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PIC4SeR

# UNSUPERVISED MACHINE LEARNING ALGORITHMS FOR EDGE NOVELTY DETECTION

## SUPERVISORS

Prof. Marcello CHIABERGE

Dott. Umberto ALBERTIN

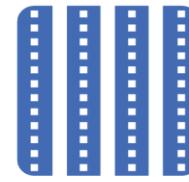
Dott. Gianluca DARA

## CANDIDATE

Ariel Priarone



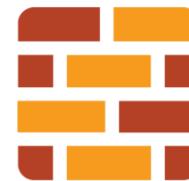
PRECISION  
AGRICULTURE



SMART CITY  
SEARCH &  
RESCUE



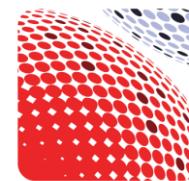
SERVICE  
ROBOTICS  
FOR  
WELLBEING



CULTURAL  
HERITAGE



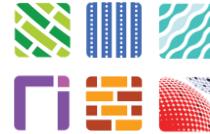
UNDERWATER



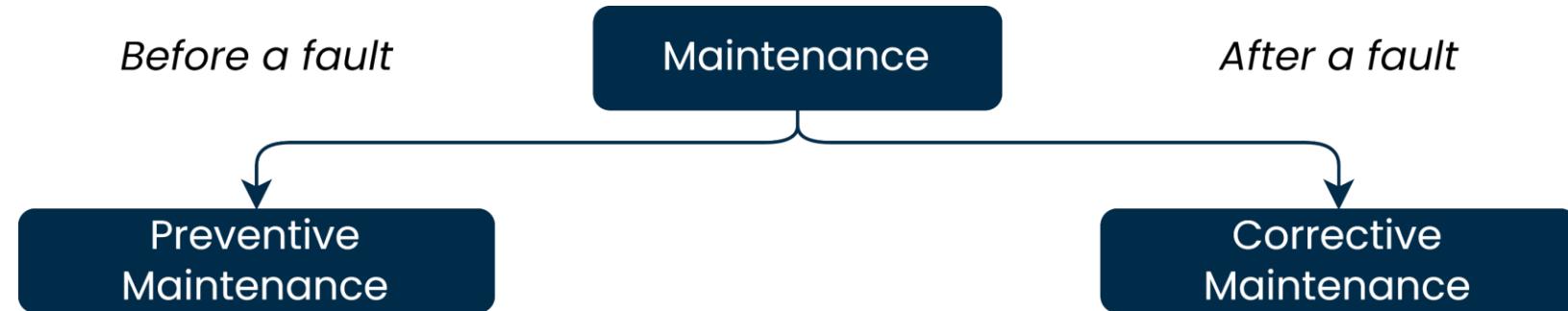
SPACE



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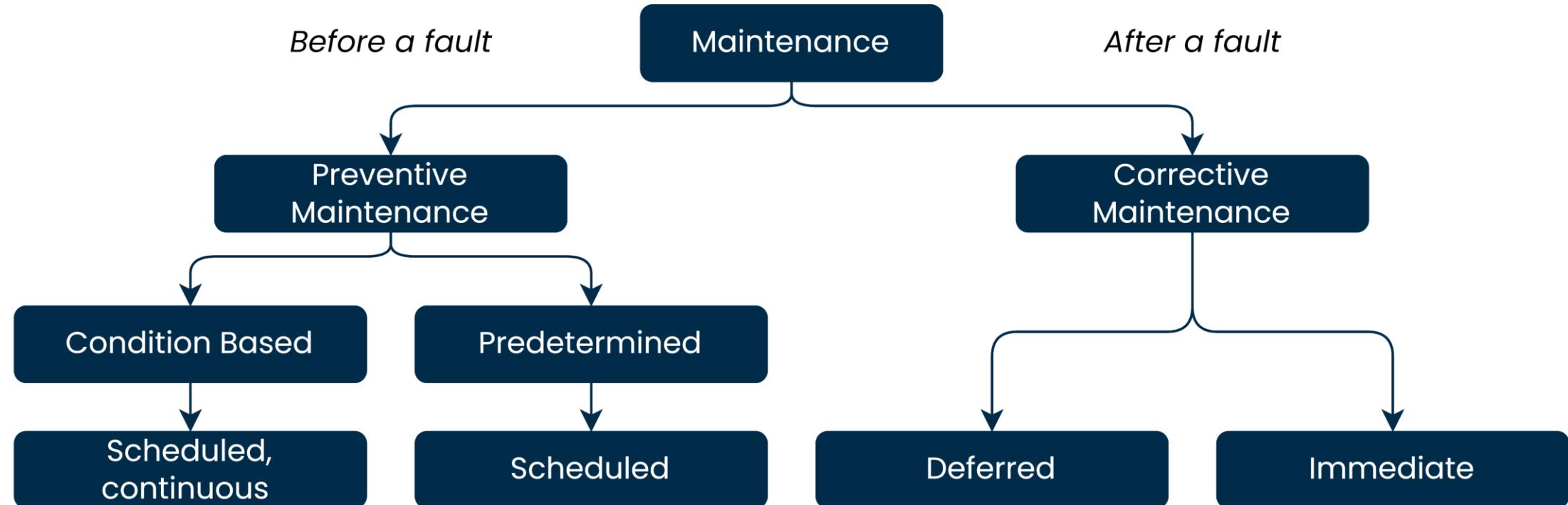


# OVERVIEW ABOUT MAINTENANCE



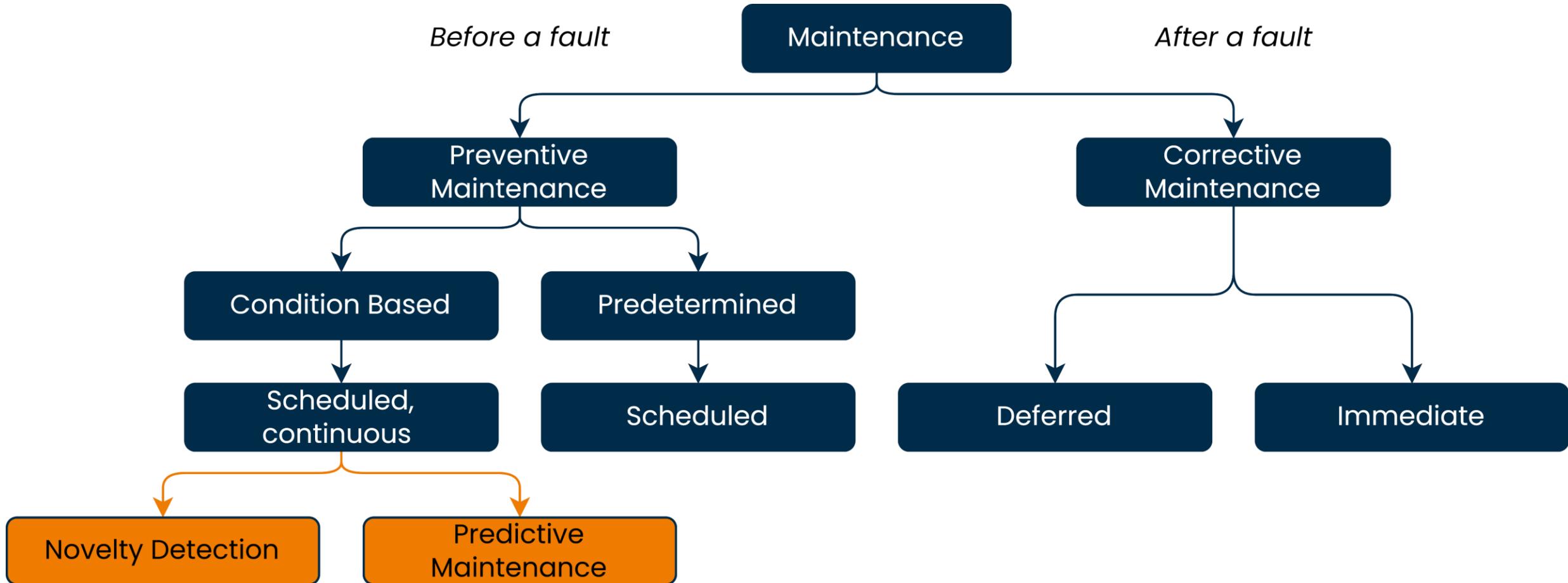


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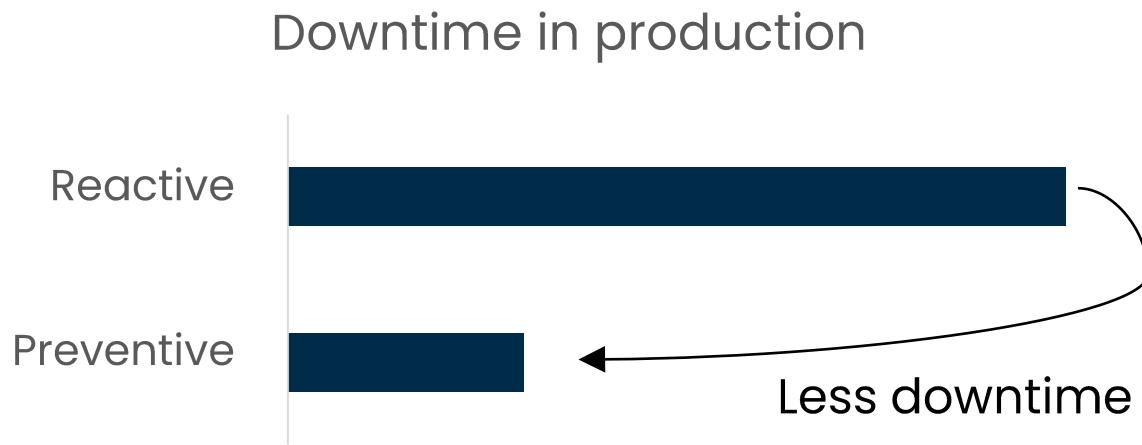


