Enhanced LoRaWAN Indoor Localization Based on BP Neural Network

Presenter: Kai-Yu Lu
Supervisor: Prof. Yong Yue

Xi'an Jiaotong-Liverpool University
西交利物浦大学

Content

1. Introduction

Problems:

- The wireless technologies in the application of IoT include 3G, 4G, Bluetooth, ZigBee and Wi-Fi. While these wireless technologies are becoming mature, there is a choice between long-distance transmission and power consumption.

Purpose:

- Reach the goal of long-range transmission with low power consumption.
- Improve the accuracy of indoor localization.

2. Background

- Four wireless technologies
- LoRa and LoRaWAN
- RSSI-Distance Relationship
- Literature Review

2.1 Background: Four wireless technologies

Parameter	LoRa	Zigbee	Bluetooth	Wi-Fi
Data rate	50 – 300 Kbps	250 Kbps	~250 Kbps	Up to 600 Mbps
Transmission Range	30 – 45 Km LOS	2 Km LOS	10 – 20 m	~ 50 m
Frequency Band	434/868/915 MHz (country specific)	2.4 GHz	2.4 GHz	2.4 GHz
Max Power	2 mW	500 mW	1 W	1 W
Power Profile	Low	Low	High	High

2.2 Background: LoRa and LoRaWAN

- Chirp spread spectrum (CSS) is a spread spectrum technology in digital communication and it can improve the distance and performance of the wireless communication.

- Long Range (LoRa) is a novel technology using CSS modulation in LPWAN (Lower-Power Wide-Area Network), which targets at providing a long-range and power-efficient solution to the problem of IoT scalability.

2.2 Background: LoRa and LoRaWAN

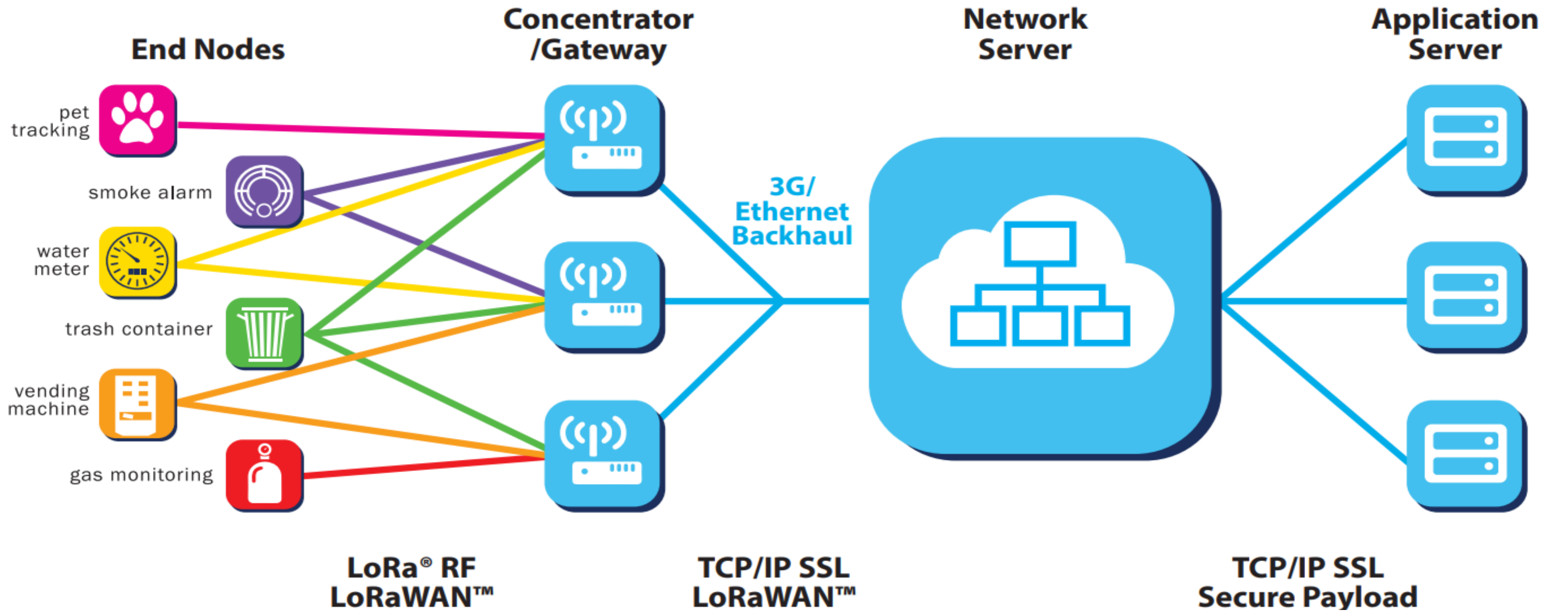
LoRa Key Properties:

- High Robustness
- Robust against Multipath and Fading
- Doppler Resistant
- Low Power Consumption
- Long Range Transmission
- Enhanced Network Capacity

2.2 Background: LoRa and LoRaWAN

LoRaWAN network are formed by several components of the network:

- End-Device
- Gateway
- Network Server
- Application Server



2.3 Background: RSSI-Distance Relationship

Log-normal shadowing model (LNSM) is a prevailing model suitable indoor environment:

$$RSSI = -10n\log_{10}\frac{d}{d_0} + RSSI_0 + X_\sigma$$

where:

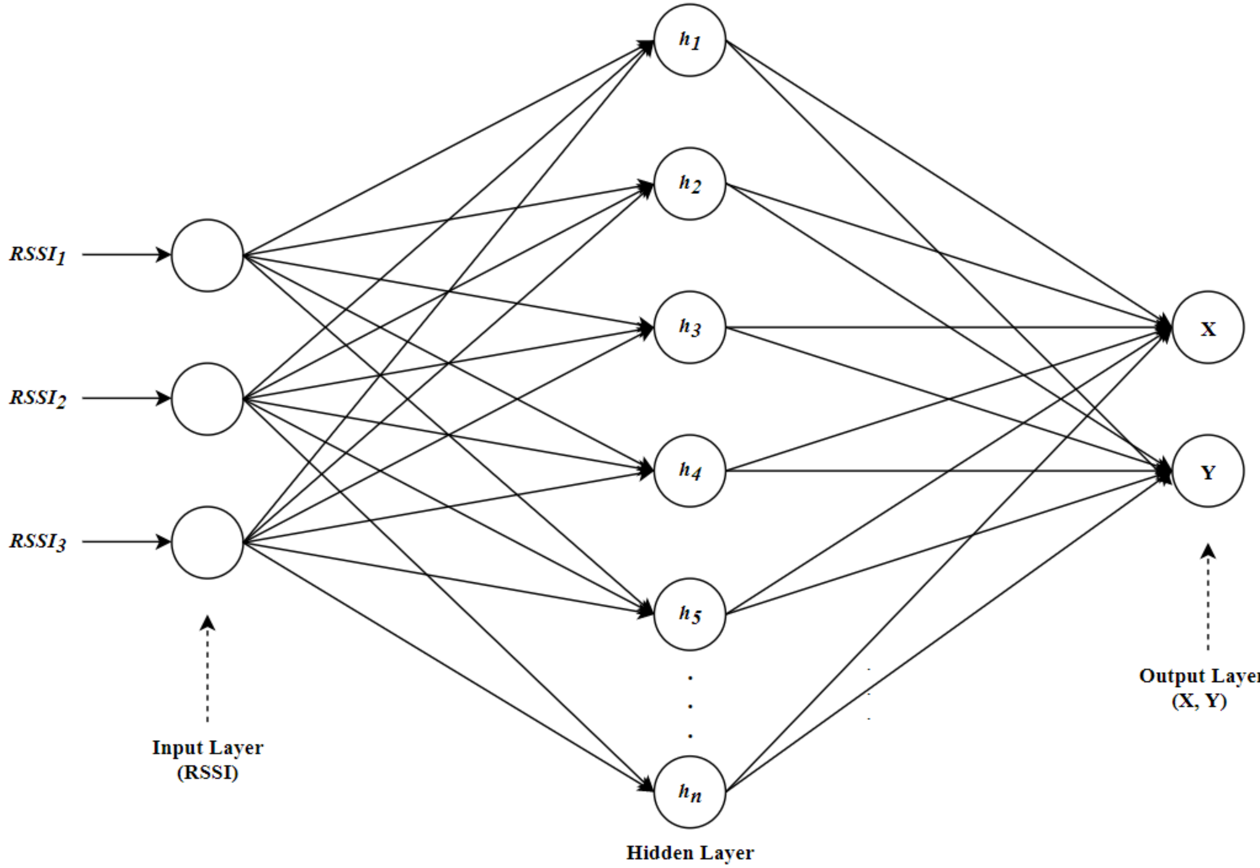
- $RSSI$ - the read-out value at an arbitrary distance d meters.
- d – the distance between the receiver transmitter.
- d_0 – reference distance which is from 1m to 10m typically. It is considered as 1m in this project.
- $RSSI_0$ – the measured RSSI when the distance is d_0.
- X_σ – the zero-mean Gaussian-distribution random variable.
- n – path loss exponent which is related to the wireless environment. n will increase with the increase of obstacles.

