MR Image Overlay Adjustable Plane System for Musculoskeletal Interventions

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Purpose: The 2D MR image overlay system (IOS) concept and its feasibility have been evaluated and proved in musculoskeletal (MSK) procedures [Fritz *et al*. European Radiology 2012]. However, IOS image plane is vertical, limiting the insertion at the scanner axial plane. In many MSK procedures, such as joint arthrography and facet joint injections, the optimal access to target requires an oblique insertion plane. To overcome such problems, we have developed the MR image overlay adjustable plane system (IOAPS). The challenges remain due to the strong magnetic field and confined operating space.

Methods: MR image overlay adjustable plane system (IOAPS) is an advanced version of the IOS. It has 4 degrees of freedom of motion (two translations and two rotations), manually actuated. These motions are indicated by calibrated encoders attached to the moving joints. The IOAPS consists of two main units; 1) out-of-room unit consisting of an interconnection box, a power control box, and a laptop and 2) in-room unit placed next to the MRI scanner and consisting of a fully MR-compatible monitor, linear and rotary motion encoders, a sensor control box, a transverse plane laser, an MRI-compatible keyboard, a semi-transparent mirror, and a supporting aluminum frame. The aluminum frame carries the weight of all devices and provides the motion of ±100 mm (in X-Y directions) and ±25° (around X-Y axes), Figure 1. The MR-compatible monitor (19-inch, RF shielded LCD monitor, Siemens Corp) allows the operator to work within 60 cm from the bore, thus minimizing table translation. The system was designed to allow for sufficient working space to execute multiple oblique needle insertions.
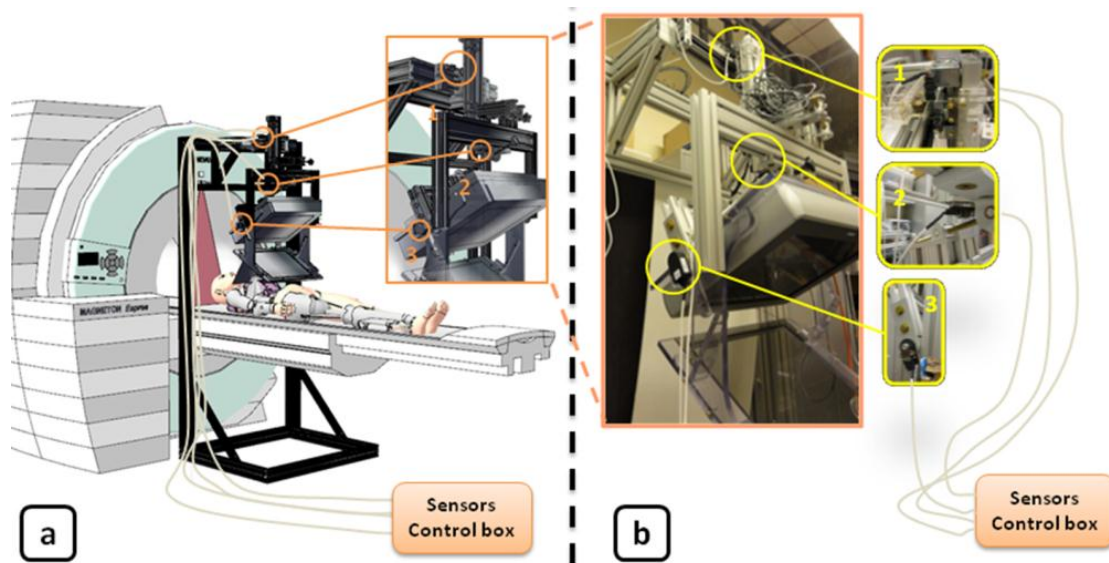
Figure 1: 3D CAD model (a) and photograph (b) of the current prototype of the IOAPS

Results: The IOAPS has been designed and built (Figure 1). Structural loading analysis has been computed with a load of 50 kg. The new system calibration is more challenging compared to IOS. Modules of the in-room unit have been tested. A system workflow and calibration processes were also designed. Technical validation of the IOAPS is currently in progress.

Conclusions: We report the design and prototype of an MR image overlay system with adjustable imaging plane, with the objective of assisting MR-guided needle insertions in oblique planes.