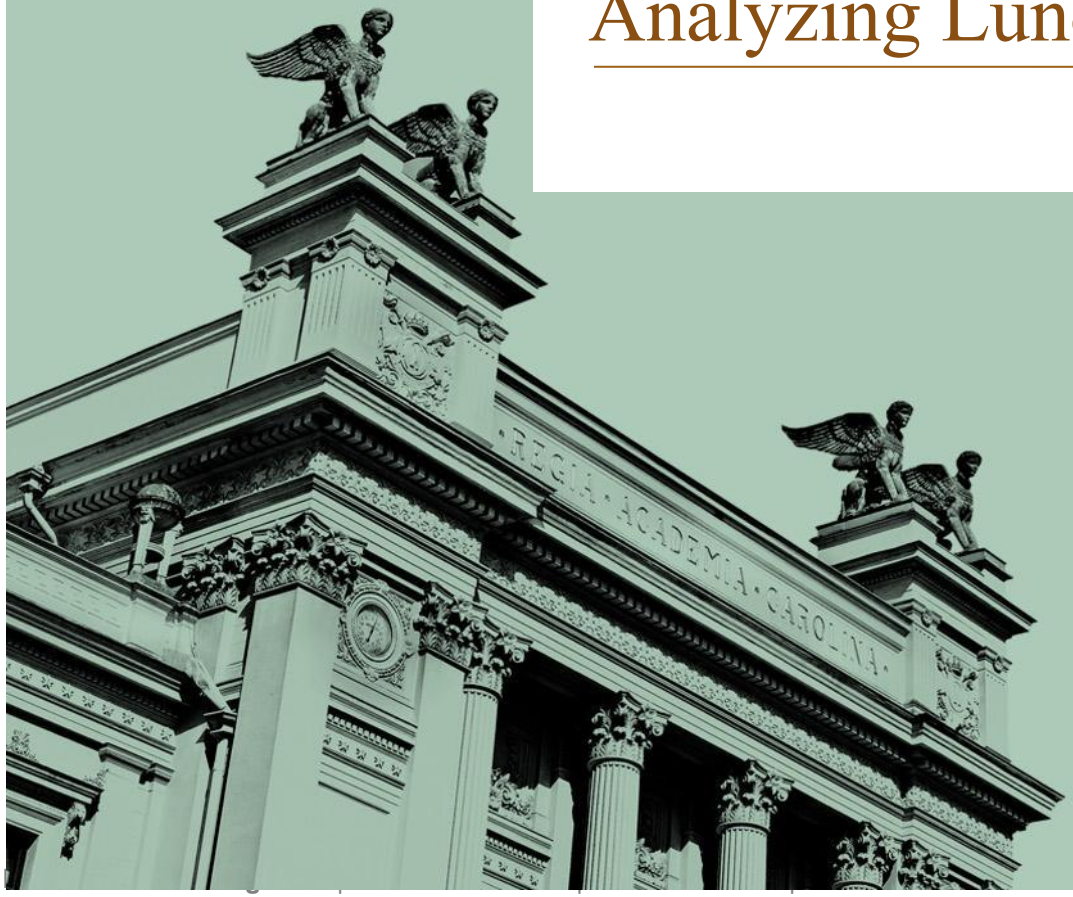
LUNDS UNIVERSITET
Lunds Tekniska Högskola

EDAN 70 project presentation:

Analyzing Lund LTE Data (Combain)



Introduction

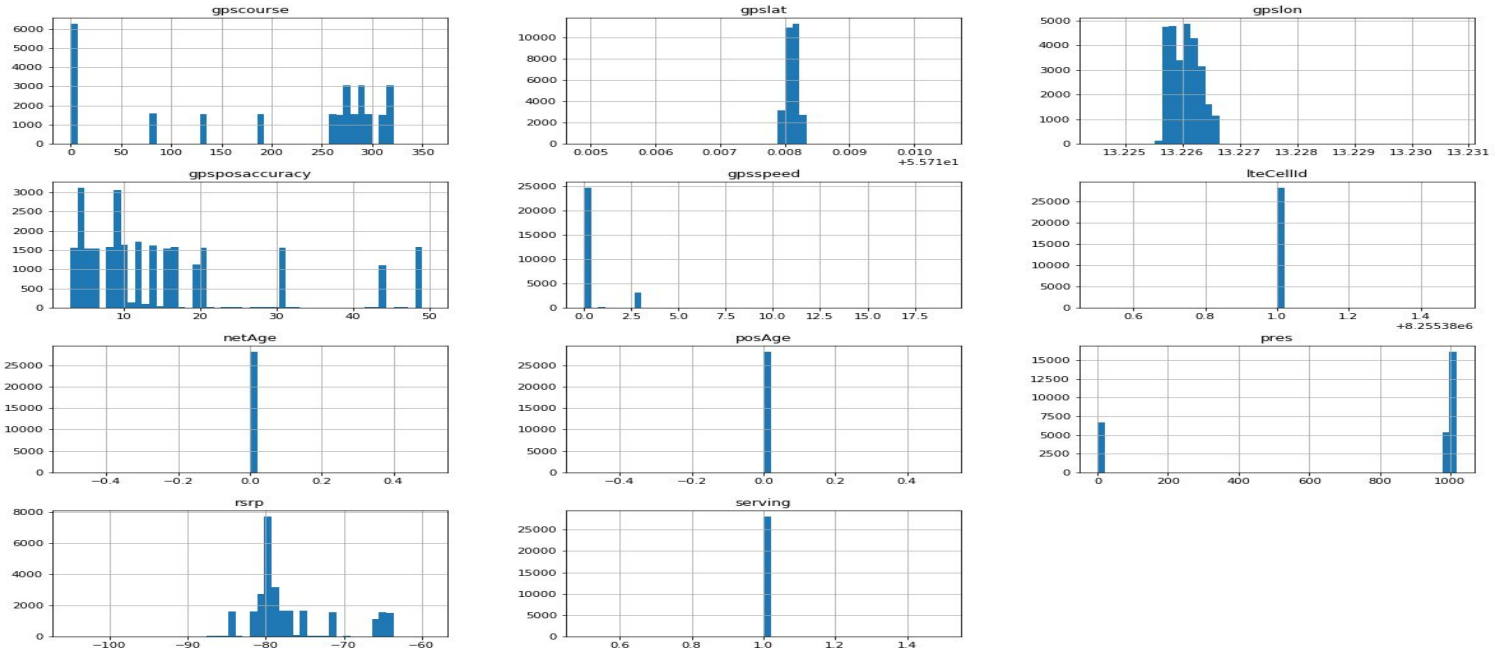
***Path loss**, or **path attenuation**, is the reduction in power density of an electromagnetic wave as it propagates through space. Path loss is the most important factor in designing a telecommunication system.*

$$L = 20 \log_{10} \left(\frac{4\pi d}{\lambda} \right)$$

Radio-Engineering Formula for the Path Loss

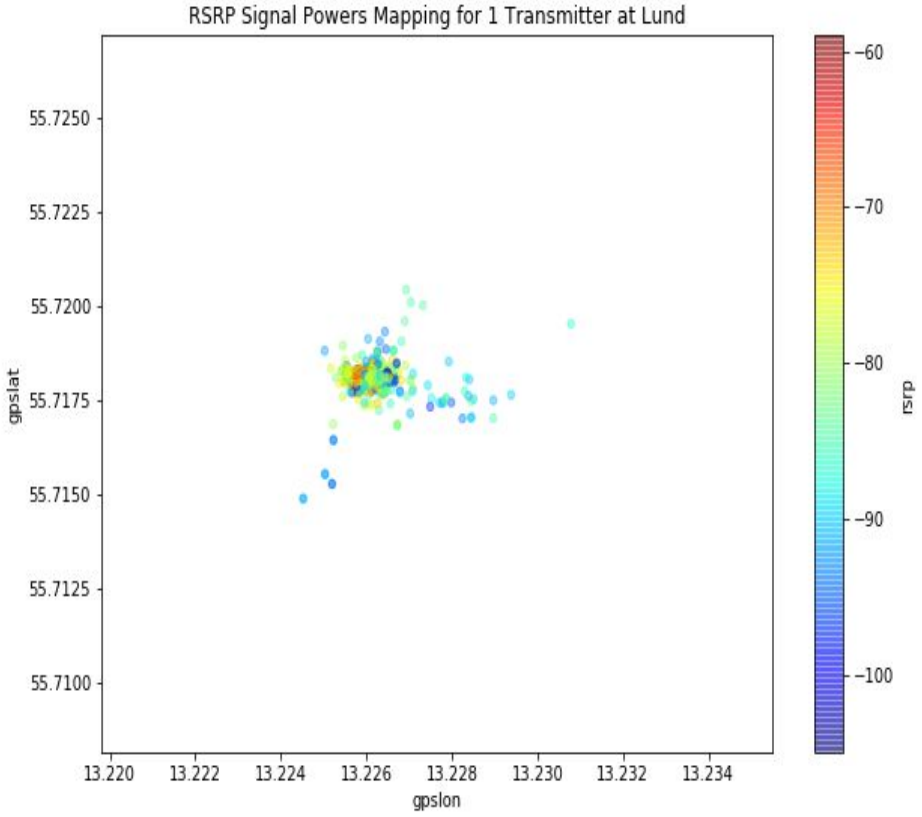
Using Combain's Dataset for the Lund, Can we predict the Signal Powers (RSRP) using Machine Learning tools ?

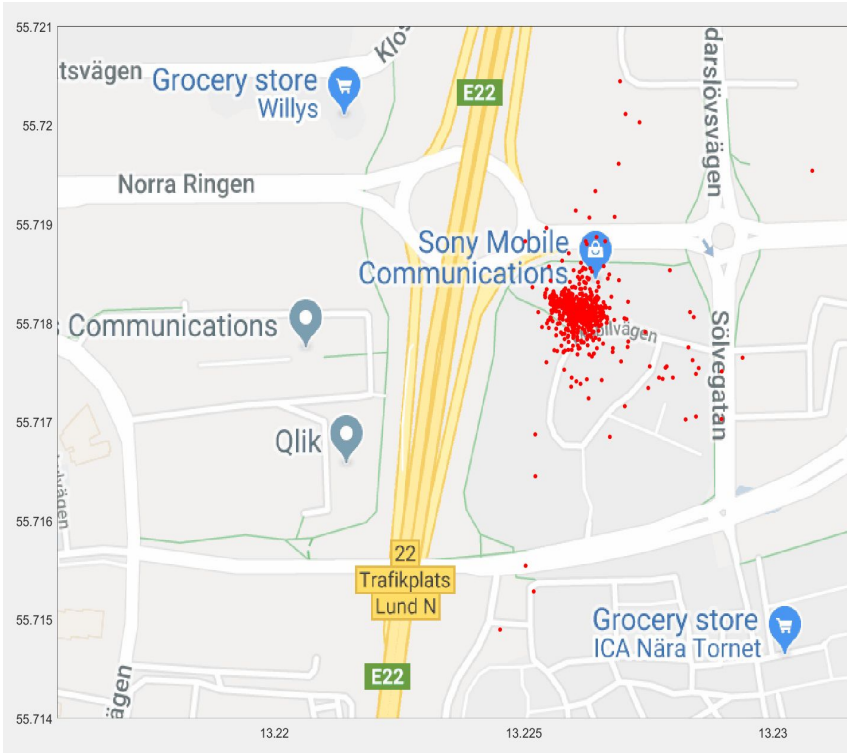
Dataset Presentation



	lteCellId	time	gpslat	gpslon	gpsposaccuracy	gpsspeed	gpscourse	serving	rsrp	posAge	netAge	pres
112724	8255381	2018-04-18 15:04:57	55.718116	13.225873	17	0	259	1	-75	0	0	1016.514893
87459	8255381	2018-03-29 07:42:41	55.718237	13.226148	16	0	319	1	-64	0	0	0.000000
86638	8255381	2018-03-29 07:42:41	55.718237	13.226148	16	0	319	1	-64	0	0	0.000000

Preprocessing Dataset

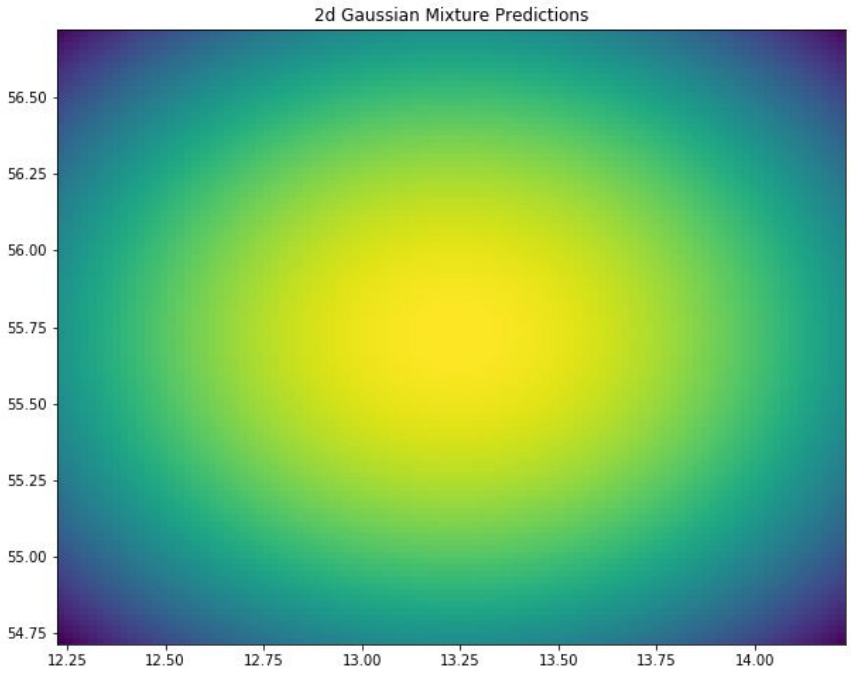


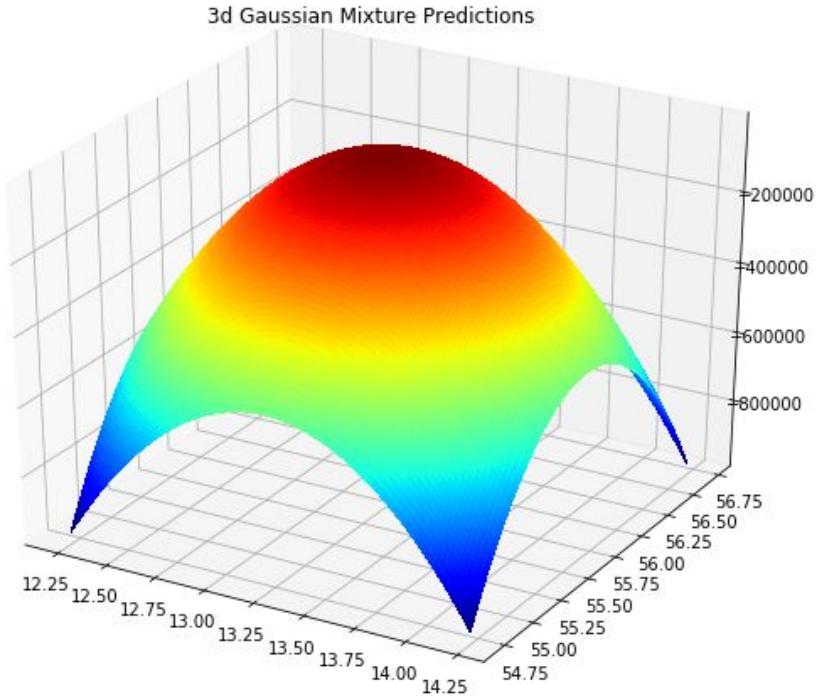


Density Map for our 1 Transmitter (LTE)

State of the Art : Gaussian Model

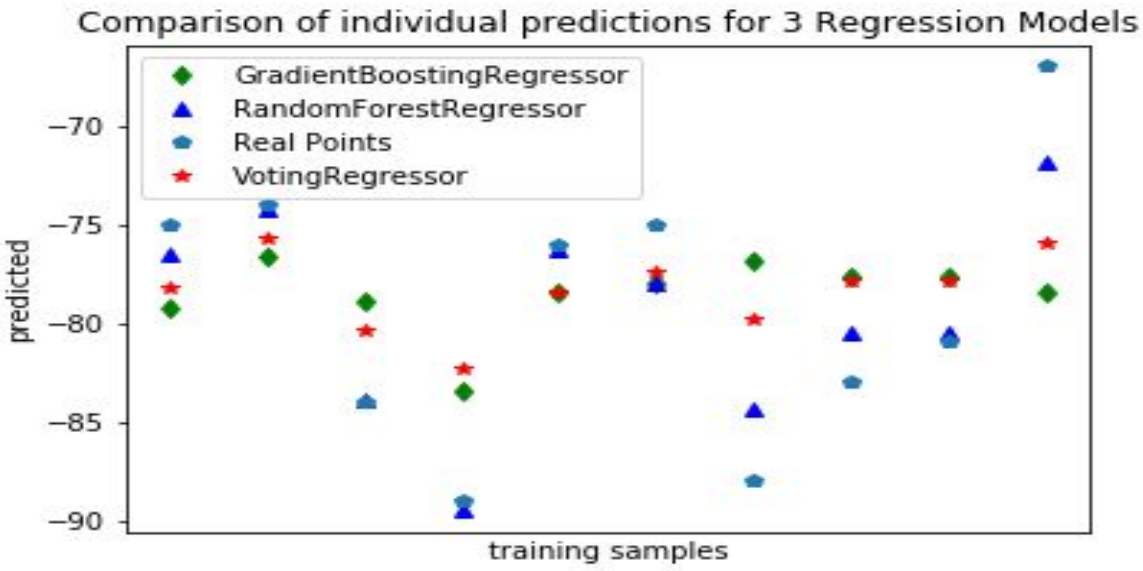
“ They observed that the RSS readings followed a mixture of multiple Gaussian distributions when both the transmitter and receivers are equipped with two antennas [...] the RSS readings for any given transmitter/AP pair are represented as a Gaussian Mixture Model (GMM). “





Average Log-likelihood of 11. 809

Benchmarking Methods



For the Same Transmitter (LTE Cell ID) we compare our 3 Regression Models :

- **Linear Regression : RMSE of 4.9376 & R^2 of 29.47 %**
- **Random Forest Regression : RMSE of 1.3346 & R^2 of 94.85 %**
- **Gradient Boosting Regression : RMSE of 1.3912 & R^2 of 94.4 %**

Regression Results

Lte Cell Id	RMSE	R^2
8255381	4.9376	0.2947
7448409	4.6801	0.1471
9404895	7.7185	0.3264
7403	5.6867	0.7372
8980593	7.5223	0.2417

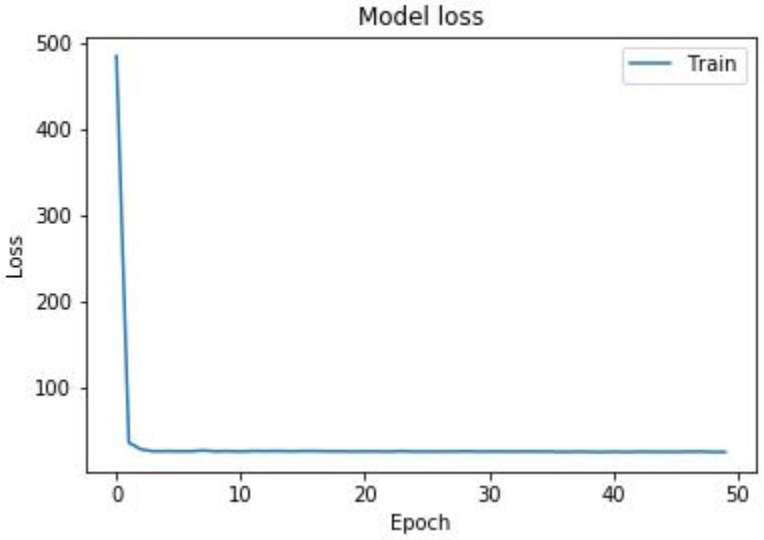
Lte Cell Id	RMSE	R^2
8255381	1.3346	0.9485
7448409	2.7452	0.7066
9404895	4.1457	0.8057
7403	2.8184	0.9354
8980593	4.1093	0.7737

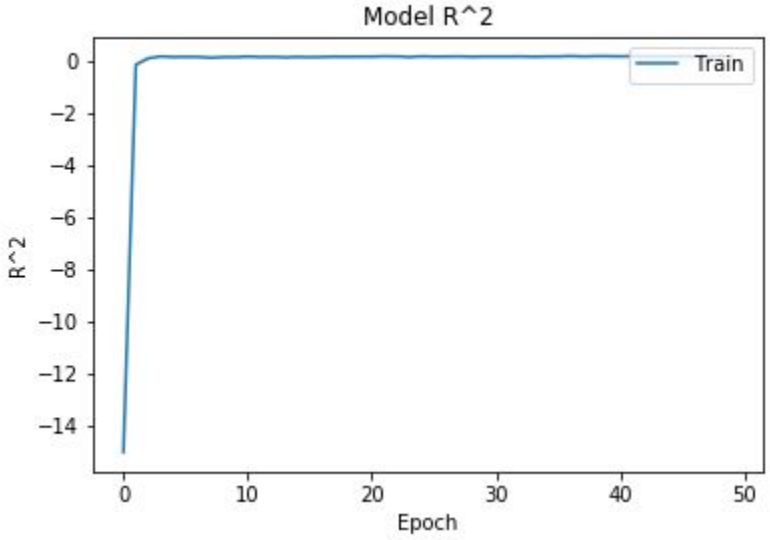
Lte Cell Id	RMSE	R^2
8255381	1.3917	0.944
7448409	3.2981	0.5765
9404895	4.379	0.7832
7403	2.735	0.9392
8980593	4.7521	0.6974

For the most important (in terms of number of positions and receivers), we compared our 3 Regression Models by computing the mean :

- **Linear Regression : RMSE of 6.10904 & R^2 of 34.942 %**
- **Random Forest Regression : RMSE of 3.03064 & R^2 of 83.398 %**
- **Gradient Boosting Regression : RMSE of 3.31118 & R^2 of 78.806 %**

Failed Experiment : Neural Networks

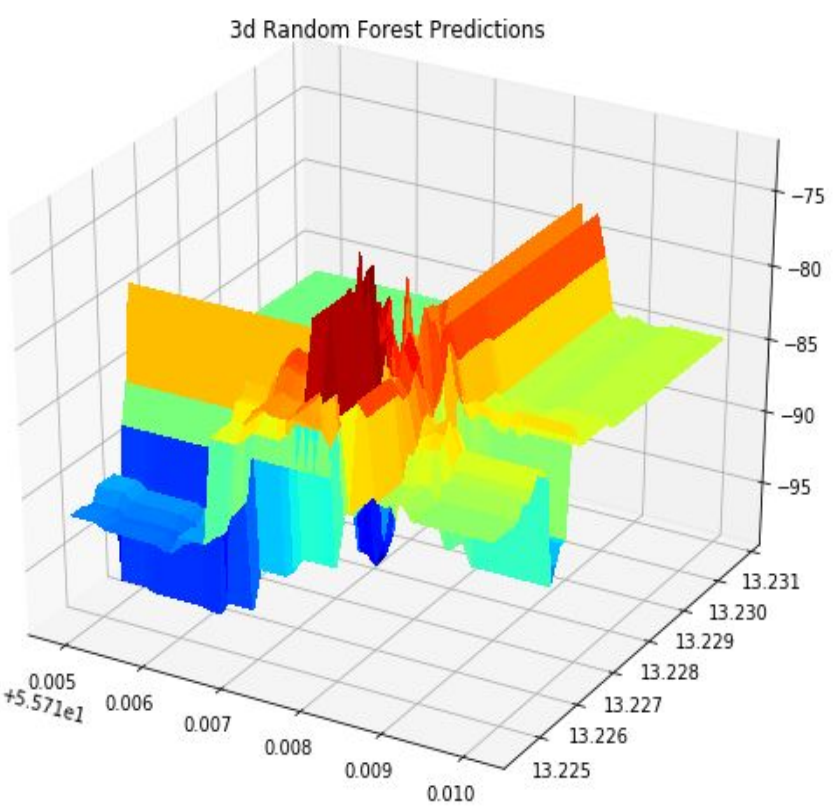


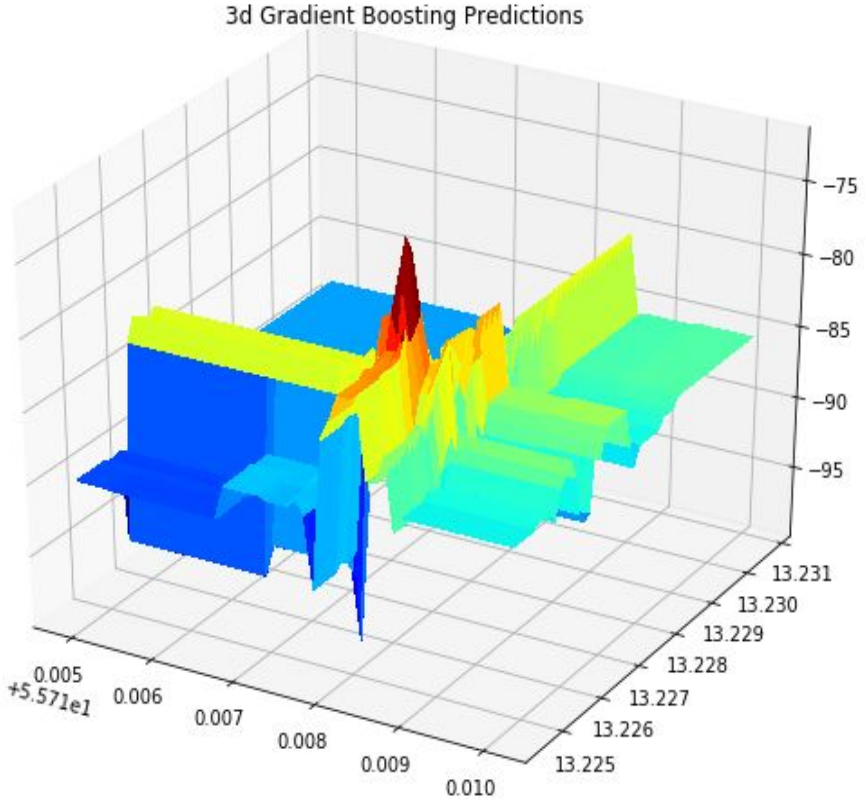


<u>After 50 Epochs & batch size of 32 :</u>
BAD R^2 Value : 20 %
BAD Loss (MSE) Value : 5.0497

```
regressor = Sequential()
regressor.add(Dense(units=6, input_dim=6))
regressor.add(Dense(units=9))
regressor.add(Dense(units=4))
regressor.add(Dense(units=1))
```

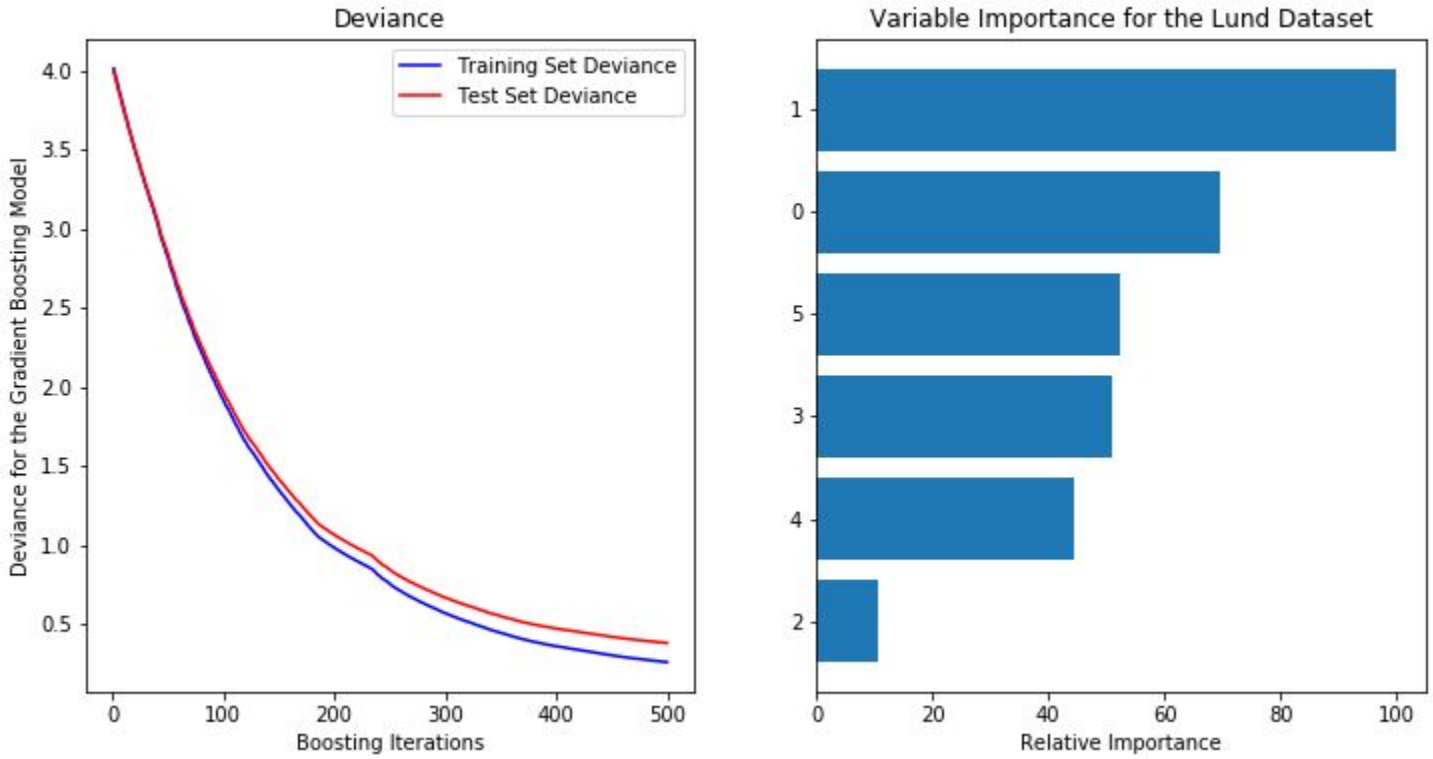
Results Analysis and Interpretation





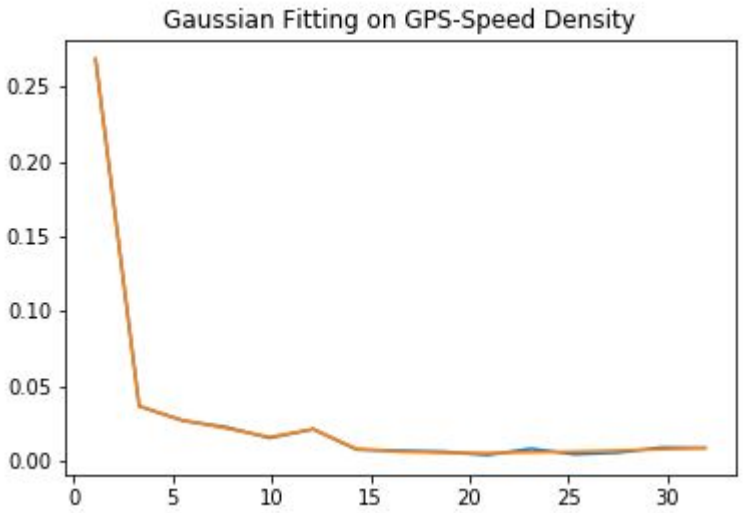
The Gradient Boosting Regressor's Shape in 3D is better.
But we still have many extreme predictions.

Gradient Boosting Demonstration



Demonstrating the Gradient Boosting Regressor :
Better than Random Forest Regressor with RMSE of 1.2986

Classification & Other Conclusions



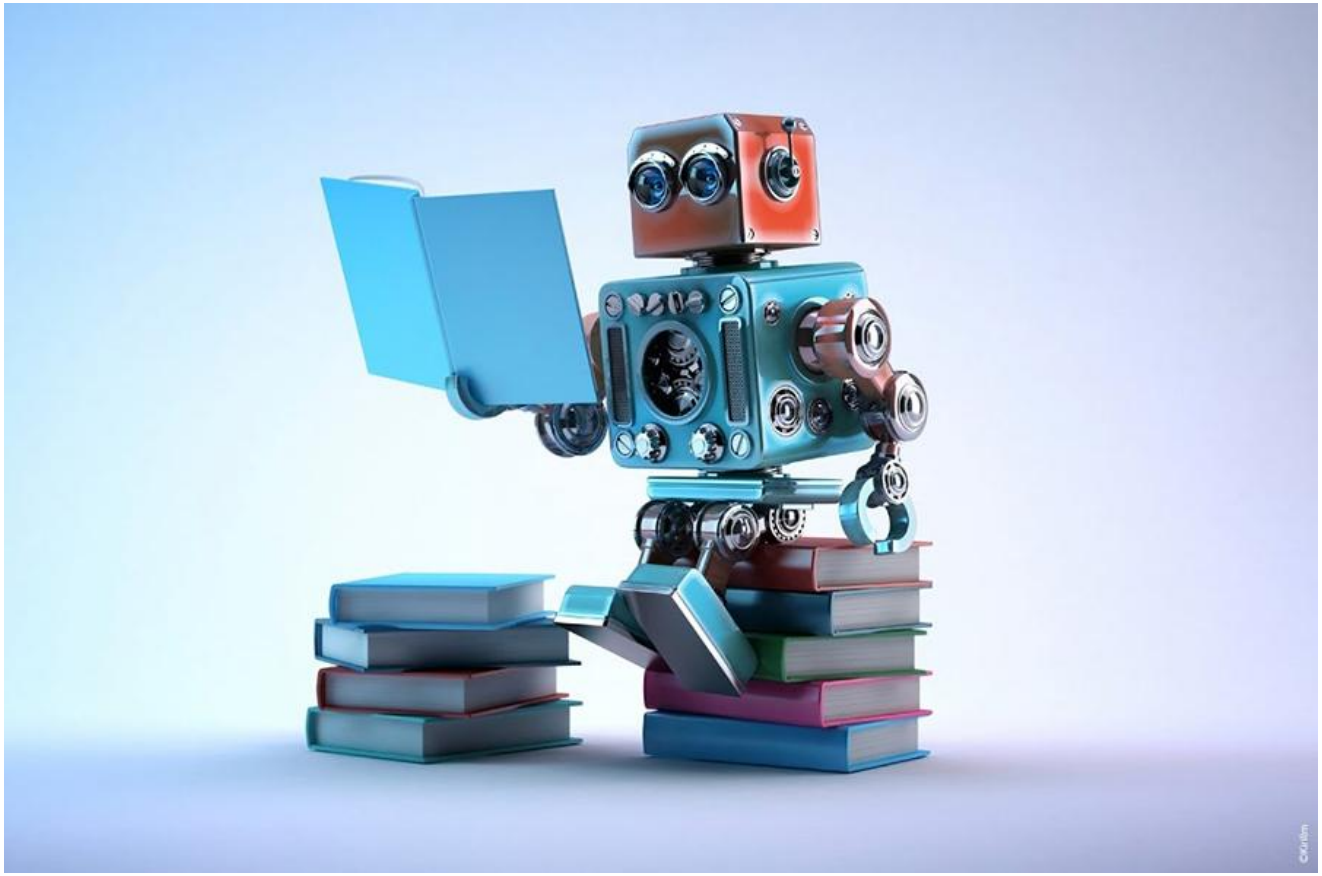
Gaussian Distributions is a recurrent theme in our Dataset :
We can apply a fitting on the GPS-Speed Density for the whole map of Lund (with 5 consecutive gaussians) :

- Fitted Mean : 11.62 m/s
- Fitted Standard Deviation : 0.22

Very Good Classification Results on both GPS Speed and RSRP :

- **Random Forest Classification on RSRP : 0.7738**
- **Random Forest Classification on GPS Speed : 0.9893**

Thank you for listening!



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