



SIGNAL PROCESSING FOR SITUATION AWARENESS & SECURITY

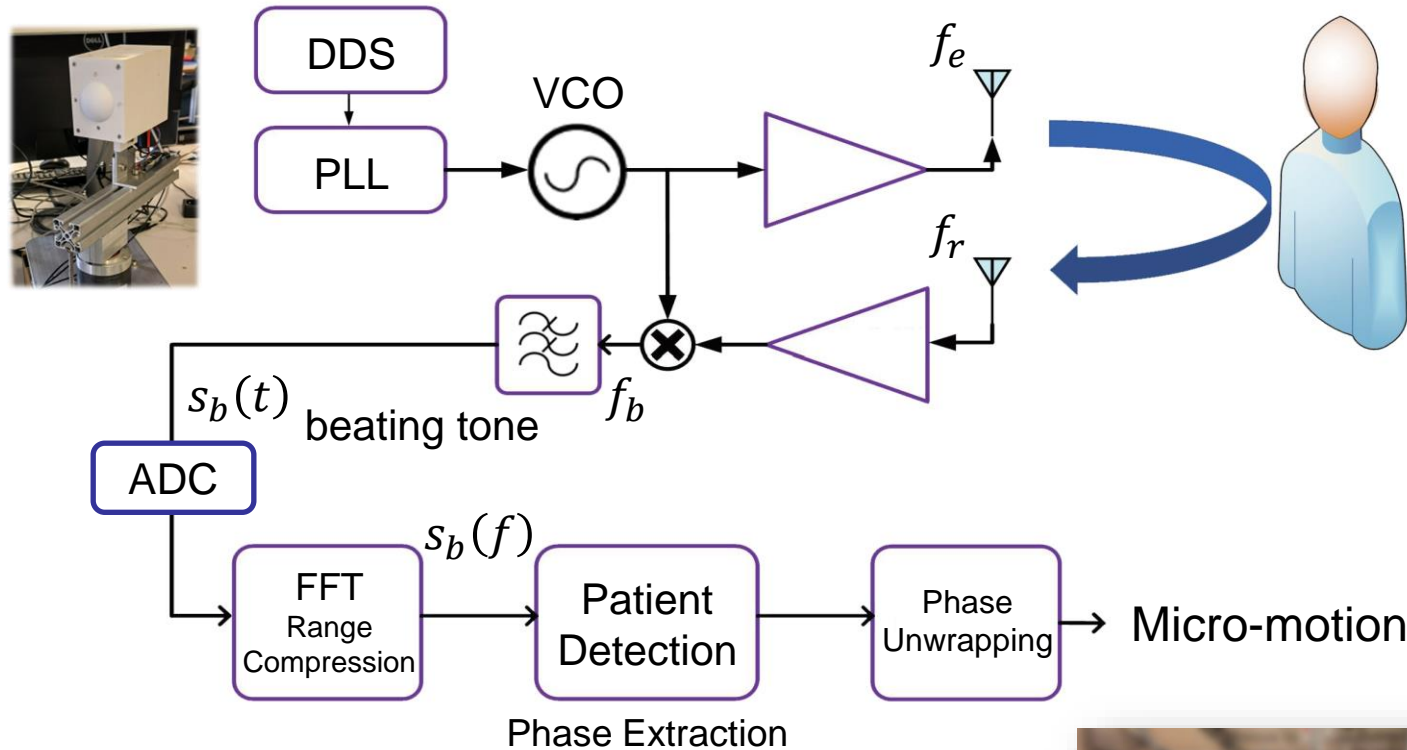
mmWave Radar System-on-Chip for Wireless Vital Sensing

*Ph.D. Candidate: **Ruochen Wu***

*Director: **Antoni Broquetas***



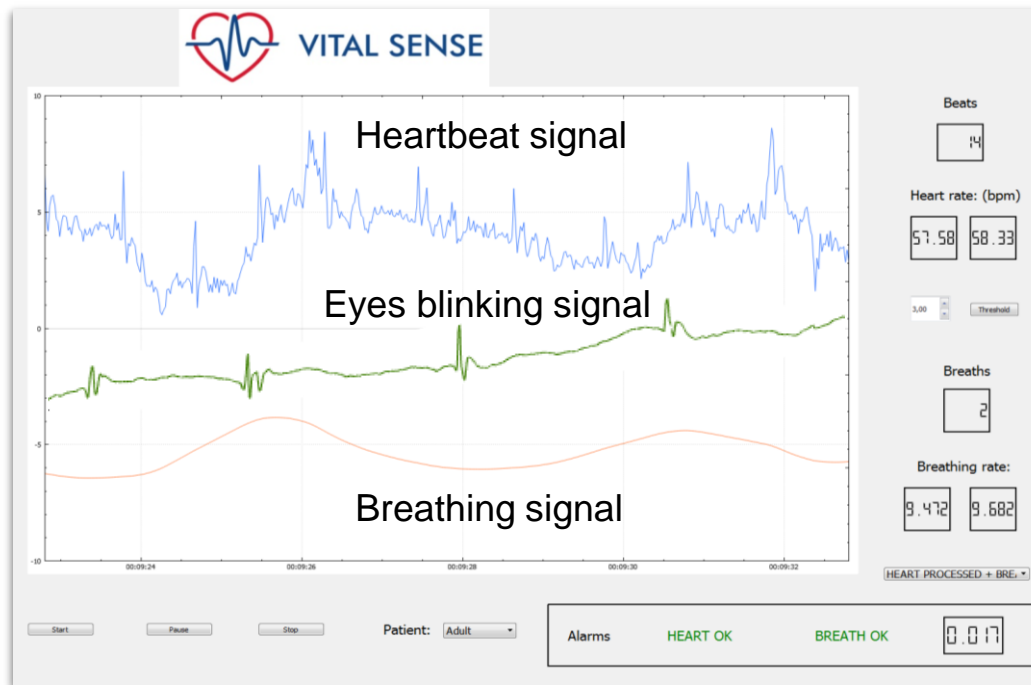
120 GHz mmWave FMCW RSoC Block Diagram



- 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

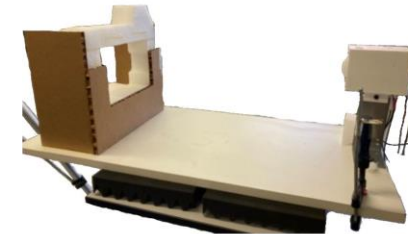


Sensed Vital Signals

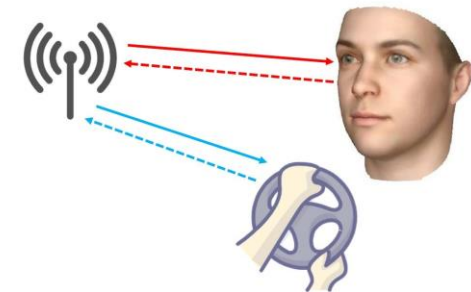


Real Time Vital Parameters monitoring with 120GHz Radar

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.

Breathing/heartbeat 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:

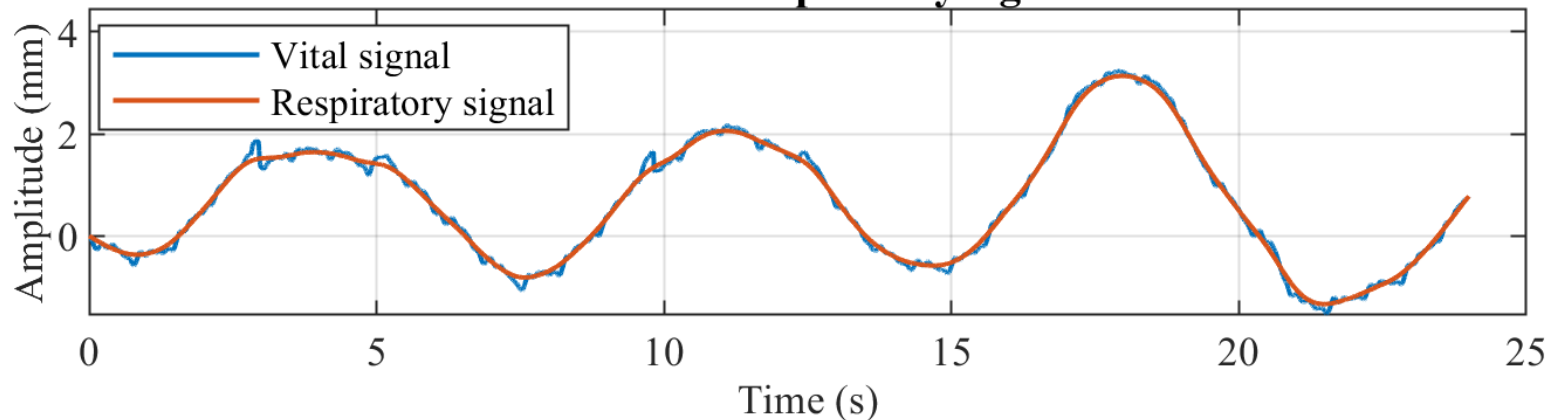
$$s_e(t) = A_e \sum_{n=0}^{\infty} p_e(t - nT_e) + N + A_m M(t)$$

Results (I)

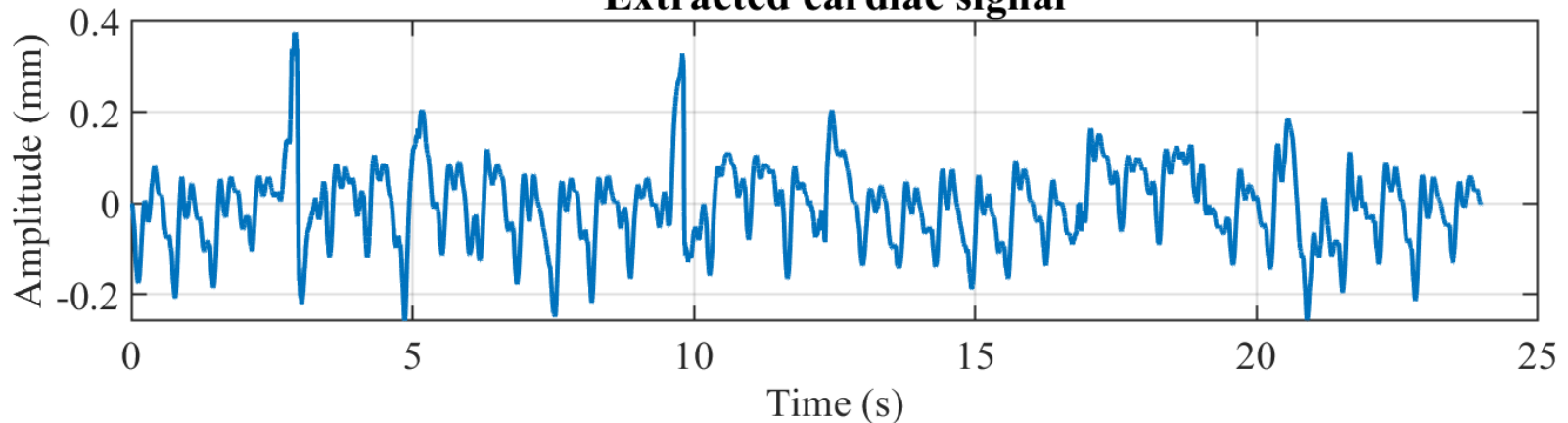
Signal Separation

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

Extracted respiratory signal



Extracted cardiac signal



Repetitive Waveform Adaptive Matched Filter

The developed Real-time RWAMF has 3 main components:

