ORIGINAL RESEARCH PAPER
Volume-9 | Issue-2 | February-2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

TOXIC GAS DETECTION AND ANALYSIS USING IOT

Computer Science

Ahmed Shoeb Department of Electronic and Telecom, Sardar Patel Institute of Technology, Mumbai, India

Y S Rao* Department of Electronic and Telecom, Sardar Patel Institute of Technology, Mumbai, India *Corresponding Author

ABSTRACT

Internet of Things (IoT) is the drifting concept introduced in the smart world. In this project, we have deployed IoT model hardware to get easy remote access through the internet. Industrial Internet of Things (IIoT) is a new concept that contributes to industrialization. In order to make the proposed device much smarter, various technologies such as Machine Learning (ML) and Statistic Data Analytics along with the IoT have been incorporated in this work. This device gathers real-time data and analyzes it appropriately, As it is known, the main element of self-driving philosophy using IoT is a smart machine that captures the data and needs human intervention. Also for better results, the communication of necessary information is a must. This work specifically focusses on safety concerns for the workers working in industrial areas. In this work, we provide a prediction of the value of toxic gases through continuous monitoring, to reduce industrial accidents. Since the intake of gases has an adverse effect on human health. To achieve this ML regression algorithm is used. The work is carried out by the IoT cloud platform. The proposed prototype consists of UCD3138128 microcontroller, ESP 8266 (Wi-Fi protocol) and Gas sensor MQ-7.

KEYWORDS

Internet of Things, Industrial Internet of Things, Machine learning, Time Series Analysis.

1 INTRODUCTION

IoT and ML a very emerging concept in the smart world and very rapidly growing craze around the world. This concept was first proposed by Kevin Ashton [1]. What is IoT? The data which come from sensor which can be in readable and visualize to the human i.e observer from Wireless Sensor Network (WSN) board [2]. What is WSN Board? It is nothing but we can say IoT board. WSN is an autonomous and compact device that has the capability of monitoring real-time data throughout the world. The WSN board contains various sensors like a gas sensors, image sensor, touch sensor, and many more sensor are connected to the communication module so that it can give the data to the user remotely [2].

Why ML? The goal of ML is to build a system that can adapt and learn from experience and perform a task which is collaborative to AI domain which makes our system smarter. The output of ML is in the form of recognition, controlling, decision making, prediction, etc. ML has a certain algorithm which we use to predict and perform analysis like Linear Regression (LR), Support Vector Machine (SVR), Regression analysis i.e Time Series Analysis, etc many more algorithms are used. This algorithm is used to predict the stock market, weather forecasting, and disaster management [3].

For toxic gas detection for this prototype, we used Carbon Monoxide (CO). Why CO? What is CO poisoning? CO is one of the most popular gases found in the environment. CO is odourless, colourless and tasteless gaseous substances. The sources of CO have come from both natural and manufactured form. The important toxic action of CO is Hypoxia i.e. deficiency of oxygen at the tissue level. CO gets to mix with the blood to form a Carboxyhemoglobin (COHb) molecule in the red blood cell. Which means reduce the oxygen level in the blood cell. Which tend decreasing level of immunity in the blood cell. Which tends to increase in chances level in disease. This effect caused by CO to health is called as CO poisoning. CO was measured in the form of parts per million (ppm). It is necessary we have to observe the gas in the form of ppm as per as mentioned by SI unit [5].

This paper is organized is as follow. In Section II, the related work is analyzed, while the architecture design of IoT prototype and hardware and software requirement has been outlined in Section III. Proposed result of IoT prototype and ML output was discussed in Section IV. Concluding remark and future scope is discussed in Section V.

2 Related Work

The IoT concept is playing the most promising result in the modern and smart world, and again on top of that ML give the bolstering result.

Basically, for doing ML for IoT data we need to understand what type of data should we have to collect. The data which should be aggregated from the sensor board is nothing but a realtime IoT data. The question is what is ML data? For the ML task for the prediction algorithm, we need to have historical data. For any ML/Data mining operation we require a set of historical data. This is the trending concept of Why Data mining/ML technology comes into play in IoT Domain? Because their algorithm can be used to make IoT application more intelligent and thus provide smart service [4]. To develop the high-performance data mining module and ML for IoT three key factor has to be remembered: Like Objectives, objective means what kind of assumption has to be applied, their limitation and at what measurement of the problem has to be specified; characteristics of Data like size and representation at a given condition; and what kind of algorithm has to be applied.

