

# Self-adjusting multi-channel UWB radar for cardiac MRI

Olaf Kosch<sup>1</sup>, Steffen Schneider<sup>1</sup>, Bernd Ittermann<sup>1</sup>, and Frank Seifert<sup>1</sup>  
<sup>1</sup>Physikalisch-Technische Bundesanstalt (PTB), Berlin, Germany

## Introduction and Motivation

We developed an alternative, contact-less, interference-free approach for the detection of cardiac mechanics and respiration by means of multi-channel ultra-wideband (UWB) radar [1], suitable to deliver trigger signals for cardiac MR (CMR) imaging. Systems with  $B_0$  up to 1.5 T typically utilize ECG signals for this purpose. At higher field strengths, however, this is increasingly hampered by the magneto-hydrodynamic effect on the ECG signal. The necessity to attach ECG electrodes to the human body is an additional obstacle in the clinical routine.

Compared to previous systems we increased the number of antennas to four transmitters (Tx) and eight receivers (Rx) antennas. This allows to measure a maximum of 32 channels (s. Fig. 1) and makes UWB motion detection less sensitive to the particular positioning of the antennas relative to the heart.

## Materials and Methods

The UWB radar device contains four modules with one Tx and two Rx channels per module [2] as shown in Fig. 2. Each module is connected to the acquisition pc via an ethernet switch. We developed a data acquisition capable to measure eight UWB data channels (1 Tx  $\times$  8 Rx) at a sample frequency up to 530.4 Hz. Sequentially activating the transmitters, the 32 channel system (4 Tx  $\times$  8 Rx) can be sampled at up to 132.6 Hz (same data size for the Ethernet connection). In a short preparatory measurement each channel is analyzed by blind-source separation (BSS) [3] to decompose the complex UWB signals, extract the relevant cardiac component and calculate the trigger events [1]. The quality of each signal channel is assessed by calculating the variation of the time interval between trigger events. In channels with the highest variation the 'cardiac' signals are likely to be contaminated with noise or other motion components; these are rejected and a common BSS analysis of all remaining 'good channels' is performed.

## Results and Discussion

For illustration, the extracted cardiac component and trigger events derived from the two best channels are shown in Fig. 3 representing the best possible result with our old two channel radar device [1]. The trigger events mark the maximum contraction of the myocardium after the strong trailing slope reflecting the contraction process. Utilizing all 32 channels for the BSS results in a smoother cardiac signal and the motion amplitude is detected with less variation over the time, but we lose some of the sharpness of the trailing slope. For this reason the third trigger event escaped detection (s. Fig. 4). Obviously, some of the 32 channels contained much noise resulting in a jitter of their cardiac signal and smearing out sharp features in the combined signal determined by the BSS. But we obtain a cardiac signal with sharp trailing slopes and well-defined trigger events (s. Fig. 5) applying the method as described before with automatically rejecting the noisy channels and recalculating the BSS with the remaining channels or applying the list of remaining channels of the analysis of the preparatory measurement in the following measurements.

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## References

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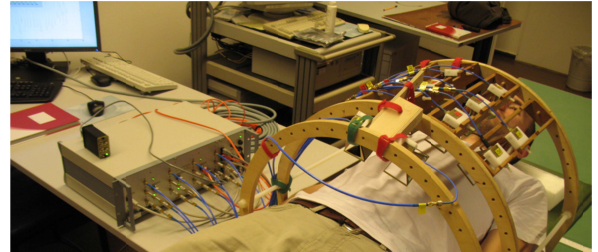


Fig. 1: UWB multi-channel setup.

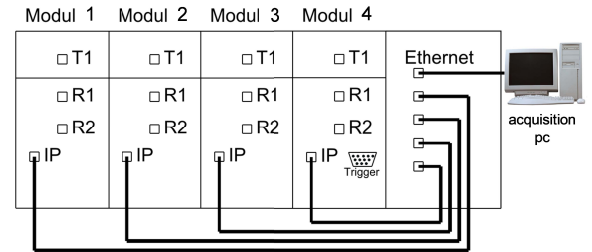


Fig. 2: Scheme of the radar device.

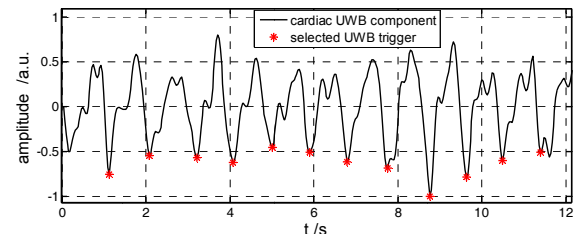


Fig. 3: Cardiac signal and trigger events by two channels

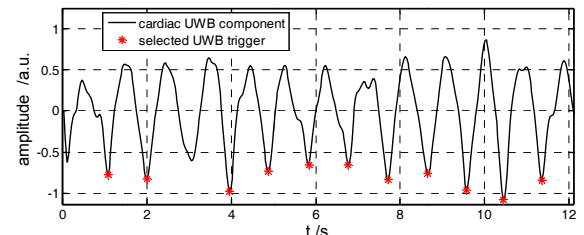


Fig. 4: Result for all 32 channels.

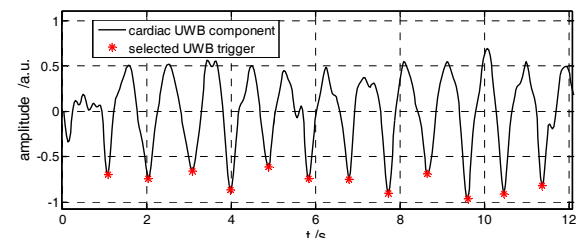


Fig. 5: cardiac signal and trigger for 24 channels (8 rejected).