

An aerial, high-angle view of an Airbus aircraft assembly line. The image shows a large, white aircraft fuselage being assembled on a yellow and white metal structure. The factory floor is filled with various tools, equipment, and workers. The lighting is bright, and the overall scene is industrial and complex.

AIRBUS

Deep Learning Anomaly Detection

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AML / EPFL Lausanne / 28.01.2020

The coming age

Unified data ecosystem.

Connected Aircraft

24,000 Parameters
100% available data



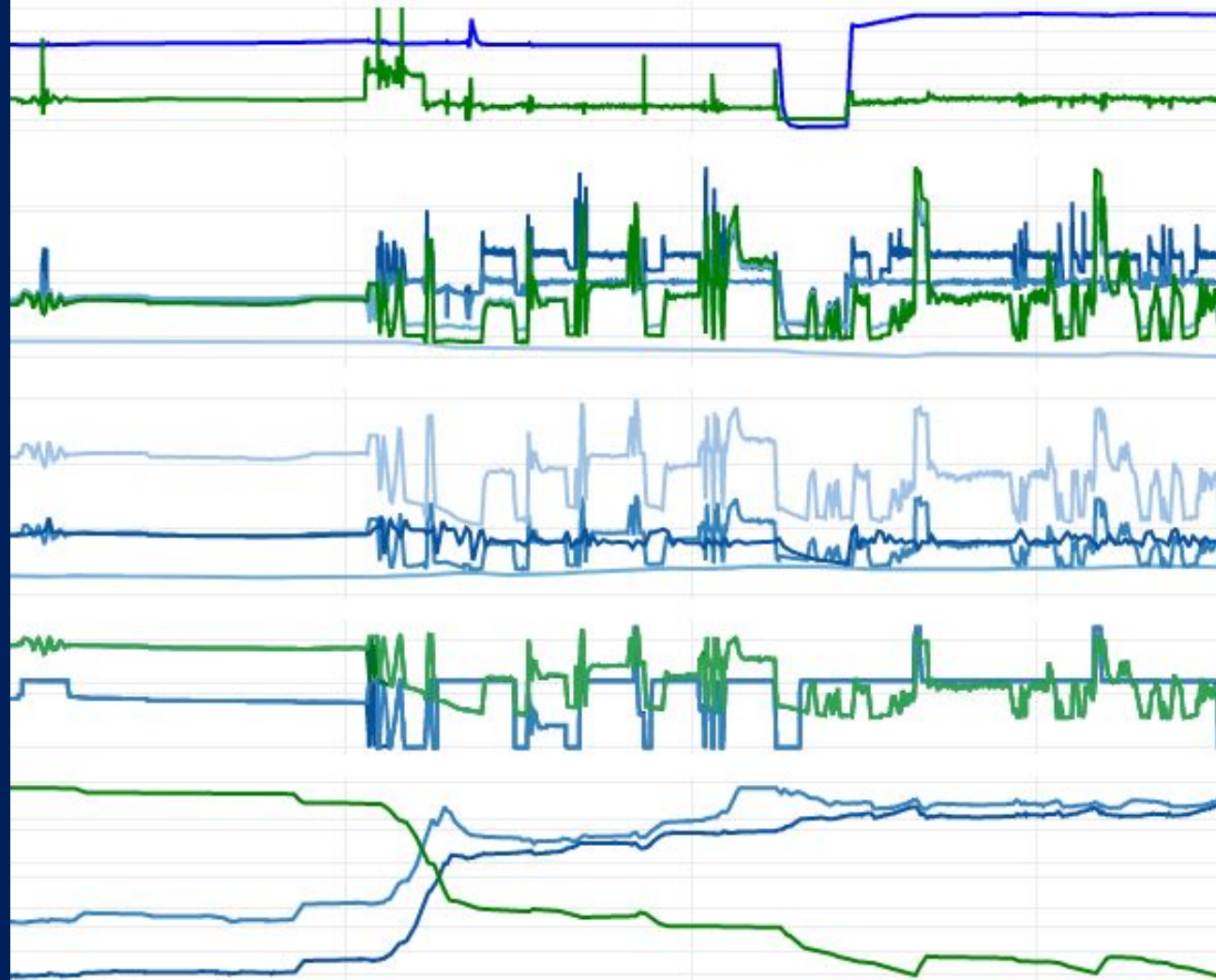
Operational Environment Data
In-Service Data
Industrial Data
Supply Chain Data

skywise.