Phase A: Iterative pulse period estimation

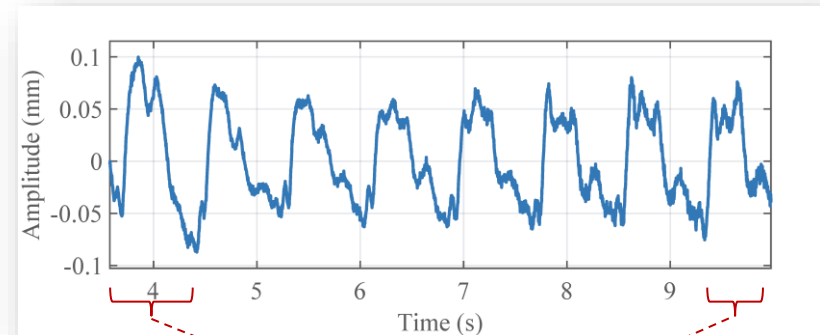
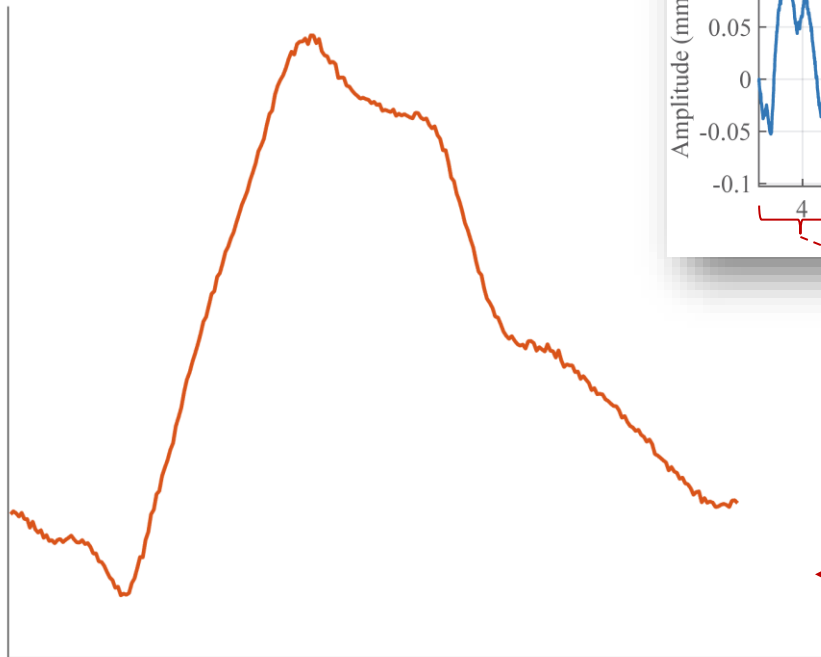
Phase B: Pulse waveform reconstruction -> Adaptive Matched Filter

Phase C: Final heart waveform parameters extraction

Main Outcomes:

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

Average Blood Pressure Waveform



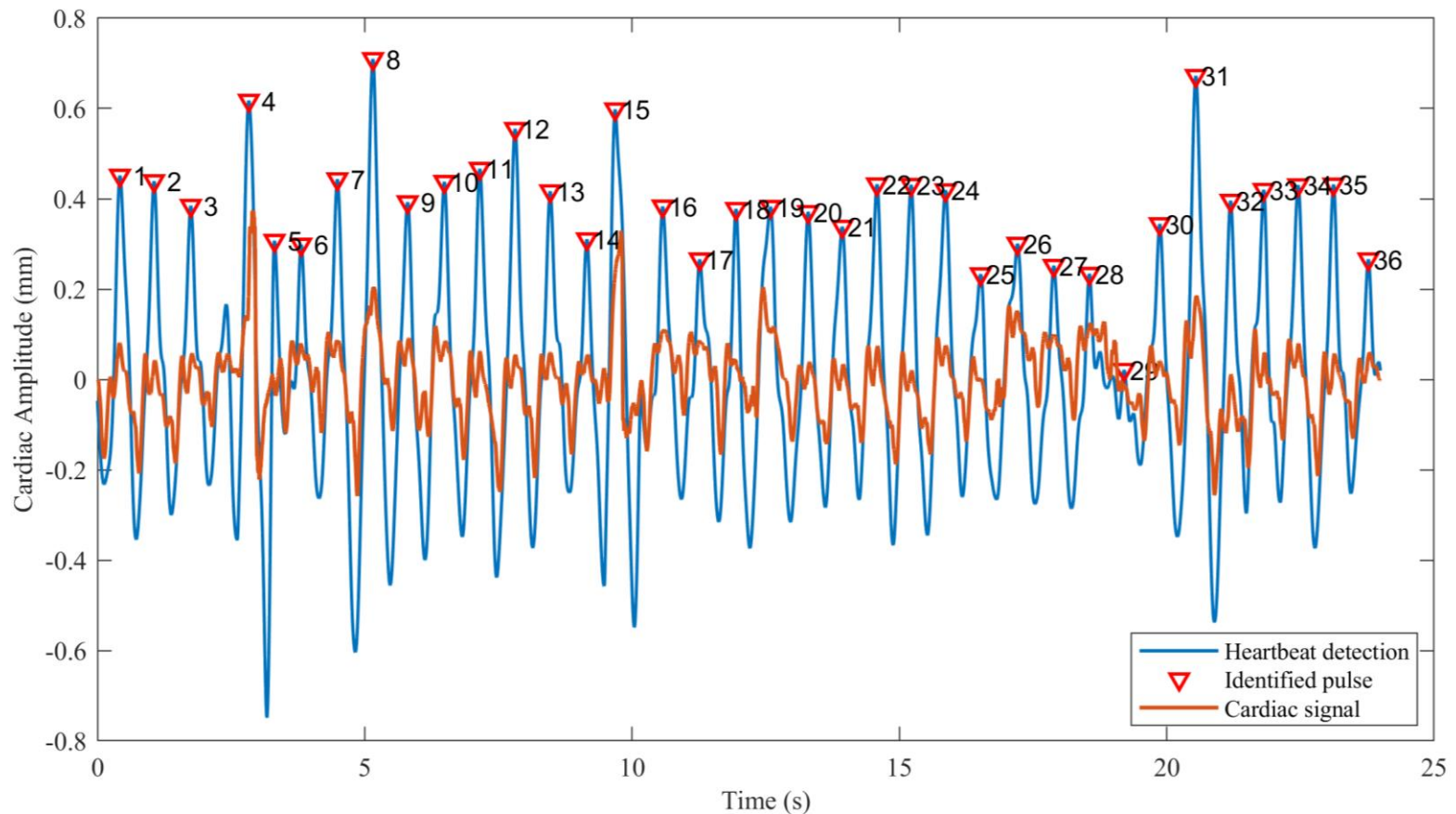
$$\frac{1}{N} \sum_{i=1}^N pulse(i)$$

Results (III)

