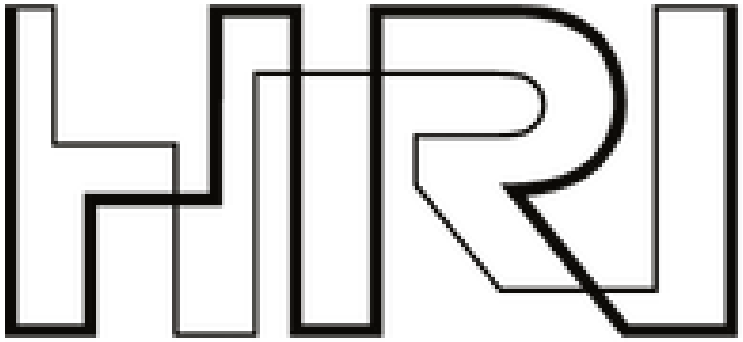


Honda Research Institute US

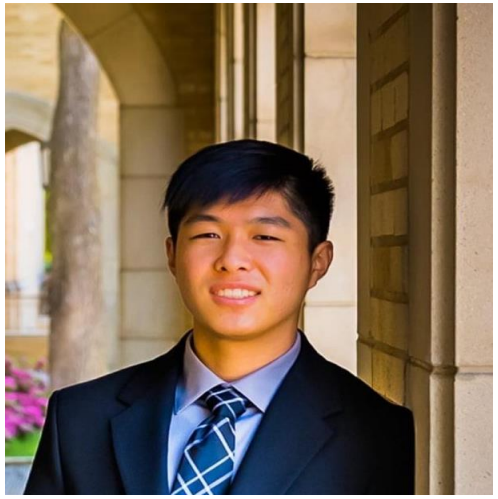
Edge-Based Spatial Rhythm

Team 30: Darren Chen, Halil Shakhpandarov, Zachary Plotkin

Date: 10/27/2025

Meet the Team

Zachary Plotkin
Embedded Software & Data



Darren Chen
Team Lead & Embedded Software

Halil Shakhpandarov
Sensors & Hardware

Problem Statement

Detecting group coordination in shared spaces using privacy-preserving, edge-based motion sensing.

Need for Anonymous, Edge-Processed Sensors

- Understanding how groups interact to improve collaboration and efficiency
- Traditional methods raise privacy concerns

Scope of Work

Use edge-based sensors to capture group spatial motion and accurately identify patterns of movement within a shared space

Stakeholders

Honda

- Ryan Lingo
- Brian Coy
- Rajeev Chhajer
- 99P Lab

Capstone Instructors

- Dr. Z
- Dr. Drew

Team 30

- Darren Chen
- Halil Shakhpandarov
- Zach Plotkin

Team Requirements Based on Sponsor Needs

Needs	Requirement	Units	Range	Ideal
Accurately capture motion data	Accuracy	Percentage	80-100%	100%
Securely encrypt all data-at-rest	Encryption	Percentage	100%	100%
Smoothly handle increase in number of tracked groups	Scalability	Groups	2-5 Groups	5 Groups
Easily read the interface	Readability	Seconds	TBD	TBD

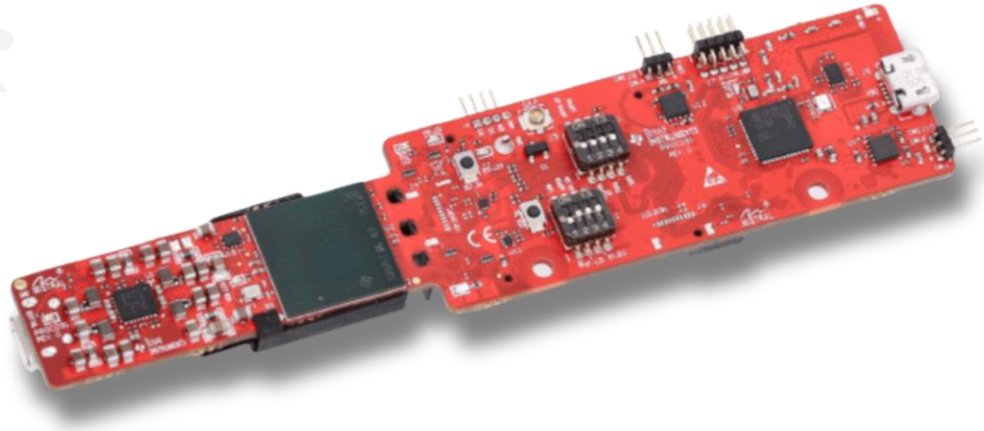
Study of Current Market & Design Ideas

- **RadHar (mmWave Radar):** Open-source TI radar dataset & pipeline for human activity recognition
  - Demonstrates radar's accuracy (3D motion and velocity) and privacy advantages
  - Focuses on individuals, not groups
- **Temperature Sensing**
- **Wearable Devices**
- **Other sensors**
  - Records images
  - LiDAR is power heavy
  - Infrared is ideal for motion detection, but not for velocity
  - Difficult to mount/ wear, not portable