AIRBUS

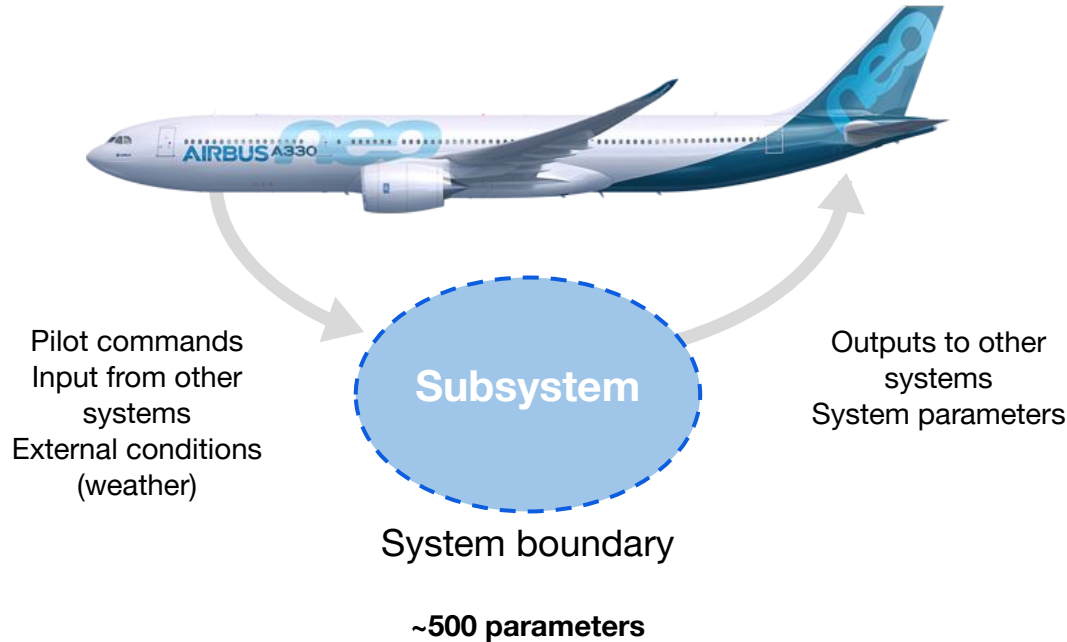
Time Series

The beating heart of an airplane

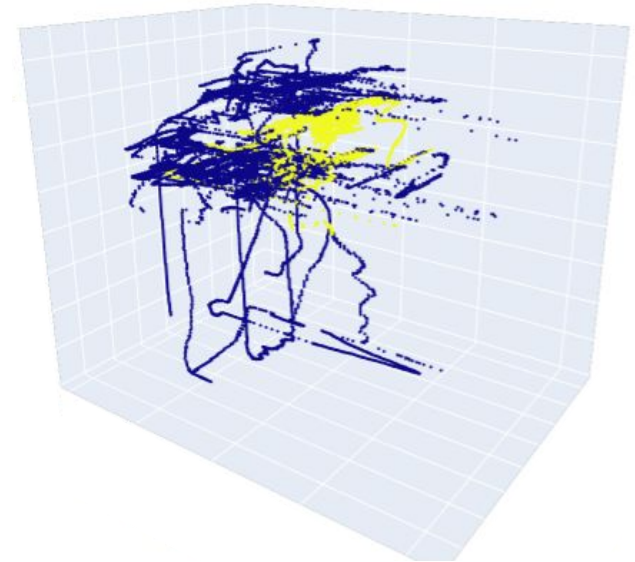


Challenge

Open Dynamical Systems

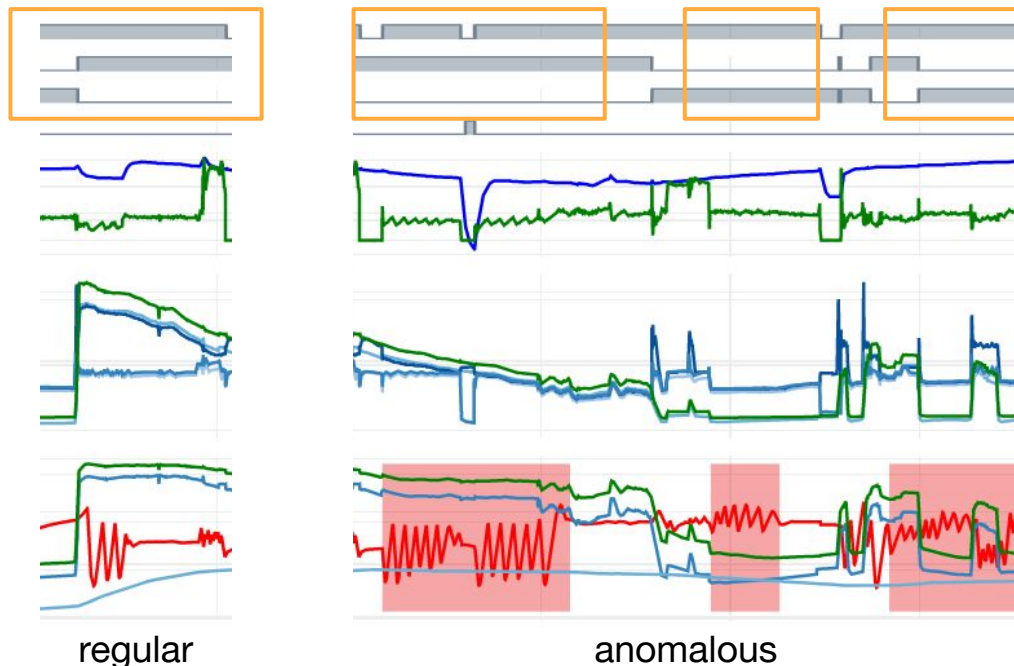