2.4 Background: Literature Review

- RSSI-based indoor localization was implemented by four wireless technologies, which are Wi-Fi, ZigBee, BLE and LoRaWAN. (S. Sadowski)
- Indoor ZigBee localization based on BP neural network and the Taylor series expansion was proposed by H. Q. Zhang and X. W. Shi.
- Applying RSSI Kalman filter and BP neural network for higher precision was presented by X. H. Zahng *et al*.

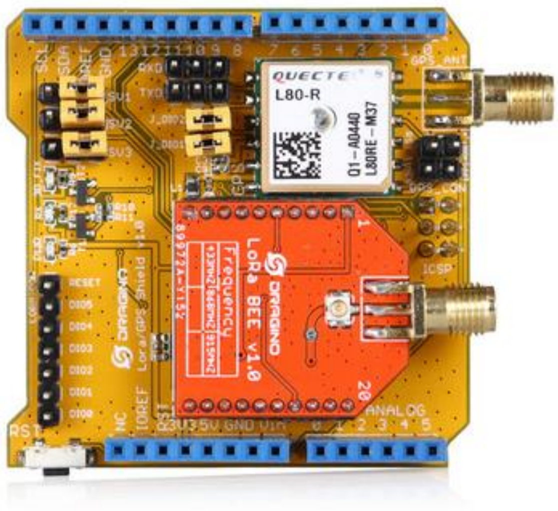
3. Proposed Strategy

Use multiple RSSI values from gateways and apply BP neural network with LNSM outlier filter to predict the corresponding position.



4. System Design and Implementation

Hardware:



LoRa GPS Shield

LoRa Gateway LG01-N

4. System Design and Implementation

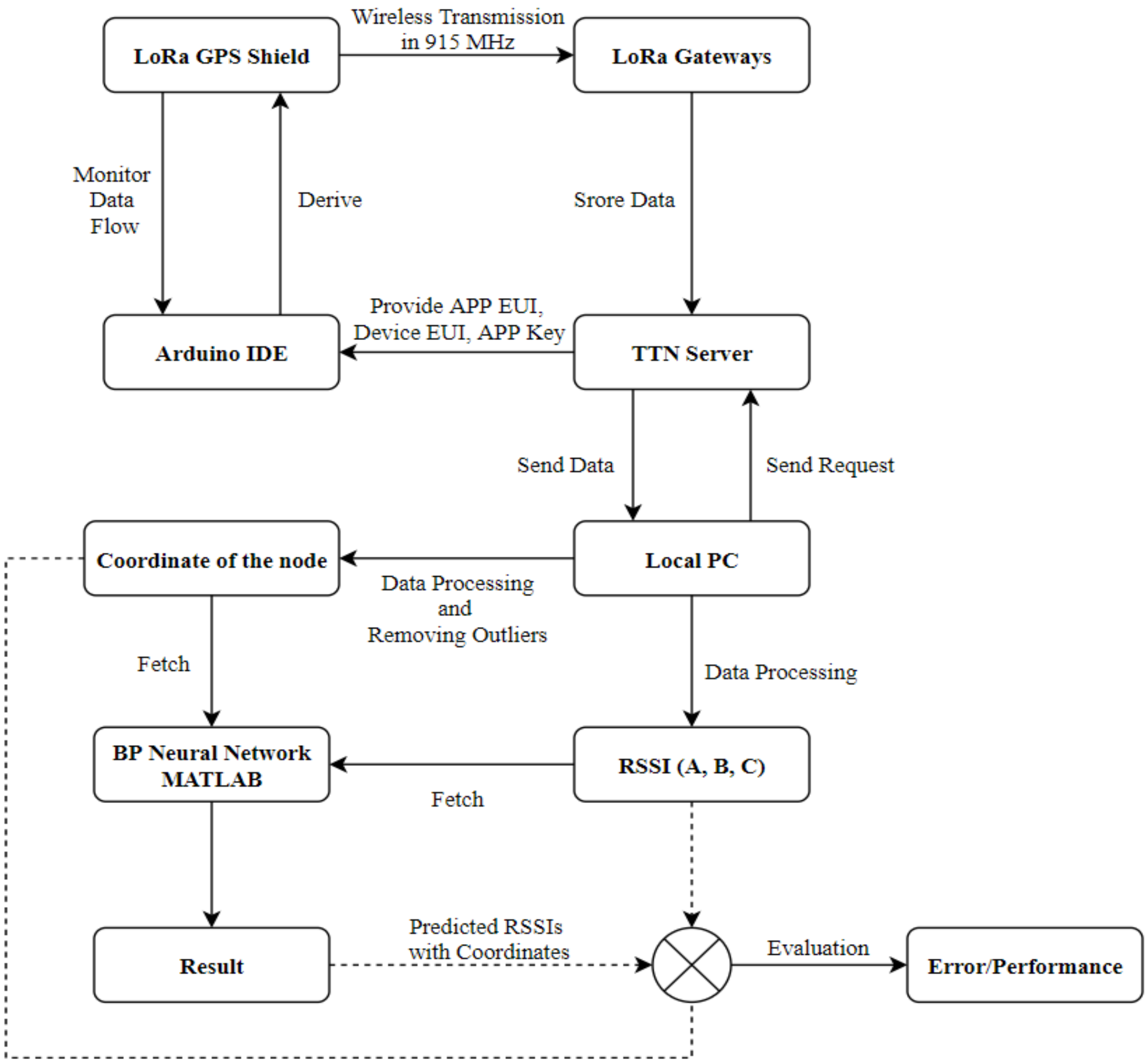
Software:

- Arduino IDE: Derive LoRa GPS Shield
- MATLAB: Realize BP neural network and the outlier filter

Network Server:

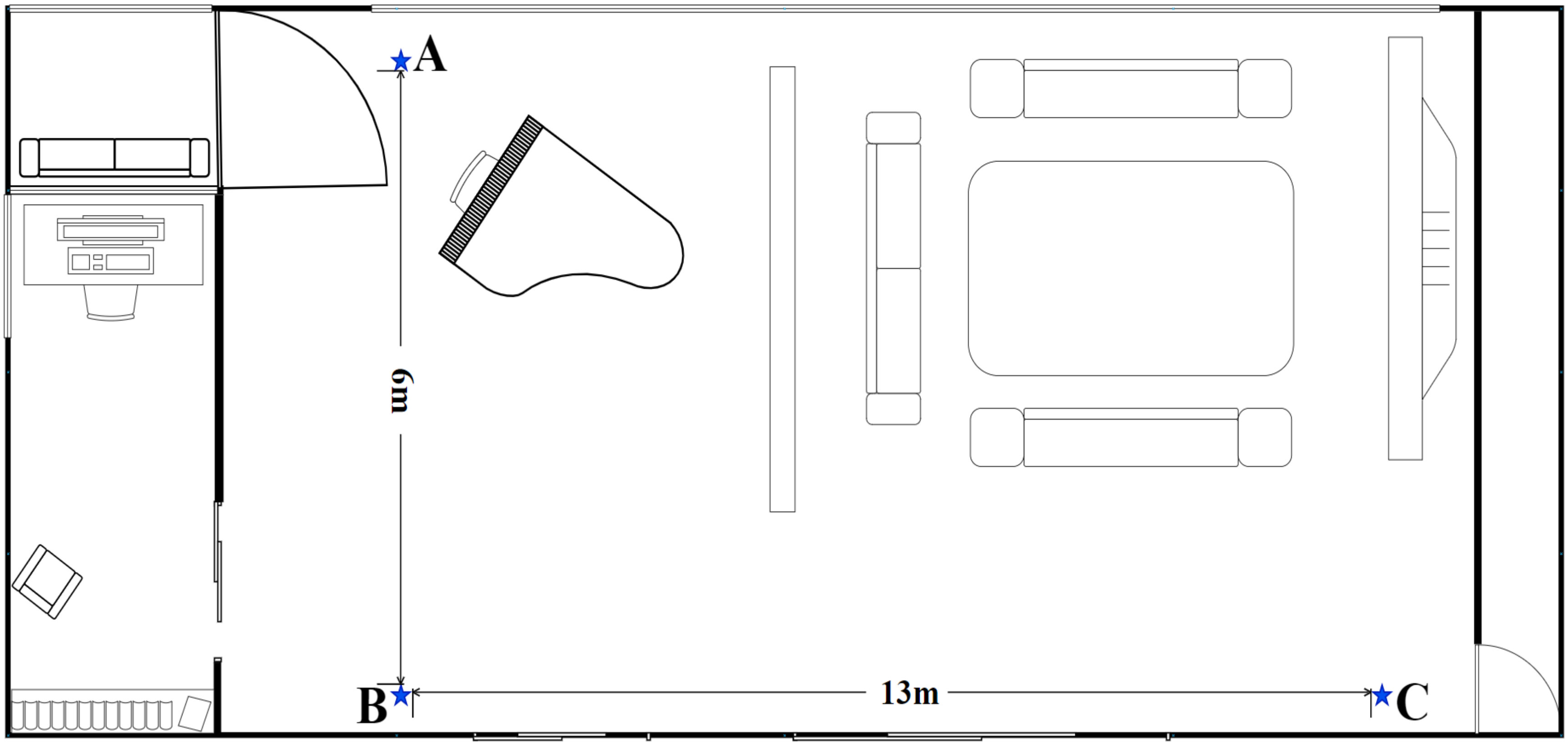
- The Things Network Server: Store and monitor data

