International Journal of Innovative Research in Computer and Communication Engineering

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | Impact Factor: 7.488|

||Volume 8, Issue 5, May 2020||

A Survey on Air Pollution Control using IoT and Deep Learning

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ABSTRACT: Air is getting polluted day by day due to industrialization and urbanization. It is not only in India; it is the major problem in all over the world. All the countries are fighting to control over the air pollution. Although Governments are setting up many rules and regulations, many industries are not following the rules and regulations of government towards air pollution control. Due to urbanization, the growth of population in urban areas are increasing immensely. As the public is using more private vehicles than using the public transportation which leads to more pollution on the air. Hence, it is very significant to monitor and control the air pollution before it reaching the hazardous level. Now a day, the hot technologies like IoT and Deep Learning are involved in all the areas. In air pollution monitoring, the IoT is implemented and doing better response. As the same way, the deep learning technology also helps to predict the pollution for future and it supports to do continuous monitoring, prediction and controlling the air pollution. In this paper, we discussed about the various IoT techniques and Deep Learning Networks which supports for air pollution control.

KEYWORDS: Air pollution;IoT; Deep Learning; RNN; LSTM; Sensors

I. INTRODUCTION

Air quality is continuously deteriorating due to emission from industries and vehicles. The air pollution level is exceeded the limit specified by the World Health Organization (WHO) in many countries. Air pollution leads to many health issues like lung cancer, heart attack, chronic bronchitis, etc. The air pollutants are SO_2, NO, NO2, $PM_{2.5}$, PM_{10}, O_3, Temperature, Humidity, etc [4]. The different sensors are available for each air pollutant monitoring separately. With the help of these sensors, the air quality monitoring devices can be developed. It is already developed in use in many countries. The monitored air quality data can have stored and used for further processing. The deep learning technologies can be applied on the air pollution data to predict the future scenario. Based on the outcome from deep learning, the controlling mechanisms can be applied.

II. BACKGROUND

Air Quality Monitoring System Design Based on Internet of Things by [1] andthis system developed using Zigbee, AM2305, GP2Y1010AU0F sensors, Nokia 5110 LCD screen, Yeelink for storing data. AM2305 Sensor is used for monitoring temperature and humidity, and GP2Y1010AU0F used for measuring $PM_{2.5}$. Yeelink is an IoT platform which supports to store and access the sensor data. IoT Based Air Pollution Monitoring and Predictor System on BeagleBone Black was developed by [2] with gas sensors, MQ-7 and MQ-11. Gas sensors were used for monitoring CO and CO_2. MQ-7 and MQ-11 were used for monitoring CO and H_2. WSN Based On Air Contamination Monitoring System was developed by [3] using MQ5 and MQ7 sensors to monitor temperature and $PM_{2.5}$.

III. INTERNET OF THINGS PLATFORM

IoT platform supports to collect, store and transmit the data from sensor unit. Depends upon the types of sensor, the different air pollutant can be sensed and the generated data will be stored or transmitted for further processing. The sensors playing important role in IoT. So defining sensor node is very important. There are lot of variety in sensors. Especially, there are various sensors for monitoring air pollutants such as SO_2, NO_2, $PM_{2.5}$, PM_{10}, CO, CO_2, and temperature, humidity, noise, etc. Out of many of variety of sensors, the few following sensor are described here.

Dust Sensors

There are so many variety of dust sensors are available in the market. Here it is described only two dust sensors.

SM-PWM-01C Sensor: SM-PWM-01C is a dust sensor which uses optical sensing method to detect the dust particle in the air.This sensor will provide more accurate measures of dust particle in the contaminated air. Fig. 1.1 shows the SM-PWM-01C Sensor.

Fig. 1.1 SM-PWM-01C Sensor

Laser Dust Sensor: It is a dust sensor which can detect the $PM_{2.5}$ and PM_{10} concentration on the air. Fig. 1.2 shows the Laster Dust Sensor.

Fig. 1.2 Laser Dust Sensor

Carbon Monoxide Sensor

There are many varieties available in the market for sensing carbon monoxide in the air. Here, it is described about two carbon monoxide sensors.

GSET11-P110 Sensor: This sensor helps to detect the carbon monoxide sensor in the air. The Fig. 1.2 shows the GSET11-P110 Sensor.