Projection to 3 parameters



Anomaly Detection

Anomalies: Patterns in data not conforming to expected behaviour

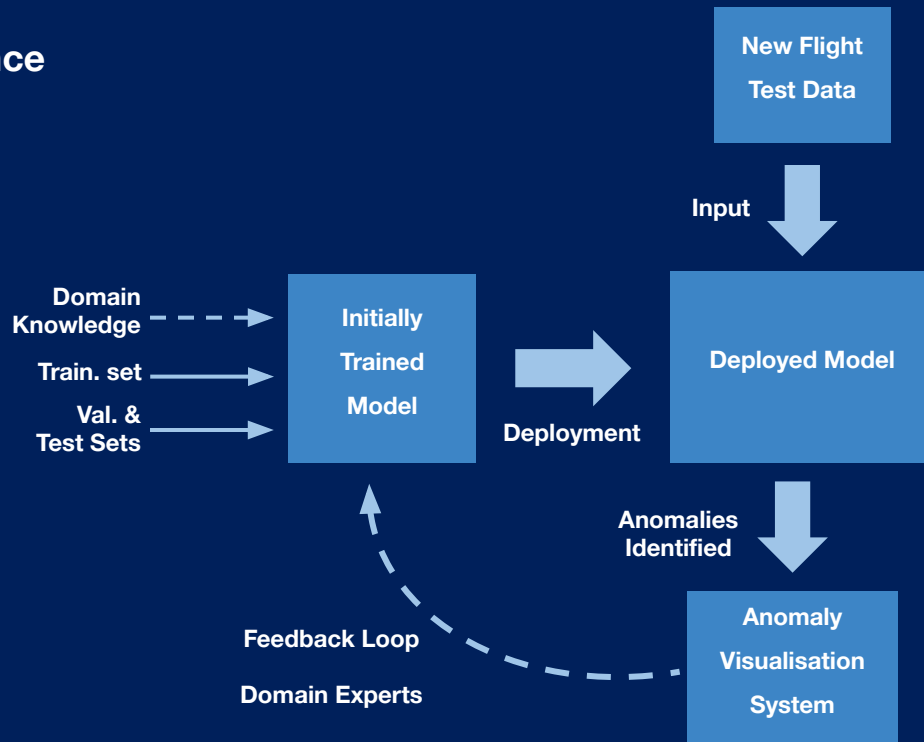
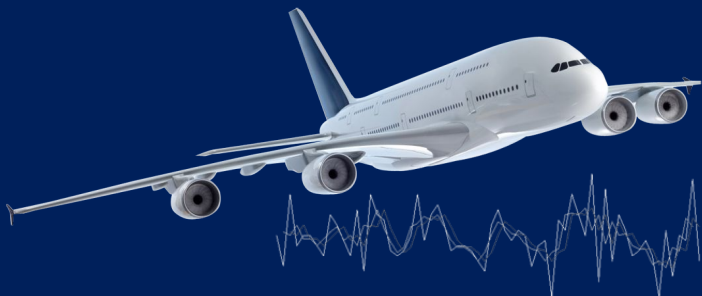


