Evaluation of an novel RFID-based navigation system for MRI-guided interventions and surgery

Felix V. Güttler[1], Andreas Heinrich[1], Michael Sonnabend[1], and Ulf Teichgräber[1]
[1]*Department of Radiology, University Hospital Jena, Jena, Thuringia, Germany*

Target audience: The topic might be of interest for researchers working in the field of medical tracking solutions and clinical scientists who operate MR-guided interventions or medical tracking systems in surgery.

Purpose: MRI-compatible optical tracking solutions are well established i.e. in neurosurgery[1]. Radio-frequency identification (RFID) allows the identification of multiple transponders (tags) in translation and rotation allowing 6 DOF. In contrast to optical tracking solutions, the RFID-based system does not need a permanent line of sight during operation. This is a great advantage and need according to various studies describing problems caused by optical tracking systems[2-3]. The MR-compatibility of RFID transponders could be proved in several studies, i.e. focusing the use of RFID for patient identification systems[4-5]. The purpose of the study is to evaluate the suitability of a novel RFID-based tracking system (Passive RFID Positioning System, Amedo smart tracking solutions, Germany) for intraoperative MRI. Therefore the spatial accuracy and signal-to-noise ratio (SNR) according to the National Electrical Manufacturers Association (NEMA) standard MS 1-2008[6] was quantified.

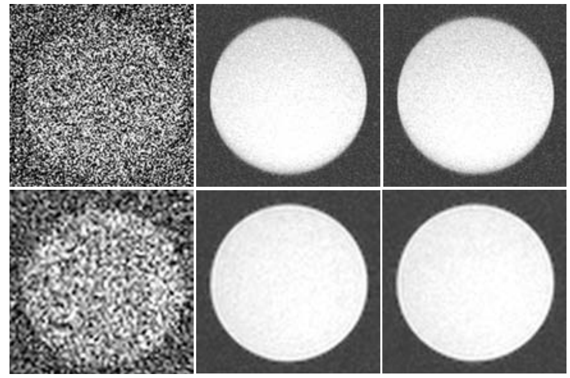

Fig. 1: *SNR before modification (left), after modification (middle) and reference measurement (right) for a HASTE- (upper row) and TrueFISP-sequence (lower row).*

Methods: The RFID receiver system (reader) was modified to fulfill MRI-compatibility according to ASTM standard F2503[7], therefor the Power-over-Ethernet component was replaced with an optical fiber for network communication and the voltage source was replaced by a lead-accumulator. All cables and the housing of the reader excepting the antenna were shielded with braided copper foil. The influence of the RFID system on MRI (MAGNETOM Sonata, Siemens, Germany) was analyzed for a phantom of 1kg H2O (dist.) with 1.25g NiSO46H2O and 5g NaCl. The SNR (n=720) was measured with a HASTE- (TR= 3000ms, TE=60-63ms, ETL 256) and a TrueFISP-sequence (TR=12.9ms, TE=2.15ms, flip angle 70°). A voxel size of 1x1x3 mm, 2x2x4 mm and 2x2x10 mm was used. The reader was positioned 90 cm to 210 cm (step 10 cm) from the isocenter of the MRI. During the measurements, the reader continuously sent RF signals at 865.7-867.5 MHz. In a second experiment the RF signal was changed from 865.0-869.0 MHz (step 0.5 MHz) and a distance of 90 cm, 150 cm and 210 cm from the isocenter of the MRI. The specific spatial resolution (n=225) was measured with and without permanent line of sight (LOS) between antenna and RFID tag (ALN-9640 Squiggle Inlay, Alien Technology, Butterfield, USA). An optical tracking system (Polaris Spectra, NDI, Canada) served as reference system.

