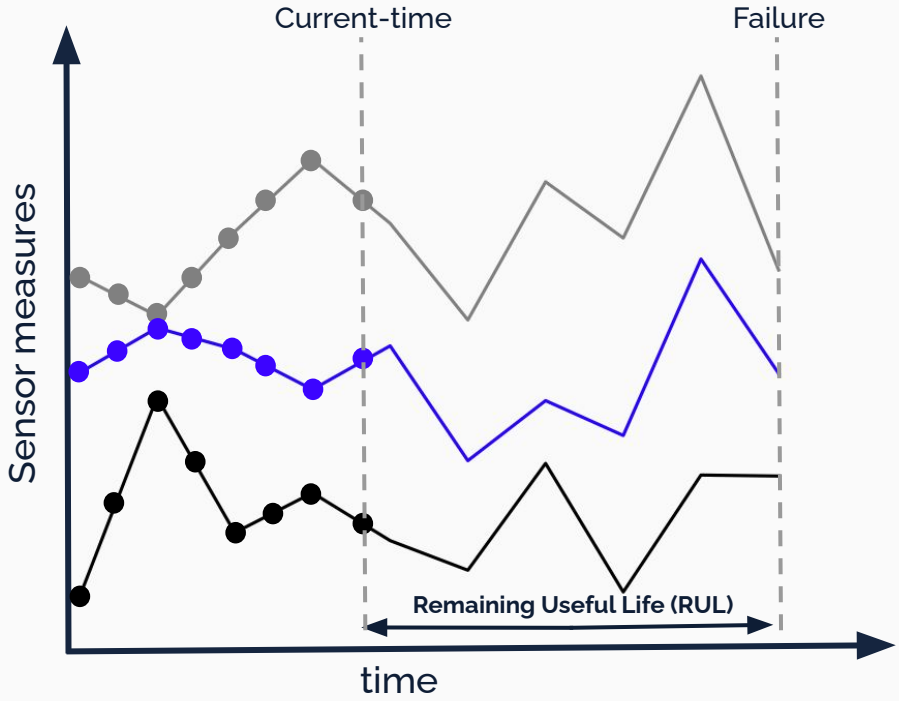
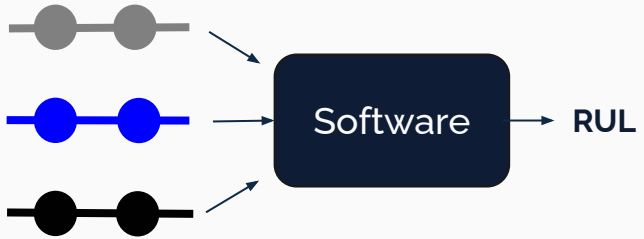
TIME-TO-FAILURE PREDICTION (TTF)

Forecasting plane engine failure with sensors data

Goal: Predicting airplane's engine failure before it happens



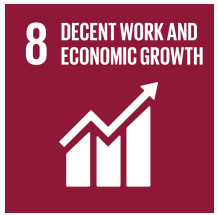


Objectives:

- Offer continuous maintenance assistance
- Decrease components production
- Decrease maintenance time
- Improve the engine efficiency

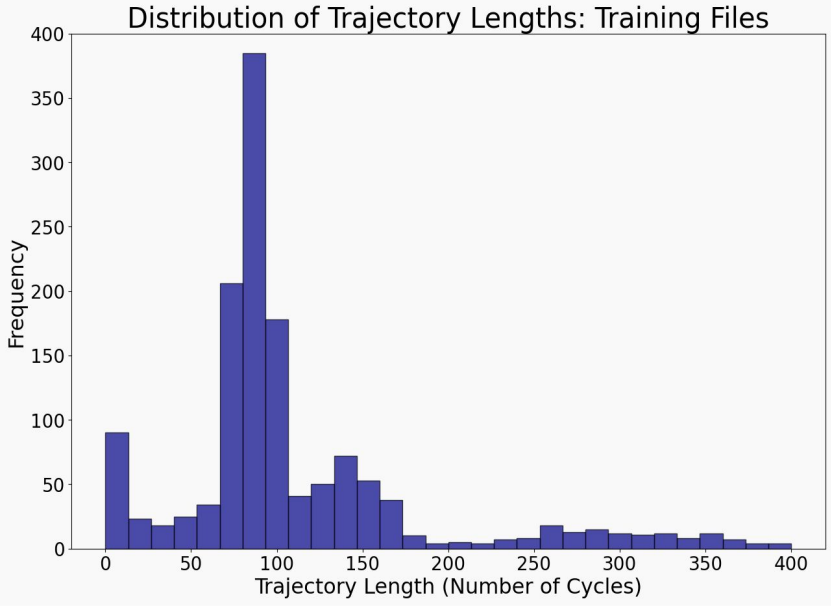
Value proposition:

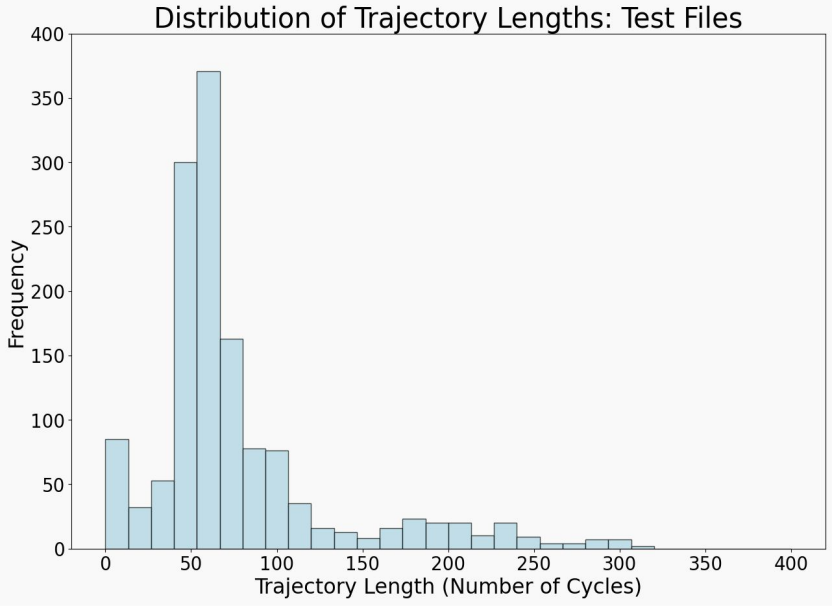
A survival analysis framework for aircraft components supports the UN Sustainable Development Goals by **improving component lifespan**, **reducing waste**, and **fostering innovation**.



Research questions

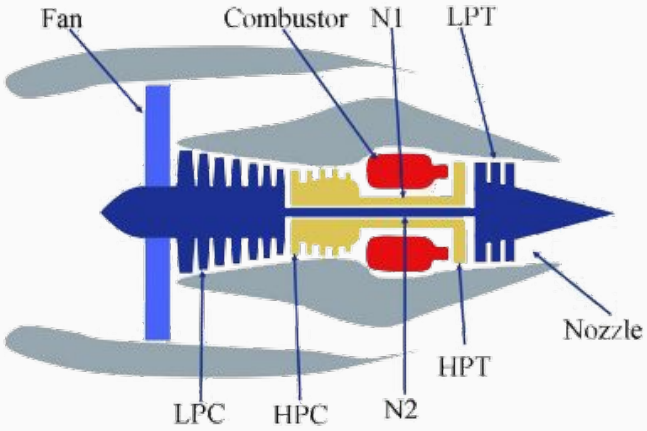
- How can we deal with trajectories having different length ?





