

A Head-Mounted Projective Display and its Applications in Interactive Augmented Environments

Hong Hua
Beckman Institute,
University of Illinois Urbana-Champaign
Urbana, IL, 61801
Email: Honghua@uiuc.edu

Technology

The concept of projective displays using retro-reflective material was initially patented by Ferguson in 1997 and head-mounted projective displays (HMPDs) were proposed as alternative to conventional eyepiece-type head-mounted displays and stereo projection systems for 3D visualization¹. An HMPD consists of a pair of miniature projection lenses, beam-splitters, and displays mounted on the head and a supple and non-distorting retro-reflective sheeting material placed strategically in the environment¹. The usage of projection lenses and the replacement of a diffusing projection screen with a retro-reflective screen distinguish HMPDs from conventional HMDs and stereoscopic projection-based displays.

Besides direct see-through capability, the HMPD technology intrinsically provides correct occlusion of computer-generated objects by physical objects, and creates ubiquitous display environments in which a retro-reflective material can be applied to anywhere in space and can be tailored to any shape without introducing additional distortion to the virtual images. Such a design also allows for larger field-of-view (FOV) and higher optical performance than eyepiece-based



Fig. 1 HMPD prototype

HMDs². In multi-user collaborative environments, the usage of retro-reflective screen makes it possible to generate unique perspectives for each user, without introducing crosstalk from other participants². We will present our recent design of a compact head-mounted prototype implementing ultra-light custom lenses². The prototype (Fig. 1) achieved 50 degrees FOV and 3.96 arcmin/pixel visual resolution at a total weight of less than 700 grams.

Application in interactive augmented environments

To demonstrate the various capabilities of this technology, we present two applications: a networked “GO” chess game and an interactive fluid flow simulation.

Play augmented “GO” chess game with a remote opponent: In Fig. 2(a), through an HMPD, a computer-generated 3D “GO” chessboard is projected onto a tabletop retro-reflective screen. The local player 1, wearing the HMPD, perceives the virtual chessboard as if it was a real object on the tabletop and manipulates his real chess pieces on the virtual board. A vision-based tracking setup detects the locations of his pieces on the virtual board and transmits this information via network to the remote player. The remote player 2 uses a PC-based game interface in which all game components are visualized on a PC monitor and chess piece manipulation is achieved via a standard mouse. When the remote player adds a piece to his board, a corresponding computer-generated piece is projected onto the HMPD user’s virtual chessboard. Therefore, the HMPD player perceives the virtual chessboard, his own real pieces, which correctly occlude the virtual chessboard, and the virtual pieces of his remote player in a seamless augmented environment. A head tracking system is used to maintain the correct registration of the real and virtual elements. The virtual and direct views of both players are shown in Fig. 2 (b) through (d) respectively.

Interactive simulation of fluid flow over a simple terrain: We are also developing an augmented tool for the simulation of fluid flow over simple terrain³. With the tool, virtual fluid is animated through physical trough models coated in retro-

reflective material. Users can dynamically alter or obstruct the flow with a variety of physical objects, which are tracked via a vision-based algorithm. Initial results will be included in the sketch presentation.

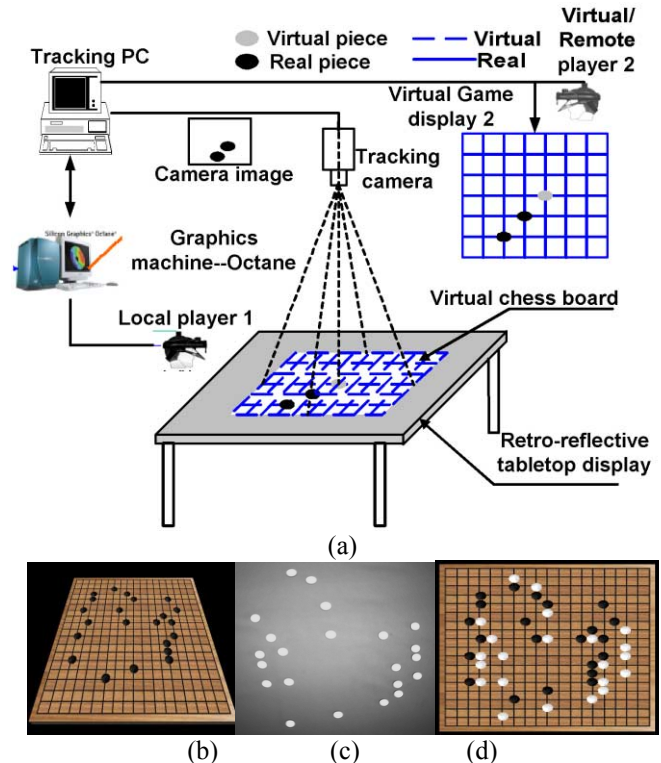


Fig. 2 Playing “GO” chess game with a remote opponent: (a) Setup illustration; (b) HMPD player’s virtual view; (c) HMPD player’s direct real view; (d) Remote player’s PC-based interface.

Contributors

Hong Hua, Leonard D. Brown, Chunyu Gao, and Narendra Ahuja from the Beckman Institute at the University of Illinois Urbana-Champaign, Jannick P. Rolland from the School of Optics/CREOL at the University of Central Florida, and Frank Biocca from Michigan State University. This work is supported by the National Science Foundation ITR Grant IIS 0083037.

References

- 1 Hong Hua, A. Girardot, Chunyu Gao, and J. P. Rolland. “Engineering of head-mounted projective displays,” *Applied Optics*, 39 (22), 2000, 3814-3824.
- 2 Hong Hua, Chunyu Gao, Frank Biocca, and J. P. Rolland. “An ultra-light and compact design and implementation of Head-Mounted Projective Displays,” *Proceedings of the IEEE Virtual Reality Annual International Symposium 2001*, March 13-17, 2001, Pacifico Yokohama Conference Center, Yokohama, Japan (In press).
- 3 Jim X. Chen, and Niels Da Vitoria Lobo. “Toward interactive-rate simulation of fluids with moving obstacles using Navier-stokes Equations,” *Graphical Models and Image Processing*, 57(2), pp107-116, 1995.