IoT-based Machinery Failure Predictive Solution Using Machine Sound Data

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ABSTRACT-

My dissertation is intended to introduce an IoT-based model for real-time condition monitoring of electrical machines, which addresses the challenges of data storage and scalability. The main objective is to correctly classify the acquired machine sound signal into the corresponding machine conditions to be faulty and normal, which is a common multi-class classification problem. This dissertation develops an IoT-based failure prediction solution to reduce maintenance costs. Our proposal allows for highly accurate failure estimates that lead to effective action when it is actually needed. Estimated maintenance is proposed as a measure for the actual maintenance of the machine and hence proper maintenance is done at the right time. This test surveys the different techniques used to classify machine sound data. The aim of the centre is to effectively compare the sound sign of the obtained machine to the conditions of the machine, for example defective and normal, which is usually a multi-category order problem. We conducted a demonstration of the proposed analysis scheme and the system design consisting on recording the sound data of a DC-motor for about 23 minutes with the variation of speed to mimic some failure scenarios. We obtained results that confirmed the effectiveness of our solution in differentiating between the failures signs with no prior learning of the failures and in tracking the slight drift in the machine behaviour. We were able to start predicting failures since day 1. The proposed system design permitted us to limit the payload of data packets which would reduce the cost of the sensor-node data transmission, the power consumption in the sensor node as well as the network traffic.

Keywords - Machine tools condition analysis, Machine learning, IoT, Sound data.

I. Introduction

Machine condition monitoring refers to the process of tracking a machine's status in order to monitor mechanic al wear and failure. Sound and temperature measurements from vibration machines are frequently used as key i ndicators of the machine's state. With the advancement of science, technology, and the economy, the modern in dustrial production process is becoming increasingly large, continuous, and integrated. The performance require ments of equipment are stringent in order to meet these characteristics. An unexpected breakdown of key equip ment not only damages the equipment but may also result in additional economic losses due to the impact on th e entire production process. As a result, businesses place a high value on equipment maintenance, investing a significant amount of manpower, material resources, and money in this area. Unfortunately, ineffective maintenance wastes a lot of money in this field. Companies' priorities equipment maintenance for this purpose and this section includes a significant amount of infrastructure, material resources, and capital. Unfortunately, ineffective maintenance wastes a significant amount of investment in this field.

Since the first machine was developed by mankind, flaws have been an unavoidable conflict. A failure might have disastrous consequences in terms of both safety and expense. As a result, plants and factories are constantly looking for new maintenance solutions to maintain both operator safety and a continuous production line. There have been three important developments in the history of maintenance. The Runto-Failure approach, also known as reactive maintenance and corrective maintenance, is the oldest maintenance strategy. It is based on the basic principle of not performing maintenance until the machine fails. This method has significant disadvantages in terms of productivity and safety. As a result, preventative maintenance, also known as planned maintenance, was implemented as a new scheme in the industry1950s [1].

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The basic methodology used in many industries, which faces issues such as data storage limitations and, in particular, scalability when monitoring several devices in different locations. The most widely used predictive maintenance technology is Condition-Based Monitoring (CBM). Data acquisition (obtaining and preserving machine health data), data processing (preparation of collected data and feature extraction), and decision making are the three primary components of CBM (recommendation of maintenance actions if necessary). As a result, predictive maintenance has been presented as a remedy to the limitations listed above. This system is based on actual machine monitoring and hence results in the proper maintenance at the appropriate time [2].

The goal of plant maintenance is always to improve uptime and productivity through better preventive or predictable maintenance and diagnostic status tracking, so targeted objectives can be met with increased revenue. This is a standard approach implemented in many industry sectors, but faces some issues such as extremely limited data storage space and especially scalability when multiple machines are operated in different locations [3].

