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SIGNAL PROCESSING FOR SITUATION AWARENESS & SECURITY

mmWave Radar System-on-Chip for Wireless Vital Sensing

Ph.D. Candidate: ***Ruochen Wu***
Director: ***Antoni Broquetas***

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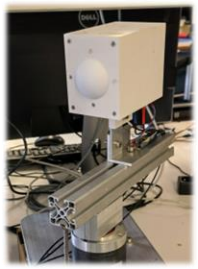
120 GHz mmWave FMCW RSoC
Block Diagram



- The FMCW Radar at 120 GHz senses micrometric motion of the body without contact
- Textiles are transparent at radar frequencies allowing monitoring in all situations

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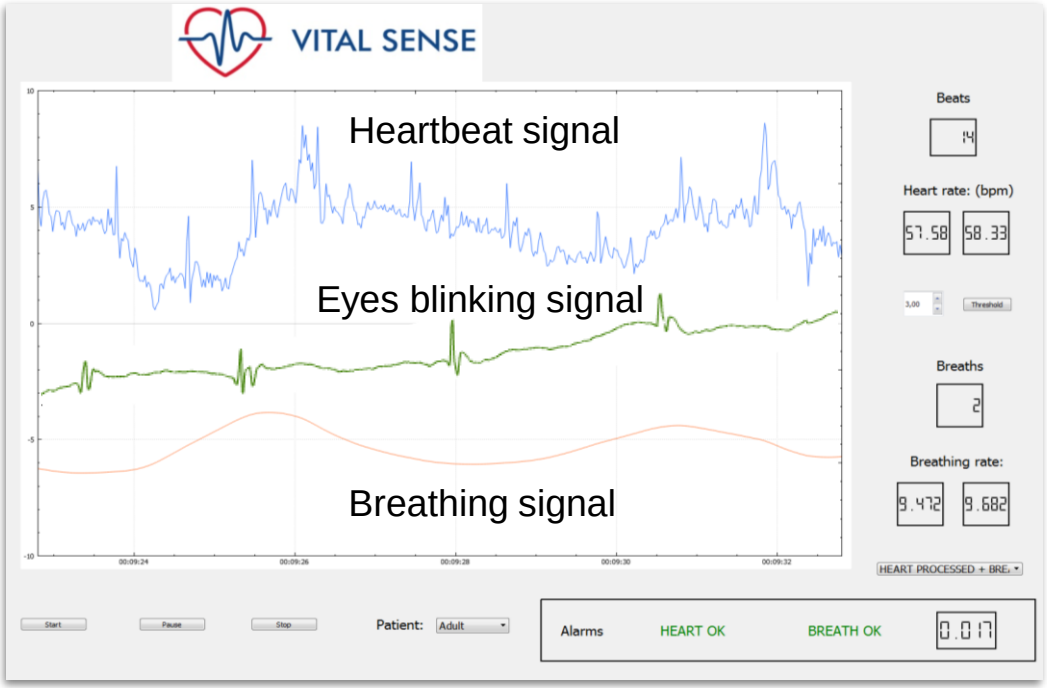
Sensed Vital Signals



Real Time Vital Parameters monitoring with 120GHz Radar

Breathing/hearbeat signals:

$$s(t) = R_0 + A_b \sin(2\pi f_b t) + A_h \sum_{n=0}^{\infty} p_h(t - nT_h) + N$$

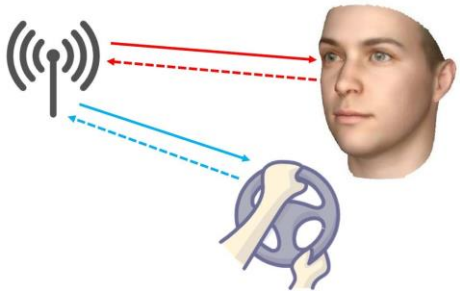
Eyelid signal:

$$s_e(t) = A_e \sum_{n=0}^{\infty} p_e(t - nT_e) + N + A_m M(t)$$

Eyelid detection:

Case 1: Clinical Assignment

Case 2: Driving Behavior



J. Hu et al., "BlinkRadar: Non-Intrusive Driver Eye-Blink Detection with UWB Radar," 2022 IEEE 42nd International Conference on Distributed Computing Systems (ICDCS), Bologna, Italy, 2022.