# OVERVIEW ABOUT MAINTENANCE



## • Efficiency

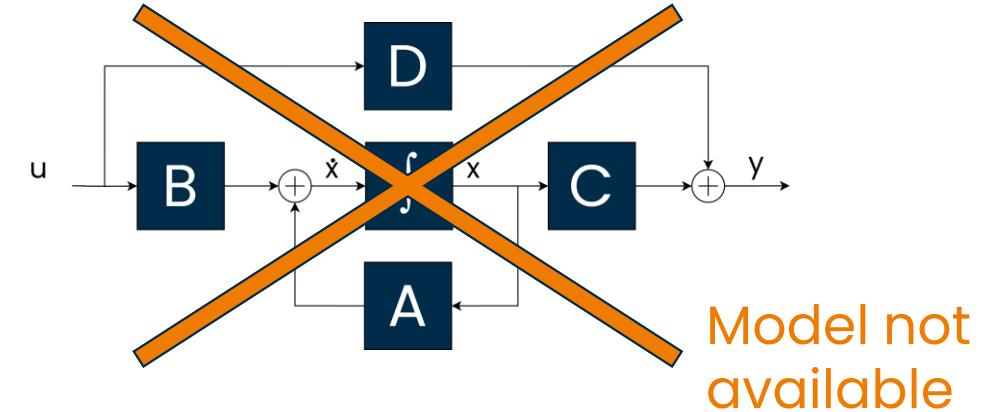
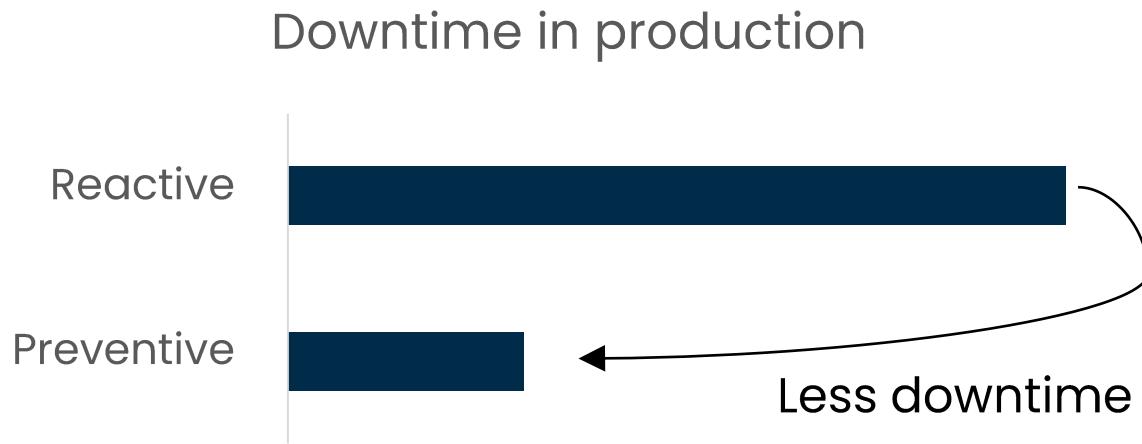
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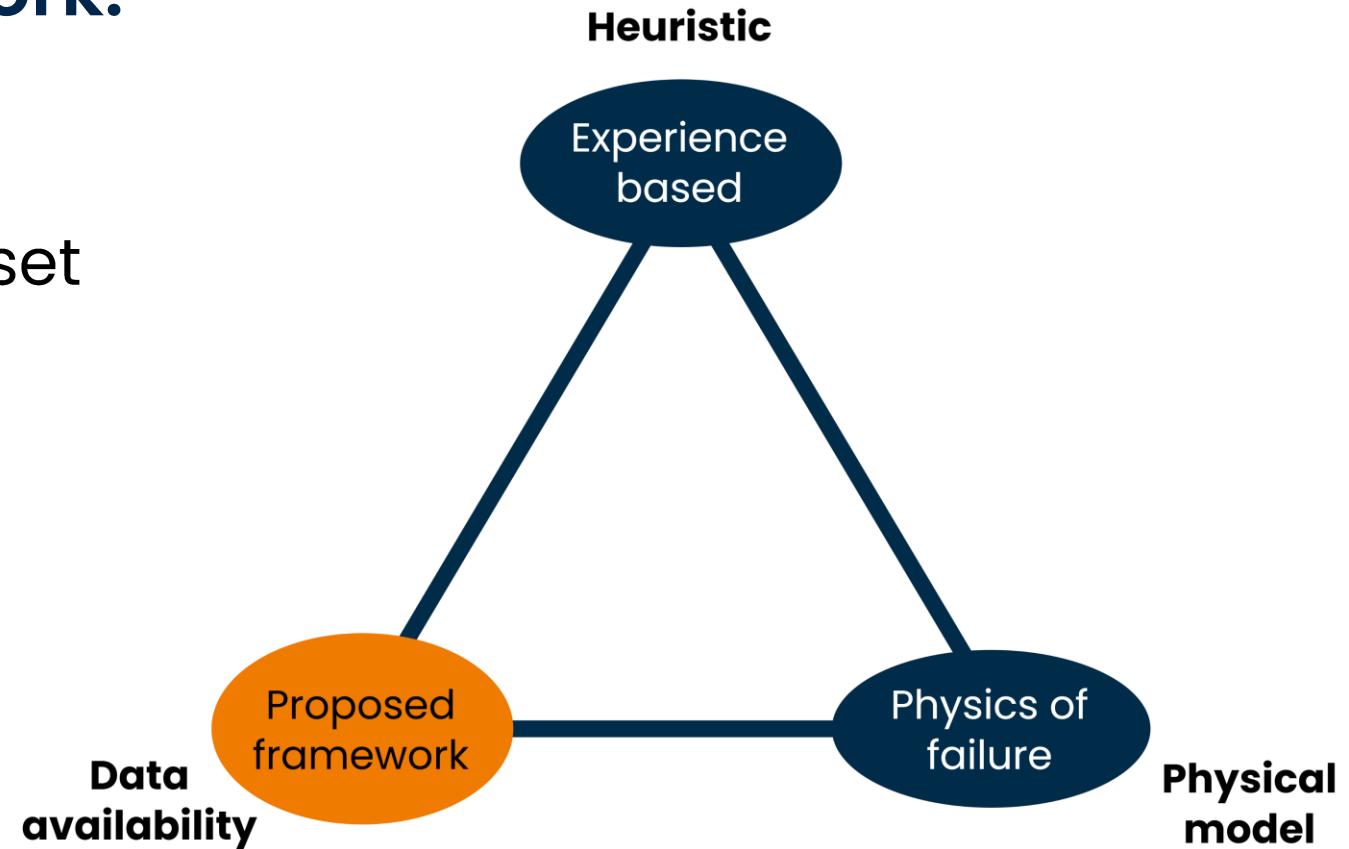


## • Knowledge

- The physical **model** of the maintained system is **not available**
- There is **no data**-driven knowledge **about the failures** of the device

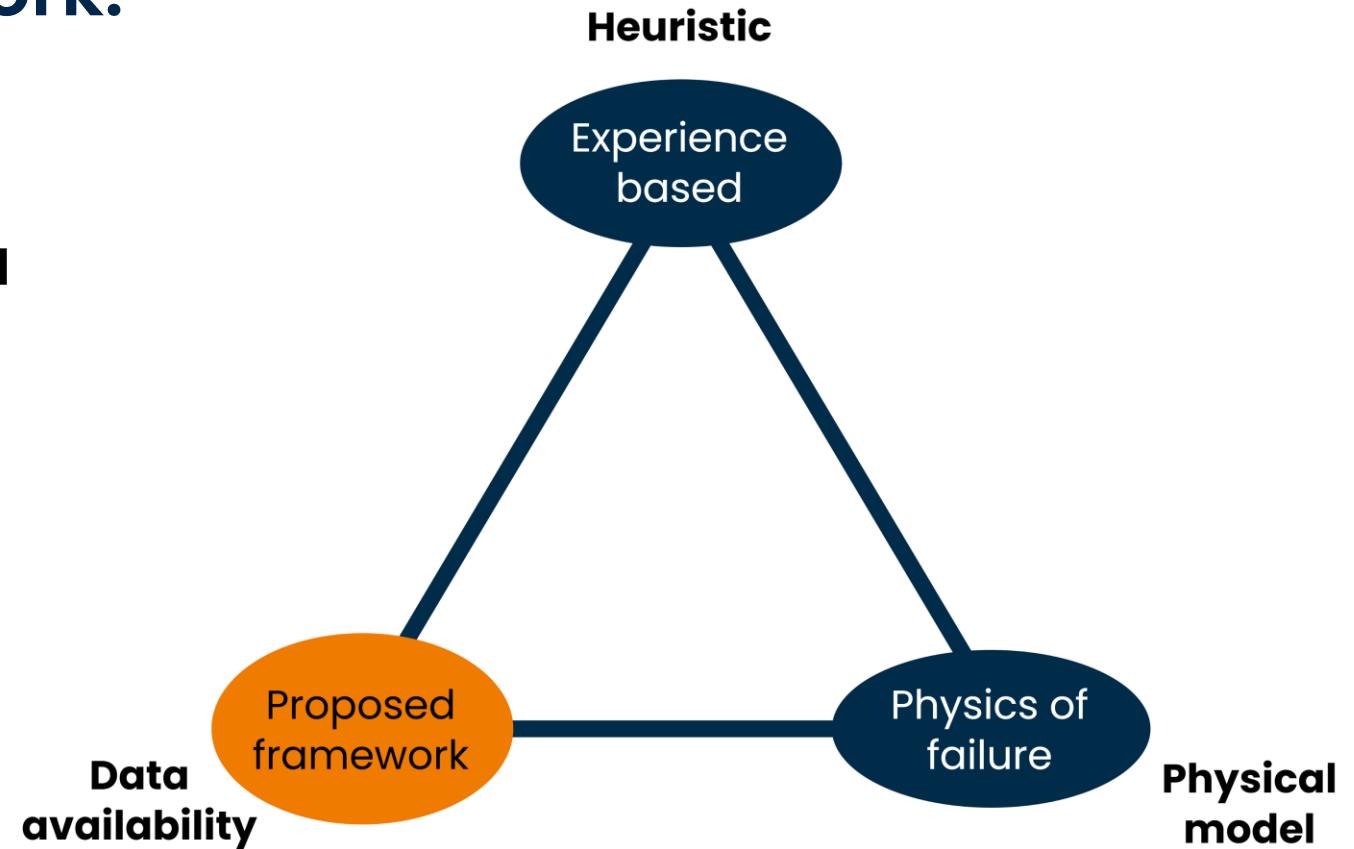
## The developed framework:

- **Data-driven**
- Collects the training dataset
- Trains a model
- Provides a Novelty Metric
- Estimates the RUL
- General purpose
- Modular



