WiFI Tomography

The aim to generate a spatial map
using a WiFi receiver and transmitter,
which send their location and
signal strength to a remote server.

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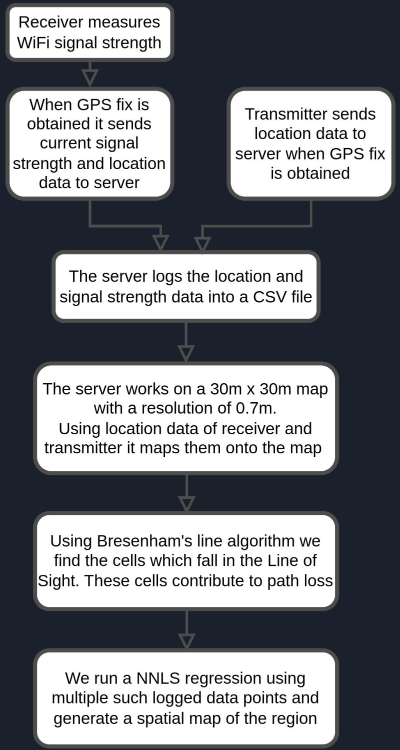
Introduction

- WiFi tomography (WiFiT) is a non-invasive imaging technique.
- WiFiT uses WiFi signals to create a map of physical space.
- The technique relies on the fact that WiFi signals are affected by encountered objects.
- WiFiT can be beneficial in emergencies, rescue operations, and security breaches.
- It enables imaging of objects that do not carry electronic devices.

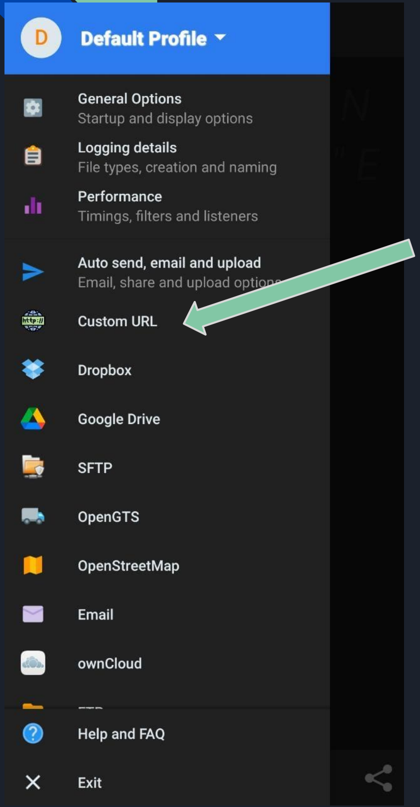
- WiFi signals pass through most obstacles; they only get attenuated
- It can be performed with very minimal setup; we only require to move around with a sender and receiver and capture data.
- Traditional tomography techniques often require time-consuming data acquisition and processing. On the other hand, WiFi tomography can produce real-time images of a subject.
- WiFi tomography uses low-power radio waves that are not harmful to humans, making it a safe imaging technique.

Methodology

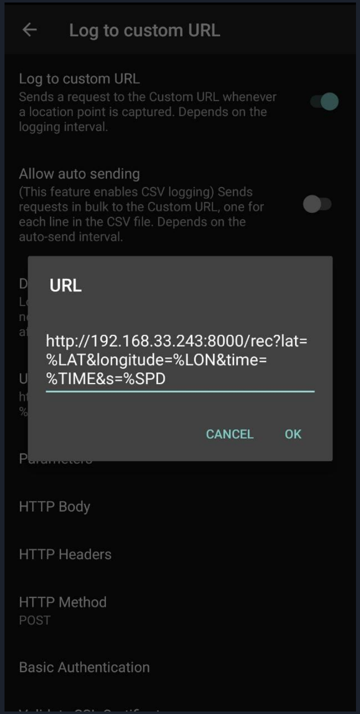


- The procedure involves capturing 2D spatial mapping images using two Android devices connected over a WiFi network.
- Samples are taken in the form of (gpsTransmitter, timestampTransmitter) and (gpsReceiver, timestampReceiver, RSSIValue).
- The objective is to create a detailed map of a physical obstruction.
- The devices are connected over a WiFi network, and GPS coordinates are collected by moving them in a circular motion.
- GPS values are automatically transmitted to the server for accurate and reliable data collection.
- RSSI values are collected to measure path loss values and determine the spatial mapping of the obstruction.
- The collected coordinates are sent to a remote server and logged into a CSV file.
- The server uses the path loss equation and regression to generate spatial mapping results as an image.

