



Research on Key Technologies of THz Radar Information Processing for Situation Awareness *A Case of Biomedical Application*

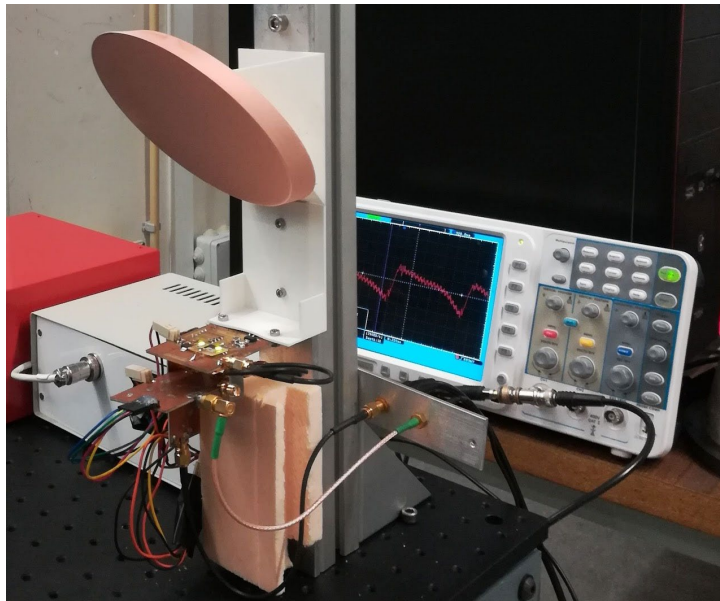
Student: Ruochen Wu

Supervisor: Antoni Broquetas Ibars

Co-supervisor: Jordi J. Mallorqui Franquet

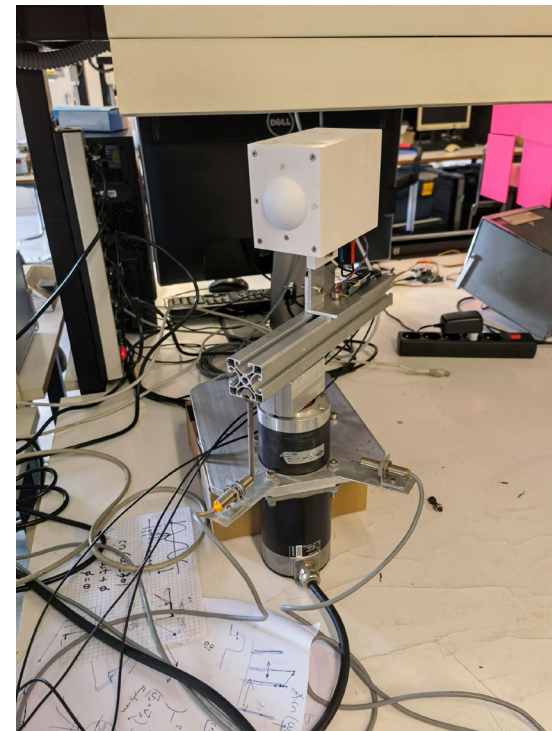


Doppler radar for measuring vital signs has been a research topic in recent years. The noncontact radar method requires neither internal nor external surrogates, but it can provide reliable respiration and heart-beat measurements.



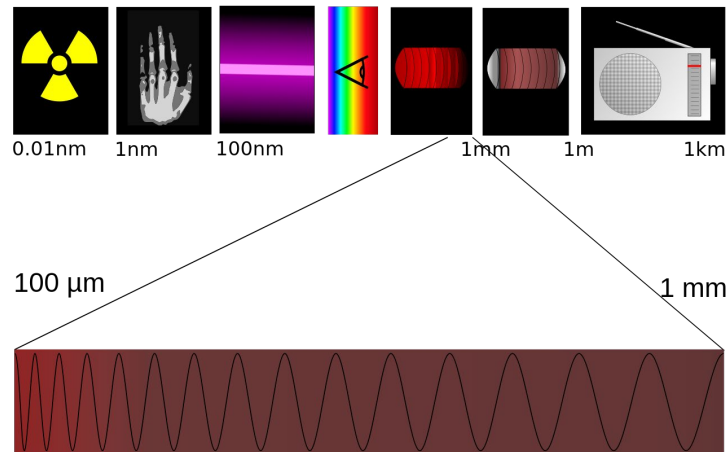
First prototype of Biomedical Radar

(<https://ars.upc.edu/projects/radar-for-medical-applications>)