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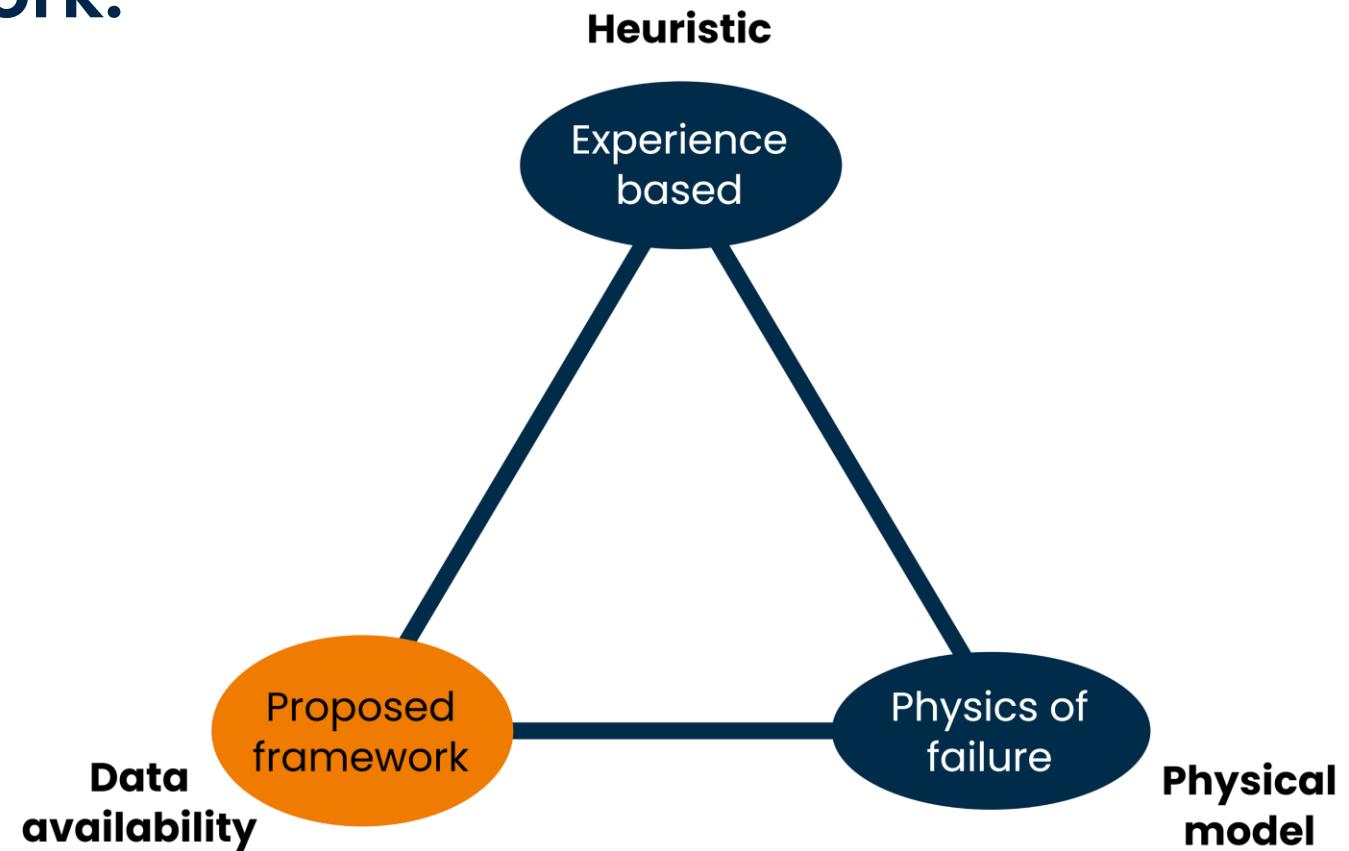
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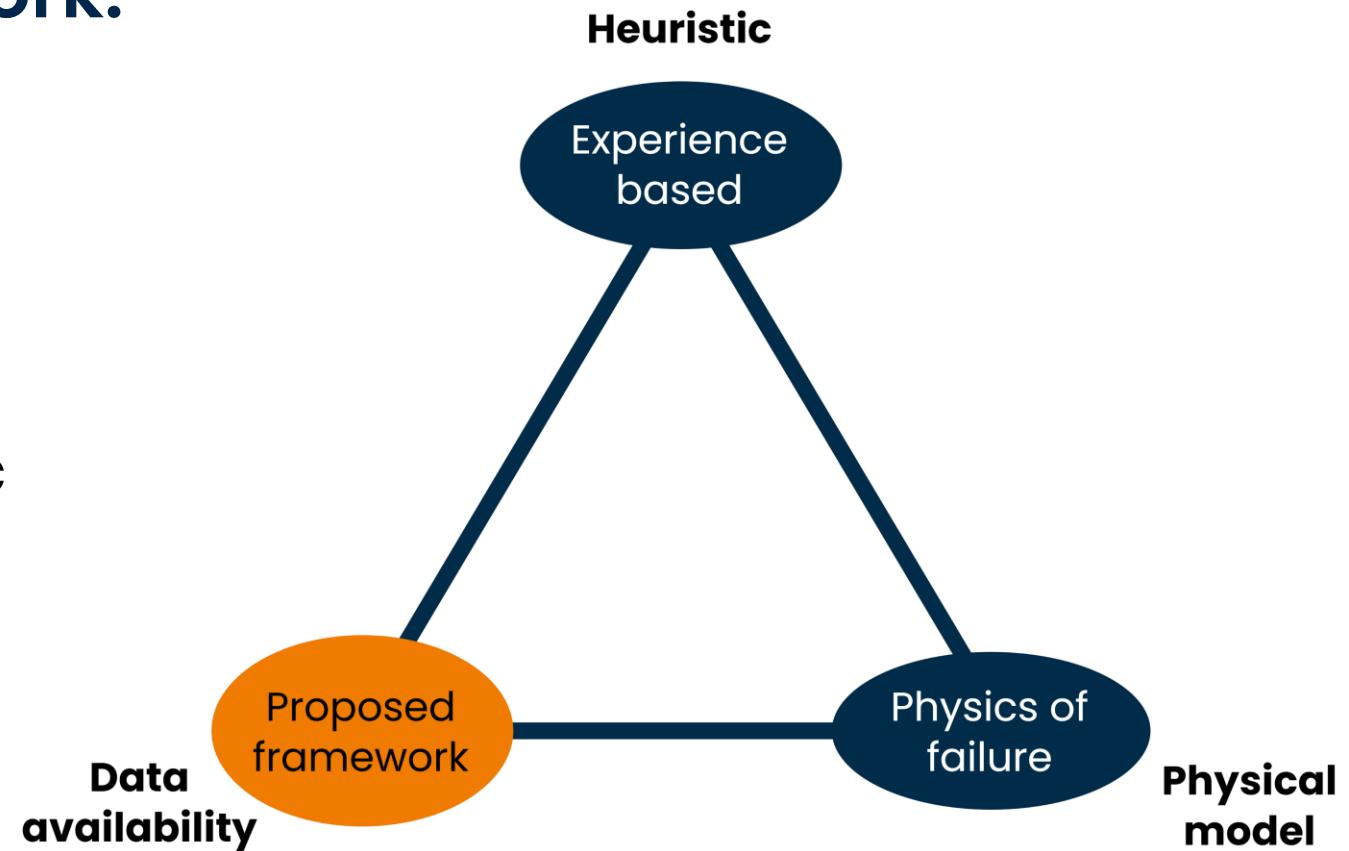
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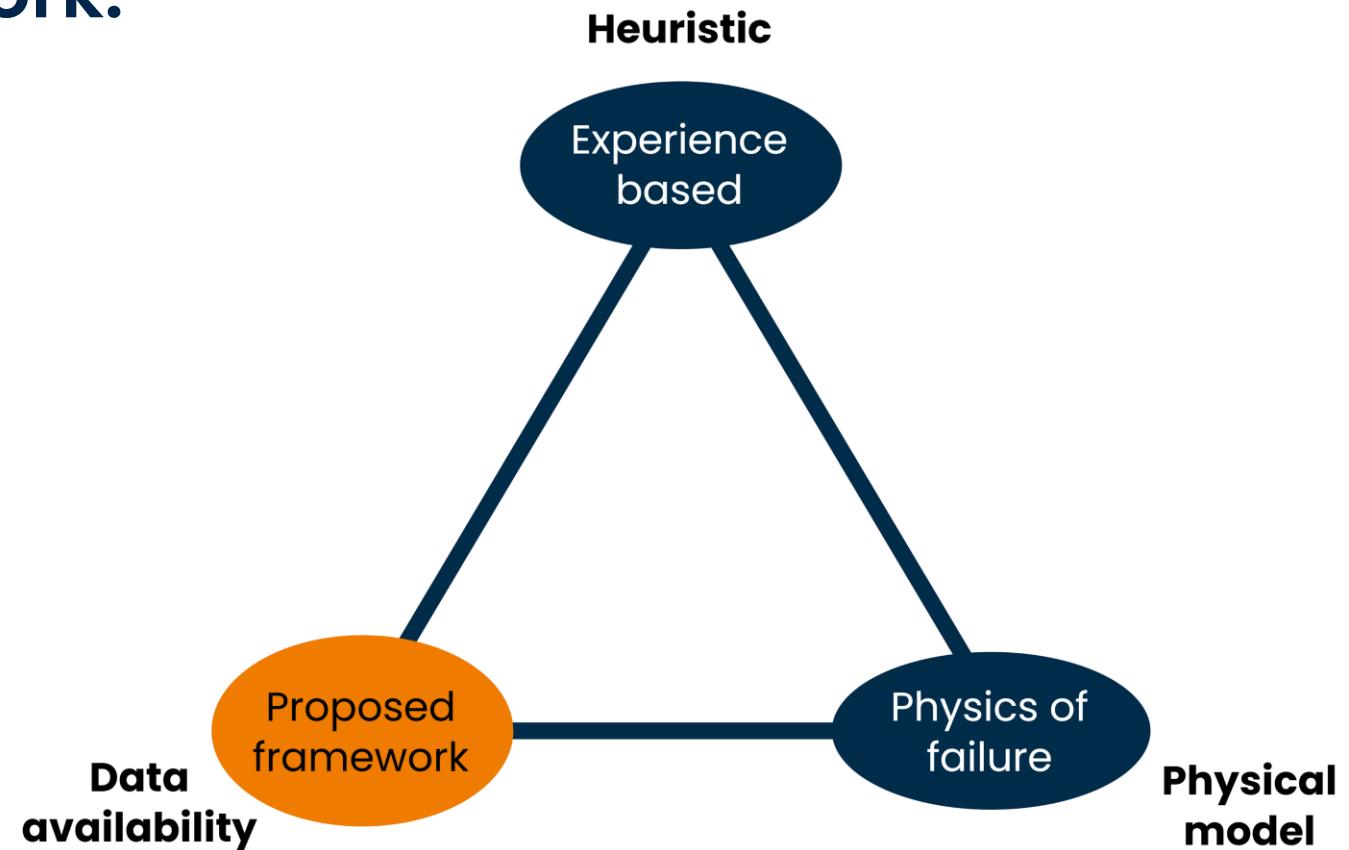