Rules find severe anomalies

Challenge:
small,
context-dependent
deviations

Industrial solution

Semi-supervised human-level performance on time series from industrial assets

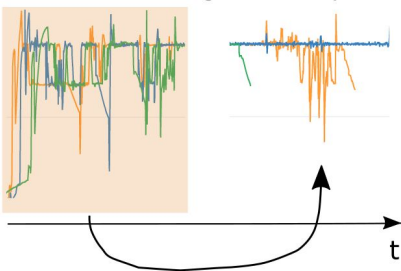


State of the art

Deep Learning Approaches

Predictive

Future from regular samples



LSTM

Malhotra et al. 2015
Hundman et al. 2018

CNN

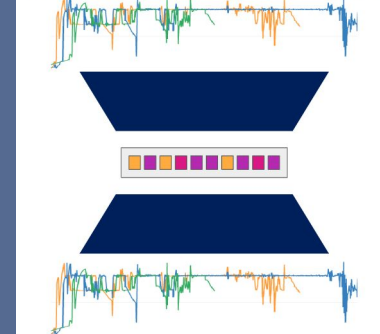
Munir et al. 2018

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Reconstructive

Latent space from regular samples



Autoencoder

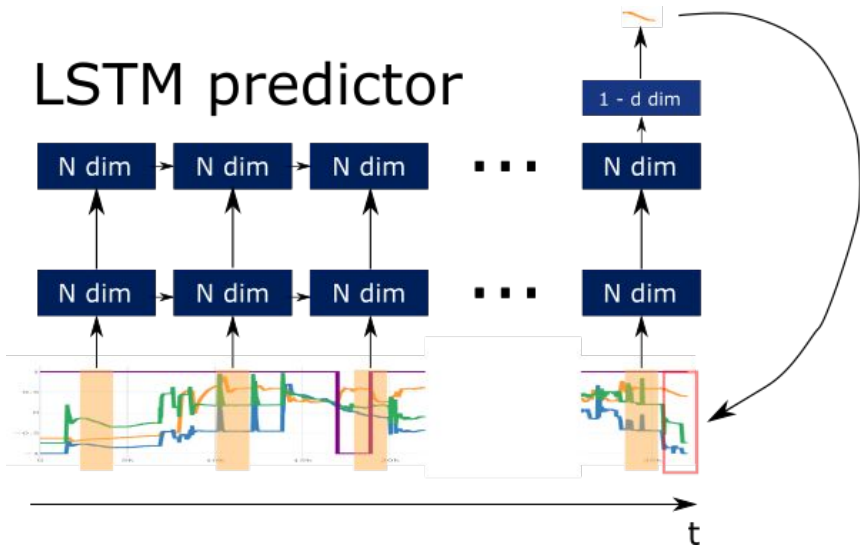
Hawkins et al. 2002
Malhotra et al. 2016 (LSTM)
Su et al. 2019 (stochastic RNN)

