A Prognostics and System Health Management process based on Health Index

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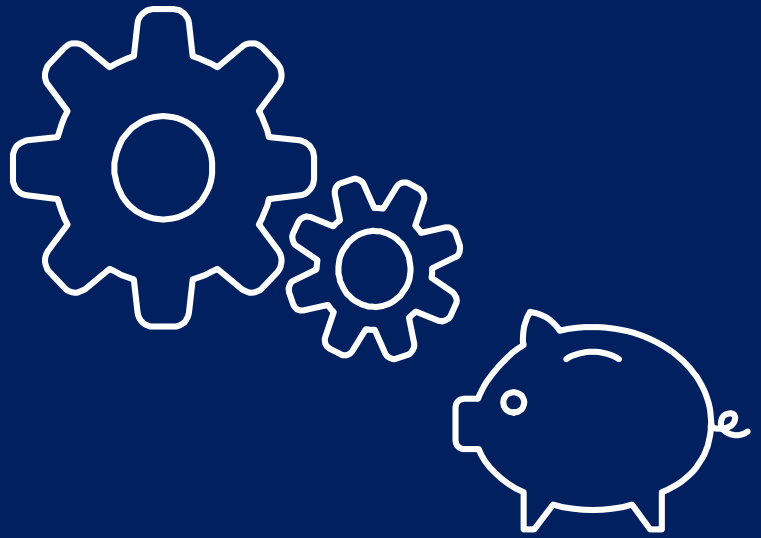
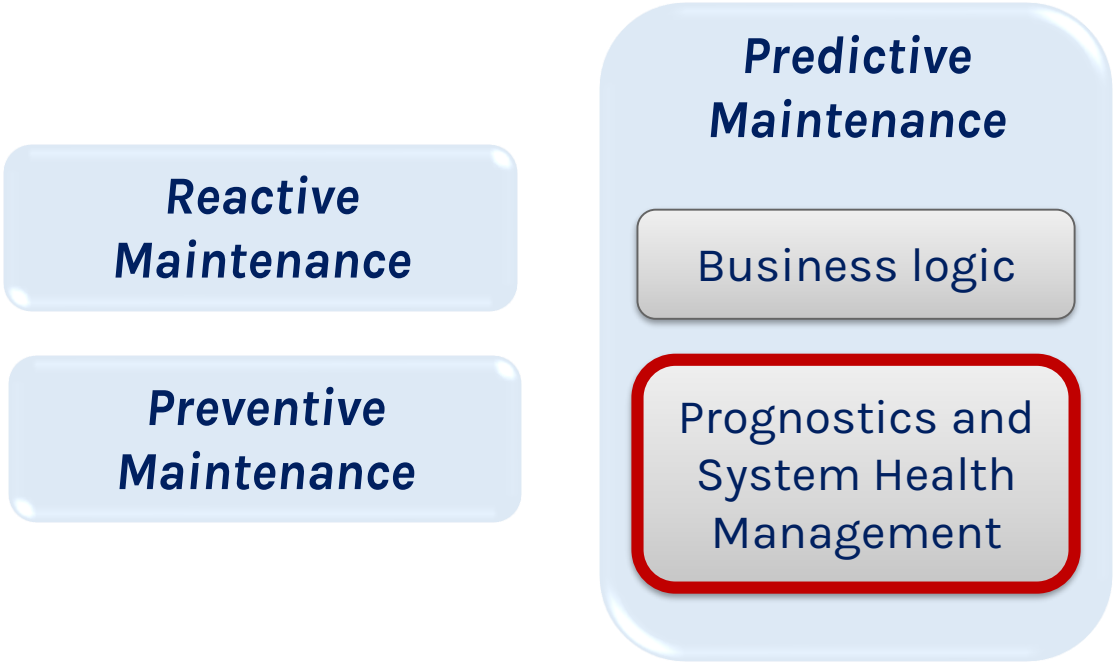
Main purposes

- Build a generic PHM framework
- Obtain good performance without losing interpretability
- Promote the development of algorithms able to provide probability density functions

Prognostics and System Health Management process

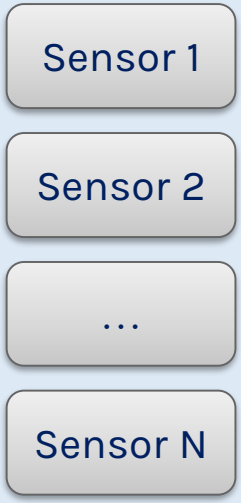


PHM process


Reactive Maintenance
Preventive Maintenance
Predictive Maintenance
Business logic
Prognostics and System Health Management