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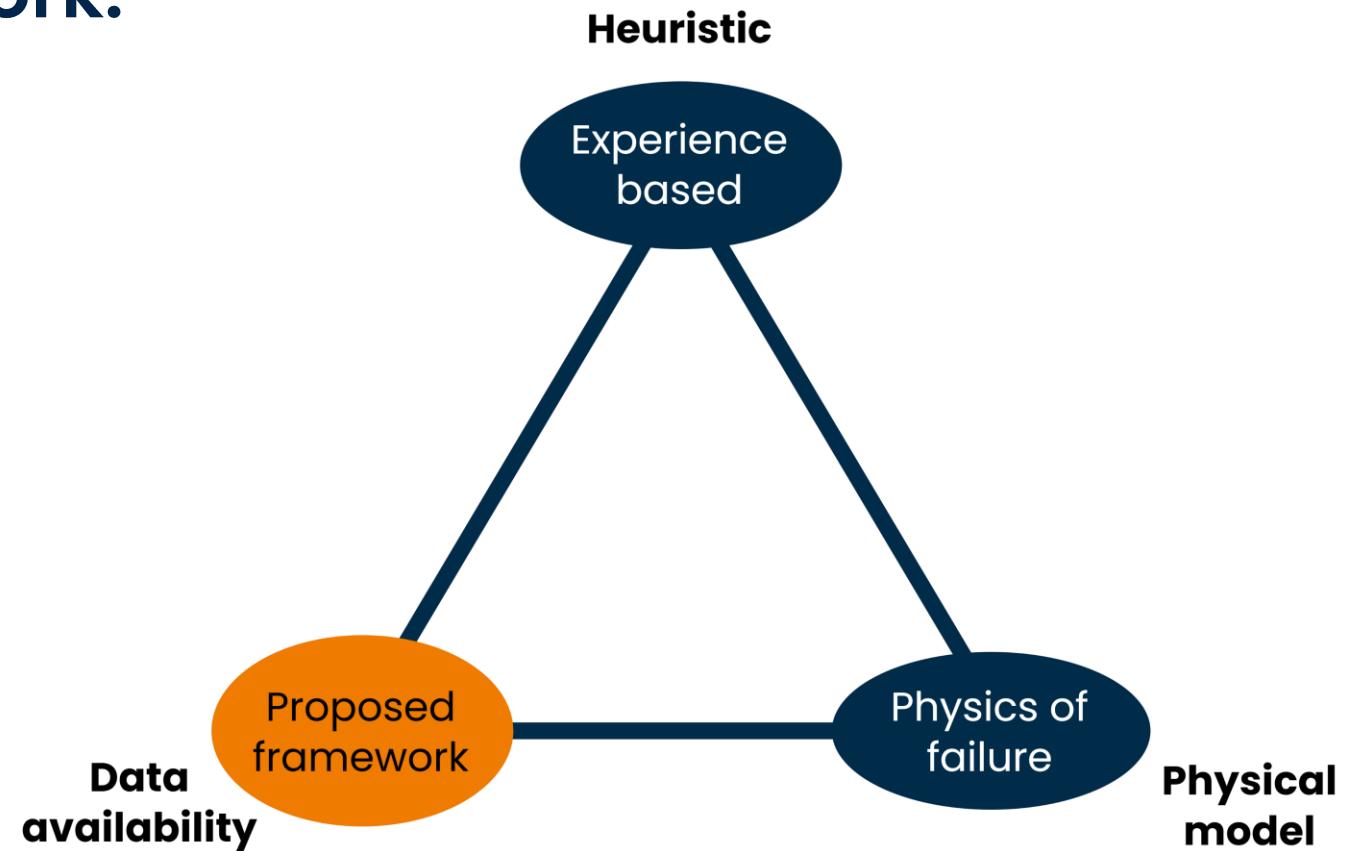
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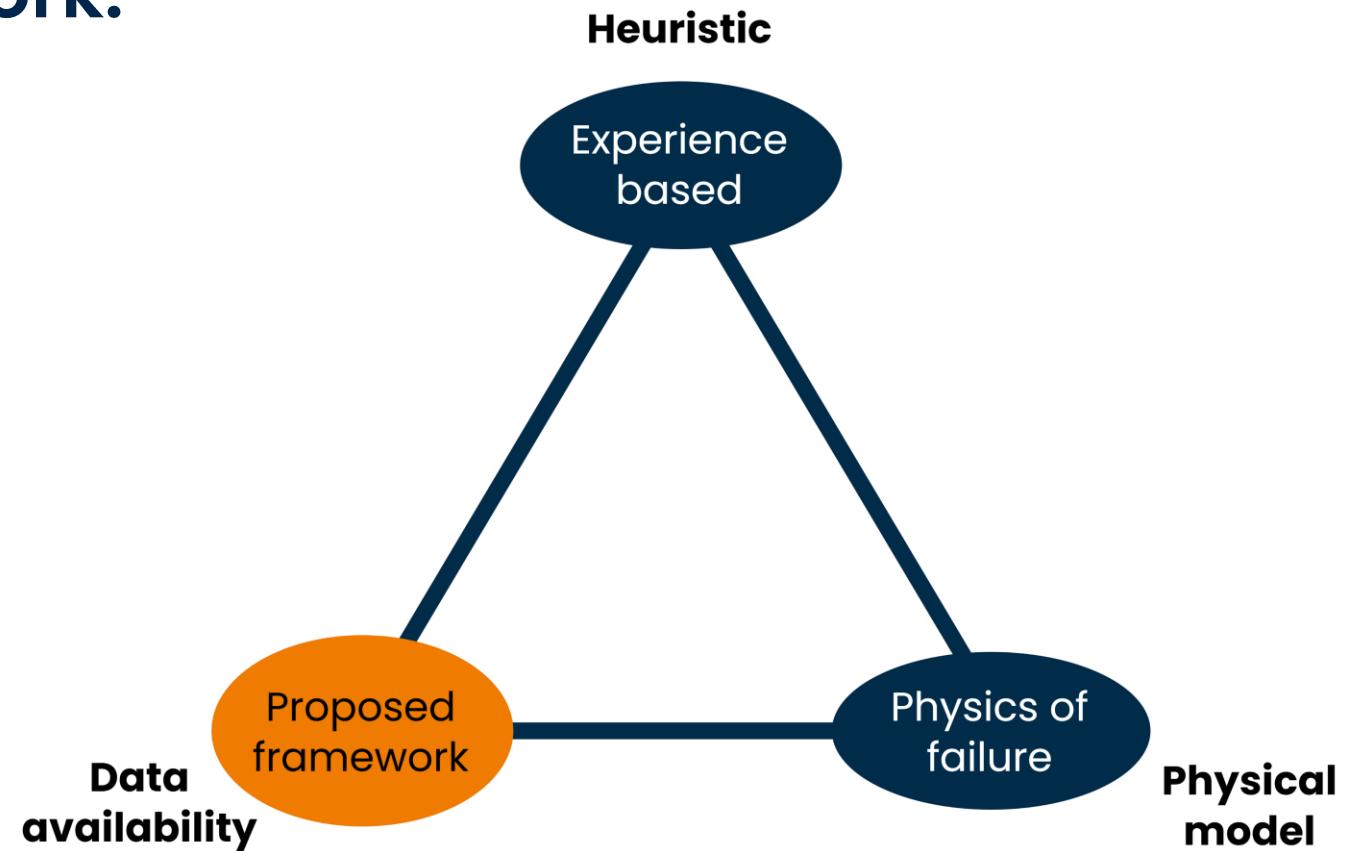
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- **Modular**