GAN

Schlegl et al. 2017
Li et al. 2019

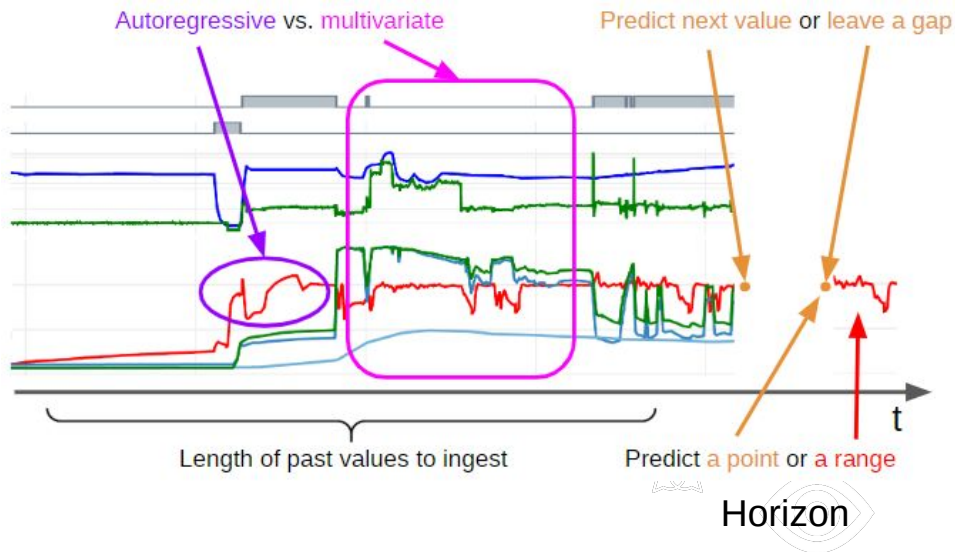
Airbus approach

LSTM predictor



Hundman, Kyle, et al. "Detecting spacecraft anomalies using lstm and nonparametric dynamic thresholding." *Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*. ACM, 2018.

Modelling Choices

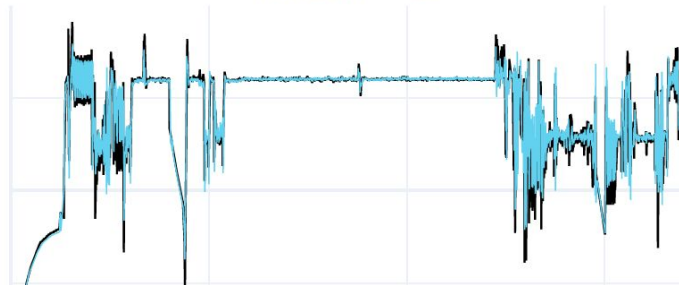


Model Development

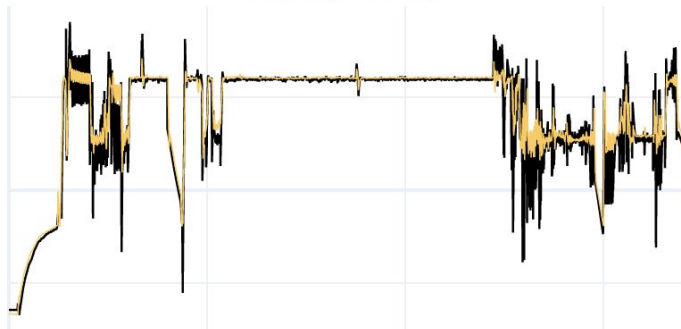
Horizon = 1



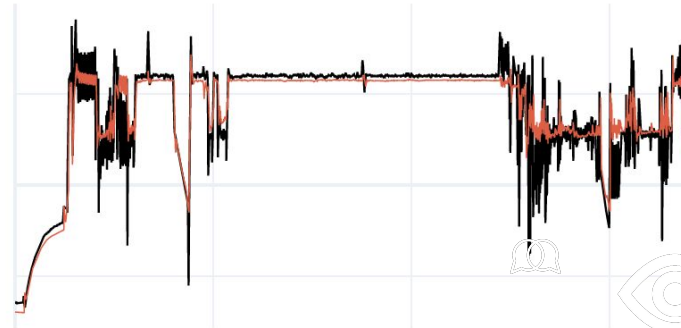
Horizon = 10



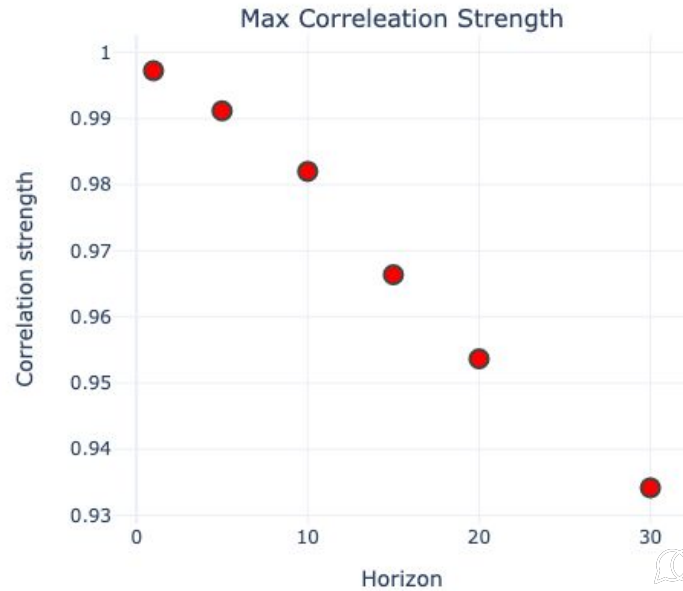
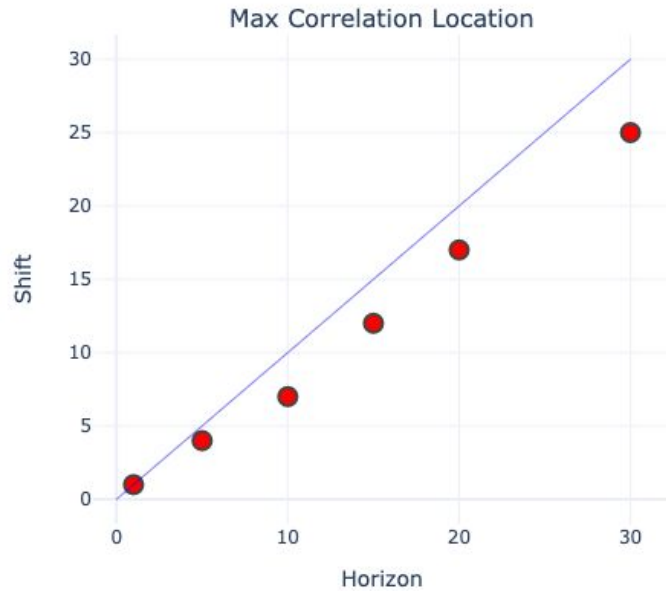
Horizon = 20



