Samira Naghiloo
IOT analytics
Samira.naghiloo@gmail.com

Indoor Localization

Many real world applications need to know the localization of a user in indoor environment.

Why Not GPS:

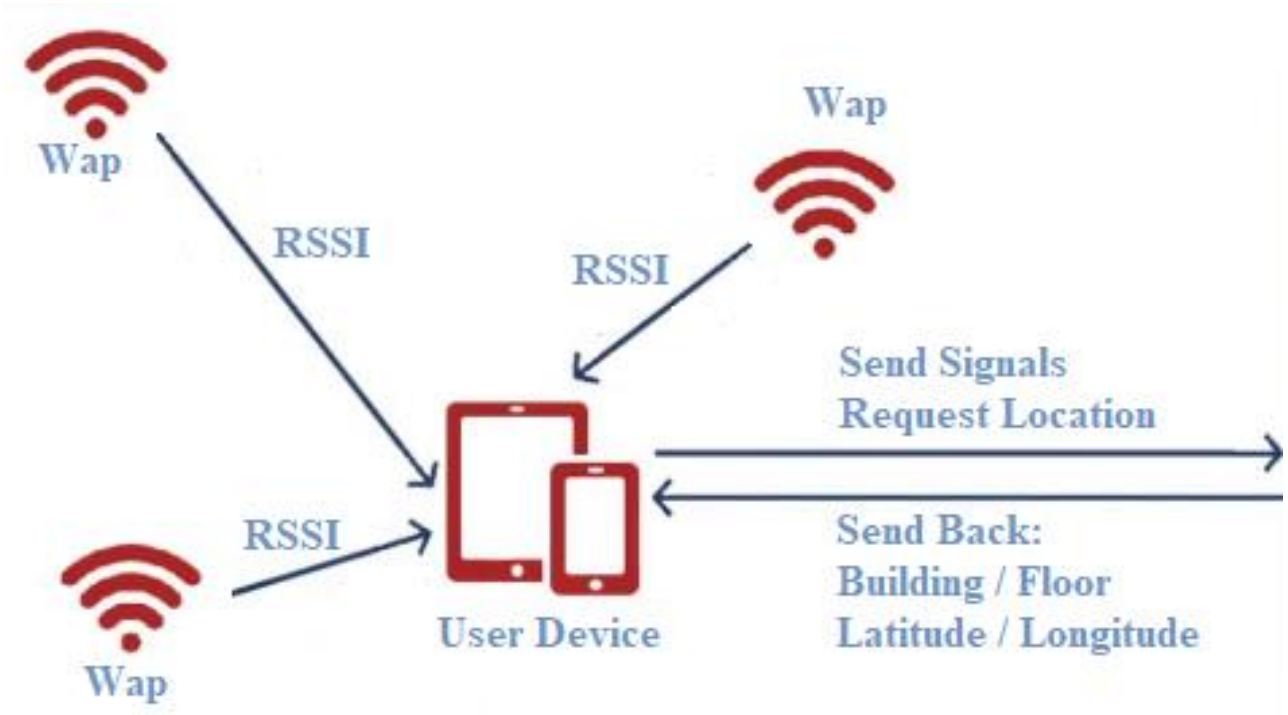
- Doesn’t work indoors
- Operate just in two dimension

Indoor Localization Technique:

- Ultra Wideband
- Wi-Fi
- Bluetooth
- RFID
- Camera
- …

Goal: Build models that predict the location of user from the WAPs signal in indoor

Wifi positioning system



Aggregation & Computation Server

Data Explanation

Data Set Includes three buildings of Jaume I university in Spain, with 4 or 5 floors