Research questions

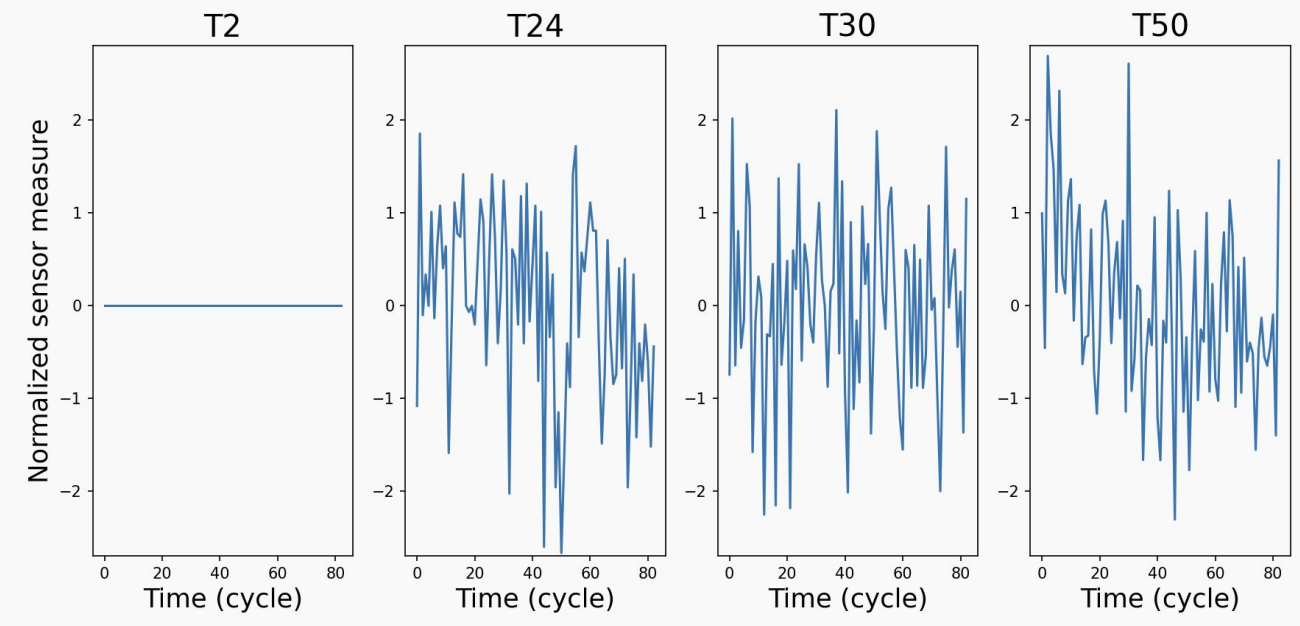
- Which are the most relevant features to collect ?



Symbol	*Description*	*Units*
T2	Total temperature at fan inlet	°R
T24	Total temperature at LPC outlet	°R
T30	Total temperature at HPC outlet	°R
T50	Total temperature at LPT outlet	°R
P2	Pressure at fan inlet	psia
P15	Total pressure in bypass-duct	psia
P30	Total pressure at HPC outlet	psia
Nf	Physical fan speed	rpm
Nc	Physical core speed	rpm
epr	Engine pressure ratio (P50/P2)	--
Ps30	Static pressure at HPC outlet	psia
phi	Ratio of fuel flow to Ps30	pps/psi
NRf	Corrected fan speed	rpm
NRc	Corrected core speed	rpm
BPR	Bypass Ratio	--
farB	Burner fuel-air ratio	--
htBleed	Bleed Enthalpy	--
Nf_dmd	Demanded fan speed	rpm
PCNfR_dmd	Demanded corrected fan speed	rpm
W31	HPT coolant bleed	lbm/s
W32	LPT coolant bleed	lbm/s

Research questions

- Which are the most relevant features to collect ?



Research questions

- How can sensor noise in time-series data be effectively mitigated to improve the accuracy in our RUL predictions?

Challenge :
Sensor data often contain noise due to external factors, calibration issues, or hardware limitations

