Fatigue damage diagnostics & prognostics of composite materials in-situ SHM data and Non-homogenous Hidden Semi-Markov Processes.

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1. System
Create an ensemble fatigue test was performed in 8 coupon coupons. Plates from autoclave coupons were manufactured as the structure process. The starting sequence was (BN/EP/45/60/EP) and triangle open hole coupons were cut in dimensions 6mm thick with central hole of 40mm diameter.

2. Feature extraction
For the raw acoustic emission data the windward cumulative RA (time/number) data are extracted, in periodic intervals of 2.5 minutes.


3.1 Training procedure-Parameter Estimation
The BIC of the model parameter \( m, M \) is obtained if parameters deal with the state transition between the degradation states, while \( \theta \) parameters deal with the stochastic conjugate between the degradation levels and f(p) damage-sensitive features \( f(p) \). The BIC criterion for the estimation of \( N \) is:

\[
BIC(\theta, M) = \sum_{t=1}^{T} \log(1 + K - 1) + (1 + K - 1) \log(\text{det}(\Sigma_{t}))
\]

3.2 Diagnostic measures
Diagnostic measures are the most likely state (ML) and the Average Degradation Level (ADL).

\[
\text{ML}(t, M) = \arg\max_{j} p(x_t | \theta_j, M)
\]

\[
\text{ADL}(t, M) = \frac{1}{N} \sum_{j=1}^{N} \theta_{j}(x_t)
\]

3.3 Prognostic measures
The remaining useful life (RUL) is the quantity of interest in a condition-based monitoring framework. The cumulative distribution function (CDF) for RUL can be defined at any point utilizing the conditional reliability according to the following:

\[
P_{\text{RUL}}(t, M) = 1 - P_{\text{RUL}}(t, M)
\]

6. Results
New fatigue lifetime degradation histories \( x(1), x(2), \ldots, x(n) \) were available from the mechanical testing, coupons A1A6. A field issue rate curve cross-validation (CV) scheme was adopted for the training of the NHCTHSMP model. Each time a specific coupon was selected as test set for diagnostics and prognostics, the rest of degradation histories were utilized for training the NHCTHSMP model to estimate the parameter \( \theta \) of the model. The test set has been always kept to unseen data regarding the training process. After the estimation process the diagnostic and prognostic measures were computed based on the estimated parameters \( \theta \).

6.4 Parameters estimation

References