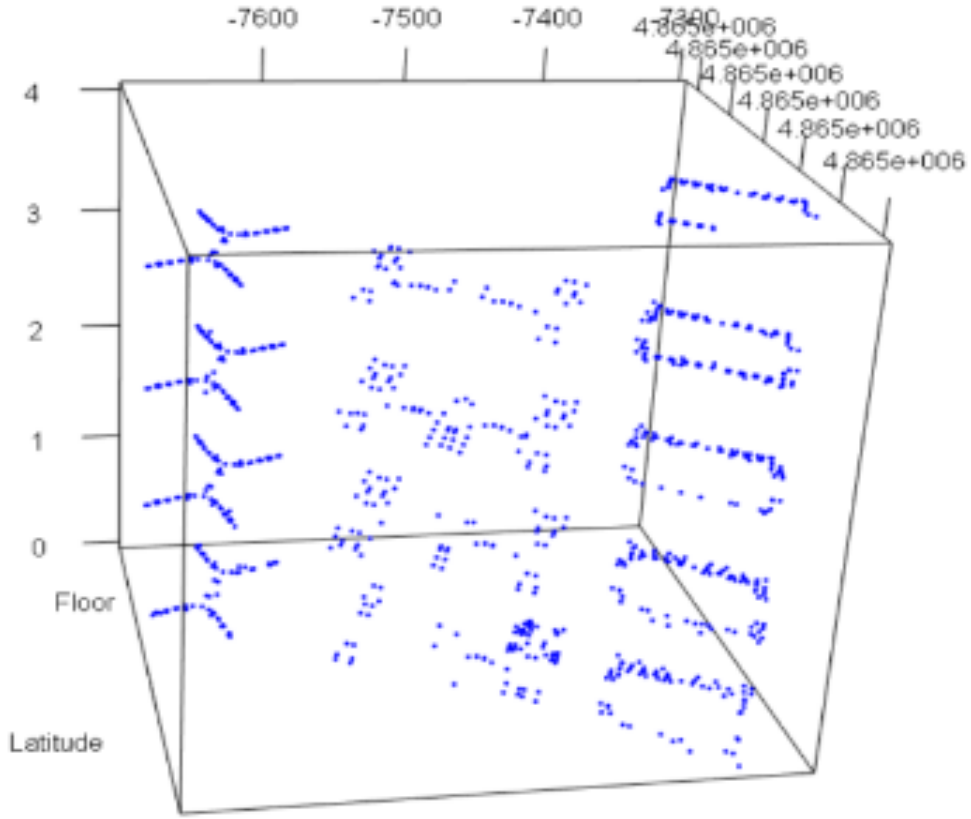
Includes:

- 19937 records in training data set
- 1111 records in validation data set
- 529 variables

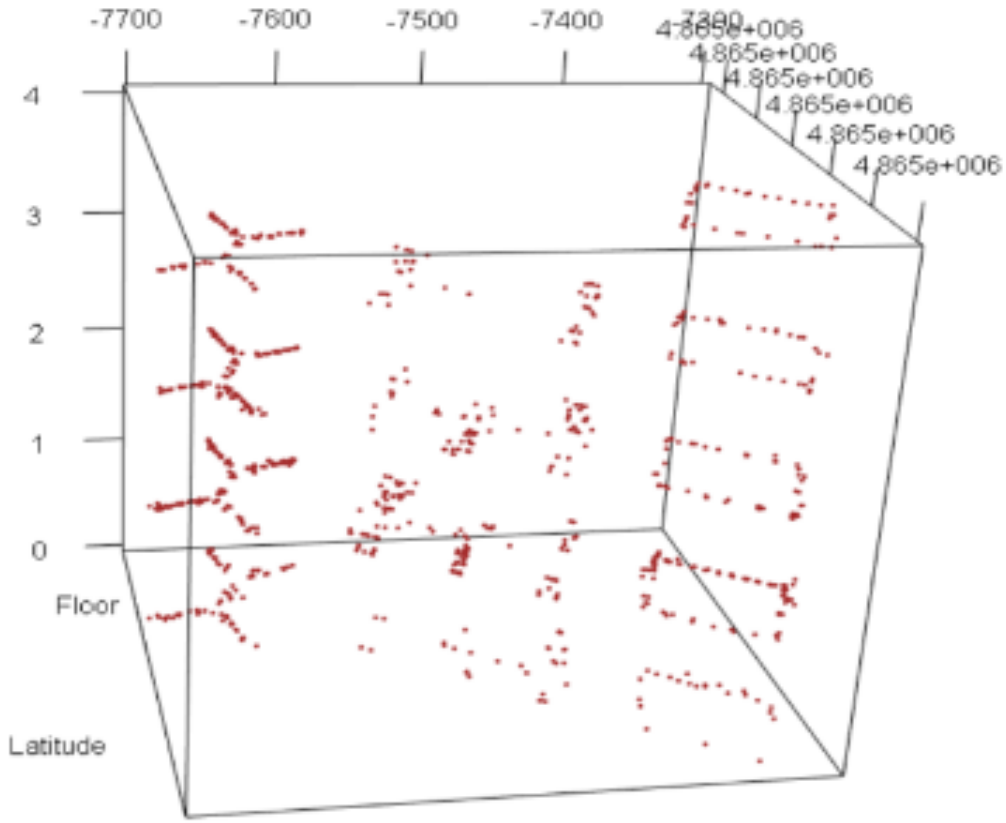
Variables:

- 520 Waps
- Longitude/ Latitude
- Building ID/ Floor
- Space ID
- Relative Position
- User ID/ Phone ID
- Timestamp

Training data set



Validation data set



Initial Preprocessing

- Transformed the type of some variable
- Converted undetected signals to -105 (-104 to 0)
- Removed all WAPs (column) and records (row) with zero variance values
- Removed repeated observations
- Converted signals less than -90 to -105 (Unusable)
- Converted signals higher than -30 to -105 (Amazing but not typical or desirable in the real world)

We didn’t find any missing value

Initial Result

	KNN		C5.0		SVM	
	Accuracy	**Kappa**	**Accuracy**	**Kappa**	**Accuracy**	**Kappa**
Building ID	0.9784	0.9660	0.9919	0.9872	0.9937	0.9900
Floor	0.865	0.8141	0.7858	0.7069	0.8893	0.8458

	KNN			Ranger			SVM		
	RMSE	**R2**	**MAE**	**RMSE**	**R2**	**MAE**	**RMSE**	**R2**	**MAE**
Latitude	14.298	0.958	7.72	10.198	0.9805	7.17	28.548	0.8348	20.85
Longitude	19.624	0.9734	8.60	10.727	0.992	7.63	58.557	0.7986	39.66

Final Result (Building ID)

Preprocessing:

- Remove the waps which are not in the validation data
- Add highest wap for each record
  - Remove waps that are among the highest waps in validation data but never provide the best signal in training data
  - Remove waps that selected as HighWap in more than 1 building

Selected feature:

Highest Wap + Building ID

ranger		C5.0		SVM	
Accuracy	**Kappa**	**Accuracy**	**Kappa**	**Accuracy**	**Kappa**
1	1	1	1	1	1

Final Preprocessing Floor/Latitude/Longitude

Preprocessing:

- Removed the waps which are not in the validation data
- Found the model per each building separately
- Normalized the waps value between (0-1) and chose strongest signal (Building 1)
- Find the acceptable RSSI range per building
- Transform waps value to exponential (Latitude/Longitude)
- Exclude relocated waps