Overall Design Idea of the Current System

Sensing - TI mmWaveRadar

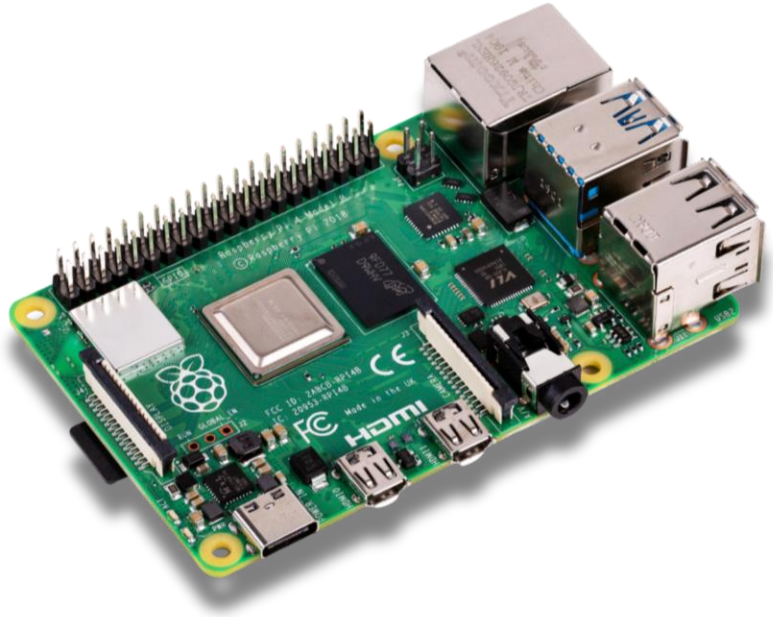
- 60 GHz radar used for motion and position detection
- Outputs 3D point-cloud data (x, y, z, velocity) via Universal Asynchronous Receiver/Transmitter (UART)
- Integrated with Raspberry Pi 4 for real-time processing



Type: IWR6843

Processing - Raspberry Pi 4

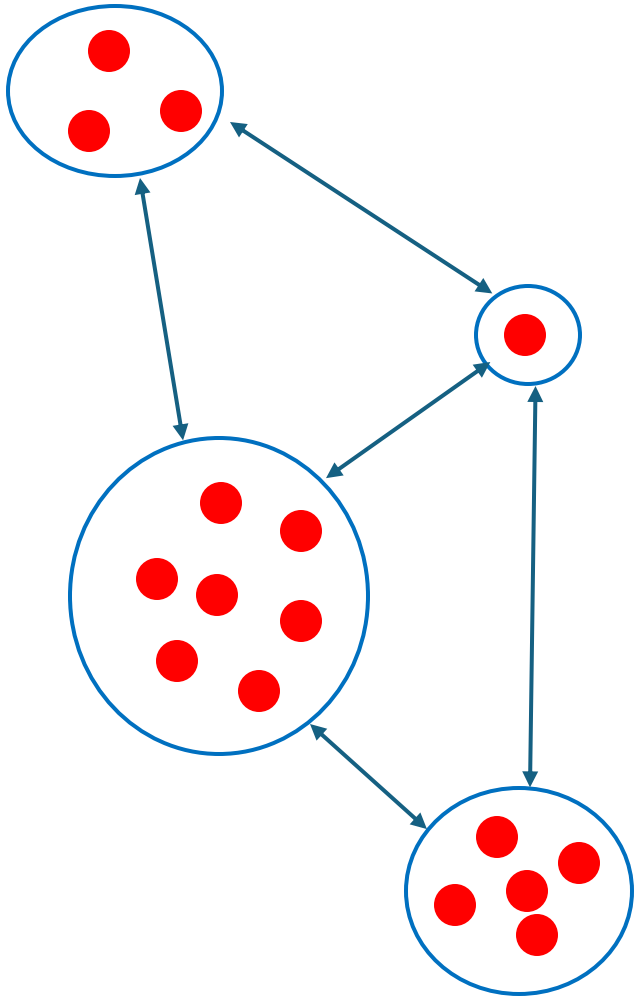
- Receives radar data from the mmWave sensor via UART
- Preprocesses point-cloud data (filtering)
- Runs ML algorithm to identify and/or track motion patterns
- Sends processed data to storage and interface for display



Raspberry Pi 4

Software - Layer 1

- Temporal Graph Transformer
  - Coordination
  - Neutral
  - Disruption
- Models temporal relationships to classify group states.



