STAR

SYSTEM FOR TRACKING ANIMALS USING RADAR

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Illegal poaching and trafficking

Current methods to track animals in the wild

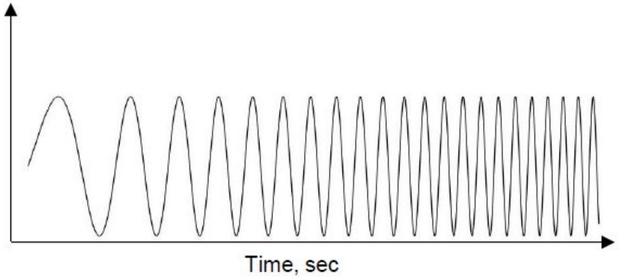
Why do we need vital signs?

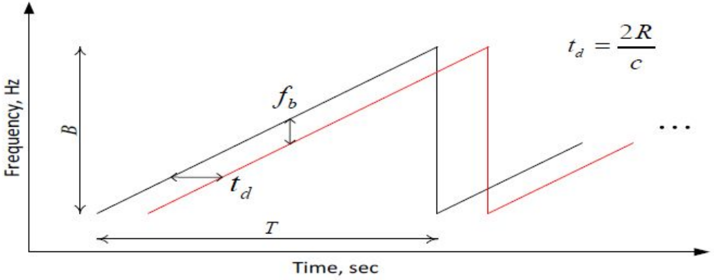
What do we need?
How do we engineer it?

We need a solution which must not require being implanted onto animals. It must measure important vital signs instantaneously and the accuracy must be as high as possible.

FMCW Technology

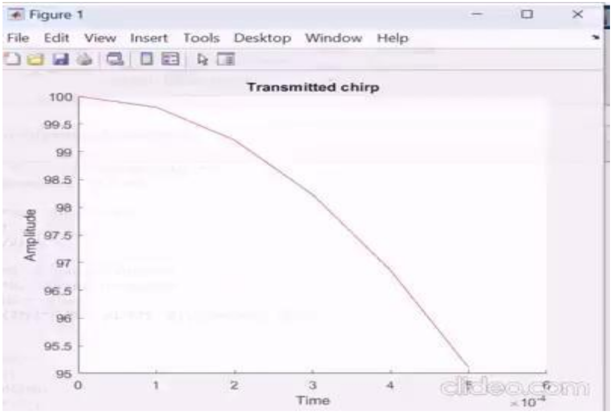
Periodic linearly-increasing frequency chirps (known as Frequency-Modulated Continuous Wave (FMCW)) are transmitted by radar towards the object.

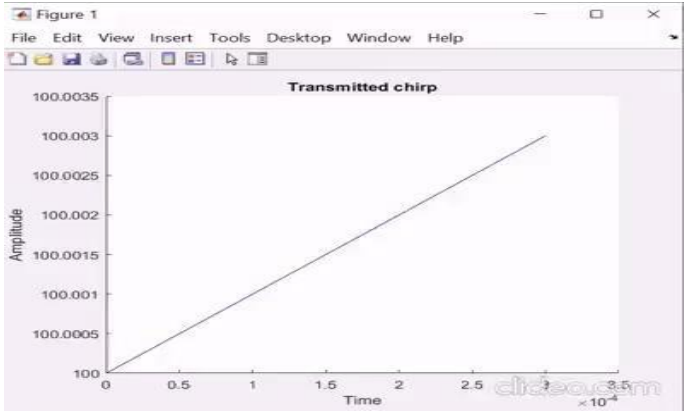




$$s(t) = e^{j\left(2\pi f_c t + \pi \frac{B}{T} t^2\right)}$$

sent wave

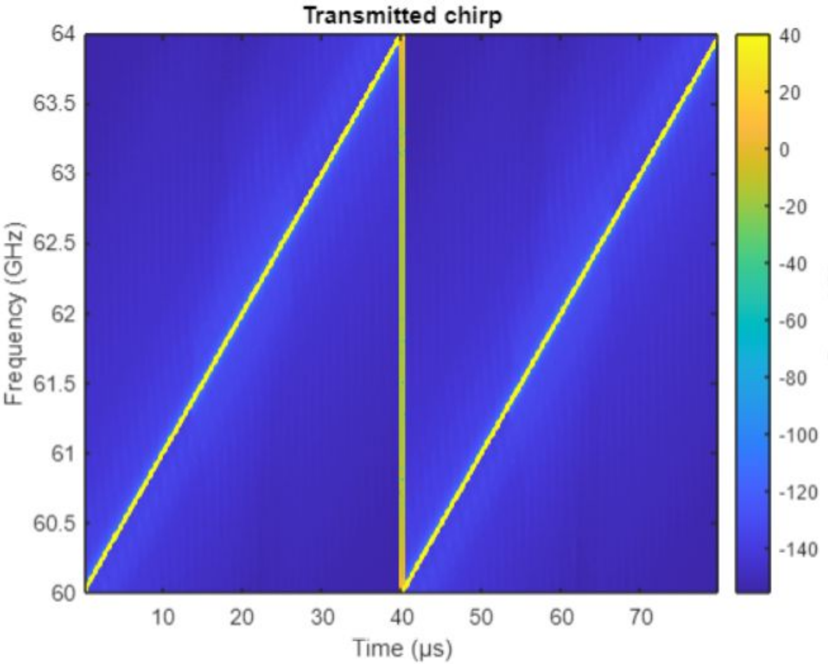


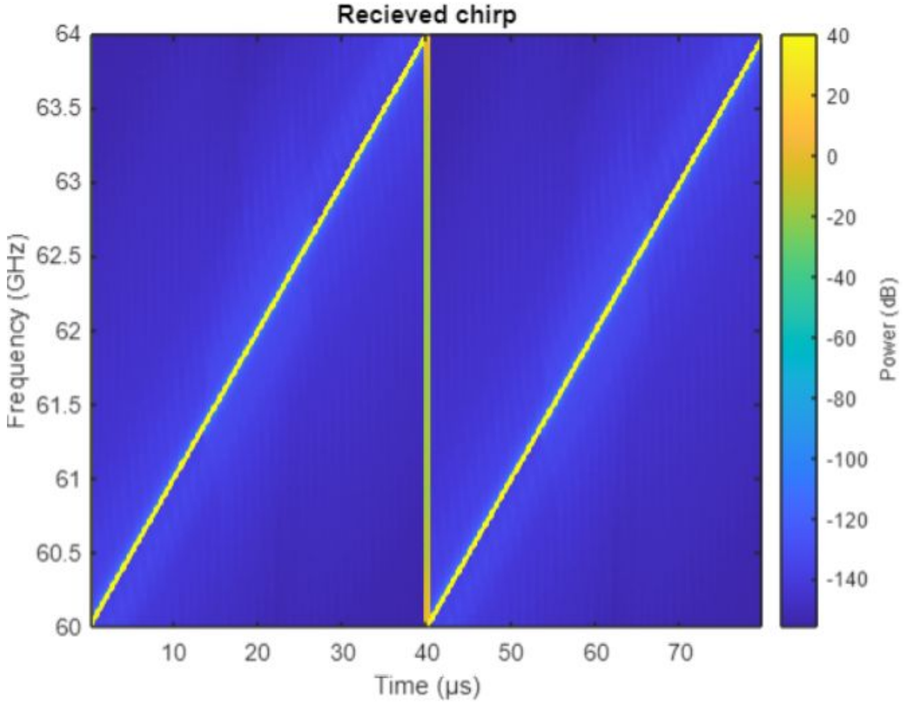


Stepwise Process of using FMCW radar

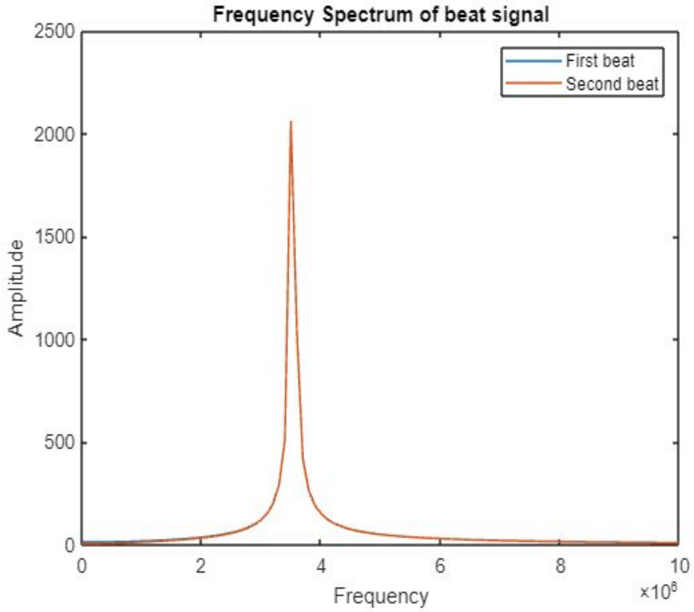
Sending FMCW signals	Phase change due to reflection & Noise from the environment	Capturing the signal and processing it
The radar emits frequency modulated waves, which follows a certain rule, into the surroundings.	Due to the position and velocity of the body/bodies a time delay and some noise is added to the sent singal. Moreover some energy is lost to the surroundings and amplitude is greatly reduced	Various transformations like amplification, ADC, mixing, etc are then applied over the signal received. The information of heartbeat and respiration rate are also embedded in this.

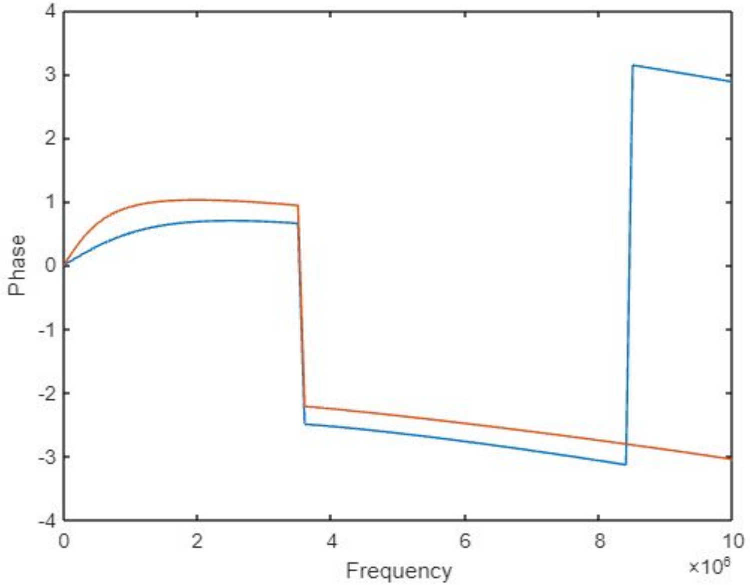
Range and Velocity Estimation of a Single Body



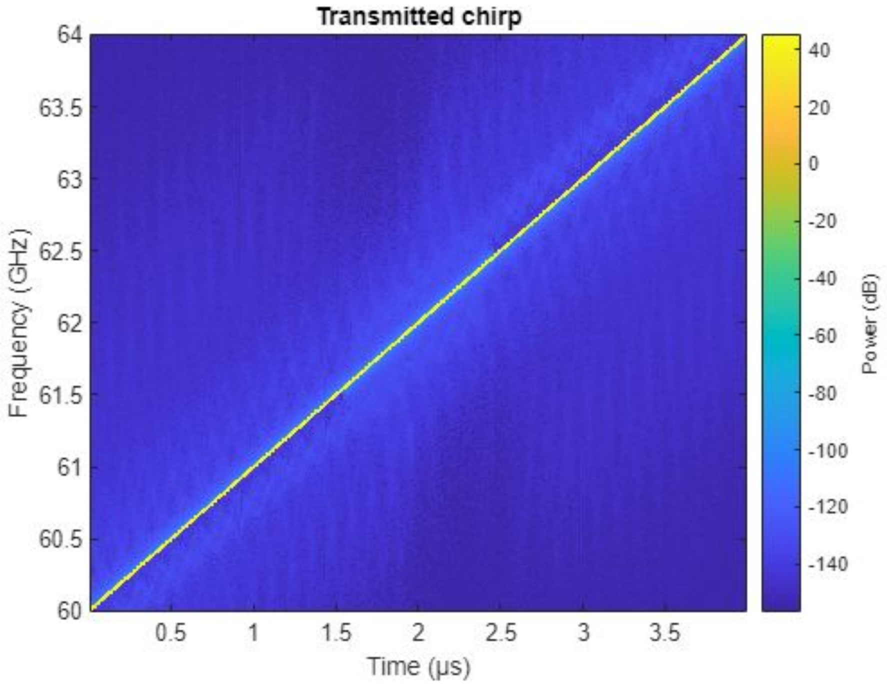


Range and Velocity Estimation of a Single Body

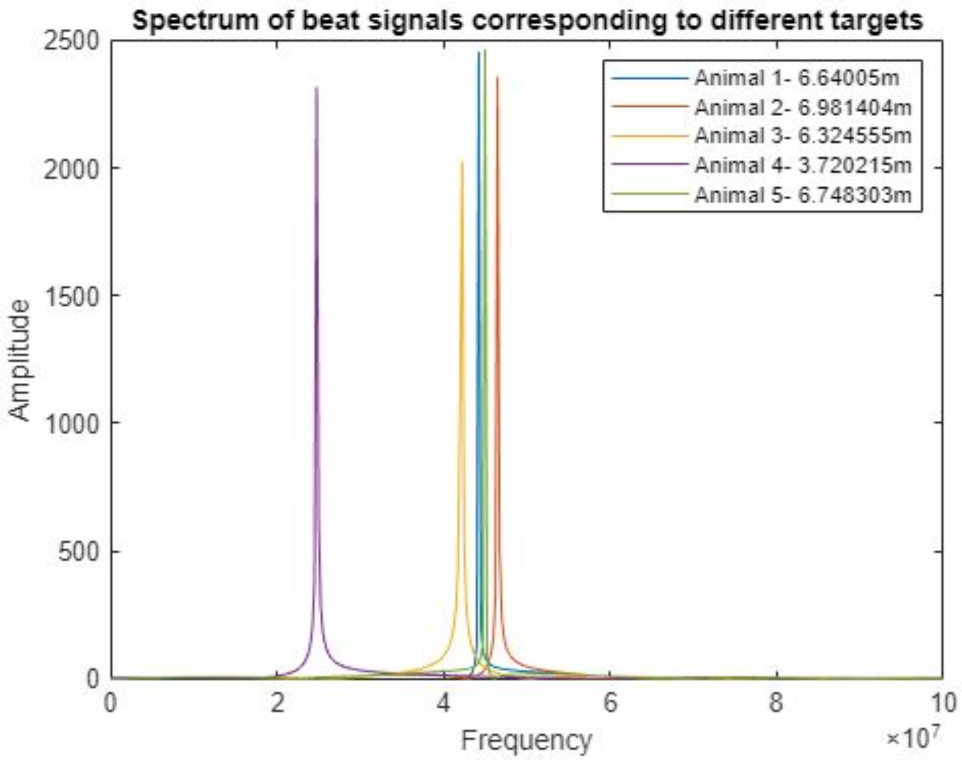


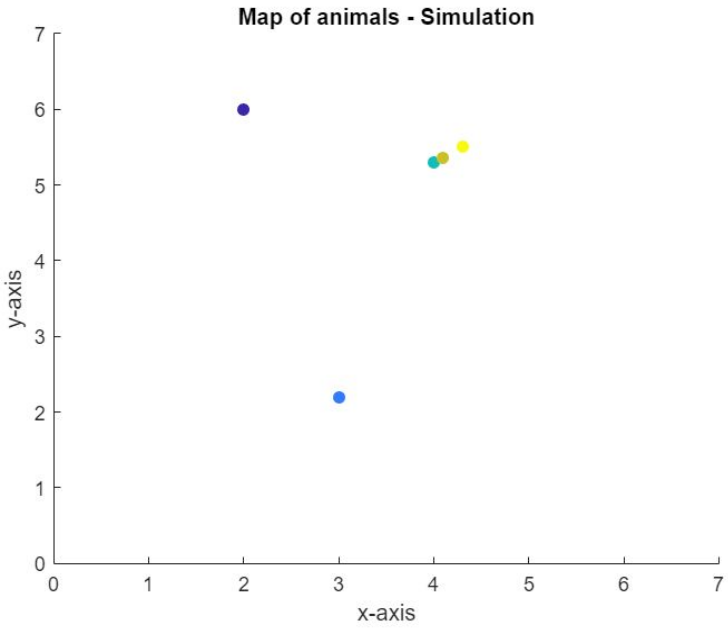


Range and Velocity Estimation of Multiple Bodies



Range and Velocity Estimation of Multiple Bodies





The principle behind measuring vital signs

Heartbeat and respiration rates are very small movements occurring in a body. To measure small scale vibrations/displacements, we measure the change in phase of the FMCW signal with time at the target range bin

$$\Delta\phi_b = \frac{4\pi}{\lambda}\Delta R$$

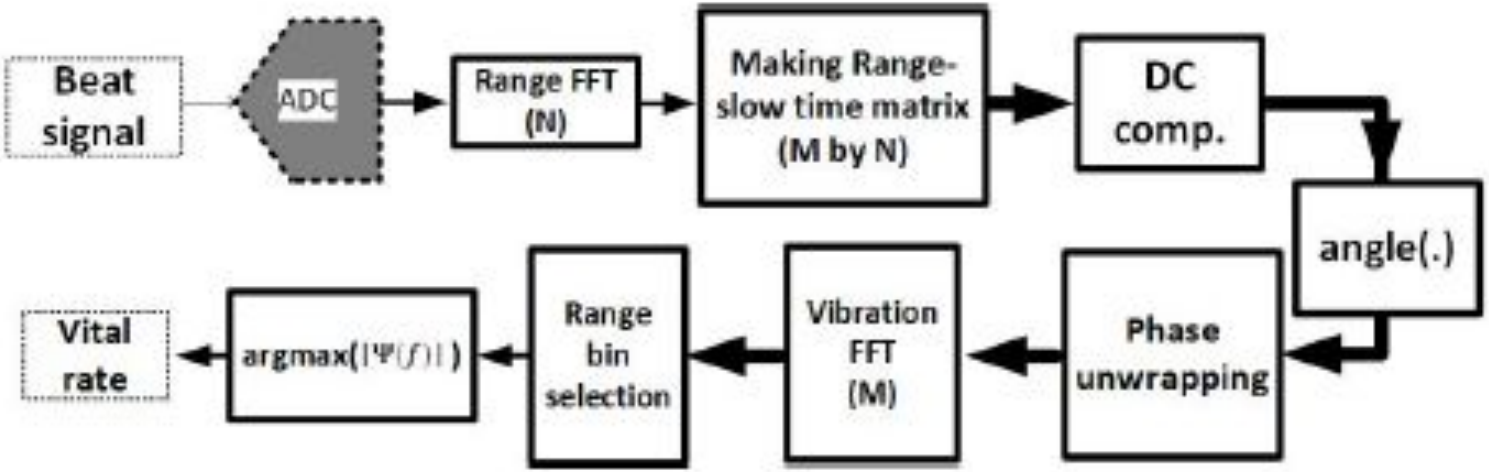
