Contribution ID: **12** Type: **not specified**

Variable-Domain Multivariate Functional PCA for PHM and RUL Prediction

Functional data analysis methods are increasingly used in Prognostic Health Management (PHM) to model degradation from multi-sensor systems. Multivariate Functional Principal Component Analysis (MFPCA) is effective in this context, but its standard formulation assumes that all units are observed over a common time domain. In practice, operational data often exhibit variable domain lengths due to heterogeneous usage conditions and lifespans. We propose a Variable-Domain Multivariate Functional Principal Component Analysis (vd-MFPCA) framework that extends MFPCA to handle multivariate functional observations defined over unit specific domains. By estimating a domain dependent covariance structure, the method extracts principal components that adapt to the observed operational domain of each unit. This enables more flexible modeling of degradation trajectories across heterogeneous units. The proposed method is applied to the NASA C-MAPSS aircraft engine dataset. Results show that vd-MFPCA improves Remaining Useful Life prediction accuracy compared to conventional MFPCA while offering clearer functional interpretations of degradation patterns. The approach provides a practical and interpretable framework for PHM applications and RUL predictions involving variable-length, multi-sensor functional data.

Primary author: Mr YILDIRIM, CEVAHIR (UC3M)

Co-authors: Dr FRANCO PEREIRA, Alba Maria (UCM); Prof. KUNDU, Pradeep (KU Leuven); LILLO, Rosa (Universidad Carlos III de Madrid)

Presenter: Mr YILDIRIM, CEVAHIR (UC3M)

Track Classification: Spring Meeting