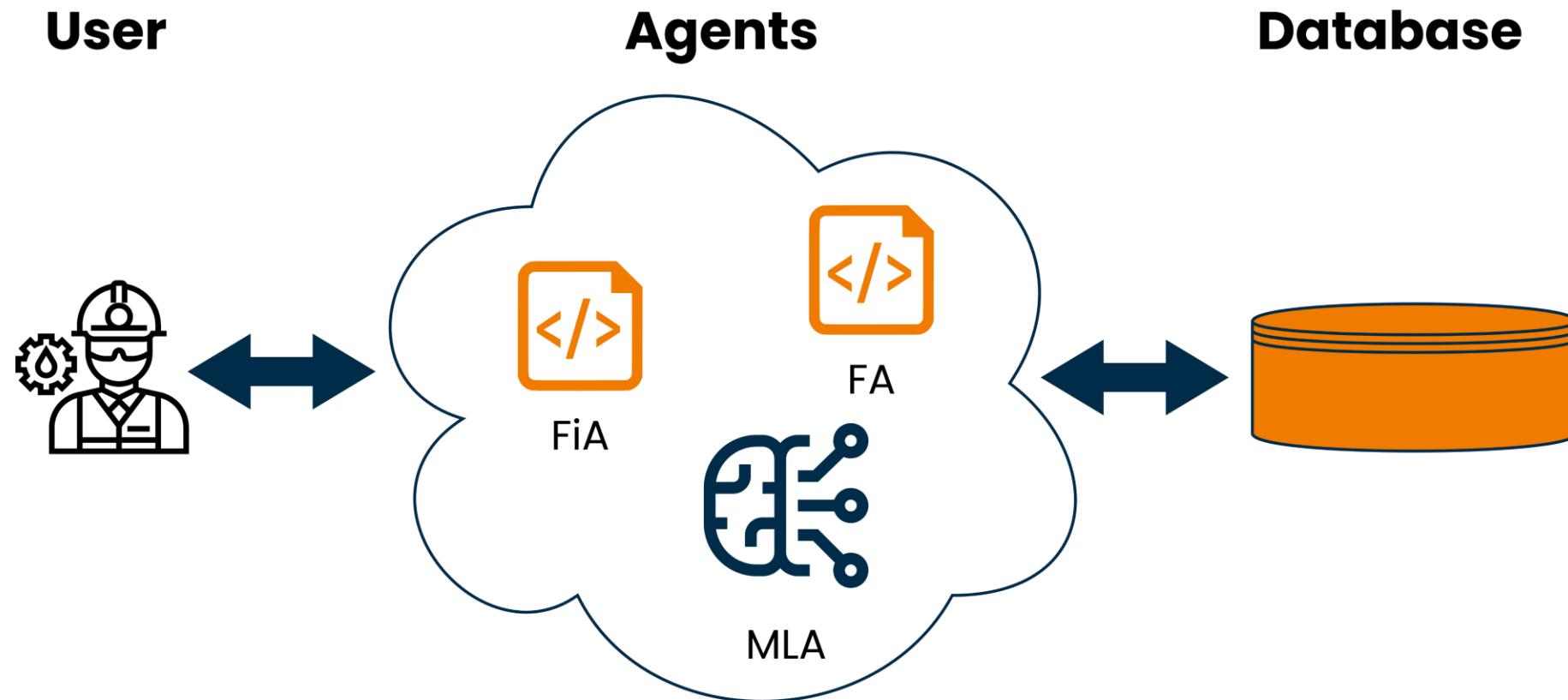




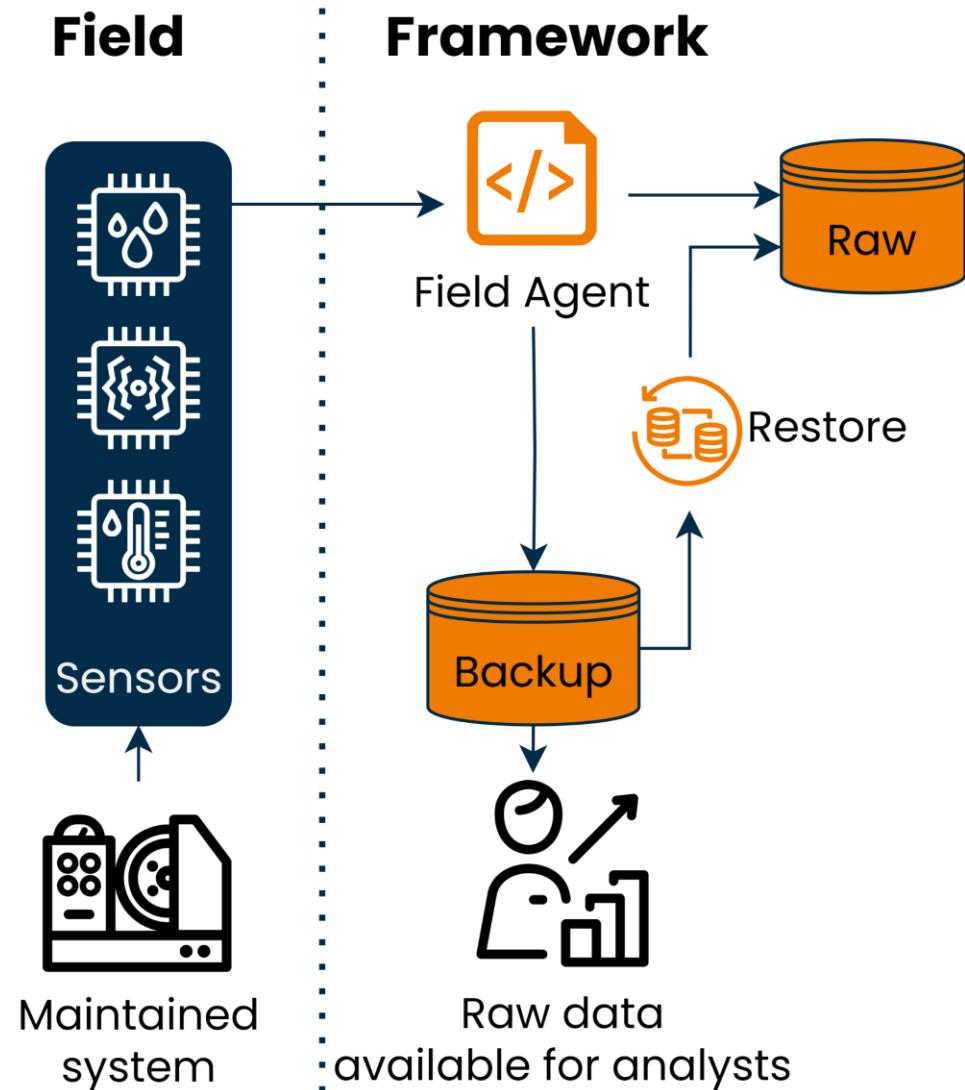
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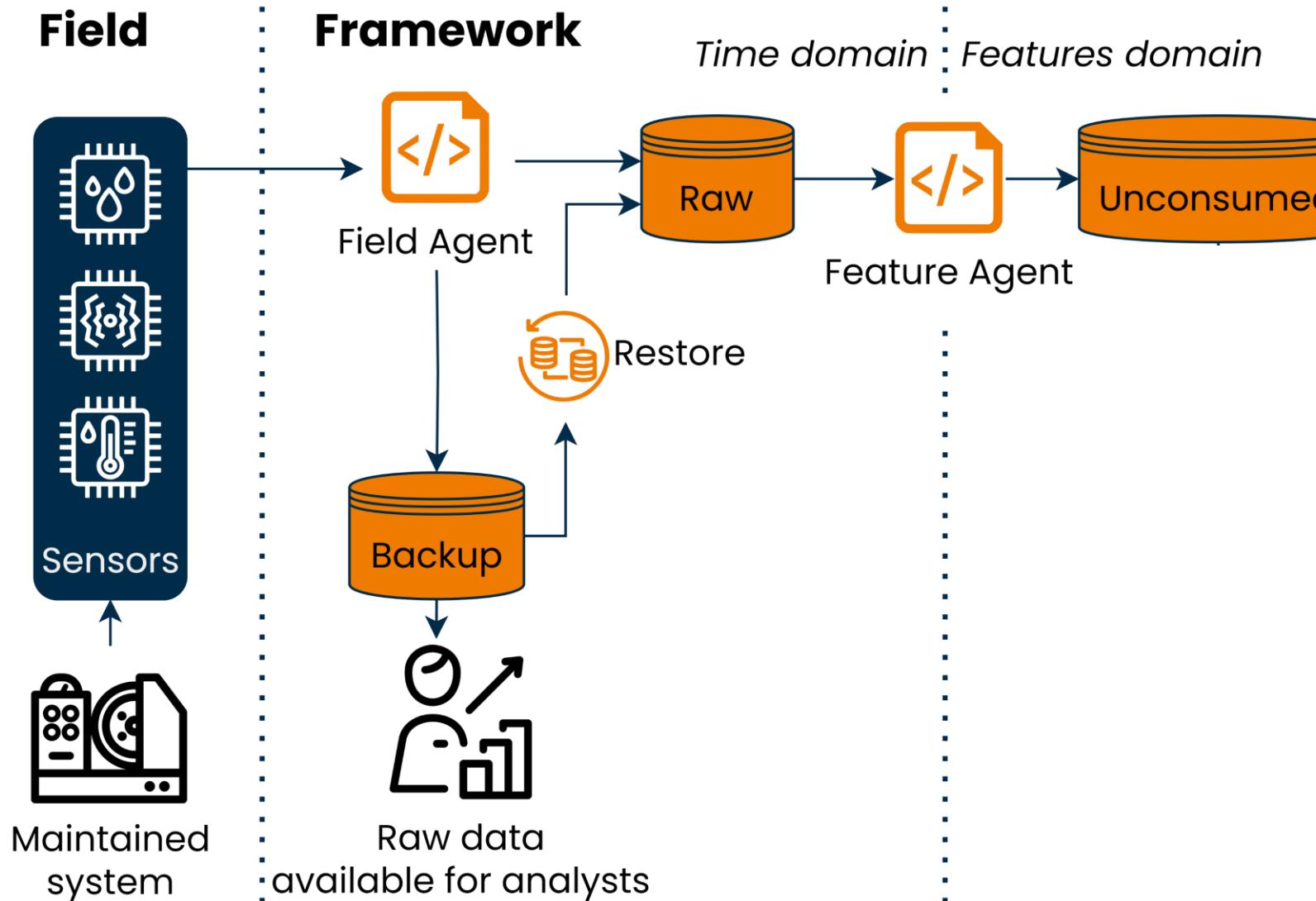
# FRAMEWORK STRUCTURE



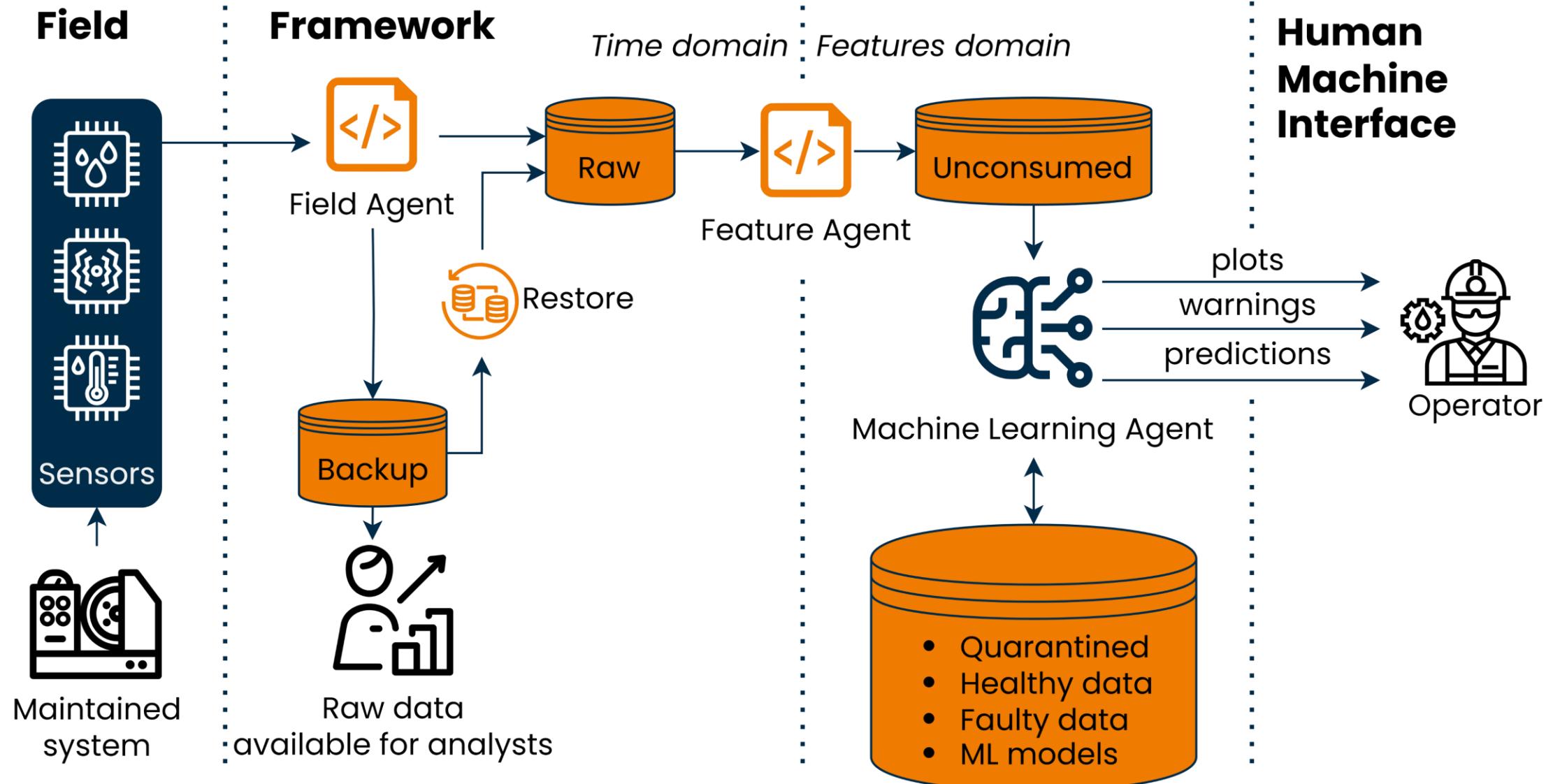
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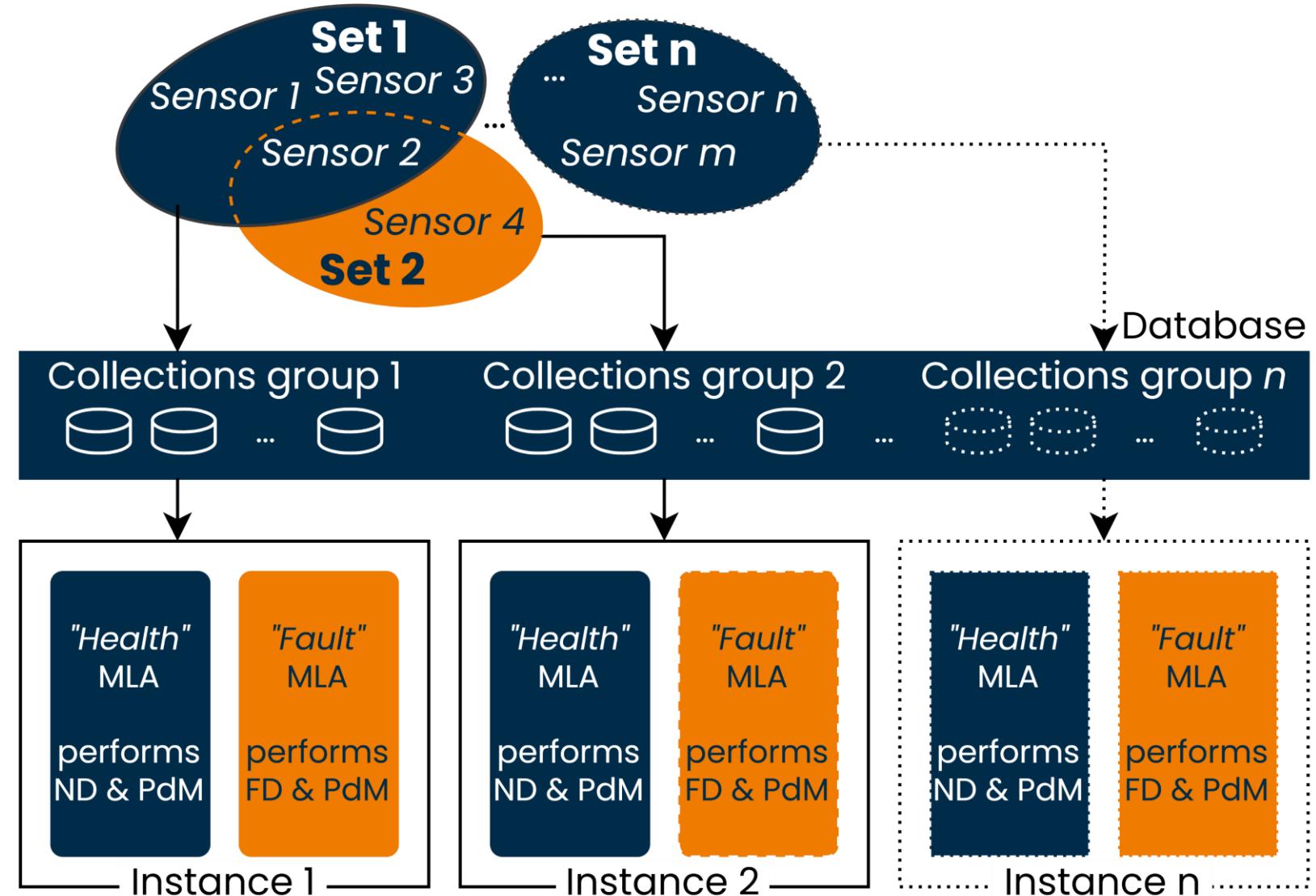




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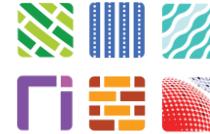


