

Development of a Closed Loop FMCW Radar Device to Extract Biometric Data for Security and Irregularity Detection

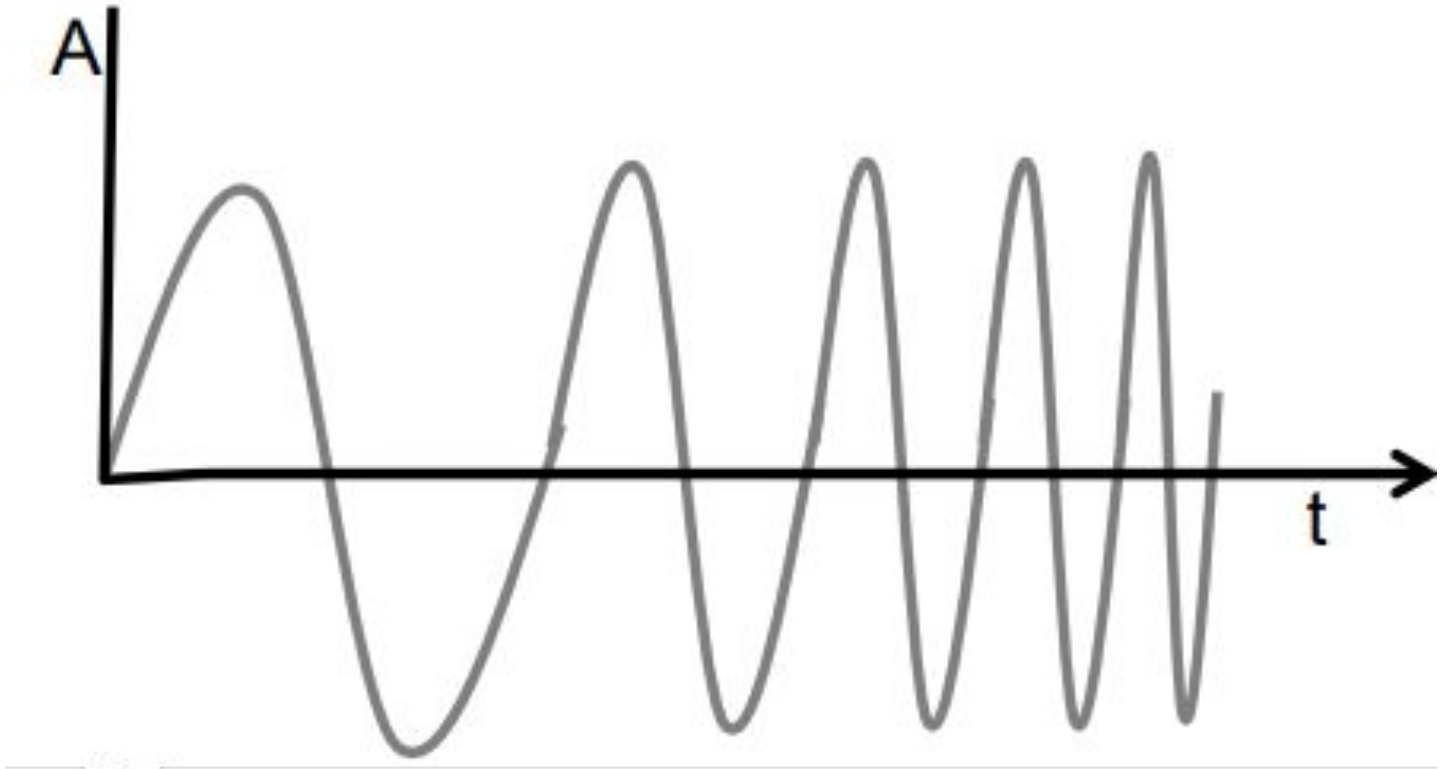
Dr. Qiuye He / Areesh Sobhani

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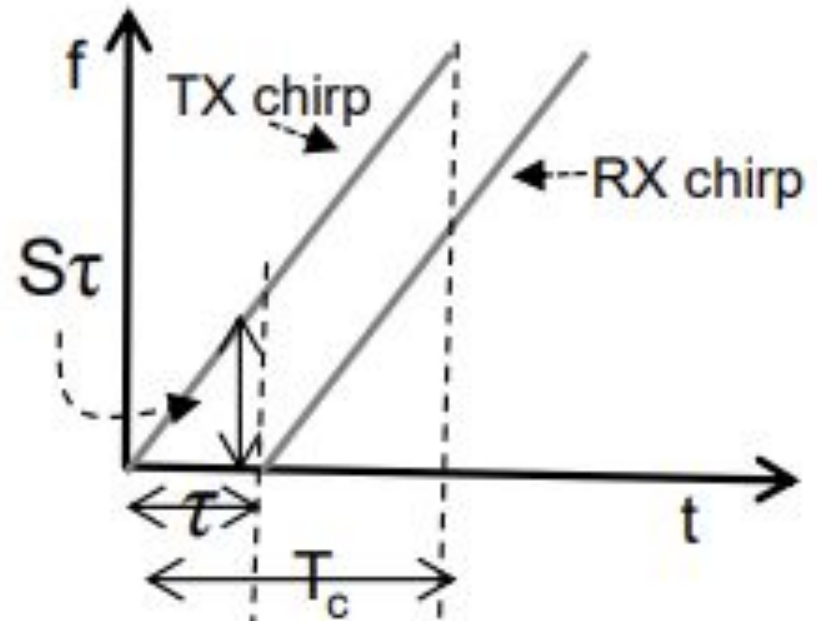
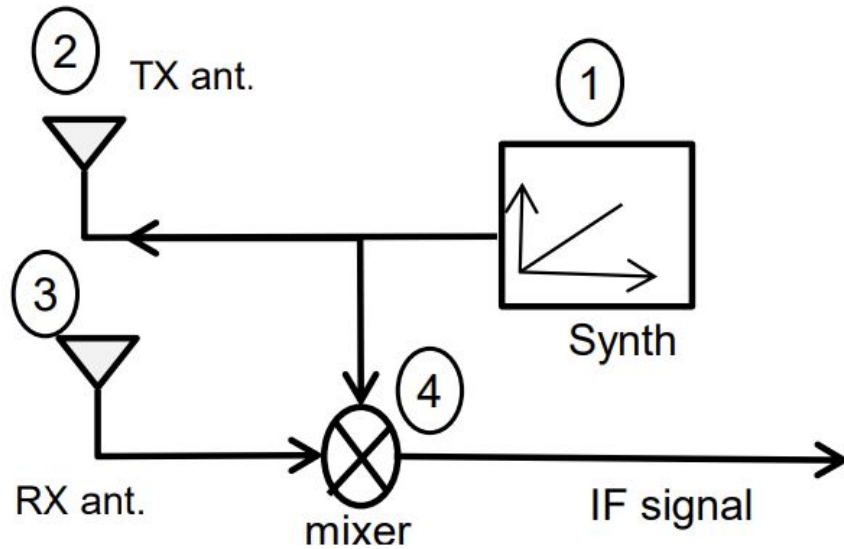
Problem Statement Overview

This project applies a Frequency Modulated Continuous Wave (FMCW) radar within a closed-loop, commercial-ready device to allow for the protected sensing and storage of biometric data such as heart and respiratory rate for security purposes, as well as for the purpose of early irregularity detection.

