MR-Compatible Optical Tracking Device with Active Markers

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Introduction

It was shown that optical tracking systems can be used for motion artefact correction of MR images [1,2] or to support MR guided interventions [3,4]. These studies use passive optical tracking systems to determine position and orientation of static or moving objects. Passive optical tracking systems use markers consisting of reflective spheres that reflect infrared pulses emitted by the tracking system. The reflected light is detected by the system and, through triangulation, the position of the spheres and therefore also the position of the object can be calculated. Precise and real-time determination of the spatial position and motion may also be helpful in the supervision of complex motor fMRI experiments our group is interested in. In this case, hand or fingers have a configuration which can change over time when the subject carries out movements. This makes it impossible to use passive optical tracking systems as they will loose track of the different markers when these cross position. Therefore, only active tracking systems which undoubtedly identify the light source can be used in our foreseen application. The purpose of this study was to evaluate the MRI compatibility of an active optical tracking system for real-time position measurements of objects moving during image acquisition.

Methods

In the experiments, a commercially available active optical tracking system (easyTrack 500 system from atracsys, www.atracsys.com) was used. This system consists of three linear cameras and measures the 3D position of pulsed infrared LEDs by triangulation. It is able to calculate the position of 300 LEDs per second with a precision better than 0.2mm. For the experiments, the active optical tracking system was slightly adapted to be compatible with the MRI environment: The shielding was improved and the system was grounded whereas the electronic circuits required no changes. All ferromagnetic parts were removed and replaced by compatible materials. The compatibility of the device electronics and the cables which supply the LEDs to the MRI system was assessed via SNR measurements using a spherical phantom and a standard EPI sequence with high acquisition bandwidth. In this first study, rigid markers containing four IR LEDs were used. For the detection of limb movement, these LEDs will be individually placed on a cast so that the actual position of the limb can be tracked in real-time with high accuracy.

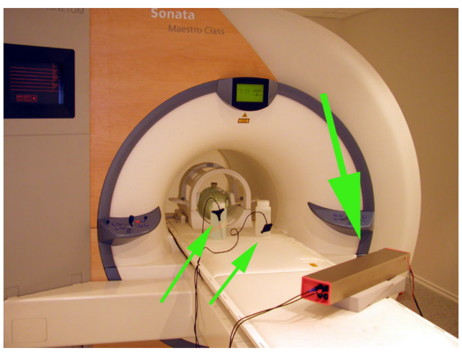

Fig. 1: Camera system (thick arrow) and LED probes (small arrows) of the optical tracking device.

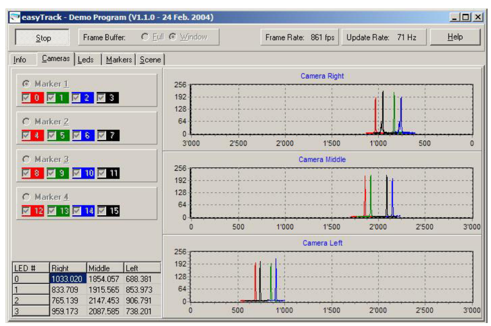

Fig. 2: Position in pixel units of individual LEDs (different colors) as seen by the three CCD elements of the active optical tracking device.

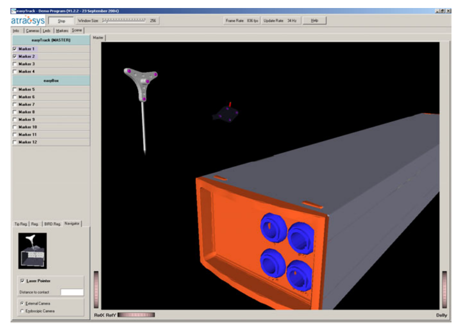

Fig. 3: Screenshot of the atrac software showing a 3D representation of the easyTrack and the markers.

Results

Neither main magnetic field nor field gradients or radio-frequency signals disturbed the functioning of the tracking device. SNR measurements showed a decrease of SNR of about 2% when the camera part of the tracking system was positioned in a way that allowed tracking objects in the first half of the MR bore and at the same time giving free access to magnet bore and bed. The cables which supply the LEDs had no influence on the MR signal but will be replaced by optical wave guides for safety reasons. Since only minimal modifications to the mechanics of the easyTrack were necessary to make the system MRI compatible, this active system is well adapted for fMRI experiments with objects that change configuration.

Discussion

The modified active tracking device allows precise three-dimensional real-time tracking of position and orientation of objects located in the MR scanner. Residual noise caused by the electronics of the device is most likely emitted by the switching power supply which will be replaced for future experiments. The usefulness of the device for functional experiments is currently tested in a motor study that examines complex finger movements.

References

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Acknowledgement

This work was funded by the Swiss National Science Foundation.