Indoor localization using WiFi RSSI fingerprinting

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Introduction

GPS not an option

- Knowing the accurate position of devices is of great importance.
- Indoor positioning can be used in shopping malls, Hospitals, Autonomous vehicles, Manufacturing, Sports Industries, Space Exploration, and Smart homes for a better user experience and better management of resources.
- A satellite-based radio navigation system has poor performance in the indoor environment.
- Due to the availability of WiFi access points in most buildings indoor localization using WiFi RSSI fingerprinting has gained huge popularity.

- kNN and ANN are the algorithms with best performance in useSingh, Choe, and Punmiya 2021.
- These algorithms don't consider the properties of the EM wave and have a scope for overfitting
- So in this report, we propose a new algorithm that will consider the properties of the propagation of EM waves.
- We will use UjiIndoorLoc and NISER Library dataset.

S. No.	Algorithm	MSE
1	kNN	0.11
2	ANN	0.27
3	kNN with GNN	0.3

Table. Performance matrix of Baseline algorithms.

Our work is available on the GitHub repository
`https://github.com/rahul3613/ml_project`

DataSet

- UJIindoorLoc is a multi-building and multi-floor database for indoor localization.
- This dataset covers approximately $110m^2$ of three Jaume I University buildings with four or more floors.
- It can be used both for both classification and regression.

Data collection from NISER Library

Autonomous localization and framing

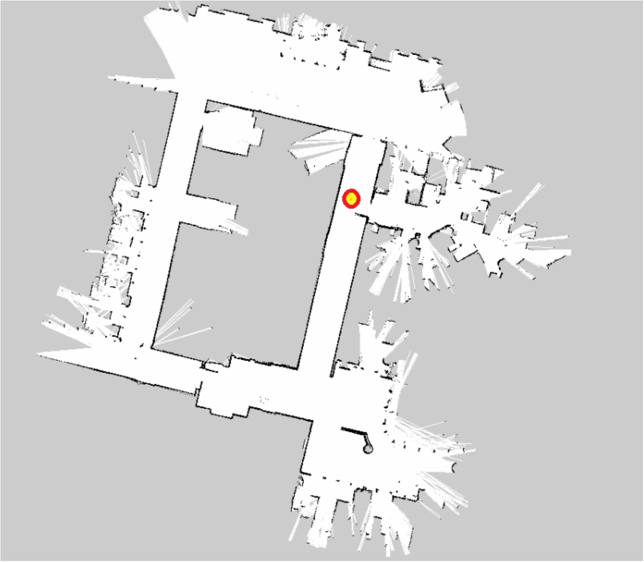


Figure. Autonomous Localization and Mapping

- Given any random indoor location, The first step is to collect localization and mapping data along with WiFi RSSI values. This is achieved using a robot which attains this in 2 steps:
    1. Mapping the area using appropriate SLAM hardware and software.
    2. Traverse the map suitably to scan and collect localized values for WiFi RSSI.

Data collection from NISER Library

Simultaneous Localisation and Mapping - SLAM

The bot uses the following features to create a map of the concerned area.

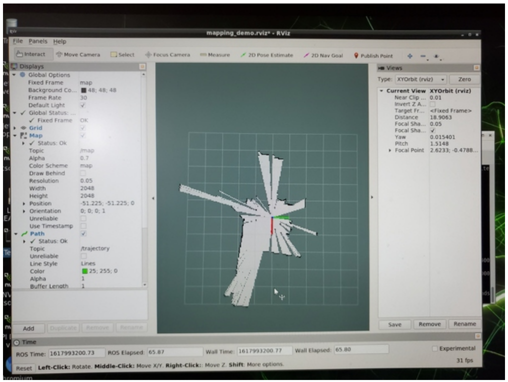
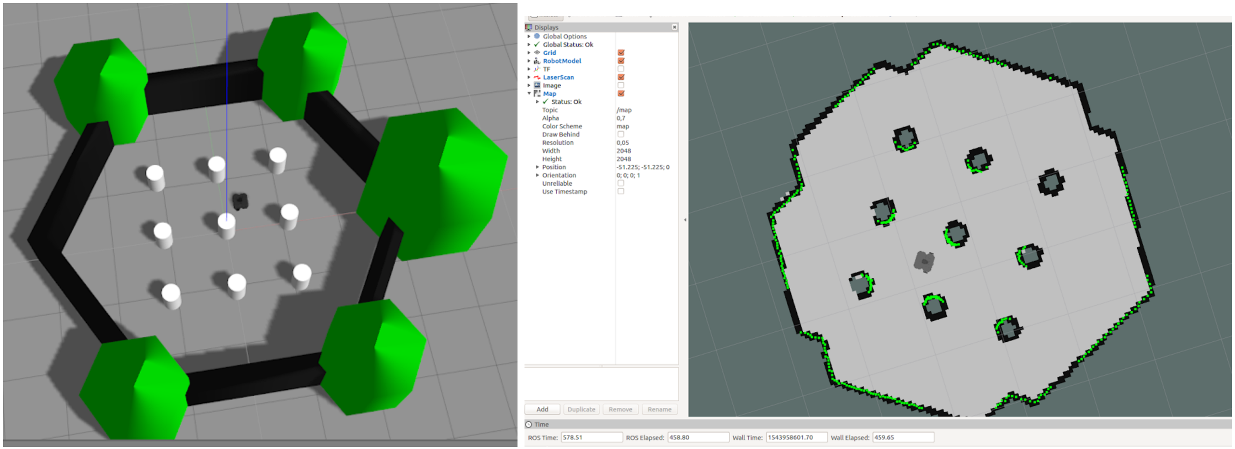


