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Internet of Things Enabled Device Fault Prediction System Using Machine Learning

Kotte Bhavana, Vinuthna Nekkanti, and N. Jayapandian(✉)

Department of Computer Science and Engineering,
CHRIST (Deemed to Be University), Kengeri Campus, Bangalore, India
Jayapandian.n@christuniversity.in

Abstract. Internet of Things (IOT) started as a niche market for hobbyists and has evolved into a huge industry. This IoT is convergence of manifold technologies, real-time analytics, machine learning and Artificial Intelligence. It has given birth to many consumer needs like home automation, prior device fault detection, health appliances and remote monitoring applications. Programmed recognition and determination of different kinds of machine disappointment is a fascinating process in modern applications. Different sorts of sensors are utilized to screen flaws that is discovers vibration sensors, sound sensors, warm sensors, infrared cameras, light cameras, and other multispectral sensors. The modern devices are becoming ubiquitous and pervasive in day to day life. This device is need for reliable and predicate algorithms. This article is primarily emphases on the prediction of faults in real life appliances making our day to day life easier. Here, the database of the device includes previous faults which are restored in online by using cloud computing technology. This will help in the prediction of the faults in the devices that are to be ameliorated. It additionally utilizes Naïve Bayes calculation for shortcoming location in the gadgets. The proposed model of this article is involves the monitoring of each and every home appliance through internet and thereby detect faults without much of human intervention.

Keywords: Internet of Things · Sensors · Cloud computing · Home appliance · Machine learning · Naive Bayes

1 Introduction

The modern internet world everything is linked with internet network. The same concept is also involved in electrical and electronic device that means all the devices interlinked with internet connection in the name of Internet of Things (IoT). That device is various field that is electrical, electronics, mechanical and health sector device. In modern lifestyle almost 90% of our home appliance is also interconnected with this IoT technology [1]. Example of this appliance is sensor based washing machine, IoT based air conditioner and Internet based electricity controller. This technology is working with the help of internet, cloud computing and sensors [2]. Cloud computing is a new technology that has become increasingly important and had developed into a great potential for the business world. It has come into existence since 2000 and is currently on a great demand. Cloud computing gives us access to servers, storages, databases, and a broad set of application services over the internet. It helps us

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to innovate in a faster approach than any other technology [3]. In this article cloud computing has an immense role in the storage of the device information which includes previous fault detections, controls, and makes use of prediction algorithms for efficiency. Disappointments lead to framework breakdown or shut down of an appliance. That as it may, disperse figuring and along these lines, distributed computing is described by the idea of fractional disappointments [4]. An issue may happen in any constituent hub, procedure or system segment. This prompts a halfway disappointment and thus, execution debasement rather than a total breakdown. Despite the fact that this outcomes in vigorous and reliable frameworks, deficiencies ought to be taken care of adequately by appropriate adaptation to non-critical failure systems for better performance. This cloud computing data processing is deal with some third party service provider [5]. Customers expecting reliable service at the same time higher speed. The main purpose of using this technology is not required for special software installation and not need for any maintenance. This cloud computing is mainly used for data storage apart from this they provide platform and infrastructure service [6]. This technology is used for various fields like education, social media, healthcare industry and government sector [7]. The time of introducing cloud computing is used for industry and the IT field, now it is slowly interlinked with human day to day life.

Internet of Things is a booming shift in IT epoch. The internet uses TCP/IP protocol suites for interconnecting the computer networks in our global system. In our day to day life internet plays a crucial role for exchanging of data, news and technologies. Internet states about the data created by people, while the new-born is about data created by things. “IOT is an open and encyclopedic network of intelligent quick-witted devices that have the ability to share data, resources, technologies, acting in the real time situations and reacting to the changes in environment”. This is a huge network which can allow the communication between humans-to-things, things-to-things and vice versa by providing a unique identity for each and every person or for a device [8]. It describes about the eye-witted intelligent connection and communication in our global system. IOT devices receives input through sensors which are highly miniature via technology and sends the output information through wired and wireless interfaces to cloud. For example: A smartphone application acknowledges the end user, to monitor the exact location of the vehicle, and views the route path using google maps (GPS) and helps the user to reach exact location. It even shows the arrival time of the vehicle. Ensuring safety and arrival time the prediction algorithm is used for the computation of arrival time. The software applications can continuously monitor the devices and update the faults to the end user. IoT technology is implemented in various real life products. For example, our heart beat is automatically monitored and send the data to cloud server. In modern healthcare sector is used in this IoT in various purposes. IoT based home automation is latest innovation in construction sector. This technology should help to monitor electricity, water flow and home appliance. This project comes under the smart city; smart city is another booming field to interlink with entire city by using IoT [9]. This home automation is working with IP gateway connected with smart mobile phone and other internet enabled devices. Artificial intelligence is a branch of science which aims to invent intelligent machines which can react and work like human beings without any action of the technological industry [10]. It has become the heart of the modern science. This develops a main difference between the human decisions and

