Indoor Localization Using WI-FI Fingerprints

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Introduction

• The majority of indoor location have Wi-fi coverage, users can connect to this wireless network.Therefore, it is possible to construct an indoor positioning system based on this infrastructure.

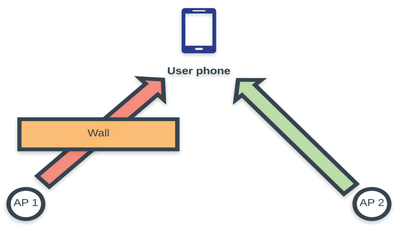
Problem

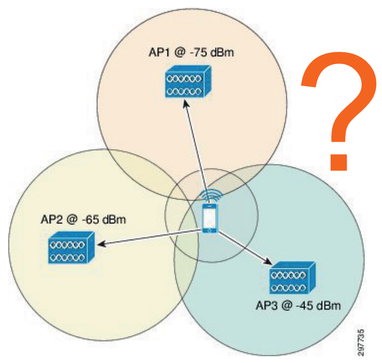
• The main goal is to perform a prediction of the indoor position of users.
• GPS signals cannot be used for indoor location due to attenuation caused by building walls and other materials.

• People turn to sensor-based systems to solve this problem such as WI-FI-based localization

• This technique performs poorly when used for determining a propagation model that describes the relationship between time to flight(TOF) and signal strength to predict the distance between the user and WI-FI routers.

• Static solution could not be applicable for long term usage (eg: mathematical model based on theoretical hypotheses), since those models need costly human recalibration, hence the need for a more dynamic solution.



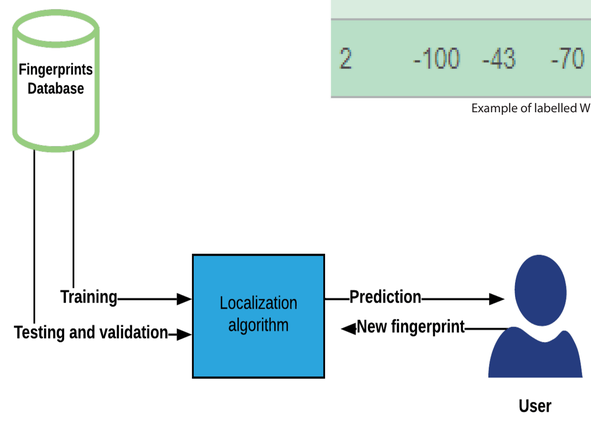


Solution

• We've chosen Wi-fi fingerprinting -based method to predict the user's position.
• It consists of mapping a space of physical measurement(signal strength from every router in the surveillance area(Dbm)) to a space of positions.
• The mapping operation utilizes the similarity in WI-FI signal strength within the region to assign every wifi fingerprint to the appropriate cluster.
• Instead of traditional methods ,this problem will be handled as a machine learning problem to reduce human intervention and guarantee dynamicity

index	AP 1	AP 2	AP 3	LABEL
0	-56	-83	-60	Classroom 1-E01
1	-87	-74	-56	Classroom 1-D03
2	-100	-43	-70	Amphi D

Example of labelled WI-FI fingerprints



Methods

1.Database creation and reconstruction:

• The database contains labelled fingerprints , each one includes a group of WI-FI signal measures with a reference to the point where it was measured.

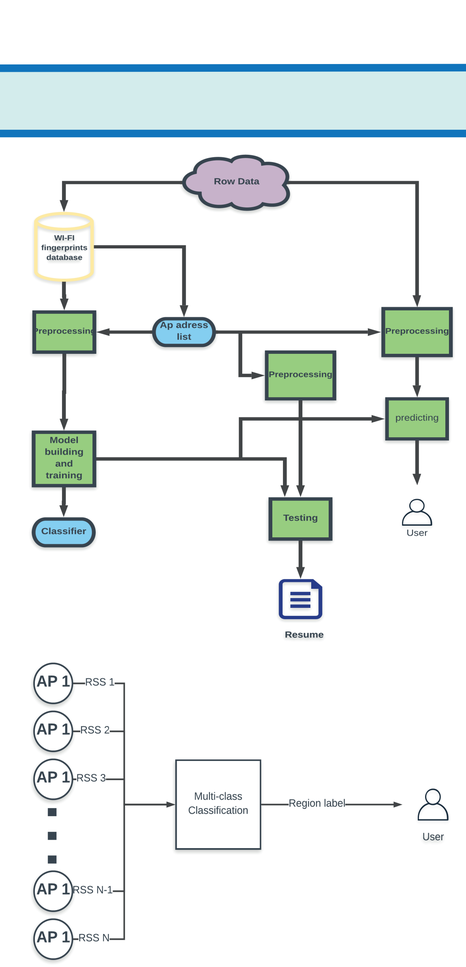
• We regroup those fingerprints as clusters where every cluster refers to a specific region in the surveillance area (eg: classrooms, hallway, amphitheatres …)

2.Model building and maintaining :

• Model training :
We've chosen random forest where we try to map WI-FI fingerprints to those class labels.
• Model validation :
recollect new fingerprints to test model accuracy, verify any possibility of overfitting and perform model parameters tuning for better results.

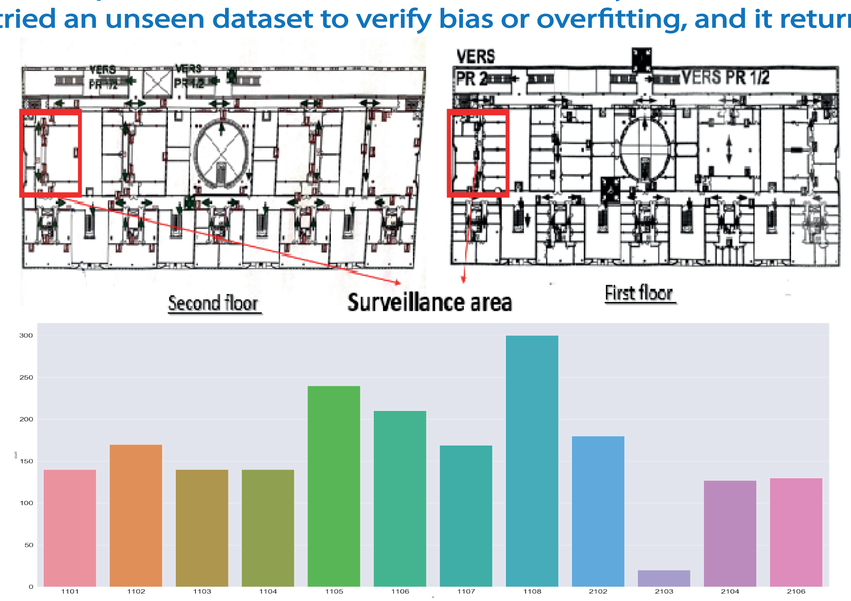
3.Deployment:

• The model is saved and then housed in a rest API that accepts both methods: post and request.
• The user scans for wifi signals, the fingerprint is then sent to the API, preprocessed to match the format of the input vector of our model. Finally, the API returns a prediction .

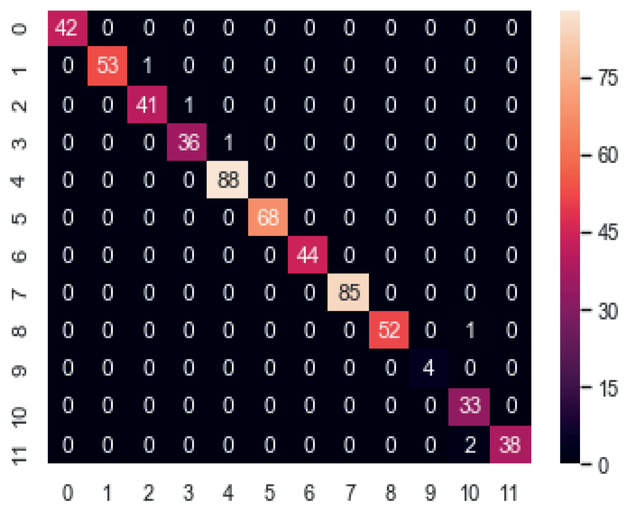


Experimentation

Surveillance area specifications: • First floor of the classrooms hall bloc E (8 classrooms)
• Second floor of the classroom hall bloc E (3 classrooms)
Number of wifi routers detected: 182 routers
Number of fingerprints collected for training: 1966 samples
Data collection method :
• We used a basic Android app to scan for WI-FI signals (mac address of the router and relative RSSI value).
• The data then preprocessed to create a normalized dataset and fed to the model after splitting between test and train dataset.
• model used : Random forest from Scikit-learn implementation
• Parameters: 100 estimator, max depth:50 ,criterion: entropy
Model accuracy :
• The model performed well with a + 95 % accuracy.
• We tried an unseen dataset to verify bias or overfitting, and it returned an identical level of accuracy.



fingerprint's spatial distribution



Covariance matrix(589 samples)

Conclusion

• Accuracy must be verified periodically using a new testing dataset to see if we need to tune model parameters.

• This experiment phase(includes 11 classrooms) showed good accuracy that encouraged us to enlarge the surveillance area so we can verify the scalability of this solution.

• We are aiming to move to a more challenging problem: predicting the exact position of the user (spatial coordinates of the user) ,thus the need for a regression model.

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