Figure. working depiction of Lidar

- **Lidar Sensor:** LiDAR, or Light Detection and Ranging, is a remote sensing technology that uses lasers to measure distance and create detailed 2D/3D maps of objects and surfaces, commonly used in self-driving cars, robotics, and surveying.
- **ROS Software Framework:** ROS, or Robot Operating System, is an open-source framework for building robot software that provides tools, libraries, and conventions for creating complex robotic systems, used in research, education, and industry.
- **Hector SLAM:** Hector SLAM is a Simultaneous Localization and Mapping algorithm for mobile robots that uses laser range data and odometry to build a map of the environment and localize the robot, commonly used in robotics research and navigation applications.

DATA COLLECTION FROM NISER LIBRARY I

COLLECTION OF LOCALIZED WIFI RSSI VALUES:



(a) Simulation of Indoor environment

(b) SLAM generated using Hector SLAM

Figure. Illustration of working of Hector SLAM algorithm. [*ROS Hector SLAM Installation Guide Tutorials — samialperenakgun.com* n.d.]

Data collection from NISER Library II

Collection of localized WiFi RSSI values:

After SLAM is established, the robot then proceeds to sweep the area in a zig-zag manner (Followed by the same scan in perpendicular orientation afterward) and stopping at fixed distances for -

1. Collect WiFi RSSI Values at that location
2. Capture images from the 3 cameras onboard the robot.

The cameras help the robot collect other link-able data such as bar-codes of products kept on the aisle of a supermarket or book codes of the books in a library. This helps create a database that can be used in practice for navigating a user to a specific product or book after the model has been trained successfully.
Collected data for localized WiFi RSSi values is then used to process our model.

Developing Algorithm

- Get the location of all the access points by taking the weighted average of latitude and longitude with respect to the signal strength of the APs.
- Create rays of polynomials (degree of the polynomials being the hyper-parameters) for all the APs originating from the location of APs (calculated in step 1).
- Use kNN Regression to get the signal strength of the access point on the regular interval of distance on the rays.
- For each APs train all the polynomials to fit the signal strength in that direction.
- Then, predict the location of a received RSSI vector by finding the distance at which the given signal strength is achieved for each APs.

Developing Algorithm

- **Issues**
- We could not proceed with step 5 of the Algorithm development as getting the inverse of a polynomial is computationally hard.
- Polynomials at discrete angles.
- **Solutions**
- Using a function from $f : R^2 \rightarrow R$ and we will train this function to learn the signal strength around each APs.
- Perform gradient descent over this to predict the location based on minimizing the difference in the signal strength of each APs.
- Using this function will enable us to use the gradient descent method for predicting the location of a given RSSI vector.

References I

ROS Hector SLAM Installation Guide Tutorials — samialperenakgun.com (n.d.). `https://samialperenakgun.com/blog/2021/01/hector-slam/`. [Accessed 10-Mar-2023].

Singh, Navneet, Sangho Choe, and Rajiv Punmiya (2021). “Machine learning based indoor localization using Wi-Fi RSSI fingerprints: An overview”. In: *IEEE Access* 9, pp. 127150–127174.