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IoT Based Tools for Data Acquisition in Electrical Machines and Robotics

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Abstract—Internet of Things (IoT) has seen rapid growth along with the recent advancement in information and communication area. With the introduction of new technologies, it has become easier to interact with machines and communicate with them. IoT cannot only be used to communicate and control these machines but it can be used further in diagnostics related to the detection or prediction of faults. As the infrastructure is advancing at a rapid speed, it has also become a need of the hour to update the way diagnostics and maintenance are carried out over them, to not only save cost but also time. This paper is a work in progress, where these opportunities will be explored in the context of IoT industrial applications.

Keywords— *Internet of Things, Data Acquisition, Condition Monitoring.*

I. INTRODUCTION

Internet of Things (IoT) is the communication of different intelligent devices over the internet. The advancement in technology has not only made our life easier but has also paved new ways to be more efficient. The data from devices can be used to predict results but can also be used to diagnose the machine and predict faults [1], [2]. Hence, cutting time on the maintenance of a single machine but also making it cost-efficient to remove unnecessary maintenance checks. IoT has a lot of applications in the industrial area including predictive maintenance of industrial equipment [3].

As manufacturing has been advancing, IoT applications related to industrial development and monitoring have been increasing rapidly too. The inclusion of data collection from machines to monitor them [4], [5] and run predictive analytics for maintenance [6] is becoming a norm in the industrial field. Due to the advancement in this field, maintenance has been divided into several stages as described in Fig. 1. Usually, predictive maintenance is used, as it is not only cost-efficient but also saves time, as it gives a detailed report on the diagnostics of the fault.

Machine learning algorithms are used to train models for predictive analysis. The accuracy of any such model highly depends on the data set used for training. These models can be used for prediction of faults based on previous patterns, but they require a high number of data sets for accurate or near accurate predictions. Deep learning algorithms and pattern recognition algorithms also come in the subdomain of machine learning and are commonly known as Artificial

Fig. 1. Maintenance stages of electrical machines.

Neural Networks (ANN), which is inspired by the working of a human brain [7]. As these trained models need high processing power and storage, they are mostly integrated with cloud computing [8], [9].

This paper presents an overview of the methodology used for collecting data at high frequency and syncing it with the cloud without data loss. The paper further explains the prospects of the research and in what direction it is heading.

II. RELATED WORK

The main architecture that is considered in the power of IoT related to a smart grid is mainly applied to the overall transmission of power, perception of grid and fault diagnostics architecture. The hierarchical structure is similar to that of a traditional IoT system including the network, transmission, perception and application layer [10]. The general overview of the architecture is shown in Fig. 2.

Fig. 2. Architecture for power Internet of Things

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Nowadays, as the requirements for human resources are increasing with the growth in population, the need for energy resources is also escalating, whereas the conventional resources are decreasing with time. Hence, there is an urgency to look for alternative energy sources and researches is being done in different fields to find feasible energy sources. Among these researches for alternative energy, wind energy is rising as one of the preferred possibilities. Wind energy is being widely used because of its advantages, like no greenhouse effect, nonpolluting, availability, no gas emission, etc. [11]. Wind turbines are being used to convert wind energy into a useful form of electrical energy but to get the maximum out of this system, this process should be monitored and controlled [12], [13].

Most of the time, wind turbines are in complex topography with limited access and a difficult way of communication. Therefore, much work has been done in controlling and monitoring the wind turbines remotely and sending the maintenance staff only when it is necessary. Monitoring the condition of the wind turbines at regular intervals is applied universally and is necessary to reduce the downtime of the turbines and get the maximum out of them [14]. Examples of work done, related to wind energy, utilizing wireless technologies are given in [15], [16]. Some researchers have also tried to deploy wind turbines on the roofs of buildings, but the turbines deployed cannot be bigger in size and their productivity is lacking with respect to cost [17], [18].

With time, more and more offshore wind turbines are being erected, hence, giving in space for an urgent need for predictive, proactive and commercial maintenance. Major problems faced due to these wind turbines are in maintenance and the downtime due to faults in bearings, gearboxes or other electromechanical components. These can be overcome by installing sensors [19] and continuous monitoring of the wind turbine. The fault rate of a wind turbine is high, which also results in a cost for maintenance of these wind turbines as offshore maintenance teams must be deployed after a specific number of days to check for faults, which also emphasizes the need for reliable fault detection and monitoring system for wind turbines [20].

With the current advancement in technology more complex systems are also being used in robotics [21], [22] and autonomous vehicles[23]. The current systems used for data acquisition in robotics are still developing and changing over time due to the increase in the number of sensors and safety circuits[24]. The need to process these readings in real-time has also increased the need for higher sampling frequency. More research is being done in this regard taking into account different environmental effects too[25]–[28].

Some of these monitoring systems have already been developed in SCADA but these systems are very expensive and require more space and complex installation [29]. There are some methods based on IoT [30], [31] but their sample rate for collection of data is not only low but they are also solely focused on the purpose of collection rather than premature detection of faults and monitoring of turbines. Wind energy monitoring based on IoT should have strong reliability, accessibility, profitability and flexibility. It should include the main aspects of real-time monitoring of wind turbines, real-time collection of data from sensors, premature fault detection based on patterns generated from data collection, prediction of wind generation and other predictive analysis. Therefore, in this paper, we are presenting research that is a work in progress covering all the basics mentioned above.