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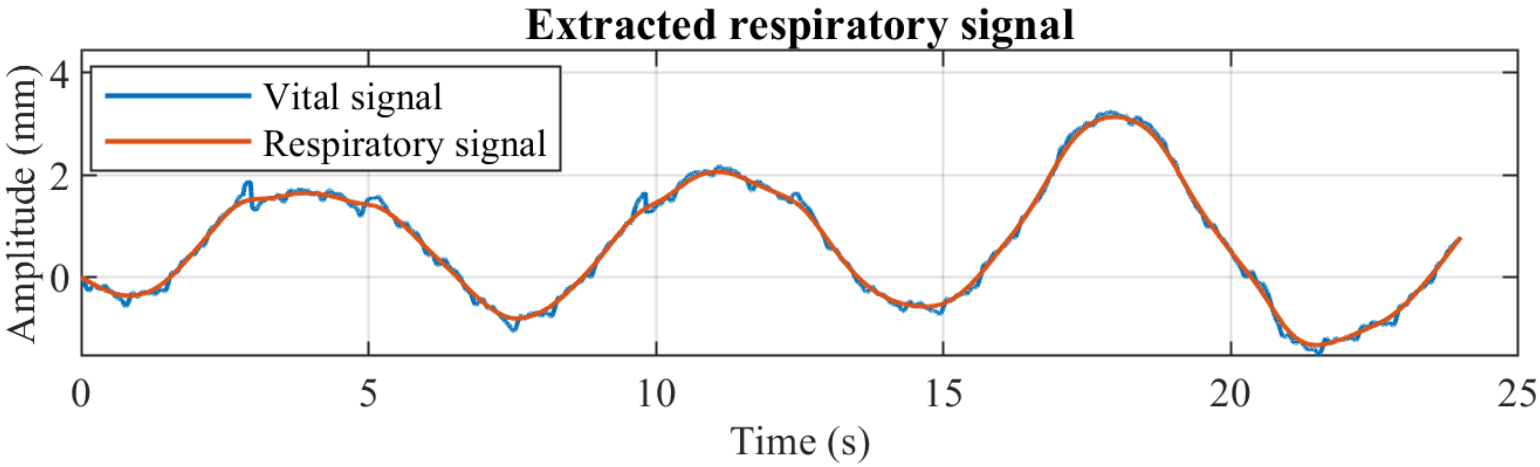
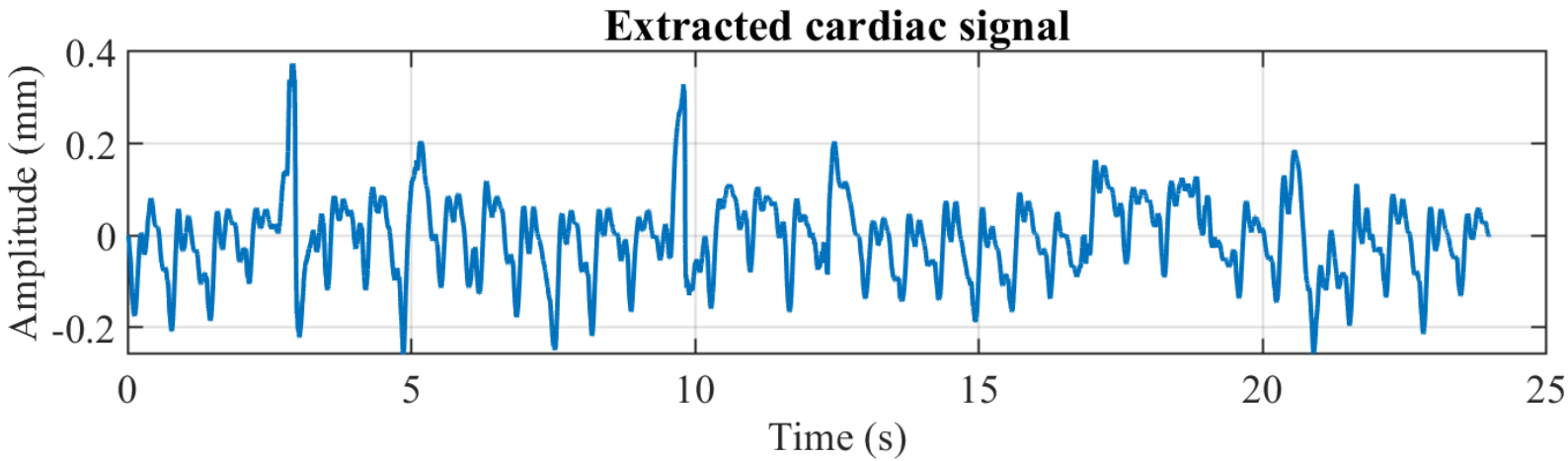
Results (I)
Signal Separation

