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PREDICTING RELIABILITY BY RECURRENT NEURAL NETWORKS

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ABSTRACT

Reliability predictions are conducted throughout the life-cycle of an item with the aim of anticipating potential failures so as to allow taking the proper maintenance actions. Such predictions must be robust in that they properly treat and represent all the uncertainties involved, due to incomplete knowledge of the item physical properties, its loading and working conditions as well as to limited adherence of the models to reality.

Performing reliability predictions generally requires developing a reliability model of the system. The level of detail that a model can have depends on the level of design detail available at the time of which the prediction is performed. Several system reliability modeling approaches are available depending on the problem (e.g. reliability block diagrams, fault tree analysis, state-space methods, failure rate prediction methods). Although these methods are widely used, they bear some limitations when used for predicting the evolution of reliability with time.

On the other hand, the changes in the reliability behavior of a component can be treated by time series modeling. However, in practice the complexity and nonlinearity of the involved processes poses strong challenges to the standard time series analysis methods. On the contrary, artificial neural networks can be quite efficient for time series forecasting, due to their general nonlinear mapping capabilities.

The use of neural networks is not widespread in reliability engineering. On the other hand some studies exist, demonstrating how feed-forward multilayer perceptron (MLP) networks can successfully identify failure distributions and estimate their parameters. In particular, [1] applied feed-forward MLP and radial basis function (RBF) neural networks to predict engine reliability. The results obtained showed that the proposed neural model has superior predictive performance than the traditional MLP and autoregressive integrated moving average (ARIMA) models.

In this paper, an Infinite Impulse Response Locally Recurrent Neural Network (IIR-LRNN) [2] is used for forecasting the reliability and failures of complex systems. To investigate the IIR-LRNN capabilities in reliability prediction, the predictive performance of various time series models found in literature, including MLP, ARIMA

and RBF, are evaluated in a comparative study regarding diesel engine failures.

More precisely, a single- and a two-step ahead IIR-LRNNs have been set up for forecasting the failure time of turbochargers in diesel engines. The significance of the adopted modelling approach is that no a priori specifications of parametric failure distributions need to be made and verified. The results obtained show the capability of IIR-LRNN in forecasting the failures of engine systems.

Furthermore, the results of the comparative study show that a time series modelling technique based on recurrent neural networks provides a promising alternative and leads in general to better predictive performance than the ARIMA models. Finally, the particular IIR-LRNN architecture proposed is capable of achieving comparable or lower prediction errors, compared to traditional feed-forward MLP network and RBF models.

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