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Fig. 1.3. GSET11-P110 Sensor

MQ7 Sensor: This sensor helps to sense the carbon monoxide in the air. The Fig. 1.4 shows the MQ7 Sensor.

Fig. 1.4 MQ7 Sensor

Carbon Dioxide Sensor

Huge variety of sensors available to detect carbon dioxide in the air. The level of carbon dioxide increases more which leads to dangerous for living things. So, many sensors are developed to monitor CO_2. Out of it, only two sensors are described below.

CM1103 Sensor: This sensor helps to detect carbon dioxide in the air. It is based on infrared. The fig. 1.5 shows the CM1103 Sensor.

Fig. 1.5 CM1103 Sensor

MQ135 Sensor: The MQ135 sensor is used to detect carbon dioxide in the air concertation. It can also sense NH3, NOx, alcohol, Benzene, smoke, and some other gases. Fig. 1.6 shows the MQ135 Sensor.

Fig. 1.6 MQ135 Sensor

Temperature-Humidity Sensor

Temperature and Humidity are playing very important role to increase the air pollutant concentration on the air. There are so many variety of sensors available for detecting temperature and humidity. Two temperature and humidity sensors are described below.

DHT11 Sensor: This sensor helps to detect temperature as well as humidity level in the air. Fig. 1.7 show the DHT11 Sensor.

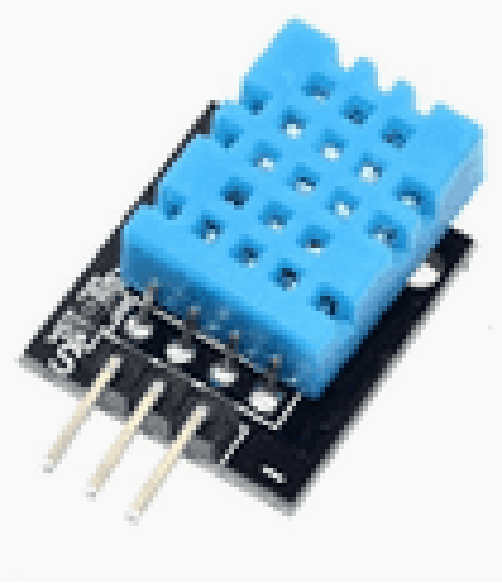

Fig. 1.7 DHT11 Sensor

IV. DEEP LEARNING

Deep learning is the sub part of machine learning. It helps to create model which supports to learn the data. Based on learning, the deep learning technology can be applied as classification, clustering, and regression. There are lot of deep learning architecture which supports for classification, clustering and regression. Auto-encoder, stacked auto encoder [5]are the architecture which supports for unsupervised learning. We can do clustering of data.

Auto-Encoder

Auto-Encoder is neural network which supports to rebuild its inputs [6]. For reconstruction of input, auto-encoder encodes the input and decodes it. It is represented in equation form. Fig. 1.8 show the architecture of auto encoder.

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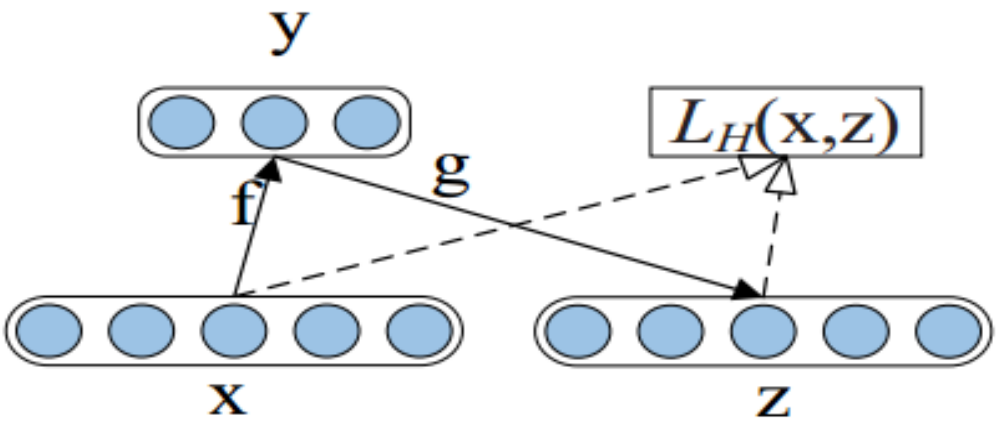

Fig. 1.8 Auto Encoder Architecture

$m=b(X1j + p)$ (1)
$n=c(X2k + q)$ (2)

where X1, X2 are weight matrices and p, q are bias vectors.