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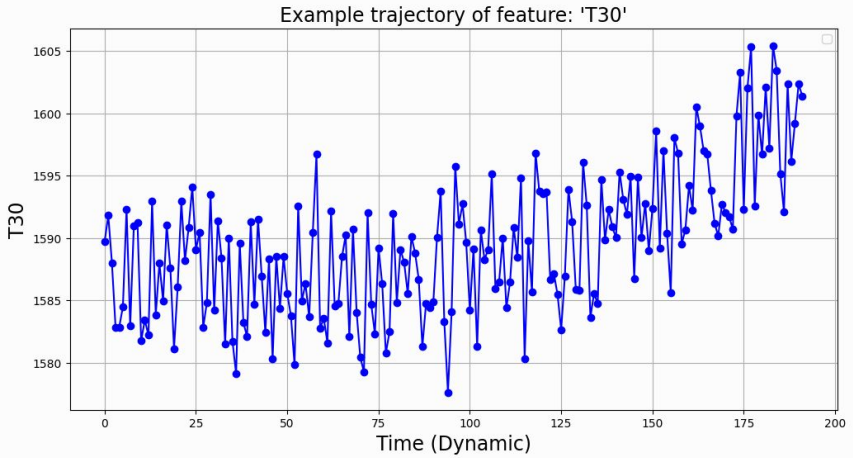
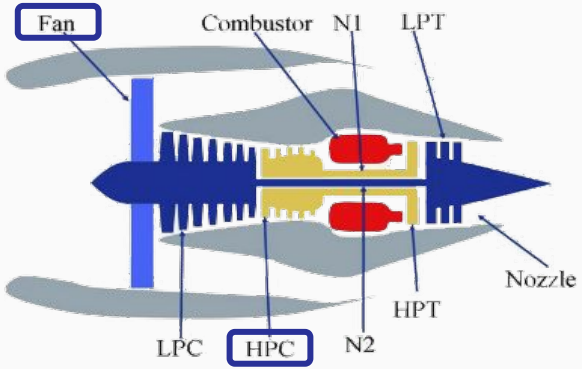
Impact :
Noise reduces the accuracy and reliability of predictive models



Other challenges ?

How to deal with different types of failure?



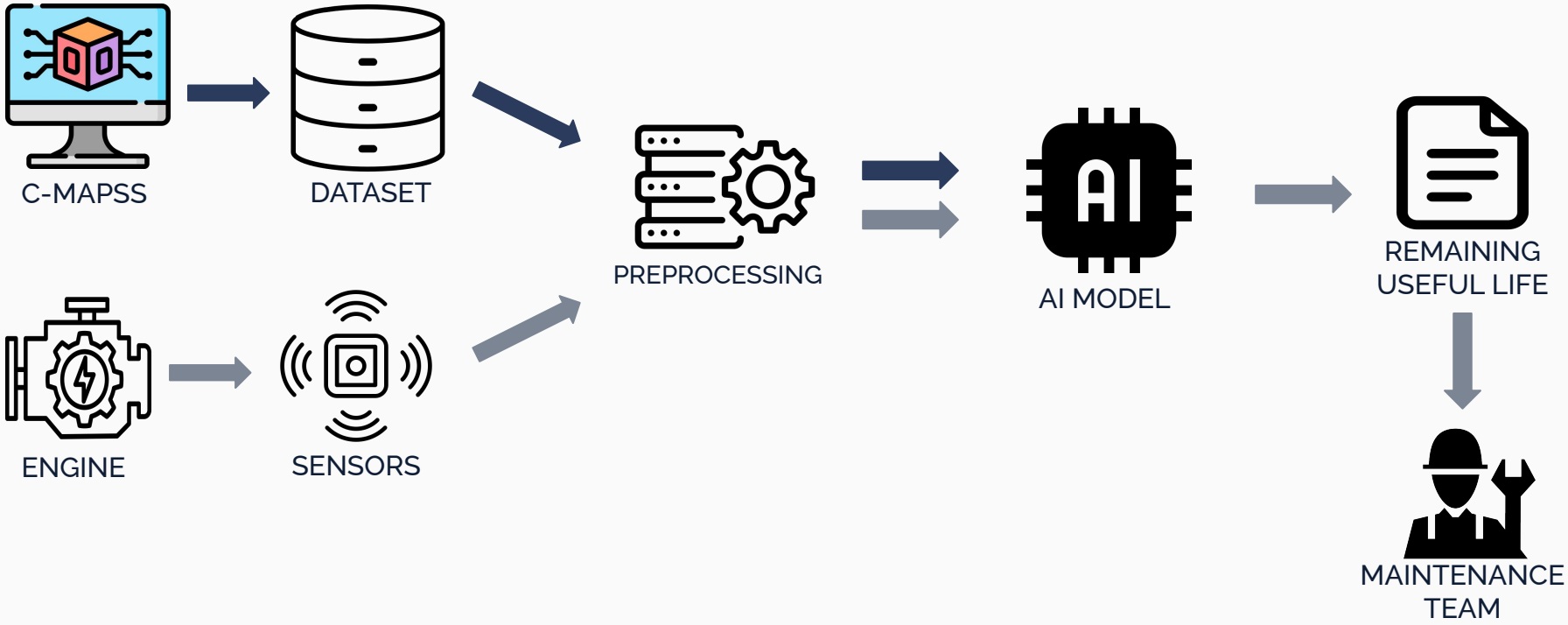
How to adapt forecasts to environment settings?

