DCNN FOR ‘MACHINE RUL PREDICTION USING TIME-SERIES DATA’

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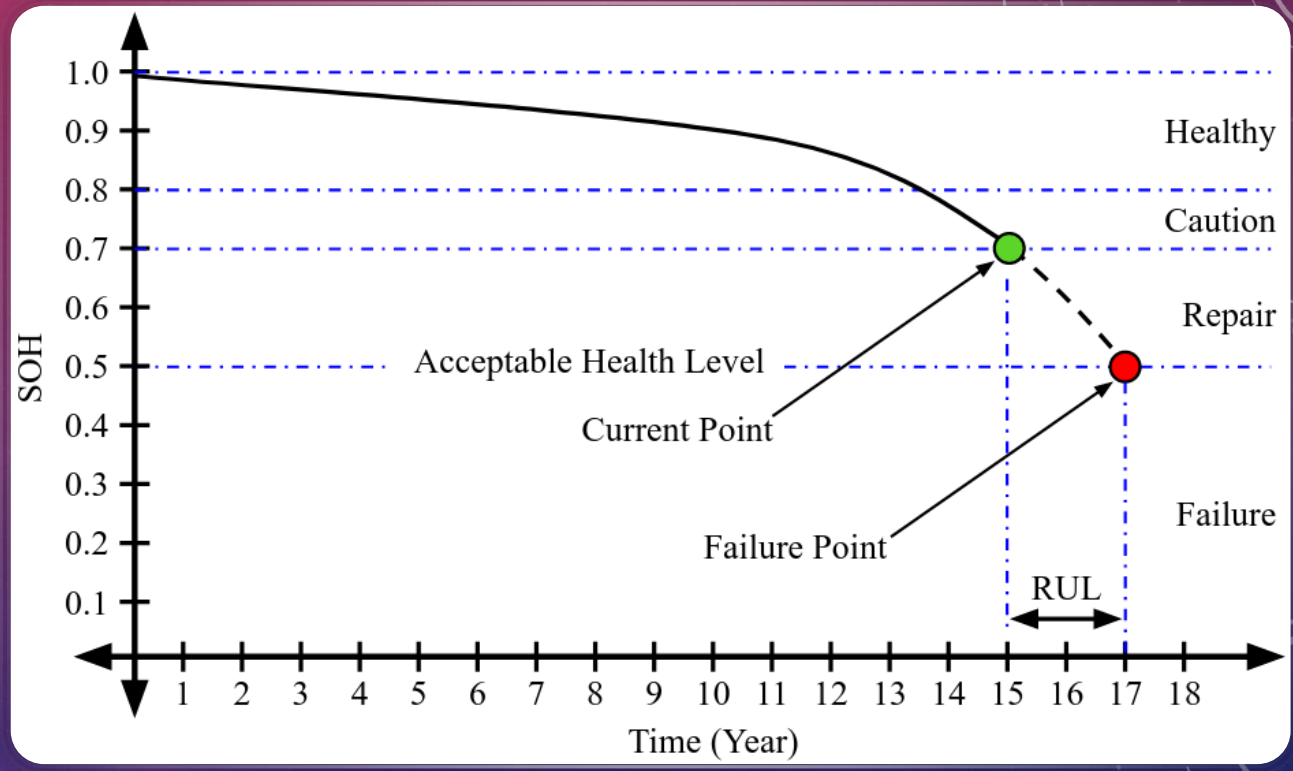
Hands-on

WHAT IS MACHINE RUL?

