Real-Time Ultrasound Imaging for MR Motion Correction

Sven Rothlübbers[1], Steffen H. Tretbar[2], and Matthias Günther[1,3]

[1]Fraunhofer MEVIS, Bremen, Germany
[2]Fraunhofer IBMT, St.Ingbert, Germany
[3]University Bremen, Bremen, Germany

Abstract

In medical imaging ultrasound and magnetic resonance modalities are well established. Relying on different physical backgrounds they can in principle be applied independent of each other and at the same time. While MR imaging is advantageous for the visualization of various tissue contrasts with high spatial resolution, ultrasound is cost-efficient and known to work in real-time. This real-time applicability renders it particularly interesting for MR motion correction approaches. Here we will give an overview of past work, present a commonly applied ultrasound tracking algorithm and show current work in progress.

First MR-ultrasound experiments focused on the feasibility of operating an ultrasound device inside the scanner room, because applying MRI and ultrasound simultaneously can cause severe hardware interference on both systems. Shielding the ultrasound device properly was shown to solve these problems and tracking simple phantoms inside the scanner was found to work reliably[1]. Following in-vivo experiments with motion correction during cardiac MRI acquisition revealed promising results[2].

The main challenge for an ultrasound tracking algorithm is its real-time applicability. At the same time demands for its robustness are high due to the generally noisy and cluttered nature of ultrasound images. In this environment, a stochastic algorithm[3] has been tested successfully. It approaches the tracking problem with multiple hypotheses and has provided reliable results in previous studies[1, 2]. As it is easily extensible it will be capable of dealing with more sophisticated ultrasound hardware features yet to come.

Currently, MR compatible ultrasound hardware is undergoing several improvements. The opportunity to track in three dimension might give rise for new motion correction approaches. Fraunhofer IBMT develops a 3D real-time ultrasound device which is being implemented and combined to the MR research site of Fraunhofer MEVIS. Its special feature is the acquisition system for 3D volumes. A three dimensional ultrasound volume is acquired by a rotating ultrasound transducer inside a shielded ultrasound probe and data processing is speeded up to fit the needs of real-time applications. First experiments with a motion phantom show very promising results in terms of acquisition speed as well as tracking performance.

Acknowledgments The authors would like to give special thanks to the Fraunhofer project 'MARIUS - Magnetic Resonance Imaging Using Ultrasound' for providing material for this work.

References

[1] Matthias Günther and David A. Feinberg. Ultrasound-guided MRI: preliminary results using a motion phantom. *Magnetic Resonance in Medicine*, 52(1):27–32, 2004.

[2] David A. Feinberg, Daniel Giese, D. Andre Bongers, Sudhir Ramanna, Maxim Zaitsev, Michael Markl, and Matthias Günther. Hybrid ultrasound MRI for improved cardiac imaging and real-time respiration control. *Magnetic Resonance in Medicine*, 63(2):290–296, 2010.

[3] Xiaohui Zhang, Matthias Günther, and André Bongers. Real-time organ tracking in ultrasound imaging using active contours and conditional density propagation. In Hongen Liao, P. J. "Eddie" Edwards, Xiaochuan Pan, Yong Fan, and Guang-Zhong Yang, editors, *Medical Imaging and Augmented Reality*, number 6326 in Lecture Notes in Computer Science, pages 286–294. Springer Berlin Heidelberg, January 2010.