Prototype of 120GHz radar

Terahertz (THz)

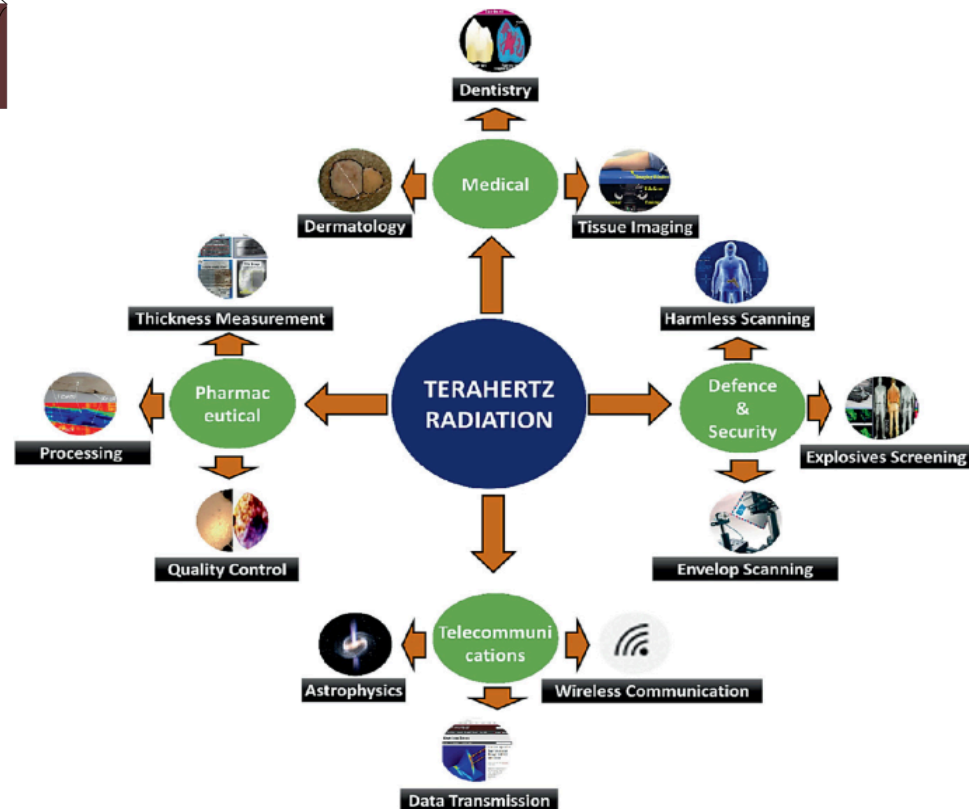


Band range: 0.1mm ~ 1mm
Frequency range:
0.1THz ~ 10THz

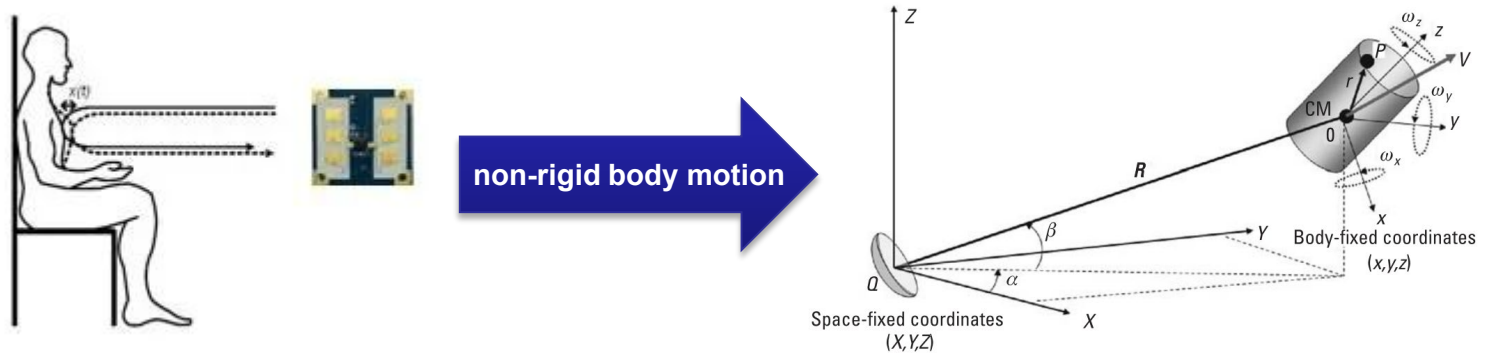
Characteristics:

- 24/7 observation
- Suitable for all weather conditions
- Short wavelength, large bandwidth
- Strong Doppler resolution
- No ionizing effect on irradiated organisms

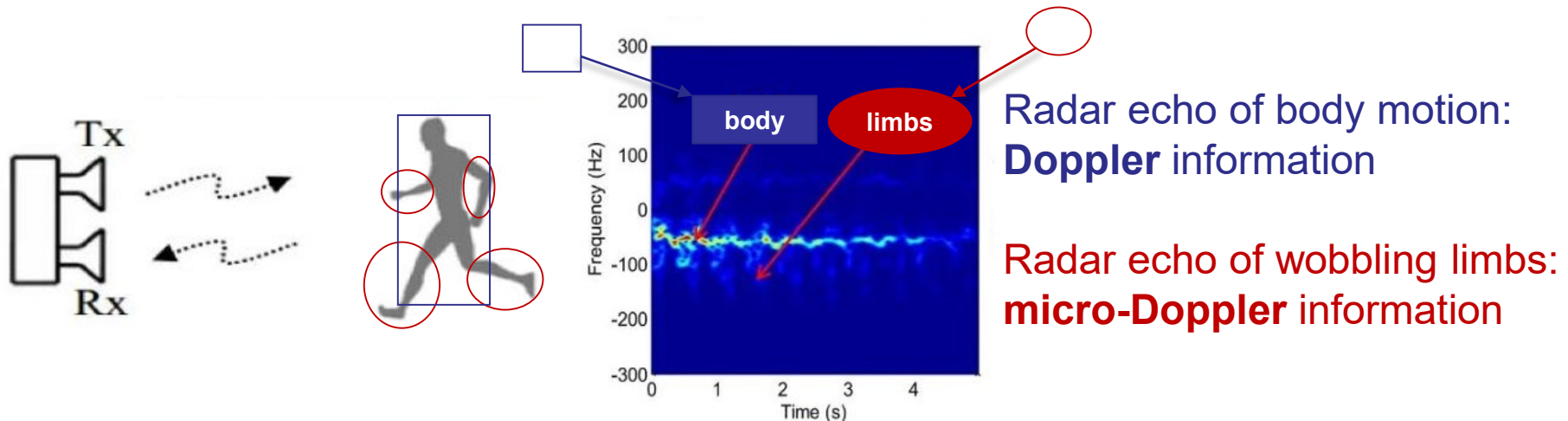
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Micro-Doppler (I)



- Doppler effect: Doppler frequency shift occurs when there is relative motion between the radar and the target
- Micro-motion: other tiny movements of the target itself



Micro-Doppler (II)



Victor C. Chen

- Rigid body
 - Human – body
 - Helicopter – propeller
 - Pendulum
 - ...
- Non-rigid body
 - Human – limbs, vital sign...
 - ...

The relative motion between the human body and the radar will produce a small radial motion, so that the radar echo contains Doppler information that characterizes the motion, which is the micro-Doppler effect.

Different targets will cause different micro-motion modulations that result in the radar echo due to their own physical properties.

Vital Signal Analysis

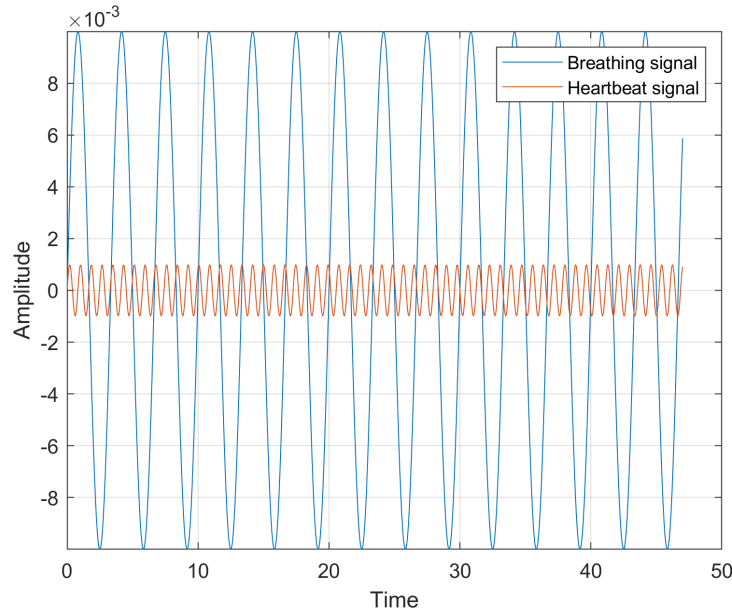
Modeling and Simulation (I)

$$f(t) = R_0 + \overbrace{A_r \sin(2\pi f_r t)}^{\text{respiration signal}} + \overbrace{A_h \sin(2\pi f_h t)}^{\text{heartbeat signal}} + \underbrace{N(0, \sigma^2)}_{\text{Gaussian noise}}$$

