

AI-Enabled Predictive Maintenance for Marine Auxiliary Machinery: A Smart Ship Approach

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Abstract:

The progressive integration of artificial intelligence into maritime operations has created a compelling paradigm shift in how shipboard machinery health is monitored, diagnosed, and maintained. This paper presents MAPPS (Marine AI Predictive and Prognostic System), a comprehensive AI-enabled predictive maintenance framework specifically architected for marine auxiliary machinery including diesel generators, centrifugal pumps, compressors, and purifiers aboard commercial vessels. MAPPS employs a multi-layer computational architecture combining Long Short-Term Memory (LSTM) neural networks for real-time anomaly detection, a fine-tuned ResNet-50 convolutional neural network for image-based defect classification, and a nonlinear Bayesian remaining useful life (RUL) estimation model with sequential parameter updating. The system integrates multi-modal sensor fusion encompassing vibration, temperature, pressure, current, and ultrasonic thickness data, processed through an edge computing gateway before cloud-based AI inference. Simulation results across four distinct operational phases demonstrate that MAPPS achieves a fault detection precision of 97.3% with a false alarm rate below 2.7%, a weighted validation accuracy of 91.4% across seven defect categories, and a RUL prediction uncertainty reduction from plus/minus 3.4 years to plus/minus 0.55 years after five sequential inspection cycles. Economic modelling for a 15-vessel Indian coastal fleet projects annual maintenance cost reduction of INR 9.65 lakh per vessel, with payback in 13 months and 10-year NPV of INR 8.17 crore at 8% discount rate. An industry survey (N=40) validates 70% adoption intent among maritime professionals.

Keywords:

Predictive maintenance, marine auxiliary machinery, LSTM anomaly detection, ResNet-50, Bayesian RUL estimation, Hull Health Index, smart ship, MAPPS, IoT-enabled condition monitoring.