, I., Wolter, M. & Kuhlen, T. Automated Positioning of Annotations in Immersive Virtual Environments. *Proc. Joint Virtual Reality Conference,* 2010.

[3] Polys, N., Kim, S. & Bowman, D. Effects of Information Layout, Screen Size, and Field of View on User Performance in Information-Rich Virtual Environments *Proc. ACM Symp. Virtual Reality Software and Technology,* 46-55, 2005.

[4] Cruz-Neira, C., Sandin, D.J., DeFanti, T.A., R.V., K. & Hart, J.C. The CAVE: audio visual experience automatic virtual environment. *Communications of the ACM*, 35(6), 64-72, 1992.

[5] Israel, J.H., Zöllner, C., Piatza, S. & Müller, A. Sketching in Space. *Proc. IEEE VisWeek Art Show*, 20-21, 2011.

[6] Wertheimer, M. Untersuchungen zur Lehre von der Gestalt. *Psychological Research*, 4 (1), 301-350, 1923.

[7] Palmer, S. & Rock, I. Rethinking perceptual organization: The role of uniform connectedness. *Psychonomic Bulletin & Review,* 1(1), 29-55, 1994.