RUL - REMAINING USEFUL LIFE

- RUL is remaining time a machine is likely to operate before it requires repair or replacement
- Duration from last check or maintenance performed on it until the system fails or the degradation of the system performance exceeds a certain threshold
- RUL enables to estimate the future reliability and scans the degradation of the system along the time
- RUL help engineers to schedule maintenance, optimize operating efficiency, and avoid unplanned downtime



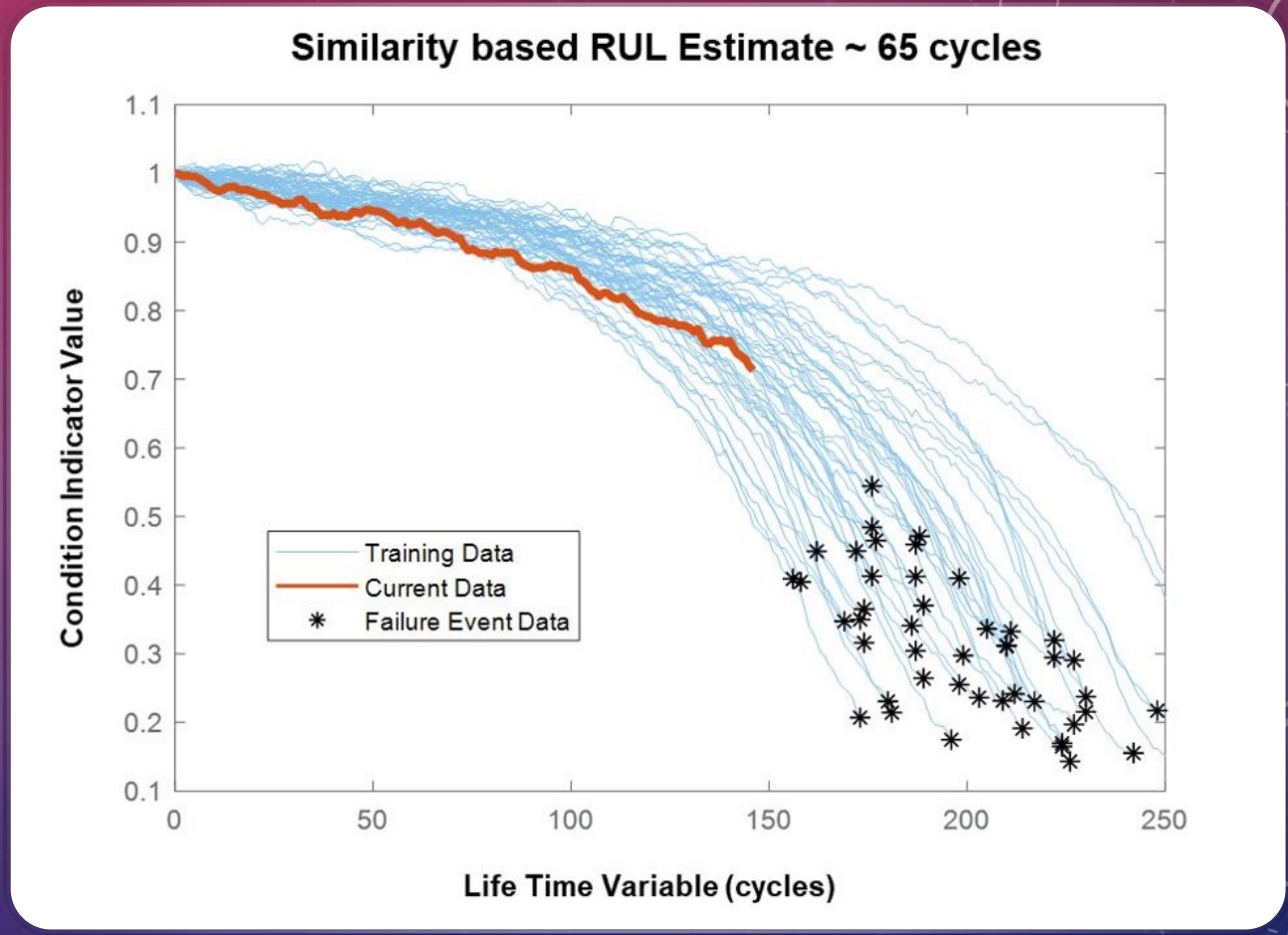
SOH – State of Health

WHY IS MACHINE RUL RELEVANT?

