Paper ID: 74332
oral

IAF SPACE SYSTEMS SYMPOSIUM (D1)
Interactive Presentations - IAF SPACE SYSTEMS SYMPOSIUM (IPB)

Author: Dr. Krishna Kumar
Ryerson University, Canada, krishnadevkumar@yahoo.com

REAL-TIME REMAINING USEFUL LIFE PREDICTION OF SPACECRAFT REACTION WHEELS USING HYBRID MODEL BASED ON ARTIFICIAL INTELLIGENCE TECHNIQUES

Abstract

This paper proposes a hybrid model using long short-term memory (LSTM) and recurrent neural network (RNN) layers. The selection of hyperparameters of the hybrid model is automated and optimized via a genetic algorithm. The efficacy of this model is tested on generic datasets, derived from the high-fidelity model of spacecraft attitude dynamics with reaction wheels, as well as Kepler spacecraft reaction wheels datasets, for remaining useful life (RUL) predictions. The proposed model provides RUL predictions with root mean square error values that are competitive, and often better when compared to other models in the literature. A time window approach is adopted, and various values are tested to show the effectiveness of different hybrid models with convolutional layers. Given the temporal nature of the data, the hybrid and CNN models are compared by varying the time window size of the data input. It is found that for datasets with a single operating condition and a variable number of faults, the deep CNN provided the best results. Besides, the datasets with single operating conditions are less sensitive to the time window size when compared to datasets with a greater number of operating conditions. The hybrid model provides the best results when compared to the deep CNN, whilst varying the time size window. For datasets with a greater number of operating conditions, the sensitivity to the change in time window size was much greater. The effectiveness of the ability of CNN layers to extract features from raw sensor data is also tested. It is found that the CNN layers can extract higher-level features from raw noisy sensor data. This shows that an end-to-end prognostics model is possible using CNN layers to extract features from noisy data and no separate data pre-processing is required. Finally, the results of the numerical simulations show that the proposed method is highly successful in remaining useful life predictions of spacecraft reaction wheels.