III. METHODOLOGY

In this research topic, a method will be implemented to connect electrical machines over the cloud, thus forming a communicative IoT system. Apart from the implementation of the IoT system, cloud computing will also be utilized to run different machine learning and pattern recognition algorithms to predict and detect faults in electrical machines. One of the aims of this research area will be to switch electrical machines over to predictive maintenance from scheduled maintenance to make maintenance more time and cost-efficient for offshore electrical machines. One of the other tasks will be monitoring the incoming data and removing any noise if present. An industrial example for such type of IoT system is represented in Fig. 3.

Fig. 3. Wind Turbine IoT Industrial implementation

Fig. 4. Experimental setup for data gathering from wind turbine

Our research focuses on not only collecting data in real-time for monitoring of the wind turbines but also a prediction of the faults beforehand so that they do not propagate into a major fault. This will also help to reduce the time taken by the maintenance team on offshore turbines and help them identify the fault beforehand. The research can be divided into two parts with first being considered as a prerequisite for machine learning and predictive analysis, and the second being predictive analysis and fault diagnostics. For our first part, we have set up an in-house test bench for the collection of data sets using wind turbines and wind tunnel. The running example of this setup is shown in Fig. 4. Also, we are developing our own setup for collecting data from sensors, which will be set up inside the wind turbines to detect different parameters like vibration, wind speed, temperature, voltage, etc. We are collecting data at high frequency to collect more information for the dataset, hence, we will be able to identify even a slight fluctuation and can predict the faults beforehand, which will not only decrease the overhead caused by major fault occurring later but also will reduce the downtime for the wind turbine.

The setup used for collecting data comprises of two-part with our sensors being attached to a Teensy card that can also act as an analog to digital converter and forwards the data in digital form to Raspberry Pi, which will not only act as a hub for different sensors but will also keep a local database as a

backup to the cloud. The setup we will use for the collection of data from wind turbines is not only cost-effective as compared with other equipment but also does not take much space. Fig. 5 shows the setup of Raspberry Pi with an IoT card for the collection of data from a wind turbine. This setup can be used with any sensor for the collection of data and can be placed with any electrical machine for monitoring.

Raspberry Pi with the card and sensor is used for gathering data from the experimental setup and the values gathered at

Fig. 5. Experimental setup of the card for gathering data

Fig. 6. Flow chart for data acquisition from a windmill to cloud

high frequency were accurate in accordance with the values gather through the Dewetron data acquisition device. Furthermore, the values recorded were also pushed into the database at high frequency without any loss of data. The sampling frequency attained until now by our setup is approximately ~3400 samples per second from recording to inserting it in the database in real-time, shown in Table I. The flow chart of the whole setup is shown in Fig. 6. The aim of our setup is also to explore different ways of communication between machines and to see, which one of the current methods is the most feasible and fastest way to transfer data without any loss. This is the first part of the research that we are currently working on, whereas for the second part we will be doing predictive analysis along with different machine learning and pattern recognition techniques to detect faults at a premature level. This step will be further worked on once we have enough data to train models and do predictions accurately.

TABLE I. SAMPLE RATE FOR DIFFERENT TYPES OF COMMUNICATION METHODS

Communication Method	Sample Rate / sec
UART	1800
SPI Interface	3600

TABLE II. PROCESSING TIME FOR DIFFERENT IOT CARDS PER 10,000 SAMPLES

Card	Processing time for 10,000 samples in seconds
Arduino Mega	4.5 sec
Teensy 4.0	0.75 seconds

Table II shows the time taken in the case for the processing of 10,000 samples for different cards. The processing time includes data acquisition from the sensors, processing of incoming data inside the card and then transmission of data to Raspberry Pi using either UART or SPI Interface communication.

IV. CONCLUSION

IoT devices and cloud computing are becoming more and more popular now a day as it gives the monitoring team more control over the electrical machine. This research aims to not only monitor offshore electrical machines but also to cut off extra expenses and save time from unnecessary scheduled maintenances. It will also help later to predict faults using incoming signals and diagnosis to pinpoint the necessary reasons for the generation of fault, which will further save time on maintenance and removal of that fault. We will be researching and implementing such an IoT system for offshore wind turbines. We already have different points for data generation, including the availability to monitor a real-life 3 MW wind turbine. Also, we have access to the TalTech satellite ground control tracking antenna in addition to the in-lab setup.

One of our future research aims is to extract data at 10000 samples per second in real-time on the cloud so that we can have enough data to not only train our models efficiently but also to determine even a slight fluctuation in values. The sampling frequency of 10,000 is taken as reference, for now, considering multiple sensors acquiring data at the same time, with further testing this value will be optimized. This will also help us to predict more accurate values in terms of power generation and maintenance due dates. This will further help our research aim to reduce the cost and time taken for offshore maintenance and will help detect the faults remotely.

This research can be further enhanced for monitoring the wind turbines remotely and predict whether a minor fault can give way to a major one, later on, this will also help to send

out maintenance teams when needed and not periodically even where there is no need.

This research can also be applied in the field of robotics as there are several sensors implemented in its circuit and there is a high frequency for data acquisition in real-time. This setup can be used to acquire data and process it in real-time to predict movements and to keep remote maintenance of sensors and circuits. This can also be further enhanced to control the working of a robot remotely.

The technology developed is independent of any specific data generation point or hardware so it can be further adapted in other fields of research in electric transportation, vehicles, medical equipment, robotics, etc., and is open for future research.

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