Air temperature

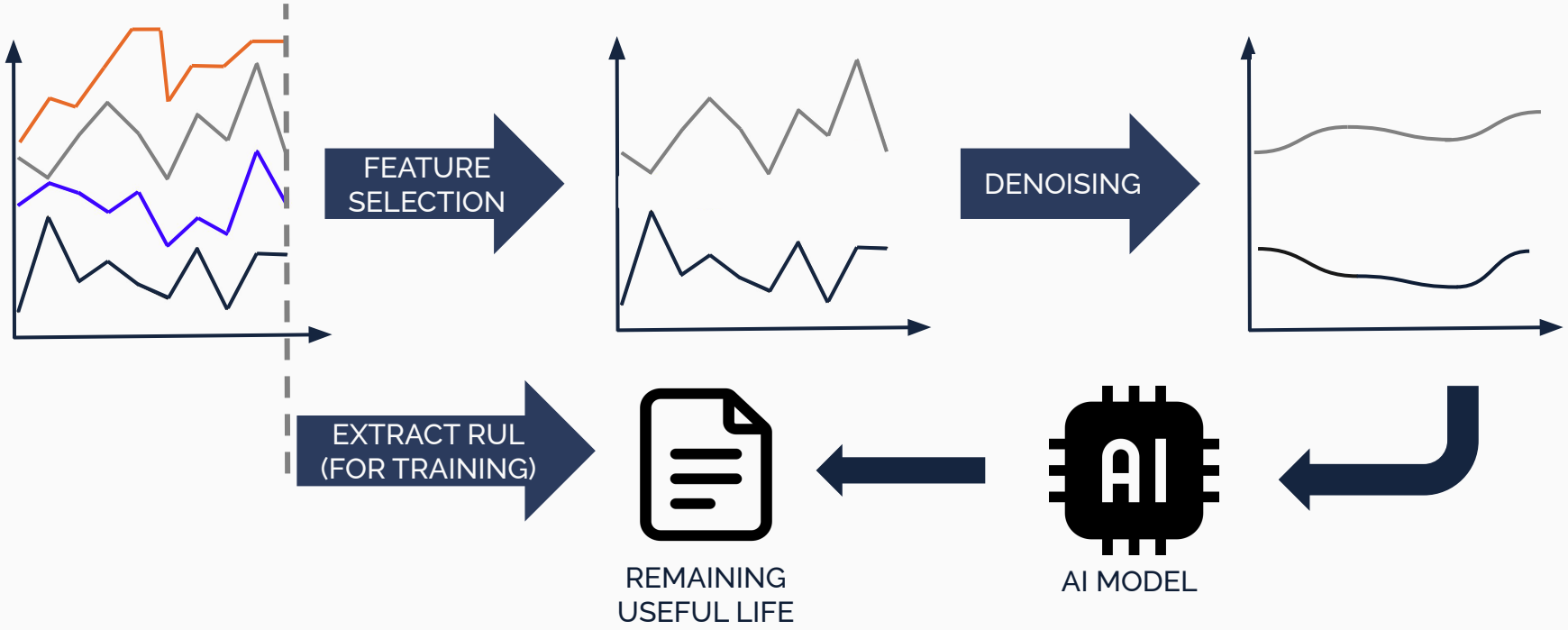
Altitude

Speed

Functional diagram:



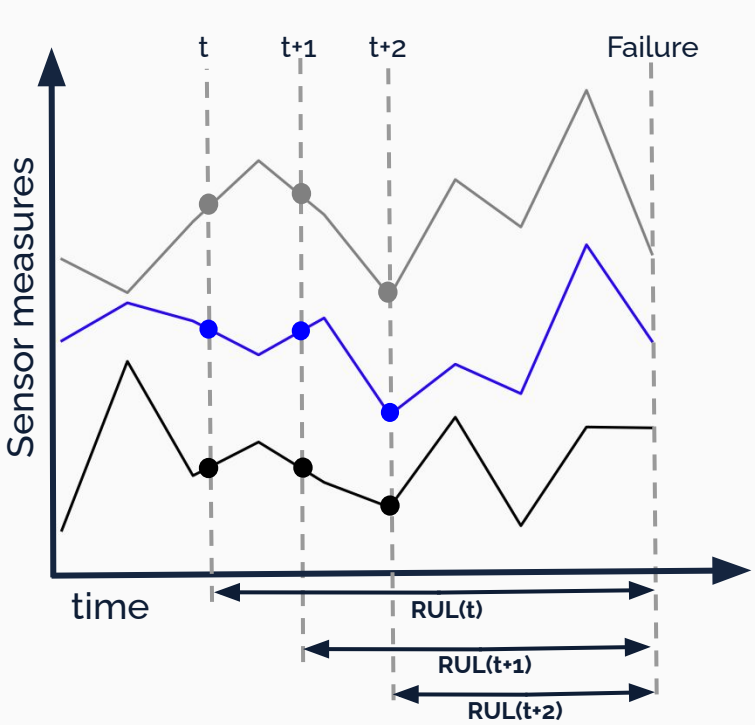
Zoom on the software:

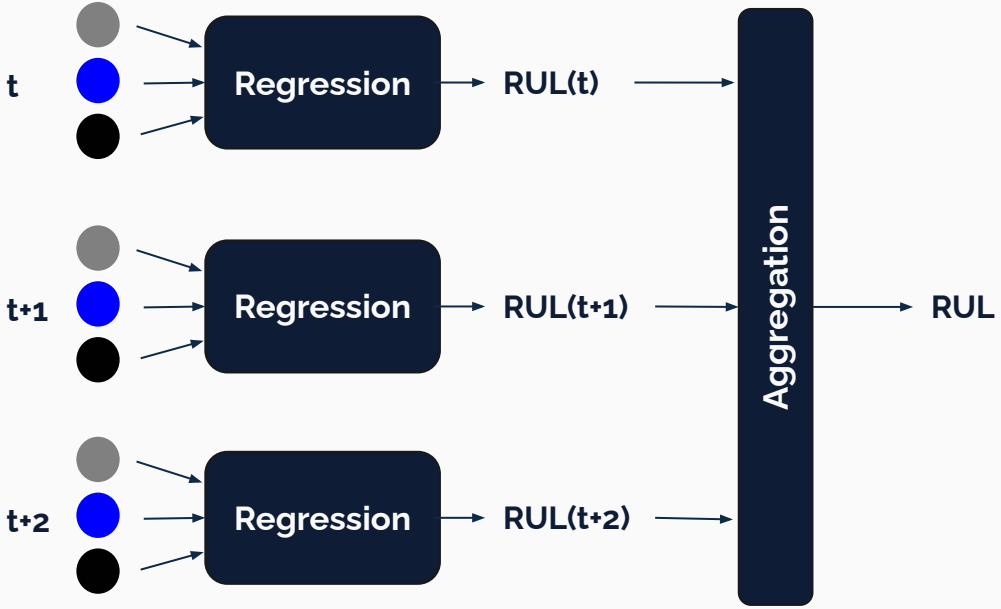


Strategies:

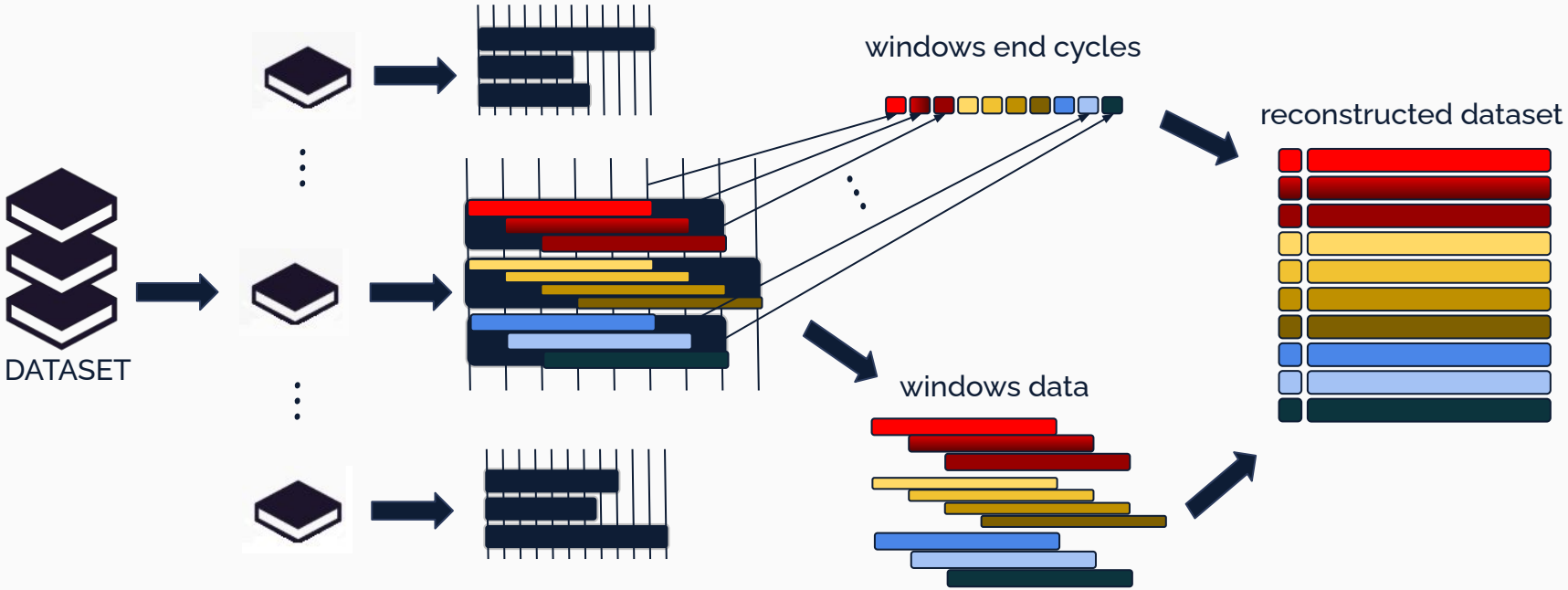
- Machine Learning Models
- Long Short-Term Memory
- Transformers