- $\Delta\phi_b$ corresponds to the change in phase when the target moves a distance ΔR
- Note that a smaller wavelength λ will give better displacement sensitivity

Note that we are assuming that the vibrations *x(t)* are small so that the object remains in the same range-bin during the duration of the measurements

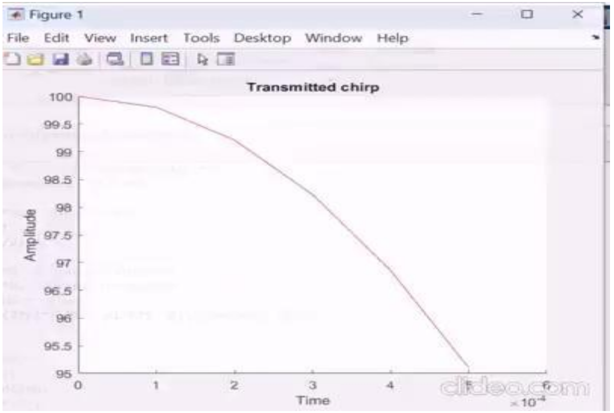
		From Front	From Back
Vital Signs	**Frequency**	**Amplitude**	**Amplitude**
Breathing Rate (Adults)	0.1 – 0.5 Hz	~ 1- 12 mm	~ 0.1 – 0.5 mm
Heart Rate (Adults)	0.8 – 2.0 Hz	~ 0.1 – 0.5 mm	~ 0.01 – 0.2 mm

Using FMCW technology it is possible to perform range and velocity estimation as shown in the upcoming slides.

