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Condition-based maintenance policy for two-component balanced systems under dynamic environments

Balanced systems are widely employed across various industries and are often exposed to dynamic environments. While most existing research emphasizes degradation dependence, this study focuses on optimizing maintenance strategies for balanced systems by jointly considering dependent competing risks and environmental influences. System failure is defined under three conditions: (1) soft failure; (2) hard failure; and (3) imbalanced failure. To capture environmental impacts on component degradation, we adopt a Lévy process that integrates a gamma process, compound Poisson shocks, and an embedded Markov chain. Maintenance decisions, including do-nothing, repair, and preventive replacement, are made at periodic inspection epochs. The problem is formulated as a Markov decision process (MDP) and solved using both value iteration and a Dueling Deep Q-Network (DQN) algorithm. A flap system case study, along with a thorough sensitivity analysis, illustrates the efficacy of the proposed methodology and highlights the benefits of proactive maintenance in harsh environments.

Special/ Invited session

Classification

Mainly methodology

Keywords

Balanced system; Dynamic environment; Condition-based maintenance

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