Industrial Internet of Things or IIoT, uses the Internet of Things platform to improve industrial operations and sectors. IIoT is a network of communication-based tools that design a framework that records, collects, exchanges and analyzes data and offers useful insights that enable industrial companies to make quick business decisions. Intelligent resources, i.e. sensors, automatically relay information over a data transmission network, where, for example, a particular piece of machinery is translated into reliable information about how it operates. This data can be used for predictive management and design of business process applications [3] [4] [5].

II. LITERATURE REVIEW & RELATED WORK

In recent years, machine learning ML has become a popular part of research. Some work has been done in this area of machine situation based prediction and monitoring. The most relevant published papers analyzed are listed below:

In [1], Yanyu Zhang et al. proposed Online and Remote Machine Condition Monitoring and Fault Diagnosis System Using Wireless Sensor Networks that tracks the status of engines with vibration transmitters, transmits include information by means of WIA-PA arrange, and permits visualizations through the specific master program. Advanced remote control of PC condition and gadget for flaw conclusion utilizing remote sensors.

In [2], D. Ganga et al. proposed an IoT ongoing checking of the condition of electrical machines concentrated on vibration examination by utilizing gateway IoT2040.

In [3], Sana Talmoudi et al. proposed IoT-based failure prediction application for system monitoring using the toorPIA Big Data Engine sensor node used to evaluate the prediction of system failure.

In [4], Yasser Alsouda et al. proposed IoT-based Urban Noise Detection Using Machine Learning: Efficiency of SVM, KNN, Bagging, and Random Forest In which machine learning technique is used for urban noise detection, for audio feature extraction MFCC and supervised learning algorithm is used. To accomplish this the authors used low-power and resource-constrained hardware device Raspberry Pi Zero W.

In [6], H. M. Hashemian et al. discussed the State-of-the-Art Predictive Maintenance Techniques, In which time-based machinery maintenance approaches and predictive monitoring techniques use the latest sensor technology to prevent excessive failure in machine tools, time and expense are also saved.

In [7], M. Pan et al. proposed Remote online computer control system in which TCP / IP internet communication interface is used and BCB programming language is used for application coding. The module is trained using ANN backpropagation algorithm.

In [8], W. Wang et al. proposed a Smart Sensing Unit for vibration measurement and machinery condition monitoring, a new signal processing method, wavelet energy spectrum, for bearing fault detection and t he max-envelop method and one-scale WT technique is used for feature extraction.

In [9], Z. Zhanf et al. proposed Fault diagnosis and prognosis using wavelet packet decomposition for decomposing the vibration signal, for transforming that signal in frequency domain using Fourier transformation and From the frequency-domain data, they extracted the features to train an ANN.

In [10], S. S. Goundar et al. Designed a wireless monitoring system for industrial motors using vibration and temperature sensors, vibration data converted into frequency domain using FFT and this real time monitoring is done by using IoT.

In [11], D. Jung et al. proposed the algorithm estimates the Remaining Useful Time (RUL) by considering the threshold of difference and projecting the features of the equipment over space to verify whether the projection reaches this threshold. RANSAC's key principle is to shape various basic predictions from a data set, and classify that assumption with the most helpful measurements.

The target application of the proposed solution is mainly the monitoring of machines in plants and factories as well as facilities. Therefore, most of the target machines to be monitored are electromechanical systems where vibration and sound monitoring have been proved efficient for the last decades. Literature is highly rich in CBM applications using accelerometers and microphones as data source. In this section we will highlight some IoT solutions where a vibration sensor and/or a microphone are the core of a sensor-node.

III. PROPOSED WORK

- **BACKGROUND**

It provides an overview of relevant background studies on structural design, providing an overview of machine learning and information regarding the hardware platforms used.

In the past decades, various effective monitoring techniques have been developed for machine monitoring and diagnosis; such as; vibration monitoring, visual inspection, thermal monitoring and electrical monitoring. These techniques mainly focused on how to extract the pertinent signals or features from the equipment health information. However, the related yet more important problems are methods to analyze this information. Various traditional methods have been used to process and analyze this information. These techniques include conventional computation methods, such as simple threshold methods, system identification and statistical methods. The main shortcoming of these techniques is that they require a skilled specialist to make the diagnosis

Machine learning is closely related to computational statistics, which also focuses on divination. Now, machine learning is widely used in machine environmental monitoring and maintenance.