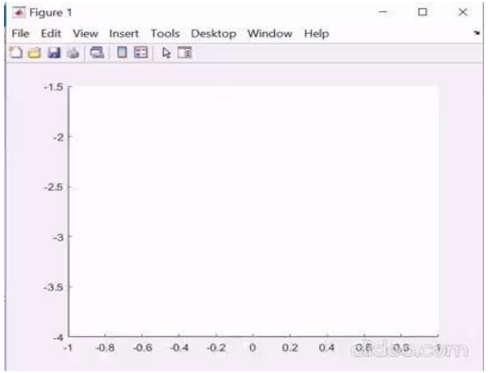
Algorithm to be used



Modelling HeartBeat



Sent Wave



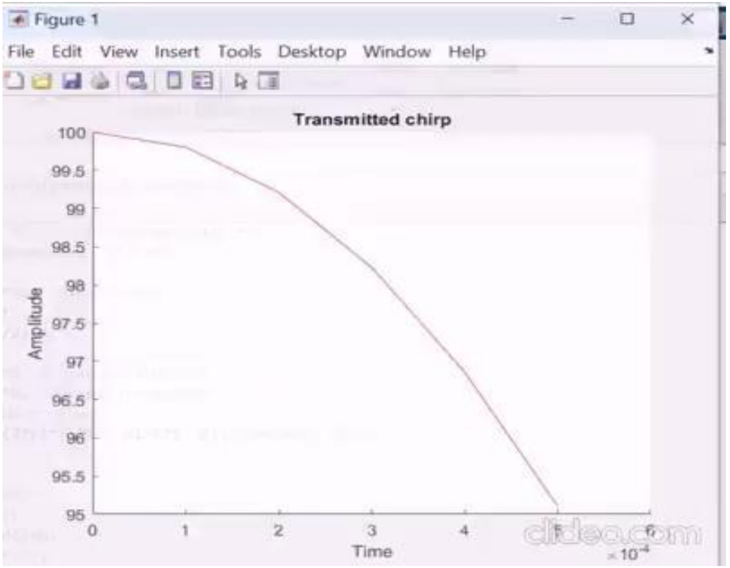
First Animal

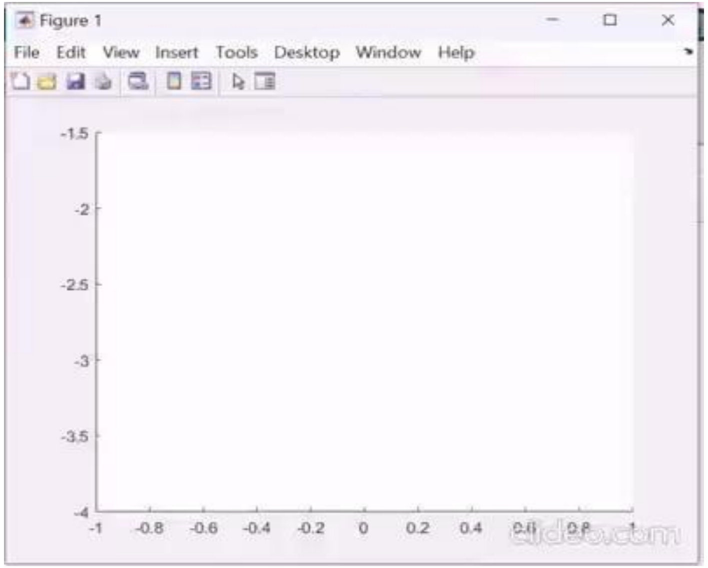
Second Animal

Third Animal

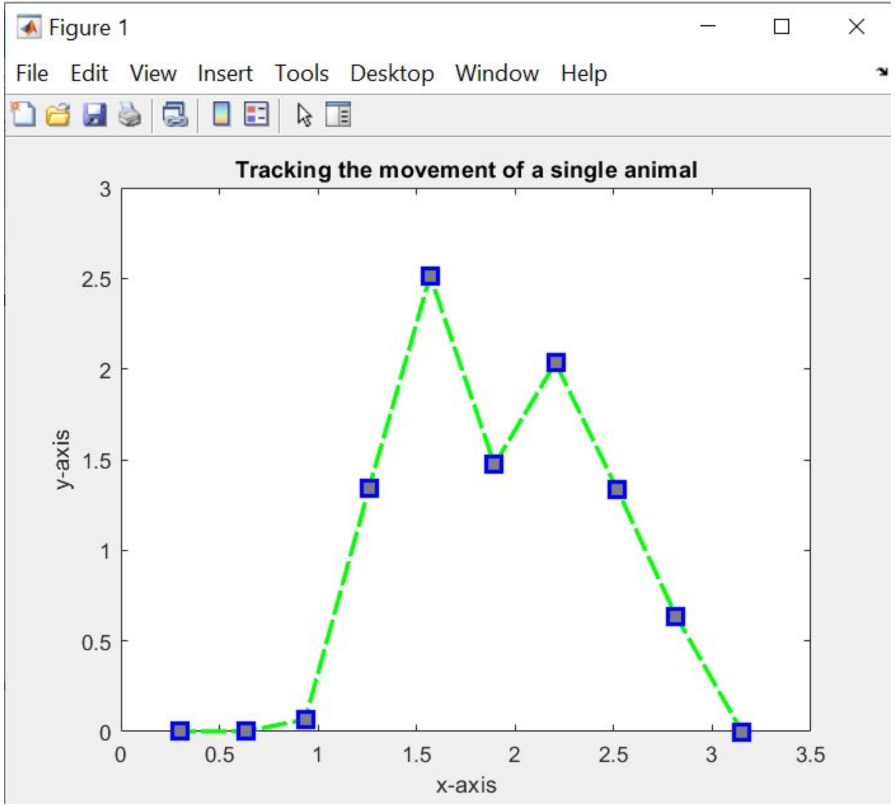
Abnormal

Modelling Respiration rate