smart machines. AI has shown its significance in machine learning (ML) and deep learning (DL) in modern systems. This can automate the responses and processes of the systems. As per the analysis, companies spend around 70% on AI workers and compounded annual will reach $57.6 billion by 2021. The companies that fail to adapt AI and ML are fated to be left. There are some traditional problems in AI which includes reasoning, planning, learning and perception. Al can generate automated responses for the action given by any device or network without any human interaction by using ML and DL [11]. According to the analysis AI can completely replaces the employment where this is going to be a danger to humanity. The world is going to show the transformation of our vehicles to self-driven vehicles. This plays a crucial role in this paper where it needs to generate automated responses of the devices for our prediction. Despite the software engineers putting great efforts for developing fault detection models, fault detection gives us various challenges. Naïve Bayes is an integrated machine learning algorithm that has proven high-performance for this problem. It helps in the prediction of faults in the devices and is one among the most practical approaches for solving problems. This algorithm makes use of the database which comprises of previous faults that have occurred in the appliance, analyzes various cases by which the faults have occurred and thereby provides a prior information regarding the future faults that might occurred and alert the users. The following is the idea behind which the probable fault data is given.

2 State of Art

In the last decades, dependency on software has increased in our daily lives. Now a days it is very difficult to imagine human life without software. Every domain like medical, railway signal, home appliances has started to work with software. Here software reflects the meaning of devices working using AI, IOT, ML technologies. The development of the appliances in each domain is challenging a problem of failure. The impact of these failures, leads the human life into a miserable condition. Therefore, there is a growing solution to ensure the devices without undergoing faulty conditions [12]. The work initiated by Air Force's Rome laboratory was one of the best efforts made to predict the faults in the devices. Number of factors is selected by the research to measure the fault rates. Devices may have several problems such as wireless connection, no power capacity, interrupts. These interrupts undergo certain operation, by causing the device failure or a system failure. Markov chain model helps us to analyze the devices and its current state with a monitoring technique if a device is faulty [13]. Through monitoring resource information can calculate the fault tolerance. But if wrong information is provided to our devices then there is a chance of facing an accuracy problem. There is a model called push and pull model to detect the device nature. In the push model, the user sends information to the device, and then the device starts working if there is no fault. In the pull model the device sends a signal to user by stating the problem in a device. So by the prediction method the device problem can be resolved.

The most intelligent fault prediction system is based on internet of things, this aims at growing the efficiency of devices and detecting the faults. There are three steps need to be followed to ensure the working of a device. The first step is to monitoring the set-

up of the devices, which is connected to the AI, ML. The second step is to identify the fault of the device and diagnosing the fault. Third stage is to resolve the problem by modifying the device or the procedure which is done in setup. Fault prediction is a large safety key according to the IOT, and this is one large safe operation to prevent the faults. The work on fault prediction has been done in many countries. There are some groups in the industry to predict and diagnosis the fault in devices. The MFDT (Machinery Failure Prevention Technology) in the USA had founded the prediction group. The major applications of IoT are its increasingly being used in the manufacturing industry. More specifically, productivity improvements enabled by IoT technology have major impact on economy and competitiveness in manufacturing industry. Especially the mankind are entering the fourth phase of industrialization with the use of cyber-physical systems to monitor, analyse, and automate business. In particular, industrial maintenance contributes largely to this competitiveness through reliability and availability of production equipment. Especially in continuous production industries. The ratio "maintenance costs/added value product" is even higher than 25%. Apparently, defect components or process failures can stop the whole production and significantly impact the competitiveness in manufacturing industry. The effect of IoT in the business segment brings about noteworthy upgrades in proficiency, efficiency, gainfulness, basic leadership and adequacy [14]. IoT is changing how items and administrations are created and circulated. The foundations are overseen and kept up; it is additionally rethinking the communication among individuals and machines. IOT is about making your information meet up in new ways. Take of information with IOT dashboards reveal actionable realization. And modernize how you work together. IOT is an idea and a worldview that look prevalent attendance in the environment of a variety of things that from wireless and cable associations. One of a kind addressing schemes are capable to react with one another and coordinate with different things to make new usage/administrations and achieve shared target. In this setting the research and expansion challenges to make an intelligent world are large. A world where the true, digital and the practical are converging to make clever environments that make transport, power, town and many else regions very smart. Internet of Things is to can things to be linked, anywhere, anytime, with anything and anybody in a perfect use any path and any management. Alongside the quick improvement of Internet of Things and the country's strong support, innovations for IOT are connected to different fields.

Cloud computing is an engineering for encouraging registering administration through the web on necessity and pay per use access to a gathering of mutual assets specifically arranges, capacity, servers, administrations and applications, without physically procuring them [15]. Cloud DBMS is a conveyed database that gives processing as an administration. It is sharing of web framework for assets, programming and data over a system. The cloud is utilized as a capacity area where database can be gotten to and figured from anyplace. Cloud computing has gotten expanding enthusiasm from undertakings since its origin. It has inventive data innovation (IT) administrations conveyance model. Cloud computing could increase the value of endeavors. Cloud computing presents exceptionally concerning interior and outside issues. Cloud Computing frameworks inquire about motivation to investigate the already underexplored regions with respect to cloud computing appropriation factors and procedures.

3 Problem Statement

A fast and reliable method to detect faulty IoT devices is indispensable in IoT environments. To lessen the term of blackouts and limit reaction time to real blames, and to advance unwavering quality of supply. It is unavoidable for individuals to think of another innovation to look for minimal effort conveying gadget which sends an alarm to the screen which can imply us right on time to set it up. The individuals are seeking after regularly developing high caliber of their lives today. This issue prompts increasingly more bother to offices and home apparatuses including into their structures. Generally ordinary divider switches are situated in various corners of house, structures and workplaces. Consequently, when something goes off then entire framework is harmed alongside the switch. So as opposed to putting these changes to on or off, it wants to utilize the robotized gadgets which can distinguish the issue and inform us before something turns out badly. There is a lot of failure crisis in current situation of our country. Moreover, people have become negligent in proper utilization of the devices in proper way. People often forget to turn off the light sources and home appliance while staying out from home, even this may lead to the outage of appliance. Even in those situations, application of fault detection makes it possible to control them and to change the appliance.

4 Proposed IoT Based Fault Prediction System

The modern device is working with electronic based technology. The proposed system is electronic based technology also it will increase the performance and reduce the device cost. The proposed system comprises of various components that help in the detection of faults. The components include controller, database, smart phone, Control Unit, home appliances and Fault Maintenance Unit. Control unit is to monitor the home appliances, whether their working condition is normal. If the software application is turned open, Control Unit starts to track the data received from the controller which stores the up-to-date database of the appliances. Hence, the abnormal condition in the appliances can be detected and stored in the Fault Maintenance Unit using the naïve bayes algorithm. Furthermore, the alert message is generated to the end user (smart phone) from the control unit after a deviation from the normal working of the appliances is predicted. Control Unit has non-volatile memory and the data are retrieved from the controller every day. It stores the data in cloud using cloud computing technology. The data stored is used by algorithm to compute the faults that occurred or going to occur. This is the main functional unit of the entire system. The purpose of this control unit is to maintain the protocol structure of the proposed system. The concept of this proposed system is to connect the home appliance by using internet with interconnection of IoT technology. The working mechanism of this washing machine is monitored with the help of IoT sensor that means water utilization, machine running time and spinning time. This timing is monitored and sends this data to control unit. The controller notices if any home appliances are turned ON or OFF. If the appliance is ON, then it starts working to check if appliance is working or not. The control of each device is taken care of by controller by supplying the required amount of power for

working of the devices. The controller is maintained by the Control Unit through checking the faults in appliances. Controller stores the data of each and every fault occurred in appliances. It has volatile memory and so the details are stored until then the Control Unit retrieves the information from the controller.

The Fig. 1 is discussed proposed fault identification system using machine learning algorithm. The major unit of our proposed system is Machine Learning Algorithm Unit, this unit is using Naïve Bayes algorithm. The basic working principle of this algorithm is probabilistic classifier method. This algorithm is interlinked with the concept of Bayes concept. The basic structure of machine learning algorithm is to predict the future based on existing data set. This Bayes theorem is to split or cluster the data based on similarity. This cluster data set is stored in one particular database then future this data set is used to predict the result. This algorithm is also working in support vector mechanism. This method to find the similarity of different data, based on the similarity this system helps to predict the future. This mechanism is implemented in the IoT enabled home appliance, to maintain both with fault and without faulty device history. The purpose of maintain both the data is finding the similarity. Inside of this unit another major unit is also working that is named as software unit. Software application is used to find all the databases of all the home appliances. When the users enroll in the application with their residential address, they have allowed this application. The users can view the power consumption and the power wastage of each

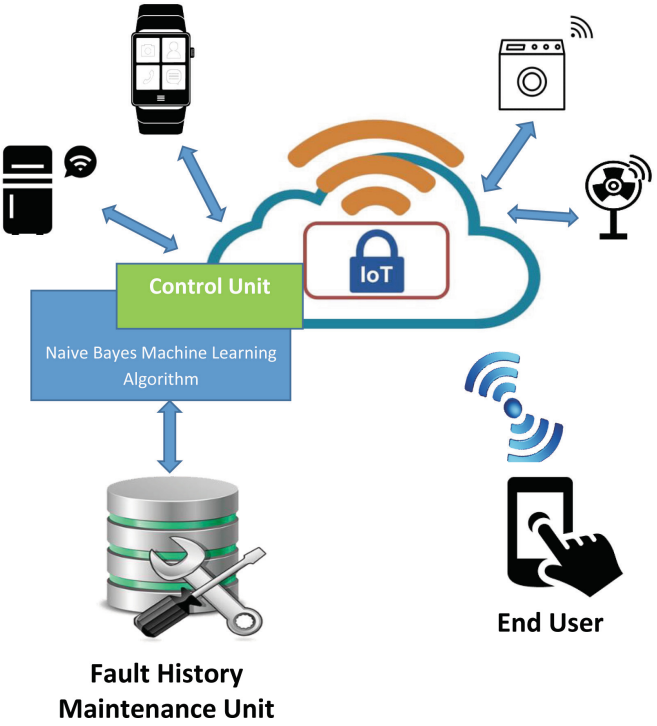

Fig. 1. IoT enabled fault history maintenance architecture

home appliance and also the occurrence of the fault in the device. Any change in the database table leads to the intervention of the user for alert. Hence this software is helpful to reduce the wastage of electric power that may occur during the fault period.

Here we can consider washing machine, fan, refrigerator as home appliances connected to Control Unit and cloud. These devices are controlled by Control Unit. The Control Unit and cloud allows to perform any tasks automatically. These can interact seamlessly and securely with any of the devices. These appliances play a key role in every home automation area. The Control Unit helps the appliances to connect directly to the software for detecting the faults. IoT based fault history maintenance unit helps to maintain these existing fault data and current machine situation. This is a cloud based database storage server. This is database system is dynamic with automated system, when small changes are observed that is updated in this unit. This particular unit is the heart of this proposed method. The reason is that without this particular unit is not able to predict the future fault. The major advantage of fault history maintenance unit is error free server. The working method of proposed system is home appliances generate data that means performance of that machine. This data is collected by using IoT technology, after that data is send it to machine learning algorithm unit. Here Navie Bayes algorithm is used to predict the future fault. Then that particular data is stored in separate database that is named as Fault History Maintenance Unit. That database is connected with cloud server, this prediction process is done with the help of machine learning algorithm unit, it is similar to the work of processor. The computer processor do the process in system input, similar to that device data is analyses and predict the future fault. Then this information is shard in end user. That end user look into this information by using mobile application. End user may be any smart device like a mobile phone or a PC used by us, which comprises of the software that keeps a record of the database of the devices and alerts the users when an abnormal condition or a deviation has been noticed in the working of an appliance.

5 Conclusion

A framework that distinguishes and recognizes flawed gadgets is basic in smart homes to give solid administrations to clients. Monitoring of home appliances using controller helps the Control Unit to monitor and maintain the maximum number of home appliances at the same time. Hence, this proposed system helps in the detection of faults without any intervention of human effort and also saves a lot of time. In this proposed system is implemented with the help of cloud computing, Internet of Things and Mobile App. This is a multi-technology environment, because more than one technology is involved in this proposed system. In future, this method can be implemented to improve industrial appliance.

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