4. System Design and Implementation



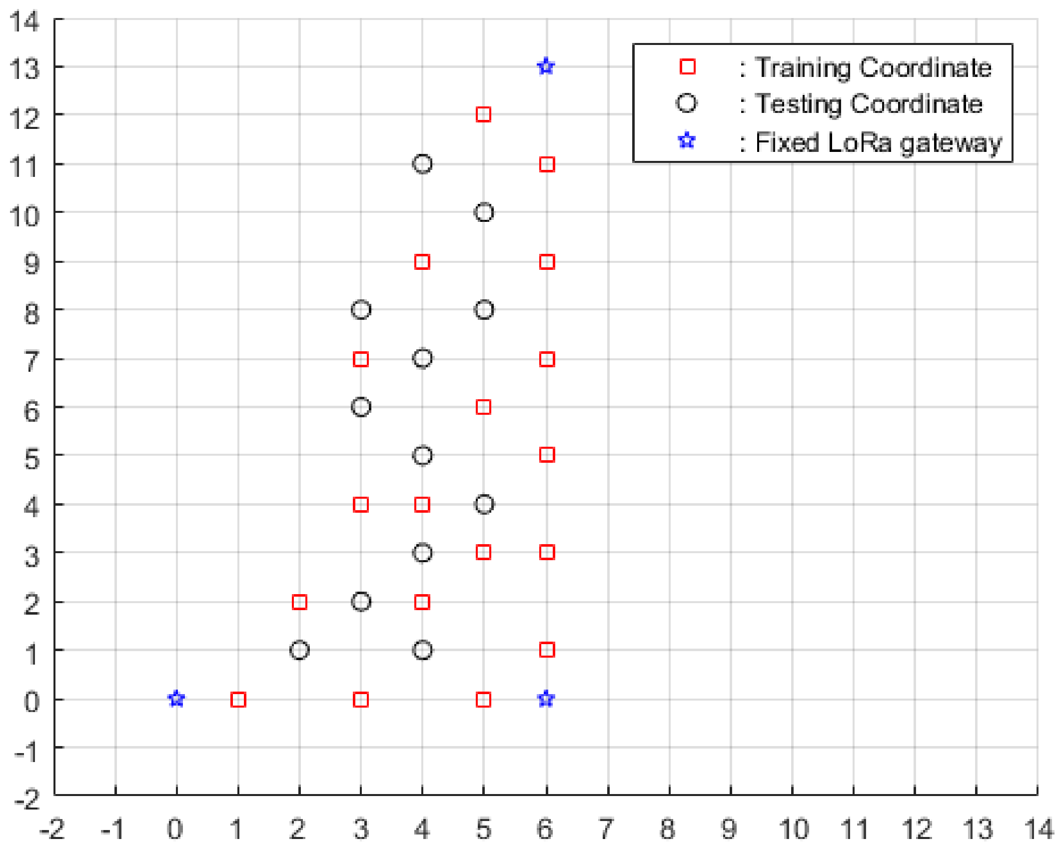
4. System Design and Implementation

Experimental Environment



4. System Design and Implementation

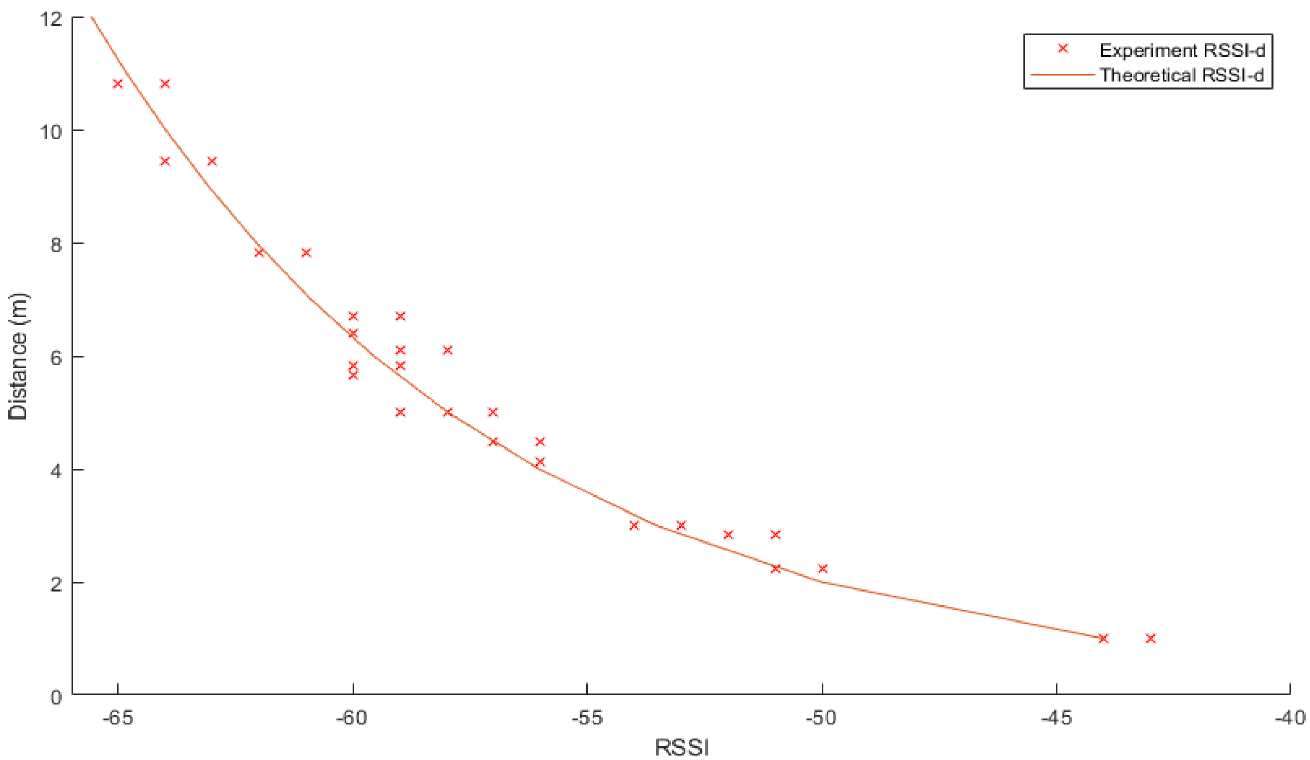
Measuring Topology



4. System Design and Implementation

Outlier Filter:

- Log-normal shadowing model
- Measuring the RSSI values in a long time



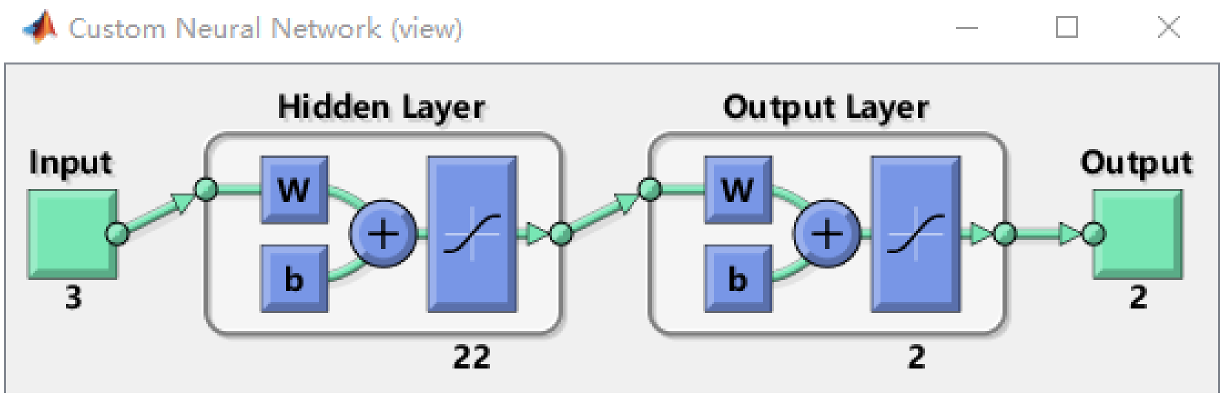
5. Experimental Result

- Structure of BP neural network
- Visual coordinate
- A table of distance error

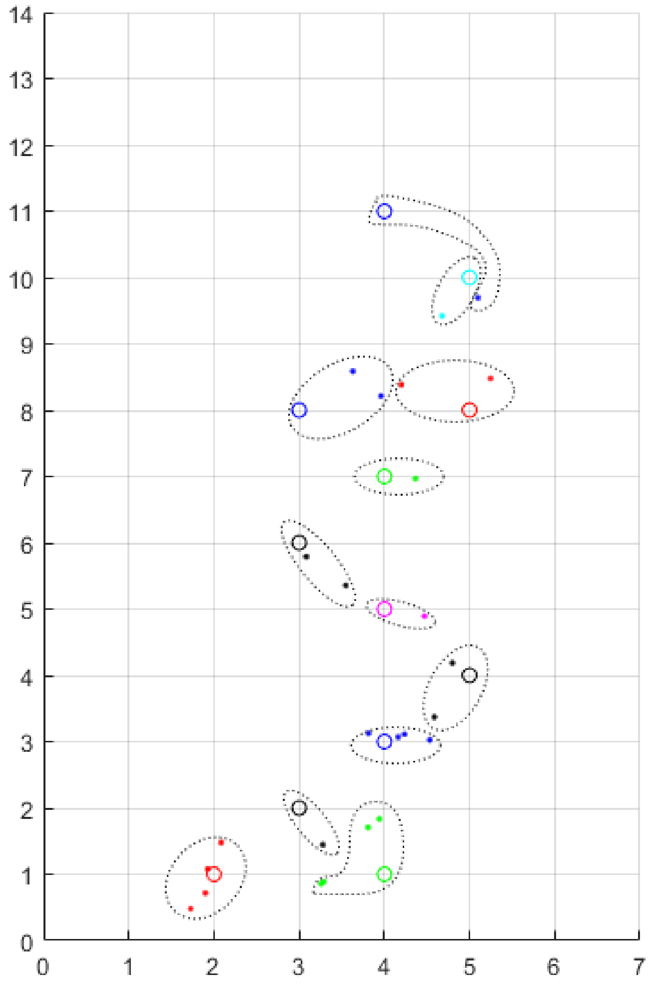
5. Experimental Result

Parameters of BP neural network:

- Structure: 3 – 22 – 2

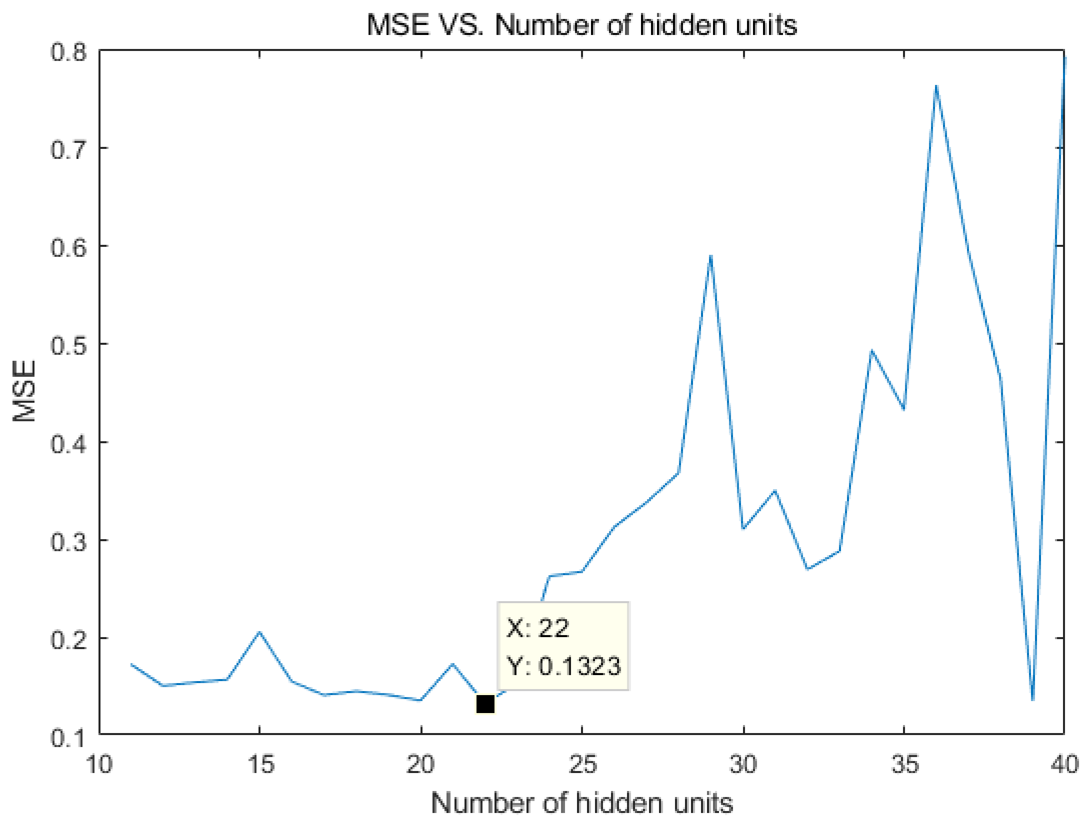


5. Experimental Result



Minimum Distance Error (m)	**0.1075 m**
Maximum Distance Error (m)	**1.7073 m**
Average Distance Error (m)	**0.5971 m**

5. Experimental Result



Trials for finding lowest MSE with corresponding number of hidden units

6. Evaluation

The proposed design system has higher accuracy than those in the literature review:

This project	S. Sadowski	H. Q. Zhang and X. W. Shi.
0.5971 m	1.19 m	2 m

- Higher accuracy
- Larger experimental area

6. Evaluation

❑ Superiorities of Proposed Design and Solution:

- Quickly establish a integrated system from bottom to top.
- Designed filter plays a significant role in removing outliers.
- Higher accuracy and larger experimental area.
- Becomes an inspiration for indoor localization strategy.

7. Future Works

- Project progress:
  - ✓ Can collect data without outliers.
  - ✓ Can send the collected data to the server.
  - ✓ Have built a BP neural network and it can predict the position in a satisfying range.
  - ✓ Provide a visual coordinate and a list of distance errors.
- Remaining work:
  - ➢ Try to adjust BP neural network for higher accuracy.

7. Future Works

- Explore larger size of the experimental area and more sites.
- Explore better measuring topology.
- Explore more types of neural network such as KNN, SVM and RBF neural network.

Thank You

Question?

Xi'an Jiaotong-Liverpool University
西交利物浦大学