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Enabling Technologies for Robotic MRI-Guided Interventional Procedures

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Magnetic Resonance Imaging (MRI) can provide high-quality 3D visualization of soft tissue, thus granting potential to be a superior medical imaging modality for guiding and monitoring interventions. However, the benefits can not be readily harnessed for interventional procedures due to difficulties that surround the use of high-field (1.5T or greater) MRI. The inability to use conventional mechatronics and the confined physical space make it extremely challenging to access the patient. I will be presenting a robotic assistant system that overcomes these difficulties and promises safe and reliable needle placement for the purpose of targeted prostate cancer diagnosis and therapy. The robot is a servo pneumatically operated automatic needle guide, and effectively guides needs under real-time MR imaging. MRI compatibility of the robot has been evaluated under 3T MRI using standard prostate imaging sequences and average SNR loss is limited to 5%. Needle alignment accuracy of the robot under servo pneumatic control is better than 0.94mm RMS per axis. The complete system workflow has been evaluated in phantom studies with accurate visualization and targeting of five out of five 1cm targets. I will describe the systems requirements development, robotic system design, controller design, system integration, and evaluation of the accuracy, MRI-compatibility, and workflow. Further, I will discuss the evaluation of other MR-compatible actuation techniques and give an overview of other interventional systems developed at the Johns Hopkins Computer Integrated Surgery Research Center.

Gregory Fischer is completing his doctoral studies in the Mechanical Engineering Department at The Johns Hopkins University. He has been a researcher with the Johns Hopkins NSF Engineering Research Center for Computer Integrated Surgery since 2002. He received the B.S. degrees in electrical engineering and mechanical engineering from Rensselaer Polytechnic Institute, Troy, NY, in 2002 and the M.S.E. degrees in electrical engineering and mechanical engineering from The Johns Hopkins University, Baltimore, MD, in 2004 and 2005. His research interests include development of medical robotics and computer integrated surgery systems including interventional robotic systems, robot mechanism design, pneumatic control systems, surgical device instrumentation and MRI-compatible robotic systems.

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