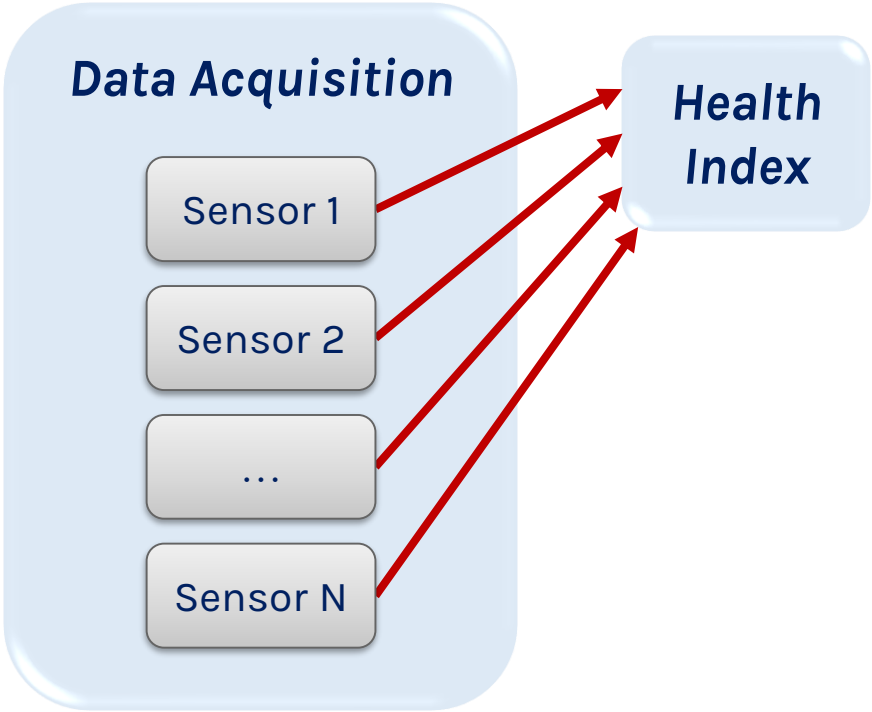
PHM process

Data Acquisition



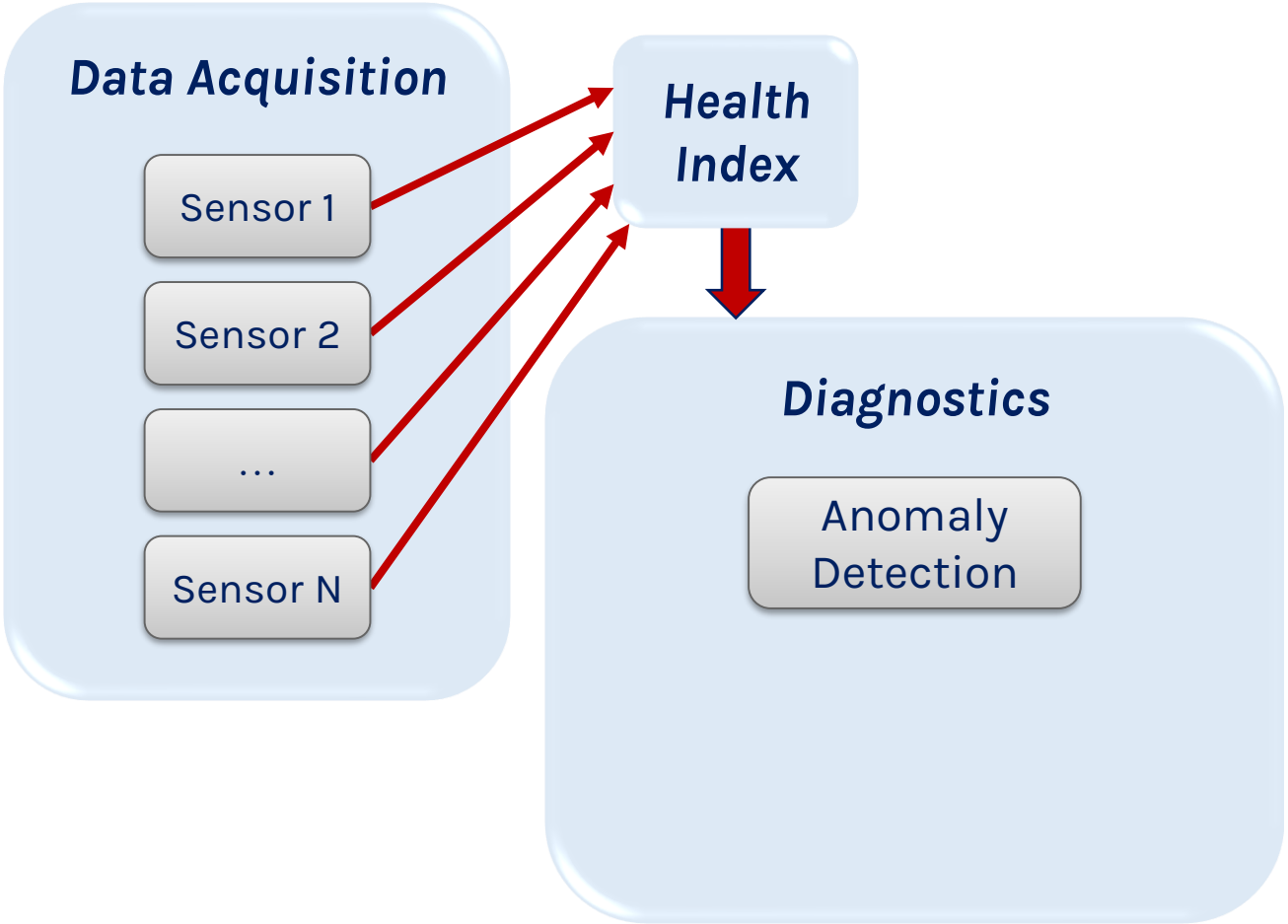
Yaguo Lei et al. (2018). "Machinery health prognostics: A systematic review from data acquisition to RUL prediction"

PHM process



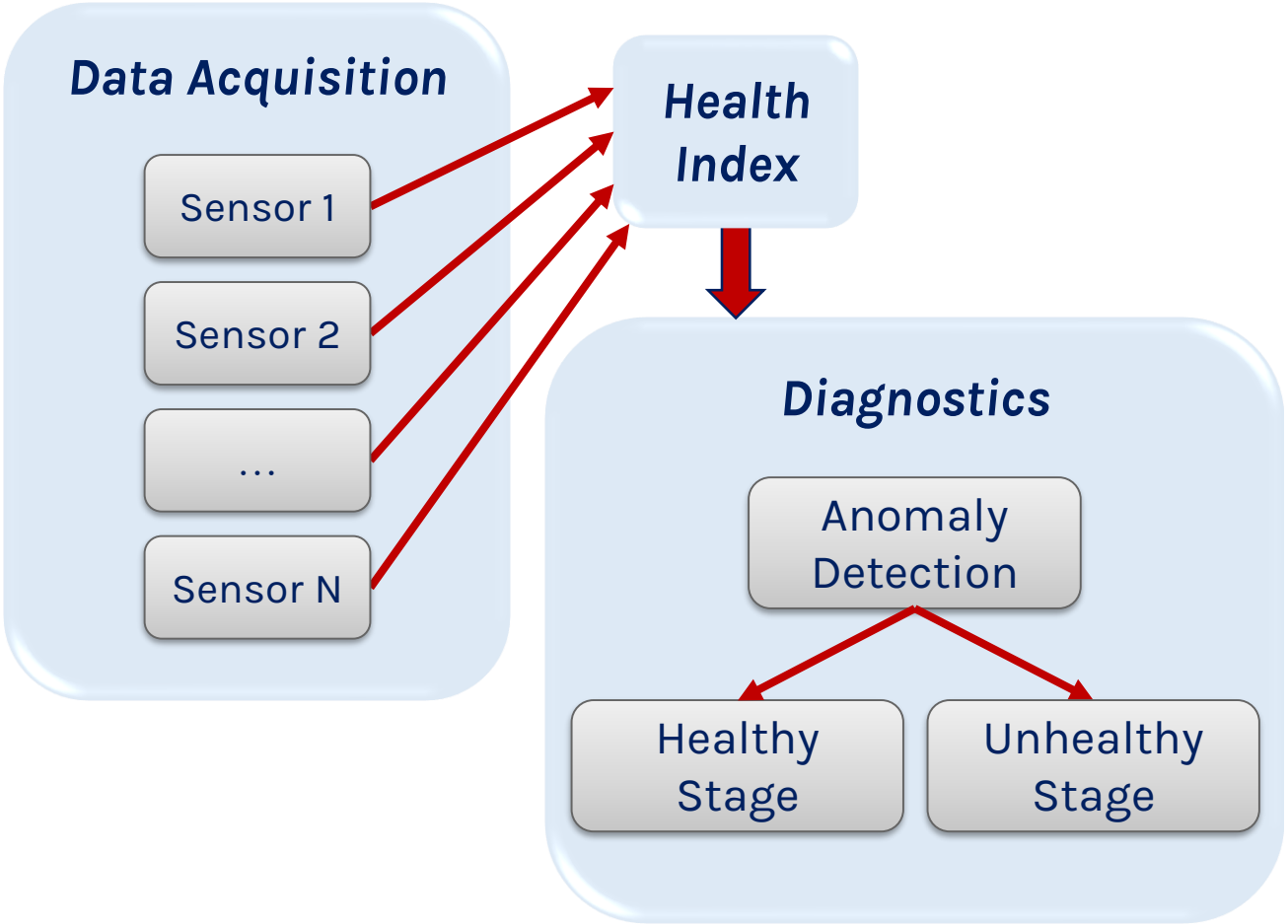
Yaguo Lei et al. (2018). "Machinery health prognostics: A systematic review from data acquisition to RUL prediction"

PHM process



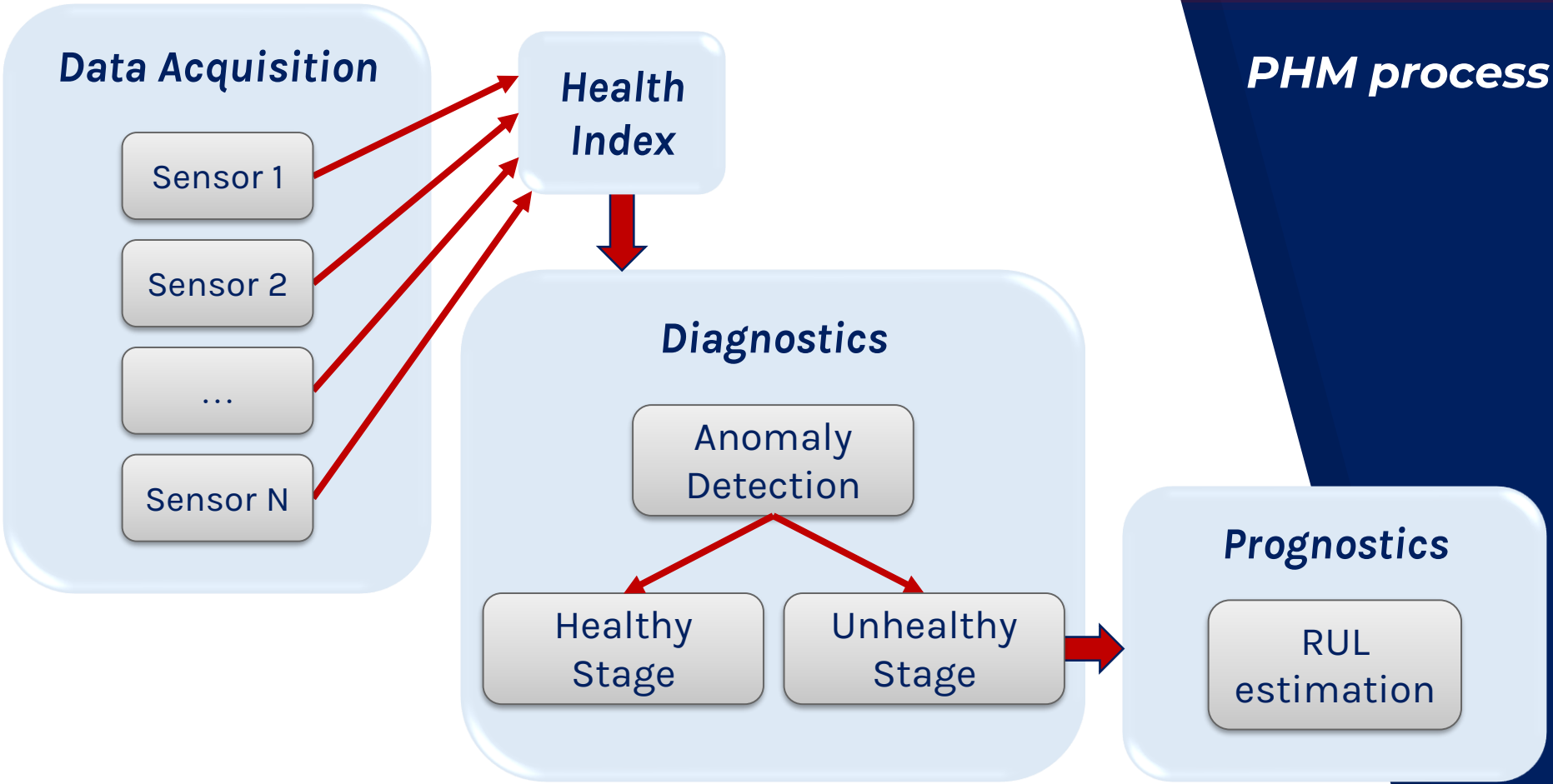
Yaguo Lei et al. (2018). "Machinery health prognostics: A systematic review from data acquisition to RUL prediction"

PHM process



Yaguo Lei et al. (2018). "Machinery health prognostics: A systematic review from data acquisition to RUL prediction"

PHM process



Yaguo Lei et al. (2018). "Machinery health prognostics: A systematic review from data acquisition to RUL prediction"

C-MAPSS datasets

Turbofan Engine Degradation Simulation Dataset

C-MAPSS datasets

Dataset	FD001	FD002	FD003	FD004	PHM08
Training Trajectories	100	260	100	249	218
Test Trajectories	100	259	100	248	218

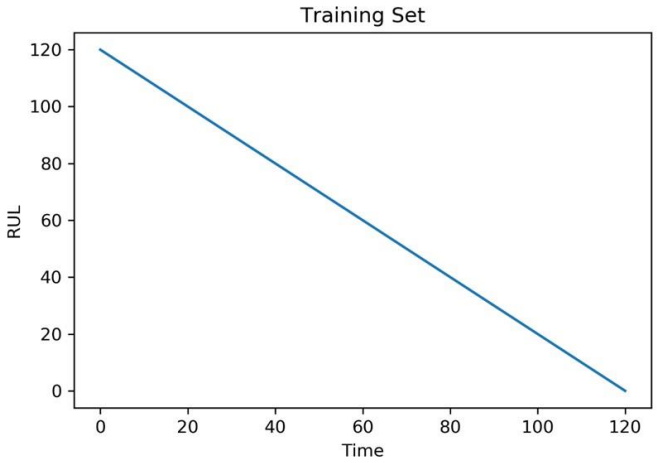
~ 200,000 observations

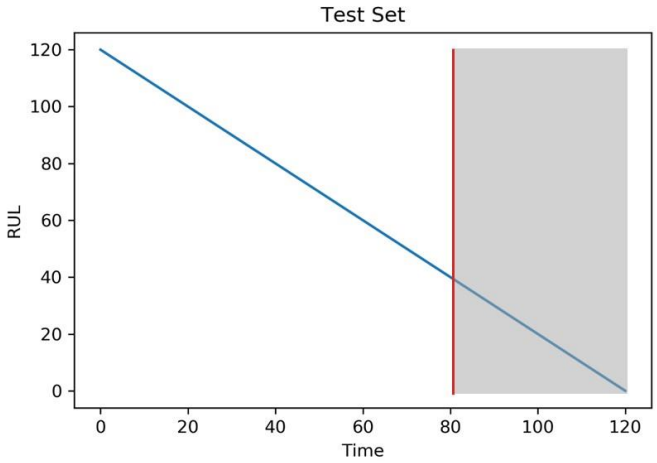
https://ti.arc.nasa.gov/tech/dash/groups/pcoe/prognostic-data-repository/#turbofan

Input features

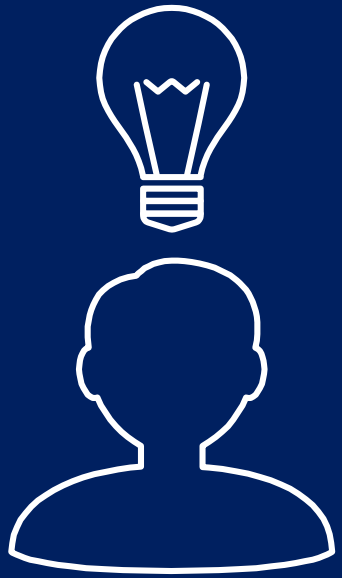
- Engine ID
- Cycle
- 3 operating condition variables (altitude, TRA, Mach number)
- 21 sensory features

Target feature

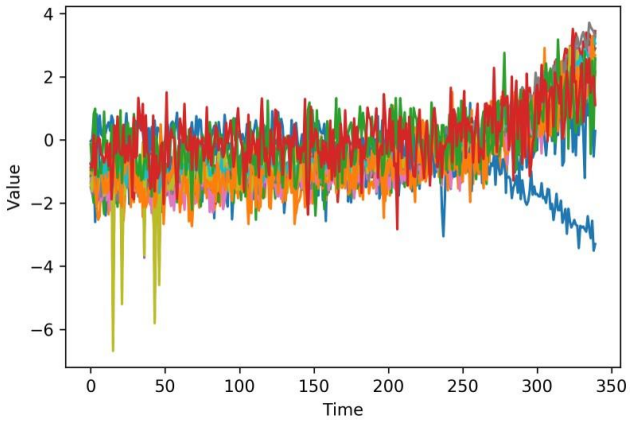




Proposed approach



Denoising



Gaussian Noise

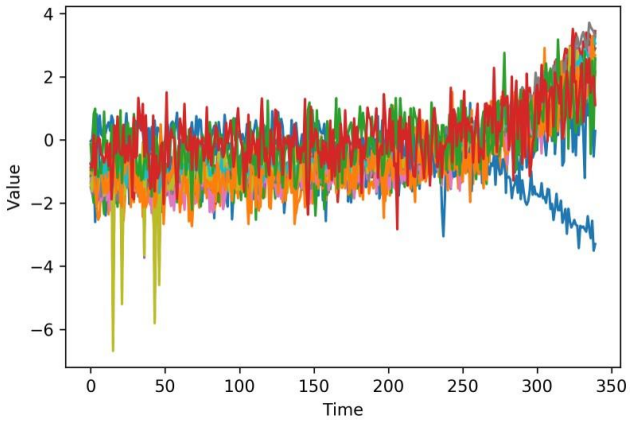
Gaussian Dropout

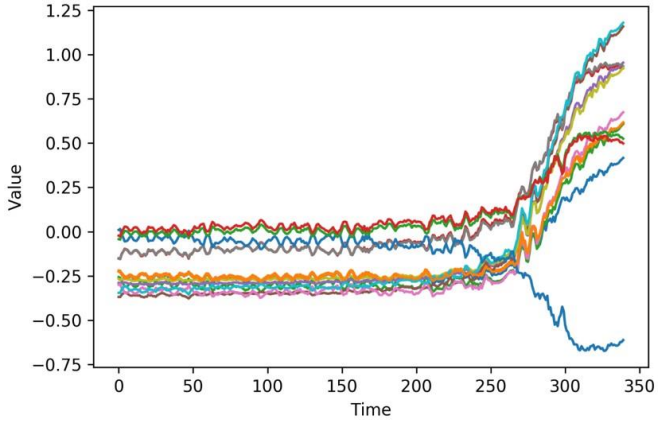
ENCODER

LATENT VECTOR

DECODER

Denoising


Value
Time
4
2
0
−2
−4
−6
0
50
100
150
200
250
300
350


Value
Time
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
0
50
100
150
200
250
300
350

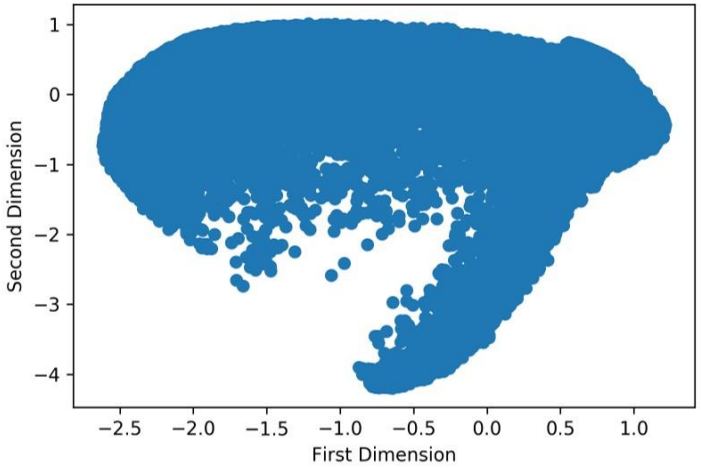
Health Index construction

ENCODER

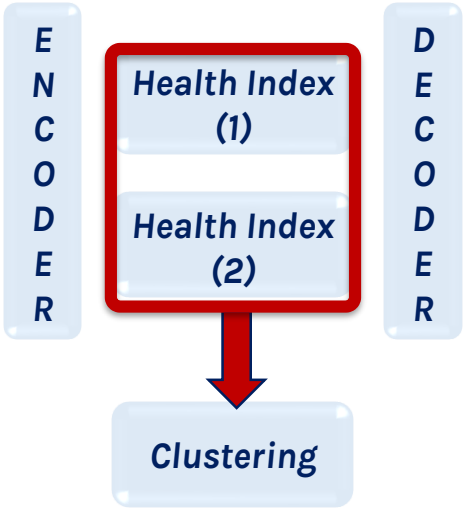
Health Index (1)

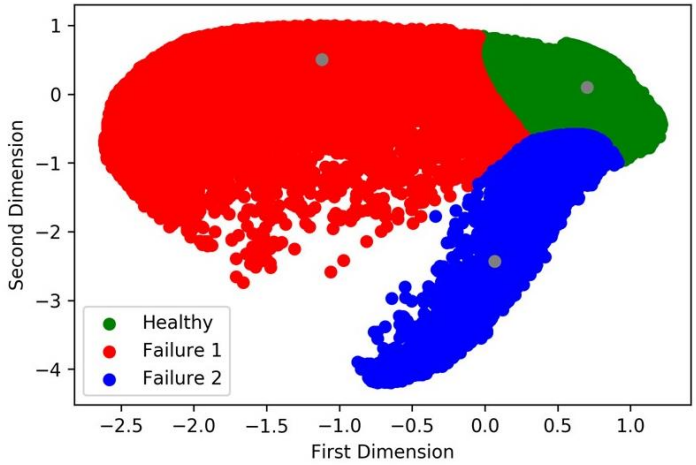
Health Index (2)

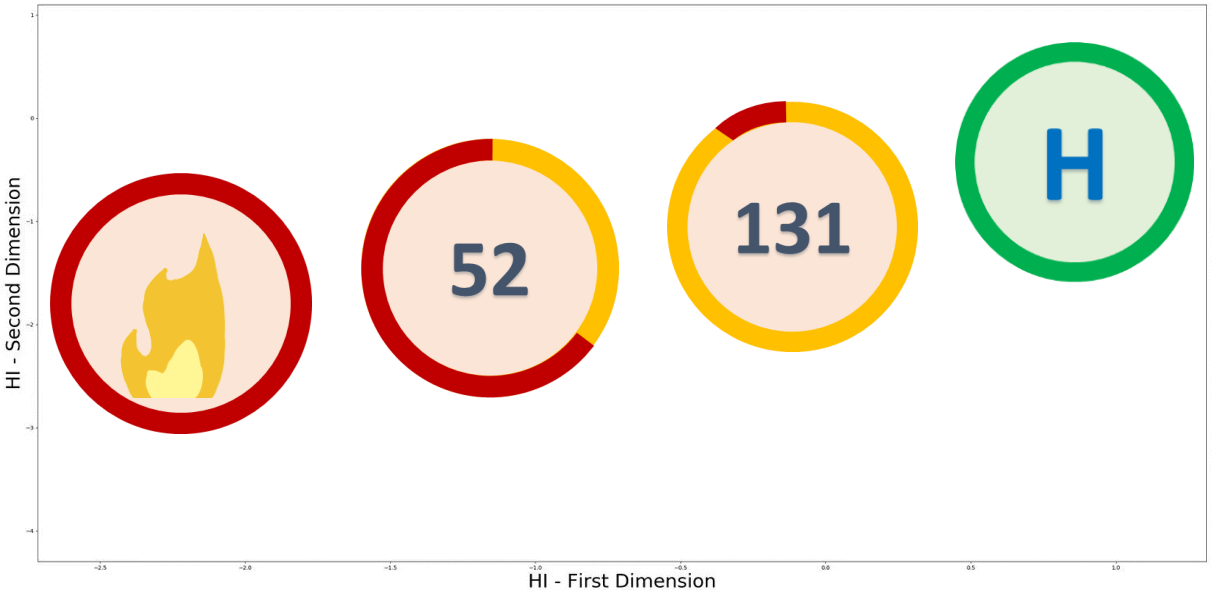
DECODER



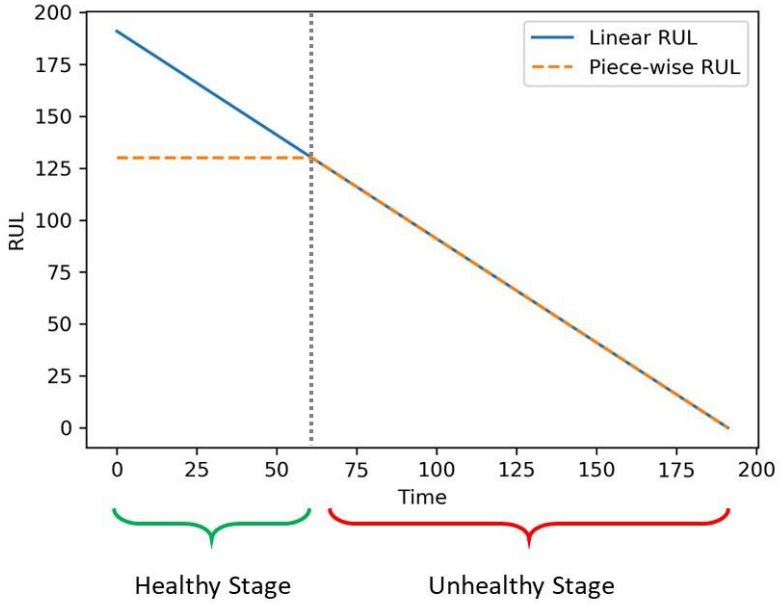
Health Stages division





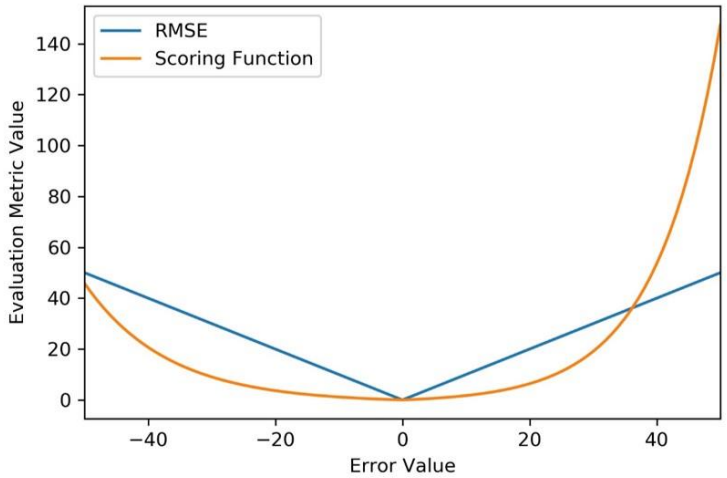

HI - Second Dimension
HI - First Dimension
52
131
H

RUL estimation



Point predictions

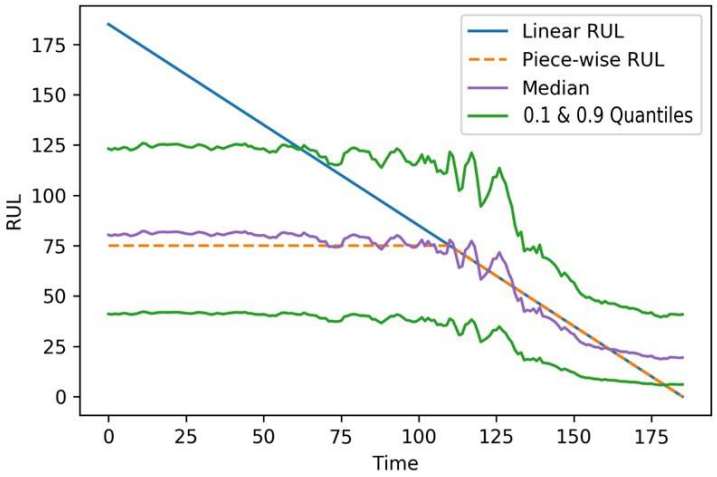
- Gradient Boosting Machine
- Scoring Function



Abhinav Saxena et al. (2008). "Damage propagation modeling for aircraft engine run-to-failure simulation"

Probabilistic predictions

- Weibull neural network
- Prognostic metrics



Egil Martinsson (2016). "WTTE-RNN : Weibull Time To Event Recurrent Neural Network"
Abhinav Saxena et al. (2010). "Metrics for Offline Evaluation of Prognostic Performance"

Results

- Scores comparable with other researches on the FD001, FD002, FD003 and FD004 datasets
- Basing on the PHM08 Data Challenge results in terms of Scoring Function, 4th on the first test set and 6th on the final test set
- 10th on the updated final test set ranking

Conclusions & Future work

- The proposed methodology guarantees good performance and a certain degree of interpretability to domain experts
- The applicability of the developed PHM process in real use cases is an open question
- This thesis will be used by Cefriel as a starting point in a research project about “Industry 4.0”

Questions?