- Extract breathing signal s_b with FIR linear-phase filter
- Heartbeat signal $s_h = s_{vital} - s_b$





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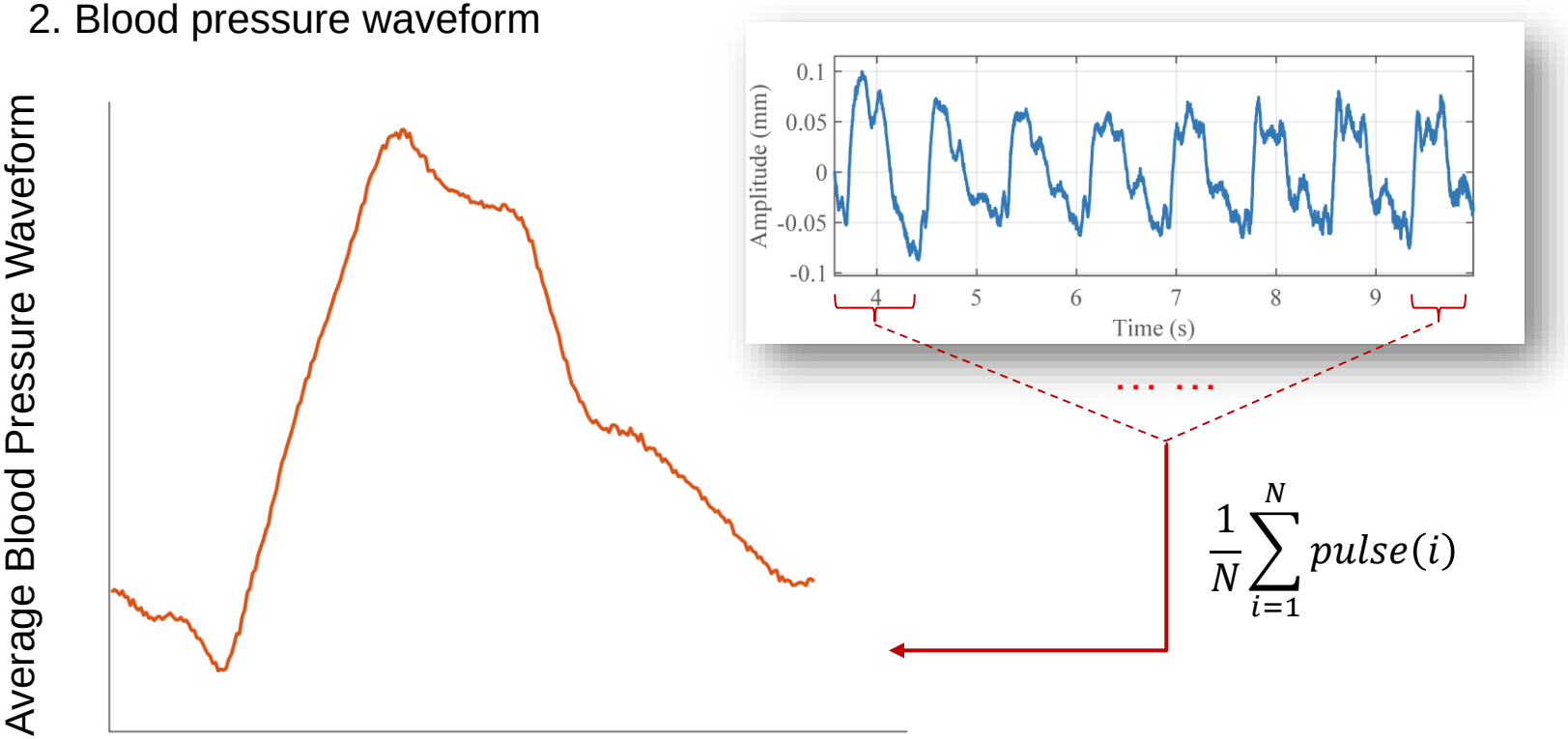
Results (II)

