Chapter 15
A Cyber Physical System Framework for Industrial Predictive Maintenance Using Machine Learning

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ABSTRACT

The rampant developments in the field of predictive analytics, artificial intelligence, big data, along with information and communication technologies have opened new ventures in cyber physical systems (CPS). The wide range of opportunities presented by CPS facilitated massive transformation of industrial processes that converged to building smart systems under the umbrella of Industry 4.0. The manufacturing and energy sector are now shifting their focus on predictive maintenance to pre plan their maintenance activities to reduce the downtime at optimized costs. This proactive maintenance planning involves the integration of multiple technologies like big data analytics, machine learning, and internet of things to build a complete, comprehensive framework that predicts the onset of failure from the early warning signs. The primal focus of this work is to develop a generic CPS framework for predictive maintenance (PdM) in industries from the condition monitored data.

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A BRIEF OVERVIEW OF CONDITION MONITORING AND INDUSTRY 4.0

Condition Monitoring (CM) is the latest buzzword in the manufacturing sector. CM is defined as the uninterrupted process of monitoring a system, in the context of diagnosing a fault or failure. This process can be fractionated into a sequence of activities such as monitoring, detection of faults, diagnosing the cause of fault and fault prognostics. CM involves closely monitoring the critical parameters that can effectively characterize the health state of the system or equipment under study. Not all the parameters contribute to CM which is followed by fault detection. The domain experts have to delineate the critical variables or parameters whose deviated values can be a direct implication of the occurrence of faults.

CM is broadly bifurcated into reactive and proactive CM. The former diagnoses the causes of the fault after its occurrence while the latter strives to foresee the fault before its occurrence. It is very evident that the world is moving deeper into the era of Artificial Intelligence (AI) and its cognate technologies. The maintenance sector in industries also harness its benefits by embracing Machine Learning (ML), Big Data Analytics (BDA) and Deep Learning (DL) in CM and failure prediction of equipment. Fault prognostics is an integral part of smart manufacturing, which is the pivotal objective of Industry 4.0. Predicting the fault from the early signs offers many fold advantages to the industries:

- Demean the overall equipment maintenance time and downtime
- Accelerate the productivity rate
- Increase the working time
- Mitigate the maintenance costs
- Ensure safety

CM is an effective tool in fault prognostics, since it can avoid mitigating the frequency of unplanned maintenance activities. Predicting the failures has become an inevitable part of any smart infrastructure. The advent of technologies like Internet of Things (IoT), Cloud computing, Digital twins, Edge computing and Edge AI has accelerated the advancements in industries, facilitating the evolution of Industry 4.0.

Evolution of Industry 4.0

The smart transformation of the industries towards embedding intelligence and empowering the workers by using modern control systems is the primary motto of Industry 4.0. The conviction of Industry 4.0 is perceived to achieve the following traits:

Nature-Inspired Algorithms and Smart City Applications

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