Wireless Network Final
利用WiFi定位USRP

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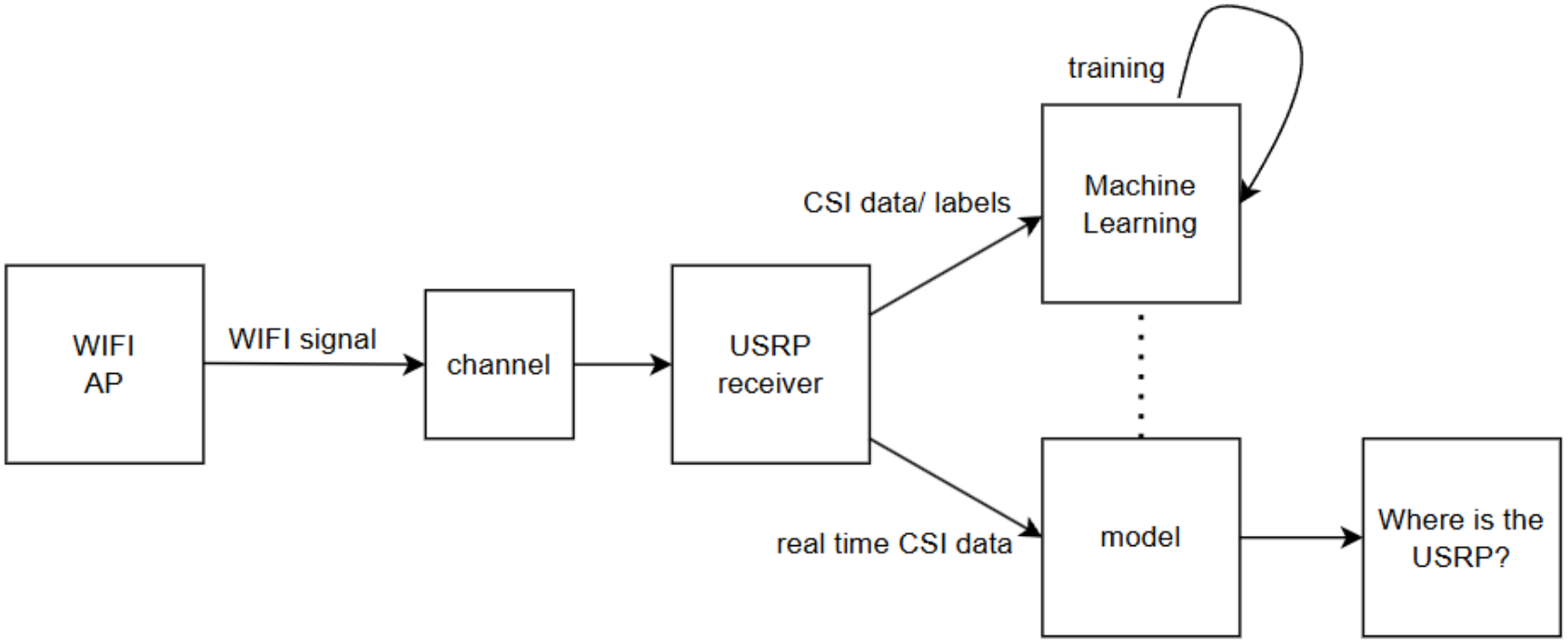
Introduction

- Motivation
  - Indoor localization is crucial for smart environments (robotics, AR, security)
  - Leverage existing Wi-Fi infrastructure
- Objective
  - Use Wi-Fi signals to determine location
  - Collect Channel State Information (CSI) from different spots
  - Train a model to classify based on CSI
  - Evaluate localization accuracy

