Damage Propagation Modeling for Aircraft Engine Run-to-Failure Simulation

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Overview

- This paper describes how damage propagation can be modeled within the modules of aircraft gas turbine engines.
- Response surfaces were generated for all sensors via a thermo-dynamical simulation model for the engine as a function of variations of flow and efficiency of the modules of interest.
- A health index was defined as the minimum of several superimposed operational margins at any given time.
- The data generated were used as challenge data for the Prognostics and Health Management (PHM) data competition

Dataset Used: FD001

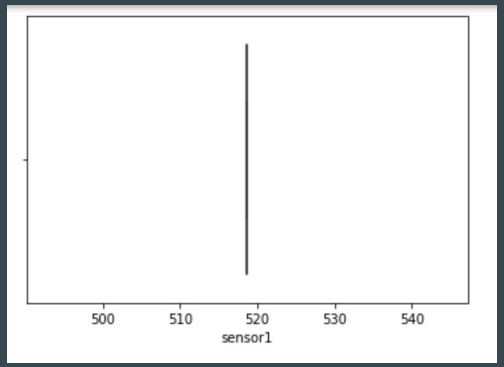
- Imported the dataset train_FD001, test_FD001 & rul_FD001 on the jupyter notebook.
- Dataset rul_FD001 was integrated into dataset train_FD001 and data analysis was conducted.

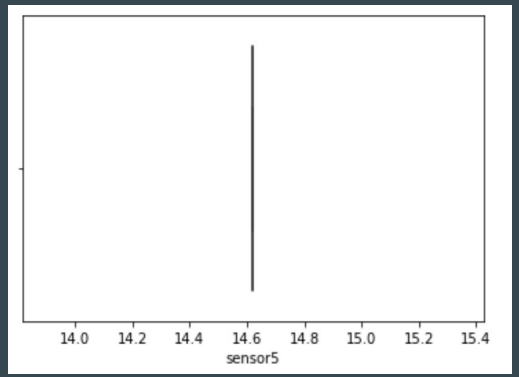
- Total unique engines present in the data were 100.

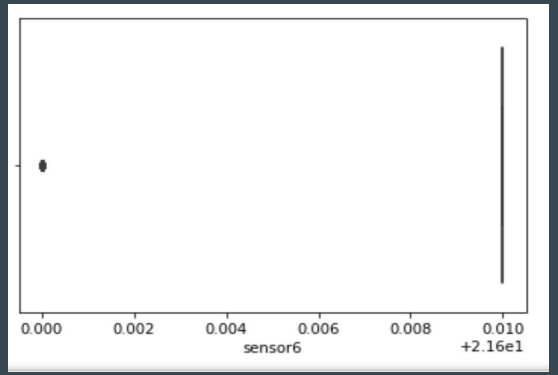
	engineNumber	cycleNumber	opSetting1	opSetting2	opSetting3	sensor1	sensor2	sensor3	sensor4	sensor5	...	sensor13	sensor14	sensor15	sens
0	1	1	-0.0007	-0.0004	100.0	518.67	641.82	1589.70	1400.60	14.62	...	2388.02	8138.62	8.4195	
1	1	2	0.0019	-0.0003	100.0	518.67	642.15	1591.82	1403.14	14.62	...	2388.07	8131.49	8.4318	
2	1	3	-0.0043	0.0003	100.0	518.67	642.35	1587.99	1404.20	14.62	...	2388.03	8133.23	8.4178	
3	1	4	0.0007	0.0000	100.0	518.67	642.35	1582.79	1401.87	14.62	...	2388.08	8133.83	8.3682	
4	1	5	-0.0019	-0.0002	100.0	518.67	642.37	1582.85	1406.22	14.62	...	2388.04	8133.80	8.4294	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
20626	100	196	-0.0004	-0.0003	100.0	518.67	643.49	1597.98	1428.63	14.62	...	2388.26	8137.60	8.4956	
20627	100	197	-0.0016	-0.0005	100.0	518.67	643.54	1604.50	1433.58	14.62	...	2388.22	8136.50	8.5139	
20628	100	198	0.0004	0.0000	100.0	518.67	643.42	1602.46	1428.18	14.62	...	2388.24	8141.05	8.5646	
20629	100	199	-0.0011	0.0003	100.0	518.67	643.23	1605.26	1426.53	14.62	...	2388.23	8139.29	8.5389	
20630	100	200	-0.0032	-0.0005	100.0	518.67	643.85	1600.38	1432.14	14.62	...	2388.26	8137.33	8.5036	

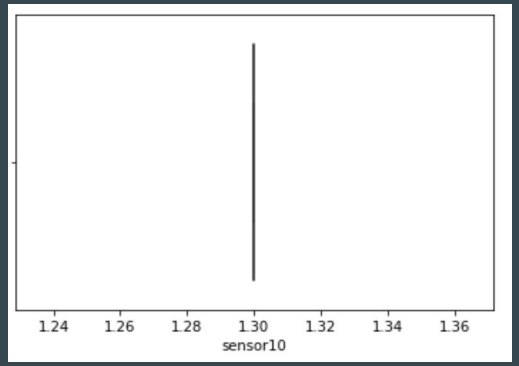
20631 rows × 27 columns

- By analysing with the help of boxplot and taking the info of sensor dataset, it was found out that sensors 1, 5, 6, 10, 16, 18, 19 should be removed as they produce no variation.

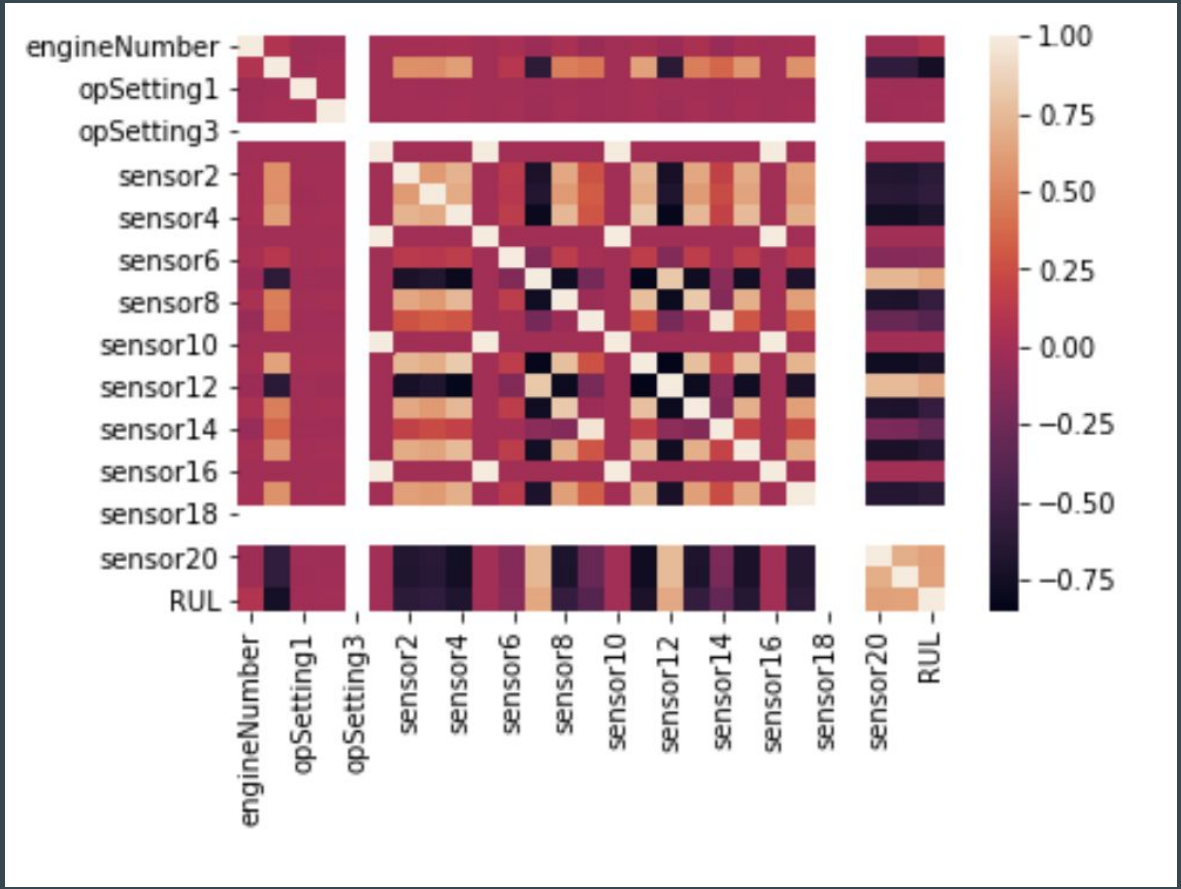




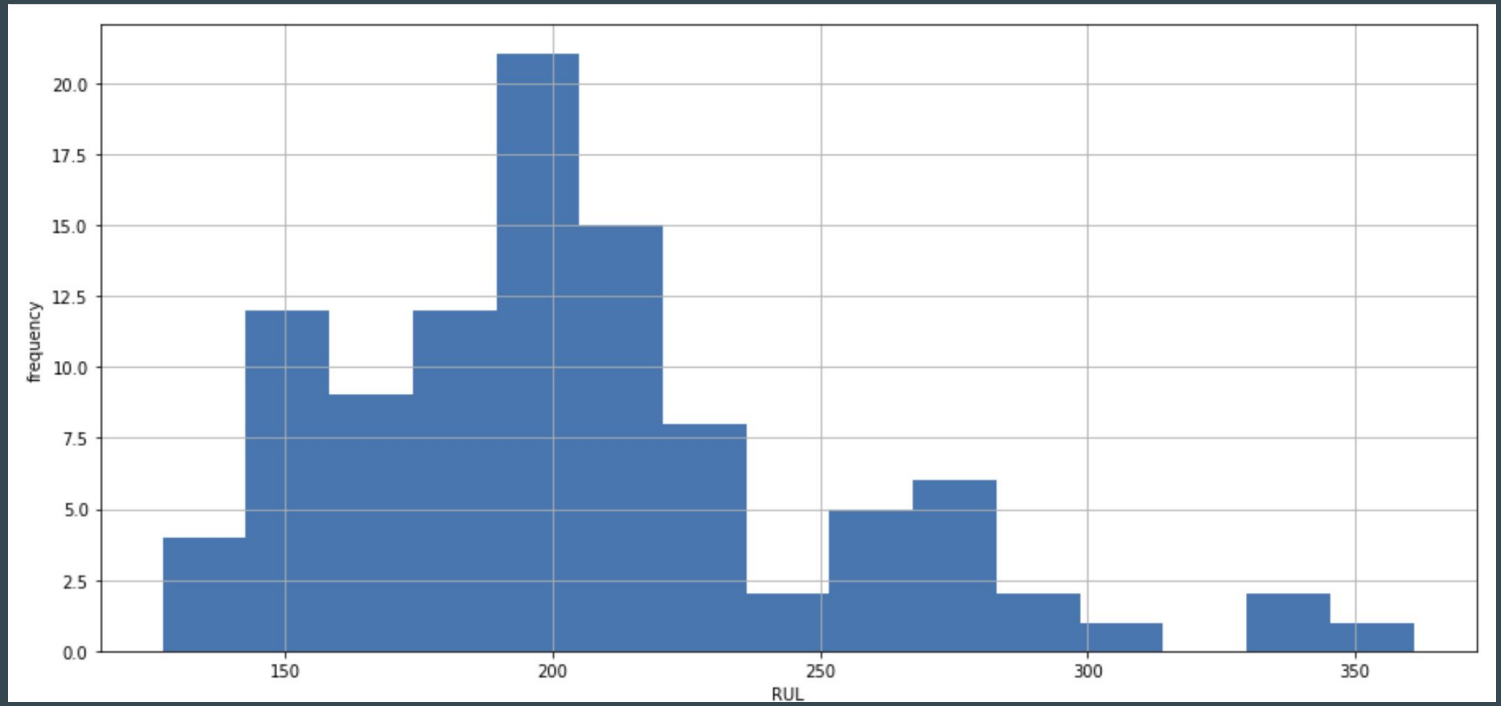




- Heatmap of correlation of sensors

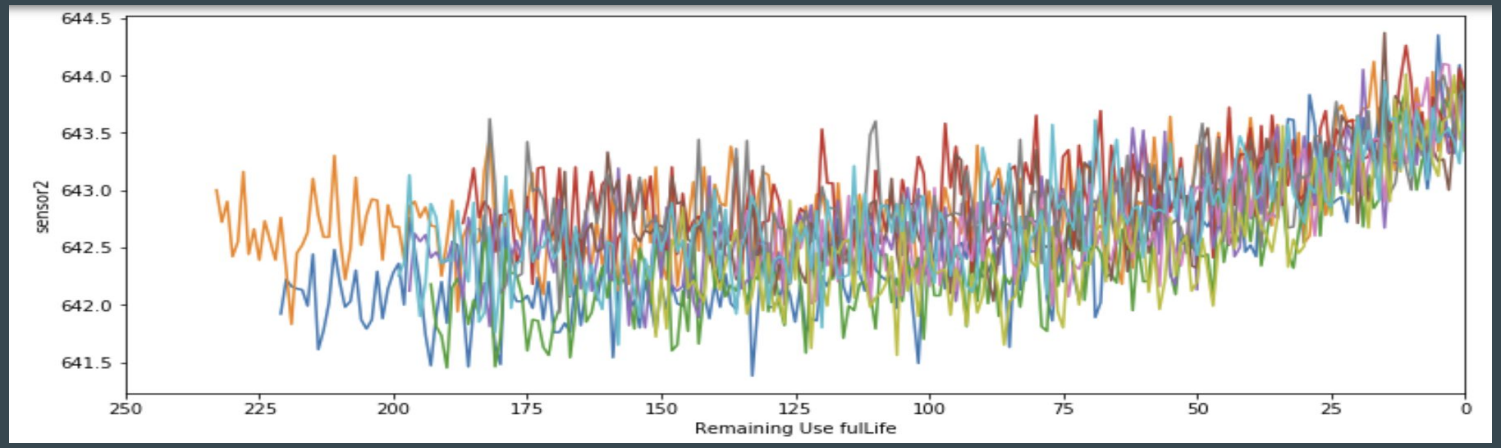


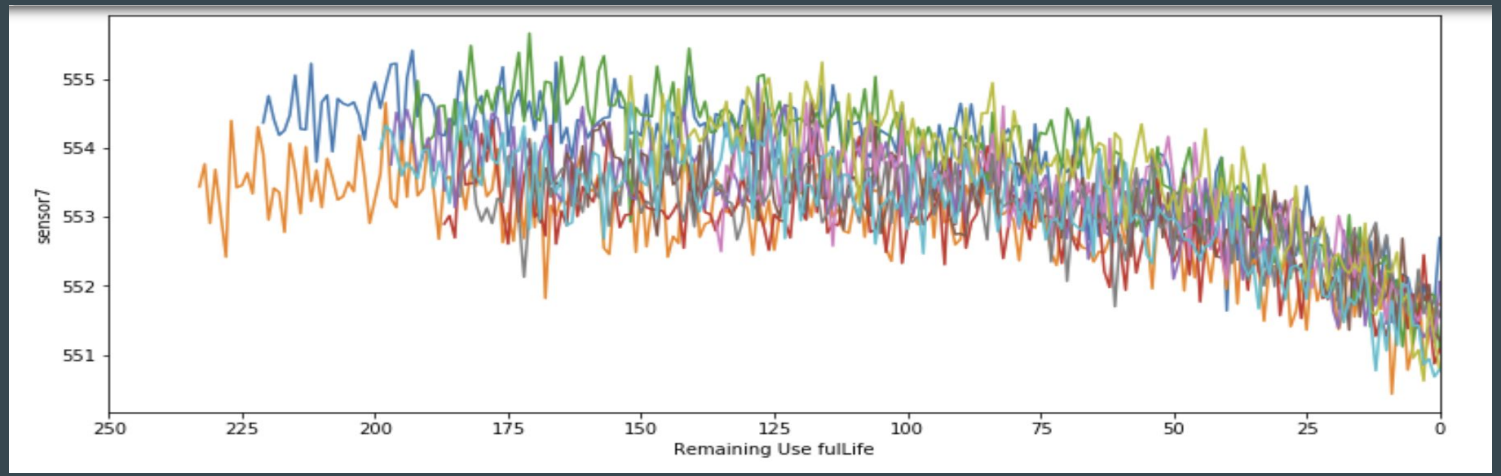
- Frequency of engine breakdown



This represents that most of the engines breakdown at around 200 cycles.

Plotted the graph of sensors vs Remaining Use life(RUL)





- After performing Exploratory Data Analysis, I trained linear regression model on train_fd001 dataset

- Achieved an RMSE of 39.58 and
  R2_score of 0.6697

- After using Linear regression model, i tried using Decision Tree regressor to improve my model with criteria like:
  - criterion='mse'
  - max_depth=7
  - random_state=1

- After using decision tree regressor, i achieved RMSE of 30.4126 and
  R2_Score of 0.8050

Predicted RUL of test dataset:

And then using DTR model, i predicted the RUL of test dataset

array([194.86309524, 126.02889246, ... 120.22818792, 96.8447205 , 151.96884735, 14.35])