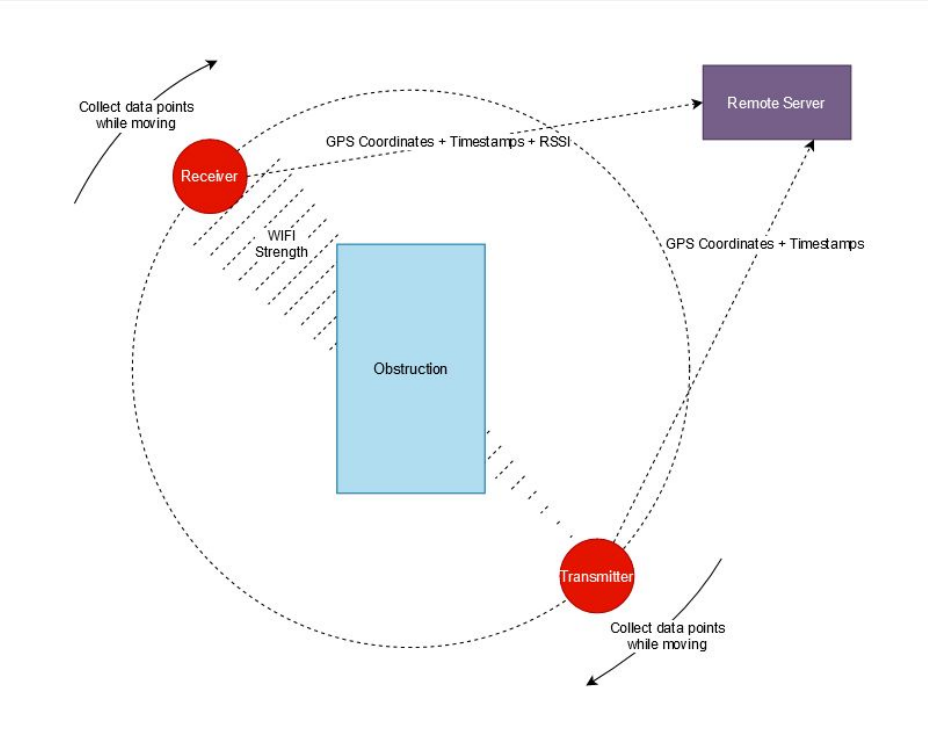
Procedure



Open the modded app and chose the custom URL option to log data points to server instead.



Procedure



Upon establishing a Wi-Fi network connection between the devices in a receiver/transmitter configuration, users have the flexibility to move in a circular motion, even in an asynchronous manner.

During this motion, GPS fixes for their respective coordinates are obtained. Subsequently, these coordinates, along with the receiver's corresponding RSSI values, are transmitted to a remote server for the computation of spatial mapping.

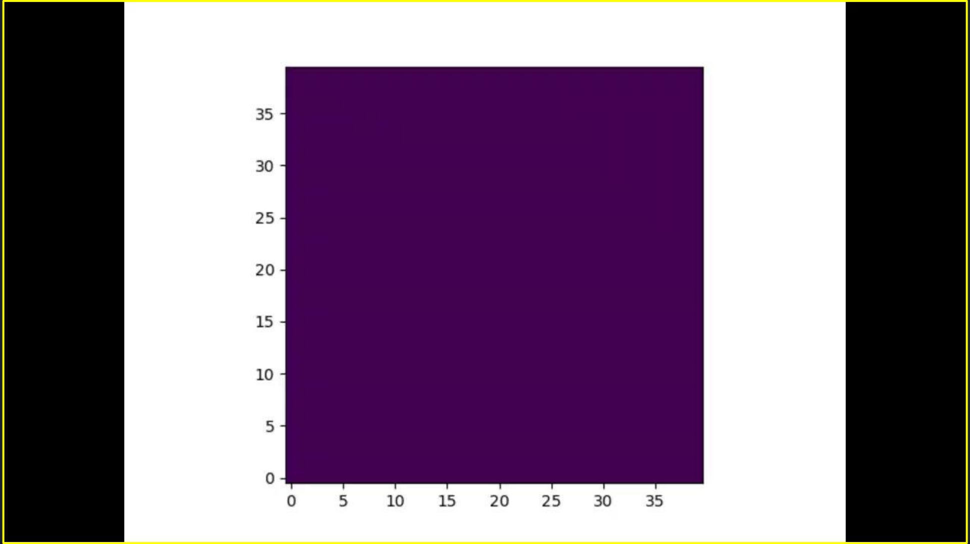
The spatial mapping is performed for a discrete set of data points, employing two prominent techniques that map the GPS coordinates from the receiver and transmitter to each other.

Mapping GPS coordinates :

Sequential/Direct mapping : This strategy involves establishing a one-to-one mapping relationship between the GPS coordinates received from Device A and Device B. The coordinates are synchronized based on their sequential order, ensuring that they correspond to similar or related locations. To maintain a complete mapping, timestamps without suitable values in both devices are discarded.

Nearest Timestamp Mapping : The assumption that temporal proximity implies spatial proximity is utilized in the mapping process. This assumption suggests that GPS coordinates collected at similar timestamps are associated with similar or related locations. To address temporal discrepancies or variations in data rates between the devices, a nearest timestamp mapping approach is employed. In this approach, tuples with the closest timestamps are matched in an m-n style, ensuring each data point is paired with the closest corresponding point from the other device.

Final Result



Video of obstacle map being generated

Inferred outline of the obstacle map

Obstacle Map generated by a
rectangular obstacle (Grass Roller).

Future Research Scope

- Gathering enough data points, especially in closed spaces, currently takes a significant amount of time.
- This is problematic because mapping closed spaces is a major use case for this research.
- Closed spaces are often inaccessible, making it challenging to gather sufficient data.
- Incorrect GPS fixes can lead to erroneous maps, making it difficult for users to differentiate between low attenuation due to transparent materials and singular incorrect fixes.
- There is a need to explore better methods of location tracking to address these issues.

References

- Wireless tomography, Part I: A novel approach to remote sensing
- Radio Tomographic Imaging with Wireless Networks
- Bresenham's line algorithm
- Non-negative least squares
- GitHub repository link for the project.