INTERACTIVE 3D VIRTUAL HYDRAULICS

Using virtual reality environments in teaching and research of fluid power systems and components

L. Pauniaho, M. Hyvönen, R. Erkkilä, J. Vilenius, K. T. Koskinen and M. Vilenius
Institute of Hydraulics and Automation, Tampere University of Technology

Abstract: In this paper we show how three-dimensional virtual reality models can be used in teaching the structures and functions of hydraulic components. This technique allowed the teacher to show exactly how a slide moved inside a valve and how it affected on the opening of flow orifices thus increasing or decreasing the flow. Students were taken on a tour inside components to examine the critical points in component behaviour. The use of virtual reality benefits the students in learning hydraulic phenomenon faster and more accurately. In this paper the techniques and use of virtual reality system in teaching and research are presented.

Key words: graphics, human computer interface, modelling, research, simulation

1. INTRODUCTION

At the Institute of Hydraulics and Automation (IHA) in Tampere University of technology (TUT) different methods of virtual teaching has been used since autumn 2000, when first internet-based course was held. From using Internet–based technologies the Virtual teaching extended to using virtual reality. The use of 3D interactive virtual reality in teaching fluid power started with Introduction to water hydraulics -course in autumn 2002 after the acquisition of virtual reality system in summer 2002. This course is part of Tampere University of Technology's Virtual University project.

Both the software and the structure of the hardware of the system are presented. It is also shown how the system is used in teaching and in research and design.

2. THE VIRTUAL REALITY SYSTEM

The system used is a German made system provided by IC:IDO GmbH. It utilizes so called passive stereo projection system. The projection screen is 1500mm in height and 2000mm in width.

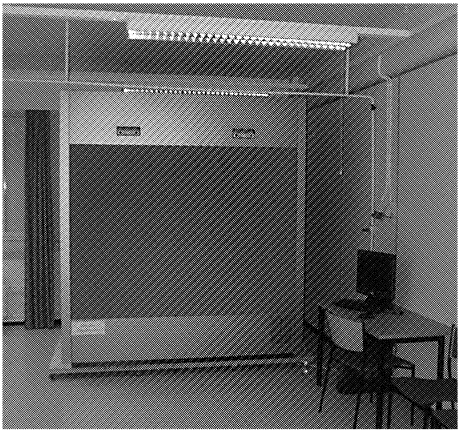

Figure 1. The IC:IDO virtual reality system

In this system a three dimensional image is created using two projectors so that two slightly different images are presented simultaneously one over the other. Images are seen separately by both eyes using polarized lenses on the projectors. The lenses filter the images to vertically and horizontally polarized images. The system user then has lightweight polarized glasses which then filters out the right eye image from left eye vision and vice versa. This creates a feeling of only one image that is three dimensional.

2.1 System Hardware

The hardware consists of three parts: image projection, interaction and computing. Image projection is done in a closed box to avoid scattered light interference on the images. Two Digital Light Processing™ (DLP™) projectors send images to a mirror which reflects it on the backside of the projection screen. The mirror is used to reduce space needed.

Interaction is made so that both the user and the 3D-control device are position tracked. User is tracked with optical position tracking with two infrared cameras. That gives the benefit of user being able to look at the object from different angles by moving around it just like in reality. Because the image is wall projected the user cannot walk all the way around the object, but the user can for example look closer or walk back to get more distance to the object presented. The 3D control device used to control the views and functions of the image is magnetically tracked. This gives the device a true 3D handling capabilities with all six degrees of freedom in space. For example a joystick has only two degrees of freedom.

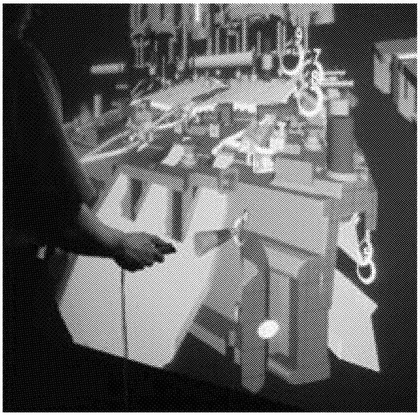

Figure 2. 3D control device.

