Bluetooth Low Energy Location Tracking

Dr. Baris Aksanli | Leo Chatterton | Hada Marabeh | Tristan Richmond | Zach Rocha | Sri Harsha Shatagopam

Background

- The Transport Security Administration (TSA) is responsible for upholding security at transportation terminals.
  - TSA agents must be fully alert to carry out their responsibilities, such as identifying contraband or suspicious activities.
  - TSA agents follow specific procedures to ensure passenger safety, but mental and physical fatigue can affect their alertness over the course of their shift. Location is directly tied to their movement and fatigue.

- We are creating a network of Bluetooth Low Energy devices to monitor the location of TSA agents during their shift.
  - TSA shift coordinators may analyze the data collected with our framework to optimize agent coverage in an area.

Solution

- Received Signal Strength Indicator (RSSI): gain value determined by power loss (dB) from a transmitting device to a receiver.
  - As distance between wireless devices increase, RSSI decreases as more power loss occurs in the air medium
- Mesh network:
  1. 4 anchor nodes at each corner of the 10 meter by 10 meter grid.
  2. 1 (+) mobile nodes on the TSA agent's person.
  3. 1 holistic node that compiles data.

- Low energy consumption is an important factor for embedded devices, where battery life is an important restraint.
  - Bluetooth Low Energy (BLE) can be used to facilitate communication while preserving battery life compared to traditional Bluetooth.
  - BLE uses advertisements to broadcast data to devices in the local proximity to read momentarily as a notification.
    - This eliminates the need for point-to-point connections for wireless communication.

- RSSI measurements from each corner is insufficient, as it can be affected by noise and changes in the environment.
  - We utilize a classification algorithm to form relationships between RSSI values from each grid corner and the TSA agent's location within the grid.
  - The model takes four RSSI inputs and outputs a coordinate location.

Hardware

Arduino Nano 33 BLE

This microcontroller features a embedded bluetooth low energy module which is fully programmable through Arduino C libraries.

Adafruit Mini USB LiIon/LiPo Charger

This mini USB charging module ensures a 3.6 V lithium ion battery is safely recharged. It regulates the voltage and current levels to the correct amounts depending on the state of the charging process.

Raspberry Pi 4 (8GB of RAM)

This small computer hosts an lite Linux operating system with a robust 4 core ARM processors and Bluetooth receiver. It provides enough computation power for a machine learning model and custom graphical user interface application.

Nodes Types

Anchor Node

- Battery-powered, static device that is mounted in one of the four corners of the defined grid.
- Responsible for scanning for mobile node broadcast packets and measuring the RSSI between them.
- Advertises measured RSSI along with the ID and gender of the mobile node that was scanned.

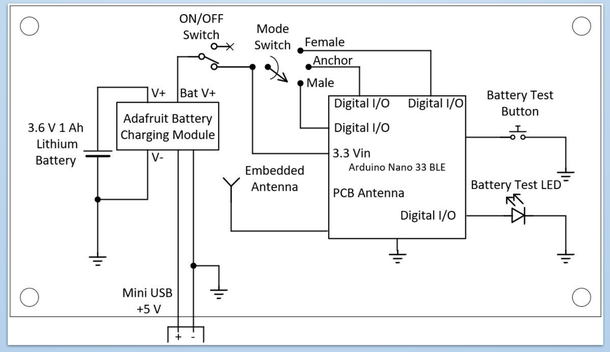
Mobile Node

- Battery-powered, mobile device that is clipped onto the TSA agent's waist.
- Hosts BLE service that contains the agent's gender and mobile node ID.
  - By having a BLE service discoverable by other BLE devices, the anchor nodes are able to capture the aforementioned information and the measured RSSI.

