Bluetooth Signal Emission Detection System for Enhancing Pedestrian Safety in Urban Environments

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Introduction

- ❑ Pedestrians at UNH in front of Thompson Hall are constantly crossing the main intersection during the week. This causes a large amount of traffic safety concerns. A police officer is needed to guide traffic.
- ❑ **How can a system be developed to monitor real time data of a pedestrian's location without privacy invasion?**
- ❑ The goal is to create a system that can detect the approximate location of multiple pedestrians using localization techniques without an app, website, or invading privacy.
- ❑ Bluetooth is a common RF technology, which means most devices in an urban environment use this communication protocol for exchanging data between devices.
- ❑ Research has commonly been done on indoor triangulation/trilateration for localization, but not outdoors for pedestrian activity
- ❑ Received Strength Signal Indicator (RSSI) can be used to calculate distance from a sensor from a corresponding Media Access Control (MAC) address.

Methodology

- ❑ By collecting the RSSI and MAC address from individual Bluetooth devices, a script can be run to convert the RSSI into approximate distance from a sensor and the MAC address assigned to that data point.
- ❑ By using multilateration shown in Figure 1, a distance matrix can be formed from each sensors MAC address by providing a distance measurement from the RSSI values.
- ❑ Inputting the distance matrix into a least squares estimator will provide an approximate location of a particular pedestrian.
- ❑ New data is then plotted on a graph with the relative location of each device every ~.75 seconds.

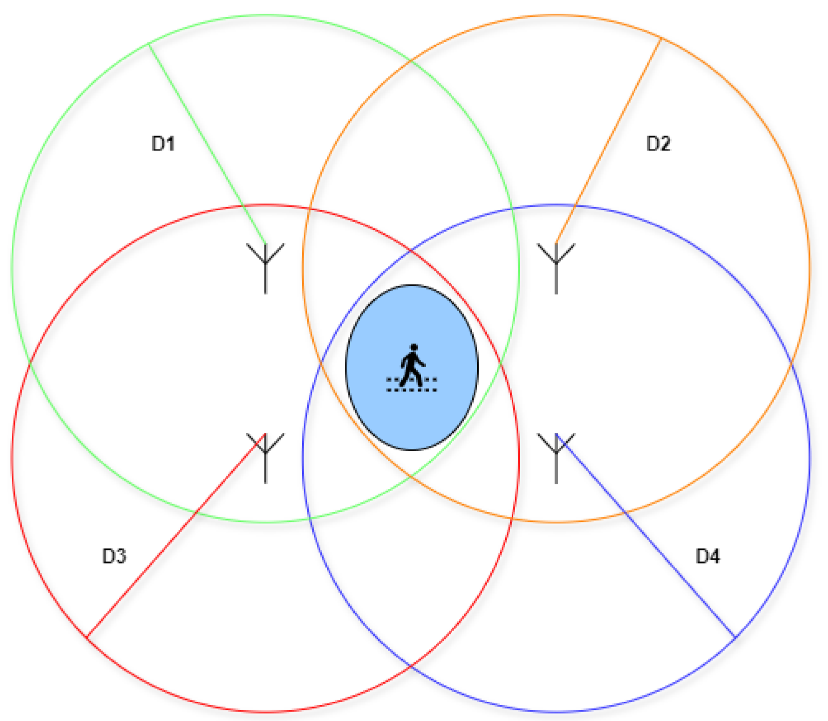

Fig 1: Multilateration Diagram for Localization

System Design

- ❑ This distance detection system is built using 4 Raspberry PIs with Bluetooth extenders for hardware, shown in Figure 2.
- ❑ For software Python and MATLAB are used to collect and compile the RSSI and the MAC address of Bluetooth devices.
- ❑ A central computer will use a MATLAB script to preform mulilateration on collected sensor data, providing a distance matrix.
- ❑ A least squares estimator will be used to achieve an approximate location from a pedestrian's Bluetooth device.
- ❑ A graph will be generated in MATLAB, consistently updating the pedestrian location.