# MULTIPLE INSTANCES





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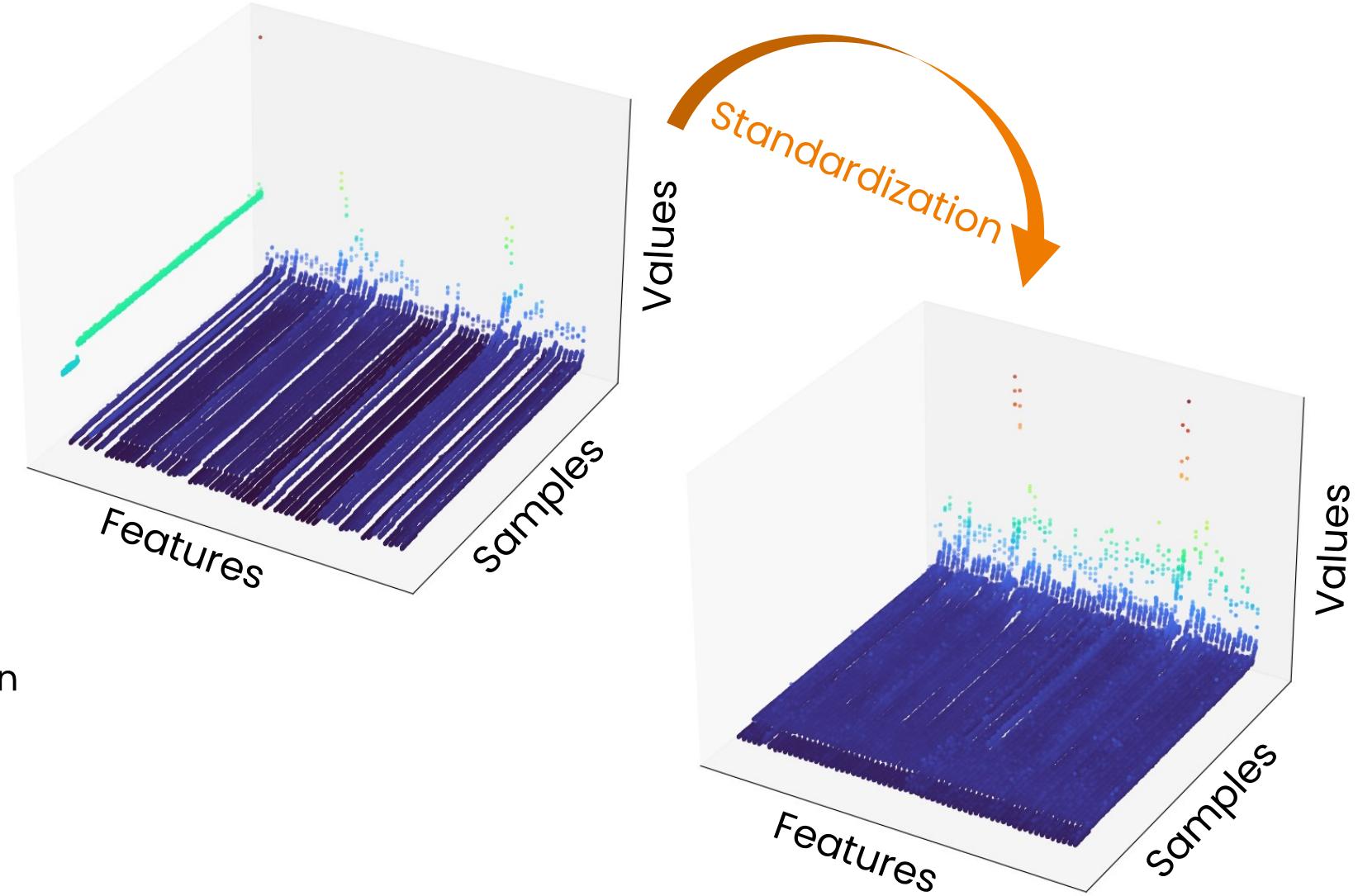
# FEATURES EXTRACTION

## Time domain

- Mean
- Standard deviation
- Peak-to-peak (P2P)
- Root Mean Square (RMS)
- Skewness
- Kurtosis

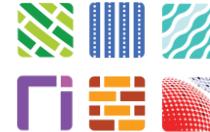
## Frequency domain

- Fast Fourier Transform (FFT)
- Wavelet Packet Decomposition (WPD)





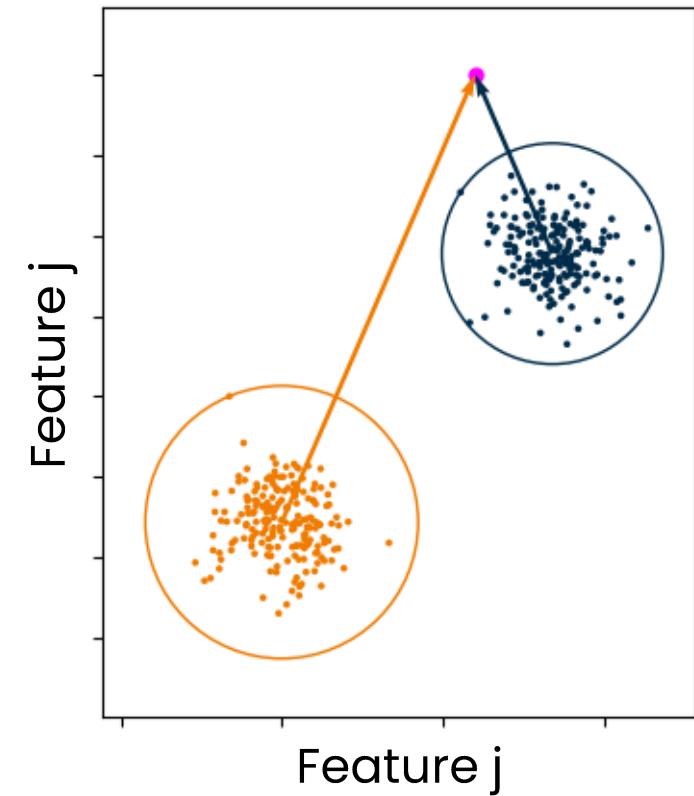
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## VALIDATION ON VIBRATION DATASET

Algorithm	ND Event	Lead Time [min]	LT [days]
K-means	16/11/2003 07:46	13913	9.6
DBSCAN	22/11/2003 15:06	4833	3.3
GMM	22/11/2003 03:47	5513	3.8
BGMM	22/11/2003 03:45	5514	3.8
$\nu$ -SVM	22/11/2003 14:56	4844	3.3
IF	16/11/2003 10:08	13771	9.6
LOF	16/11/2003 07:48	13912	9.6