- Unexpected delays are costly
- Untimely maintenance increase the operational expenses and reduce the efficiency
- Prognostics and health management is an important topic in industry for predicting state of assets to avoid unplanned downtime and failures
- Negative impressions from customers because of delay

HOW TO PREDICT MACHINE RUL?

- Using run-to-failure histories of machines similar to the one you want to diagnose
- If you have a database of run-to-failure data from similar components or different components showing similar behavior, you can estimate RUL using similarity methods.
- In Figure, the degradation profiles of historical run-to-failure data sets from an engine are shown in blue and the current data from the engine is shown in red.

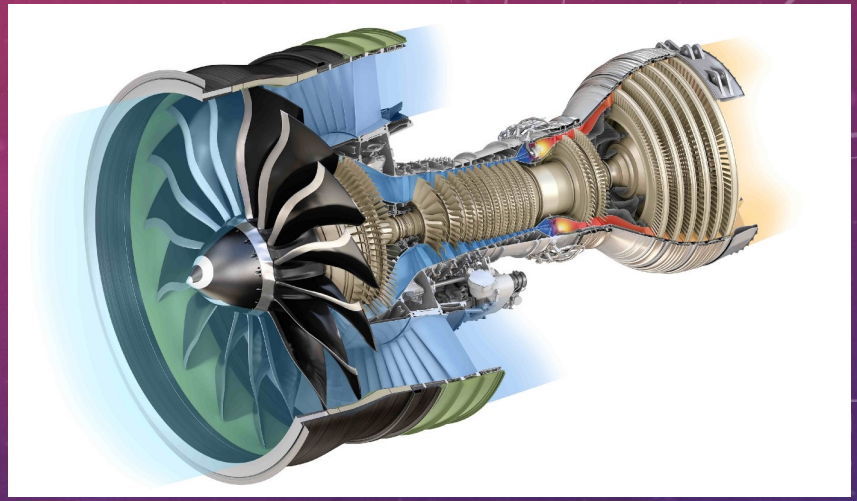


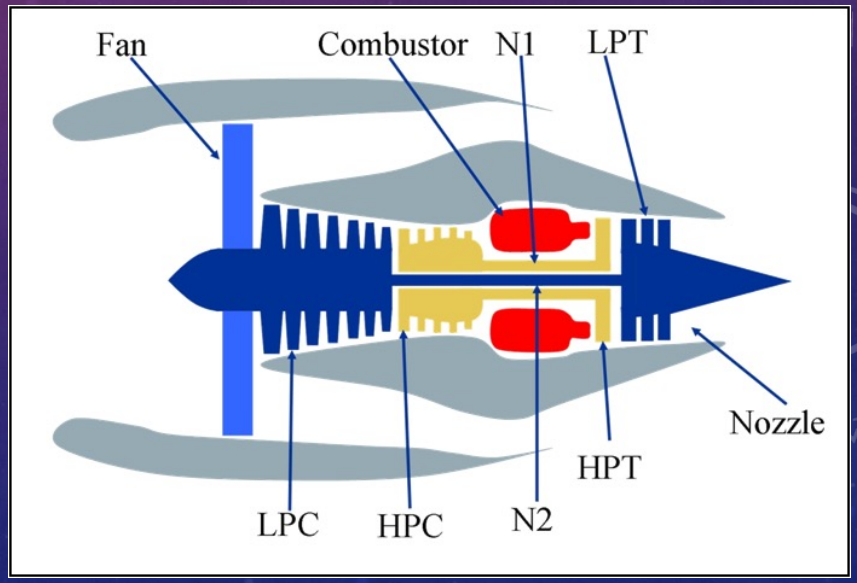
Plot - Run-to-Failure Data of a Machine

Ref - https://www.mathworks.com/

TURBOFAN JET ENGINE – RUL PREDICTION

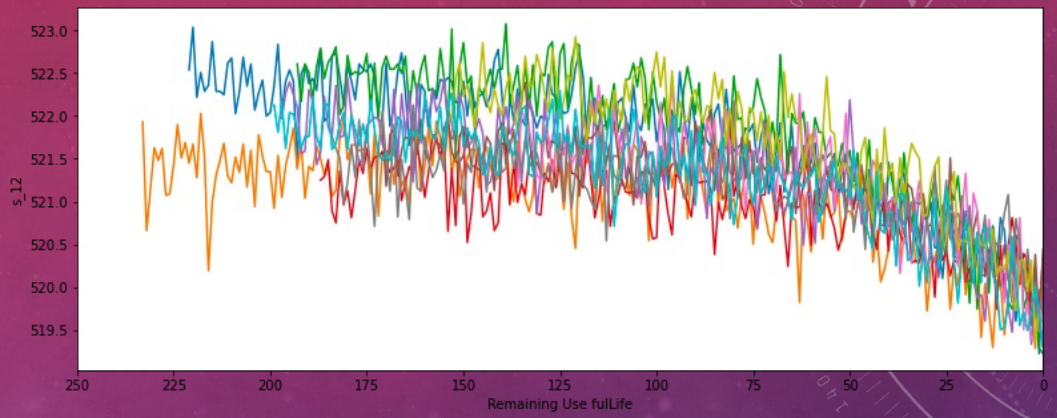
- We use the Turbofan Engine Degradation Simulation data set in the session
- The data set includes time-series measurements of various pressures, temperatures, and rotating equipment speeds that for the jet engine
- these measurements are typically measured in a commercial modern turbofan engine
- All engines are of the same type, but each engine starts with different degrees of initial wear and variations in the manufacturing process, which is unknown to the user
- There are three optional settings that can be used to change the performance of each machine. Each engine has 21 sensors collecting different measurements related to the engine state at runtime.