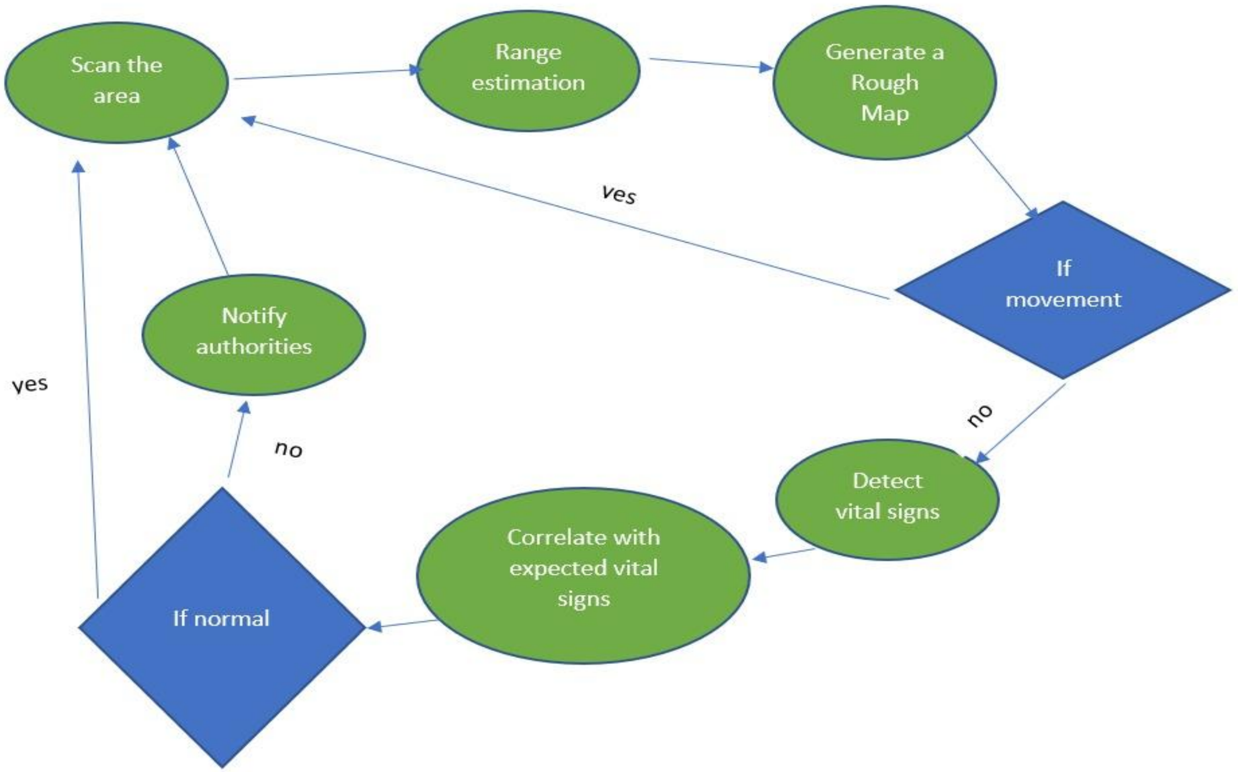




Tracking the Movement of a Single Animal

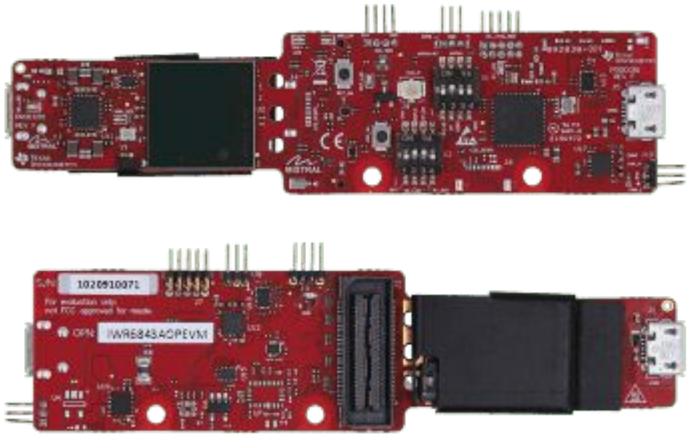


Proposed Working Algorithm



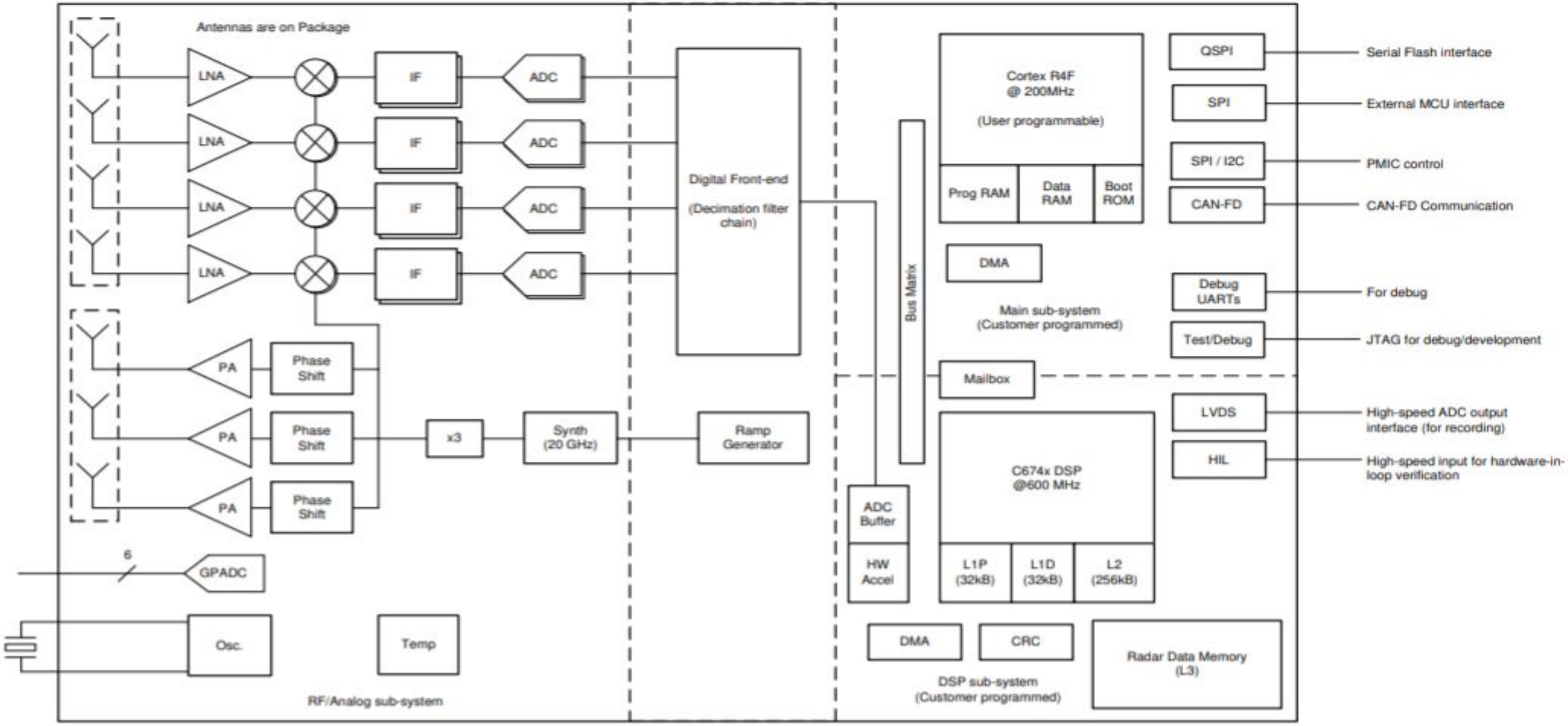
IWR6843AOPEVM: Industrial Wireless Radar

IWR6843 TI-mmWave sensor measures the breathing and heartbeat rate by analyzing the motion of the chest.



- 60-GHz to 64-GHz mmWave sensor
- 4 receive (RX) 3 transmit (TX) antenna with 120° azimuth field of view (FoV) and 120° elevation FoV
- Maximum output power of 10 dBm; the IWR6843AOPEVM has an antenna gain of ~5 dBi

