IOT BASED CONDITION MONITORING OF ROTATING MACHINERY AND PREDICTIVE MAINTENANCE

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DECLARATION

I declare that this project entitled "IoT Based Condition Monitoring of Rotating Machinery and Predictive Maintenance" is the result of my own research except as cited in the references. Therefore, the Choose item has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours.

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DEDICATION

The research is entirely dedicated to my beloved family, which have inspired me and given me strength when I am exhausted and on the verge of surrendering. In addition, they continue to provide various support in terms of spiritual, moral ,emotional, and financial support.

My appreciated supervisor and panel examiner have advised and encouraged me to complete this study. Additionally, all UTeM lecturers gave me the strength and faith to conquer all obstacles.

Finally, I would like to dedicate this book to the Almighty God for guidance, strength, mental power, protection, inspiration, and long and healthy life.

ABSTRACT

OEE is Overall Equipment Effectiveness, a hierarchy that measures the performance of a machine for enhanced productivity. The evolution of industry 4.0 is providing immense possibilities to monitor factory equipment like never before. OEE is a powerful tool that helps perform diagnostics as well as manages the production units in different industries. Internet of Things (IoT) technology is helping manufacturing agencies to improve their OEE evaluation with a detailed understanding of equipment performance through instrumentation and analytics. Therefore, the current project proposes an IoT platform for real-time monitoring of factory equipment, such as rotating machinery. The accelerometer sensor inside an Android-based smartphone collects vibration data from rotating machinery. The data is then published to the public MQTT broker via the smartphone's developed application. The application was created with MIT App Inventor, an open-source developer tool. The published data is then subscribed to through Node-RED and visualised in a series of dashboards. A real-time state of the rotating machinery is realised using the proposed system. Furthermore, the time domain data are transformed into the frequency domain in order to validate the collected data from the developed application. The frequencies from the machine are compared to those calculated from the frequency domain using the Fast Fourier Transform (FFT) method. The results showed that both frequencies were in good agreement, proving that the developed application was capable of sensing the correct data. The current project also includes the development of an early warning system as part of a predictive maintenance framework. The system is built with Node-RED as an IoT platform to notify the user of the machine's status via email. The results demonstrated that the developed early warning system could notify the user when the trigger condition is met. Finally, when combined with predictive maintenance, IoT technology has the potential to detect equipment failures in advance. With the introduction of Industry 4.0 in the manufacturing sector, facilities are eager to use IoT technology to gain better insights into operations.

