

Heart Sound Detection Using an Ultra-Wideband FMCW Radar

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STATUS QUO

Contactless Vital Signs Monitoring

- CW radars:
 - ✓ good accuracy for heart rate/beat-to-beat intervals; heart sound detection
 - ✗ no absolute range; target separation difficult
- FMCW radars:
 - ✓ absolute range, target separation easier
 - ✗ heart rate usually averaged → no/imprecise beat-to-beat intervals; no heart sound detection



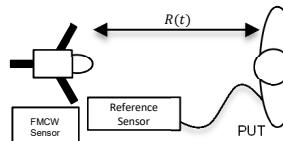
DESCRIPTION

- ✓ Beat-to-beat heart sound detection with FMCW

- ✓ Vital Sign detection with UWB FMCW Radar



NEW INSIGHTS



Proposed Data Processing Chain

Measurement Scenario

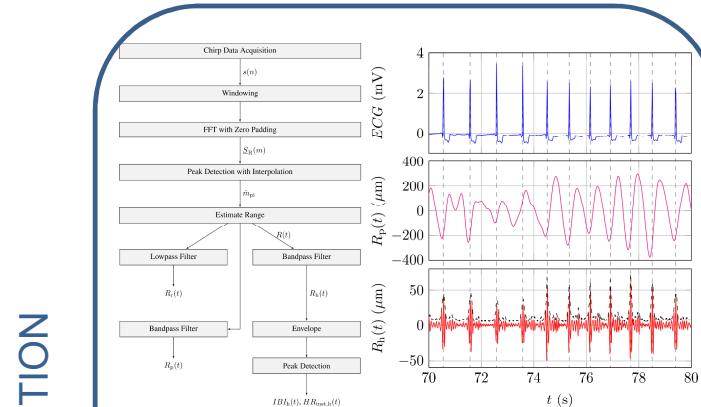
- Person sitting at $R_0 = 0,5$ m and breathing normally

Data Processing

- FFT range estimation with enhanced resolution
- Digital filtering of range signal to extract:
 - respiration
 - pulse wave
 - heart sounds
- Calculate heart rate in a beat-to-beat manner

Reference System (MAX30001EVSYS)

- Respiration: Impedance pneumography (IP)
- Heart rate: Electrocardiography (ECG)



PROPOSED CONCEPT GOALS

QUANTITATIVE IMPACT

- ✓ Results of the instantaneous heart rate

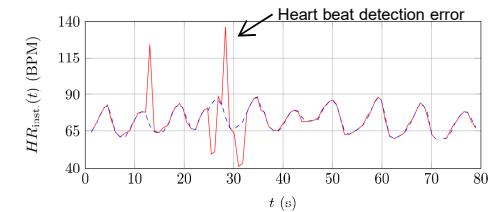


Figure 1: The instantaneous heart rate calculated from (---) the ECG and from (—) the heart sound signal.

- ✓ Comparison with other FMCW systems

Ref.	Frequency	Sample Rate	HR based on	Estimation Time	Accuracy
[1]	120 – 125 GHz	178 Hz	Pulse Wave	3 sec.	90.54%
[2]	119.5 – 125.5 GHz	174 Hz	Pulse Wave	3 sec.	95.62%
[3]	77 – 81 GHz	20 Hz	Pulse Wave	6.4 sec.	80%
This	126 – 182 GHz	500 Hz	Heart Sounds	Beat to Beat	95.7%



Vital Sign Sensing with UWB FMCW Radar:

- First time ever detecting heart sounds with FMCW radar
- High accuracy calculating beat-to-beat heart rates **without** averaging
- extendable to non-stationary targets and MIMO systems for target tracking