Automatic Landmark for MRI Scanners

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Introduction: Positioning the anatomy of interest in the center of the magnet, characterized by the best field homogeneity, is a critical step in the imaging process. A landmark error may produce images of low diagnostic quality, and may provide inadequate coverage of anatomy for automatic scan plane prescription algorithms. Because of the risk of inadequate coverage of anatomy, automatic scan plane prescription may require acquisition of additional images in the S/I direction, increasing exam time. In figure 1, the yellow line represents the landmark, and the blue area represents coverage necessary for automatic scan plane prescription. Despite acquiring 38 additional slices (~100mm) beyond “necessary and sufficient” for automatic scan plane prescription, due to the improper landmark position, there are missing slices, as indicated by the blue area above the top of the image. To solve these problems, a system is presented that completely eliminates the manual landmark procedure, and automatically positions the imaging coil and patient anatomy in the center of the magnet. The landmark is detected as the patient is automatically advanced from home position to magnet isocenter. Once at isocenter, following a short localizer scan, the ideal center of the scan volume is computed and used as an offset from the landmark position. In such a way, by measuring coil position and then recognizing patient anatomy, patient positioning errors can be compensated, or the operator can be directed to reposition the subject. This system also uses automatic scan plane prescription for the knee, known as OneTouch Knee[1].

Figure 1

Methods: An 8mm strip of corner reflective sheeting (3M Company, St. Paul, MN) was affixed to a knee coil (Invivo Corporation, Gainesville, FL), as a marker at a defined position on the coil (Figure 2). An infrared (IR) LED and infrared receiver module was mounted to the front of a GE MR750 scanner (GE Healthcare, Milwaukee, WI). The IR detection mechanism was calibrated by an automatic landmarking of the coil, then manually returning to the landmark position, where the table position was adjusted until the laser alignment light was coincident with the coil center. The offset was then used as the landmark error. This calibration process needs to be done only once. Figure 3 illustrates the auto landmark system. The output from the IR receiver module was input to a microprocessor programmed to filter the signal, and to send a detection signal to the MR scanner using TCP/IP. An exam begins with the table and patient at the home position (fully outside of the magnet); when the scan button is pushed, the table and patient travel into the bore. As the coil marker passes the IR emitter/detector assembly, the IR beam is reflected from the 3M sheeting and detected by the IR receiver module. This sends a signal to the scanner digital subsystem, which adds the pre-calculated detector-isocenter distance to the current table position, and then moves the table to this new position. With the approximate coil center at isocenter, localizer images are acquired, and processed by algorithms to determine the scan volume center. As shown in Figure 4, a 2D axial image is acquired and processed to determine the L/R and A/P coverage of the knee, then the L/R coverage and the location of a 3D sagittal localizer are automatically determined and images are acquired. The knee joint location is then computed by performing a maximum intensity projection in the L/R direction to highlight femur and tibia, detection of the femur and tibia and computing the center line between the two bones. The knee joint location is used to determine the scan volume center in the S/I direction, which can further reduce the error caused by a knee not perfectly located in the middle of the coil.

Figure 2

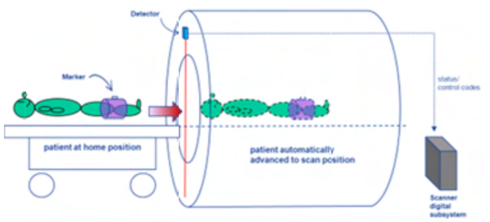

Figure 3

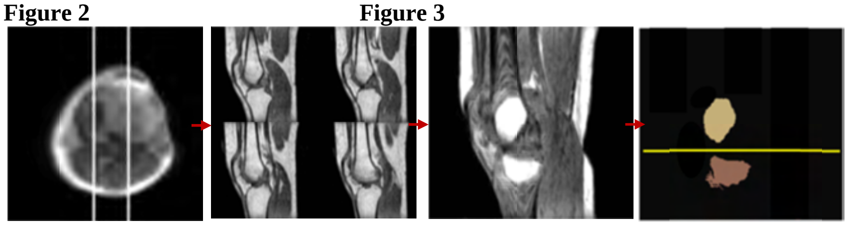

Figure 4

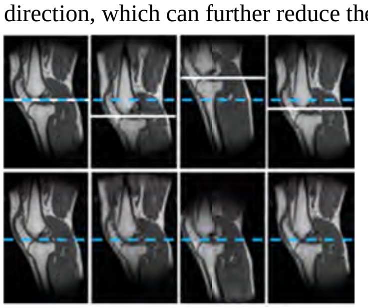

Figure 5

Results: Localization of the imaging coil via the coil marker proved very robust. Following the calibration procedure described above, the coil was positioned within 0.6 (±4.6) mm of the true landmark position. Elapsed time for the auto landmark procedure, starting with the patient at home position, and ending with the patient advanced to scanning position, was 21 seconds. Localizer images used to compute center of the scan volume took 5 seconds to acquire, and the scan volume center calculation took less than 1 second. Figure 5 shows 4 vertical sets of knee images, where the first column represents a knee properly positioned in the coil. In the other 3 sets the knee has deliberately been improperly positioned within the knee coil. In the top row of figure 5, the blue line shows the location of the automatic landmark, and the white line shows the offset from landmark computed by the center of scan volume computation. The bottom row of images was acquired after applying the computed center of scan volume offset to the automatic landmark position. The offsets determined for the center of scan volume, left to right, were: .5mm, -24.9mm, 46.3mm, -16.1mm.

Discussion and Conclusions: We have developed a system that completely eliminates the manual landmark procedure for a MRI exam. This system adds additional precision to the landmark by computing the center of the scan volume for the anatomy of interest, and applying this as an offset to the landmark. The system employs a passive coil marker, achieving sub-mm precision with an infrared emitter/detector system. Different markers, such as coupling coils, RF ID chips or IR diodes/detectors may be used to mark a coil position. Multiple positions on a coil may also be marked. Knowledge of coil localization relative to patient anatomy allows only the coil elements near the anatomy of interest to be enabled and distant elements disabled, reducing image reconstruction time. It also permits detection of a malpositioned coil, allowing a prompt to the operator to reposition the coil, prior to acquiring diagnostic images.

References: **1:** Tao, Xiaodong, An Automated Method for Scan Geometry Planning for MR Knee Imaging, Proceedings of ISMRM 2010, p4532.