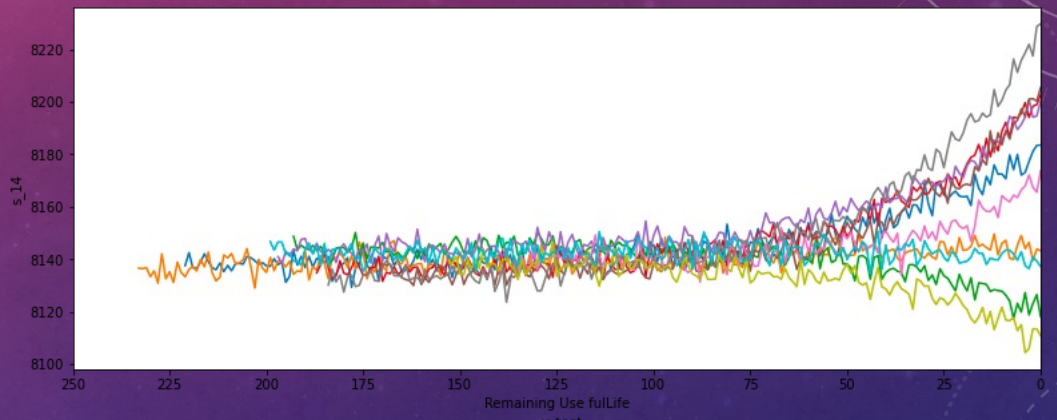


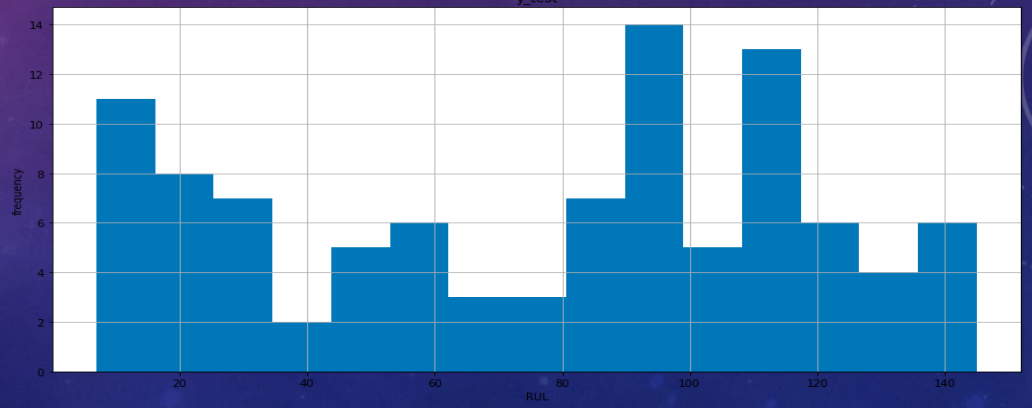


DATASET

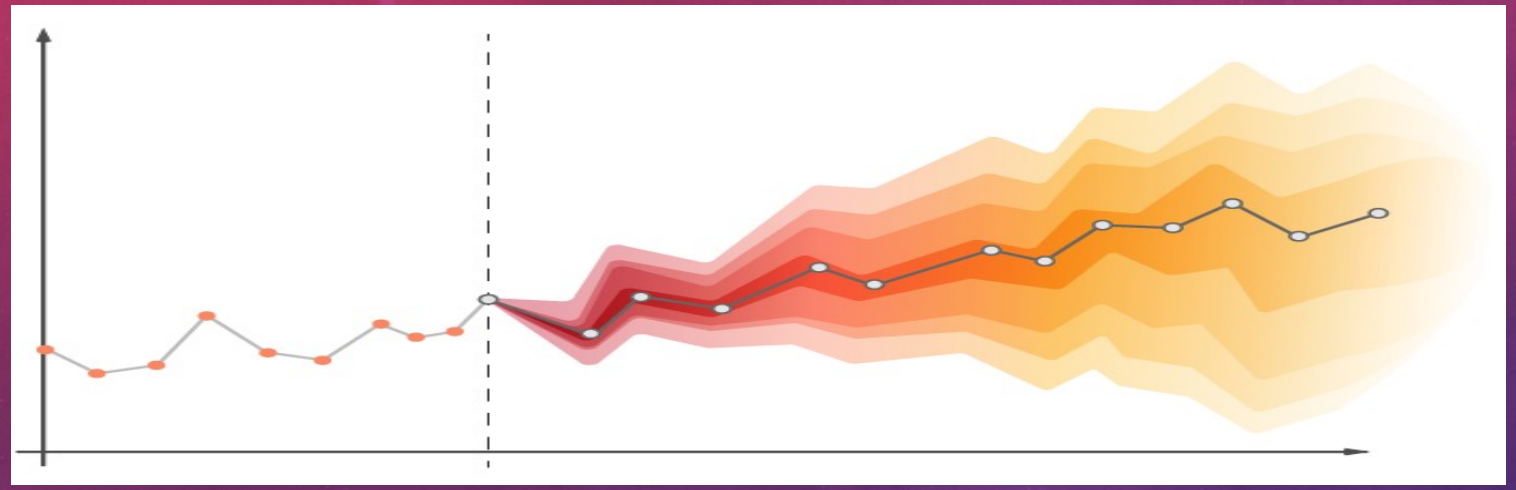
Symbol	Set	Description	Units
alt	W	Altitude	ft
Mach	W	Flight Mach number	-
TRA	W	Throttle-resolver angle	%
T2	W	Total temperature at fan inlet	ºR
Wf	X_s	Fuel flow	pps
Nf	X_s	Physical fan speed	rpm
Nc	X_s	Physical core speed	rpm
T24	X_s	Total temperature at LPC outlet	ºR
T30	X_s	Total temperature at HPC outlet	ºR
T48	X_s	Total temperature at HPT outlet	ºR
T50	X_s	Total temperature at LPT outlet	ºR
P15	X_s	Total pressure in bypass-duct	psia
P2	X_s	Total pressure at fan inlet	psia
P21	X_s	Total pressure at fan outlet	psia
P24	X_s	Total pressure at LPC outlet	psia
Ps30	X_s	Static pressure at HPC outlet	psia
P40	X_s	Total pressure at burner outlet	psia
P50	X_s	Total pressure at LPT outlet	psia
Fc	A	Flight class	-
h_s	A	Health state	-

