Design and Implementation of a Stereoscopic Display in a Lecture-room

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Figure 1: A view of the stereo screen used in the project described in this paper.

Abstract

This paper describes the master thesis project *3DIS4U: Design and implementation of a distributed visualization system with a stereoscopic display* carried out at Uppsala University. The main contributions of the thesis are the installation and evaluation of a wall-sized stereoscopic display in a class room-like environment and improvement of the quality, interactivity and usability of visualizations at Uppsala University by connecting the system to one of UPPMAX high-performance computing (HPC) clusters. The project involved modifications to open source softwares, mainly the Visualization ToolKit (VTK) and ParaView. Furthermore, software was developed to aid users in creating interactive stereoscopic simulations. Software was installed and modified for better usability. The option of using HPC resources for larger interactive visualizations also exists. As a final step, evaluations of the display and of the software were carried out together with background research on distributed rendering techniques to be able to produce a proposal for further development of the project. The result of this work is a class room environment which in a few minutes can be turned into a visualization studio with a stereoscopic display with the ability to create interactive visualizations. The lecture room retains its function as a class room and can support up to 30 simultaneous viewers.

Keywords: interactivity, stereoscopic displays, distributed visualization, high performance computing

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1 Introduction

The Centre for Image Analysis (CBA), at Uppsala University and the Swedish University of Agricultural Sciences, has recently acquired equipment for building a stereo projection wall. The project has a close collaboration with Uppsala Multidisciplinary Center for Advanced Computational Science (UPPMAX) that will provide access to high-performance computing (HPC) clusters for performing visualizations on. How do we setup this in a way that it becomes available to as many users as possible? This question is answered in detail in [Ericsson 2008] and briefly presented here.

A prerequisite is that the system should be installed in a class room environment that supports up to 30 simultaneous users (see Figure 1). The room should retain its function as a lecture room while at the same time be able to switch to stereo projection in a matter of minutes. The hardwares used in this project are two workstations, one with AMD dual-dual-core processors equipped with a high-end graphics card and one workstation with a two Intel quad-core processors and a mid-range graphics card. One of the workstations has a 2Gbit/s link to a 200 node cluster provided by UPPMAX.

Software development is also part of the project where suitable solutions are to be found, setup and modified when necessary. The solution should strive to be as usable as possible but at the same time have good performance to allow for interactive visualizations. The expected user of the system does not necessarily have a computer science background as the facility is open to all researchers and students at the university.

2 Implementation

The stereoscopic display is using spectral multiplexing, so called Interference Light Technology (INFITEC) [Jorke and Fritz 2003], to mediate improved depth perception and color representation. Spectral multiplexing works by dividing the visual spectra into bands, two bands for each of the primary colors red, green and blue. These bands are then separated by filters and divided so that one band of each type reaches each eye, i.e., half of the red spectra reaches the left eye and the other half reaches the right eye. The filters are mounted onto the two projectors used in the system as well as in a pair of lightweight glasses that the user wears. The INFITEC technology fits well into the project as it provides a solution for multiple viewers both with good image quality and at a reasonable price. Two possible alternatives would have been a temporal multiplexing solution or a polarized light based solution. Temporal multiplexing uses a pair of active glasses which is a bit heavier than glasses used in passive methods, which was undesirable for this project. Reasons for not choosing a polarized based method were the lower image quality and the need for a specialized screen.

One of the software solutions chosen is the open-source Visualization ToolKit [Schroeder et al. 2006] (VTK) by KitWare. VTK was modified for additional support for side-by-side rendering, which interleaves both the left and the right view on the projector screen at the same time. This way of rendering does not conform well with the underlying rendering of the normal window manager; the users see both the left and the right view at the same time and the interaction with the mouse pointer can be confusing as the user must keep track of on which desktop it currently resides. Our modification automatically changes from the normal clone mode setup where both projectors shows the same image, which is easier to navigate in, to side-by-side rendering when entering stereo mode.

ParaView [Squillacote 2006] also by KitWare was chosen as the primary software for visualizing larger data sets for this project. ParaView is developed for larger scale visualizations built upon VTK, uses the Message Passing Interface (MPI) for interprocess communication and comes with a mature user interface. ParaView was compiled and tuned for the cluster that we are using to achieve as high interactivity as possible for larger scale visualizations.

Another aid for converting existing applications for use with the stereo wall was also developed. A small library with help functions meant to be used as guidelines when porting an application source code that the user is well oriented with. The library is written in C and uses OpenGL for rendering.

3 Results

The, by today's standard, relatively low resolution (1024×768) of the projectors was evaluated by inspection. Users of the display share the opinion that there is no noticeable artifacts due to the resolution. A similar conclusion is drawn about the brightness of the display. The projectors have a listed brightness of 3500 ANSI lumen and three different test scenes where setup under three different lighting conditions to explore under what conditions the display is deemed usable. The display is as a normal projector dependent on the brightness of the material it is displaying and on the lighting condition in the room. The stereo effect is perceivable under all of the tested light conditions, but deemed most comfortable when the dim lights in the lecture room is turned on. What was noted during the tests was that the fluorescent light in the room creates a very disturbing effect in combination with the filters in the glasses. In fact, it produces a green and pink flicker, although the perception seems to vary from individual to individual. A spectral sample of the light gives some hint to why this might be happening. The nature of which the light is produced in a fluorescent light creates spikes which coincide with our filters. Replacing the light with regular light bulbs or a LED light with a more even spectral distribution solves this problem. The projection setup is optimized for the person sitting in the middle of the room, all other viewers get a mildly skewed perspective. The perspective distortion has not been commented on by any of our test users and we consider this effect to be minor. All in all we are very satisfied with the quality of the stereoscopic display.

The experience with the different software used was good and users have created both interactive and pre-rendered visualizations for displaying on the stereo wall. Users with prior knowledge of VTK could port their visualization for displaying on the stereo wall within minutes. With ParaView our users could visualize raw data volumes interactively that before was needed to be down sampled due to performance problems. The guide lines that were presented as a small code library have been used to port existing OpenGL application for the wall without much effort. A non-invasive method of porting applications to stereo was also investigated, the Chromium library, but was not used in this project.

4 Conclusion

We have designed and implemented a lecture room with a stereoscopic display. We have produced guide lines for using the stereo wall and also produced and modified software to help users port their own software to the stereo wall. By distributing the data processing as well as rendering computations onto larger computational resources, we have made it possible to interactively visualize larger sets of data than previously possible for our users.

Future possible directions for the project have been identified. And further development is important in three areas: remote, collaborative and distributed/parallel visualization. These areas are described in the master thesis report [Ericsson 2008].

The stereo wall is fully functional today (see Figure 1) and in regular use in our visualization studio called *Three-Dimensional Image Studio for Uppsala* (3DIS4U). The abbreviation *3DIS4U* can also be read as *3D is for you* which underlines the goal with the project, an accessible stereo wall for all users at the university.

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References

ERICSSON, M. 2008. *3DIS4U: Design and implementation of a distributed visualization system with a stereoscopic display*. Master's thesis, Uppsala University.

JORKE, H., AND FRITZ, M. 2003. INFITEC — a new stereoscopic visualisation tool by wavelength multiplex imaging. *Electronic Displays* (September).

SCHROEDER, W., MARTIN, K., AND LORENSEN, B. 2006. *The Visualization Toolkit, An Object Oriented Approach to 3D Graphics*. Kitware Inc.

SQUILLACOTE, A. H. 2006. *The Paraview Guide, A Parallel Visualization Application*. Kitware Inc.