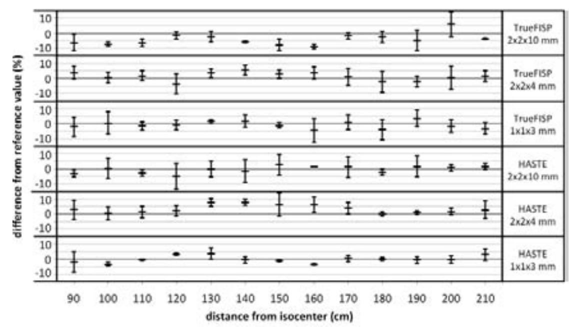

Fig. 2: *The percentage difference (±15%) between RFID system and reference measurement (without RFID system) for varying distances from isocenter of the MRI is shown.*

Results: Compared to the SNR of reference measurement, a SNR of 8-10% could be measured for the unmodified reader (Fig 1). After modification no significant change of the SNR could be observed with increasing distance of the RFID system from the isocenter of the MRI (Fig 2). Also the RF signal of the reader does not significantly influence the SNR of the MRI (Fig 3). The specific spatial resolution deviates on average by 9,0 mm with LOS and 11,6 mm without LOS from the reference system.

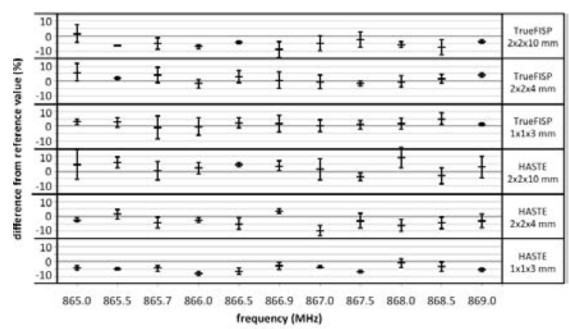

Fig. 3: *The percentage difference (±15%) between RFID system and reference measurement (without RFID system) for varying frequencies of RFID system with 90 cm distance from isocenter of the MRI is shown.*

Discussion: The RFID system does not interfere with the MRI. The galvanic isolation of the unit, the power and connection to digital processor supply solves problems related to medical safety and MRI-image quality, because an electronic interaction between the MRI receiver coil and RFID receiver is significantly reduced. However the specific spatial resolution is still too inaccurate for intraoperative MRI.

Conclusions: The installation of an RFID system including transponders and receivers in the magnet room in close distance to the magnet has low of non-relevant influence on MRI. However the spatial accuracy have to be improved for an application as tracking system in intraoperative MRI.

[1] *Sutherland, G.R., I. Latour, and A.D. Greer, Integrating an Image-Guided Robot with Intraoperative MRI. Engineering in Medicine and Biology Magazine, IEEE, 2008. 27(3): p. 59-65.* ***[2]*** *Metson, R., R.E. Gliklich, and M. Cosenza, A comparison of image guidance systems for sinus surgery. The Laryngoscope, 1998. 108(8): p. 1164-1170.* ***[3]*** *Rotenberg, D., et al., Real-time correction by optical tracking with integrated geometric distortion correction for reducing motion artifacts in functional MRI. Magnetic Resonance in Medicine, 2013. 69(3): p. 734-748.* ***[4]*** *Steffen T, Luechinger R, Wildermuth S, et al. Safety and reliability of radio frequency identification devices in magnetic resonance imaging and computed tomography. Patient safety in surgery. 2010;4(1):1-9.* ***[5]*** *Lamberg J. Magnetic Resonance Imaging & VerChip RFID Human Implant at 1.5 Tesla. University of Minnesota Twin Cities, http://www.rfidjournal.com/whitepapers/7/3 (accessed Nov 1, 2010). 2005.* ***[6]*** *NEMA. Standards Publication MS 1-2008 Determination of Signal-to-Noise Ratio (SNR) in Diagnostic Magnetic Resonance Imaging. National Electrical Manufacturers Association, 2008.* ***[7]*** *ASTM Standard F2503-08. Standard Practice for Marking Medical Devices and Other Items for Safety in the Magnetic Resonance Environment: ASTM International, West Conshohocken, PA, 2008, DOI: 10.1520/F2503-08, www.astm.org.; 2008.*