Enhancing Accuracy of Received Signal Strength Indication (RSSI)-based Indoor Positioning Systems for Elderly Safety

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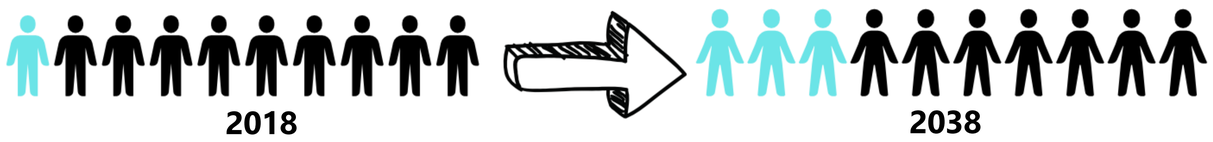
Introduction:

This project aims to improve and enhance the precision and reliability of current indoor positioning systems. Through a series of experiments and the integration of mathematical models, innovative methods such as wireless module calibration, signal fingerprint identification, triangulation, machine learning, and Time of Arrival (TOA) simulation are employed to enhance the accuracy of the RSSI-based indoor positioning system (IPS). Furthermore, the strategic deployment of multiple wireless access points or beacons is implemented to enhance the coverage and accuracy of RSSI indoor positioning. This research project aligns with the goals of the Hong Kong SAR Government by combining Gerontechnology with Low Power Wide Area Network (LPWAN) technology. This integration enables accurate tracking of elderly individuals in various environments. By enhancing the safety, well-being, and independence of elderly individuals, this project contributes to the government's focus on the concept of *"Aging-in-place".*

Background:

According to Census and Statistics Department's population projections, Hong Kong's aging population is expected to nearly double in the next 20 years, with the number of elderly individuals projected to increase from 1.27 million to 2.44 million. By 2038, approximately 31.9% of the population will be elderly, with those aged 75 or above representing 18.3% of the total population. This demographic shift underscores the urgent need for effective solutions to address the unique challenges faced by the elderly, including safety and healthcare management. Accurate and reliable indoor positioning systems are increasingly in demand to enhance the safety, independence, and overall quality of life for elderly individuals in Hong Kong.



ref:https://www.hkeconomy.gov.hk/tc/pdf/el/el-2019-02c.pdf

Objectives:

- To refine RSSI-based approaches for indoor positioning systems.
- To test these IPS technologies such as calibration, trilateration, signal fingerprinting, machine learning, simulated time of arrival (TOA), and sensor filtering to establish combined methods to improve the accuracy and precision of RSSI-based systems.
- To address environmental limitations of RSSI readings and results through continuous monitoring and adaptation strategies.
- To strategically deploy multiple Access Points (APs) to significantly enhance RSSI-based positioning coverage and accuracy.

Project Evaluation:

Strengths

- Integration of techniques such as calibration, trilateration, signal fingerprinting, machine learning, simulated TOA, and filtering enhanced accuracy.
- Utilization of robust data collection and pre-processing methods.

Limitations

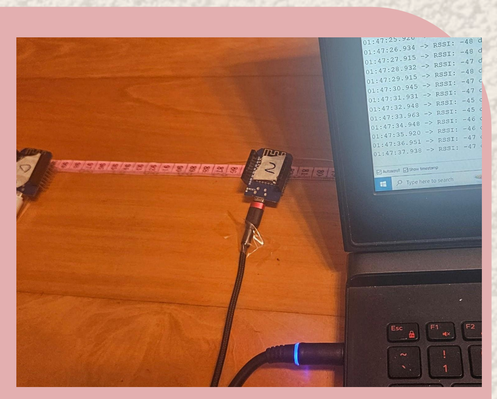
- Limited scope to RSSI-based indoor positioning systems, excluding other positioning technologies.
- Effectiveness may have been impacted by environmental variability and signal interference.
- Time constraints and complexity of implementation limited evaluation and optimization of the system.