Results of Novelty Detection on a bearing vibrations dataset

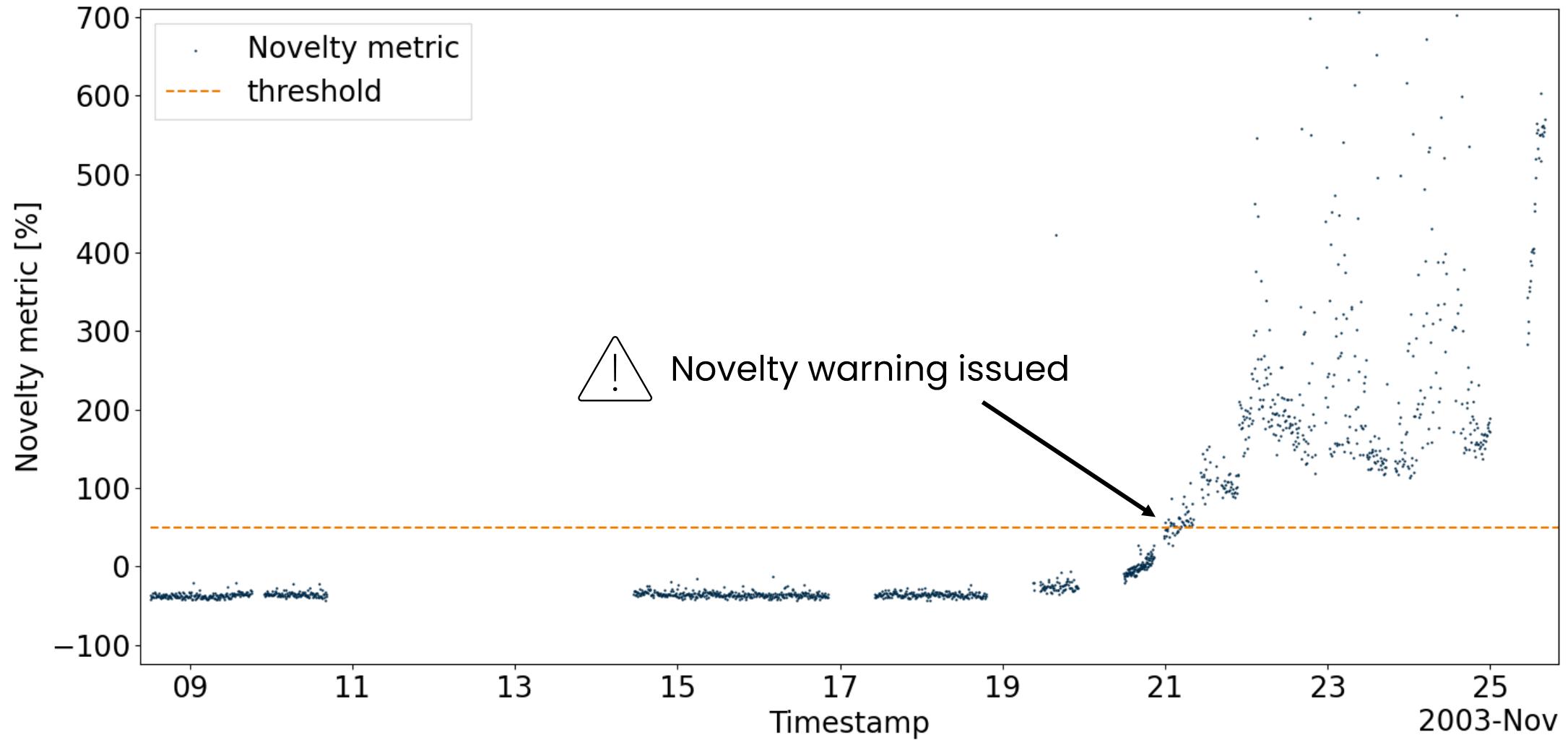




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# NOVELTY DETECTION

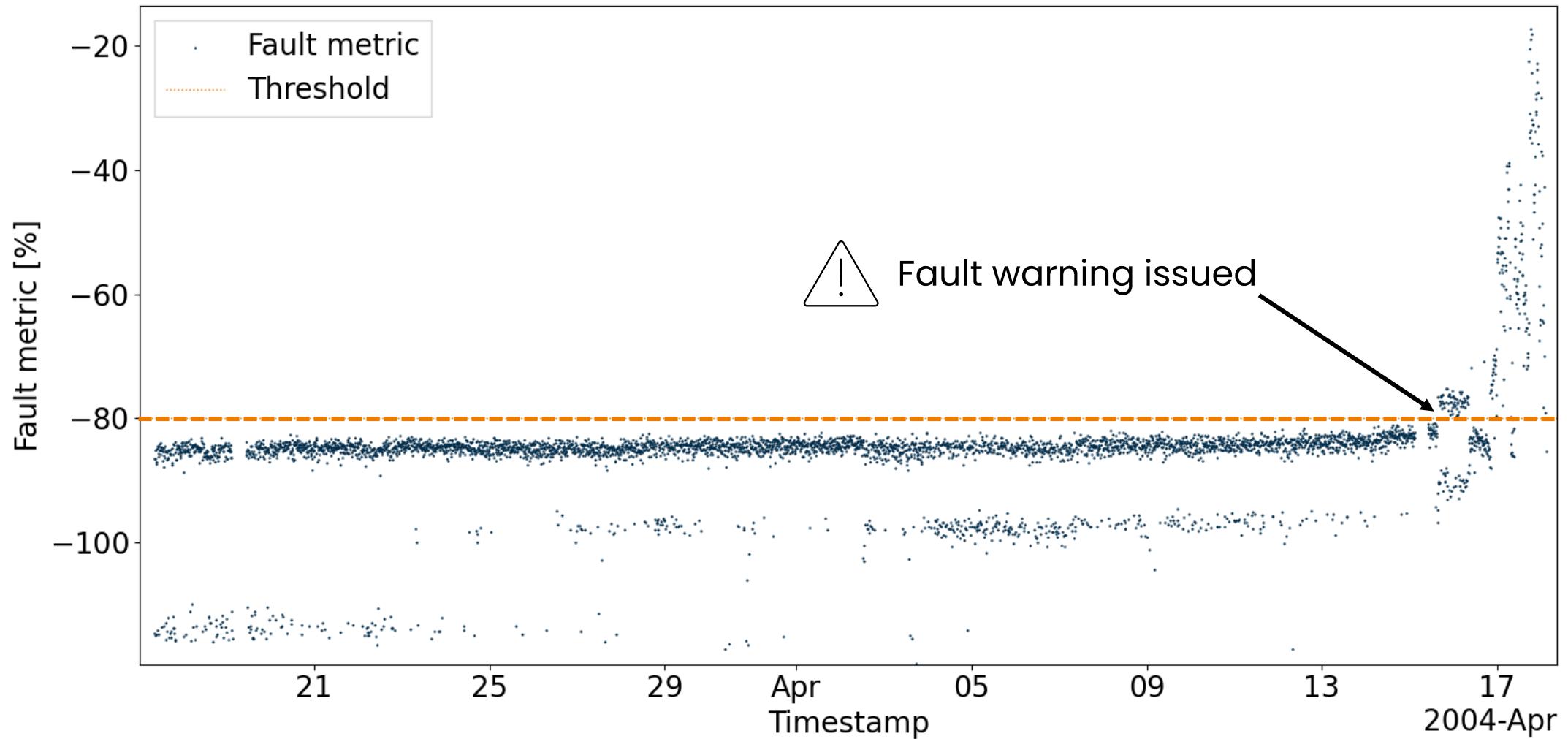




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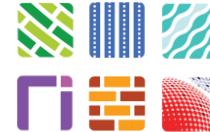


# FAULT DETECTION

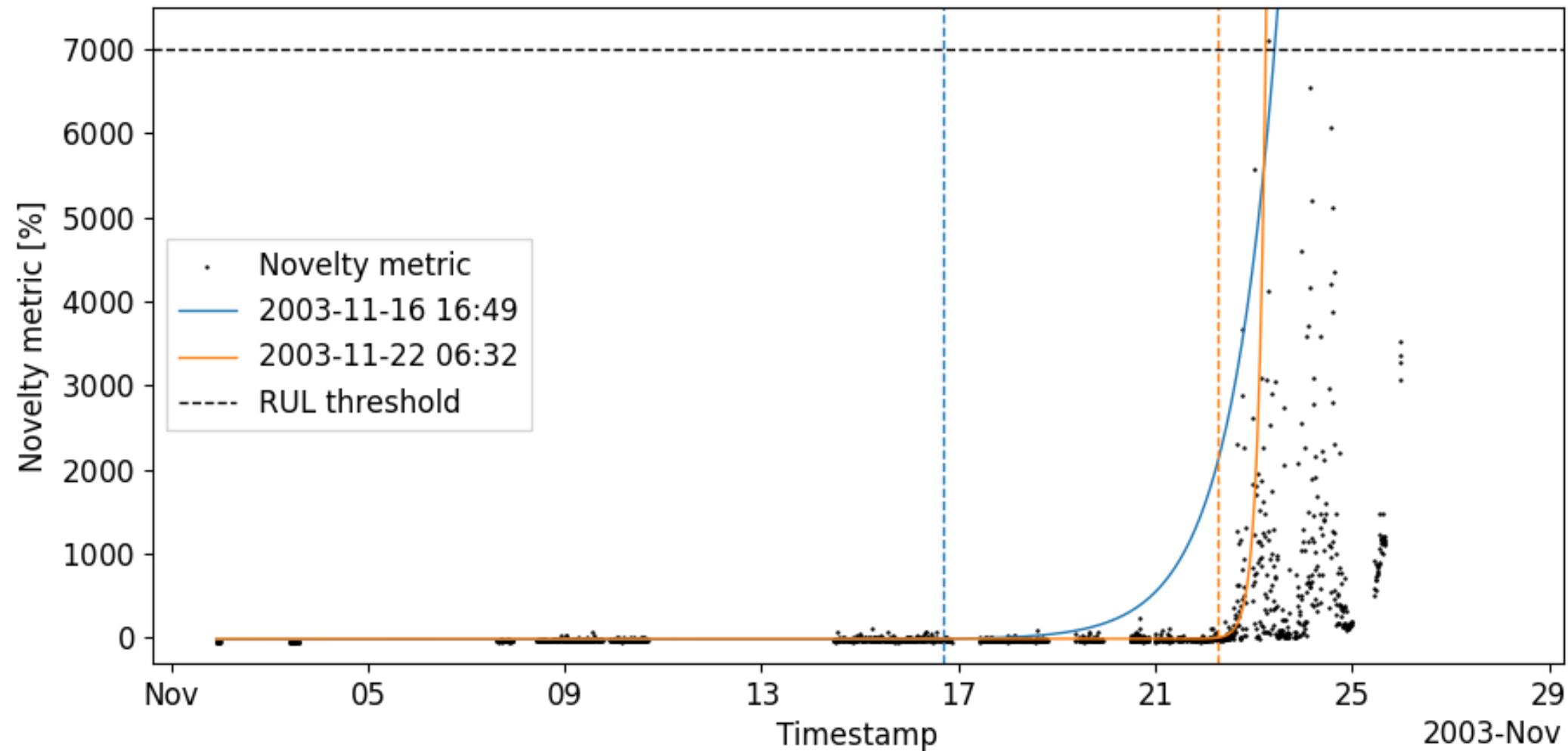




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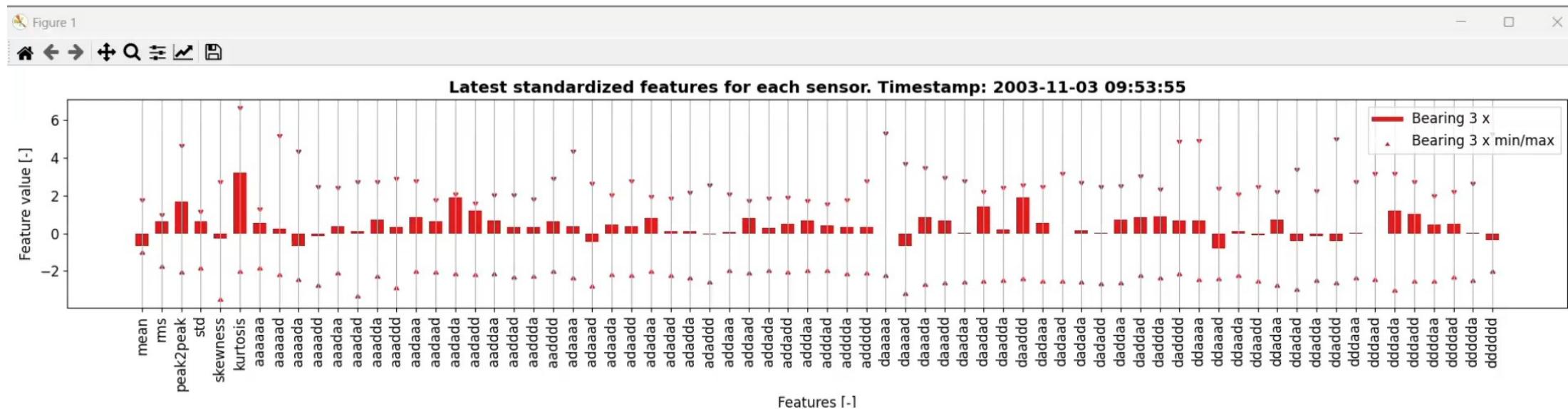
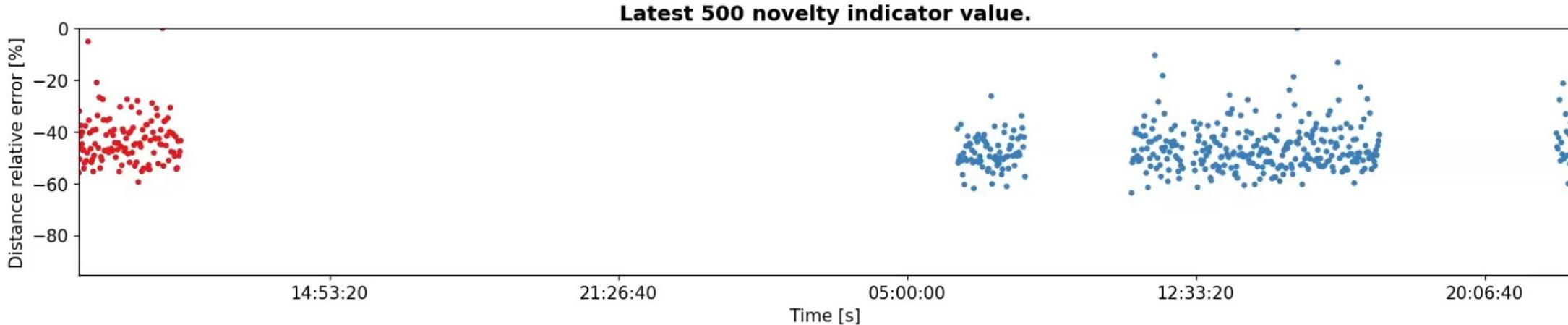


## PREDICTIONS





## REAL-TIME EVALUATION





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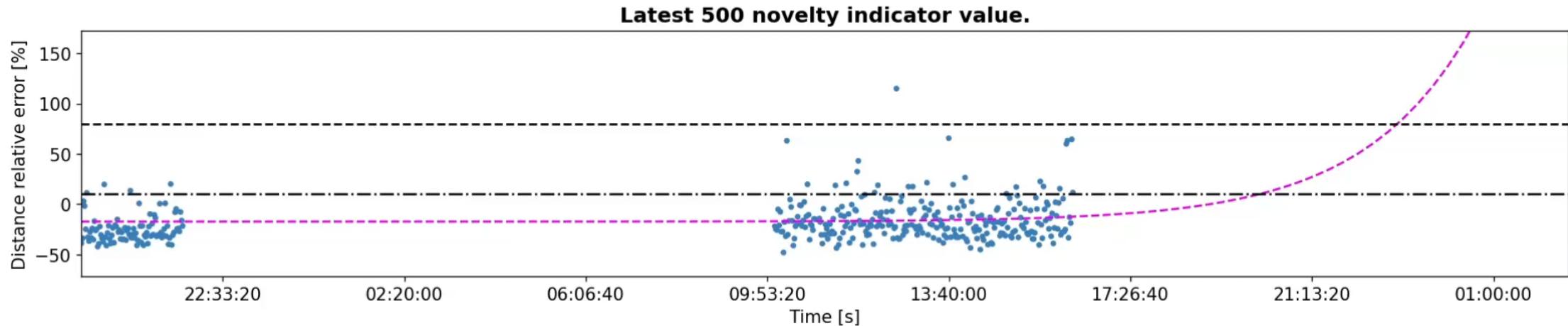
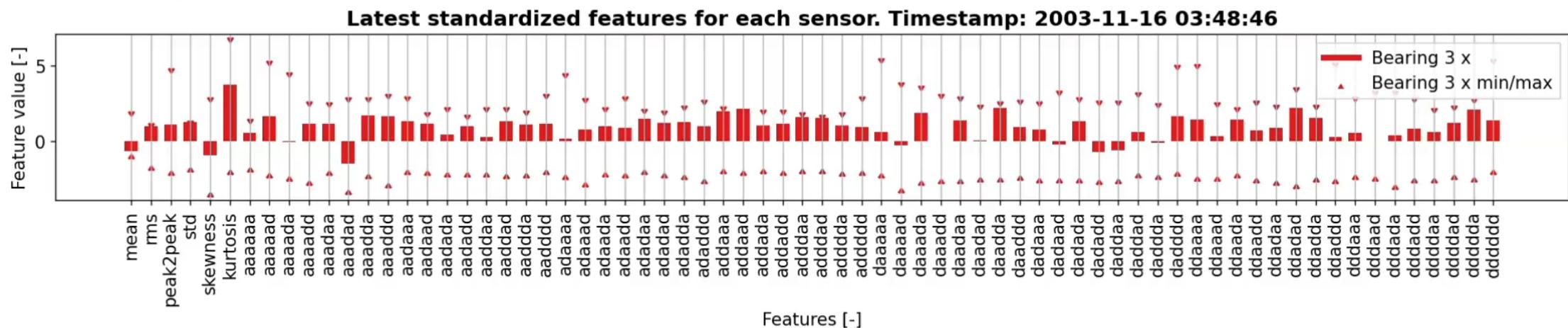
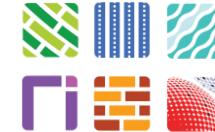