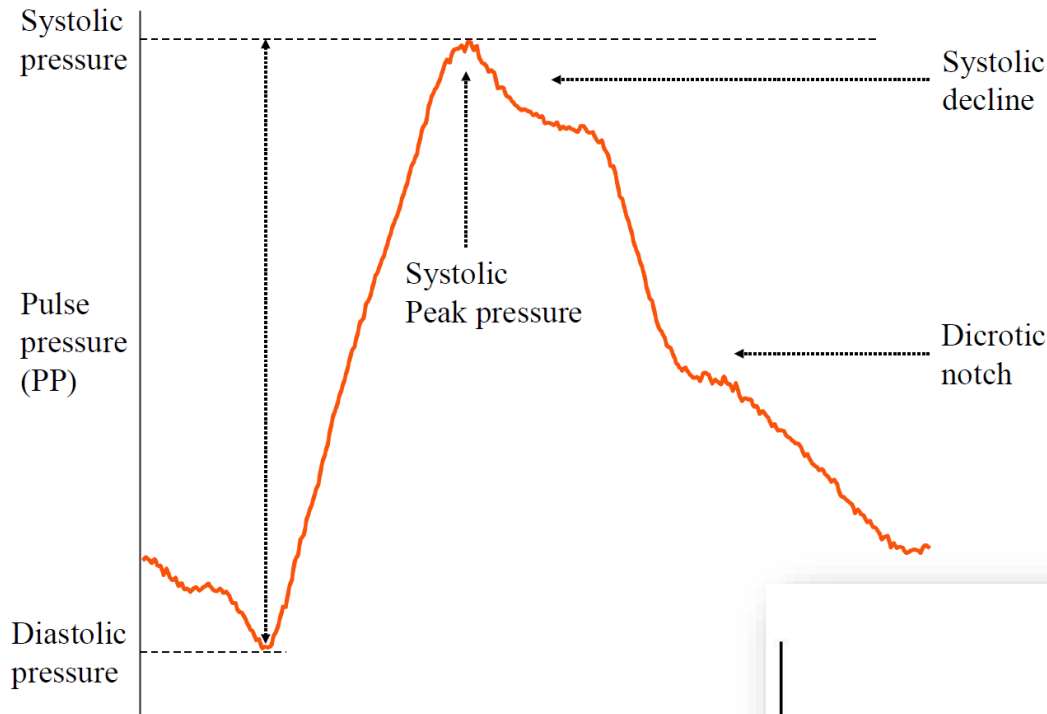
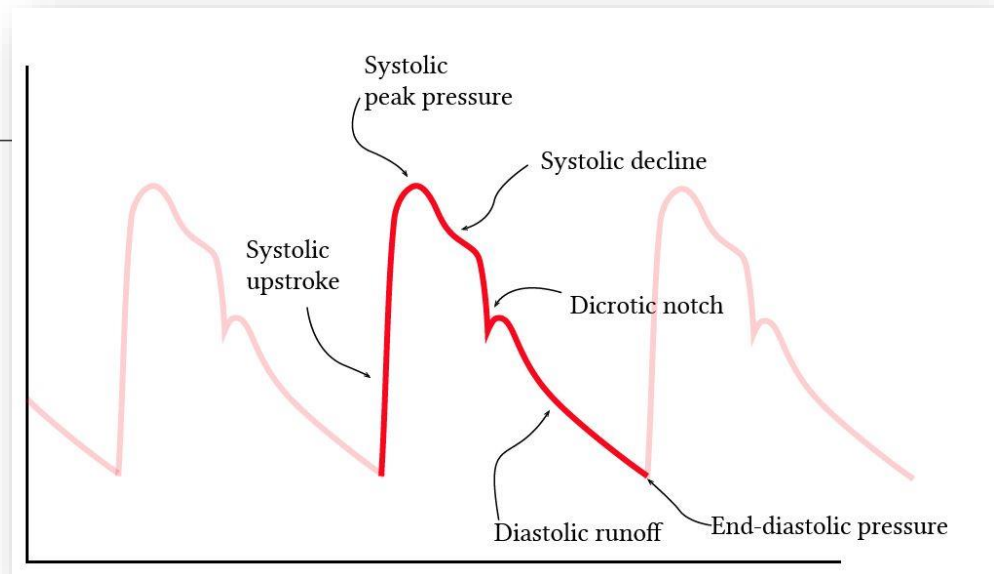
Cardiac Pulse Recognition

