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MOTION ESTIMATION FROM 4D (3D+TIME) ULTRASOUND OF THE LIVER AND KIDNEY

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Future therapy using MR-guided focused ultrasound (MRgFUS) to treat tumors in abdominal organs, such as the liver, must incorporate motion tracking of these organs due to breathing. This is needed to ensure accurately located sonications. **We have** performed a quantitative validation of a methodology for motion tracking of the liver and kidney with 4D ultrasound (4V probe, E9 scanner, GE Healthcare, USA). Three healthy volunteers were scanned over several breath cycles from various positions and angles on the abdomen, with three repetitions of each scan (totally 27 4D scans). A skilled physician performed the scanning and manually annotated well defined anatomic points for assessment of the automatic algorithm. **To extract** the 3D displacements of the liver structures (and kidney) from the raw image data over time, a fully automated image registration algorithm can be used. We have performed an off-line analysis of the volunteer data, using a recently published non-rigid registration algorithm that was specifically designed for motion estimation from dynamic imaging data. The method registers the entire 4D sequence in a group-wise optimization fashion, thus avoiding a bias towards a specifically chosen reference time point. Both spatial and temporal smoothness of the transformations are enforced by using a 4D free-form B-spline deformation model. The software is publicly available as an extension to the open source registration package *elastix* (http://elastix.isi.uu.nl). **We found** that the methodology was able to accurately and robustly track the motion of the liver and kidney in the 4D ultrasound data (Figure 1). Based on the promising results from this study, we recommend exploring this alternative further with respect to motion tracking for MRgFUS.

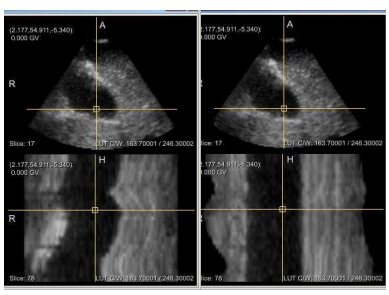

Figure 1. Example of motion estimation in 4D US. Upper row: original image (left) and the motion compensated image (right). Lower row: evolution of an intensity profile over time (where the vertical axis represents time). The large horizontal motion that can be observed in the original image has been

successfully recovered in the motion compensated image.