An Immersive Environment for Interactive Medical Visualization

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Introduction

We present a system that supports effective visualization and interaction with volumetric medical data, in a manner that is intended to improve training, planning and surgical tasks.

In this context, we posit that display and manipulation of the data in a manner that more closely corresponds to the dynamics of the physical world, combined with the simultaneous display of multiple data sources, can significantly aid in understanding.

Our approach integrates direct volume rendering of multiple modalities with stereoscopic display, and interaction with the data through several interaction paradigms including a tangible user interface and a free- handed gestural vocabulary.

Objectives

The goal of this research is to support high-fidelity medical data visualization, using similar gestures and interaction techniques as would be appropriate for manipulating physical objects. This includes the need for:

- stereoscopic viewing capability
- integrated direct volume rendering, combining multiple data sources
- efficient user interaction, supporting direct manipulation of the volume

Motivation

- DVR uses the entire data set to contribute to the output image; this helps present structural details and the relationship between different materials.
- Immersive stereoscopic visualization of neurological data in 3D leads to an improved level of interpretation.
- We expect that similar benefits may arise from the option to integrate any or all data in the same visualization.
- Direct manipulation tends to be more efficient than keyboard-mouse control.

Design Approach

Visualization:

- slice-based direct volume rendering
- on-demand integration of multiple modalities

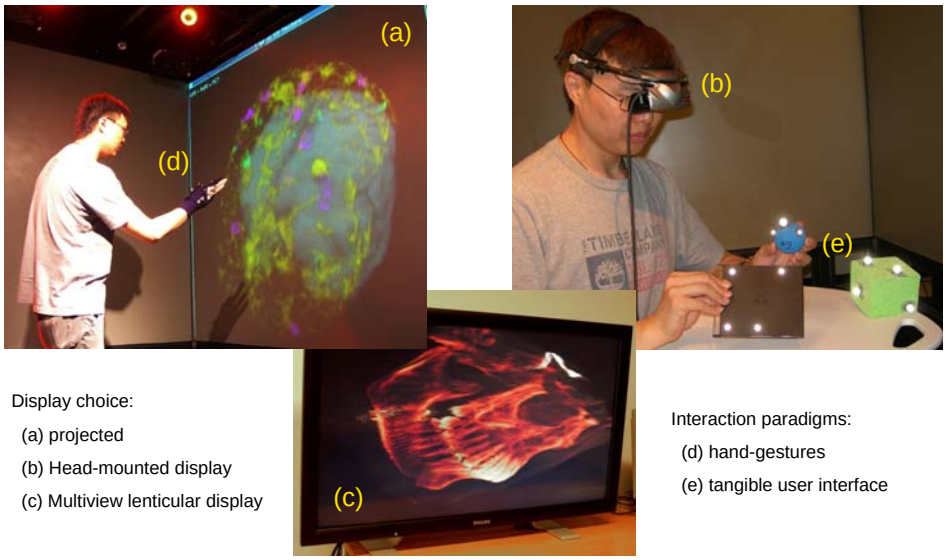
Interaction:

- tangible user interface for training and planning
- single-hand gestures for surgical use

Stereoscopy:

- Head-mounted display (HMD) for individual surgical diagnose and planning
  - HMD is real immersive but isolates the user.
- Multiview lenticular display (MLD) for educational and collaborative applications
  - MLD is well-suited to simultaneous viewing by multiple individuals without the need to wear special eyegear.

Prototype System



Display choice:

(a) projected

(b) Head-mounted display

(c) Multiview lenticular display

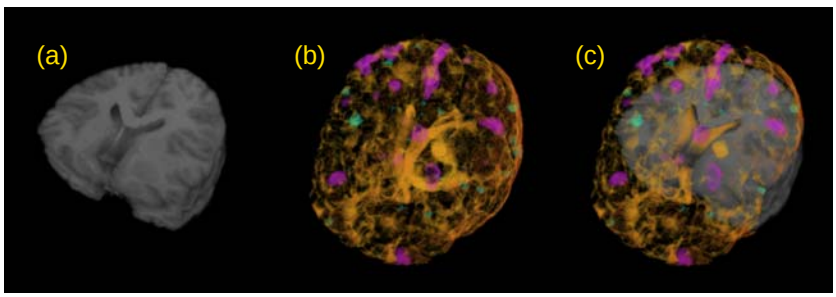
Interaction paradigms:

(d) hand-gestures

(e) tangible user interface

Medical Visualization

High-quality integrated visualization results: (a) traditional cutting plane result, (b) direct volume rendering of mixed modalities, (c) combined view with cutting plane. MRI data (yellow), fMRI (blue), PET (magenta), cutting plane result (gray).



Tangible User Interface

Hand Gestures

Stereoscopy

Stereoscopic viewing can be supported by a number of technologies, including head-mounted display (HMD), two-color anaglyph, polarized stereo projection, LCD shutter glasses, and multiview lenticular display (MLD).

- Although HMDs are often used to provide an immersive and borderless 3D environment, as beneficial for gaming and simulation environments, these suffer a drawback of isolating individual users from the physical world.
- With two-color anaglyph and polarized stereo projection, two images, which pass through different filters, are superimposed onto the same screen. These are viewed through eyeglasses containing a matched pair of filters so that each eye sees a different image, although with an obvious loss of color quality.
- LCD shutter glasses blank the view of each eye, synchronized to the display of an alternating left-right view. These technologies, however, can only render a single view for all participants, and often limit the viewers' position to a specific sweet spot.
- The MLD technique employs an array of transparent lenses over the display surface that selects from different pixels (typically divided by column) based on viewing angle. This allows multiple users to experience both stereopsis and motion parallax without restricting mobility or wearing eyegear.