The WEKA~\cite{weka} is the machine learning/Data mining workbench. It has several graphical interfaces for a different type of process. It contains a visualization tool and has an algorithm for normal data and prediction analysis.The WEKA forecasting used basic statistical model Autoregressive Moving Average (ARMA) and Autoregressive Integrated Moving Average(ARIMA). It technique still prove for worthy of forecasting technology. Many of the application where perform by this ARIMA and ARMA model **[12] [13].**

The most important step for designing the IoT prototype is to chose what kind of microcontroller should have to choose.So i have chosen UCD3138128 microcontrooler [11]. The UCD3138128 microcontroller which is manufactured by Texas Instrument. There is a certain key point for the selection of IoT microcontroller is mention with UCD3138128 preferences [6]:

- Bit: Mostly microcontroller were sold by number bits. What does the microcontroller bits perform? The bit is used for conversion of an analog signal into a digital signal. more the number of resolution bit will increase the number accuracy or we say an amount of precision value. UCD3138128 microcontroller used 12-bit resolution.
- ADC channel: ADC does the conversion of an analog signal into digital signal vice versa. ADC can also give Command in digital form when our IoT device as to give a response to actuator also just like example on and off valve using servo motor. It has 15 ADC channel. The number of ADC channel which increases chances of adding more device.
- GPIO: GPIO stand for general purpose input-output. This pin is used for connection most of the input-output device. Where we can attach the sensor and actuator also. UCD3138128 has 43 GPIO pins. Out of 39 are convertible GPIO pins are available.
- Flash: Flash is that kind of the memory that can still remain in the memory in offline mode. The flash memory retains the data in the absence of power. This controller has 'On the Fly' Firmware update that means, it is easy to update the firmware by turning the power supply off or restarting the firmware. This feature has a great scope that has firmware over the air which for IoT device which was recently proposed by Samsung [10].

- Connectivity: connectivity is an important key role for the microcontroller. This pin is used to connecting all the communication module. UART transceiver and receiver is also used for connection of WiFi module and for programming also. The communication pin I2C also used for programming and data transmission and receiving. The JTAG play an important role in my prototype for programming. Connectivity is used for the communication of the microcontroller to outer world we called PC or cloud via connectivity module.
- Power consumption: This specification implies how much power supply for microcontroller hungry for processing and task. The sensor, microcontroller, and WiFi module depend on the power supply. The IoT system simply relies on the battery operated the system. The power consumption should be of 3.3V to 5V.
- Development tool and Community: The most important thing for how microcontroller process task without given any task and command. The development tool is available for the microcontroller should be programmed and perform the task. We simply called an IDE (Integrated Development Environment). The Code Composer Studio (CCS) is for the Texas instrument microcontroller.

3 System Description

3.1 Problem Description:

For ML data we need to require to collects a lot of data near about or above thousands of data. Our device should be fully powered with fully connected internet devices. So that to collect the data throughout the day, or a week or month to analyze the data and make a training data should that we should get more accuracy in prediction result.

The UCD3138128 microcontroller has the capability to perform the task of does the IoT microcontroller. The aim of this project is to build the IoT prototype using this UCD3138128. And on top of that to build the ML and IoT project too.

3.2 UCD3138128 IoT prototype:

The basic block diagram of IoT prototype by using UCD3138128 is shown in Fig.1

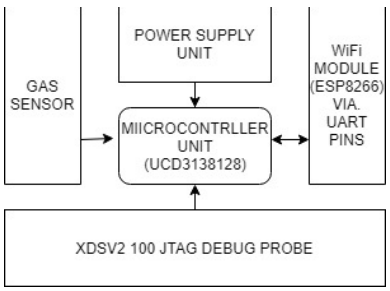

Fig.1: Block Diagram of IoT prototype

3.3 Hardware and Software Requirements:

The hardware part of this prototype consists of microcontroller UCD3138128PFC which has an ARM7TDMI-S architecture which means that perform real-time monitoring; For communication and internet connectivity a Wi-Fi Module is used that is ESP8266; For detection of gas, an MQ-6 gas sensor is used with an amplifier gain unit. The programming is done by IDE. The microcontroller is programmed in C languages with specific IDE which is provided by the organization.UCD3138 is manufactured by Texas Instrument(TI). The IDE is used to programmed UCD3138 controller is Code Composer Studio which is provided by TI. This IDE is programmed in C language. As per WSN concept, this prototype is nothing but it is a WSN board.

The proposed prototype in the form of a block diagram is shown in the figure. We look into the power supply module, it provides 5V and it will be regulated to further 3.3V by using a voltage regulator LM318. The microcontroller, Wi-Fi module, and gas sensor will take 3.3V. Sensor and Wi-Fi module supply was also be provided by the microcontroller. Wi-Fi module was an interface to the microcontroller via UART pins which was present in microcontroller itself. This board is programmed through JTAG (XDS-100V2).