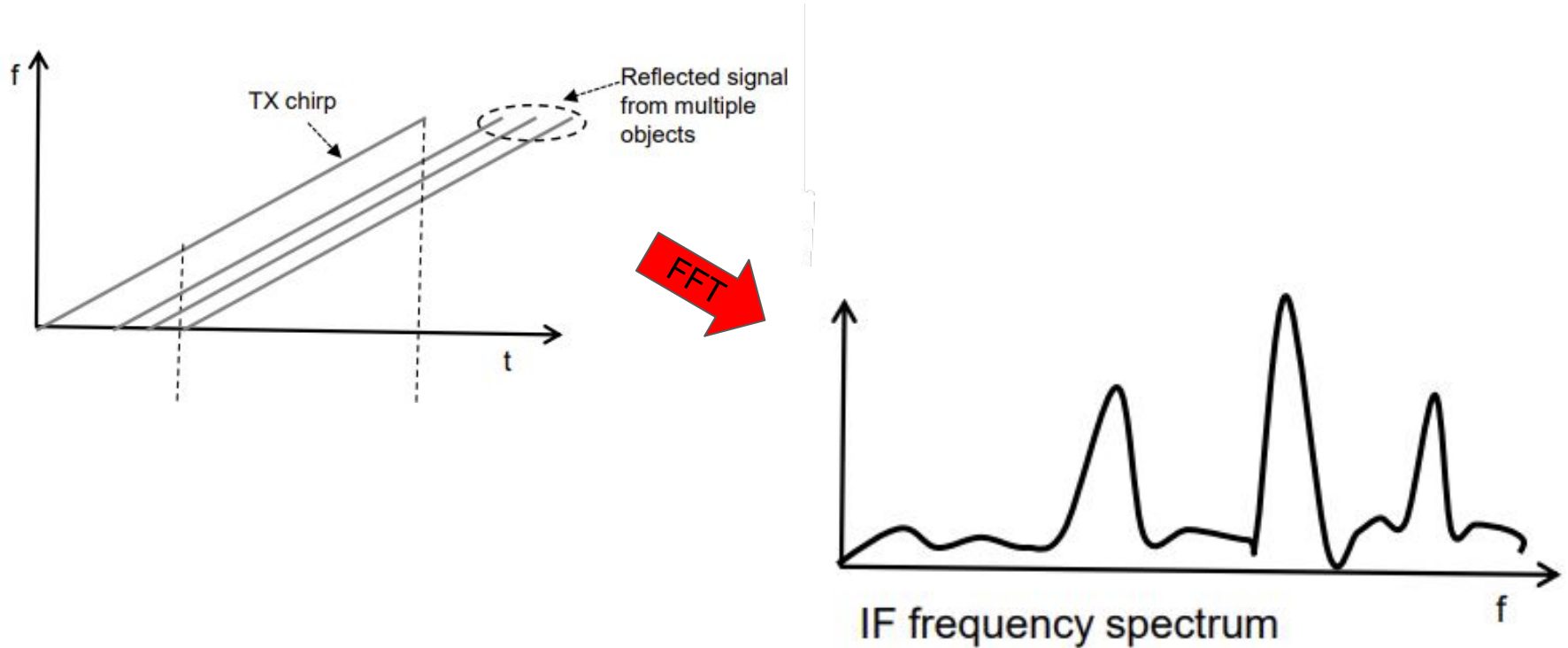
Related Work / Background - Source 1



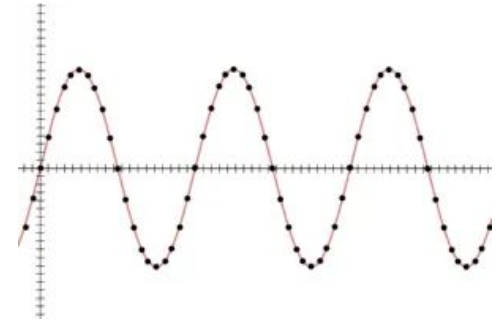
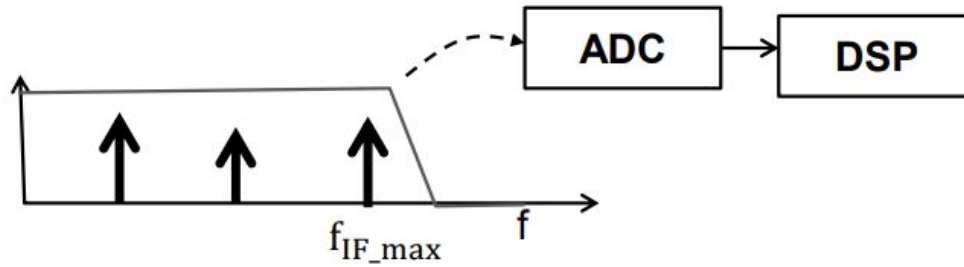
Related Work / Background - Source 1



