A multivariate time series based approach for the study of the remaining useful life for aircraft engines

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Abstract

In this research, a model for predicting the remaining useful life (RUL) of aircraft engines is presented. With this model, the values of the variables that determine the engine status can be predicted as the RUL of the engine decreases. Therefore, this allow to infer at which stage of the RUL the engine is, and to predict how the measurements of its characteristics will decline. For this approach, data taken from the variables are considered as multivariate time series, taking the changes in the RUL as the temporal steps. A dimensional reduction technique called time series factor analysis (TSFA) is applied to reduce the number of input variables. With this technique, relevant measures are selected and a reduced number of factors, are estimated. Afterwards, vectorial auto-regressive moving average (VARMA) models are applied for each turbine. VARMA processes advantage over univariant time series relies on taking the relation in the temporal evolution between variables into account. The main novelty of the present research is that as far as it is known by the authors, this is the first time that both techniques will be employed and combined in order to predict the RUL of aircraft engines.

TSFA are useful in those cases when the researchers does both measurement and modeling because specific assumptions about factor dynamics are usually much more fragile than the assumption the factor exist. By means of TSFA, those factors can be measured before modeling their dynamics. TSFA does not assume covariance stationarity and estimation is conducted in the time domain. TSFA does not include exogenous variables and deterministic functions of time, and only uses a proper covariance or correlation matrix. Furthermore, data is detrended by differencing and weak assumptions under which TSFA gives consistent estimates. Finally, it can be said that TSFA is a way to link measured data also called indicators to the factors which are underlying phenomena of interest.

A finite order vector autoregressive (VAR) process with finite order moving average (MA) error term is called a VARMA process. The VARMA models have the advantage of being closed with respect to linear transformations, that is, a linearly transformed finite order VARMA process has again a finite order VARMA representation. VARMA models can be parametrized in different ways. It means that different parametrizations describe the same stochastic process.

The estimated models represent a simplified alternative, while maintaining the relation between variables and its information. The performance of the models obtained is compared with an average model for all the turbines and with other models obtained by means of artificial intelligence techniques. The obtained model, will not only allow to predict, but also determines which variables are relevant in the determination of the RUL, consequently, the number of sensors can be reduced to measure just the significant variables.