Extended Abstract:

Remote Volume Rendering for Virtual Environments using PC Clusters

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The volume rendering software which we are using is based on a perspective version of the shear-warp algorithm. The shear-warp algorithm for parallel projection is described in [1], its extension for perspective projection and important improvements for virtual environments are described in our paper [3].

The remote rendering algorithm is an MPI parallelized version of the single processor perspective shear-warp algorithm. Only the compositing part of the shear-warp algorithm is done remotely, the warp is done on the display computer. This is because the warp can be performed very efficiently in computer graphics hardware. The compositing, which is the compute intensive part of the algorithm, can be parallelized fairly well as long as each compute node has access to the whole volume dataset.

The display PCs decode the images and transfer them to the graphics cards as 2D textures. Finally, the warp matrices are used to display the textures, thus displaying the volume at the correct position in space and with the right perspective.

The remote rendering functionality has been integrated with the VR System COVER [2]. COVER provides a plug-in mechanism which allows a comfortable integration of custom renderers with the system. We developed a transfer function editor which one can use directly from within the virtual environment. Its main features are described in [3], its extension to collaborative environments can be found in [4].

In a virtual environment, the image has to be updated permanently due to the head tracking, so the remote renderer generates images non-stop. Before the display machine renders an image, it sends the current view matrix to the remote renderer, so both renderings can occur in parallel. Further events that require sending information to the rendering cluster are changes of the transfer function, changes of the time step for transient data, and changes of the dataset. Only the transfer of a new dataset to the renderer generates a significant delay, depending on its size, but since this occurs just rarely it is not a major issue.

For performance measurement, we used a cluster consisting of 10 nodes. Each node was equipped with two 1 GHz Pentium III processors and 2 GB memory. The nodes were interconnected by a Myrinet network. We compared the rendering speed to a SUN Fire system, a 64 Processor XEON 2.4 GHz system and an Onyx2. VR output was performed on two systems. First, a single wall passive stereo projection with a Flock of Birds tracking system driven by an off-the-shelf 1.8 GHz Pentium 4 PC with an NVidia GeForce 4 TI4200 graphics card. It is connected to the rendering clusters via a 100 Mbit/s network. Second, a 4 wall active stereo CAVE with a Motionstar tracking system driven by a cluster of four 3 GHz XEON PCs with NVidia Quadro 4 graphics boards. These PCs are connected to the rendering cluster via a gigabit Ethernet. Detailed numbers will be presented at the workshop.

We showed that the system runs fast enough for interactive visualization in a VR environment. Compared to a solution for volume rendering without a cluster, but with optimal use of the graphics board, for instance by textured volumes, our solution provides more flexibility and generates comparable image quality for full screen datasets of medium sizes.

Reference List

1. Lacroute, P. and Levoy, M. Fast Volume Rendering Using a Shear-Warp Factorization of the Viewing Transformation. ACM SIGGRAPH 94 Proceedings. 451-457. 94.

2. Rantzau, D., Frank, K., Lang, U., Rainer, D., and Wössner, U. COVISE in the CUBE: An Environment for Analyzing Large and Complex Simulation Data. Proceedings of 2nd Workshop on Immersive Projection Technology (IPTW '98), Ames, Iowa. 98.

3. Schulze, J. P., Wössner, U., Walz, S. P., and Lang, U. Volume Rendering in a Virtual Environment. Proceedings of 5th IPTW and Eurographics Virtual Environments, Springer Verlag. 187-198. 2001.

4. Wössner, U., Schulze, J. P., Walz, S. P., and Lang, U. Evaluation of a Collaborative Volume Rendering Application in a Distributed Virtual Environment. Proceedings of the 8th Eurographics Workshop on Virtual Environments (EGVE), May '02, ACM Press. 113-122. 2002.