Figure 1

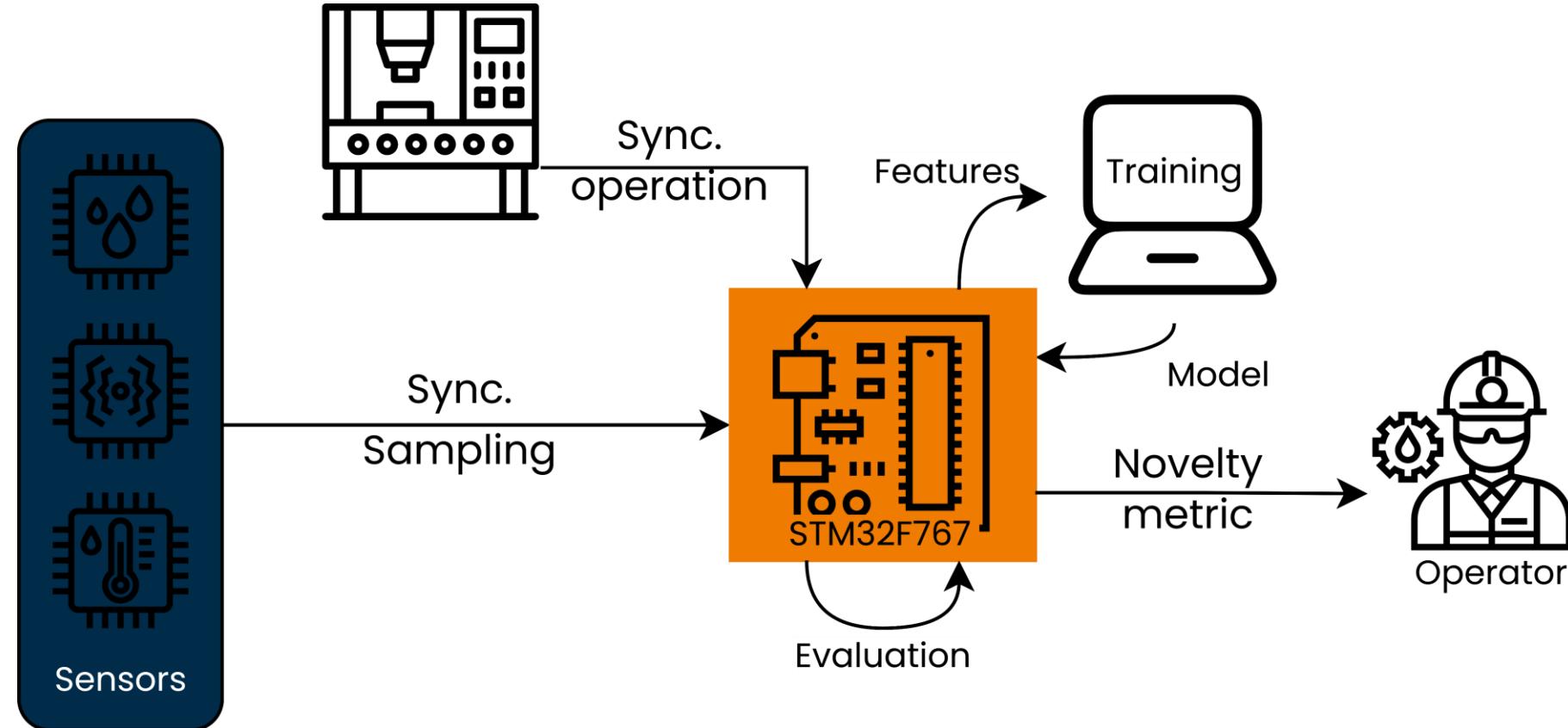




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# EMBEDDED IMPLEMENTATION





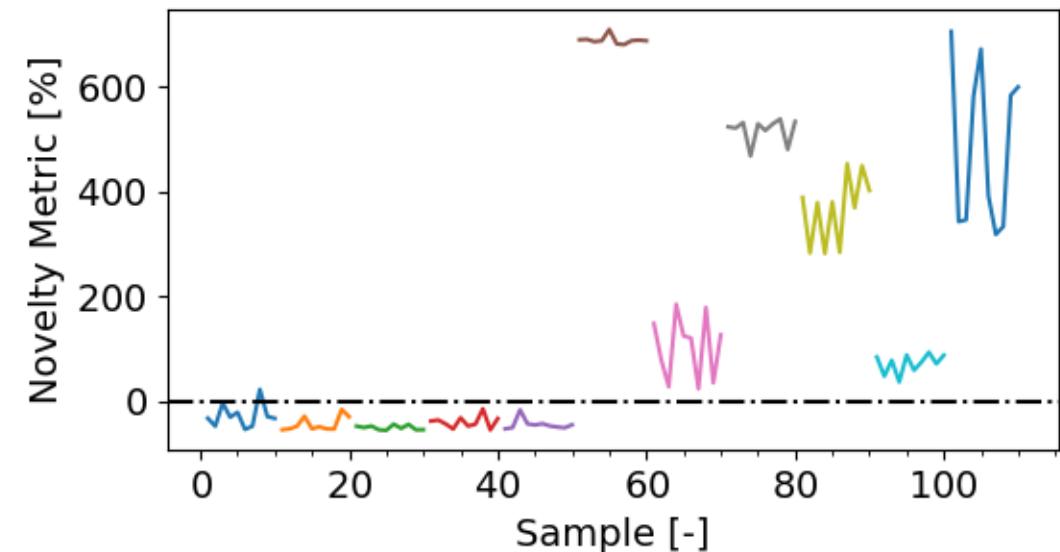
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## EMBEDDED TESTING & FUTURE WORK

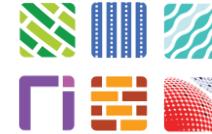
### Laboratory tests:

- Shaker
- Linear actuator





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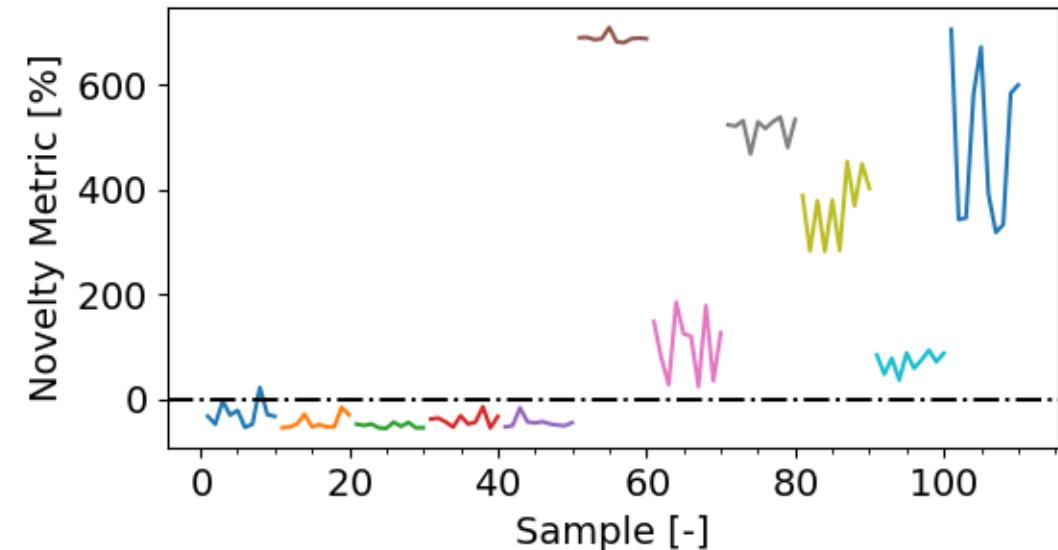
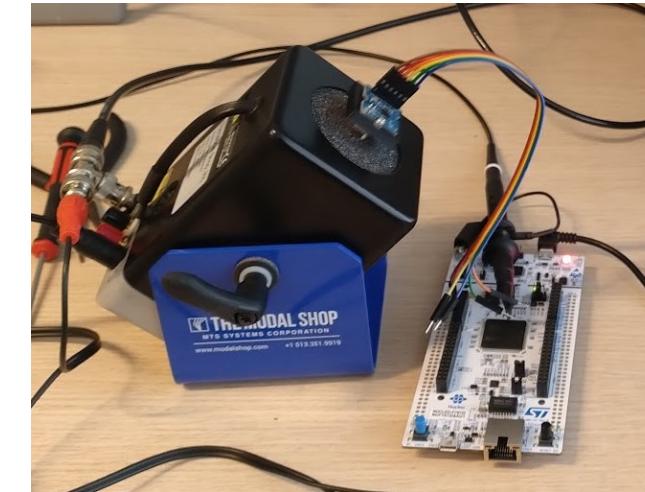
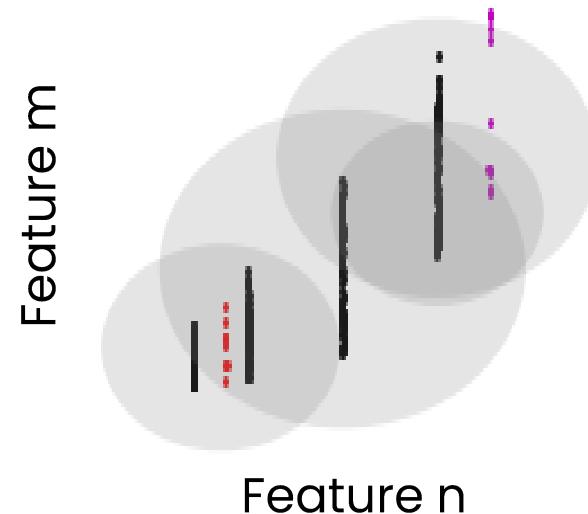
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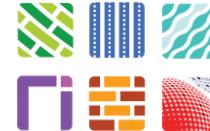
## Future work:

- Implement **LOF** or **iForest** for embedded applications





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# FEATURE SCALING