For storage of the real-time data, we need to require more storage. Our microcontroller doesn't have that much to memory store ML data or we say real-time data of CO. We are taking a cloud storage database called Firebase database. For the IoT concept of view, the data is stored in the cloud. We need to perform ML data science practical testing and final prediction result task was performed by WEKA toolkit.

4. RESULT

4.1 Application Implemented:

After reading the IoT microcontroller requirement specification, we should have analyzed what part we need to implement the prototype.

The Eaglecadsoft PCB design is used for designing the schematic and board layout of the prototype.

Fig. 2: Basic flow this project.

The block diagram of the system implemented of IoT prototype is as shown in Fig.1. The Fig.2 shows the basic flow of the project how IoT data is transformed into ML data to perform the task on ML toolkit on cloud or any ML platform.

As discussed in the previous section many data analytics and IoT prototype have been implemented by using various microcontroller. Now we will discuss what application has been implemented in this paper. By using UCD3138128PFC microcontroller has 15 ADC channel which collects the sensor value data. This sensor value data is convertible into a readable form to do the ML task and this value is sent to the WiFi module through UART Tx and Rx. This data is sent to WiFi through AT command. This AT command is connected through cloud-based service through the RESTful API by using command CIPSTART. The data from the sensor should be transfer to the cloud database i.e Google Firebase [9]. This is used to store the tons of data for ML process. This Firebase stored the data in the JavaScript Object Notation (JSON) format. After collection of the data in term of an hour of span may be 2hr or more in minute form. This data is converted into Comma Seperated Value(CSV) format. Then finally applying this data to machine learning toolkit named WEKA Toolkit. Which contain most of the machine learning algorithm for predictive analysis.

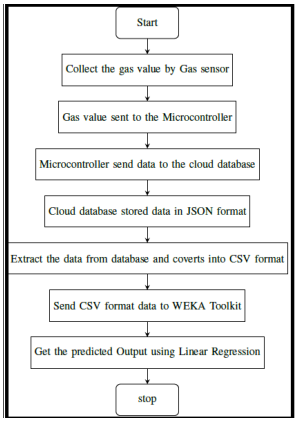

Fig. 3: Flowchart of the application implemented by IoT prototype using UCD3138128

The fig. 3 shows the flowchart algorithm of application implemented using gas sensor prototype and ML toolkit.

The data is collected from the gas sensor through microcontroller and then is send it to the cloud database. The resulted output data of the gas sensor value is stored in Google Firebase is as shown Fig.4.

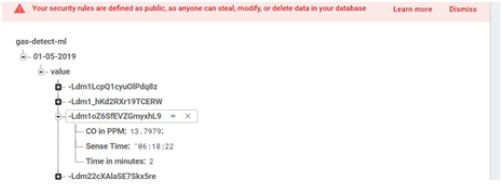

Fig. 4: IoT data stored in Cloud Database (Google Firebase).

After storing the data to the database. We can extract our data in JSON format. To find the predicted output in the WEKA workbench, we need to make our data in a readable format the weka used. Here we can choose in CSV format.

Fig.5 shows that all the prediction (forecasting) is done by the ARMA model. Basically, ARMA is a combination of both Autoregressive (AR) and Moving Average (MA). This technique comes under the time series analysis.

The equation of AR (p) [13]:

$$Yt = \delta + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots\ldots + \phi_p Y_{t-p} + \alpha_t \qquad (1)$$

Where Y_t and α_t are actual value and white noise error value respectively. And Y_{t-1} so on defined as a past value series. Where ϕ_1, ϕ_2, so on are the parameter of models.

Where δ is defined by:

$$\delta = (1 - \sum_{i=1}^{p} \phi_i)\mu \qquad (2)$$

The equation of MA (q) [13]:

$$Y_t = \mu + \alpha_t - \theta_1 \alpha_{t-1} + \theta_2 \alpha_{t-2} + \theta_3 \alpha_{t-4} + \ldots\ldots + \theta_q \alpha_{t-q} \qquad (3)$$

Here $\theta 1, \theta 2, \theta 3 \ldots$ are the parameter of the models.

For prediction/forecasting of the data, we used the ARMA model. ARMA is a combination of AR and MA. The equation for ARMA (p,q) as mention below[13].

$$Y_t = \delta + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \alpha_t - \theta 1 \alpha_{t-1} \qquad (4)$$

for ARMA (2,1).

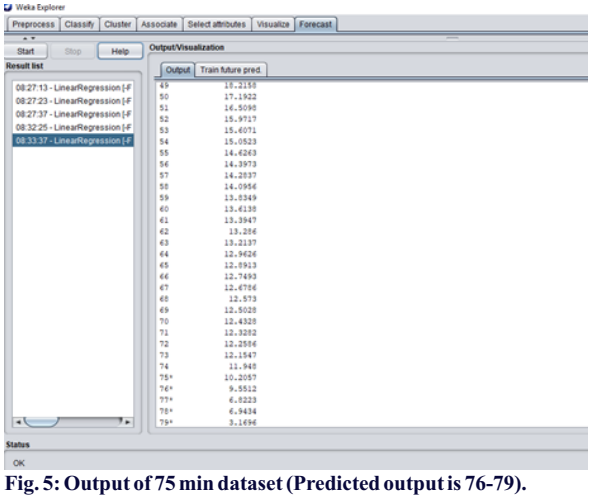

Fig. 5: Output of 75 min dataset (Predicted output is 76-79).

So the numerical predicted value is shown in the above figure Fig. 5. Plotting or Statistical visualization of the predicted is as shown in Fig. 6.

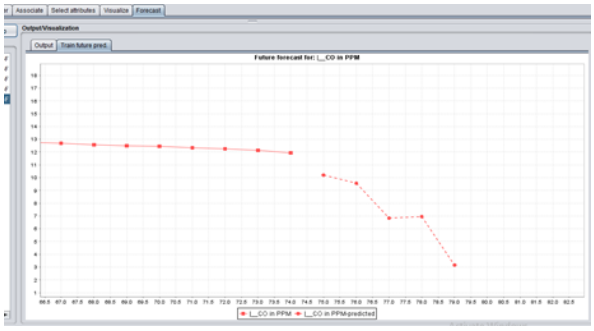

Fig. 6: Statistical output of 75 min dataset (Predicted output is 76-79).

5. CONCLUSION

We have designed an IoT prototype by using microcontroller UCD3138128 which is manufactured by TI. This microcontroller is 32-bit ARM7TDMI-S processor. It also consist of gas sensor MQ-7, a WiFi Module ESP8266. The microcontroller is programmed in such a way that it collects the gas value and send to a cloud database for analysis. The WEKA workbench is used for prediction analysis/forecasting of the data. Using LR, Time series analysis, various algorithm has been carried out.

This project has a great scope in regarding industry for forecasting of furnace temperature, gases leaked/expelled by the chimney of the factory and many more factory related terms. And by using linear regression forecasting in WEKA we can do most of the prediction like stock market prediction, number of sale in business per day, weak, month, or yearly. For ML practical we need bulk of data for processing the task.

6. Acknowledgements.

The author is sincerely thanks to the Bhartiya Vidya Bhavan's Sardar Patel Institute of Technology, India for providing various necessary facilities for completing this project, we also thanks to Institute faculty, research staff and students for guidance.

7. REFERENCES

1. Kevin Ashton, "That 'Internet of Things' Thing", RFID Journal, 22 June 2009.
2. C. Bambang Dwi Kuncoro, "Miniature and Low-Power Wireless SensorNode Platform: State of the Art and Current Trends", IPTEK, Journal of Proceeding Series, Vol. 1, 2014.
3. Adnan Akbar, Abdullah Khan, Francois Carrez, and Klaus Moessner, "Predictive Analytics for Complex IoT Data Streams", IEEE Internet of Things Journal, Volume: 4, Issue: 5, pp. 1571 - 1582, Oct. 2017.
4. Chun-Wei Tsai, Chin-Feng Lai, Ming-Chao Chiang, and Laurence T.Yang, "Data Mining for Internet of Things: A Survey", RFID IEEE Communications Surveys Tutorials, Volume: 16, Issue: 1, First Quarter2014, pp. 77-97, 2014.
5. Mark Goldstein, RN, BSN, EMT-P I/C, Royal Oak, Mich, "Carbon Monoxide poisoning", Journal of Emergency Nursing, December 2008, pp. 538-542, 2008.
6. https://dzone.com/articles/how-to-choose-a-microcontroller-for-iot [Accessed on 23 Sept, 2018].
7. http://www.ti.com/lit/ds/symlink/ucd3138128.pdf [Accessed on 30 Oct, 2018].
8. https://www.cs.waikato.ac.nz/~ml/weka/ [Accessed on 1 May, 2019].
9. https://firebase.google.com/docs [Accessed on 30 April, 2019].
10. https://www.samsung.com/my/support/mobile-devices/what-are-the-requirements-when-upgrade-firmware-with-fota-firmware-over-the-air/[Accessed on 3 May, 2019].
11. Zhang Yingwen, Guo Xinhua, Guo Baojia, and Bian Yuanjun, "A digital PFC control system design based on UCD3138", IEEE Conference and Expo Transportation Electrification Asia-Pacific (ITEC Asia-Pacific), 03 Nov. 2014.
12. https://wiki.pentaho.com/display/DATAMINING/ [Accessed on 17 May, 2019].
13. J. Durbin, "The fitting of time series models," Rev. Int. Statist. Inst. 28 (1960), pp 233-243.