

WIFI FINGERPRINTING

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Overview

- Indoor positioning system?
- Feasibility of using "Wifi fingerprinting" to determine a person's location in indoor spaces
- Wifi fingerprinting uses the signals from multiple wifi hotspots within the building to determine location, analog to how GPS uses satellite signals
- WLAN fingerprint based indoor localization method – based on RSSI values
- RSSI (dBm) - received signal strength indicator – measurement of the power present in the received radio signal
- Large database of wifi fingerprints for a multi-building campus with a location (building, floor, and location ID) associated with each fingerprint

Data

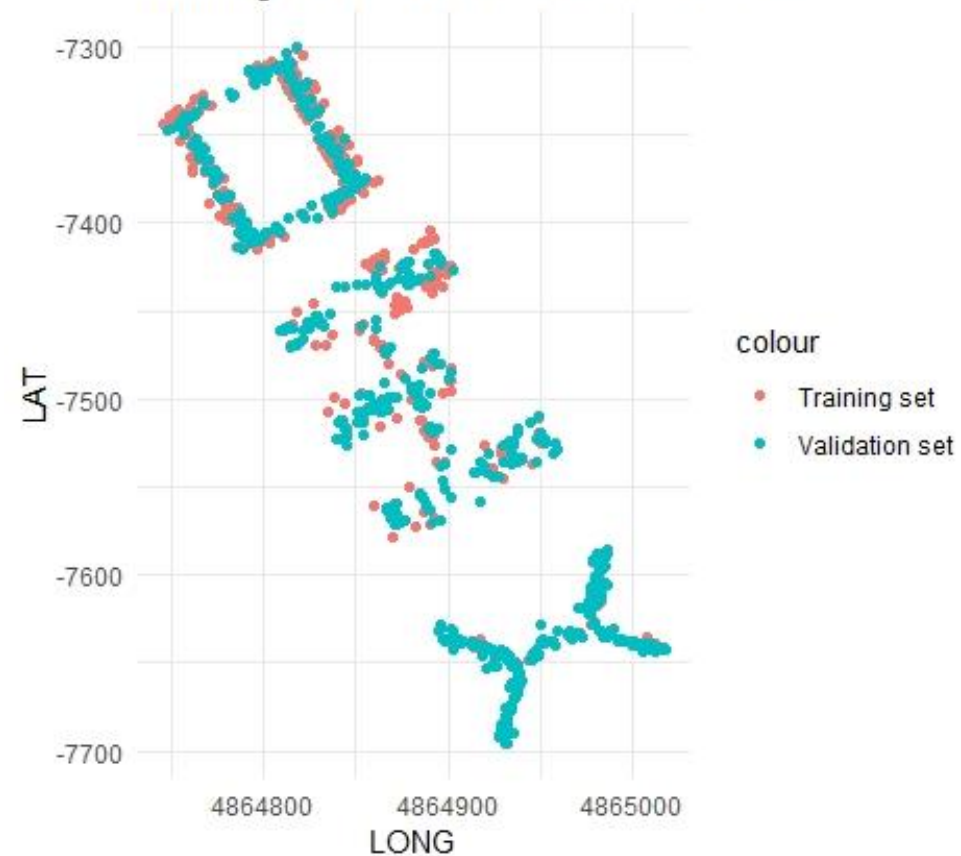
- Collected on university campus – 3 differently shaped buildings with 4 or 5 floors
- 933 reference points and 520 WAPs with RSSI values from 0 to -104 and no signal values as 100 dBm
- Almost 20 users and 25 different phones
- 19938 training set captures and 1111 testing set captures
- Training and testing sets collected 4 months apart
- Capture Loc app – info from app about the location sent to the server
 - process repeated 10 times for each location
- Validate Loc app – only WAPs and RSSI levels are sent to the server
 - app gets location (longitude, latitude and floor) from the server
 - accuracy is checked by asking the user – if inaccurate user sets right location