ABSTRAK

OEE ialah Keberkesanan Peralatan Keseluruhan, hierarki yang mengukur prestasi mesin untuk produktiviti yang dipertingkatkan. Evolusi industri 4.0 menyediakan kemungkinan besar untuk memantau peralatan kilang tidak seperti sebelum ini. OEE ialah alat berkuasa yang membantu melaksanakan diagnostik serta mengurus unit pengeluaran dalam industri yang berbeza. Teknologi Internet of Things (IoT) membantu agensi pembuatan mempertingkatkan penilaian OEE mereka dengan pemahaman terperinci tentang prestasi peralatan melalui instrumentasi dan analitik. Oleh itu, projek semasa mencadangkan platform IoT untuk pemantauan masa nyata peralatan kilang, seperti mesin berputar. Sensor pecutan di dalam telefon pintar berasaskan Android mengumpul data getaran daripada mesin berputar. Data tersebut kemudiannya diterbitkan kepada broker MQTT awam melalui aplikasi yang dibangunkan telefon pintar itu. Aplikasi ini dicipta dengan MIT App Inventor, alat pembangun sumber terbuka. Data yang diterbitkan kemudiannya dilanggan melalui Node-RED dan digambarkan dalam satu siri papan pemuka. Keadaan masa nyata jentera berputar direalisasikan menggunakan sistem yang dicadangkan. Tambahan pula, data domain masa diubah menjadi domain frekuensi untuk mengesahkan data yang dikumpul daripada aplikasi yang dibangunkan. Frekuensi dari mesin dibandingkan dengan yang dikira dari domain frekuensi menggunakan kaedah Fast Fourier Transform (FFT). Keputusan menunjukkan bahawa kedua-dua frekuensi adalah dalam persetujuan yang baik, membuktikan bahawa aplikasi yang dibangunkan mampu mengesan data yang betul. Projek semasa juga termasuk pembangunan sistem amaran awal sebagai sebahagian daripada rangka kerja penyelenggaraan ramalan. Sistem ini dibina dengan Node-RED sebagai platform IoT untuk memberitahu pengguna status mesin melalui e-mel. Keputusan menunjukkan bahawa sistem amaran awal yang dibangunkan boleh memberitahu pengguna apabila syarat pencetus dipenuhi. Akhir sekali, apabila digabungkan dengan penyelenggaraan ramalan, teknologi IoT berpotensi untuk mengesan kegagalan peralatan terlebih dahulu. Dengan pengenalan Industri 4.0 dalam sektor pembuatan, kemudahan tidak sabar-sabar untuk menggunakan teknologi IoT untuk mendapatkan pandangan yang lebih baik tentang operasi.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT	-	Internet of Things
MIT	-	Massachusetts Institute of Technology
App	-	Application
PdM	-	Predictive Maintenance
MQTT	-	Message Queuing Telemetry Trasport
Wi-Fi	-	Wireless Fidelity
RxM	-	Prescriptive maintainance
SOP	-	Standard Operating Procedure

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CHAPTER 1

INTRODUCTION

1.1 Research Background and Motivation

The advent regarding Industry 4.0 offers medium and small-sized enterprises (SMEs) an opportunity for improved production processes. Considering that such businesses have restricted investment ability, innovations such as algorithms based on artificial intelligence, the Internet of Things (IoT), and cloud computing, which are typical for industry 4.0, will benefit from their low-cost features (Dias et al., 2021). However, there are still challenges to research, counting also about central background of Industries 4.0, such as interoperability, modularity, distributed data processing in large quantities generated by these disparate devices, and their interaction with other industrial processing systems (Souza et al., 2021).

The management model of the Internet of Things (IoT) is the management process and a scientific management model that effectively connects perception and communication. Next, the successful integration of the cloud and application fosters technical innovation, managerial innovation, and system innovation (Wu & Xiao, 2021). The emergence of connected devices and instrumented settings, together with existing data analysis and cognition capabilities, created the circumstances for the Internet of Things to be consolidated (da Silva et al., 2016). Linking "things" on the Internet has become commonplace since the Internet's inception in 1989. The Trojan Room coffee pot is most likely the first of its kind. (Gupta et al., 2010). John Romkey invented the very first Internet in 1990, coining the term 'the computer,' a toaster that can be turned on and off over the Internet.

Meanwhile, in 1994, Steve Mann discovered WearCam, and It worked almost in real-time on a 64-bit processor machine. Moving on, Paul Saffo gave the first summary of the sensors and their potential course of action in 1997. Moving next, Kevin Ashton, who positioned as an executive director at Auto-ID centre of MIT, developed the term "Internet of Things" in 1999. They also developed a global RFID-based object detection program in the same year (Ashton, 2009). such as significant growth in promoting the Internet of Things; they announced in 2000 that they would make an 'intelligent' refrigerator that checks if the food in it is running low on shelf life, replenishing itself, and informs you (Dvali & Belonin, 2009).

The internet of things is the collaborative network of physical devices with APIs which can write programs capable of sensing, connecting, and navigating to a chosen internet domain. Such objects are embedded in electronics (microcontrollers and transceivers), applications, cameras, actuators, and network connections to encapsulate data for specific protocols (Atzori et al., 2010). Thus, IoT connects with others in new ways to computers, systems, and facilities beyond Machine-to-Machine (M2M) communication, and it has a broad application in numerous fields. (N. Sharma et al., 2019).

The Internet of Things (IoT) is a central pillar that is a fundamental component of Predictive Maintenance or, in short, PdM (Kwon et al., 2016). It allows machine behaviour to be transformed from computers into digital signals, which PdM then uses. The IoT technology can continuously stream numerous sensor data such as temperature, Vibration, and many more. This is for real-time monitoring purposes and from other outlets, such as the Programmable Logic Controller (PLC), the Computerized Maintenance Management System (MES) terminals, possibly also an ERP (Enterprise Resource Management System). Such understanding constitutes the base for determining approaches to PdM (Compare et al., 2019).

Currently, for actuators, sensors, and appropriate data systems, alongside developed devices' performance conditions, can monitor the installation and remote control of automated industrial systems. Besides that, due to the possibility of numerous sensors generating big data. This scenario has the potential to generate massive volumes of data throughout operation (Manyika et al.,2011). Next, models, analytic can test the related data, optimise industrial procedures of operation, and stretch the observed machines' life period. All of these are the primary objectives and explain why the industrial revolution wave is gaining momentum (da Silva et al., 2016).

IoT products have become viral and have numerous demands. Most people prefer to use them because it is easy to use intelligent IoT products in home appliances such as light, fans, air conditioning, and even certain kitchen appliances like coffee machines (Gubbi et al., 2013). There are issues in handling the collection of IoT devices in a home environment. For instance, the machines may be in several places in a house, and there may not be a way to handle all the appliances in one home. Moreover, there is no way to determine whether a particular sensor or another IoT device module is about to get corrupted or permanently damaged. It is an effort to incorporate an architecture at the system level that uses the computational capacity of the Machine Learning algorithms to predict a compromised sensor or module and, besides, will be able to notify the user of the issue in such a manner that the user can easily avoid it from happening, saving not only money or other devices from affected, but also users themselves from possible physical harm when a machine malfunction.

Though it is easy to think that devices can be substituted out if they get permanently damaged, there is more to this issue. The challenges can range from IoT devices permanently damaged to inflicting severe damage on other devices that data may be transmitted to perform tasks. Besides that, it may inflict life-threatening harm to home environment customers when the system is tightly linked to handling users' everyday lives. Furthermore, the challenges do not just result in business collapse, and they could end up physically destroying them (Adikari, 2017).

Rotating machines are widely utilised in the industry (from minor to significant businesses) and are often driven by electric motors. Moreover, continuous track related to these machines is crucial so that unforeseen output stops due to malfunctions or failures are able to hinder. An intelligent faulty diagnostic system is therefore used for identifying and recognising anomalies all the while computer activity. These are known as condition monitoring systems, and they are capable of detecting mistakes or deteriorating processes in advance of a functional failure (Vanraj et al., 2016). Manufacturing processes are fundamental to industry, and among the several types of equipment, one that is ubiquitous are electrical's motors. The circumstance simply explains that electrical power consumption is attributed to either motors or engines by 40 per cent. This was accounting for the electrical power consumed by the industry for two over three of total consumed (Saidur, 2010). Although the proposed infrastructure is sufficiently versatile to be used in many industrial scenarios, however, in a demonstration system to follow the operation of the sensor and the actuator controlled system in the context of exhaust monitoring and feedback management cloud platform for an industrial electric motor (da Silva et al., 2016)

Predictive Maintenance or known as PdM, is a technique for monitoring machinery status to avoid costly failure and also to execute Maintenance only when essential. PdM has evolved from the earliest methodology that is a visual inspection, to automated systems utilising modern techniques, that is, signal processing. Historically, for Maintenance has created a trade-off situation in where it is an option between maximising a part's useful life at the expense of machine downtime, referred to as run to failure, and maximising uptime by replacement of potentially good parts earlier, referred to as time-based PdM, which has