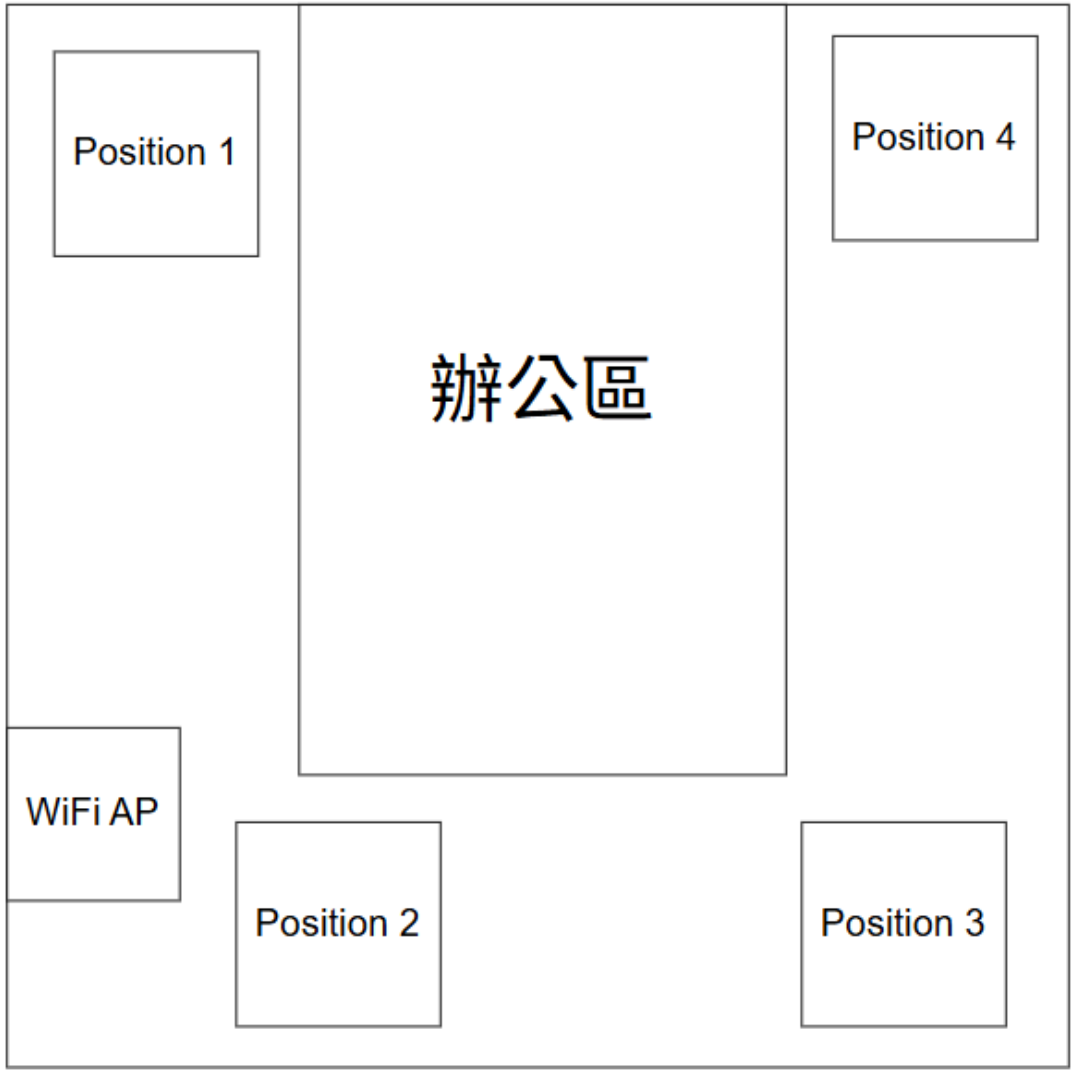
System Overview

- Transmitter: Wi-Fi AP
- Receiver: USRP B210 + Laptop running MATLAB



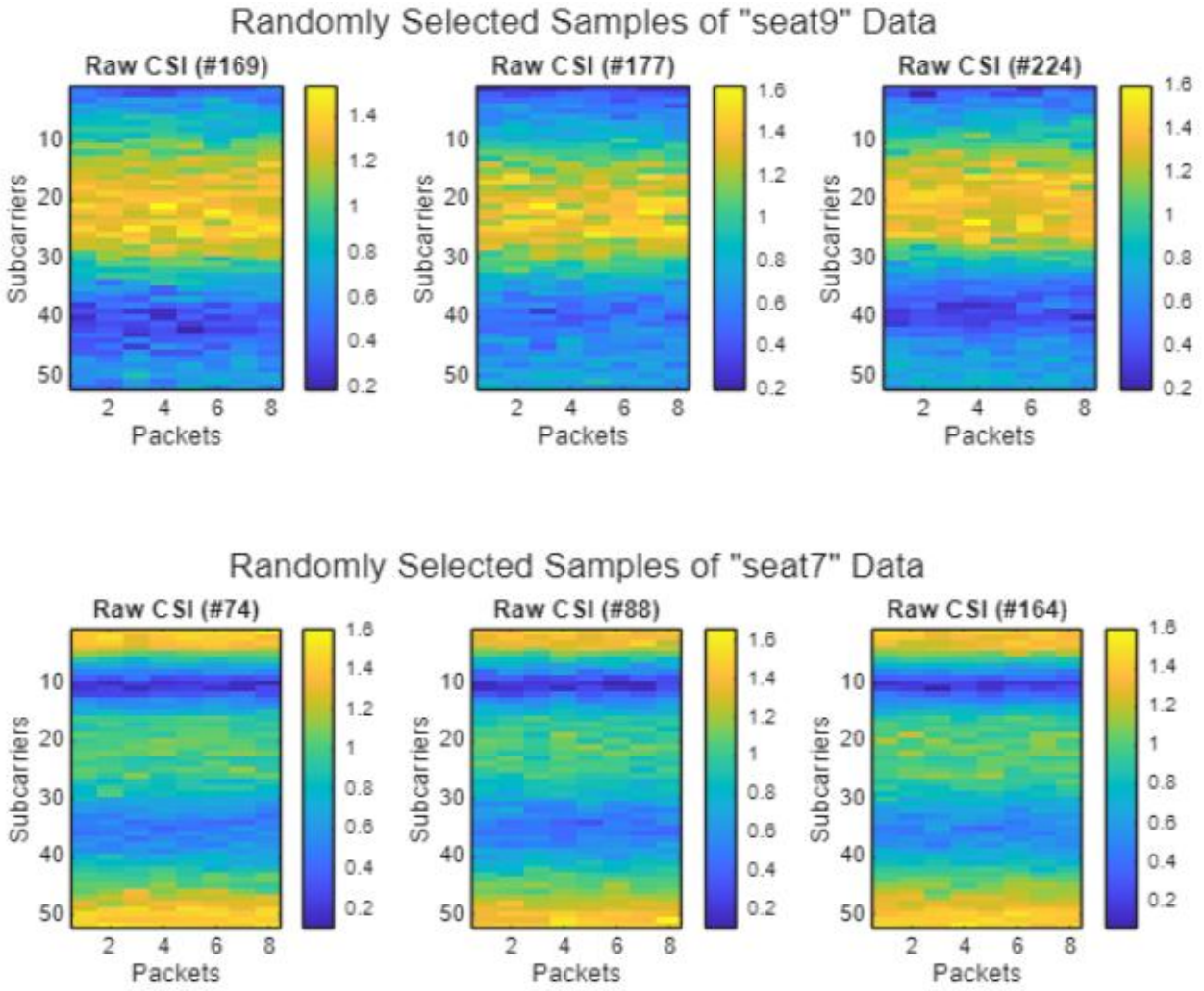
Data Collection Setups

- Environment: Lab Room, 4 position marked.
- Frequency: 5 GHz Wi-Fi
- Channel number: 149
- 8 packets per sample.
- Data amount
  - Position 1: 500 samples
  - Position 2: 900 samples
  - Position 3: 900 samples
  - Position 4: 500 samples