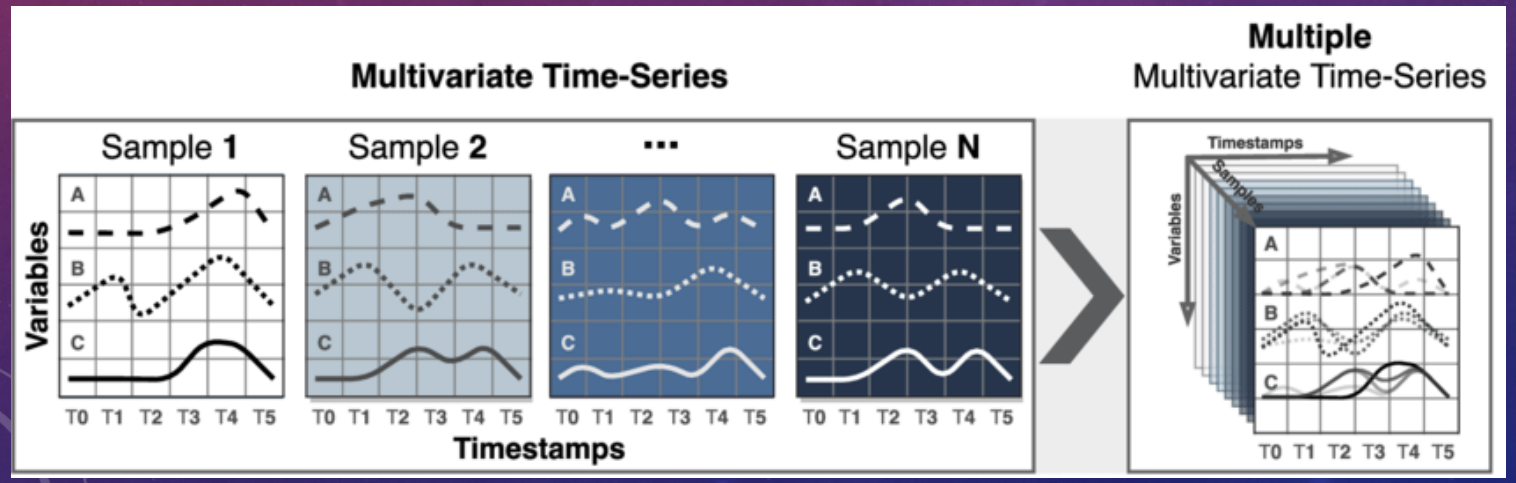






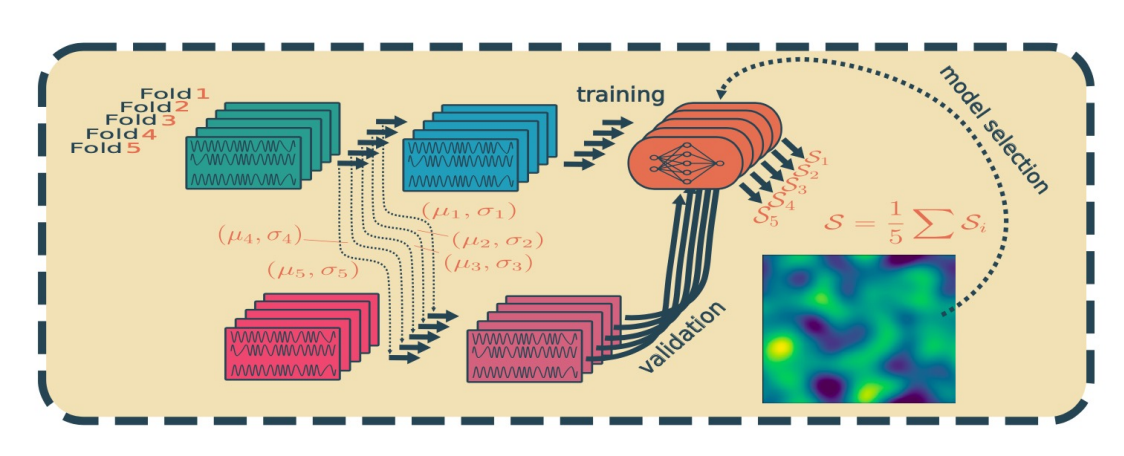
MULTI-VARIATE TIME-SERIES

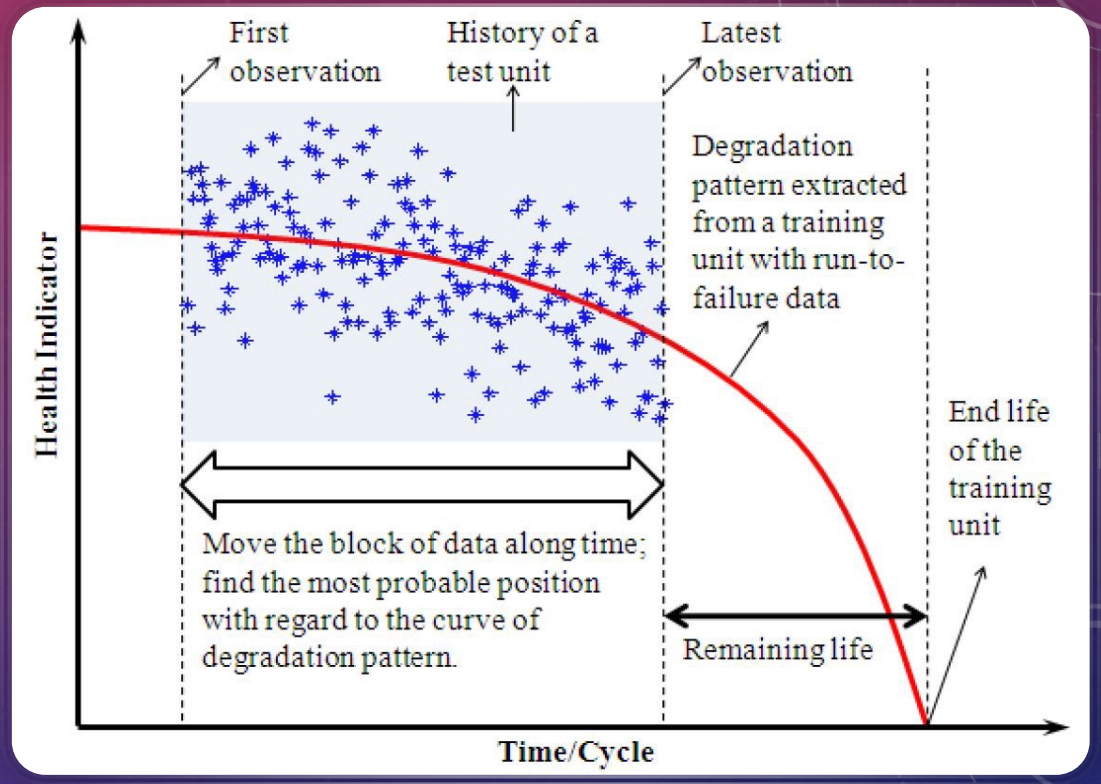




A Multivariate Time Series consist of more than one time-dependent variable and each variable depends not only on its past values but also has some dependency on other variables

DCNN





Ref - https://arxiv.org/abs/2111.12689

HANDS-ON

https://github.com/mohan-mj/DCNN-timeseries-RUL

REFERENCES

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[3] Data Set Citation: A. Saxena and K. Goebel (2008). "Turbofan Engine Degradation Simulation Data Set", NASA Prognostics Data Repository, NASA Ames Research Center, Moffett Field, CA

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[5] https://www.mathworks.com/help/predmaint/ug/remaining-useful-life-estimation-using-convolutional-neural-network.html

[6] https://github.com/datrikintelligence/stacked-dcnn-rul-phm21

THANK YOU

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