Related Work / Background - Source 1



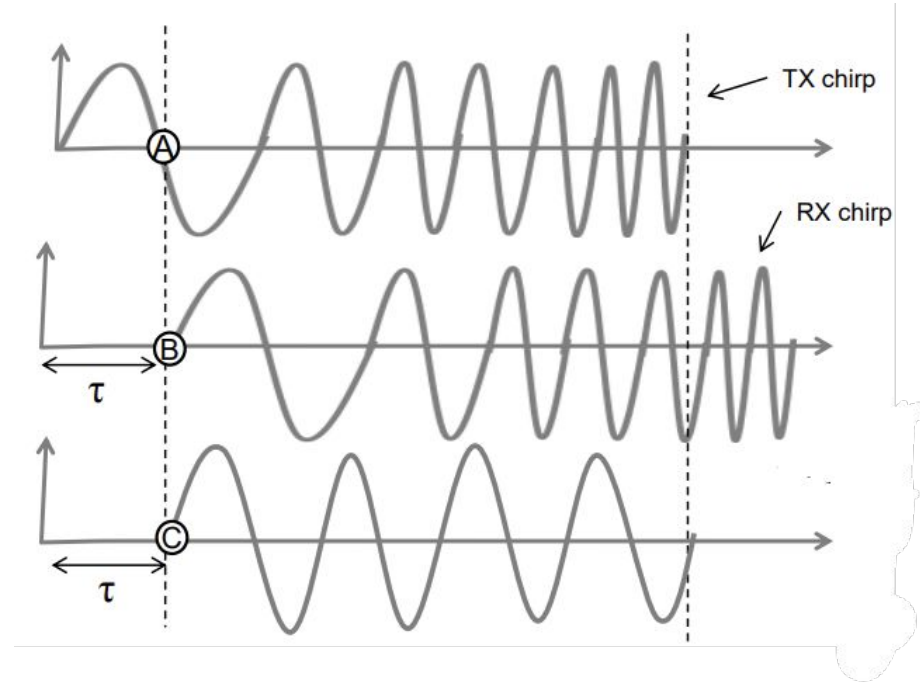
Related Work / Background - Source 1



An ADC sampling rate of F_s limits the maximum range of the radar to

$$d_{\max} = \frac{F_s c}{2S}$$

Related Work / Background - Source 1

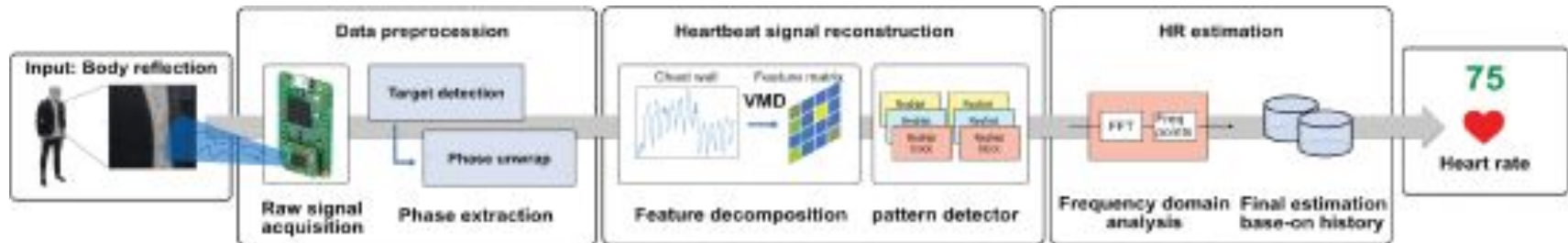


The phase of the IF signal is very sensitive to small changes in object range

Related Work / Background - Source 2

HeRe: Heartbeat Signal Reconstruction for Low-Power Millimeter-Wave Radar Based on Deep Learning

- Low Power >> Worse SNR
- Preprocessing
 - Noise elimination
 - Phase Restriction
- Reconstruction
 - VMD for feature matrix for neural network
- Limits
 - Reflective Noise
 - Bodily function interference



Related Work / Background - Sources 3 & 4

GitHub Repository for Non-Contact Heart Rate

Monitoring Using MmWave

- Application integration reference
- Seeed-Studio 60 GHz module
- Bad reference for data processing

GitHub Repository for Mmwave Hrv Sensor

- Lab setup implementation
- Similar sensor + MATLAB
- Better reference for data processing and signal extraction
- Reflects idea of Source 2 in how the heart rate signal is viewed
- Not accessible to the general user

AI Methods Being Used

N/A >> Still in literature review stages

- Potential for deep learning applications in faster computation and more efficient processing of multiple targets simultaneously

Initial Setup / Screenshots

N/A >> Still in Literature Review Stage

Next Steps / Timeline

- 1) Literature Review [CURRENT]
- 2) Data Simulation / Generation
- 3) Signal Extraction Algorithm Creation / Optimization
- 4) Algorithm Testing
- 5) Device Prototyping
- 6) Application Integration
- 7) Device Testing

Current Challenges / Questions

- High-level understanding of signal processing techniques and algorithmic implementation
- Familiarity with data simulation techniques and processing
- Familiarity with FMCW radar device

References

- Adamma-caulay. (2021, February 21). *Adamma-caulay/mmwave-HRV-sensor: Capstone project to measure heart rate variability using mmwave Radar*. GitHub. <https://github.com/adamma-caulay/mmwave-hrv-sensor?tab=readme-ov-file>
- Can-Yesilyurt. (2024, February 27). *Can-yesilyurt/non-contact-heart-rate-monitor: OSX App Interface for Seeed-Studio 60ghz mmwave module - respiratory heartbeat detection*. GitHub. <https://github.com/can-yesilyurt/Non-Contact-Heart-Rate-Monitor>
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- Wang, H., Du, F., Zhu, H., Zhang, Z., Wang, Y., Cao, Q., & Zhu, X. (2023). Here: Heartbeat signal reconstruction for low-power millimeter-wave radar based on Deep Learning. *IEEE Transactions on Instrumentation and Measurement*, 72, 1–15. <https://doi.org/10.1109/tim.2023.3267348>