CSI feature extraction

- Extract complex CSI from received signals
- Transform into 2D spectrograms



Model Architecture

- Model: Convolutional Neural Network (CNN)
- Input: 2D CSI representation
- Output: Discrete location

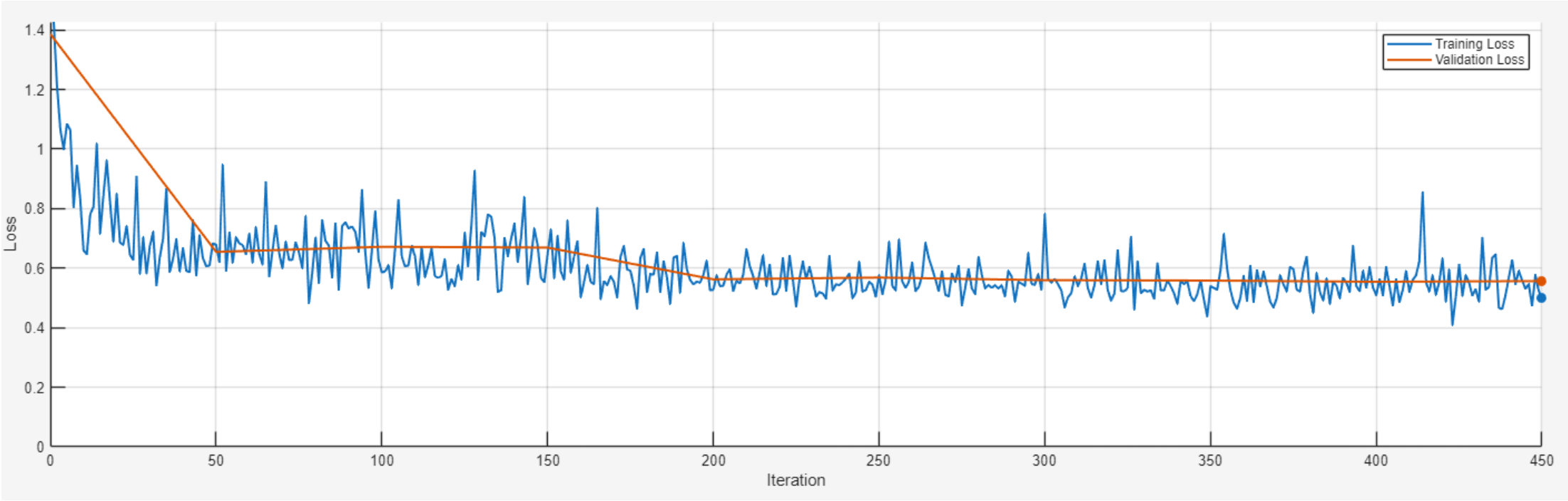
552.4k
total learnables

18
layers

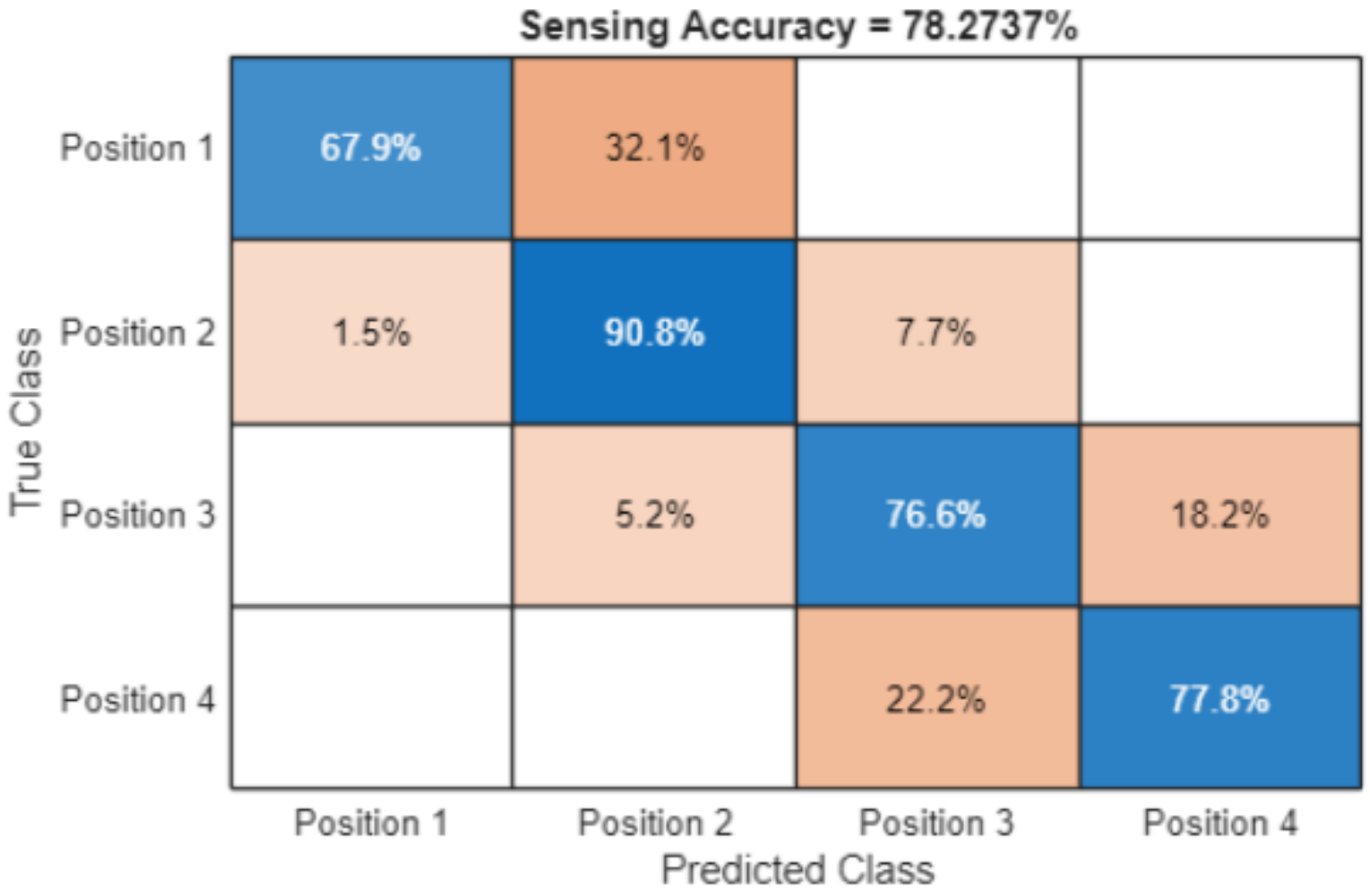
in 51×7×1 images with 'zscore' normalizati...	Image Input
conv_1 256 5×1×1 convolutions with stride [1 1] ...	2-D Convolution
batchnorm_1 Batch normalization with 256 channels	Batch Normalization
relu_1 ReLU	ReLU
conv_2 256 3×1×256 convolutions with stride [1 ...	2-D Convolution
batchnorm_2 Batch normalization with 256 channels	Batch Normalization
relu_2 ReLU	ReLU
maxpool 2×1 max pooling with stride [2 1] and pa...	2-D Max Pooling
conv_3 256 1×3×256 convolutions with stride [1 ...	2-D Convolution
batchnorm_3 Batch normalization with 256 channels	Batch Normalization
relu_3 ReLU	ReLU
hconvDW 64 groups of 128 1×3×4 convolutions wi...	2-D Grouped Convo...
batchnorm_4 Batch normalization with 8192 channels	Batch Normalization
relu_4 ReLU	ReLU
dropout 30% dropout	Dropout
gap 2-D global average pooling	2-D Global Average ...
fc 4 fully connected layer	Fully Connected
softmax softmax	Softmax

