Virtual Reality and Visualization Research at Bauhaus-Universität Weimar

http://www.uni-weimar.de/medien/vr

Bernd Froehlich, Stephan Beck, Andreas-C. Bernstein, Henning Gruendl, Michael Grunwald, Alexander Kulik, André Kunert, Patrick Riehmann, Andre Schollmeyer, Sebastian Thiele

Figure 1: The six-user 3D projection system in our lab. Each user is individually tracked and perceives a perspectively correct stereoscopic 3D image through our custom-built high frequency shutter glasses. The users can travel through virtual scenes using our group navigation device, the Spheron, which is centrally placed in front of the display. The 360Hz projection system is visible as bright color spots on the right.

1 Highlights

The Virtual Reality and Visualization Research Group carries out research and development in stereoscopic display technology, 3D human-computer interaction, information visualization, scientific visualization and real-time rendering. We developed and operate the only projection-based stereoscopic display that provides six users with individual perspectively correct 3D images and, for the first time, enables effective teamwork when visualizing complex 3D models. Recent work on immersive group-to-group telepresence allows distributed groups of users to meet in shared virtual 3D worlds and explore them together. Our innovative user interfaces are designed and evaluated for complex two- and three-dimensional tasks in collocated and distributed virtual reality environments. We also develop the rendering and visualization infrastructure for the real-time display of large multi-variate image, volume and time-dependent data sets, which occur in medicine and other fields. The VR group received various awards for their work during the past years.

2 Multi-User Virtual Reality

One of the major topics of our research is the development of multi-user 3D visualization systems for the collaborative evaluation and analysis of 3D data [2]. Our stereoscopic projection systems provide up to six tracked users with perspectively correct 3D views of a shared virtual environment (Figure 1). Such multi-user 3D displays offer many new opportunities for collaborative interaction, which we pursue with the development of novel 3D input devices and interaction techniques.

In 2013 we presented our novel immersive group-to-group 3D telepresence system [1] where groups of users are captured in real-time by a cluster of color and depth cameras. The acquired image streams are then transmitted to a remote location where they are used for the online reconstruction of 3D Video Avatars inside virtual worlds (Figure 2). Our system allows for two or more remote groups of users to meet in a virtual environment and use advanced interaction techniques for work or play. Figure 3 (left) shows two groups of users discussing a virtual 3D city model.

Figure 2: Two groups of users meet in a virtual city. The users on the left side are three-dimensionally captured in front of our six-user display in real time and rendered as 3D Video Avatars on the remote side (right) and vice versa.

Figure 3: Left: Two groups of users meet in our immersive group-to-group telepresence system and discuss the tower of a church using a WIM by direct pointing and gesturing. Right: A Photoportal is used to capture a group photo as a souvenir of a virtual city tour.

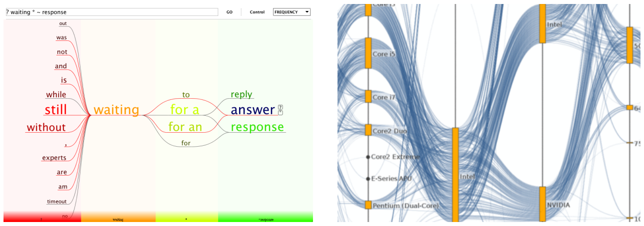

Figure 4: Exploring phrases with the Wordgraph (left). The Product Explorer provides insight into all available configurations at a glance (right).

More recently, we presented Photoportals [3], a versatile 3D interaction technique based on the metaphor of virtual photography. The technique enables groups of users to create, exchange, and organize spatial and temporal references in shared virtual environments. The virtual photos provide users with tangible handles to virtual objects, and thereby support the collaborative examination from multiple perspectives. Moreover, represented virtual locations can directly be entered, which reduces the need for group locomotion across large virtual environment (Figure 3 (right)).

3 Visualization Research

Another major area of our research is the visualization of large seismic volumes with interpreted data such as large stacks of horizon height fields. This rendering system is based on an unified out-of-core data virtualization. The virtualization abstracts complex multi-resolution data layouts from the logical data representations and thus allows access to the data without regard of its physical storage. The visualization of the data is accomplished in a single rendering pass using a two-level acceleration structure for efficient intersection computations for horizons interleaved with pre-integrated volume rendering. Our approach works also for multiple arbitrarily overlapping multi-resolution volume data sets [4].

Our research interests also focus on Information Visualization, particularly visual text analytics, visual decision support and visualization of time-dependent multi-attribute data. The Wordgraph [5] supports non-native writers in exploring and choosing appropriate phrases by aggregating the results of the Netspeak search engine into an interactive graph-like interface (Figure 4 left). The Product Explorer [6] serves as an interactive parallel-coordinates display for facilitating the selection process of products with many attributes (Figure 4 right). Our novel approach for visualizing time-dependent aspects in large multi-variate datasets considers time as an extension in depth of the parallel-coordinates display. It integrates pseudo-perspective time-series plots between parallel axes and facilitates the exploration of time-related aspects without the need to switch to a separate display (Figure 5). We generally think that there is a large potential for using the third dimension in information displays.

4 Real-Time Rendering

We are furthermore committed to research and development in the field of interactive visualization of large and complex datasets. In particular, we developed real-time rendering methods for higher-order data representations used in CAD/CAE applications. Our rendering approach for trimmed NURBS surfaces [7] performs the trimming per-pixel using the parametric description of the trim curves. Furthermore, we developed a direct isosurface ray casting approach for the visualization of the simulation results of NURBS-based isogeometric analysis [8]. In both methods, ray casting is performed directly on the underlying parametric model.

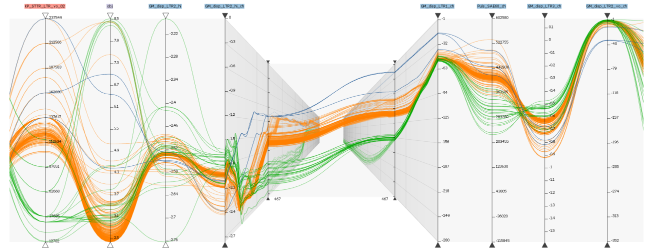

Figure 5: A pseudo-perspective view of two time-series plots is integrated between two adjacent parallel axes. A translucent parallel-coordinates panel connects the two time-series plots and allows the analysis of trends in time as well as the exploration of the relationship between time-dependent attributes.

All advanced rendering techniques are integrated into our rendering framework guacamole[1]. One particularly interesting feature of the system is the support for real-time rendering of large point clouds of up to several hundred gigabytes in size. The renderer is based on an appearance-preserving multi-resolution approach and an out-of-core data management. In addition to point clouds and polygonal geometry, guacamole currently supports trimmed NURBS surfaces and and large volumetric data sets (Figure 6).

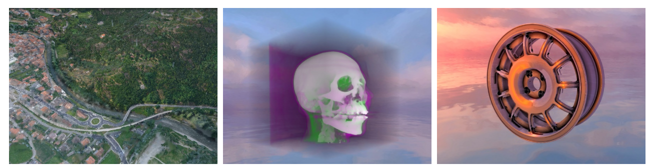

Figure 6: Our rendering framework guacamole supports various data representations, e.g. large point clouds (left), volumes (middle) and trimmed NURBS surfaces (right).

References

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[1] Available on `https://github.com/vrsys`