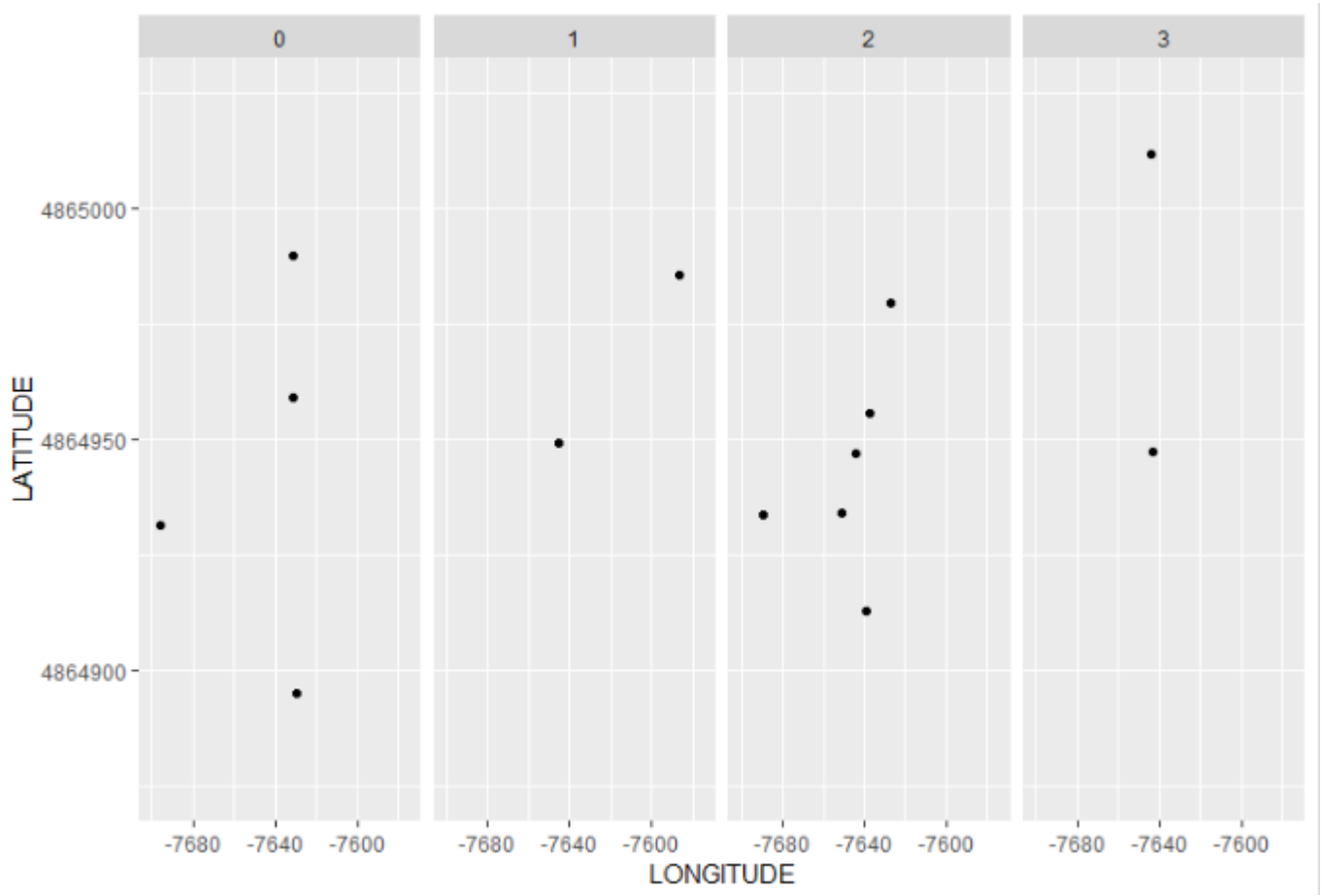
Final Result (Floor)

Selected feature:
Waps + Building ID + Floor

Floor	KNN		Ranger		SVM	
	Accuracy	Kappa	Accuracy	Kappa	Accuracy	Kappa
Building 0	0.9627	0.9473	0.972	0.9604	0.9646	0.9499
Building 1	0.9251	0.8892	0.9511	0.9268	0.9251	0.89
Building 2	0.959	0.9444	0.944	0.9239	0.9515	0.9342

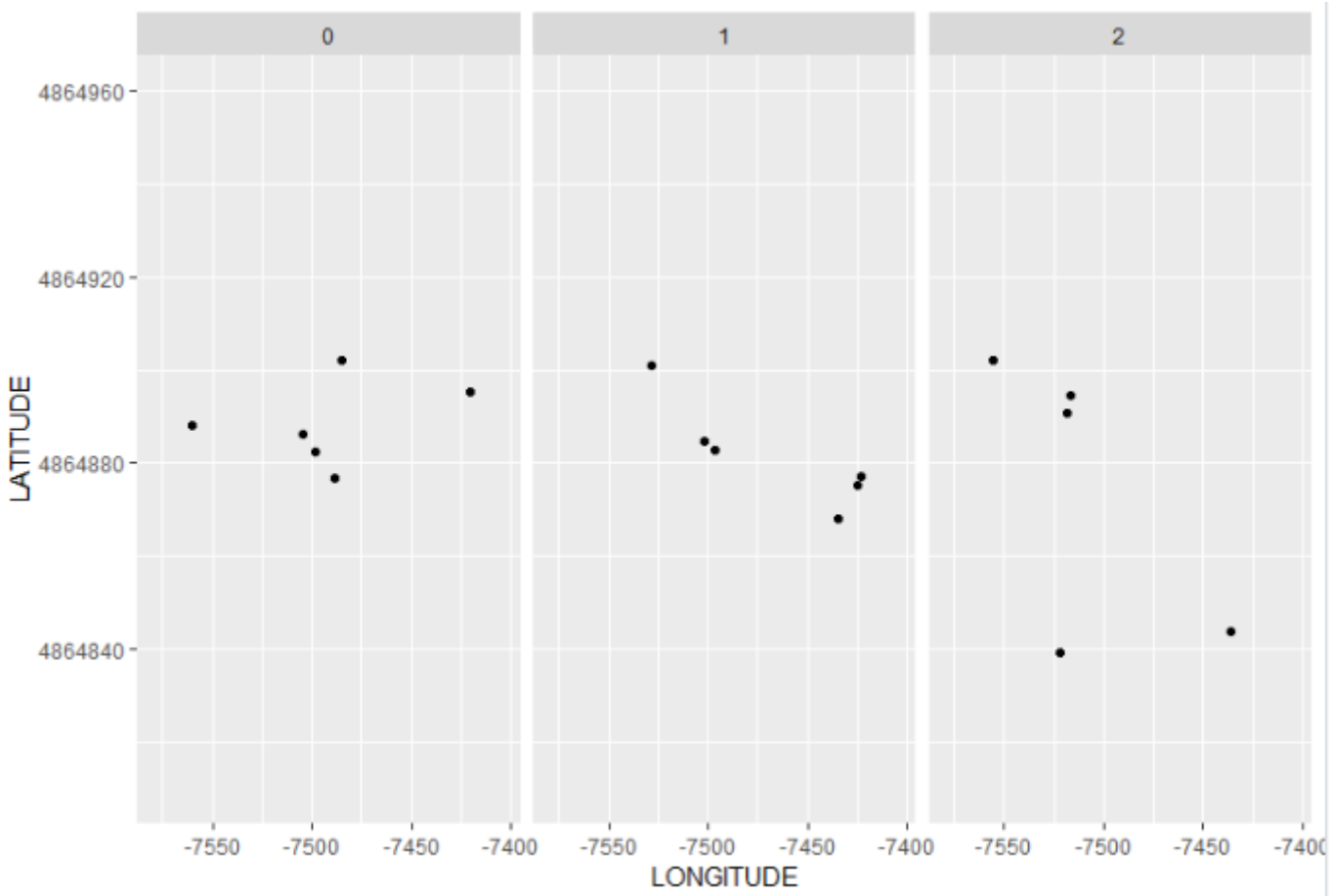
Error Point Building_0(Floor Prediction)

```
Confusion Matrix and Statistics

          Reference
Prediction   0   1   2   3
         0  74   1   0   0
         1   3 206   6   0
         2   1   1 158   2
         3   0   0   1  83
```