Horizon = 30



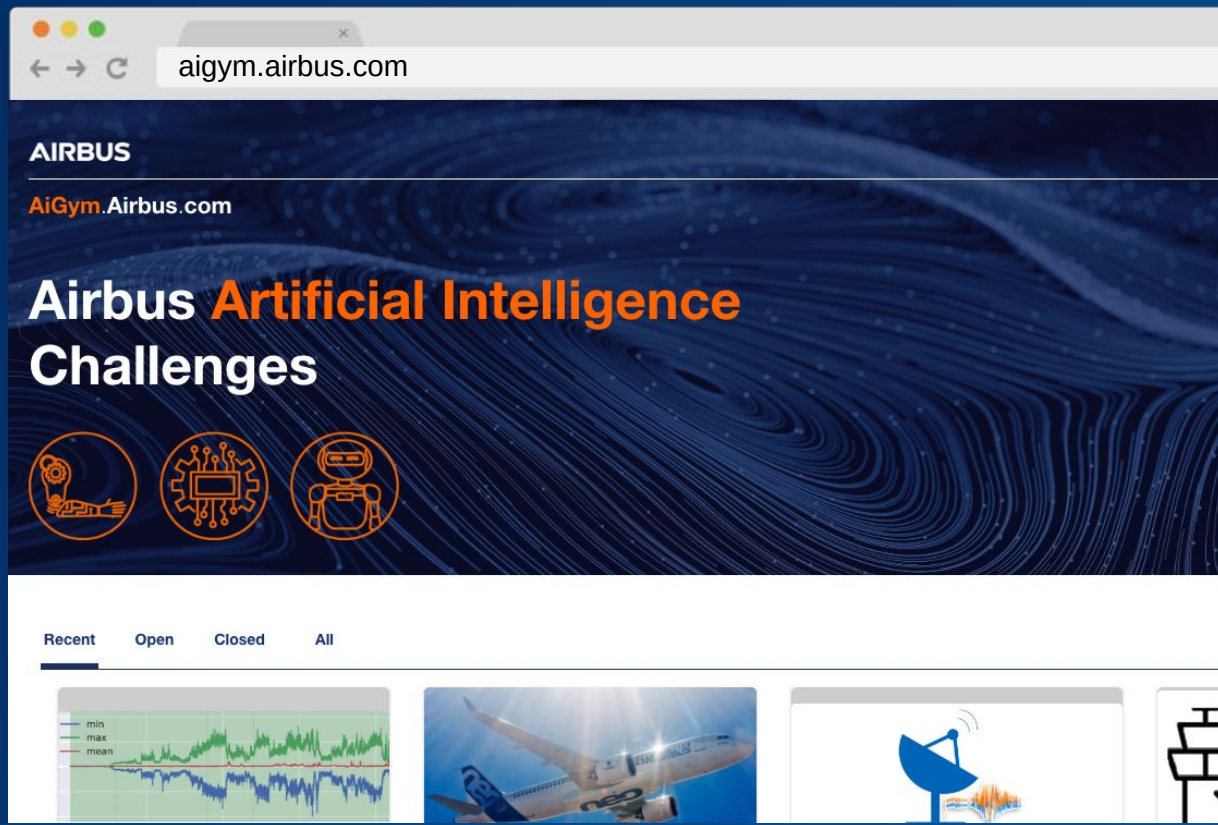
Model Development



Co-Innovation

AI Gym

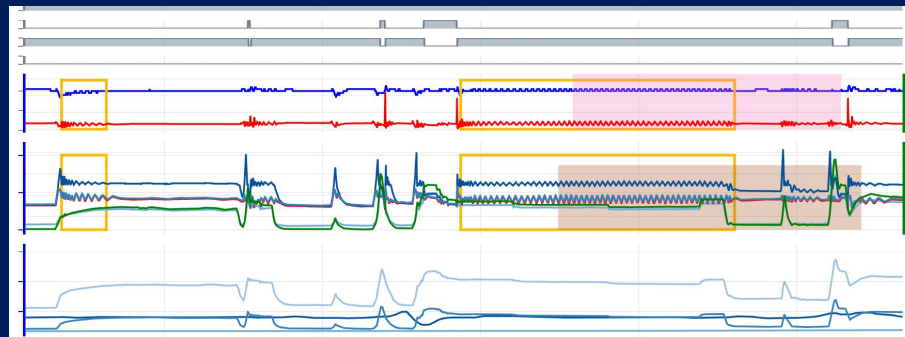
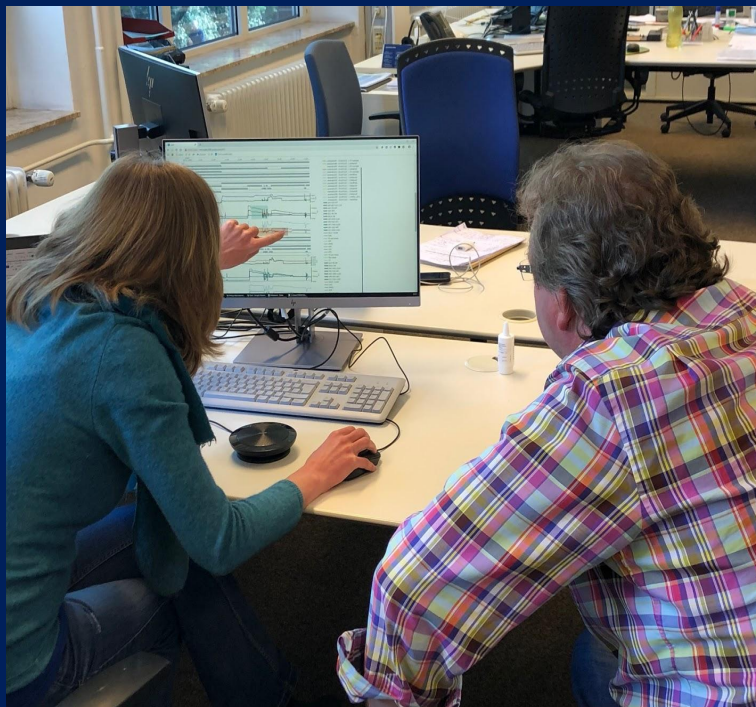
Collaborate with
the most
innovative
companies at
massive scale.



The screenshot shows a web browser window with the URL `aigym.airbus.com`. The page header includes the **AIRBUS** logo and the text **AiGym.Airbus.com**. The main heading is **Airbus Artificial Intelligence Challenges**. Below the heading are three circular icons: a hand holding a gear, a circuit board, and a robot head. A navigation bar below the icons has tabs for **Recent**, **Open**, **Closed**, and **All**. The **Recent** tab is selected, showing a grid of challenge thumbnails. The first thumbnail is a line graph with 'min', 'max', and 'mean' lines. The second is an Airbus A320neo aircraft. The third is a satellite dish. The fourth is a partial view of a ship's bridge.

