INDOOR LOCALIZATION METHODOLOGIES

- Comparison of Methods of indoor localization using WiFi & LoRa Received Signal Strength Indication (RSSI)
  - Two Machine learning based Methods:
    - Random Forest Regression
    - Long Short-Term Memory (LSTM)
  - One Classical Localization Method:
    - Trilateration

Localisation with Trilateration

- The ML methods used "Finger Printing" of a Radio Map created by the RSSI values from 89 WiFi access points at known locations throughout the ECE basement.
- An automated data collection robot was built on a MUSHR car platform to collect radio map data.
- The Trilateration method used LoRa hotspots at known locations in the ECE basement and calculated distance based on Wave Propagation Equations for this research methodology, the proposed model features two LSTM layers after the input layer and employs a single drop-out layer in between the two LSTM layers to prevent overfitting. This structure was chosen for its simplicity and ease of implementation.

LOCALIZATION WITH RANDOM FOREST REGRESSION

Random Forest is a machine learning method that constructs multiple decision trees on randomly selected data subsets to improve prediction accuracy while reducing overfitting, requiring a large dataset and computational resources for training.

- Benefits:
  - Tolerant of missing data, multiple features, and outliers
  - Less prone to overfitting and easier to interpret

In comparison to other methods, Random Forest Regression was quicker to train than LSTM and the learned model consumed less memory. The disadvantage of the ML-based methods (Random Forest Regression and LSTM), is the need to collect WiFi RSSI data in the environment and train the ML model on a large dataset and computational resources.

LOCALIZATION WITH LSTM

LSTM is a machine learning method that is well-suited for modeling long-term dependencies in time series data. Random Forest Regression proved to be the most effective method of the three. Our future work will evaluate real-time performance on an embedded system and explore sensor fusion methods to improve accuracy. Random Forest Regression shows the most promise for future development based on its performance and computational cost.

COMPARING LOCALIZATION RESULTS

Average Euclidean Error (meters) and Mean Squared Error (MSE) to evaluate the accuracy performance of the models utilized.

1. The ML-based methods outperformed the trilateration method. Random Forest Regression proved to have the smallest MSE (1.6 m) and Average Euclidean Error (1.1 m).
2. The disadvantage of the ML-based methods (Random Forest Regression and LSTM), is the need for user training data or a "database" as well as hardware characteristics for path loss calculation.
3. The disadvantage of Trilateration is that the absolute location of the routers needs to be known as well as hardware characteristics for path loss calculation.
4. Random Forest Regression was quicker to train than LSTM and the learned model consumed less memory.

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