Repetitive Waveform Adaptive Matched Filter

The developed Real-time RWAMF has 3 main components:
Phase A: Iterative pulse period estimation
Phase B: Pulse waveform reconstruction -> Adaptive Matched Filter
Phase C: Final heart waveform parameters extraction

Main Outcomes:
1. Pulse repetition interval, Heartbeat Rate, Detection of abnormalities
2. Blood pressure waveform



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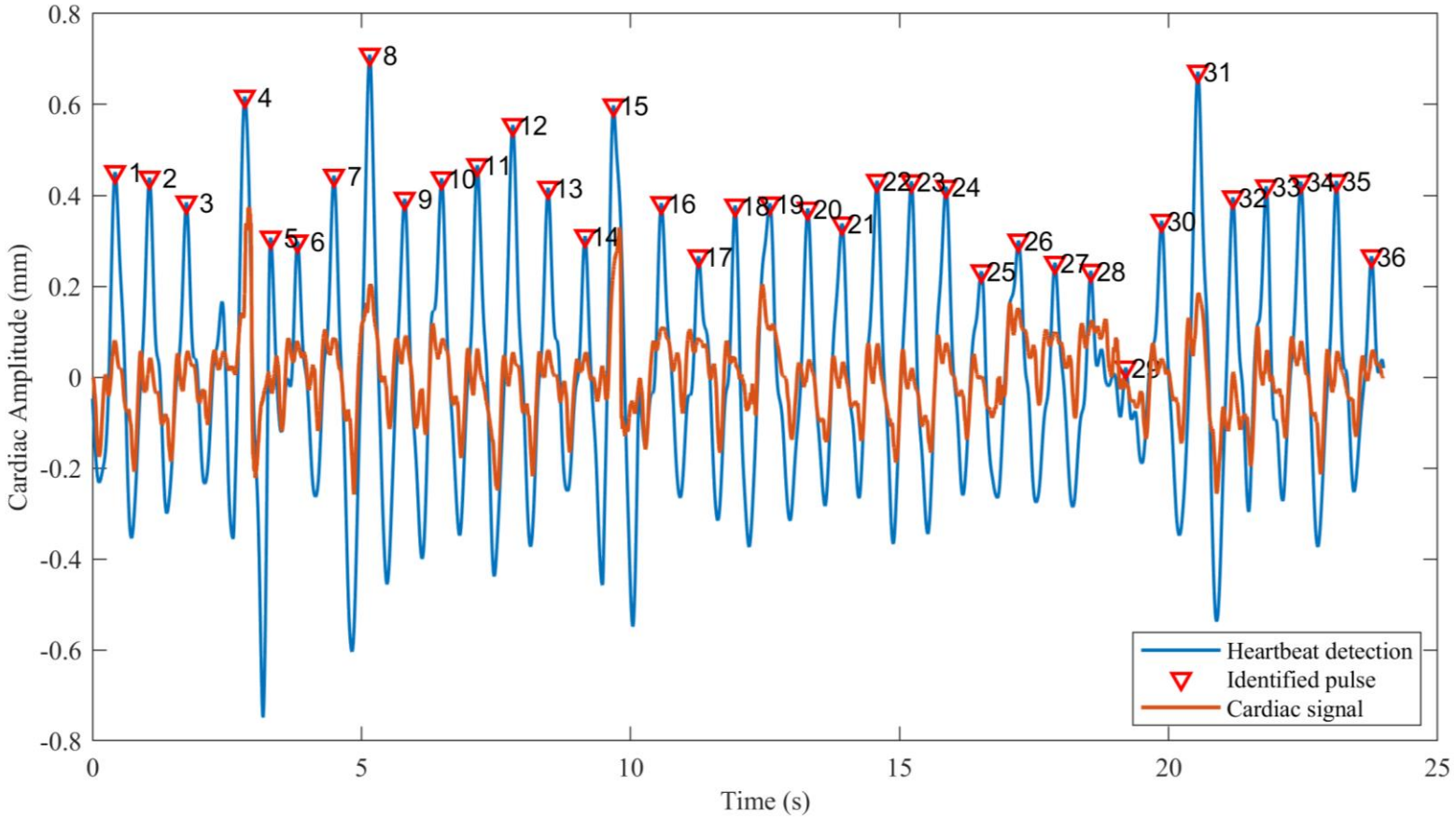
Results (III)
Cardiac Pulse Recognition