- R_0 → Distance between the human body and the radar
- A → Amplitude
- f → Frequency
- t → Pulse repetition interval

Vital Signal Analysis

Modeling and Simulation (II)



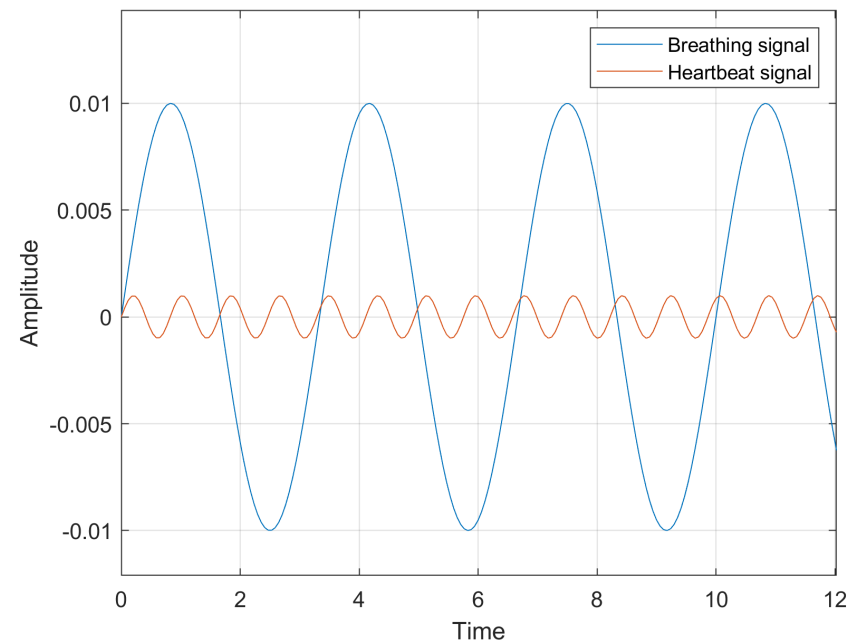
(a) Ideal vital signal model

```
% breath/heartbeat number per min
r=18;
h=73;

% amplitude(m)
ar=0.01;
ah=0.001;
```

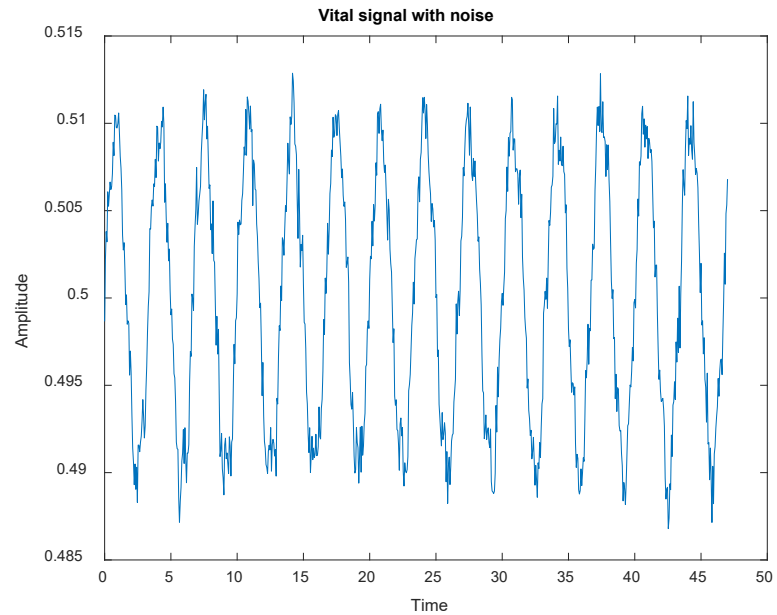
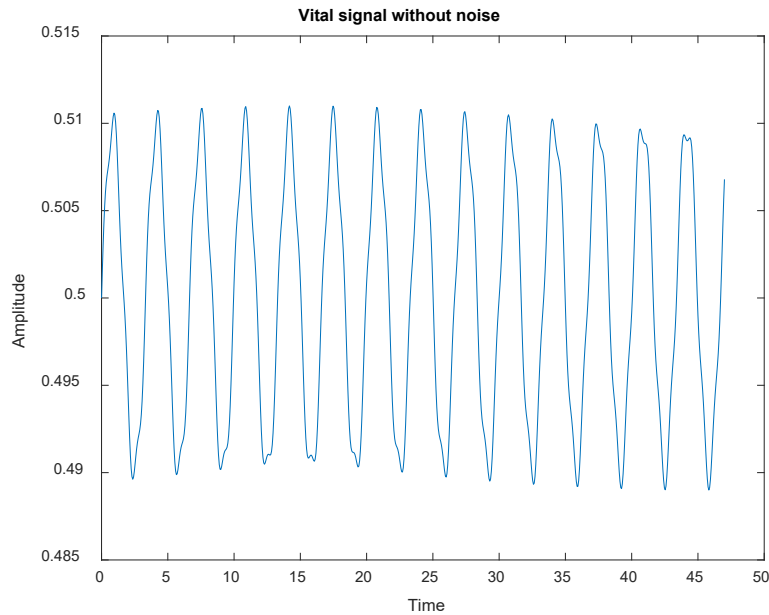
Fig. (a) shows an overlay of the heartbeat and breathing signals, and the zoom part is shown in Fig. (b).