Point Clusters

Software - Layer 2

- PointNet & LSTM
- Collaborative Movement
  - Walking
  - Sitting
  - Leaning over

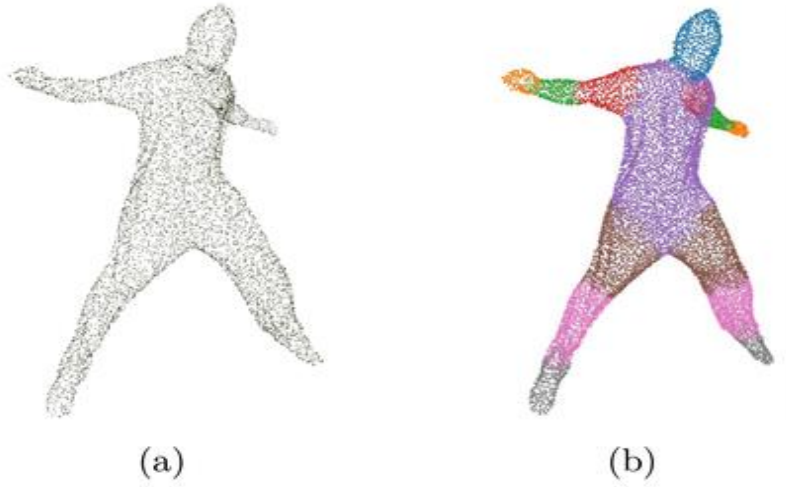


Figure 1: Example of 3D human body segmentation.
(a) Generated Point Cloud as Input
(b) Segmented Result [1]

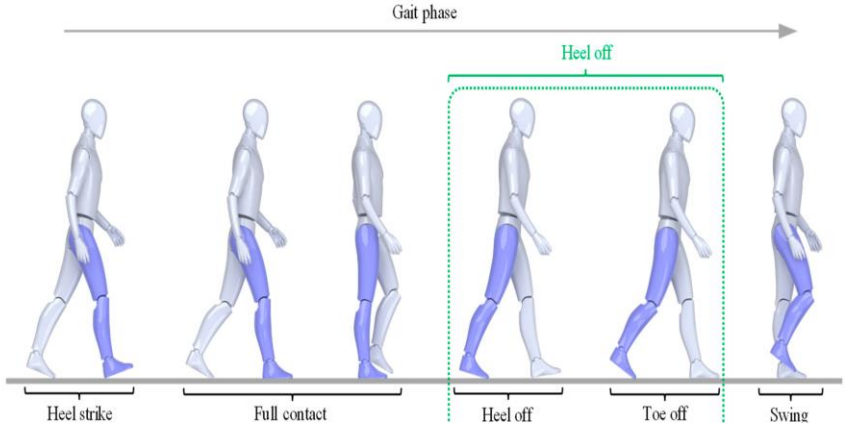
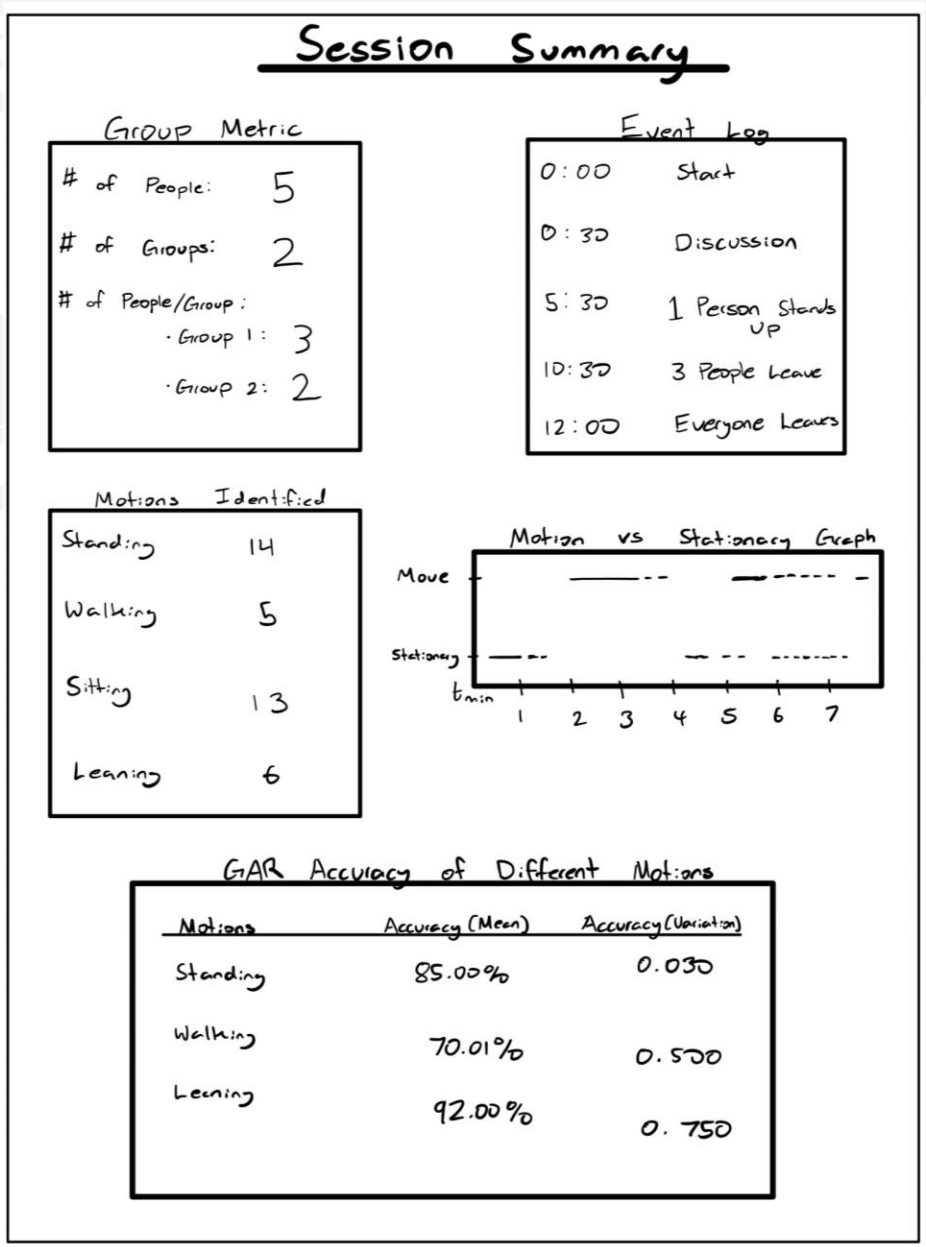