Training settings and Learning curve

- Epoch: 30
- Initial learning rate: 0.001
- Learning rate schedule: piece wise
- Dataset split: 70% train, 15% validation, 15% test
- Loss function: Cross-entropy (classification)

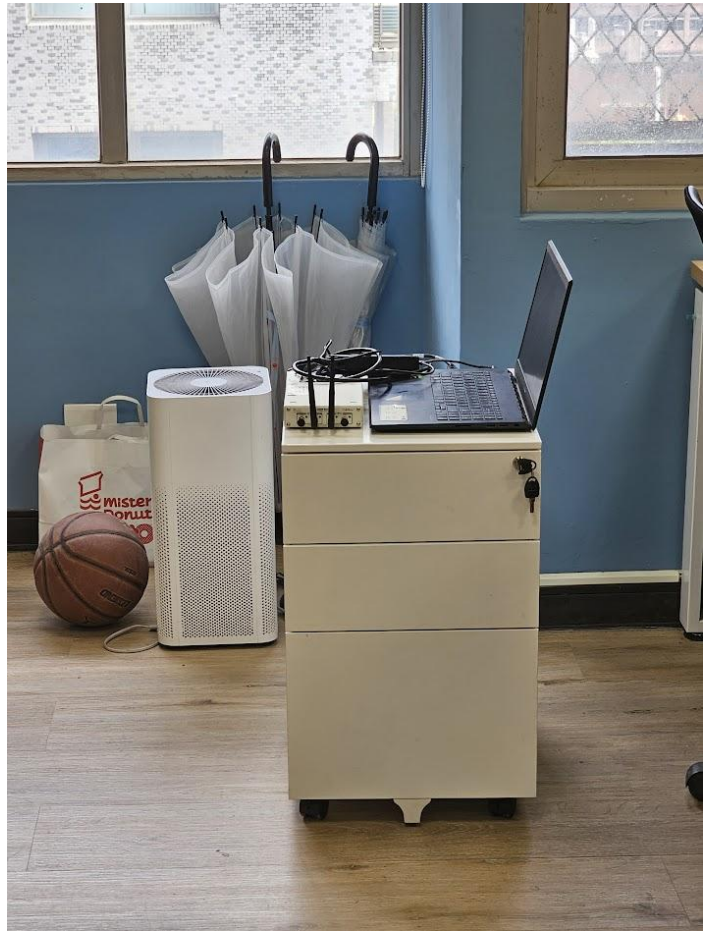


Testing Result



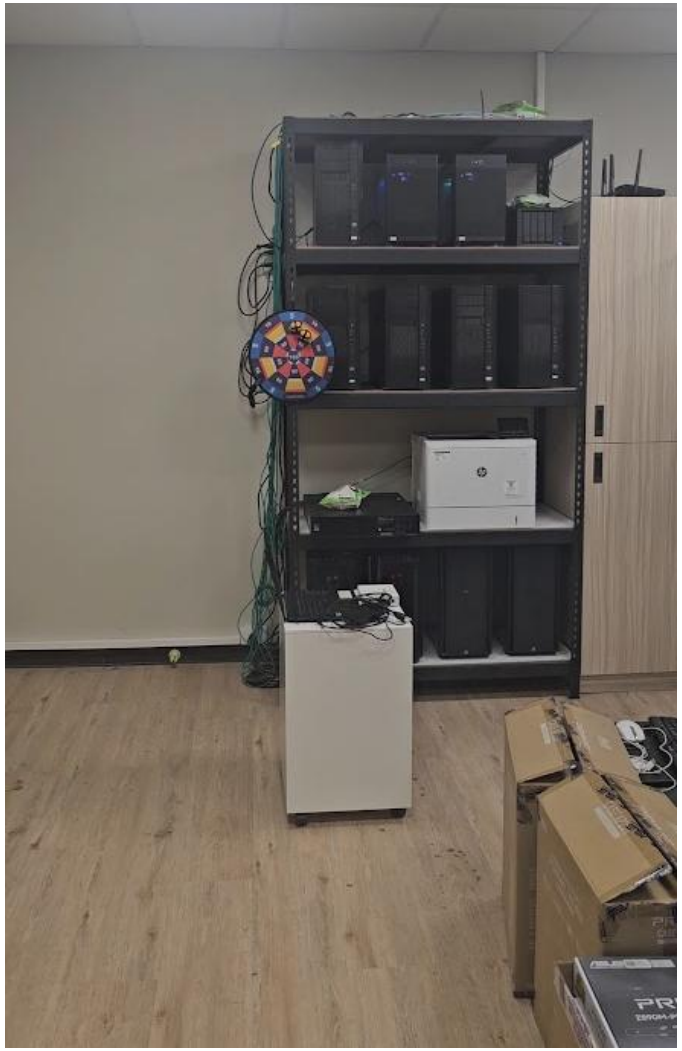
Real-time Demo--position 1

- 影片 檔太大請見report: Zone-1.mp4



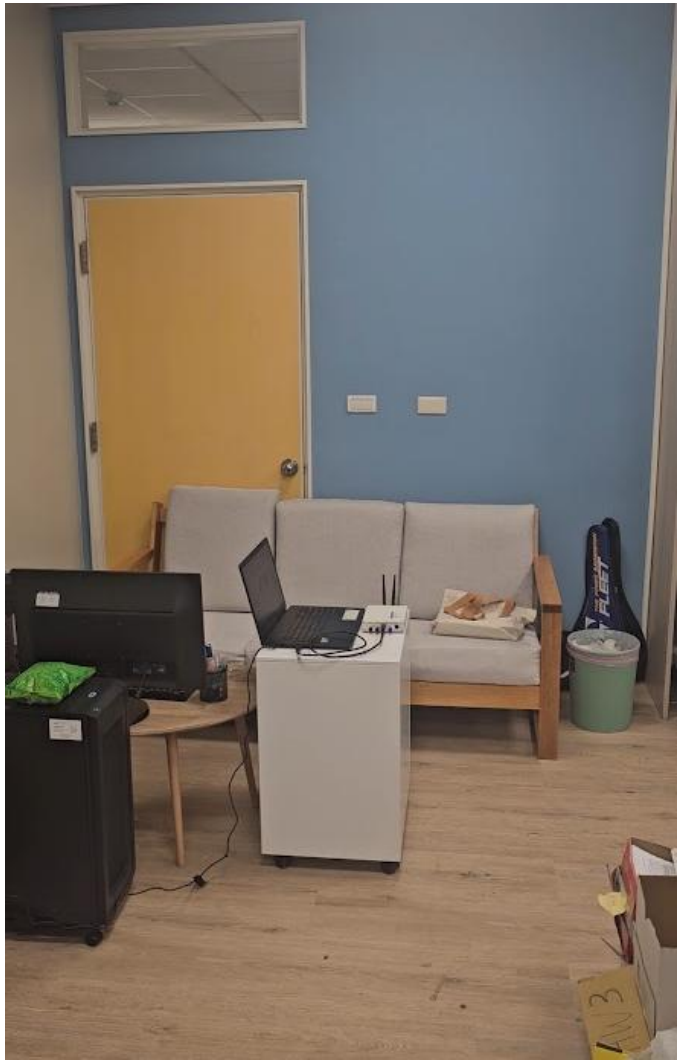
Real-time Demo--position 2

- 影片檔太大請見report: Zone-2.mp4



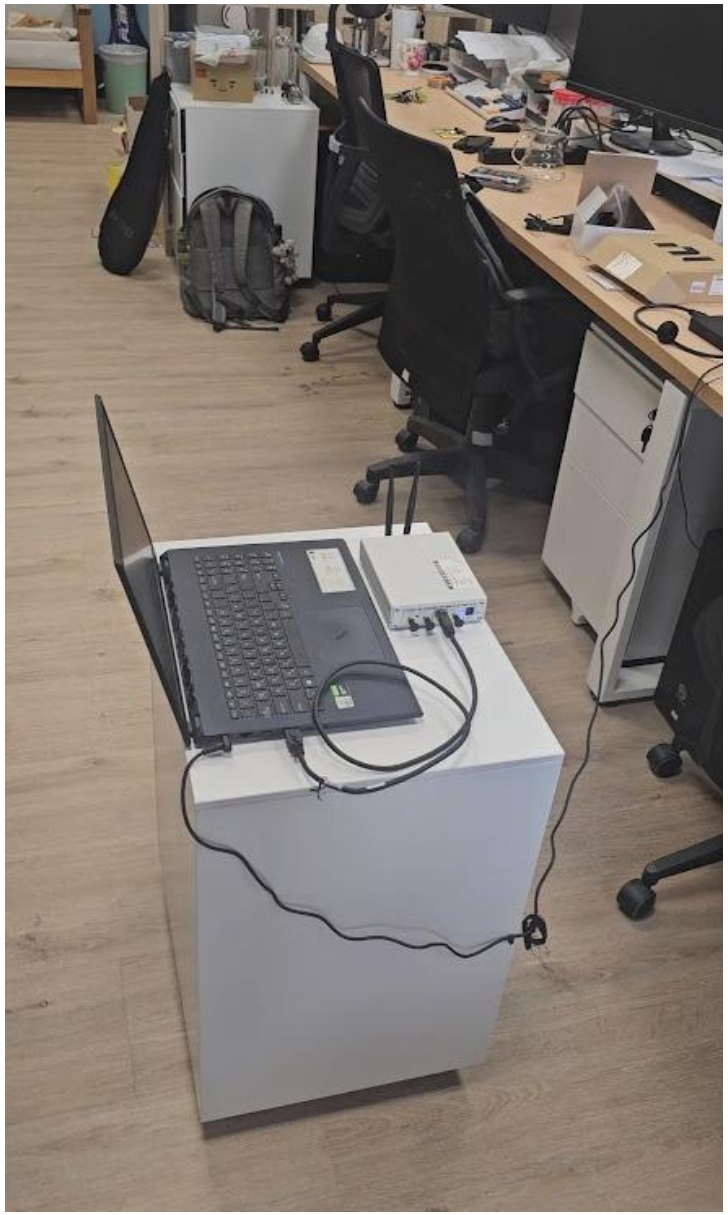
Real-time Demo--position 3

- 影片 檔太大請見report: Zone-3.mp4



Real-time Demo--position 4

影片檔太大請見report: Zone-4.mp4



Challenges

- Inconsistent CSI across time
  - Attempted to use two antennas for improved spatial resolution
  - Faced inconsistent behavior and driver warnings due to USRP limitations
  - Sometimes only one antenna provides usable data

```
Warning: Receive unsuccessfully: Could not execute UHD driver command in 'receiveData_burst_c': receiveData:ErrOverflowInBurstMode
Overflow occured in middle of a contiguous burst.
Recapture for 2th CSI
Warning: Receive unsuccessfully: Could not execute UHD driver command in 'receiveData_burst_c': receiveData:ErrOverflowInBurstMode
Overflow occured in middle of a contiguous burst.
Recapture for 2th CSI
```

Conclusion

- Successfully demonstrated CSI-based indoor localization using Wi-Fi signals and USRP
- Designed and trained a model to classify locations based on real CSI data
- Implemented and tested a **real-time location classification system**