Computing part of the system consists of three Linux PCs, a tracking computer and IC:IDO synchronization module. These are connected with Local Area Network and serial connections. One PC is the controller with session management while others manage image processing tasks.

2.2 Stem Software

Software can be divided into three parts: data and file handling, image handling and connection programs.

The first; IDO:Base interactive, is used in uploading images to the controller computer and there optimizing the images for fluent VR usage. It has, among other things, support for all common interaction components in VRML, VR graphics libraries and multi-channel graphics support.

The second part, IDO:Review, is used with 3D interactive ball-shaped menus and the 3D-control device to handle the images on the screen. User can have mock-up functions (installation/removal), interactive cutting function (whole object or individual parts and assemblies), measurement function with snap-in function, annotations and screen shot to get still images from a session together with fly-through function and simulation control for kinematics and deformation processes.

The connection programs handle the data flows from magnetic tracking and other devices together with communications between the three computers. The software of this system is of commercial production and therefore it cannot be edited to suit any other learning domain as it is. However it is possible to make some programming to it with high-level commands using separate developer-kit software. With this for example other input devices could be linked to the system, but this is something we have no experience with.

2.3 Usability of the System

The images used in this virtual teaching are not images of real industrial made hydraulic components because when an object is as accurate in details as a real component is, its virtual model becomes so large in bytes that handling them with this system becomes disturbingly slow and jerky. The desired goals in teaching are not achieved with this because all students will lose the attention wondering will this VR-system ever work. Instead the images are made from newly designed components where most significant factors are visualization of main component functions and structural features.

To create a virtual object one needs a model in Virtual Reality Modeling Language (VRML) -format. In this case they were done by first drawing the selected components with ProEngineering 3D design program and then converting them in to VRML -format. Use of almost any other 3D design program is also possible.

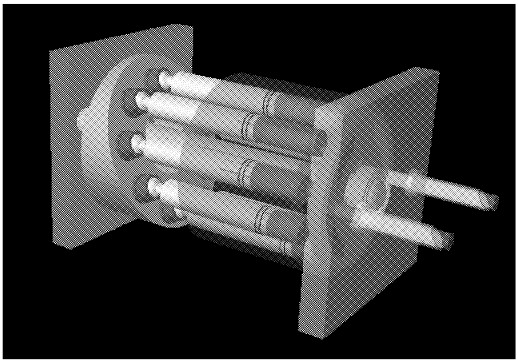

Figure3. A rough presentation of axial piston motor

The use of ProEngineering program is justifiable because at IHA we had some drawings made with that program already. Also to make the components accurate enough one needs to design them very carefully and in professional manner so that their main functions and structural features wouldn't differ significantly from actual components used in real hydraulics. Since this system is not using high-power super computers in image handling this kind of image optimizing already in the drawing phase is needed. That is not the best possible usability, but very well in line with the resources needed in establishing this system.

3. 3-D VR IN TEACHING OF FLUID POWER SYSTEMS AND COMPONENTS

3.1 The courses

The system was used in Introduction to water hydraulics course. The course took place in autumn 2002 and 15 students attended to this course. The course objectives are to give basic information on the theory of water hydraulics, water hydraulic components and systems, and the application of water hydraulic technology in the design of hydraulic machines. Also is the course handles basic theory of water hydraulics, water hydraulic components, design of water hydraulic systems, proportional and servo systems in water hydraulics and applications. At the moment the system is not used in other courses, but it will be presented in other courses as well. The usage is now settled to presenting components and their functions but other ways of using it will be presented later.

3.2 Possibilities in VR visualization

The problem with many of the hydraulics courses is the difficulty of displaying the structure, motion and functions of hydraulic components so that they are easily understandable for students. Problems occur especially on visualizing altering pressure, fluid flow in orifices, sliding couples or parts moving compared to each other. Using two dimensional pictures is easy for teachers; pictures are quite easily available from partners in hydraulic industry so that they don't have to be drawn from scratch. Also some animations and videos are available, but they are rare and don't show all the components or functions desired. Using those methods students have been able to understand hydraulics – eventually.