Figure 2: Four gait sub-phases according to 3-ch FSR measurement results [2]

[1] Ueshima, Takuma, et al. "Training PointNet for Human Point Cloud Segmentation with 3D Meshes." *Spiedigitallibrary.Org*, 16 July 2021, www.spiedigitallibrary.org/conference-proceedings-of-spie/11794/117940B/Training-PointNet-for-human-point-cloud-segmentation-with-3D-meshes/10.1117/12.2589075.full.
[2] Jeon, Haneul, and Donghun Lee. "Bi-Directional Long Short-Term Memory-Based Gait Phase Recognition Method Robust to Directional Variations in Subject's Gait Progression Using Wearable Inertial Sensor." *MDPI*, Multidisciplinary Digital Publishing Institute, 17 Feb. 2024, www.mdpi.com/1424-8220/24/4/1276.

Storage & Interface

- Computer serves as both data storage and user interface
- Stores processed sensor data locally
- Interface outputs 3D point-clouds, motion patterns, and system metrics
- Updates interface with summary of session activity



Interface Example

Progress to Date

- Selected TI IWR6843 mmWave radar & Raspberry Pi 4 for hardware
- Established GitHub repository
- Collected and parsed sample radar point-cloud data (RadHar dataset)
- Implemented data preprocessing pipeline
- Designed preliminary two-layer ML algorithm architecture (PointNet+ LSTM + Graph Transformer)
- Cost: $272.78

Milestones

ID	Milestone	Description	Planned	Actual
1.0	Project Kick Off Meeting	Introduction with 99P Lab sponsors. Communicate project scope, communication, and success criteria.	15 - Sept	15 - Sept
2.0	Market Research	Research on the main aspects of the project. Formulate an idea of several solutions to the problem.	22 - Sept	5 - Oct
3.0	System Requirement specification	Finalize system requirements and problem statement, run it by Ryan Lingo.	29 - Sept	29 - Sept
4.0	Purchase project components	Purchase Radar.	06 - Oct	07 - Oct
5.0	PDR Presentation and report	Present preliminary design review to sponsors and Dr. Z.	27 - Oct	27 - Oct
5.1	Create Problem Statement Presentation	Create the first draft of the PDR and record ourselves presenting	10 – Oct	09 – Oct
6.0	Edge-Sensor to ML Algorithm pipeline	Implement first working version of sensing -> preprocessing -> ML algorithm	23- Nov 6 - Nov	
7.0	CDR Presentation and report	Present Critical Design Review to sponsors and Dr. Z.	02 - Dec	

Conclusion

Problem Statement:

Detecting group coordination in shared spaces using privacy-preserving, edge-based motion sensing

Main Design: