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Industrial Automation of Process for Transformer Monitoring System Using IoT Analytics

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ABSTRACT

Multiple devices interconnected with each other via the internet is the key concept behind IoT. It allows autonomous devices with the possibility to use the internet for communication and exchange of data. This paper focuses on monitoring of the transformer in real-time, fault detection and records distinct operating parameters of the transformer like voltage imbalance, load current, transformer oil levels. Based on these parameters, the transformers fail state and healthcare predicted by making use of an Artificial Neural Network (ANN) Algorithm. Use of this technology can minimize working efforts thereby improving accuracy, stability, efficiency. Thus remote monitoring and machine control are achieved, as well as ANNs helps to determine the performance and yield appropriate measures accordingly. In this case, sensors are used to sense the important parameters of equipment such as current, voltage oil level in any operating transformer. By analyzing relevant data using ANNs, this system will be beneficial in many industries. Likewise, this system is generalized to be used in a wide array of industrial automated machines.

Keywords- Real-time monitoring, Artificial Neural networks, prediction, communication module.

1. INTRODUCTION

In our daily life, electricity has become very essential and life without electricity is hard to imagine. Similarly, electricity is also very crucial for different industries; an industry comprises a variety of different machines and appliances which need a constant supply of electricity for their smooth functioning. These machines are also responsible for effective production and manufacturing services which determine the growth of any industry. Malfunctioning of these machines due to voltage instabilities and currency fluctuations will lead to losses on large scale also due to the heavy current applications of the industry; the workers working on the field can be subjected to dangerous shocks.

In order to avoid any damage to the machine as well as glitches like voltage and current distortions can be resolved and fixed with the help of a transformer. A custom current transformer constantly measures the electric current and even if the current level exceeds due to electric fluctuations, the transformer automatically eliminates excess current flow, thereby reducing the damage to a bare minimum. In other words, Transformers are designed to use electromagnetic induction to modify an alternating current voltage that runs from one electric circuit to another. Transformers do not need any moving parts, which mean that they do not require comprehensive attention unlike other types of equipment. However, undergoing maintenance check regularly is still important for a transformer as it is critical to the functioning and life of this equipment. Proper care and maintenance of the transformer are often neglected largely due to its reliability leading to a cutback in the life span of the transformer, which will eventually result in downturn and loss. Keeping this in mind, perception, veracity, and analysis of data is important, which is obtained by monitoring of the transformers. To improve the transformers functioning and reliability, evaluation of the maintenance data gathered during monitoring is important. Furthermore, by making use of powerful (ANNs) Artificial Neural Networks, relevant information on existing issues can be obtained that may result in predicting the need for the replacement or repair of the transformer.

2. LITERATURE SURVEY

Transformers are important power system components whose healthy condition needs to be ensured for safe and reliable operation of any power system network [1].The main aim of this system is distribution transformer monitoring and controlling through IOT. If any deviation or an emergency situation occurs the

system sends SMS (short message service) messages to the mobile phones containing information about the deviation according to some predefined instructions programmed in the micro controller[4].

3. METHODOLOGY

In this automated transformer monitoring system we make use of technologies like IoT and Analytics which help increase the performance and throughput of the system. In order to perform analytics on any system using neural networks, we require a large amount of dataset. This dataset is collected in real-time using different sensors like temperature sensor (LM35), Vibration sensor, humidity sensor (DHT11), and ultrasonic sensor. These sensors are controlled and monitored with the help of Arduino UNO microcontroller which is an open-source microcontroller board based on the Microchip ATmega328p, developed by Arduino.cc.

The data collected by these sensors is then stored in SQL database with regular time intervals. These sensors also notify the real-time state of the transformer. If a condition arises with the transformer where it is overheat or damaged, it will be quickly detected by the sensors attached to it and the microcontroller will inform the server. A web portal is developed to interface this complex system so that user can have high benefit of the system. This web portal has admin and user access. The admin will have the privilege to monitor the entire system in real-time. Whereas the user will focus on the output of the system.

Furthermore once a large amount of data related to different factors of the transformer that influence its performance are collected by different sensors attached to the transformer, the next step is to feed this data to the neural network algorithm. The end goal of this system is to analyze the different sensor data and to determine the fail state of the transformer. With the help of neural networks algorithm we can predict the health and the life of a transformer, we can repair any damage to the transformer prior to further loss in the system.

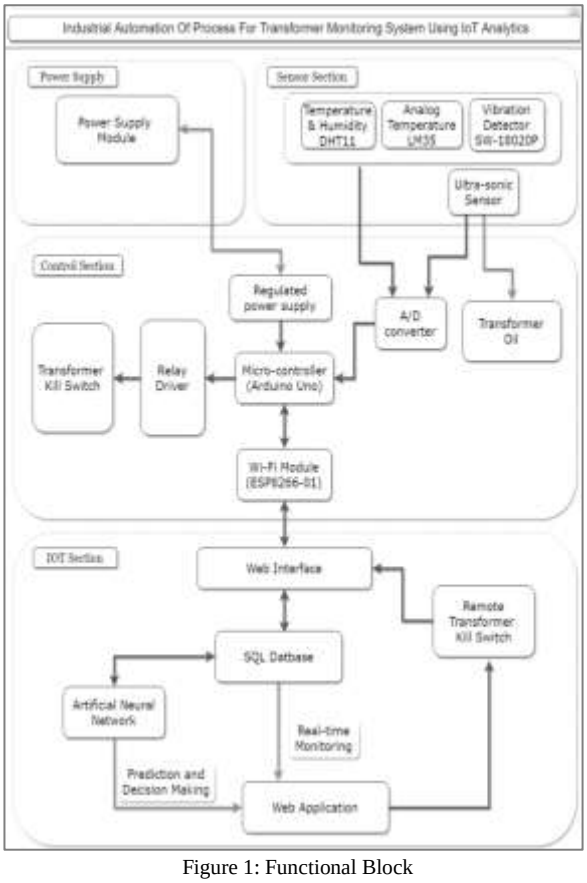

Figure 1: Functional Block

The functional block is divided into 4 fundamental blocks of the system. The first block being the power supply module which powers the entire system and provides adequate voltage to the entire sensor network?

The second block includes the sensor section which includes all the different sensors which help to monitor the different influential factors of the transformer. The DHT11 sensor is used to measure the external temperature and humidity level around the transformer. The ultrasonic sensor monitors the oil level in the oil tank of the transformer and helps to calculate the oil consumption of the transformer. Vibration sensors are

sensors used for measuring and analyzing linear velocity and displacement. It is used to identify and determine the condition and state of the transformer. The LM35 temperature sensor is used to detect precise centigrade temperature. This Sensor is used to measure the internal temperature of the transformer.

The next and very important block is the microcontroller where the sensors are connected and controlled by the Arduino UNO microcontroller. These sensors are programmed to calculate and measure different parameters of the transformer and record them at regular time intervals on the server. These parameters determine the present state and health of the transformer, also in any conditions were the sensors parameters indicate an irregular behavior of the transformer leading to malfunction of any kind, in such cases the microcontroller is programmed to take appropriate measures suitable for the transformer in that present state which includes powering down the transformer, thereby reducing the risk of high damage to the transformer.

The final and most crucial block of this system is the IoT block where the web portal plays a major role in interfacing the entire system to the user thereby making it simpler to manage the system. Furthermore the powerful neural network algorithm is used for the prediction of the fail state of the transformer and also to determine the health so that we can take necessary actions before the damage to machine increases. The ANN algorithm provides better accuracy and more precise results.

3.1Artificial Neural Networks (ANNs):

The Artificial Neural Networks is the key element of this system, which takes in the sensor values stored in the database as an input parameter, processes this parameter to produce a predictive analysis of the transformer and determine its fail state. The ANN algorithm undergoes Data Preprocessing which prepares the raw values stored in a database for further processing. Relevant data might not get recorded due to misunderstandings like equipment or sensor malfunction, the recorded data history or modifications to the data can be overlooked, missing data, particularly some attributes of tuples with missing values, may need to be inferred. Data preprocessing is a form of data mining approach where raw data is converted into a logical format. It is a proven method for resolving such issues. The traditional data preprocessing method starts with data which is assumed ready for analysis without any feedback. The main difficulty for data preprocessing is an inconsistency between data sets. Following are the major task involved in data preprocessing.

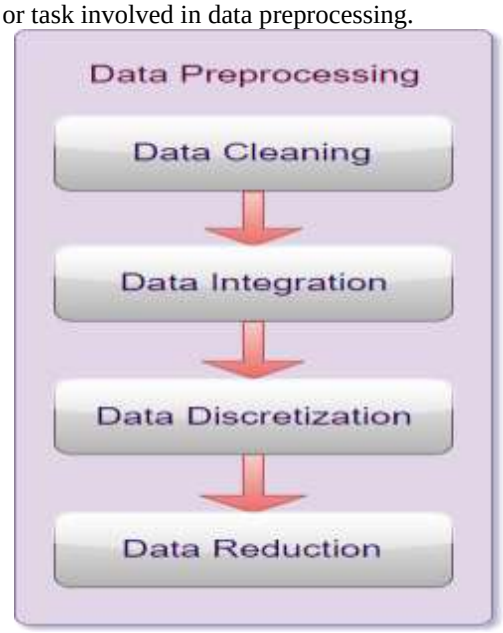

Figure 2: Steps involved in Data Preprocessing

- **Data Cleaning**: It is the process of filling the missing values, identifies and remove outliers, smoothing the noisy data and resolve inconsistencies.
- **Data Integration:** It is the process of integrating multiple files, data cubes, and databases.
- **Data Transformation**: It involves the task of data normalization and data aggregation e.g.: to transform V [min, max] to V'[0, 1].
- **Data Reduction: I**t is the process of reducing representation in terms of volume but producing similar analytical results.
- **Data Discretization:** It's a part of data reduction along with specific importance for numeric data.

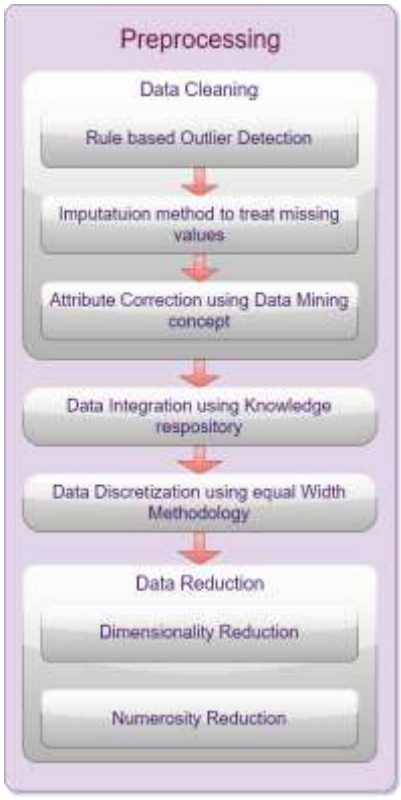

Figure 3: Process of Preprocessing

We make use of 'Keras' library which gives a high level of abstraction and is built on top of Tensorflow library, we use Tensorboard to analyze our model's efficiency.

4. RESULTS

Sensor module and communication module was designed and tested. The web application was designed using HTML, PHP, MySQL, and JavaScript and interfaced with the communication module by using ESP8266. Arduino communicates with a web application using the Wi-Fi module and can control transformer state.

After a successfullogin, the user is shown with the main menu of control and monitoring which can be seen in figure 'A'. You setup and configure the transformer parameters. By selecting a relevantoption the user can access the different modules. Real-time data of a transformer can be viewed on the 'Latest Data' tab.

Figure 4: Web Application

Predicting the fail state of a transformer is the most crucial part of this system. The ANN will consider the transformer parameters for prediction and notify the user accordingly. The developed system is designed in such a way that it can activate the emergency alert.

5. CONCLUSION

This paper discusses the complete solution for monitoring and controlling the transformer by using sensors and relay module, communication module and web application. The designed system also can predict the fail state of the transformer and alert the user about it.

All the transformer sensors are continuously monitored by ANN. The user is notified when the transformer experiences an abnormal condition and appropriate actions can be taken to prevent any disastrous failure of a power transformer.

By using web application user can view historical data and monitor real-time parameters of the transformer at easily.

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