ONTOLOGY BASED MACHINE LEARNING APPROACH FOR PREDICTIVE MAINTENANCE OF INDUSTRIAL ROBOTS

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Artificial Intelligence

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DECLARATION

I affirm that this thesis is solely my original work, and I have not included any material from any other University or Institute of higher learning without proper acknowledgment, nor have I included any previously published or written work by another person without appropriate attribution in the text. I hereby grant the University of Moratuwa the non-exclusive permission to reproduce and disseminate my thesis, either in print or digital format, in whole or in part. Furthermore, I reserve the right to incorporate this content, either wholly or partially, into my future works, such as books or articles.

05/05/2023

Signature: Date:

I hereby verify that the individual mentioned above conducted research for their Master's thesis under my guidance, and I confirm that the student's declaration is accurate and truthful.

Name of Supervisor:

Dr. Thushari Silva

Signature of the Supervisor: Date: 08/05/2023

ABSTRACT

In industrial environments, machine maintenance is crucial to ensure safe, continuous, and efficient operations. Regular maintenance helps prevent breakdowns, reduces downtime, and extends the lifespan of machinery. Maintenance tasks may include cleaning, lubrication, calibration, inspection, and other repairs. Overall, machine maintenance is essential to maintain productivity and safety in industrial environments. Currently, most of the development factories focus and practice Reactive maintenance and Preventive maintenance. Reactive maintenance allows machines to run into failures and then repair the machines. This results in unexpected downtime and brings negative impact especially on the production line. Preventive maintenance prevents issues before occurring by doing maintenance tasks based on a predefined schedule. But preventive maintenance can increase the cost by inappropriate maintenance and equipment replacements. Both Reactive and Preventive maintenance can be replaced by Predictive maintenance with the support of AI, from which the production and maintenance cost can be minimized and in return can obtain a higher profit margin for the industries as in Predictive Maintenance it uses continuous monitoring and predict faults for the maintenance approach for the machines. The study discussed in this thesis is concentrated on enhancing industrial robot predictive maintenance using better decision support that is based on a greater variety of input data from the IoT devices. IoT devices can be used to gather data about machines as these devices are often equipped with sensors that can collect data on various aspects of machine performance, including temperature, pressure, vibration, and energy consumption. The main objective of this approach is to detect any patterns in the health of a robot and with the use of prediction algorithms to predict any future occurrence of failures and classify the failure then recommend maintenance tasks accordingly. A hybrid industrial machine maintenance solution is developed for the industrial environment with ML-based fault prediction and Ontology-based maintenance task recommendation system. The data/event consumer will be used to collect the data produced by the IoT sensors on machines and this will be the input for the solution. The captured data will then be driven through a process of data cleaning and transformation, as then will be fed to a ML- Model. The developed ML model will find anomalies and patterns in the data that can aid in failure prediction in the future. The created ontology model will make maintenance recommendations based on these predicted failures. Among many possible methods and approaches such as ML, DL, and Knowledge based approaches this research is focused on ML based approach to predict machine failures and integrated with Ontology based approach for maintenance task recommendation. The Fault Prediction and recommend maintenance tasks will help to enhance the Maintenance Strategy Optimization, which in return will reduce the maintenance cost as well as any drawbacks of reactive or preventive maintenance.

Keywords: Ontology, ML, reactive maintenance, preventive maintenance, predictive maintenance

DEDICATION

It is my pleasure to dedicate this thesis to the cherished individuals in my life, including my mentor Dr. Thushari Silva and my beloved parents, husband, teachers, lecturers, and supportive colleagues who have offered their unwavering guidance and assistance throughout my personal and academic journey.

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LIST OF ABBREVIATIONS

Abbreviation	Description
OPdM	OntoPredictive Maintenance
AI	Artificial Intelligence
ML	Machine Learning
IoT	Internet of Things
FP	Fault Prediction
MSO	Maintenance Strategy Optimization
SMOTE	Synthetic Minority Over-sampling Technique