Big Science Business Forum 2024

TRIESTE
1 – 4 OCTOBER 2024

Host Organizers

REGIONE AUTONOMA FRIULI VENEZIA GIULIA · ILO Network Italia, Rete Industrial Liaison Officers · AREA SCIENCE PARK · IO SONO FRIULI VENEZIA GIULIA

Technology Transfer Track Posters

AI-powered algorithms for Anomaly Detection on Industrial and Medical Applications on IoT devices

INTRODUCTION

This technology introduces a machine learning-based platform for anomaly detection for industrial and medical infrastructures, tested on CERN's Large Hadron Collider (LHC) cryogenic system helium compressors.

The solution developed enables the automation of data post-processing and analysis through machine learning, allowing to overcome the limitations of classical vibration analysis methods used in the past, constrained by sparse data sampling and variability in the assessment of equipment condition. The results demonstrate that the developed solution optimises operational costs while minimising downtime and reducing equipment downtime.

METHODS

The platform is built using an autoencoder (AE) architecture, a type of neural network ideal for unsupervised learning like anomaly detection.

Initially, the AE is trained using the LHC helium compressors' vibrational data labelled as "normal operation", in this way the neural network can learn the nominal data distribution and identify and classify anomalies as outliers during the inference phase by comparing the acquired signal and the processed reconstruction. Once trained the model is able to continuously learn from new data, refining its understanding of the machinery normal behaviour. To recognize anomalies, the difference between the acquired data and the reconstructed signal is taken into account. If the reconstruction error exceeds a certain threshold an anomaly is flagged, indicating that the motor-compressor unit is operating outside its normal working conditions

Additionally, the reconstruction error peaks analysis allows for labelling anomalies and the estimation of the equipment's Remaining Useful Life (RUL) enabling the prediction of the remaining time before a failure is likely to occur.

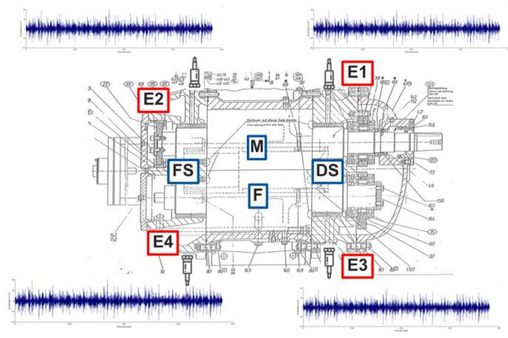
Thanks to these features, engineers can schedule proactive maintenance, enabling operators to repair or replace equipment before a critical failure occurs, minimizing downtime and preventing costly operational disruptions.

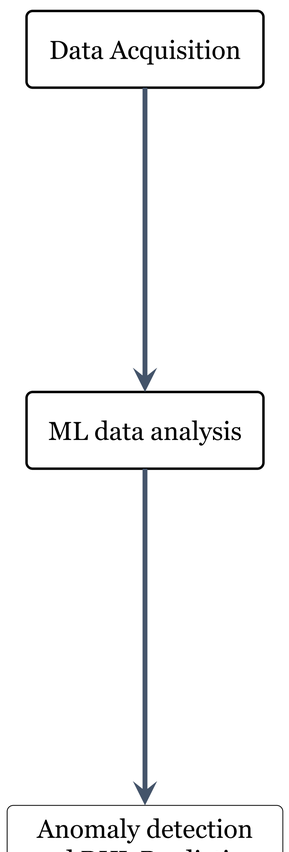
RESULTS

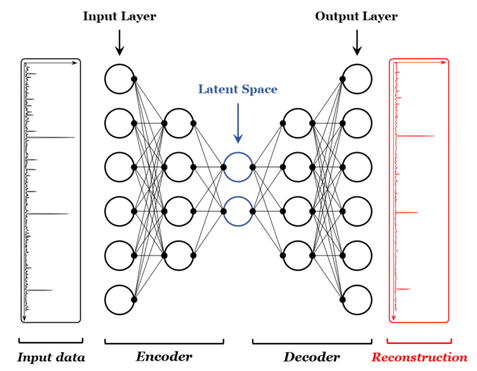
The accuracy of the model's anomaly detection was initially validated by comparing its outputs with expert-labeled data. Subsequentially, to assess the platform's ability to estimate the Remaining Useful Life (RUL) of the machinery, the model's predictions have been compared with the expert's evaluations. As a result, the developed solution outperformed the previously used methods in all the analysed scenarios,.

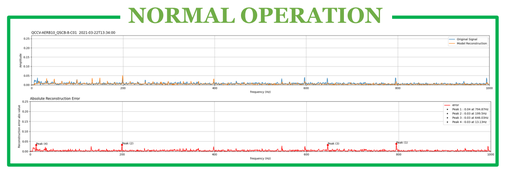
CONCLUSIONS

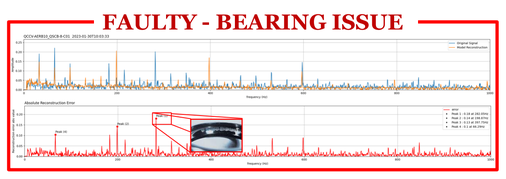
This work presents an innovative machine learning framework for automated condition analysis of helium compressors, capable of detecting and labelling anomalies and estimating the machinery's RUL. Future developments include integrating Edge-Machine Learning on IoT devices for on-site live monitoring, leveraging CERN's Federated Learning platform, CAFEIN FL. This will pave the way for the usage of the framework in the medical field thanks to the high privacy standard ensured by the FL technology.









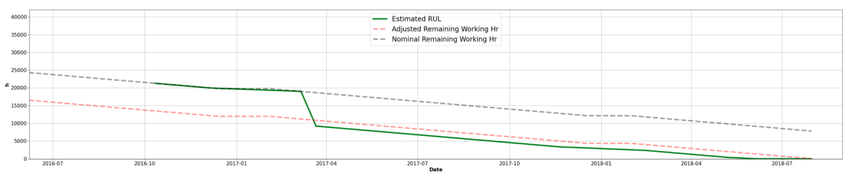


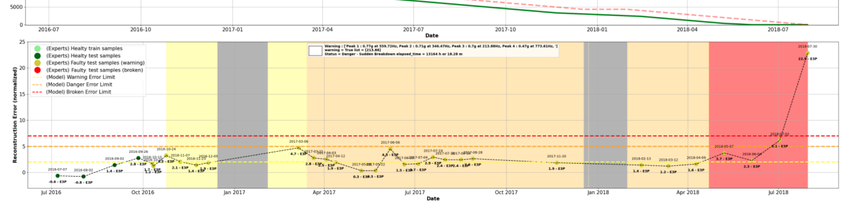
RUL Based 3 Class Classification of Type-B Compressors (C01-C02)

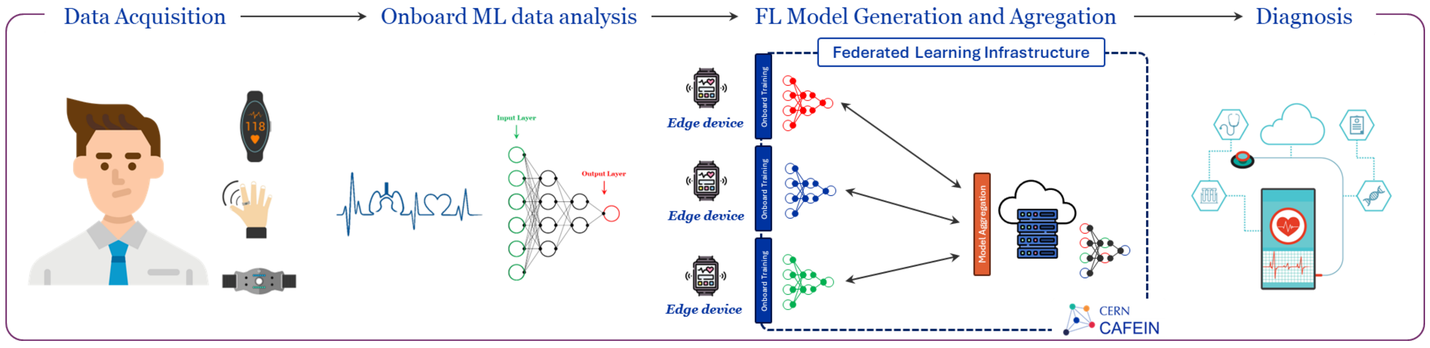
Category	Precision		Recall		F1-score		Support
Model	Our Model	Expert Labels	Our Model	Expert Labels	Our Model	Expert Labels	
Normal	**0.95**	0.94	**0.98**	0.96	**0.96**	0.95	225
Warning	**0.77**	0.55	**0.59**	0.55	**0.67**	0.55	29
Critical	**1.00**	0.00	**1.00**	0.00	**1.00**	0.00	3
RUL-Model Output Summary				***Expert Classification Summary***			
Category	Precision	Recall	F1-score	Category	Precision	Recall	F1-score
Macro avg	0.91	0.85	0.88	Macro avg	0.50	0.50	0.50
Weighted avg	0.93	0.93	0.93	Weighted avg	0.89	0.9	0.89
Accuracy		**0.93**		Accuracy		0.90	

RUL Based 3 Class Classification of Type-H Compressors (C06-C07)

Category	Precision		Recall		F1-score		Support
Model	Our Model	Exp-Labels	Our Model	Exp-Labels	Our Model	Exp-Labels	
Normal	0.95	**0.96**	**0.97**	0.93	**0.96**	0.95	183
Warning	**0.71**	0.50	0.52	**0.65**	**0.60**	0.57	23
Critical	0.75	**0.80**	**1.00**	0.67	**0.86**	0.73	6
RUL-Model Output Summary				***Expert Classification Summary***			
Category	Precision	Recall	F1-score	Category	Precision	Recall	F1-score
Macro avg	0.80	0.83	0.81	Macro avg	0.75	0.75	0.75
Weighted avg	0.92	0.93	0.92	Weighted avg	0.91	0.89	0.90
Accuracy		**0.93**		Accuracy		0.89	







BOOTH n. / HALL 28 - 27

Reference person

Paolo Cacace

Contacts

paolo.cacace@cern.ch

Website

Download BSBF2024 app for live chat

If you like this poster, download the BSBF2024 app to vote for it and live chat