Facilitating Real-Time Image Acquisition and Analysis: A Novel Hand-Immersed Paradigm *(vizDrive)*

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Introduction: One of the most significant factors contributing to long MRI acquisition times is scan prescription. This can be attributed to multiple factors including the near exponential growth in scan protocols, access to experienced operators, and increasing complexity of modern protocols. In addition, a growing number of acquired series are 3D, facilitated by faster image acquisition and reconstruction, leading to large datasets, which are time-consuming to view. In order to address these crucial needs, it is imperative that a fresh approach to the acquisition process be evolved. This new enabling methodology needs to enhance the present imaging capabilities (in terms of diagnostic image quality and accuracy) without any compromises. In the mostly unrelated field of virtual reality (VR), the research community has presented numerous applications in the field of medicine over the last two decades. Most applications focus on virtual, real-time, and often haptic exploration and manipulation of acquired data in conjunction with potential intra-operative procedures and/or therapy delivery. The vizDrive concept bridges this gap by establishing real-time communication between the acquisition console and a small foot-print hand-immersed VR environment which creates a virtual space akin to a head-mounted display [1] or the Cave [2] with the key difference that it fits compactly on a desktop. The user interacts with a model, or with 3D MRI scout data via sensors that let the computer draw a stylus where the user feels/sees one. The deployability of a "reach-in" 3D interface is vastly enhanced by assembly from off the shelf PC graphics, stereo shutter glasses, and position/rotation sensors. Unlike fish-tank VR [3], the interface uses a mirror to view the CRT; your hand raised to a display would break up the stereo, occluding objects that seem nearer and should occlude the hand, forcing indirect control. Hidden under the mirror your hand controls a 'virtual' stylus, seen where the real one is felt. The downward mirror slope places the reflection handily below a normal CRT with no special mounting, so that the bulkier footprints of ReachIn [4] and Volume Interactions (Bracco) [6] are replaced by a simple extension of a display still usable as a desktop-PC. An alternate approach using a space occupying 6-DOF robotic arm and without a dextrous work-setup has recently been presented [7]. Another noteworthy application is [5].

Methods: An application of this reach-in environment for real-time management of 3D acquisition is explored (Figure 1). The user sees in stereo the data acquired to date in a location where hand actions can grasp geometric structures such as planes and rectangular boxes that appear in positions matching the hand's, and move accordingly. The current position and geometry of these structures, controlled through natural human hand-eye coordination, are transformed by the system into spatial specifications of what data are to be gathered. (From these are derived specifications for gradient fields and pulse sequences.) The acquired data are presented in a coherent 3D scene, on which the user's viewpoint can be changed by virtual grasping and moving the scene as a whole: translating and/or rotating the collective position in which the geometric elements of the data display appear. The communication between the scanner and the *vizDrive* front-end is based on TCP/IP and sockets. This allows the transfer of a scout volume and real-time high-res images at interactive rates uni-directionally from the scanner, while rotation matrices and acquisition related parameters are passed to the scanner console.

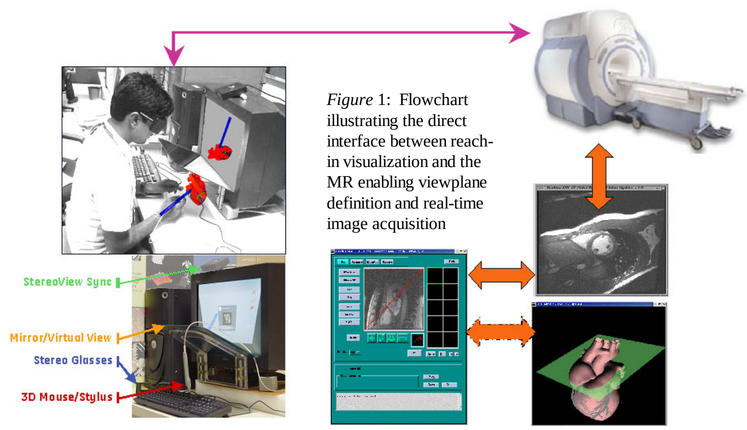

Figure 1: Flowchart illustrating the direct interface between reach-in visualization and the MR enabling viewplane definition and real-time image acquisition

Results: A novel methodology for rapid control and acquisition of medical images using a 6-DOF interactive reach-in environment is presented. The MR *vizDrive* system uses the SSFSE pulse sequence, operating at 3 frames/s, or interleaved EPI sequences, at up to 15 frames/s. Figure 2 shows the additional enabling capabilities of *vizDrive* such as interactive 3D seed placement for region segmentation incorporating powerful toolkits such as VTK[8] and ITK[9] for constrained region growing, level-set based methods, and registration. The focus of future activity is on quantifying productivity gains and testing clinical acceptance.

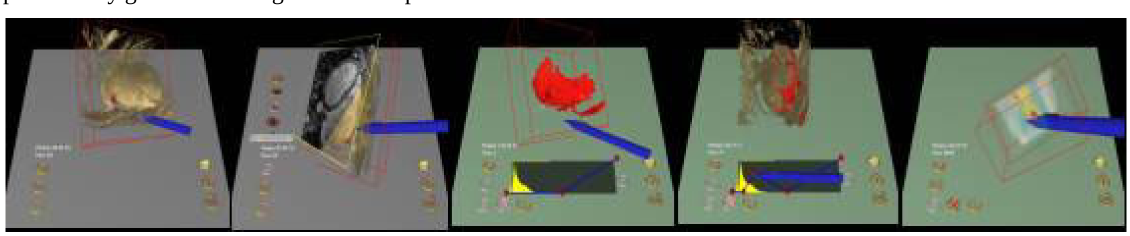

Figure 2: 3D interface and analysis screenshot: (a) & (b) tool (blue) holding the acquisition-driving plane coregistered to the scout volume (Cardiac MR) (c) & (d) Interactive segmentation, (e) multi-modal registration.

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