A Holographic Collaborative Medical Visualization System

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Abstract. We report on our work on the development of a novel holographic display technology, capable of targeting multiple freely moving naked eye viewers, and of a demonstrator, exploiting this technology to provide medical specialists with a truly interactive collaborative 3D environment for diagnostic discussions and/or pre-operative planning.

Keywords. 3D displays, holography, collaborative work, medical data visualization.

1. Background and Motivation

The collaborative, multi-disciplinary, analysis of 3D datasets derived from medical imaging is gradually becoming an important tool for the modern clinical practice decision process. Fully 3D immersive visualization could dramatically improve this process, since decisions depend on the deep understanding of complex three-dimensional shapes. The currently available display solutions capable of feeding the human brain with all the visual cues needed to reconstruct three-dimensional scenes are, however, limited to single user configurations. Here, we report on the development of a novel holographic display technology that supports multiple freely moving naked eye viewers and on a prototype application – a tool for the planning of Abdominal Aortic Aneurysm (AAA) treatment – that exploits this technology to provide medical specialists with a truly interactive 3D collaborative environment for diagnostic discussions and/or pre-operative planning and acts as a driving force for display development.

2. Display technology

Our display uses a specially arranged array of micro-projectors to generate an array of pixels at controlled intensity and color onto a custom designed holographic screen. Each point of the latter then transmits different colored light beams into different directions. The display is thus capable of generating light fields appropriate to faithfully reproducing natural scenes. Each micro-projector forms the image on a micro

LCD display and projects it through special aspheric optics with a 50 degrees horizontal field-of-view. A high-pressure discharge lamp illuminates all the displays, leading to a brightness comparable to the brightness of a normal CRT display. In the current prototype, 96 optical modules project 240 pixels horizontally and 320 vertically. Each pixel on the screen is illuminated by 60 different LCDs. Since 60 independent light beams originate from each pixel in the 50 degrees field of view, the angular resolution of the display is 0.8 degrees. With proper software control, the light beams leaving the various pixels can be made to propagate in specific directions, as if they were emitted from physical objects at fixed spatial locations. In our prototype, a custom parallel implementation of OpenGL generates the module images required for holographic viewing by appropriately reinterpreting the standard OpenGL stream. More information on our display technology is available elsewhere [1][2].

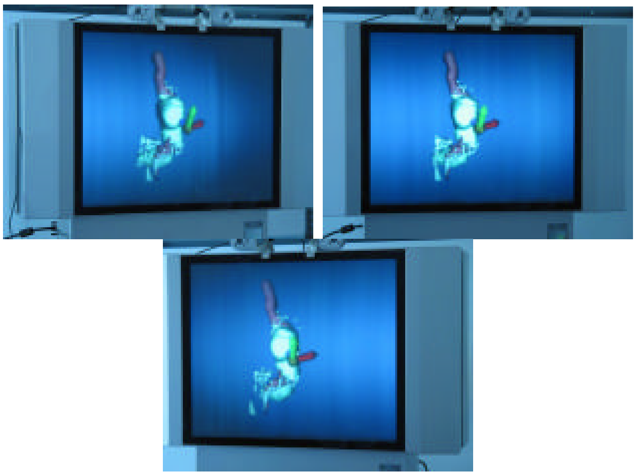

Figure 1. Selected frames of a video recorded using a hand-held video camera. Note the parallax effects.

3. Collaborative Medical Data Analysis Prototype

The current display prototype is already sufficient to develop compelling prototype 3D applications that exploit its truly multi-user aspects. We are currently developing a few domain specific demonstrators, which act as driving forces for the development of the display. In the medical domain, we are focusing on a system for supporting diagnostic discussions and/or pre-operative planning of Abdominal Aortic Aneurisms. The overall application is distributed using a client-server approach, with a Data Grid layer for archiving/serving the data, 2D clients for medical data reporting (textual/2D image browsing), and 3D clients for interacting with 3D reconstructions. The 2D user interface for model measurement and reporting has been developed as a web application that can be executed on a tablet PC or a palmtop computer. The 3D application renders reconstructed object on the holographic display, and interacts with the SRB [3] archive for data loading, and with the measurement interface for communicating anatomical measures. Since objects rendered on the holographic display appear floating in fixed positions, it is possible to naturally interact with them with a 3D user interface that supports direct manipulation in the display space. This is achieved by using tracked 3D cursors manipulated by users. Multiple cursor control interfaces have been developed, using both commercial 3D trackers (Logitech 3D mouse) and custom-made wireless solutions (camera based tracking of pointers, using a wireless USB interface for buttons).

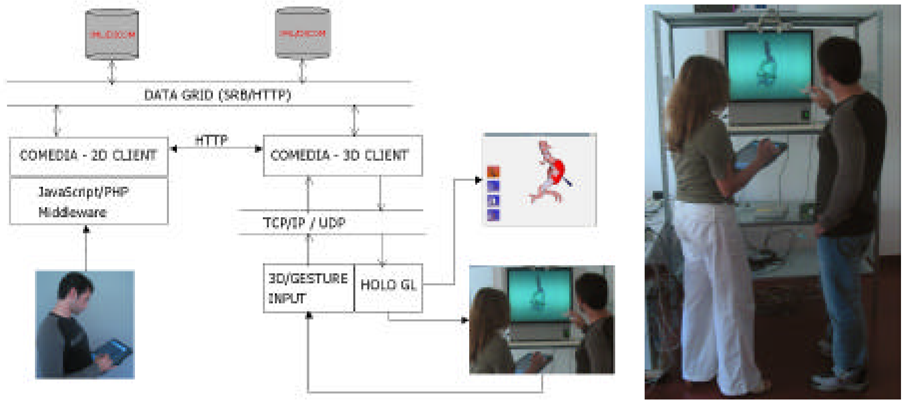

Figure 2. Left: Structure of the distributed application prototype. Right: Multi-user discussion

4. Conclusions

We presented a design and prototype implementation of a scalable holographic system, that targets multi-user interactive computer graphics applications. The current display prototype is already sufficient for developing compelling prototype 3D applications that exploit its truly multi-user aspects. On a single GeForce6800 system, the currently achieved frame-rate is about 10Hz, which proved sufficient to provide the illusion of continuous motion in animation and 3D interaction tasks. We described a particular application, targeting Abdominal Aaortic Aneurisms, that uses starndard 2D displays for accessing medical data records and the holographic display to present and directly interact with reconstructed 3D models. The application is in the early stages of development, but already demonstrates the possibility of sharing a fully 3D synthetic workspace in a local multiuser setting. Our current work focuses on improving the display drivers, completing the application prototype, and assessing its benefits and limitations.

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References

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[2] Tibor Balogh, Tamás Forgács, Olivier Balet, Eric Bouvier, Fabio Bettio, Enrico Gobbetti, and Gianluigi Zanetti. A Scalable Holographic Display for Interactive Graphics Applications. In Proc. IEEE VR 2005 Workshop on Emerging Display Technologies, 2005. CD ROM Proceedings.

[3] Storage Resource Broker, Version 3.1, SDSC (http://www.npaci.edu/dice/srb).