Data Collection:

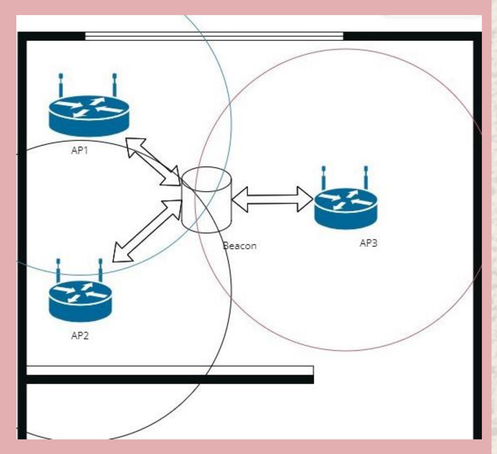
RSSI measurements were collected from multiple access points or beacons in the indoor environment. Measurements were taken at various positions to create a diverse dataset for analysis.

Methodology:

1. Calibration: Adjust RSSI measurements to account for signal propagation characteristics and environmental factors, reducing errors caused by signal strength variations.



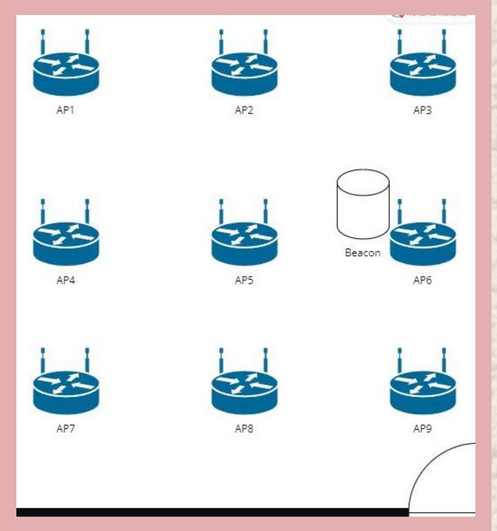
2. Trilateration: Determine position by utilizing distances between multiple access points or beacons, enhancing accuracy of RSSI-based positioning.



3. Signal Fingerprinting: Create database of RSSI patterns at different locations, compare real-time measurements for accurate position determined by matching signal patterns.

4. P2P2M (Peer to Peer to Merchant) Linearity Methodology:

i) Measurements: Apply various input signals, record corresponding output signals.
ii) Linearity Analysis: Use metrics to assess distortion, nonlinearity, dynamic range.
iii) Matrix Construction: Create matrix with input-output pairs as rows and measured values as elements.
iv) Optimization: Identify issues, optimize DUT by adjusting bias, implementing compensation.



5. Machine Learning:
Utilize machine learning algorithms to analyze collected RSSI data and predict the position of the tracked object or individual. Algorithms are trained using labeled data to improve accuracy.

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Iteration: 88 Best Fitness: 1195.0891
Iteration: 89 Best Fitness: 1195.0891
Iteration: 90 Best Fitness: 1195.0891
Iteration: 91 Best Fitness: 1195.0891
Iteration: 92 Best Fitness: 1195.0891
Iteration: 93 Best Fitness: 1195.0891
Iteration: 94 Best Fitness: 1195.0891
Iteration: 95 Best Fitness: 1195.0891
Iteration: 96 Best Fitness: 1195.0891
Iteration: 97 Best Fitness: 1195.0891
Iteration: 98 Best Fitness: 1195.0891
Iteration: 99 Best Fitness: 1195.0891
Best Position: [[0.2510066]]
Best Fitness: 1195.0891
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Conclusion:

Implementation of the proposed methodology led to significant improvements in accuracy and reliability of the RSSI-based positioning system.

The P2P2M linearity methodology provided a systematic approach for optimization, resulting in improved performance.

Overall, this research holds great potential for addressing the safety and well-being needs of the aging population in indoor environments.

Further research and development in this area can greatly enhance the independence and quality of life for elderly individuals.

UX/UI: