

A Data-Centric Edge Framework for Predictive Maintenance in Industrial IoT

ABSTRACT

The Industrial Internet of Things (IIoT) generates vast streams of heterogeneous industrial data, yet extracting actionable insights in real time remains challenging due to the limitations of proprietary platforms and non-scalable academic prototypes. This dissertation introduces a data-centric approach for industrial edge computing, focusing on feature extraction, preprocessing, and customizable analytics directly on raw data streams. The primary contribution is a framework that enables third-party developers to define and deploy custom transformations and predictive models on industrial data, decoupling analytics from original equipment manufacturer (OEM) constraints: the Concentrator. By studying both slow-varying signals (e.g., temperature) and high frequency signals (e.g., vibrations), meaningful features are generated, facilitating predictive maintenance, anomaly detection, and operational optimization. Experimental validation on an AROL capping machine demonstrated that containerized, edge-deployed analytics can achieve forecasting accuracies above 99% for slow signals and F1-scores over 98% for complex vibration anomalies. The methodology highlights how raw industrial data can be systematically understood, transformed, and personalized to support flexible, open, and collaborative IIoT ecosystems. Overall, this research establishes a practical foundation for intelligent, data-driven industrial operations, emphasizing feature engineering, edge-level customization, and actionable insight generation, rather than mere data collection.