In the machine learning community, these sound properties are considered features. Many features are often determined to generate a set of features. Depending on the number of features in the set, feature selection algorithms can further filter the set.

MFCCs, i.e., mail-frequency cepstrum coefficients and time domain characteristics are derived from a training data set of sound samples to train models using machine learning algorithms (i.e. SVM, KNN, random forest) which are used to predict what type. Sensational environmental sound. Extraction of features is the first step of an automated sound classification system. MFCCs are a well-known group of features that are commonly used for speech explanations because they relate to what the user hears.

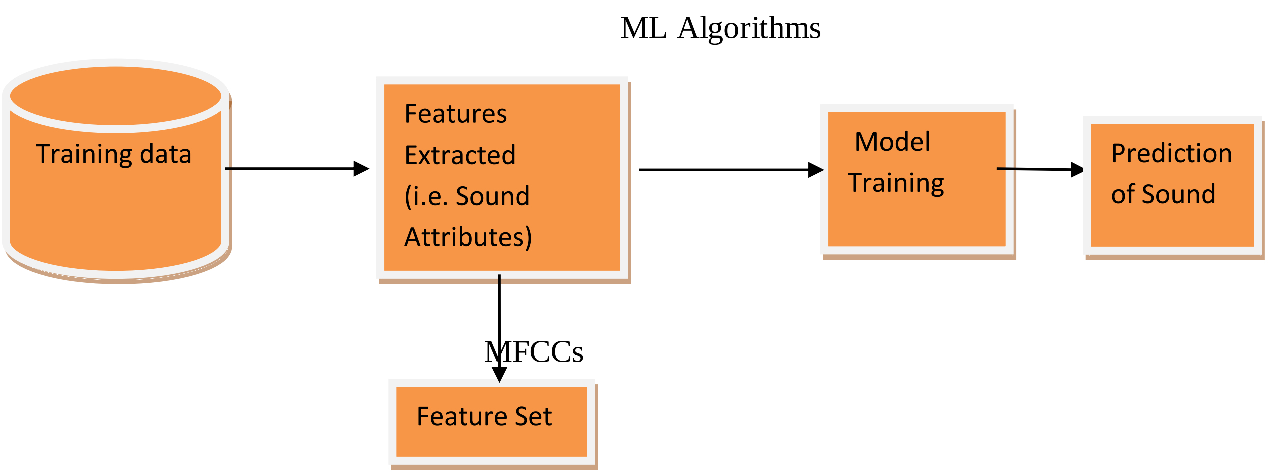
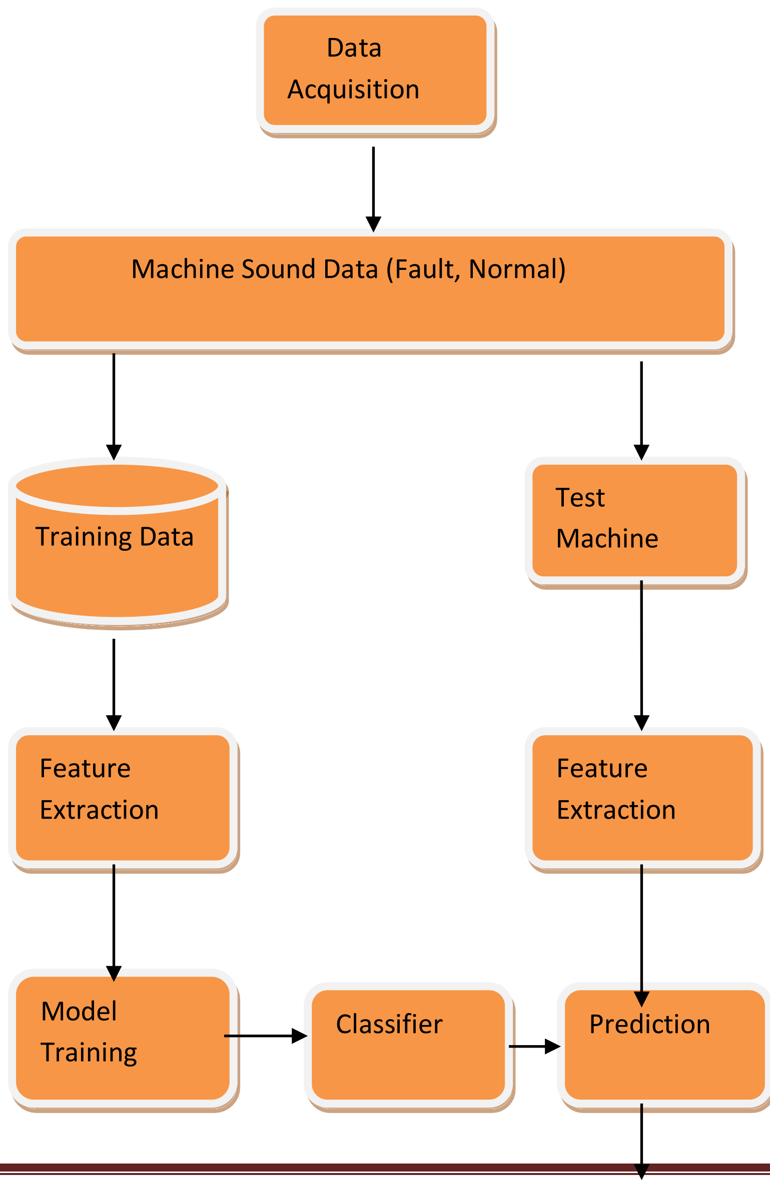


Figure 1: Approach for machine sound identification using machine learning

- **METHODOLOGY**

The core purpose is to classify the acquired machine sound signal into the related machine environment correctly i.e. faulty and normal, which is generally a multi-class categorization problem. A classic set-up of the overall framework for this problem is depicted in Figure.

The sampled vibration signal is a large collection of time indexed data point. First acquisition of Machine sound data will be taken for various machine working conditions and its data with its respective labels will be stored and then further used for training and testing purpose of intelligent learning model.



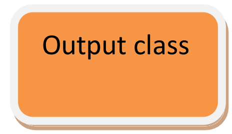


Fig 2: Flow chart for classification

Generally 70-30 percentage ratio used for learning and testing of machine sound data. To make sensible deduction automatically using a intelligent learning based classifier is not an easy task owing to the curse of dimensionality. Instead of processing the raw signals, the common approach is to compute certain attributes of the raw signal that can describe the signal in essence. In the machine learning community, these attributes are referred to as features. At times, multiple features are computed to form a feature sets.Depending on the number of features in the set, one may need to perform further filtering of the set usinga feature selection algorithm.

- **OBJECTIVES**

1. To develop machine learning to analyze machine tools condition and failure prediction.
2. To maintain the optimum productive efficiency of the plant equipment and machinery.
3. To reduce the cost of maintenance study the various learning sounds and develop algorithm.
4. To maintain the operational accuracy of the equipment.

IV. CONCLUSION

This study analyzes the sound data of the machine and reviews the various techniques used to classify the condition of the machine. The more desirable condition is that we can anticipate the breakdown of the machine and start maintenance before the breakdown, so that the machine can still operate in safe condition and perform satisfactory operation. For machine sound classification, various classification techniques are designed and proposed. Machine learning technique is the most widely used technique for sound classification, the accuracy of all algorithms varies according to their parameters. In the present work, we applied our proposed failurepredictive scheme on a sound data of valve. However, our proposal can be applied to other types of IoT data such as vibration, flow fluctuation, electric current, temperature, etc...

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