

Refining Open-Source Asset Management Tools: AI-Driven Innovations for Enhanced Reliability and Resilience of Power Systems

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Abstract-

Traditional methods of asset management in electric power systems rely upon fixed schedules and reactive measurements, leading to challenges in the transparent prioritization of maintenance under evolving operating conditions and incomplete data. In this paper, we introduce a new, fully integrated artificial intelligence (AI)-driven approach for enhancing the resilience and reliability of open-source asset management tools to support improved performance and decisions in electric power system operations. This methodology addresses and overcomes several significant challenges, including data heterogeneity, algorithmic limitations, and inflexible decision-making, through a three-module workflow. The data fidelity module provides a domain-aware pipeline for identifying structural (missing) values from explicit missingness using sophisticated imputation methods, including Multiple Imputation Chain Equations (MICE) and Generative Adversarial Network (GAN)-based hybrids. The characterization module employs seven complementary weighting strategies, including PCA, Autoencoder, GA-based optimization, SHAP, Decision-Tree Importance, and Entropy Weighting, to achieve objective feature weight assignment, thereby eliminating the need for subjective manual rules. The optimization module enhanced the action space through multi-objective optimization, balancing reliability maximization and cost minimization. A synthetic dataset of 100 power transformers was used to validate that the MICE achieved better imputation than other methods. The optimized weighting framework successfully categorizes Health Index values into five condition levels, while the multi-objective maintenance policy optimization generates decisions that align with real-world asset management practices. The proposed framework provides the Transmission and Distribution System Operators (TSOs/DSOs) with an adaptable, industry-oriented decision-support workflow system for enhancing reliability, optimizing maintenance expenses, and improving asset management policies for critical power infrastructure.

Index Terms- asset health assessment; condition monitoring; power system asset management; predictive maintenance; multi-objective optimization; machine learning; data-driven insights

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