However, sometimes auto-encoder alone will not provide better result. So, the research moved to Stacked Auto Encoder [6].

Recurrent Neural Network (RNN)

RNN is a neural network based on recurrent function. RNNs uses their internal memory for processing the input. The RNN structure is composed of one input layer, one hidden layer and one output layer [7, 8]. The neurons of each layer varies. The data collected through sensors can be used in RNN to do classification, clustering and prediction. Majorly, RNN is used for prediction. Fig. 1.9 shows the structure of RNN.

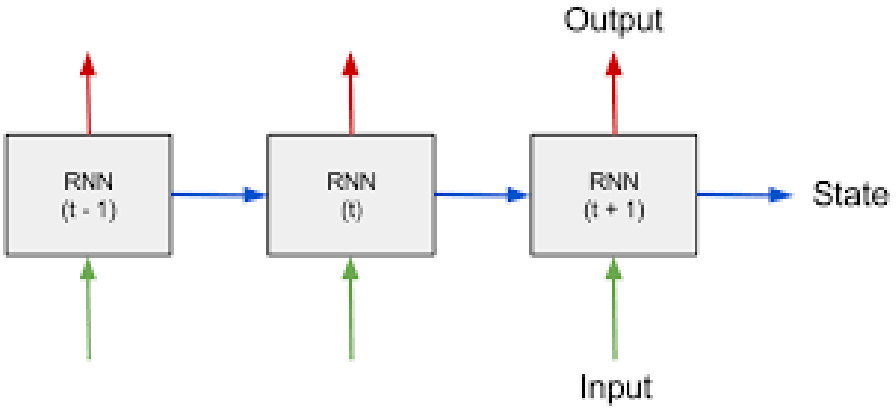

Fig. 1.9 Structure of RNN

Long – Short Term Memory (RNN-LSTM)

LSTM Networks is one category of Recurrent Neural Network (RNN). RNN's problem is, it won't store the previous in the memory. LSTM evolves to overcome this problem. In LSTM Network, memory cells are recurrently connected, with three vital gate units: Input Gate, Output Gate, and Forget Gate [9]. LSTM supports to maintain the previous data in the memory cell. Fig. 1.10 show the architecture of the LSTM.

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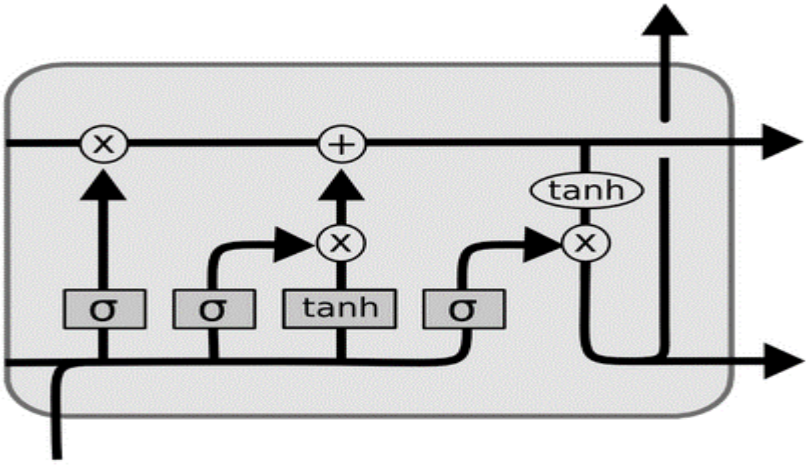

Fig. 1.10 LSTM Architecture

V. CONCLUSION

As the implementation of air pollution control system is become significant, it can be done with the help of various hot technologies like IoT and Deep Learning. Many of such systems are already in development and some are already in implementation. This paper gives authentication that how the IoT and Deep Learning are applied in various applications which was developed mainly for air pollution monitoring and controlling. This survey will be extended to inculcate how air pollution monitoring system can be developed using more specific features of IoT and Deep Learning.

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