Holistic Node

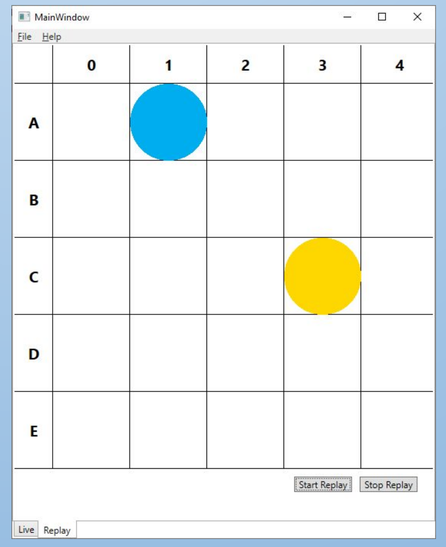
- Outlet-powered, static computer that is mounted within grid's boundaries.
- Organizes advertised data from each anchor node as input data for the machine learning model.
- Passes predicted location to GUI running on laptop outside of the grid.

Mobile & Anchor Circuit

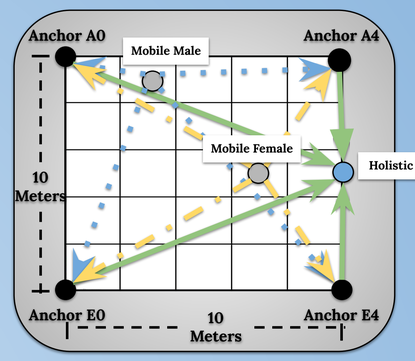


Graphical User Interface

- GUI shows up to two mobile nodes at once.
- Replayability function allows user to see history of a mobile node throughout a shift.

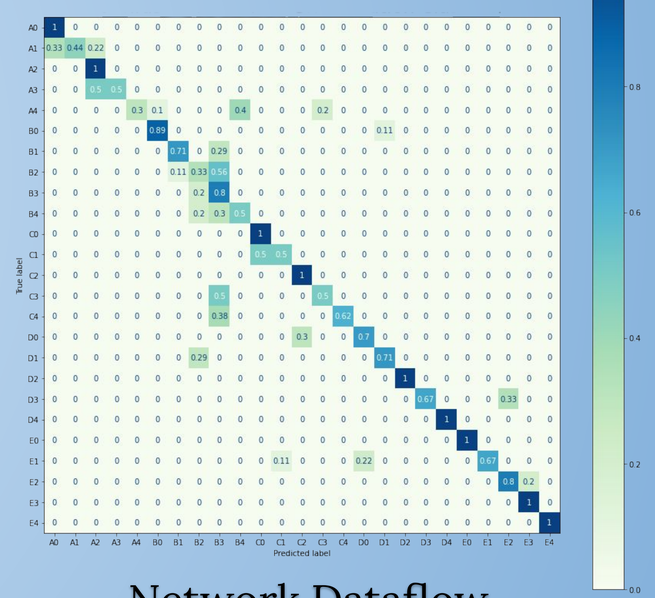


Physical Mesh Grid

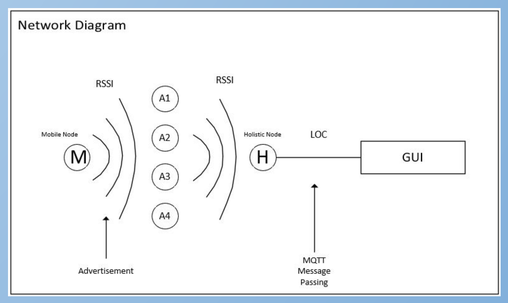


- Mobile nodes are always advertising to each anchor.
- Each anchor measures RSSI and receives the mobile node's ID and gender.
- Each anchor advertises to the holistic node.
- Holistic node uses the received RSSI data as input for the ML classification algorithm.

Classifier Confusion Matrix



Network Dataflow



Network flow of holistic system:

1. Mobile advertises data to each anchor.
2. Anchor extracts mobile data and advertises to holistic node
3. Holistic node receives RSSI data from each anchor and inputs to ML model.
4. GUI receives grid location via MQTT message passing.

***This project will be combined with the Fatigue Monitor project. CAOE is our sponsor while the TSA is our client**

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