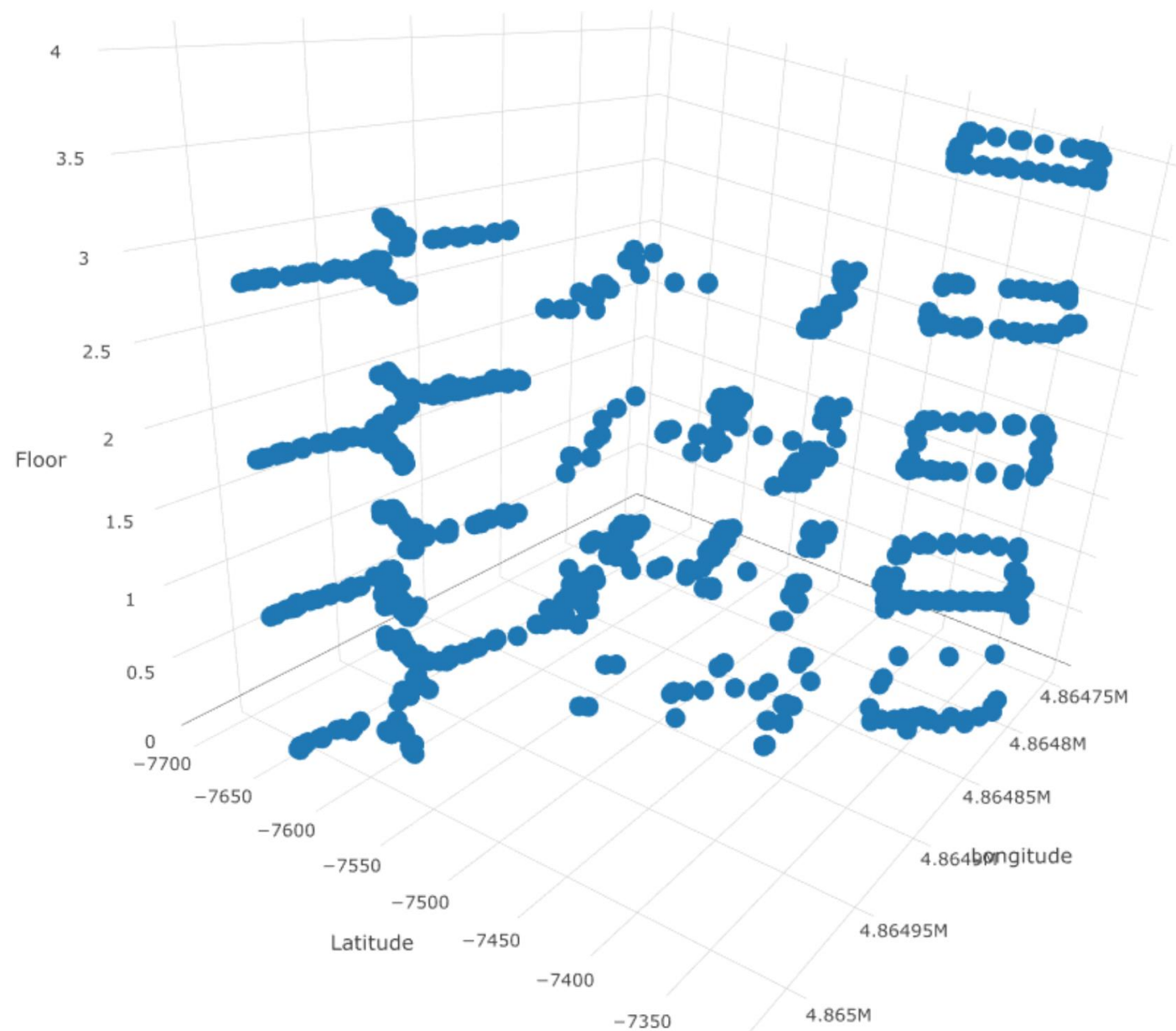
Exploratory Analysis and Data Pre-processing

- Data was converted to appropriate type
- Data was cleaned (duplicates, missing values, etc.)
- Undetected WAPs and observations with undetected WAPs removed (zero variance)
- Undetected RSSI value changed from 100 to -105
- Columns summarized by mean for same location and user (only ~10% of the data kept)
- Normalization by rows
- RSSI values below -90 dBm considered as no signal

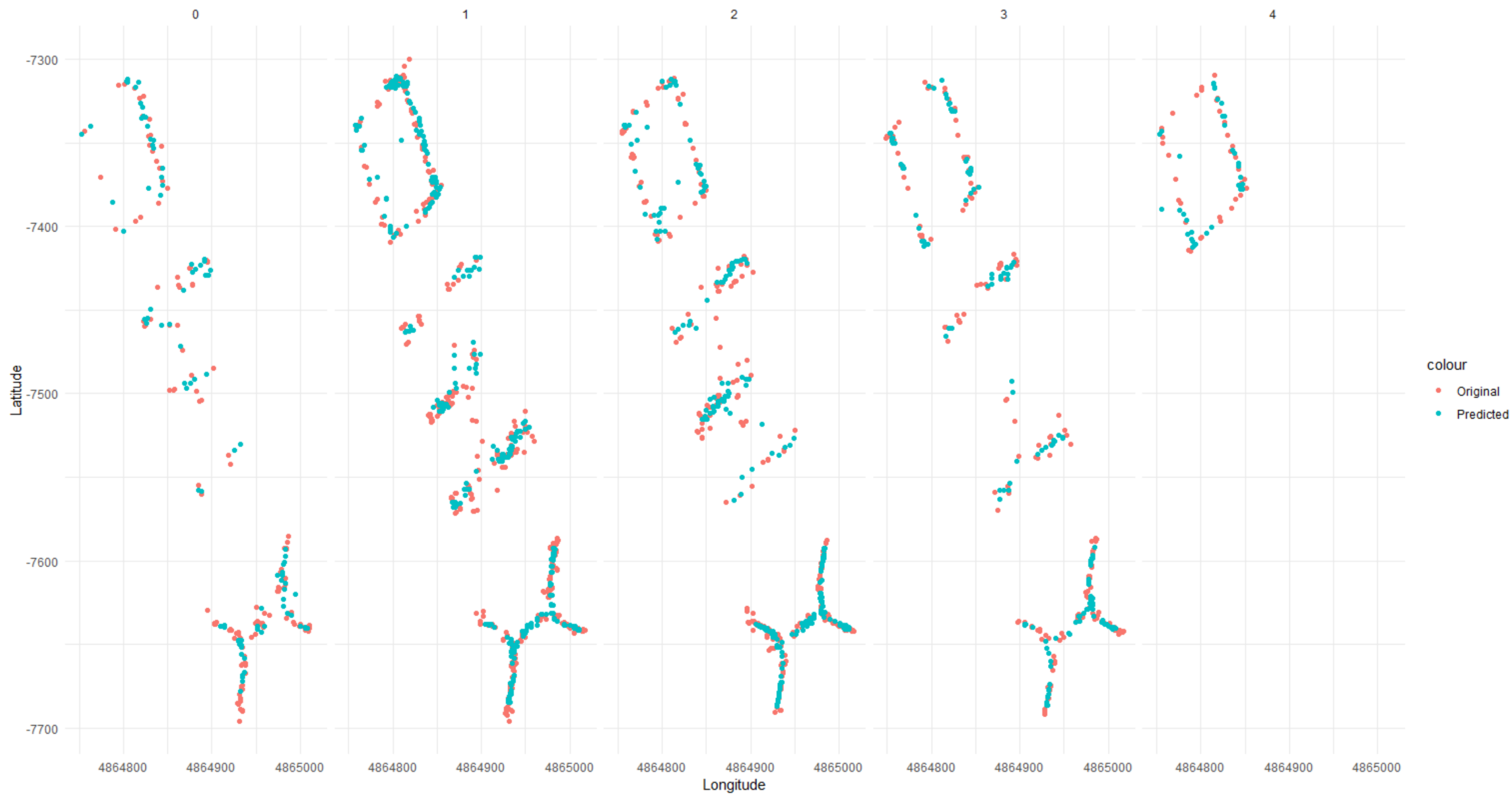


Training vs validation dataset locations





Validation location original vs predicted



Modelling and Results

- Algorithms used for modelling:
 - Random forest
 - SVM
 - KNN
- Classification and regression problem

Error evaluation

- Random forest has too high computational costs
- Response time is valued

BUILDING PREDICTION MODEL	ALGORITHM	PREDICTORS	TUNING	PERFORMANCE
	RANDOM FOREST	WAPs	Mtry = 2	Accuracy : 100% Kappa : 1
	SVM	WAPs	C = 1	Accuracy : 99% Kappa : 0.99
	KNN	WAPs	k = 1	Accuracy : 100% Kappa : 1

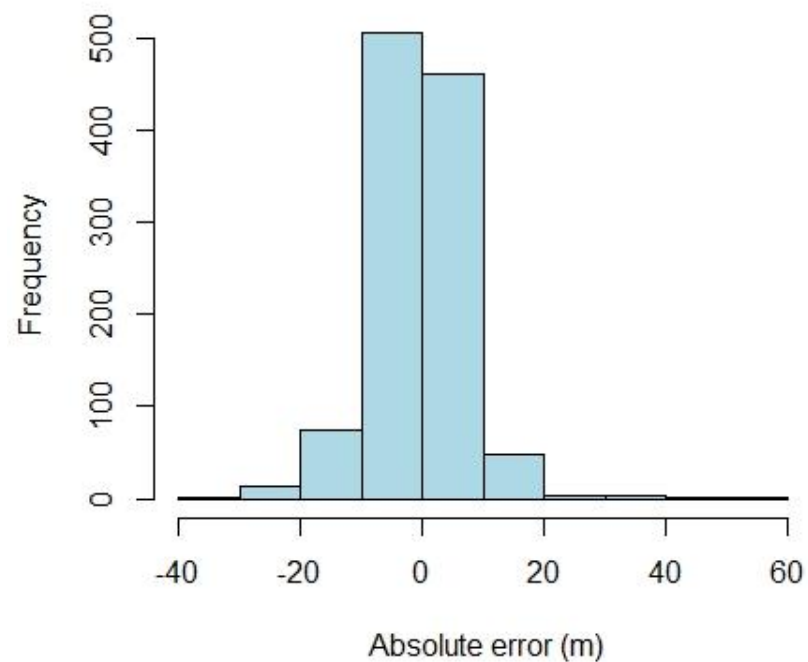
FLOOR PREDICTION MODEL	ALGORITHM	PREDICTORS	TUNING	PERFORMANCE
	RANDOM FOREST	WAPs	Mtry = 152	Accuracy :92.2% Kappa : 0.89
	RANDOM FOREST	WAPs + BUILDING	Mtry = 152	Accuracy :92.1% Kappa : 0.89
	SVM	WAPs	C = 1	Accuracy :90.5% Kappa : 0.87
	SVM	WAPs + BUILDING	C = 1	Accuracy :90.5% Kappa : 0.86
	KNN	WAPs	k = 1	Accuracy :92.1% Kappa : 0.89
	KNN	WAPs + BUILDING	k = 1	Accuracy :92.1% Kappa : 0.89

BUILDING AND FLOOR PREDICTION MODEL	ALGORITHM	PREDICTORS	PERFORMANCE
	KNN SVM RF	WAPs	Accuracy: ~91.6% Kappa: ~0.906

LONGITUDE PREDICTION MODEL	ALGORITHM	PREDICTORS	TUNING	PERFORMANCE
	KNN	WAPs	K = 5	RMSE: 7.21 R ² : 0.98 MAE: 5.03

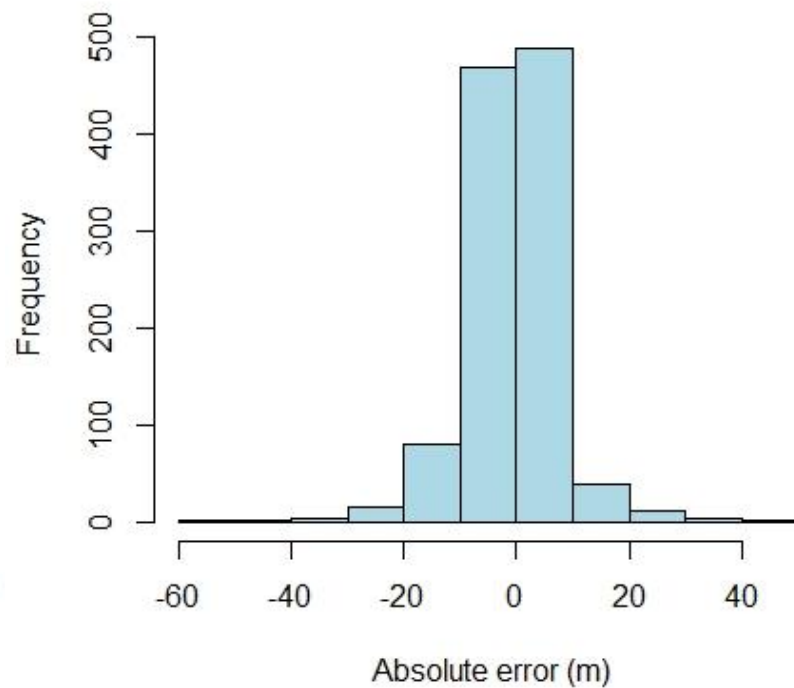
LATITUDE PREDICTION MODEL	ALGORITHM	PREDICTORS	TUNING	PERFORMANCE
	KNN	WAPs	K = 5	RMSE: 8.05 R ² : 0.99 MAE: 5.35

Distance error in meters LONGITUDE



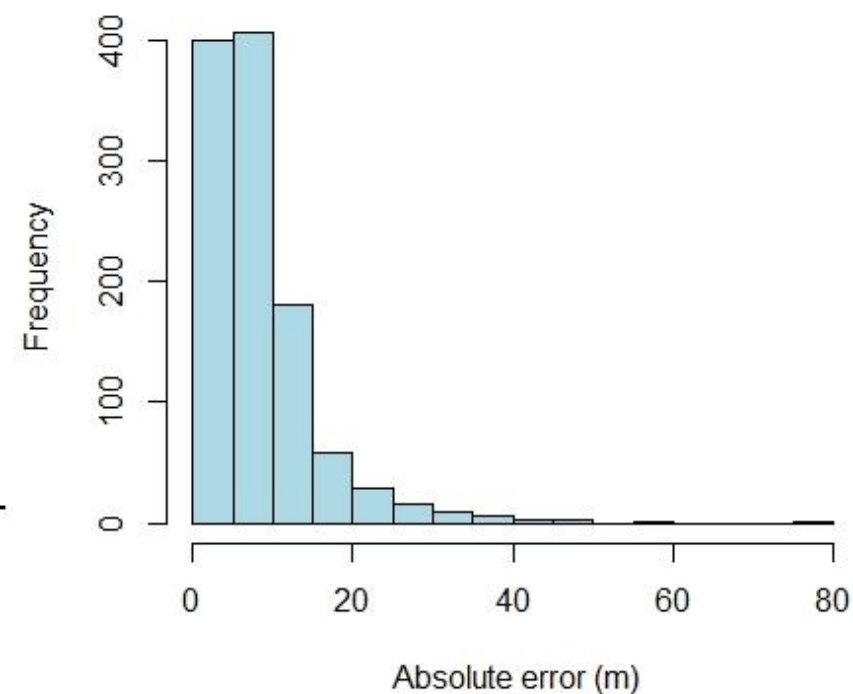
Error mean: 5 m

Distance error in meters LATITUDE



Error mean: 5.4 m

Distance error for position



Error mean: 8.2 m

Key insights

- Observed building issues:
 - Building 0 – 2 users – 4000 captures – good prediction
 - Building 1 – 12 users – 3000 captures – bad RSSI values – bad predictions
 - Building 2 – 16 different users – 6000 captures – predictions vary by floor
- Main factors that affect the number of scanned WAPs:
 - location (Wifi coverage)
 - mobile phone (Android version and hardware)
 - Position of the device
- Error range for GPS goes from 3 to 17 m and for WiFi from 5 to 15 m

Future actions

- Improvement of models through different approaches and different data preprocessing – PCA, separate models for buildings, converting RSSI values from logarithmic scale to linear, using only highest RSSI value of WAPs
- Investigation of bad service areas
- Detection of redundant WAPs
- Study of anomalies for RSSI value detection
- Analysis of device accuracy
- Other indoor locationing technologies (phone based) – bluetooth, sensors (altimeter, magnetometer, accelerometer)

Thank you!

Questions?