Collaborative MRI for Improving Patient Throughput

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Introduction: Conventional magnetic resonance imaging tends to rely on a single user/operator model: a single operator prescribes a scan, runs it, monitors that the results are acceptable, and proceeds to the next scan. For interventional procedures, while this practice still is used, despite a team of people monitoring a scan, the process can be inefficient and unproductive. Much like parallel imaging has transformed and decreased MRI scan time, we propose the parallelization of people to improve interventional MR workflow. For example, in focused ultrasound, instead of a single user defining target location, skin boundaries, and safety areas, multiple users could interact simultaneously with the same data and make the same annotations in less time. In a parallelized or collaborative procedure, users on multiple devices have access to and control of data. Each user is capable of individually interacting with it, but not all interactions are shared between users. Each display is not necessarily a mirror image of a main console as previously shown [1]. Users can make changes that are independent (i.e. adjusting the window contrast for a user's needs) or shared (i.e. adjusting a scan parameter that thus affects other connected users). We introduce our work in transforming our real time MRI imaging from a single user, individual program into a multi-user, collaborative system.

Figure 1: A shared change. In the middle frame, the user changes the geometry of the slice. Once the change is sent, both devices are updated to reflect the new position.

Methods: As a proof of concept, we created the foundation of a hub-and-spoke platform architecture for enabling collaborative MR. On a host PC, a data and control plug-in was created with Qt 4.7.4 (Nokia, Sunnyvale, CA) with two central purposes: saving data collected from the scanner and relaying control information from individual users to the MR. MR data and control was realized by connecting this plug-in to RTHawk, a real-time imaging platform (HeartVista, Palo Alto, CA) for our 3T Signa Excite scanner (GE Healthcare, Waukesha, WI). The plug-in also interfaced with a client management program written with node.js (Joyent, San Francisco, CA) to accept and manage incoming data and control TCP connections.

A real time MRI application was created on an HP TouchPad (Hewlett-Packard, Palo Alto, CA). The application's main purpose was to interface with the real time MRI application, controlling the geometry of three independent slices running simple gradient recalled echo scans (30 cm FOV, 128x128 pixels, 3 ms TE, 5-15 ms TR). The application was installed on two tablets. In one experiment, both tablets connected to the host PC and simultaneously viewed and interacted with the scan. In a second scan, a user used one of the devices to interact with the scan remotely, approximately 8 miles away.

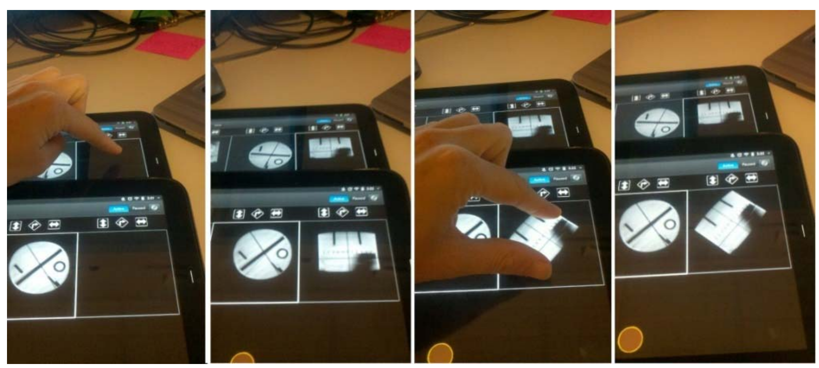

Figure 2: Shared and independent changes. In the first frame, the user activates the third independent geometry slice. The second tablet receives this change in frame 2. In frame 3, the user initiates an independent change: an image (non geometry) rotation. This change is only reflected for that device in frame 4.

Results: Figure 1 shows an example from the first experiment. Both machines are viewing the same data (Frame 1). The user makes a change on one tablet, and both devices reflect this change. In Figure 2, another "shared change" occurs, where one of the three slices is enabled, while an "independent change", a rotation (applied to the image only, not changing the MRI scan orientation), is performed. For the second experiment, the tablet was able to control the scan (imaging at approximately 1 fps) with no noticeable lag.

Discussion: These experiments represent a proof of concept for collaborative MRI. Two key feasibility tools were investigated: the ability to separately interact with incoming MRI data, and the ability to interact with data away from the scanner. These abilities can be exploited in interventional MRI studies to reduce the length of user intensive procedures done while the patient is on the table. As the second experiment shows, those other users do not necessarily have to be in the same room. By parallelizing people, interventional MR procedure times could be further decreased and be an even more advantageous option.

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References: 1. Finn JP et al. MR Imaging with Remote Control: Feasibility Study in Cardiovascular Disease. Radiology 241(2), 2006. 528-537.