Phase C

- Adaptive matched filtering
- Peak and periods estimation $\rightarrow T_d$
- Blood pressure waveform reconstruction



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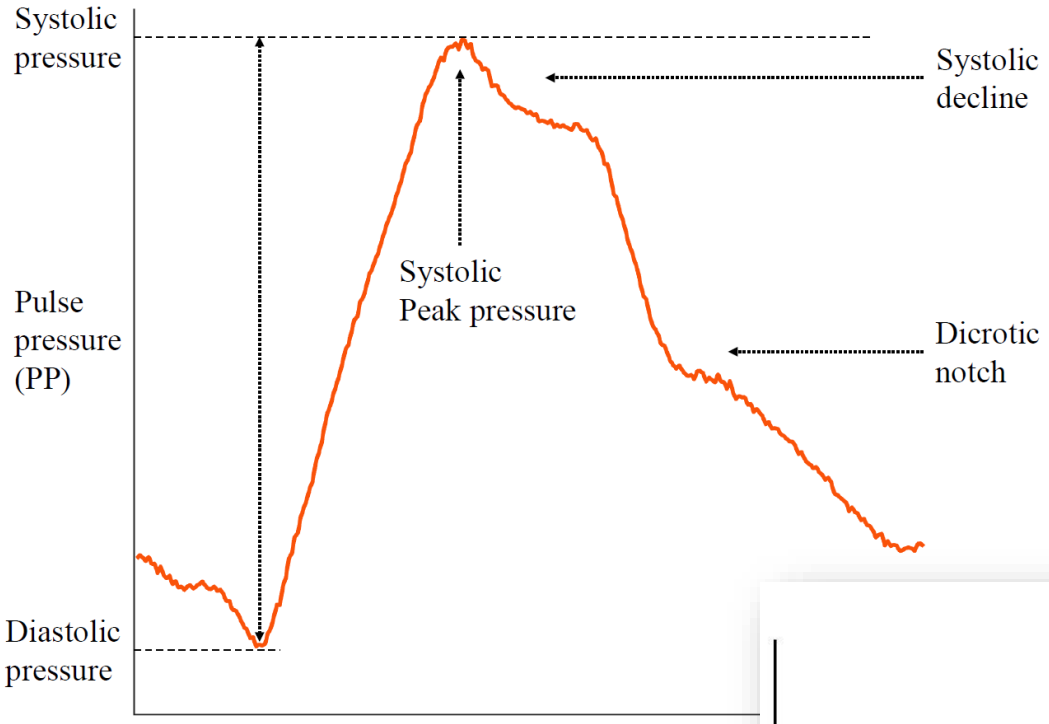
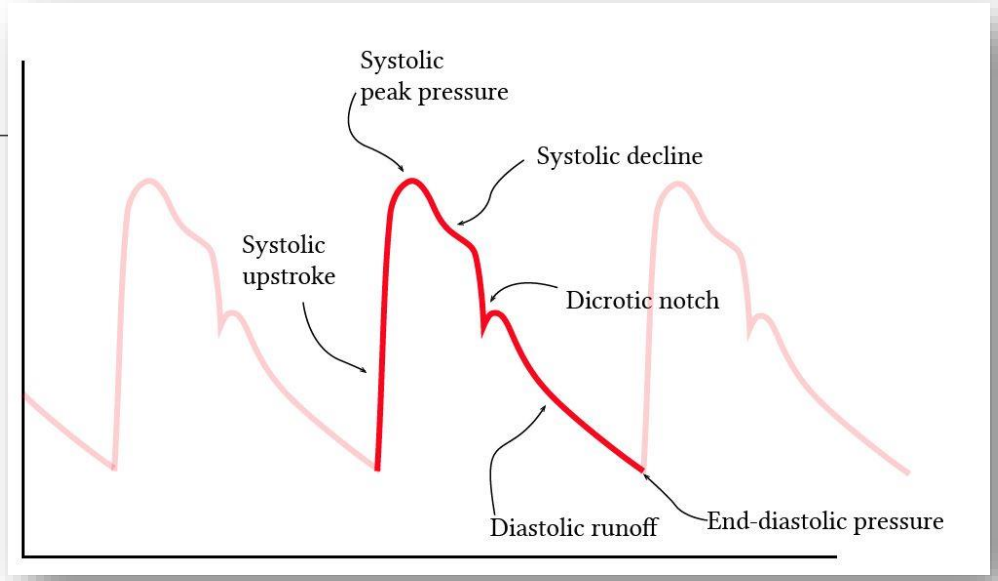
Results (IV)
Blood Pressure Waveform Extraction



