

Degradation-Aware Spare Parts Management in Service Industries

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Managing spare parts inventory is a critical challenge for service providers maintaining multi-machine systems, particularly when replenishment times are stochastic. While Condition-Based Maintenance offers valuable Advance Demand Information regarding future spare parts demand, leveraging this information to optimize inventory control within complex, uncertain supply chains remains an open challenge. This work bridges this gap by developing inventory policies for systems with multiple machines, stochastic lead times, and batch ordering. We first introduce a Proactive Base Stock Policy (ProBSP) for a multi-machine system and stochastic lead times. The ProBSP leverages degradation data to order spare parts in advance, thereby minimizing average stock levels while ensuring the fulfillment of contractual service agreements. We further advance this framework to address capacity constraints and batch ordering by developing policies using three state-of-the-art Deep Reinforcement Learning algorithms enhanced by domain knowledge. Furthermore, we investigate the explainability and scalability of these methods in an attempt to facilitate their acceptance in industry. Our results demonstrate that leveraging degradation data in spare parts inventory management yields savings of up to 70% compared to traditional methods.