Architecture of the radar module



Stepwise procedure of using the hardware

Developing firmware for the Radar Sensor

Involves writing codes

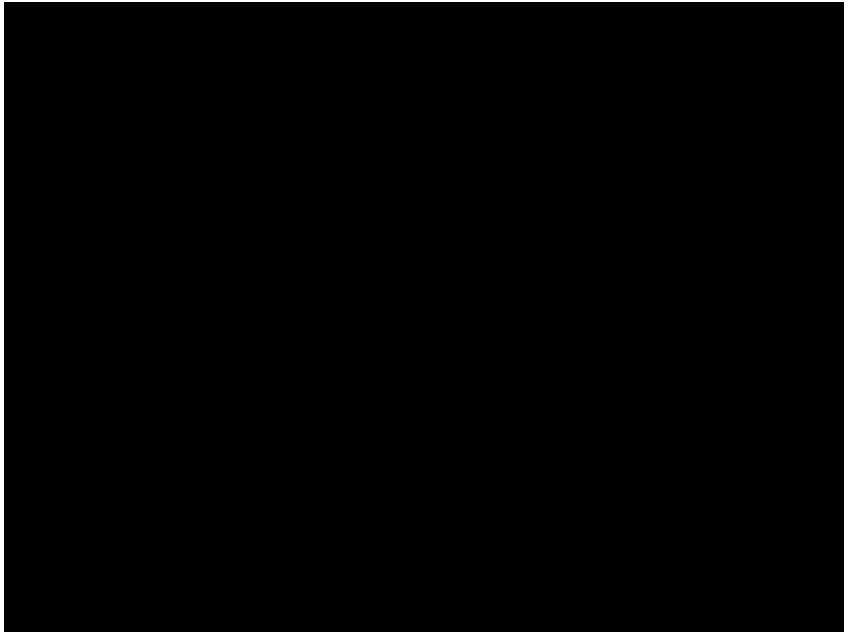
Flashing Firmware to the Board

Configuring the Radar Subsystem

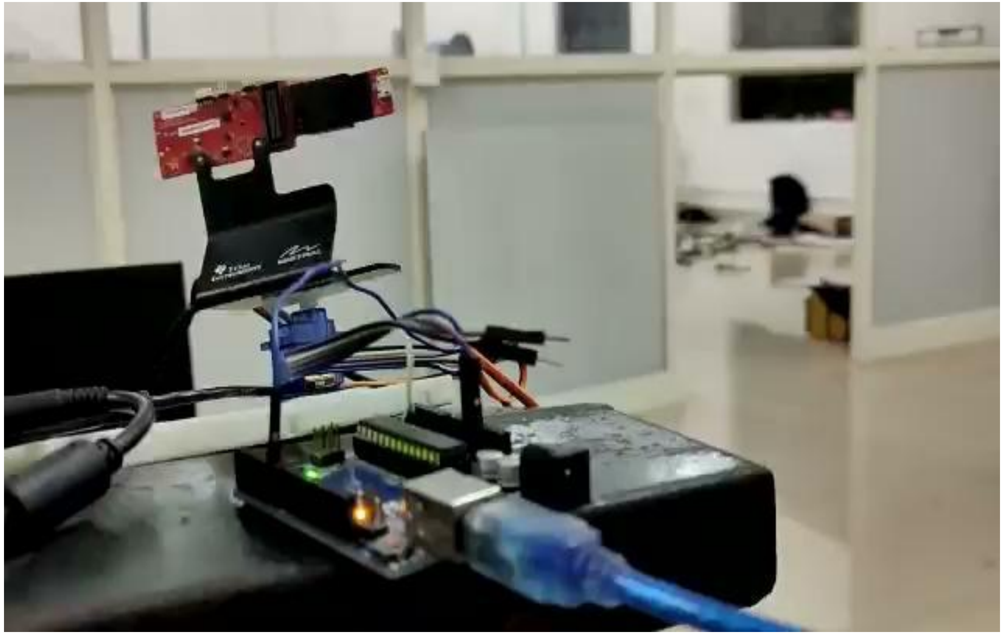
The range resolution, velocity resolution, the number of active transmitters and receivers, the ADC sampling frequency, chirp parameters, the type of data to be processed, etc

Working with communication protocol (UART-USB interface)

To enable communication with the Radar through the PC



Switching on the device



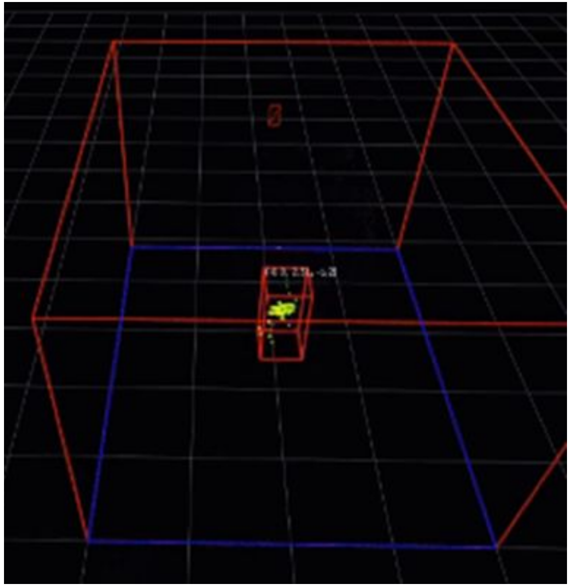
Gaining full 360 degrees coverage

Our Objective: Making this World a Safe Place for All






How are we going to expand our project in the future?



- We have performed rudimentary analysis of bodies so far and the basic foundation is laid. Range estimation, velocity estimation and heartbeat modelling is done so far for single/multiple bodies.
- Now we are looking forward to perform complex analysis such as: Area scanning, Mapping the contour of beings and long range detection.
- Generating a contour of an animal/human using the mm-wave sensor that can be used to differentiate between humans and animals with much better accuracy. It can also differentiate between different animals which helps in improving tracking.
- Improving vital signs detection and make algorithms for tracking the movement of animals with improved accuracy.
- The result should be an integrated system consisting of a network of sensors to monitor a large area.