A Hybrid Approach of Data-Driven and Physics-based Methods for Estimation and Prediction of Fatigue Crack Growth

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ABSTRACT

This paper aims to develop a hybrid method to estimate the fatigue crack growth of an aluminum lap joint specimen with and without Lamb wave signals. The proposed method is validated on the two validation specimens (T7 and T8), using the training data sets of six different specimens (T1-T6). Each validation data set includes crack length estimation of few loading cycles with the given Lamb wave signals, followed by crack estimation without the signals. First, the crack length estimation using the signals for T7 and T8 sets was performed by the data-driven based method. A set of features was extracted from the preprocessed signals. Then, a random forest model was used to estimate crack lengths with grid search-based feature selection and hyper-parameter optimization. Next, different approaches were used to estimate the crack length without the signals, since T7 and T8 were tested under different loading conditions. Assuming that the homogeneous constant loading condition leads to a similar fatigue crack growth patterns, an ensemble prognostics approach with simplified particle filter-based weight update was used to predict the crack lengths of T7 specimen. In contrast, Walker's equation model-based approach was chosen for T8 specimen as it was tested under a different loading condition. Considering the uncertainties of the model parameters, Walker's equation models were generated by Monte Carlo methods. The average of generated models were used to predict the remaining crack lengths of T8 specimen. The proposed method led to Top 3 in 2019 PHM Conference Data Challenge.