A Probabilistic Approach to Maintenance Cost Analysis Considering Time-dependent False Alarms for PHM Design

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ABSTRACT

Prognostics and health management (PHM) aims at predicting system failures in advance and timely conducting maintenance so as to minimize operation and maintenance costs. One of the challenges in PHM is how to deal with a false alarm. A false alarm in PHM implies incorrect estimation about a health state of an engineered system. This could incur unnecessary overhaul and maintenance or unexpected costly system failures. That is, the incurred costs due to false alarms should be analyzed prior to deciding the implementation of PHM. This paper presents the framework of life-cycle maintenance cost analysis considering false alarms. First, the framework estimates false alarm rates for a given PHM algorithm. In this study, two types of false alarms (i.e., false healthy and false faulty) are taken into account and health diagnostics is considered for a PHM algorithm. The false alarm rates are calculated according to their probabilistic definition while considering the time-dependent (or time-dependent) property of false alarm rates. Then, three maintenance probabilities (unnecessary, corrective and preventive) are calculated by multiplying the probability of a true health state (reliability or failure rate) by the conditional probability from the detectability matrix. For instance, the probability of the unnecessary maintenance is calculated as the conditional probability of system faulty estimation given a true healthy system (false faulty) times the probability of a true healthy system (reliability). Lastly, the expected costs of three maintenances are calculated with consideration of the calculated maintenance probabilities and their costs. An electro-hydrostatic actuator simulation model is employed for demonstration. Its expected maintenance cost during life-cycle is estimated, to demonstrate the validity of the proposed framework.