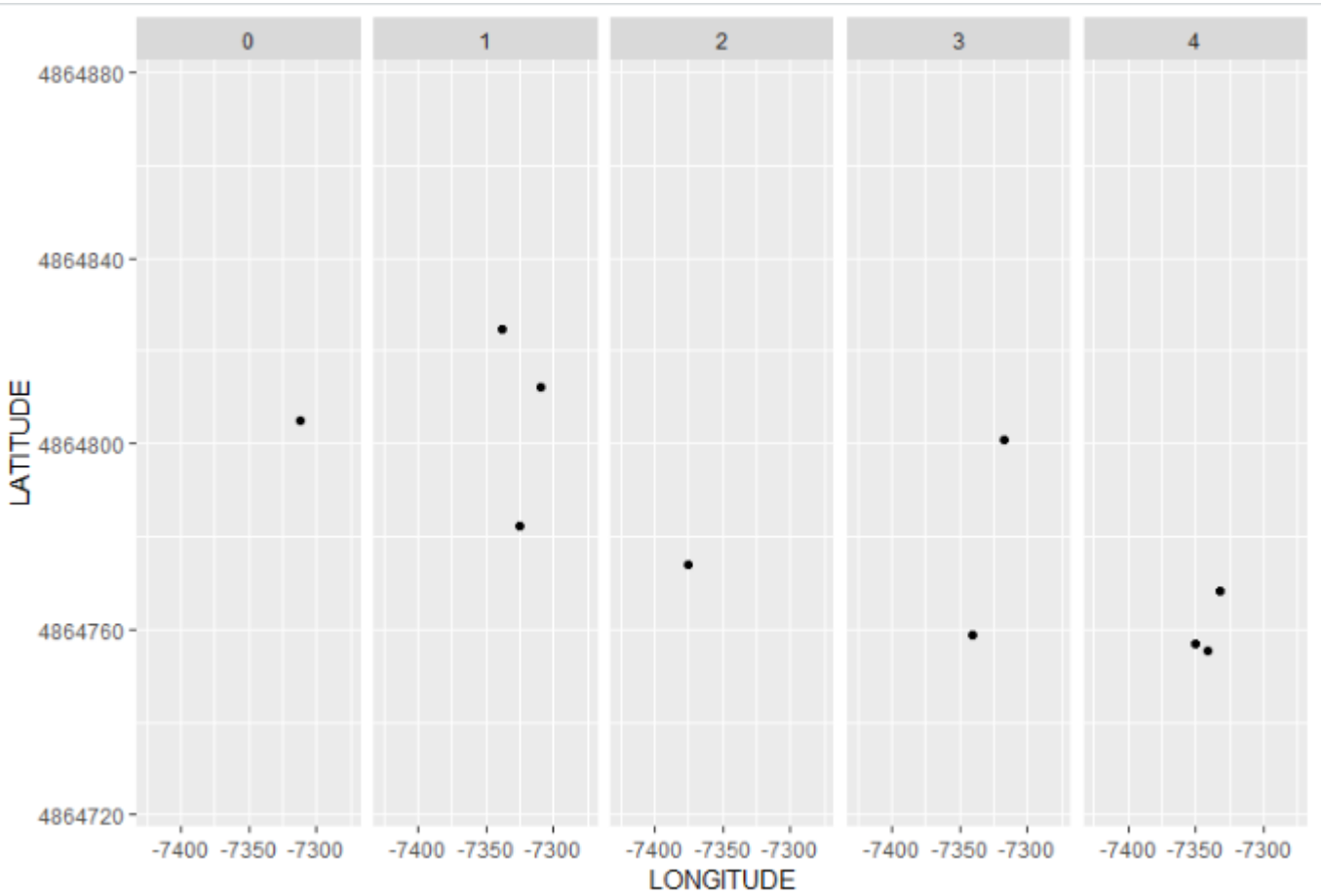
Error Point Building_1(Floor Prediction)

```
Confusion Matrix and Statistics

          Reference
Prediction   0   1   2   3
         0  24   2   0   0
         1   4 137   1   0
         2   2   4  82   0
         3   0   0   4  47
```



Error Point Building_2(Floor Prediction)

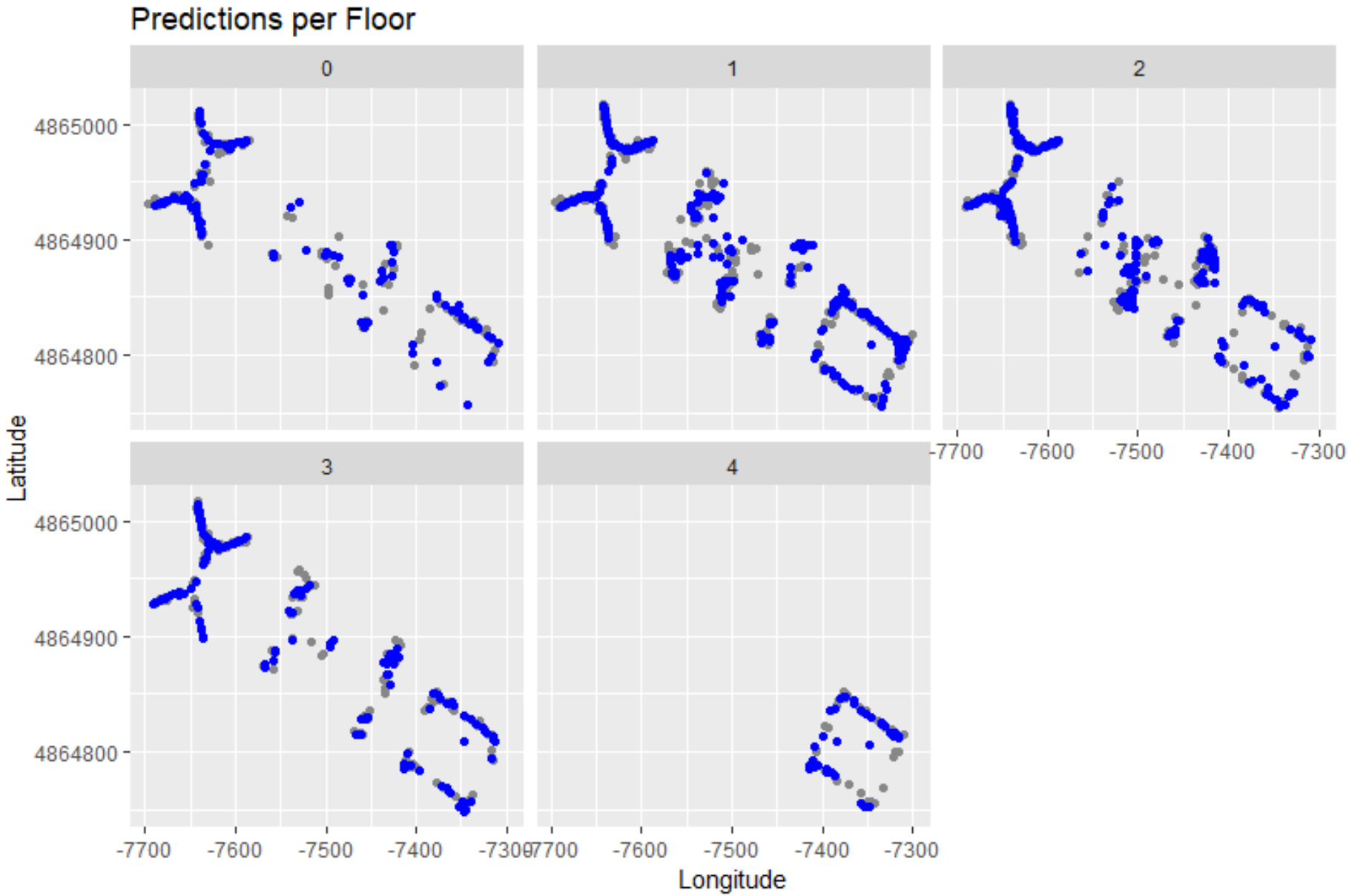
```
Confusion Matrix and Statistics

          Reference
Prediction   0   1   2   3   4
         0  23   2   0   0   0
         1   1 108   1   0   0
         2   0   1  52   0   0
         3   0   0   0  38   3
         4   0   0   1   2  36
```

