

Localização Indoor utilizando algoritmos de aprendizado de máquina a partir de medidas de RSSI



Projeto final - Introdução ao Aprendizado de Máquina

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Introdução

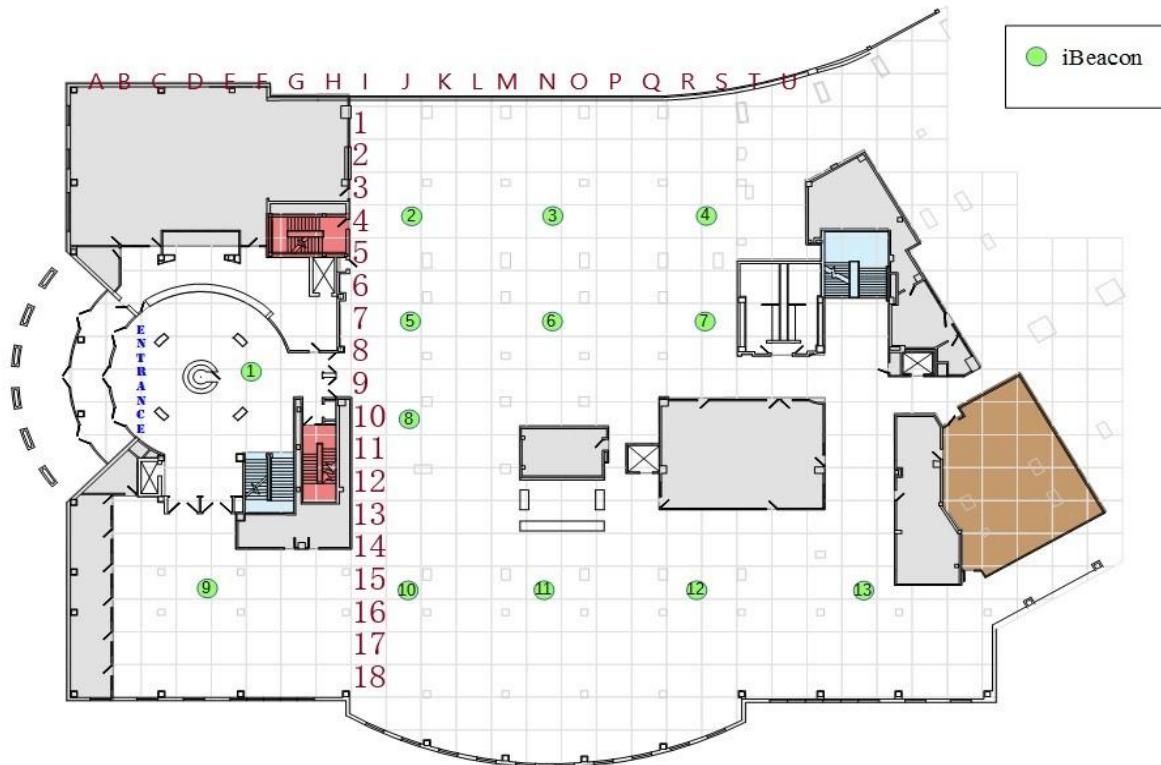
- Tecnologia de GPS não apresenta boa precisão em ambientes *indoor*.
- Técnicas clássicas de localização *indoor* apresentam baixa precisão, quando não fazem uso de *hardwares complexos e caros*.
- Técnicas de *machine learning* se tornam uma alternativa interessante.

Conjunto de dados 1

- Total de 1420 medidas de RSSI oriundas de dispositivos Bluetooth.
- Não há um trabalho na literatura que une *machine learning* e bluetooth.

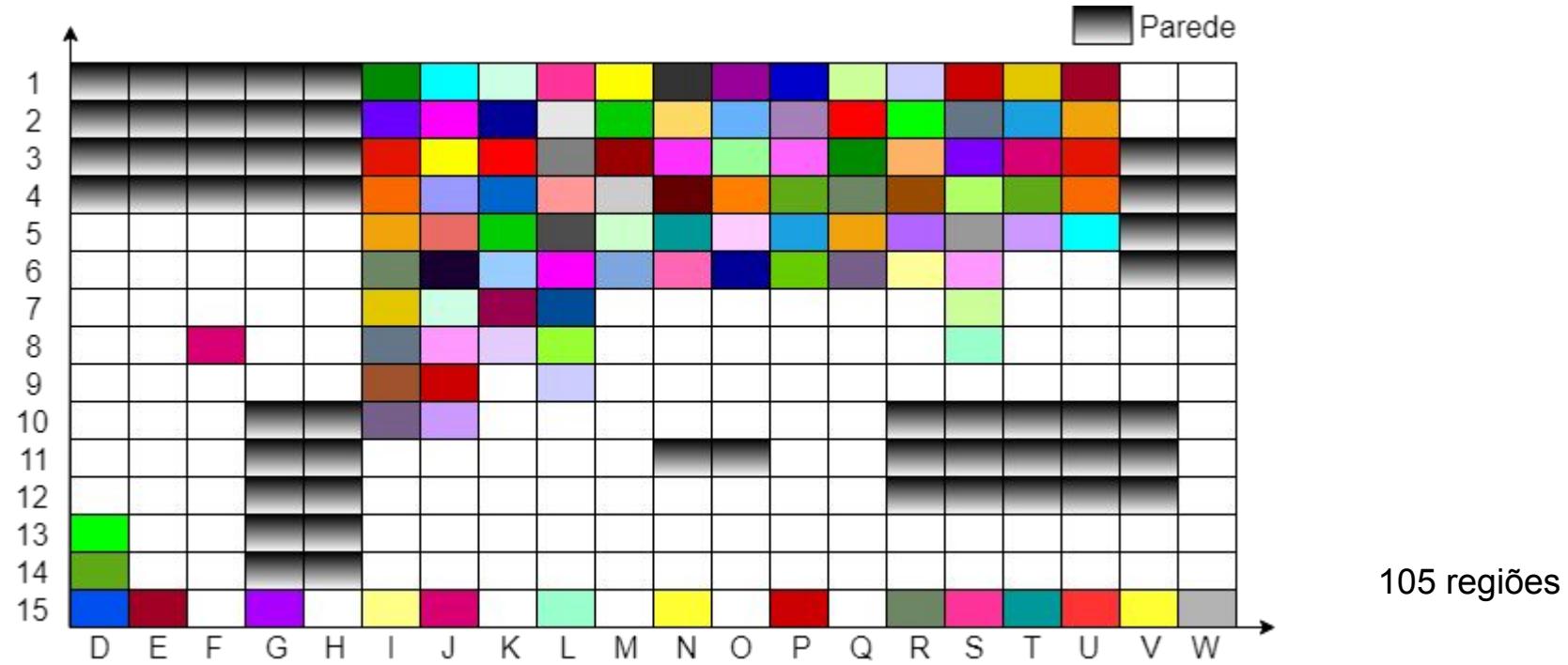
	location	date	b3001	b3002	b3003	b3004	b3005	b3006	b3007	b3008	b3009	b3010	b3011	b3012	b3013
0	O02	10-18-2016 11:15:21	-200	-200	-200	-200	-200	-78	-200	-200	-200	-200	-200	-200	-200
1	P01	10-18-2016 11:15:19	-200	-200	-200	-200	-200	-78	-200	-200	-200	-200	-200	-200	-200
2	P01	10-18-2016 11:15:17	-200	-200	-200	-200	-200	-77	-200	-200	-200	-200	-200	-200	-200
3	P01	10-18-2016 11:15:15	-200	-200	-200	-200	-200	-77	-200	-200	-200	-200	-200	-200	-200
4	P01	10-18-2016 11:15:13	-200	-200	-200	-200	-200	-77	-200	-200	-200	-200	-200	-200	-200
5	P01	10-18-2016 11:15:11	-200	-200	-82	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200
6	P01	10-18-2016 11:15:09	-200	-200	-80	-200	-200	-77	-200	-200	-200	-200	-200	-200	-200
7	P02	10-18-2016 11:15:07	-200	-200	-86	-200	-200	-200	-200	-200	-200	-200	-200	-200	-200

Conjunto de dados 1



Conjunto de dados 1

- Teste 1 - Classificação *dataset* padrão



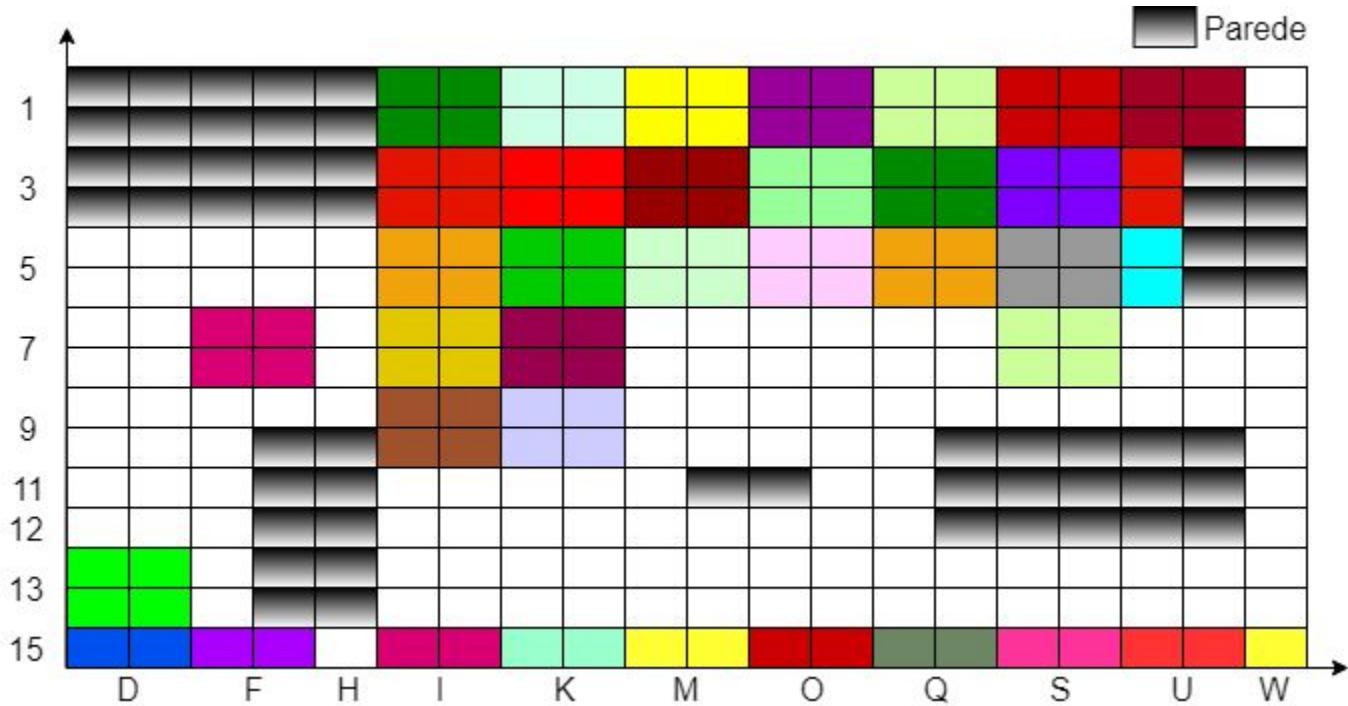
Conjunto de dados 1

- Teste 1 - Classificação *dataset* padrão

Método	Acurácia (%)
SMV	29.34
<i>Random forest</i>	27.70
k-NN	27.46

Conjunto de dados 1

- Teste 2 - Classificação dobrando dimensão das áreas



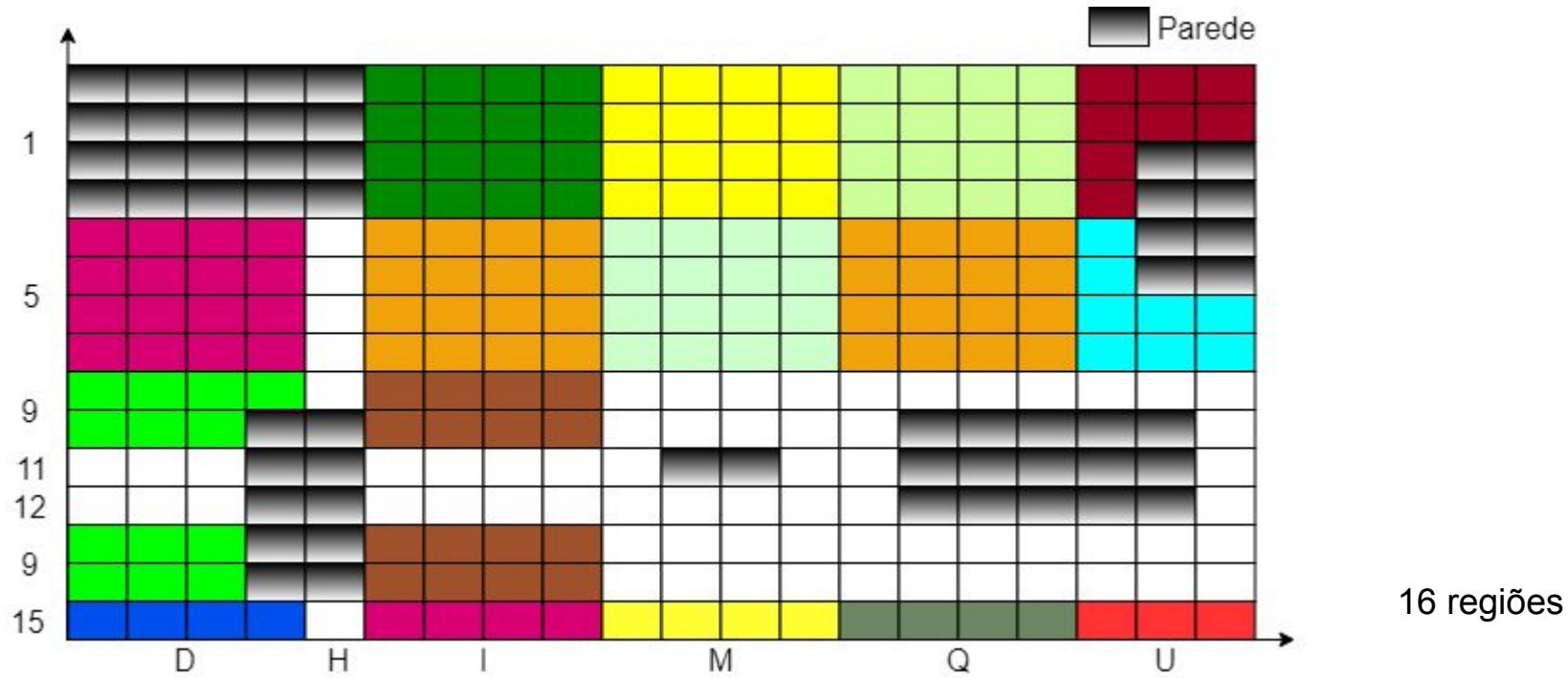
Conjunto de dados 1

- Teste 2 - Classificação aumentando dimensão das áreas

Método	Acurácia (%)
SMV	43.42
<i>Random forest</i>	42.72
k-NN	44.37

Conjunto de dados 1

- Teste 3 - Classificação quadruplicando dimensão das áreas



Conjunto de dados 1

- Teste 3 - Classificação quadruplicando dimensão das áreas

Método	Acurácia (%)
SMV	70.18
<i>Random forest</i>	72.06
k-NN	68.78

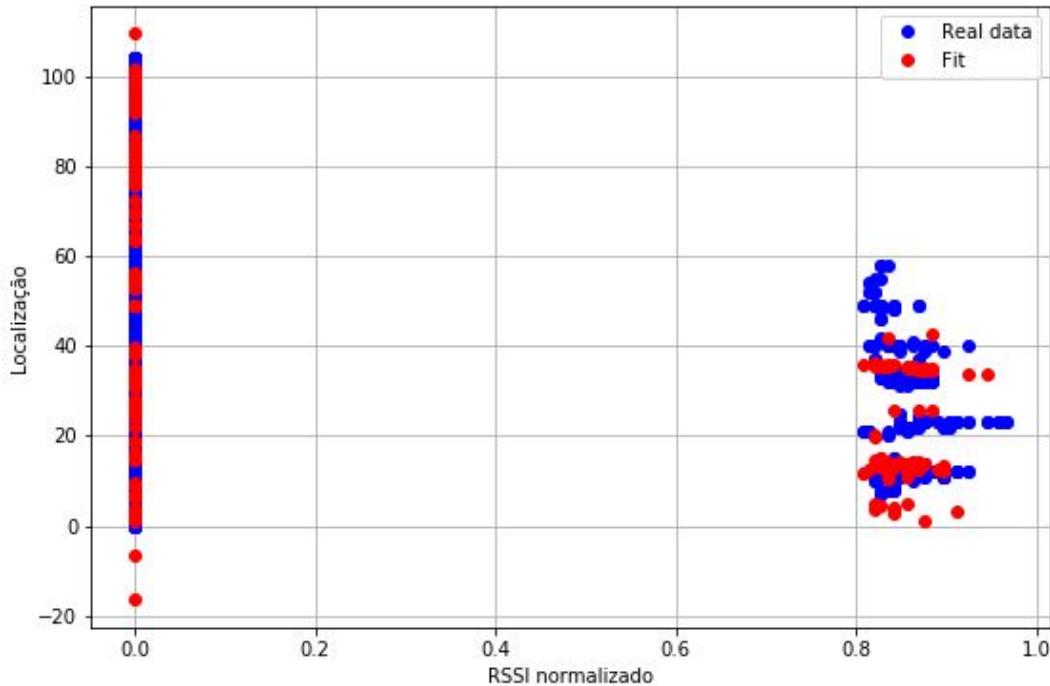
Conjunto de dados 1

- Teste 4 - Regressão linear multivariada
 - cada região é convertida em um valor inteiro [0 a 104]

$$y = \omega_0 + \omega_1 x_1 + \omega_2 x_2 + \dots + \omega_{13} x_{13}$$

Conjunto de dados 1

- Teste 4 - Regressão linear multivariada



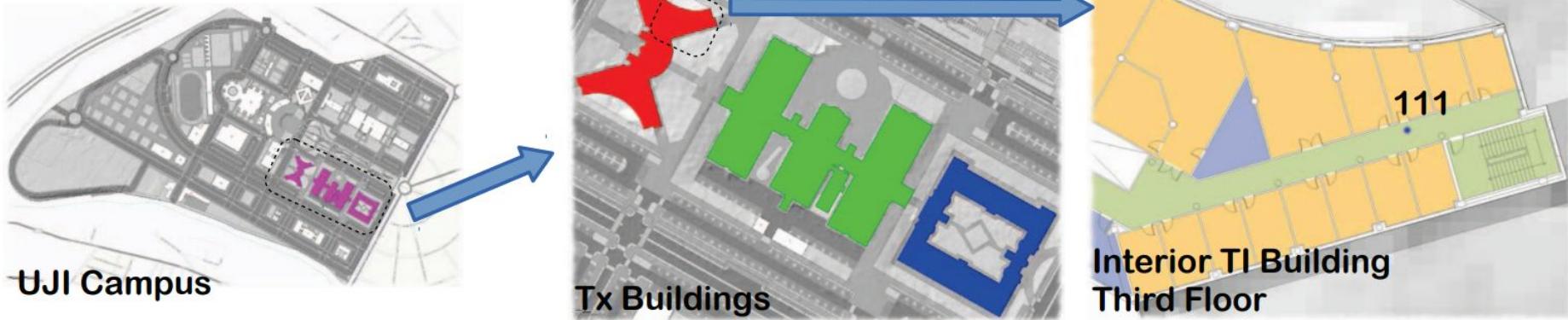
Métrica	Valor
MAE	10.86
MSE	178.98
RMSE	13.38
R^2	0.79

Conjunto de dados 2

- UjiIndoorLoc, medidas de RSSI de WLANs.
- 19937 amostras de treinamento, 1111 amostras de validação.
- 3 prédios de 4-5 andares, 123 ambientes diferentes.
- Latitude, longitude, relative position, user id, phone id, timestamp.

WAP004	WAP005	WAP006	WAP007	WAP008	WAP009	WAP010	...	WAP520	LONGITUDE	LATITUDE	FLOOR	BUILDINGID	SPACEID	RELATIVEPOSITION
100	100	100	100	100	100	100	...	100	-7541.2643	4.864921e+06	2	1	106	2
100	100	100	100	100	100	100	...	100	-7536.6212	4.864934e+06	2	1	106	2
100	100	100	100	-97	100	100	...	100	-7519.1524	4.864950e+06	2	1	103	2
100	100	100	100	100	100	100	...	100	-7524.5704	4.864934e+06	2	1	102	2
100	100	100	100	100	100	100	...	100	-7632.1436	4.864982e+06	0	0	122	2

Conjunto de dados 2

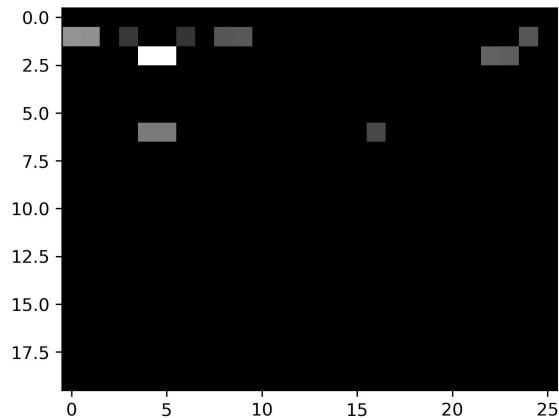
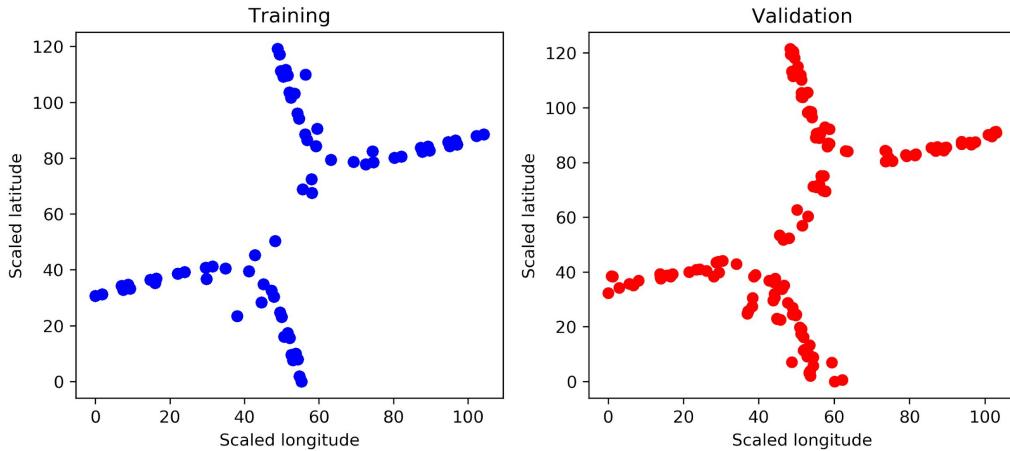


Conjunto de dados 2

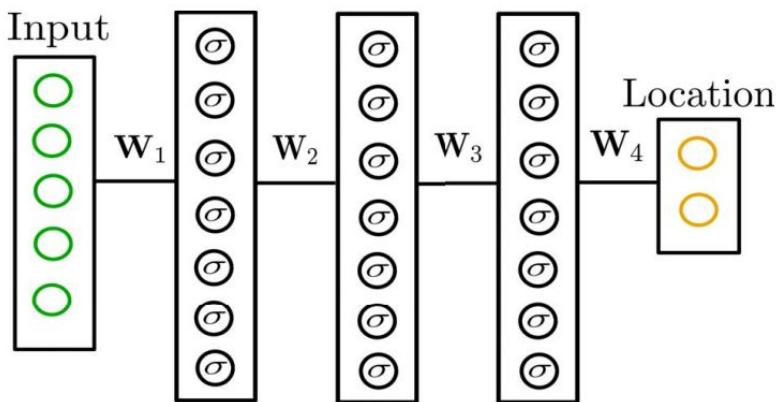
Prédio	Andar	Amostras de treinamento	Amostras de validação
0	0	1059	78
0	1	1356	208
0	2	1443	165
0	3	1391	85
1	0	1368	30
1	1	1484	143
1	2	1396	87
1	3	948	47
2	0	1942	24
2	1	2162	111
2	2	1577	54
2	3	2709	40
2	4	1102	39

Conjunto de dados 2

- Normalização min-max dos valores de RSSI.
- Subtraído os valores mínimos das coordenadas.
- “Reshape” para ser utilizado na rede convolucional.



Conjunto de dados 2



Layer (type)	Output Shape	Param #
=====		
dense (Dense)	(None, 500)	260500
activation (Activation)	(None, 500)	0
dropout (Dropout)	(None, 500)	0
dense_1 (Dense)	(None, 500)	250500
activation_1 (Activation)	(None, 500)	0
dropout_1 (Dropout)	(None, 500)	0
dense_2 (Dense)	(None, 500)	250500
activation_2 (Activation)	(None, 500)	0
dropout_2 (Dropout)	(None, 500)	0
dense_3 (Dense)	(None, 2)	1002
=====		

Total params: 762,502

Trainable params: 762,502

Non-trainable params: 0

Conjunto de dados 2

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 20, 26, 64)	640
activation (Activation)	(None, 20, 26, 64)	0
conv2d_1 (Conv2D)	(None, 20, 26, 128)	32896
activation_1 (Activation)	(None, 20, 26, 128)	0
max_pooling2d (MaxPooling2D)	(None, 10, 13, 128)	0
dropout (Dropout)	(None, 10, 13, 128)	0
flatten (Flatten)	(None, 16640)	0
dense (Dense)	(None, 300)	4992300
activation_2 (Activation)	(None, 300)	0
dropout_1 (Dropout)	(None, 300)	0
dense_1 (Dense)	(None, 2)	602

Total params: 5,026,438

Trainable params: 5,026,438

Non-trainable params: 0

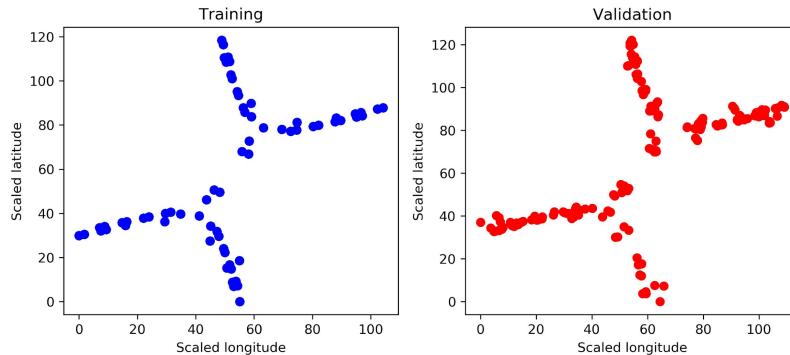
Layer (type)	Output Shape	Param #
conv2d_2 (Conv2D)	(None, 20, 26, 64)	320
activation_3 (Activation)	(None, 20, 26, 64)	0
conv2d_3 (Conv2D)	(None, 20, 26, 64)	16448
activation_4 (Activation)	(None, 20, 26, 64)	0
conv2d_4 (Conv2D)	(None, 20, 26, 128)	32896
activation_5 (Activation)	(None, 20, 26, 128)	0
conv2d_5 (Conv2D)	(None, 20, 26, 128)	65664
activation_6 (Activation)	(None, 20, 26, 128)	0
conv2d_6 (Conv2D)	(None, 20, 26, 128)	65664
activation_7 (Activation)	(None, 20, 26, 128)	0
max_pooling2d_1 (MaxPooling2D)	(None, 10, 13, 128)	0
dropout_2 (Dropout)	(None, 10, 13, 128)	0
flatten_1 (Flatten)	(None, 16640)	0
dense_2 (Dense)	(None, 128)	2130048
dense_3 (Dense)	(None, 128)	16512
activation_8 (Activation)	(None, 128)	0
dropout_3 (Dropout)	(None, 128)	0
dense_4 (Dense)	(None, 2)	258

Total params: 2,327,810

Trainable params: 2,327,810

Non-trainable params: 0

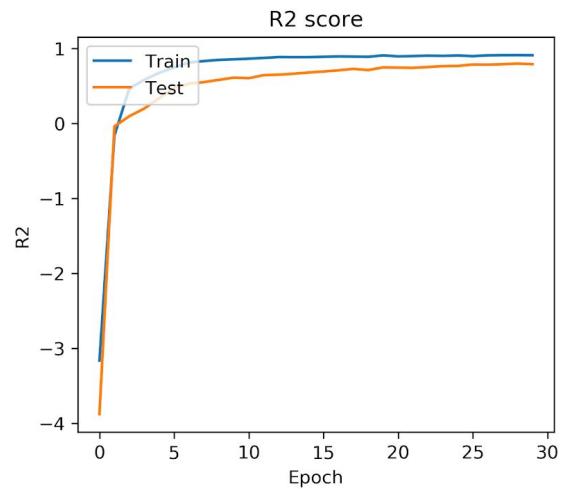
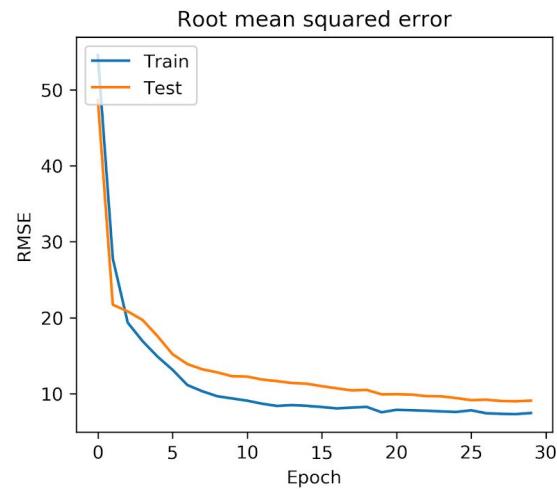
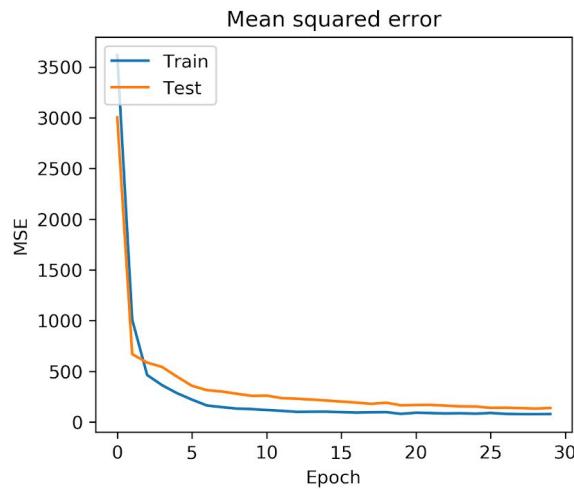
Prédio 0 - Andar 1



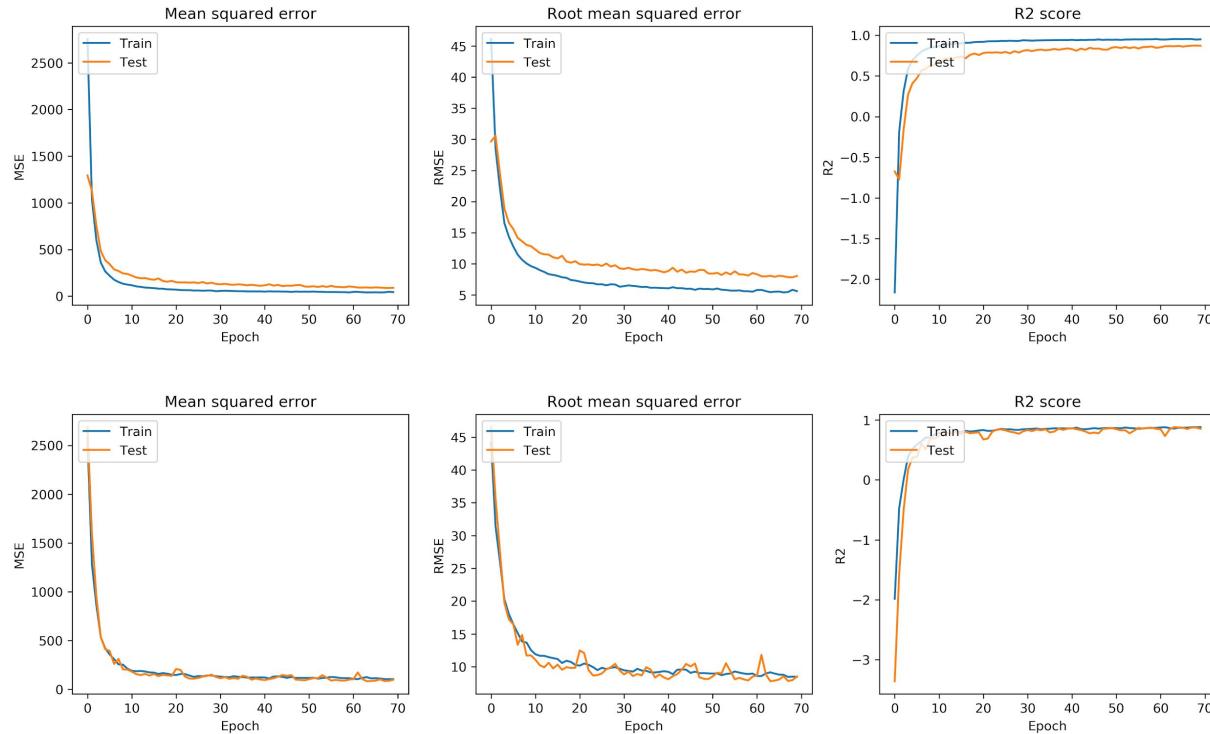
Métrica	SVM	RandomForest	KNN
Mean absolute error (MAE)	11.63	6.47	4.59
Mean squared error (MSE)	221.32	86.52	35.31
Root mean squared error (RMSE)	14.88	9.30	5.94
R square (R^2)	0.663	0.894	0.957

Prédio 0 - Andar 1

- Rede neural profunda



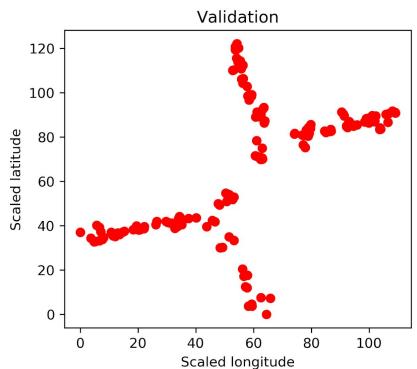
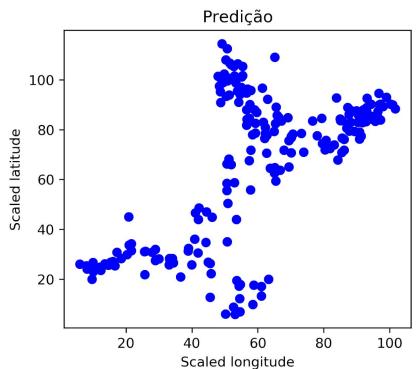
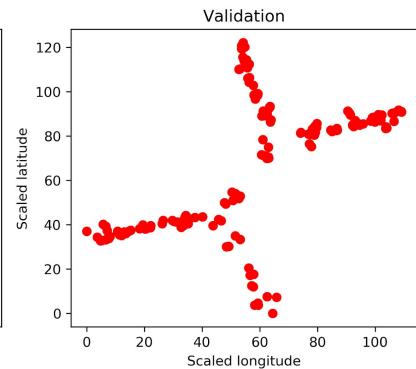
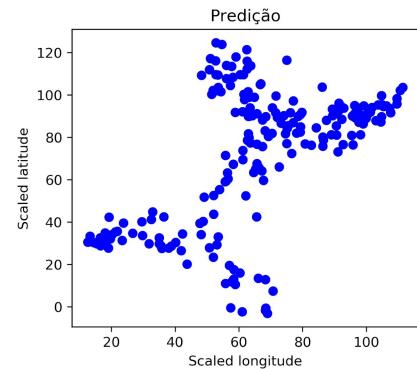
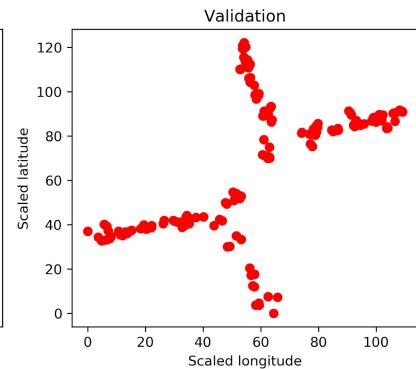
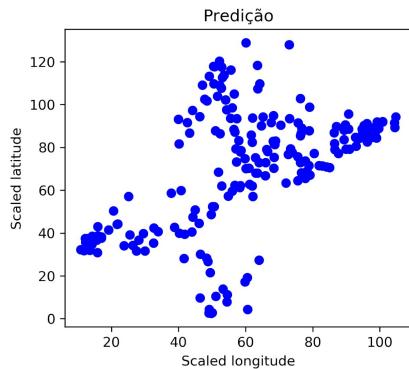
Prédio 0 - Andar 1



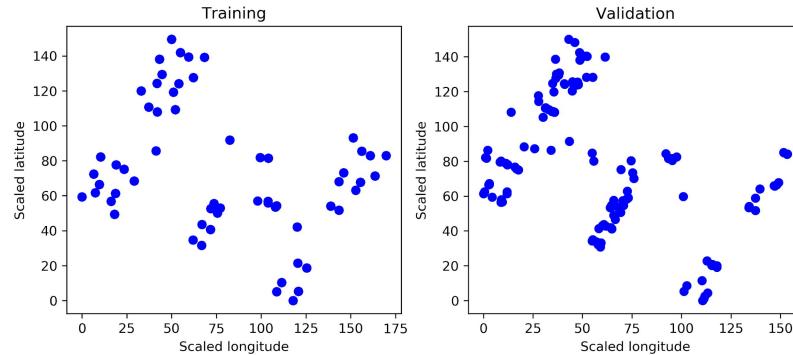
Prédio 0 - Andar 1

Métrica	DNN	CNN1	CNN2
Mean squared error (MSE)	138.58	89.32	97.73
Root mean squared error (RMSE)	9.074	8.038	8.51
R square (R^2)	0.737	0.828	0.812

Prédio 0 - Andar 1



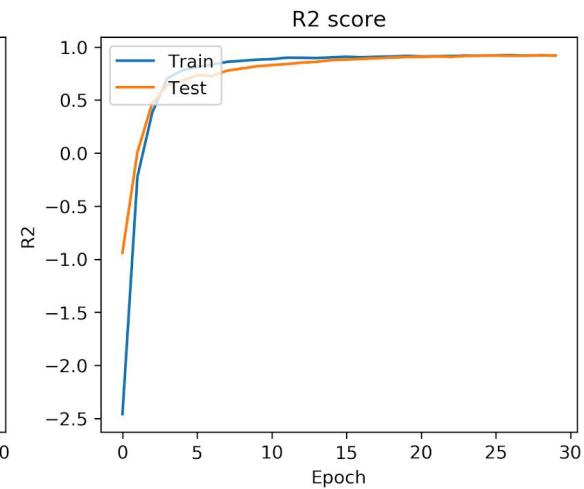
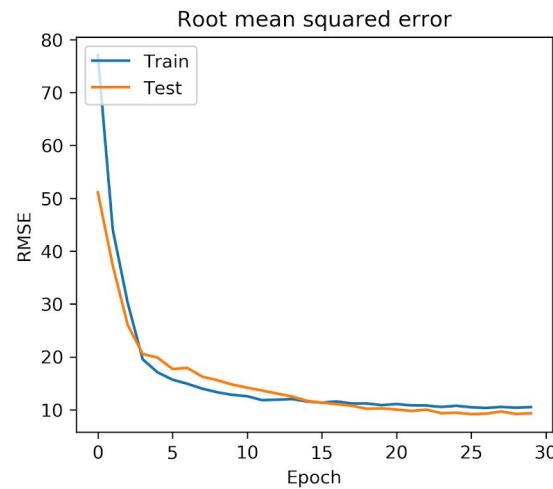
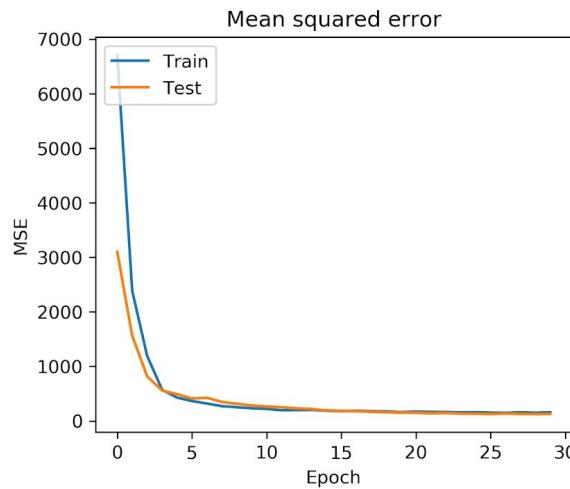
Prédio 1 - Andar 1



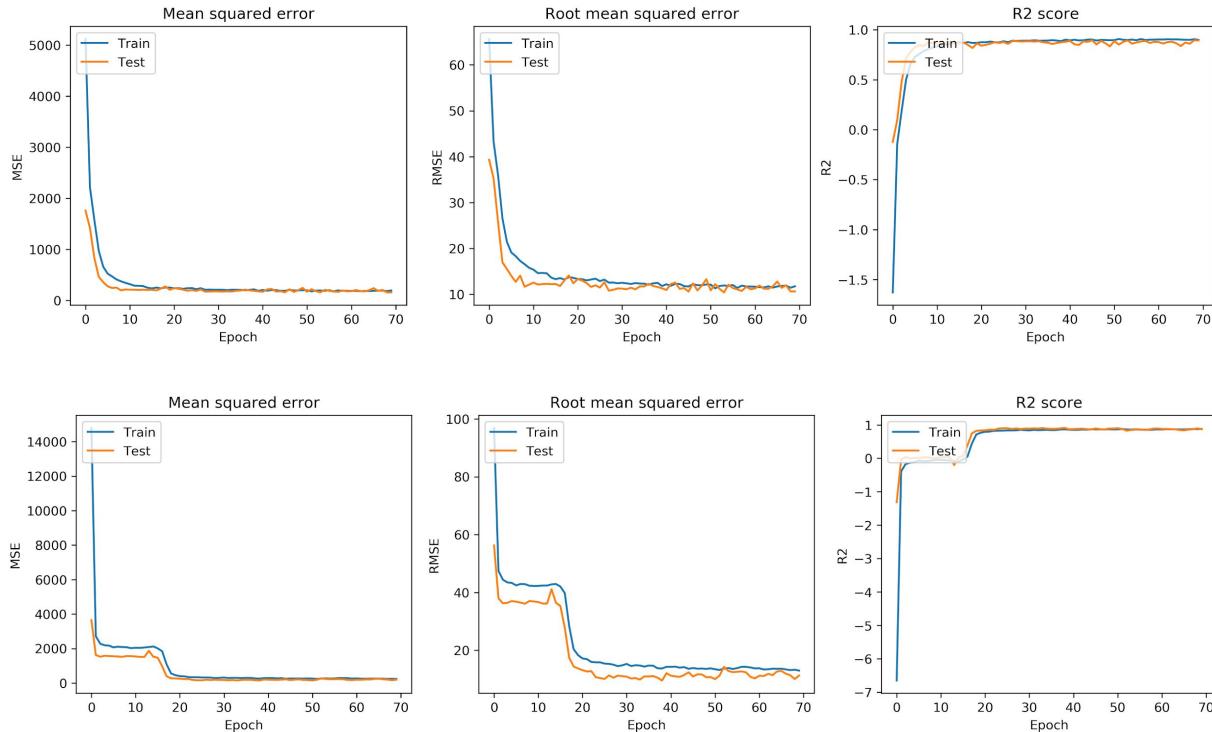
Métrica	SVM	RandomForest	KNN
Mean absolute error (MAE)	10.21	12.75	8.885
Mean squared error (MSE)	169.73	342.58	157.98
Root mean squared error (RMSE)	13.03	18.51	12.57
R square (R^2)	0.889	0.780	0.897

Prédio 1 - Andar 1

- Rede neural profunda



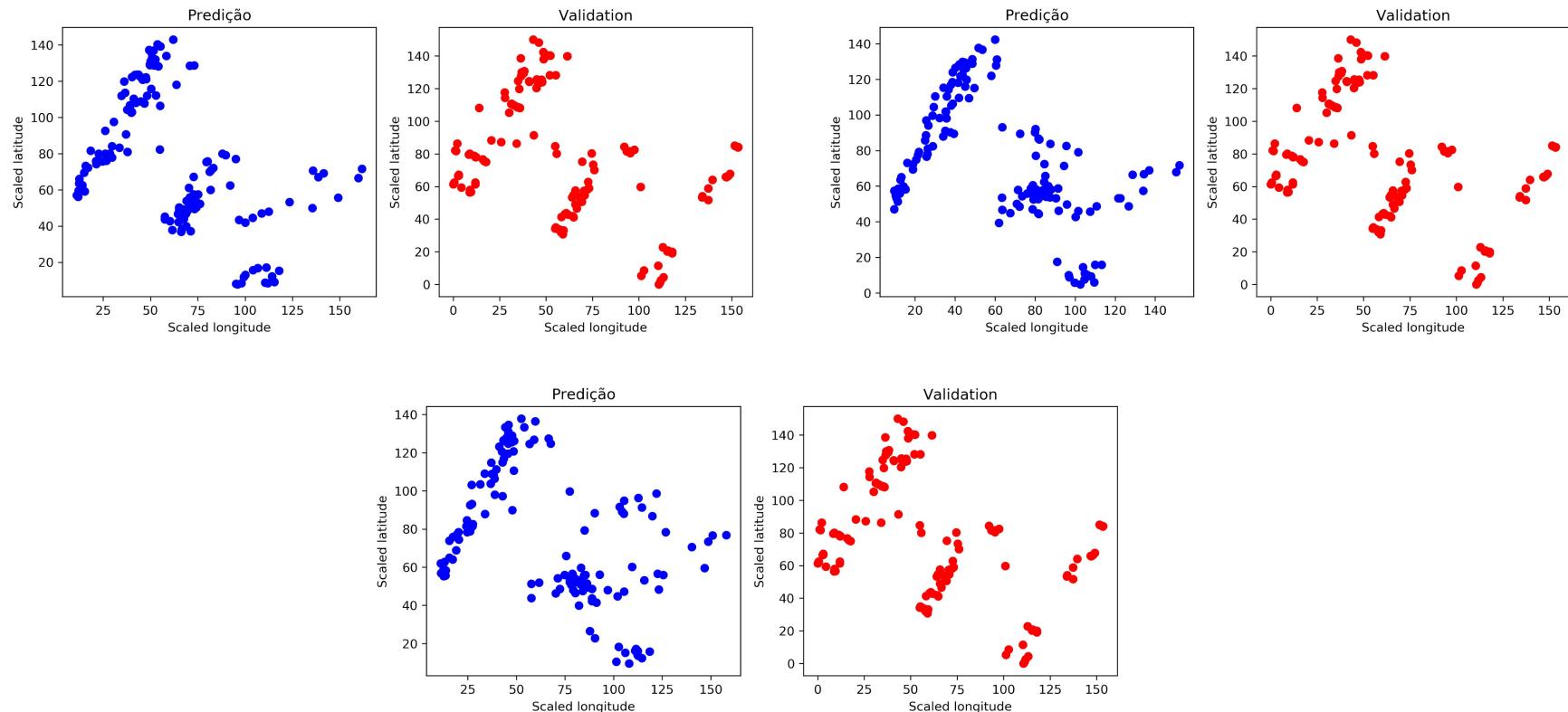
Prédio 1 - Andar 1



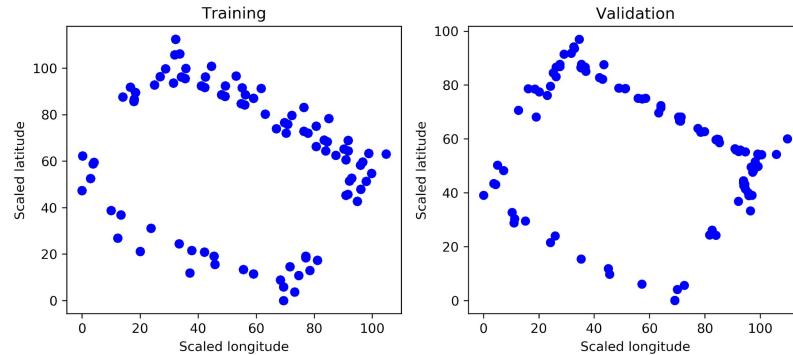
Prédio 1 - Andar 1

Métrica	DNN	CNN1	CNN2
Mean squared error (MSE)	127.45	161.36	196.09
Root mean squared error (RMSE)	9.355	10.651	11.29
R square (R^2)	0.918	0.887	0.863

Prédio 1 - Andar 1



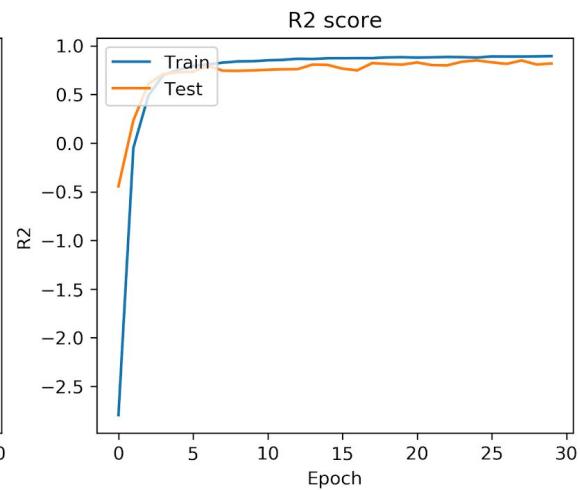
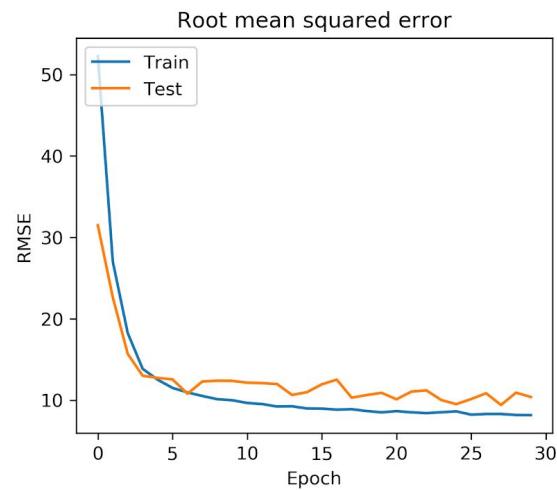
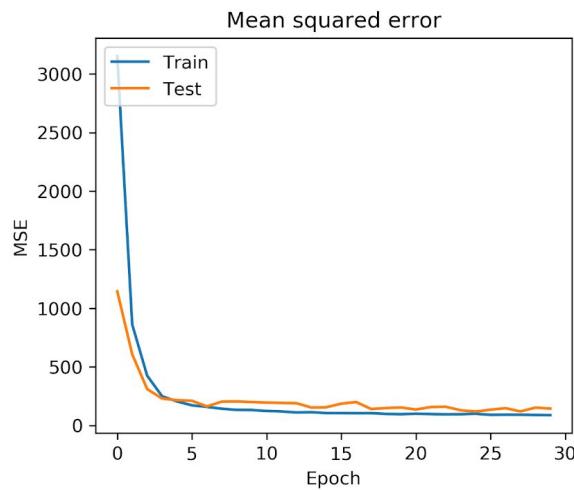
Prédio 2 - Andar 1



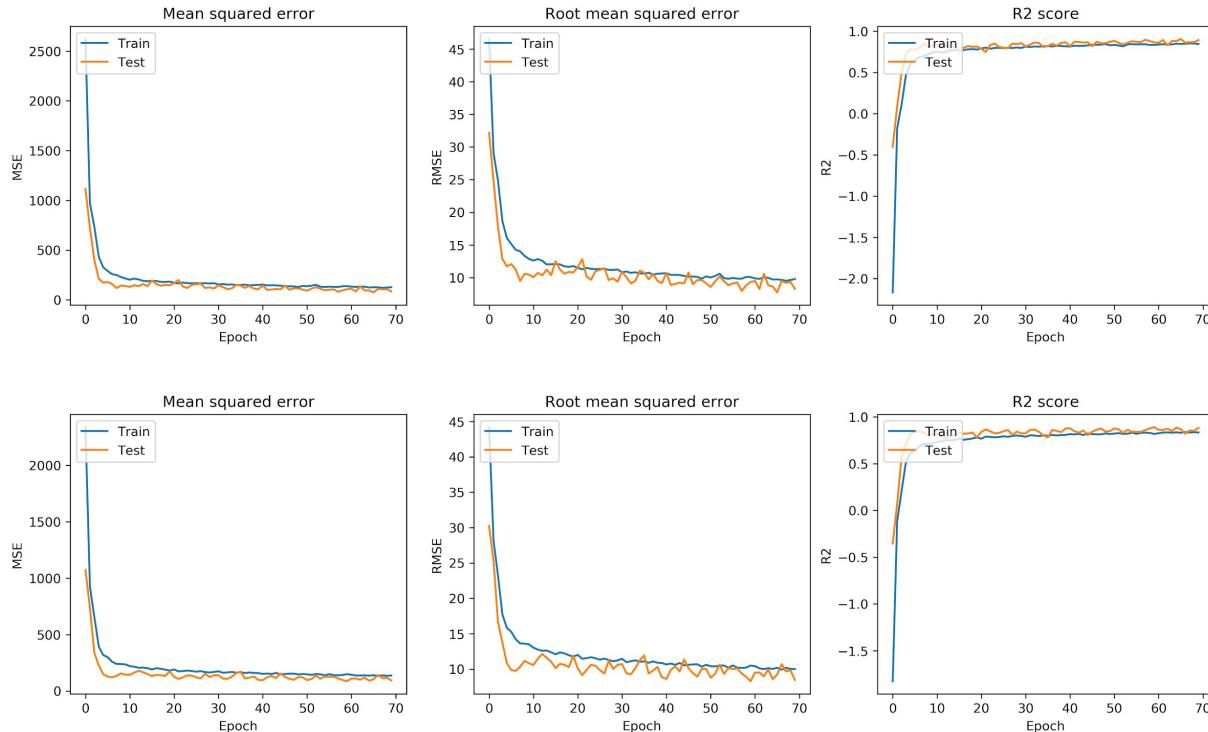
Métrica	SVM	RandomForest	KNN
Mean absolute error (MAE)	13.00	10.645	7.815
Mean squared error (MSE)	273.39	191.45	111.56
Root mean squared error (RMSE)	16.56	13.83	10.56
R square (R^2)	0.632	0.729	0.8385

Prédio 2 - Andar 1

- Rede neural profunda



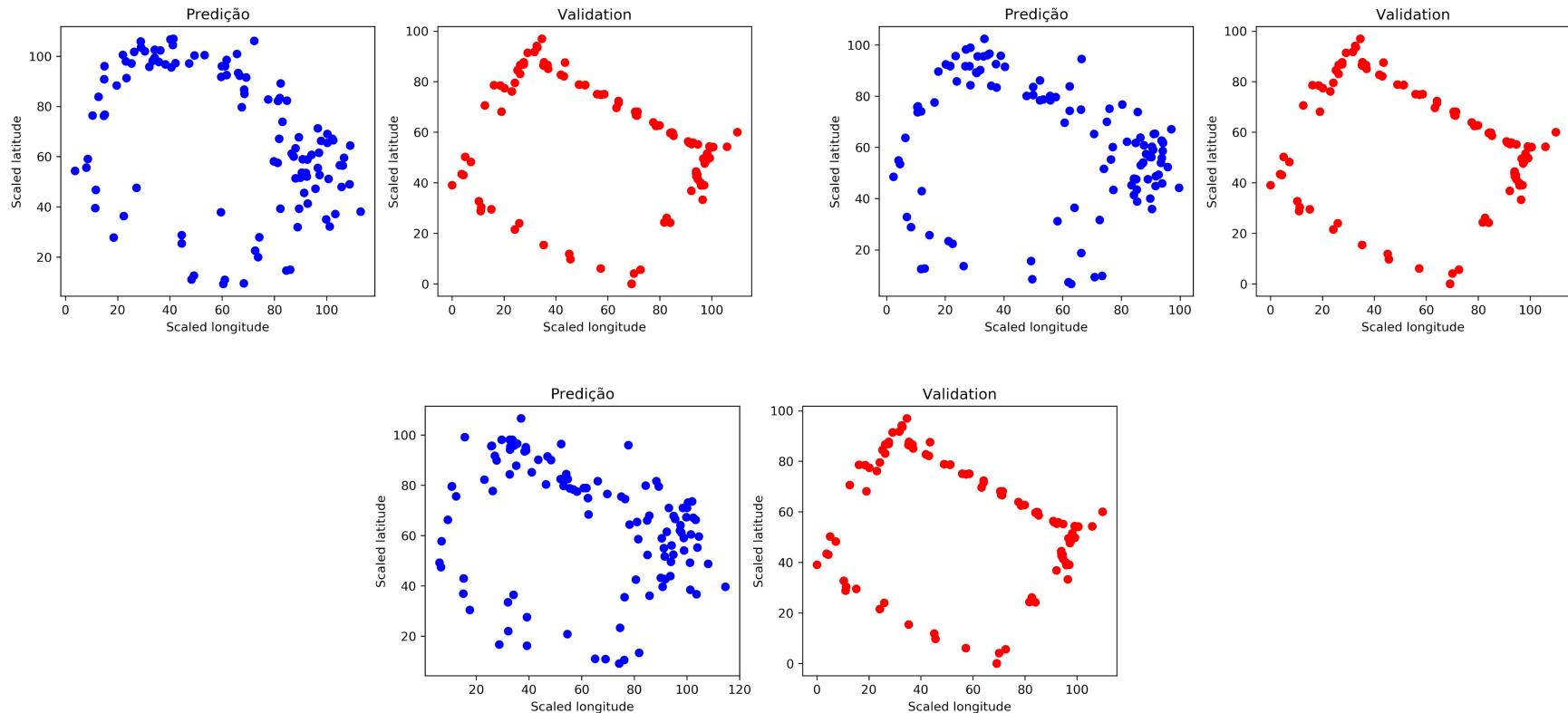
Prédio 2 - Andar 1



Prédio 2 - Andar 1

Métrica	DNN	CNN1	CNN2
Mean squared error (MSE)	144.11	85.188	92.98
Root mean squared error (RMSE)	10.38	8.27	8.462
R square (R^2)	0.781	0.878	0.866

Prédio 2 - Andar 1



Conclusões

- Regressão linear se demonstrou a melhor técnica a ser utilizada com o primeiro *dataset*.
- O KNN se mostrou como um ótimo algoritmo para a localização indoor.
- Redes neurais e convolucionais desempenharam bem mesmo com hiperparâmetros não otimizados.
- Alinhamento dos pontos de acessos no redimensionamento para a rede convolucional não foi ideal, mas os resultados foram bons.