Phase C

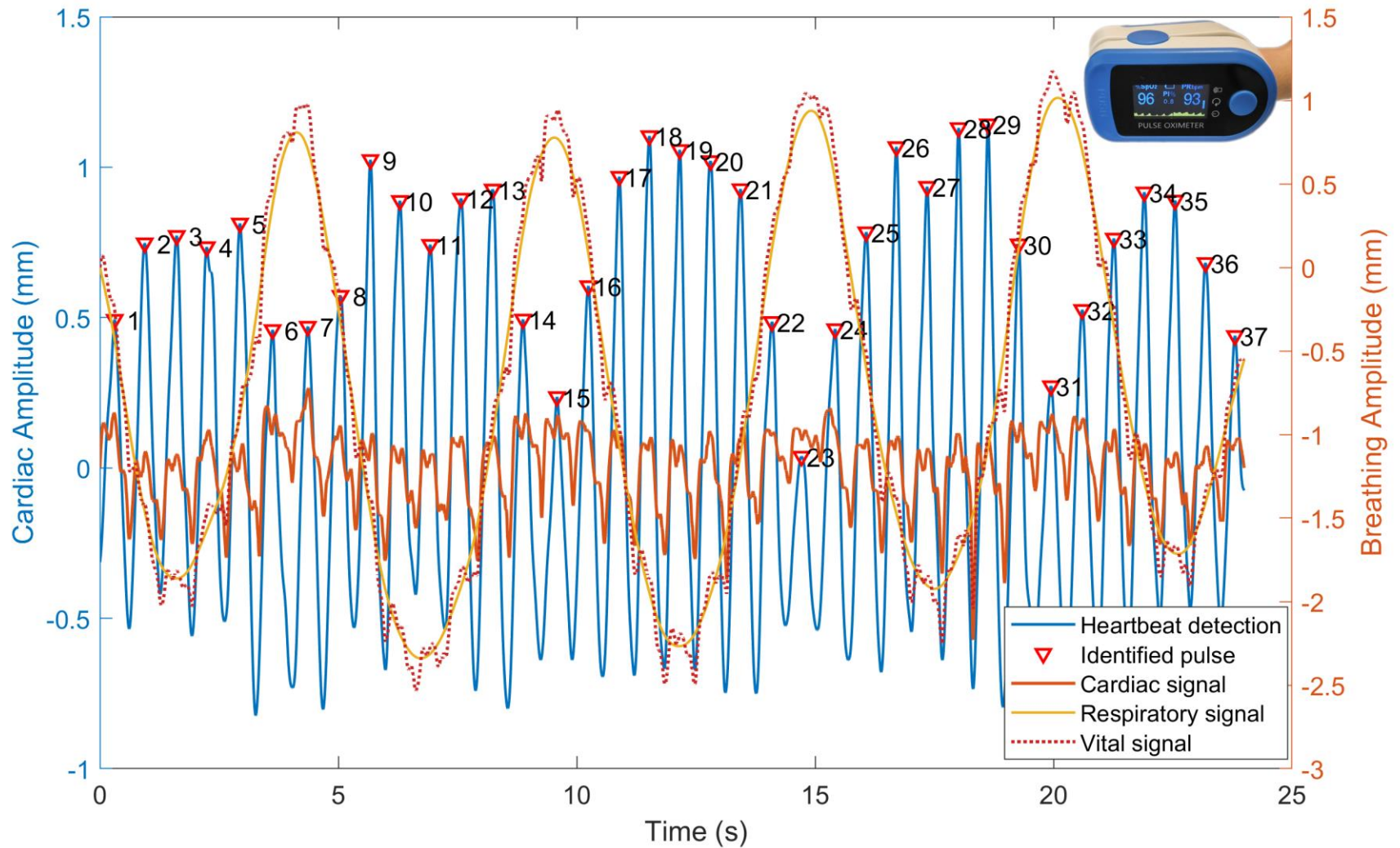
- Adaptive matched filtering
- Peak and periods estimation $\rightarrow T_d$
- Blood pressure waveform reconstruction



Blood Pressure Waveform Extraction

Blood Pressure Waveform
from contact sensorRadar signal based extracted
Blood Pressure Waveform

Overall Result (I) with oximeter



Overall Result (II) with ECG signal