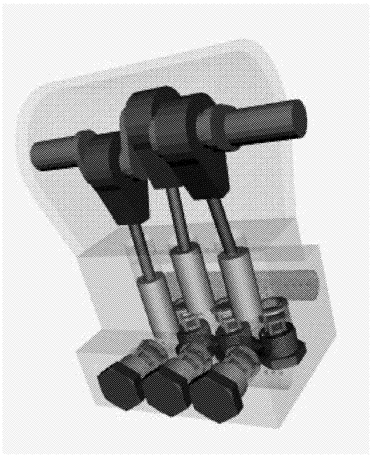

Figure 4. A piston pump 3D animation (still frame)

To be able to give students profound knowledge about hydraulics more quickly and thoroughly, one needs to be able to display hydraulic components like in real life, but with more functionality. It is not enough that they can be seen in three dimensions. They must also be presented interactively in such a way, that students can turn and roll the object and look at whichever detail they want from which ever angle or view. And then the students must be able to disassemble the objects piece by piece to see the assembly structure and to even go inside an object to see its functions in action. Also the component structure must be viewable in slices from various directions.

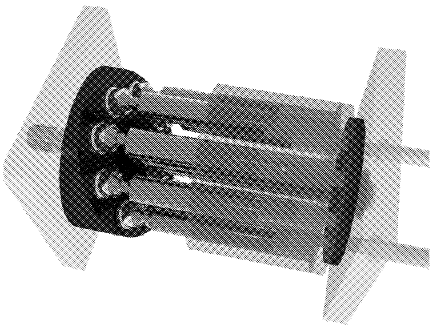

Figure 5. A still frame of an axial piston motor movie

In the course mentioned, so called virtual sessions were held in which a few components were introduced to the students. The number of students to attend to each session was limited to 7-8 students. Having more students in one session could result in reduction in viewing possibilities to some students and again the teaching results could not have been achieved.

Animations were made of selected components for virtual sessions in this course. These were axial piston motor (presented above), needle valve, flow control valve and a piston pump (presented above), ProEngineering files were also made of 15 other components, and they were transferred to VRML-files and presented to students.

3.3 Future plans

The system will be used also in other courses in the future. Generally it will be used in the same way as in this course but other ways of utilizing the system are under construction. For example connecting a real-time simulation to the system would open a new world in teaching modelling and simulation of hydraulic systems.

4. USING 3-D VR ENVIRONMENT IN VISUALIZATION OF SIMULATION IN COMPONENT AND SYSTEM DESIGN

Usually simulation gives out graphs which then are interpreted by researchers. With VR-system visualization of simulation processes improves understanding what actually happened and which circumstances were critical to the results. It also gives the opportunity to see easily that everything in the simulation model is like in real life to give the simulation reasonable basis. Adding 3D presentation to real-time simulation gives the researchers possibilities to go further for example in the field of embedded systems simulation in mobile environments.

To use 3D model of a component while designing with a 3D design program gives benefit to design process, but to be able to see the design in real 3D virtual environment gives the designer more accurate description of the whole picture. The ability to see component sub-parts' movements compared to each other or to see how a component fits into a mobile machine gives so remarkable benefit that many manufacturers are nowadays moving to use virtual environments in their design work.

5. CONCLUSIONS

The use of this kind of 3-D interactive virtual reality system in teaching fluid power components has shown its demonstrative power. Even though no official research was made among students, it was obvious that this method of explaining component functions is by far much more educating than the usual 2D drawing method. Also the ability of dismantling the components right there before the students' eyes proved to be very efficient.

Using 3D virtual reality as a way of improving teaching and design processes will be in an important role in the future. One can see an increasing interest in this technology in many industrial sectors. Research and development will probably be the most important fields but also other fields such as marketing and building trade have a vigorous increase in using virtual reality.

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BIOGRAPHY

The authors of this paper have various backgrounds from programming and simulation modelling to long-term extensive professional experience in hydraulics.