(b) Zoom of ideal vital signal



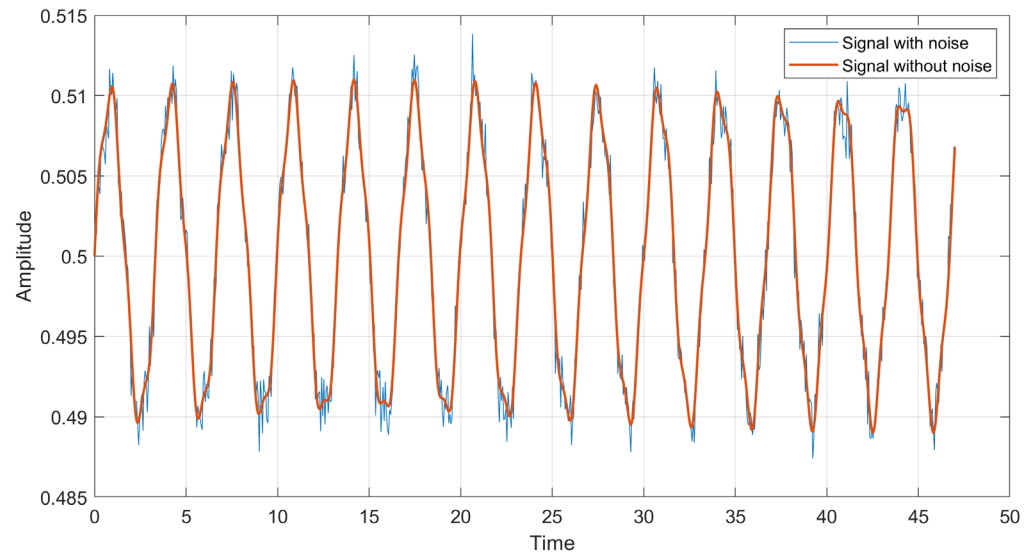
Vital Signal Analysis

Modeling and Simulation (III)



```
% distance(m)
R0=0.5;

% noise(dB)
SNR=60;
```



■ Time-frequency Analysis

- Target echo signal processing
- Extraction of the micro-motion time-varying frequency in the target echo
- Extraction of the superimposed micro-motion signal components

■ Empirical Mode Decomposition (EMD)

- Decomposition of the frequency modulation mode of the features signal into different modulation modes

■ Artificial Neural Network (ANN/NN)

- Based on signal sample data
- Neurons - Correlation of signal samples: included in the network structure
- Data normalization, denoising, numbering, training, and classification

■ Support Vector Machine (SVM)

- Find the optimal hyperplane for binary classification
- NO require a large amount of training data
- Identification of the signal modulation mode
- High signal classification and recognition rates

- Key technologies of THz radar information processing
 - Effect of micro-Doppler
 - Micro-motion target detection and recognition
 - Signal processing for situation awareness
 - Human vital signals processing
- Radar target detection and multi-type information processing technology
- Micro-motion target detection and non-communication signal analysis for situation awareness
- Application of techniques and algorithms in other fields

References

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