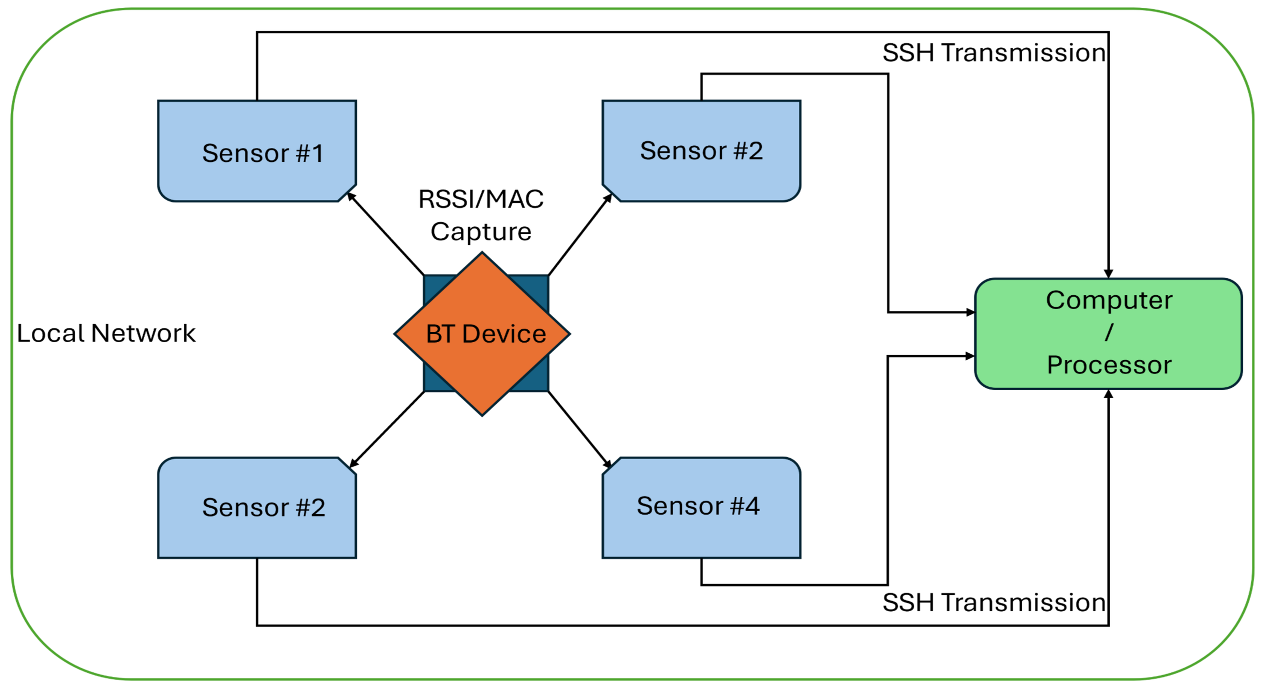

Fig 2: Block Diagram of Data Collection

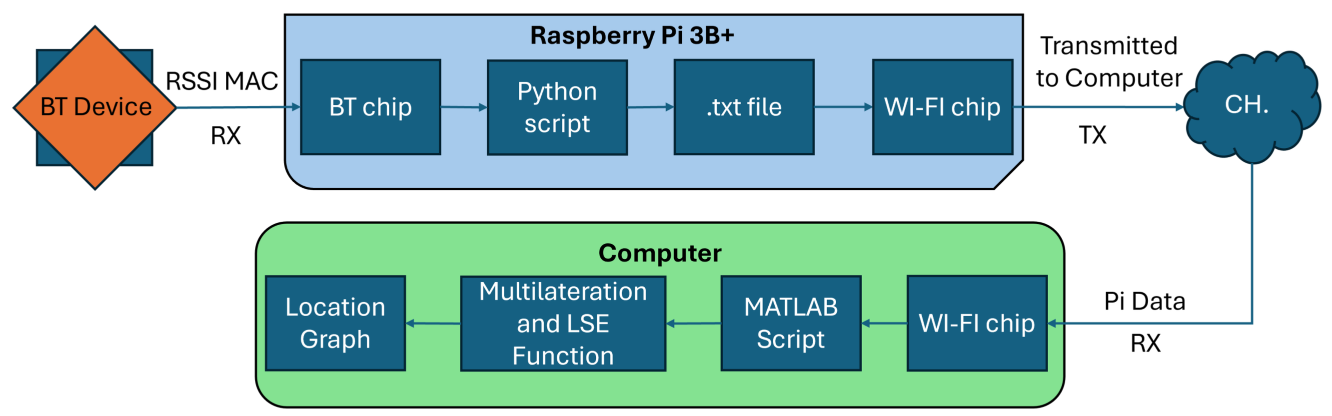

Fig 3: Single Sensor Data Path

Fig 4: Walking with a Bluetooth Speaker During System Testing

Results and Conclusion

- ❑ Data was collected and plotted to show the approximate location of a pedestrian in a two-minute time frame.
- ❑ Data can be used to reasonably distinguish the quadrant a pedestrian is in after a few samples.
- ❑ Data can be off up to ~7 meters, some points being much more accurate.

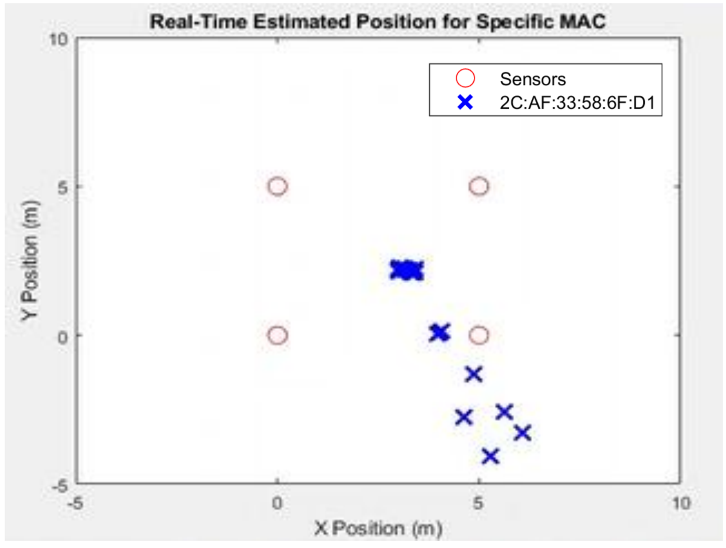

Fig 5: Location Results of Pedestrian Standing in the Center of Sensors

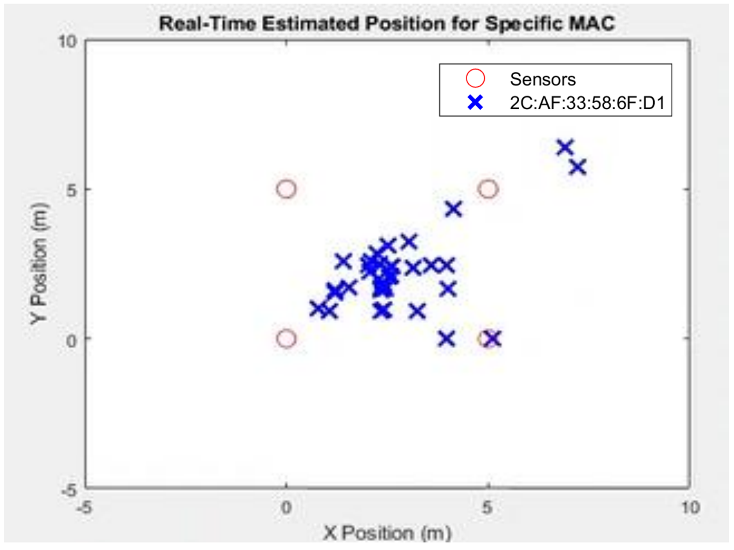

Fig 6: Location Results of Pedestrian Walking in a Line Down the Center

- ❑ Data is not consistently captured due to pairing packet transmission times.
- ❑ The system can be expanded to much larger ranges after proving the design well in a 5x5 grid.

Challenges & Future Work

- ❑ Data fusion with additional sensors
- ❑ Adding a Kalman filter to reduce error and predict next location
- ❑ Reducing the error of the distance measurements from body obstruction
- ❑ Processing time of larger datasets

Acknowledgements

- ❑ Dr. Kirsch for allowing the group to participate in a unique project that can help improve pedestrian safety across the world.
- ❑ Shuva Paul for assisting along the way and building foundational ideas for the project.

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