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Time Series Challenge



Data	Train	Validation
Unlabeled data	645 ground tests 355 flights	32 ground tests 18 flights
81 context parameters 8 parameters of interest	17 anomalies detected by community	79 anomalies labeled by engineers

Challenge results

Hard problem ...

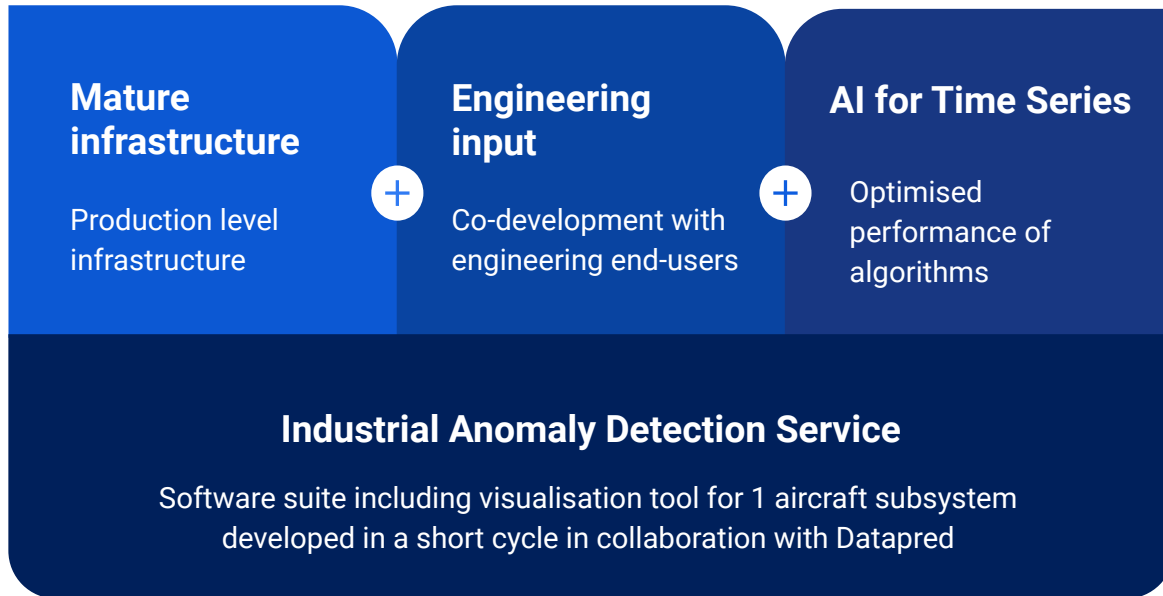
Team	F Score	Precision	Recall	Rank
Datapred	0.51	0.53	0.50	1
Industrial team 1	0.36	0.36	0.36	2
Industrial team 2	0.30	0.30	0.30	3
Industrial team 3	0.06	0.06	0.06	4
Industrial team 4	0.04	0.06	0.04	5
Academic team 1	0.02	0.06	0.02	6
Individual team 1	0.02	0.02	0.02	7
Individual team 2	0.00	0.00	0.00	8



- modeling engine for continuous intelligence
- ability to combine machine learning with other types of models in real time
- faster garage-to-factory cycle



Next steps



References

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- Hundman, Kyle, et al. "Detecting spacecraft anomalies using lstms and nonparametric dynamic thresholding." *Proceedings of the 24th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining*. ACM, 2018.
- Munir, Mohsin, et al. "Deepant: A deep learning approach for unsupervised anomaly detection in time series." *IEEE Access* 7 (2018): 1991-2005.
- Hawkins, Simon, et al. "Outlier detection using replicator neural networks." *International Conference on Data Warehousing and Knowledge Discovery*. Springer, Berlin, Heidelberg, 2002.
- Malhotra, Pankaj, et al. "LSTM-based encoder-decoder for multi-sensor anomaly detection." *arXiv preprint arXiv:1607.00148* (2016).
- Ya Su, et al. "Robust Anomaly Detection for Multivariate Time Series through Stochastic Recurrent Neural Network", Accepted for KDD 2019, 2019
- Schlegl, Thomas, et al. "Unsupervised anomaly detection with generative adversarial networks to guide marker discovery." *International Conference on Information Processing in Medical Imaging*. Springer, Cham, 2017.
- Li, Dan, et al. "MAD-GAN: Multivariate anomaly detection for time series data with generative adversarial networks." *arXiv preprint arXiv:1901.04997* (2019).

