Feasibility of gesture-based control of MRI-guided interventional procedures

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<u>Target audience</u>: Interventional MRI researchers using image-guided visualization in the scanner room

<u>Introduction</u>: In MR-guided interventional procedures, images are displayed in the scan room for use by the interventionalist. Control of the visualization software is generally done outside the scanner room by a system operator. Communication between the interventionalist in the MR room and the operator in the console area in order to control the visualization is cumbersome. A touch-free interface for control of the scanning and visualization software from inside the MR room is desirable to maintain a sterile environment and to allow direct control of the scan by the interventionalist. Other gesture interfaces have been presented for use in the OR for viewing of radiological images[1,2] and recently, MR-compatible gesture control methods have been investigated[3,4]. The Leap Motion device (Leap Motion Inc, San Francisco, CA) is a small, infrared-based sensor for tracking the position of hands and fingers as well as for recognizing gestures. It connects to a computer via a USB cable and has an API that allows developers to read tracked information into their own programs.

<u>Purpose</u>: To investigate the use of Leap Motion for interventional guidance through integration with visualization software. Specifically, the noise effects of the device were tested in the scanner room and usability was evaluated in phantom studies.

<u>Methods:</u> 1. *Noise Evaluation*: Tests were performed on a GE Signa EXCITE 1.5T MR scanner with a sphere phantom using body-coil transmit and receive at 63.86 MHz**.** The SNR of spiral fast gradient echo images was measured in the following scenarios: a) without the Leap Motion device in the scan room, b) with the cable of the device placed through the wave guide and taped to the end of the scanner bed, c) with the device connected and placed 146 cm from the end of the bore but no gestures being made, and d) with the device in place 146 cm from the end of the bore and gestures being made.

2. *Integration into platform and usability*: Gestures, finger motion and hand poses tracked by the Leap Motion device were read using the Leap Motion API and mapped to existing operations in the Vurtigo 3D visualization software[5]: a horizontal tap was used to select or deselect a real-time imaging plane, an upright open hand moving in the depth direction was used to translate the selected real-time plane, and a horizontal open hand moving in the vertical direction was used to change the opacity of the selected real-time plane.

Two scan plane control tasks were assessed for usability outside the scanner: a) the user attempted to move a selected plane to target points using translations in the depth direction, where the time to reach 15 targets within a tolerance of 2.5 mm was measured using push gestures and using mouse scrolling, and b) the user attempted to toggle selection of a real-time plane by registering a “tap” gesture 20 times. These tests were performed by each of 3 users trained for approximately 1 hour with the interface.

3. *Scanner phantom test*: Real-time acquisition and reconstruction of a GE phantom were controlled using the RTHawk platform (HeartVista, Inc., Menlo Park, CA). Imaging plane geometries were viewed and controlled by Vurtigo (Fig 1). Two orthogonal real-time imaging planes were controlled by the researcher while in the scanner room (Fig 2).

<u>Results:</u> 1. Negligible SNR degradation was measured when imaging with the Leap Motion device in the scan room with or without gestures being made compared to the control situation without the Leap Motion device. SNR measured for the various scenarios above was: a) 40.3±0.9 b) 37.0±0.7 c) 37.8±1.0 d) 39.1±0.8**.**

2. Qualitative assessment of the Leap Motion device function while the scanner was imaging indicated that gestures were detected reliably. The Leap device's self-diagnostic tests showed that it was running correctly while it was inside the scan room. A bright-light mode for the device was entered while in the scan room due to incandescent lighting but this did not appear to affect performance.

Usability tests showed that plane navigation to targets took an average of 4.1±2.6 seconds with gestures and 4.7±2.3 seconds with the mouse, with a mean difference of –0.6±3 seconds. There is a significant correlation between the difference in the targeting time with Pearson's correlation of -0.5 (non-directional t-test, $p < 0.05$), indicating an increasing advantage for more distant targets when using Leap (Fig 3). Although plane translation with gestures was fast using gestures, fine adjustment took longer. Selection of an imaging plane using the tap gesture was successful in 97% of the attempts.

3. Gesture control in the MR room was successfully used to navigate real-time scan planes to the desired positions and control their opacities.

<u>Discussion:</u> MR scan plane control using gestures via Leap Motion in the scan room is usable with minimal loss of image quality. Adjusting the resolution of the translation with another gesture or by using the palm velocity may improve this operation's performance. A small subset of interaction operations to be controlled by gestures was selected for this feasibility study; extending the gesture vocabulary to allow fuller control of the visualization interface will require careful interaction design.

<u>Conclusions:</u> Gesture-based control using the Leap Motion device is a feasible supplement to audio communication for in-room interventional MR control of scans and related visualization. As an inexpensive consumer device with built-in gesture recognition and support for multiple platforms and languages, the Leap Motion sensor provides an easy way to integrate gesture control into existing software. Future work will include expanding the gesture vocabulary and further user testing to select intuitive gestures.

[1] Ruppert et al. World J. Urol. 2012;30(5):687–91. **[2]** Strickland M, et al. Can. J. Surg. 2013;56(3):E1–6. **[3]** Paley M, et al. ISMRM 2013;21:4329. **[4]** Maier F, et al, ISMRM 2013;21:4326 **[5]** Radau PE, et al. STACOM. Heart Imaging Model Challenges Lect. Notes Comput. Sci. 2012;7085:244–253.

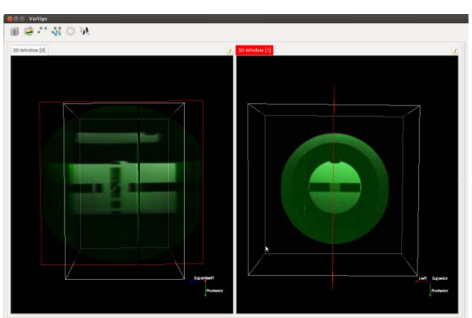

Figure 1: Two orthogonal real-time scan planes overlaid onto roadmap images are displayed in Vurtigo to the operator in the scan room. The plane outlined in red is selected for control.

Figure 2: Control of real-time scan planes using gestures in the scan room. A close-up of the Leap Motion device is shown in the inset.

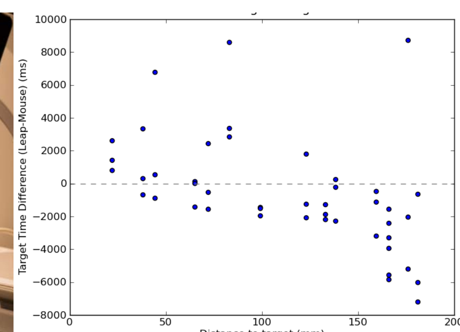

Figure 3: Difference in target navigation time