Theoretical Blood Pressure Waveform (typically detected by a contact sensor)

Radar signal based extracted Blood Pressure Waveform



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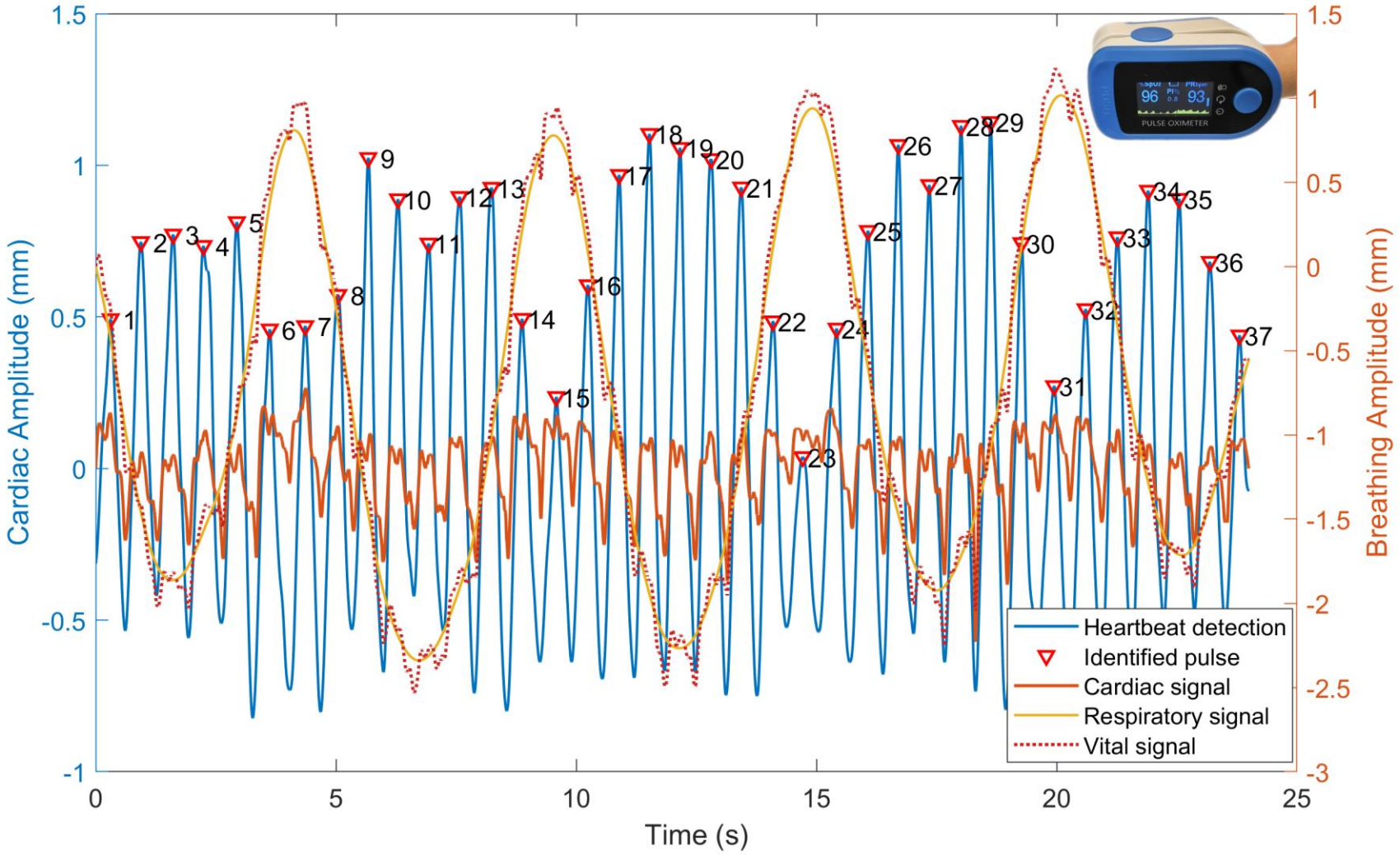
Overall Result (I)
with oximeter



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Overall Result (II)
with ECG signal