

# **Time Series-Based Anomaly Detection in Gas Turbines Using TimeWGAN-GP**

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## **Abstract-**

**Reliable early detection of degradation in gas turbines is essential for preventing failures and optimizing maintenance strategies. However, traditional fault-detection methods struggle to capture the complex temporal dynamics that precede abnormal conditions. This study investigates the use of Generative Adversarial Networks (GANs) for time-series modeling and anomaly datasets augmentation, aiming to learn the evolving behavior of turbine systems directly from sensor data and to address the insufficient amount of failure data for anomaly detection. In the first stage, GANs are trained on historical time-series recordings of turbines operating under normal conditions to address data scarcity and enhance model robustness. Validation results show that the generated sequences maintain strong statistical consistency with the original data, accurately reproducing characteristic temporal patterns of healthy operation. The second stage focuses on anomaly detection by integrating real-time sensor inputs with the learned temporal representations from both real and synthetic datasets. The discriminator detects deviations from expected behavior, enabling early identification of abnormal trends and providing insight into degradation trajectories. Experimental findings demonstrate that the proposed framework captures dynamic transitions more effectively than threshold-based methods, predicts the progression of faults, and supports the construction of an expanded anomaly catalog by generating synthetic profiles that resemble documented failure modes. Overall, the approach improves early-warning capabilities and strengthens data-driven maintenance planning.**

**Index Terms-** Anomaly detection, fault detection, gas turbine, generative adversarial network, machine learning.

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