

Verification of contactless multi-channel UWB navigator by one dimensional MRT

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Introduction and Motivation

High resolution MRI and especially cardiac MR (CMR) imaging typically require triggered data acquisition. In high and ultrahigh field MRI systems the use of ECG triggering is seriously affected by the magneto-hydrodynamic effect. Therefore, we have developed an alternative interference-free approach for the detection of cardiac mechanics and respiration by means of multi-channel ultra-wideband (UWB) radar [1, 2]. It is also contact-less which is another advantage in the clinical routine. To investigate how the detected motion is related to the cardiac mechanics we implemented a 'pencil like' MR-sequence to monitor the cardiac motion inside the human body. We applied a gradient echo sequence for low SAR values and high scan frequency. One dimensional MR profiles and motion sensitive UWB data were acquired simultaneously, allowing a comparison of both techniques and enables a verification of the UWB radar navigator.

Materials and Methods

The UWB system with one transmitter (Tx) and five receiver (Rx) channels in frontal position over the chest, and another Tx/Rx channel over the abdomen (Fig. 1), was mounted on the patient table of the 3 T MR scanner (Magnetom Verio, Siemens, Erlangen). The latter UWB channel pair was implemented to detect the abdominal respiratory displacement. The UWB channels over the chest were pointed towards the left ventricle. The UWB data were sampled at 132.6 Hz.

Two perpendicular slices (s. Fig. 2) are excited by the implemented MR sequence, the second one two times with a variable delay in between. The image data of the second slice differ only in the area of the intersection with the perpendicular slice due to the different saturation. By subtraction we obtain an image of the pencil-like cross section. Placed through the left ventricle, this pencil was scanned at a frequency of 25.4 Hz.

UWB and MR data were analyzed by a blind source separation technique (TDSEP, [3]) to separate the independent motion components by a decorrelation approach. The cardiac component in the separated sources were identified automatically by the highest ratio of the maximum spectral power within the basic cardiac frequency range of 0.5 Hz to 7 Hz to the maximum power outside this range. Respiration was separated in similar way for the frequency range of 0.05-0.5 Hz but additionally the ratio was weighted by the power of the signal components and the resulting component was filtered by the frequency band of 0.05-0.5 Hz.

In the UWB time course representing the cardiac motion, the trigger points - representing the point of maximum contraction of the myocardium - (Fig. 3: red asterisks) were determined applying the algorithm proposed in [2]. Due to the double peaks it was not applied in the cardiac component of the MR signal.

Results and Discussion

Comparing the cardiac components simultaneously gained by UWB and MR data, we observe perfectly matching slopes of both signals. In contrast to UWB radar, however, the MR signal is affected by the blood velocity in the heart producing the double peaks. Keeping this in mind, we can conclude that both modalities render the same motion and we can assume the cardiac motion detection by UWB radar as verified.

To enable the UWB detection of abdominal respiration, which dominates in supine position, we included the additional transmitter and receiver channel. Fig. 4 depicts the respiration curves by the additional UWB channels and the MR pencil. They MR signal is slightly delayed with respect to the UWB curve, reflecting the different placement of the two additional UWB channels at the abdomen and the MR pencil across the heart. In the next step we will place the additional UWB channels closer to the heart and combine cardiac and respiratory UWB motion components into a free-breathing navigator for CMRI.

Acknowledgements

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References

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- [3] A. Ziehe et al., Proc. Int. Conf. Artificial Neural Networks (ICANN'98), Skövde, Sweden, pp.675-680, 1998.



Fig. 1: UWB setup in front of the 3T scanner.

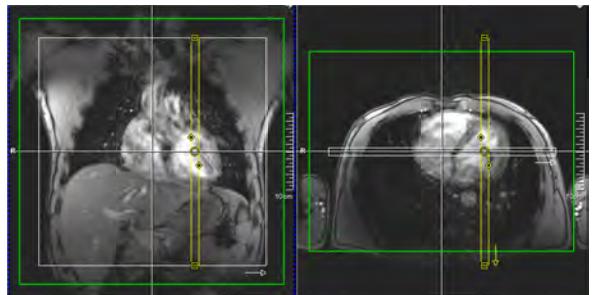


Fig. 2: Orientation of the crossing slices.

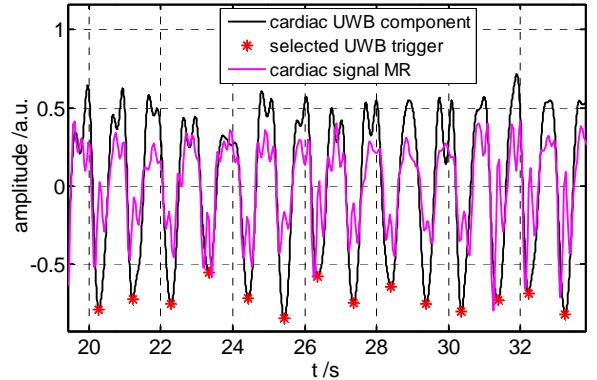


Fig. 3: Cardiac motion component by MR and UWB.

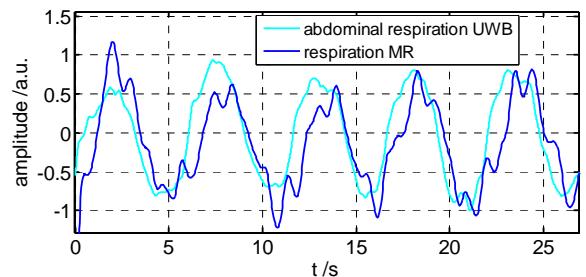


Fig. 4: Detected abdominal respiration by UWB and MR.