Chapter 2
Machine Learning Approaches for Predictive Maintenance in Wireless Sensor Networks

Sathya Selvaraj Sinnasamy
https://orcid.org/0000-0003-3676-0178
SRM Institute of Science and Technology, Ramapuram, India

Biswaranjan Senapati
https://orcid.org/0000-0002-0717-5888
University of Arkansas at Little Rock, USA

S. Kamaleswari
SRM Institute of Science and Technology, Ramapuram, India

B. Vaidianathan
Dhaanish Ahmed College of Engineering, India

U. Surendar
SRM Institute of Science and Technology, Ramapuram, India

M. Gandhi
Dhaanish Ahmed College of Engineering, India

ABSTRACT

Wireless Sensor Networks (WSNs) have permeated various domains, such as industrial automation, healthcare, and environmental monitoring, due to their ability to effectively collect and communicate data in diverse environments. The reliability and durability of WSNs have become paramount, particularly in critical applications. Predictive maintenance, which anticipates faults and mitigates them preemptively, emerges as a pivotal strategy to enhance network longevity and reliability. This paper explores using machine learning (ML) approaches for predictive maintenance in WSNs. Various ML algorithms, including regression, classification, and clustering, are investigated in terms of their efficacy in predicting and diagnosing issues within

DOI: 10.4018/979-8-3373-4672-4.ch002

the network, thereby facilitating timely interventions. The paper contributes a novel architecture integrating ML models into WSNs to monitor, analyze, and predict potential failures, ensuring optimal network functionality.

INTRODUCTION

Wireless Sensor Networks (WSNs) are ubiquitous in myriad applications, encompassing industrial monitoring, healthcare, and environmental surveillance, due to their capability to ascertain and convey information from disparate and often inaccessible environments (Bin Sulaiman et al., 2023). While WSNs are instrumental in data acquisition and communication, ensuring uninterrupted operation is imperative, especially in mission-critical applications where network failure can have detrimental consequences. Predictive maintenance, which encompasses strategies to predict and preemptively address potential network failures, emerges as a crucial endeavor to uphold network reliability and prevent unplanned downtimes (Kumar et al., 2019). Machine Learning (ML) has ushered in innovative approaches that can harness historical and real-time data to predict potential failures within WSNs, enabling timely interventions and mitigating adverse impacts (Smith and Gupta, 2020).

ML models, leveraging algorithms such as regression, classification, and clustering, can analyze patterns and anomalies in data, providing insights into the network's health and potential points of failure (Kim et al., 2019). This paper elucidates the integration of ML approaches into WSNs to facilitate predictive maintenance, ensuring network robustness and sustainability. A novel architecture is proposed, amalgamating ML models with WSNs to monitor, diagnose, and predict potential issues (Alsheikh et al., 2014; Patel et al., 2021), backed by an empirical analysis demonstrating the model's efficacy in enhancing network reliability through predictive maintenance (Wang et al., 2022; Wu et al., 2022). Additionally, recent advancements in deep learning, such as convolutional neural networks (CNNs) and edge computing, have shown promise in anomaly detection (Yang et al., 2018), offering further avenues for improving the reliability of WSNs. These developments underscore the growing importance of ML and deep learning techniques in WSNs, where predictive maintenance plays a pivotal role in maintaining network integrity and minimizing downtime (Sivapriya et al., 2023).