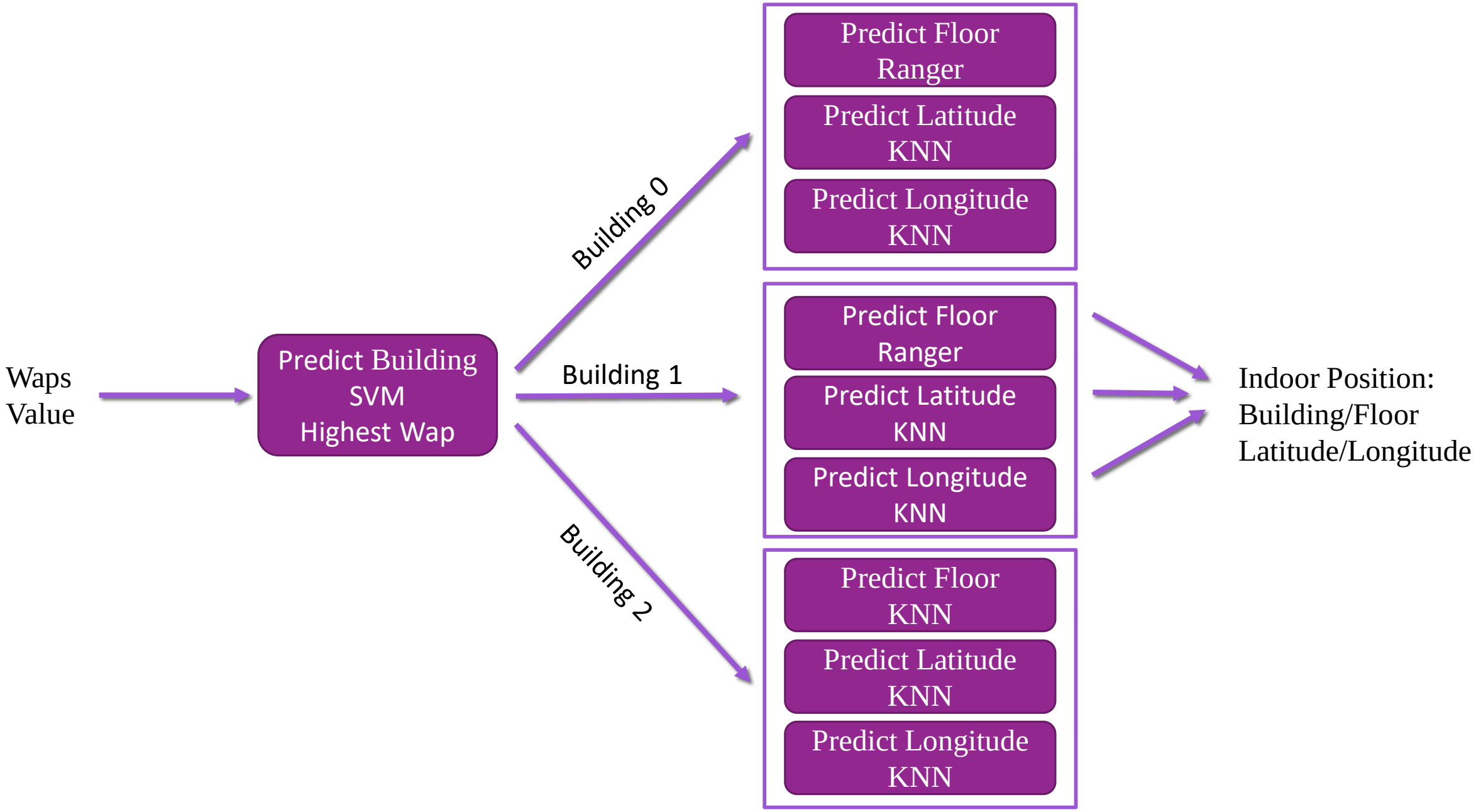


Final Result (Latitude/Longitude)

Latitude	KNN			xgbTree			Ranger		
	RMSE	R2	MAE	RMSE	R2	MAE	RMSE	R2	MAE
Building 0	4.8295	0.9772	3.08	5.33	0.9729	3.78	7.4534	0.9453	5.42
Building 1	9.2365	0.9311	6.38	15.505	0.8796	10.91	9.483	0.9273	6.69
Building 2	8.1180	0.9226	5.30	10.863	0.864	8.113	8.8588	0.9072	5.89

Longitude	KNN			xgbTree			Ranger		
	RMSE	R2	MAE	RMSE	R2	MAE	RMSE	R2	MAE
Building 0	5.676	0.9541	3.451	8.4112	0.8978	6.06	6.640	0.9399	4.60
Building 1	9.2727	0.9595	5.97	13.164	0.9196	9.82	8.4308	0.966	6.04
Building 2	10.019	0.9034	6.47	12.969	0.8370	9.19	10.014	0.8985	6.61


Predictions per Floor
0
1
2
3
4
Latitude
4865000
4864900
4864800
-7700
-7600
-7500
-7400
-7300
Longitude


Waps
Value
Predict Building
SVM
Highest Wap
Building 0
Building 1
Building 2
Predict Floor
Ranger
Predict Latitude
KNN
Predict Longitude
KNN
Predict Floor
Ranger
Predict Latitude
KNN
Predict Longitude
KNN
Predict Floor
KNN
Predict Latitude
KNN
Predict Longitude
KNN
Indoor Position:
Building/Floor
Latitude/Longitude

Conclusion

WAPs signal can be a good resource for indoor positioning

- The best way of predicting **building** is using the WAP with the highest RSSI
- For predicting **Floor**, **Latitude and Longitude** we need Building ID and all signals value

Indoor Positioning Application:

- Indoor Navigation (control robots, find places)
- People (personnel) tracking
- Asset tracking (Staff, supply chain, high value items)
- Museum tours: Give you contextual information based on your location
- ….