Machine Learning Models



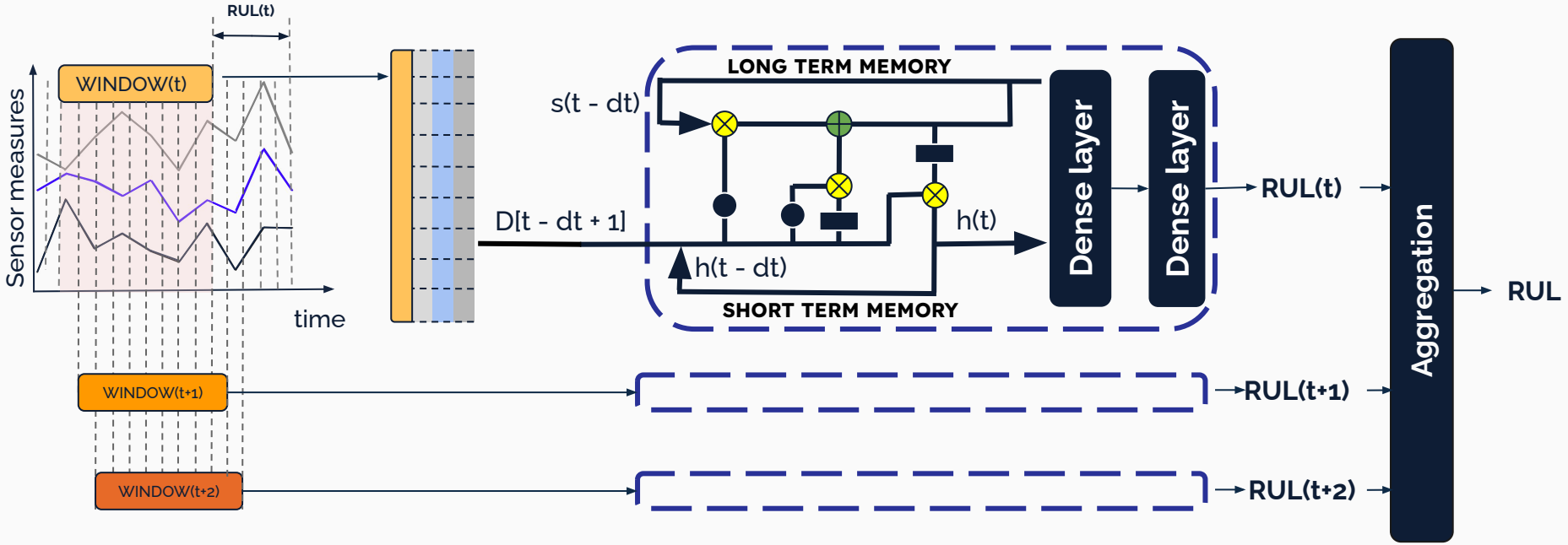


Windowing for LSTM and Transformers



Long Short-Term Memory

LSTM networks, a specialized type of RNN, that use a cell state, an input, a forget and an output gate to control the flow of information, capturing both short-term and long-term dependencies in sequential data



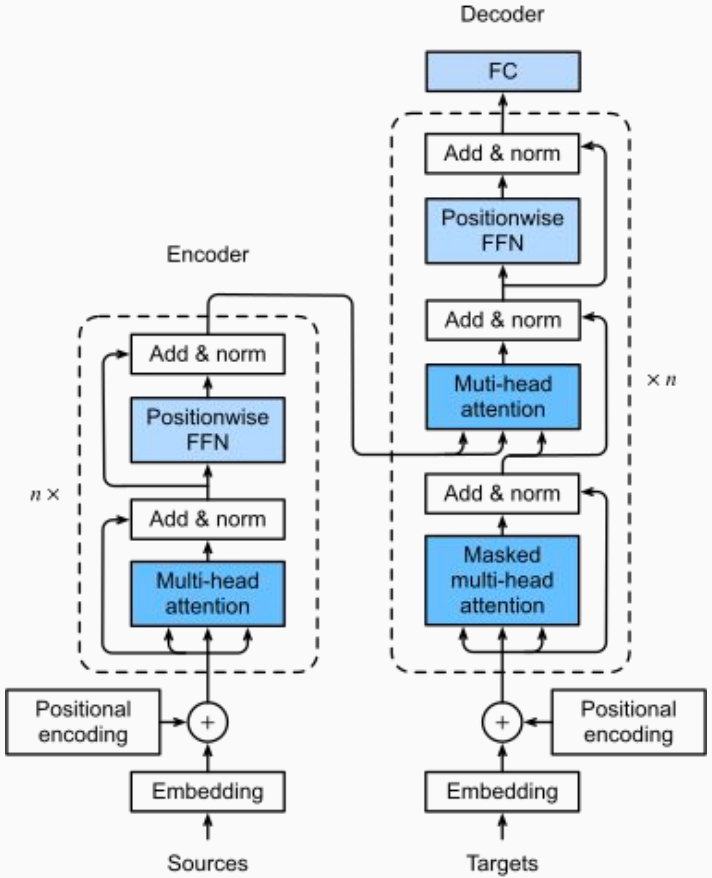
Transformers

- Transformers, leveraging self-attention mechanisms, excel in modeling long-term dependencies in sequential data, making them ideal for predicting Remaining Useful Life (RUL)

- The versatility of this powerful architecture allow us to carry on several approaches related to it.

e.g : Transformers can be pre-trained to predict the next window from sequential data, capturing global dependencies, and fine-tuned for regression to ensure accurate RUL prediction.

Unsupervised Pre-Training + Self-supervised Fine-Tuning



Any question ?

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