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Air pollution monitoring and prediction using IoT

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***Abstract*— The internet of Things (IoT) is a course of action interrelated computing devices, mechanical and advanced machines, objects, or people that are given unique identifiers and the capability of exchange information over a system without anticipating that human to human or human to machine communication. In this work an IoT based air pollution monitoring and prediction system is proposed. This system can be utilized for monitoring air pollutants of a particular area and to air quality analysis as well as forecasting the air quality. The proposed system will focus on the monitoring of air pollutants focus with the combination of IoT with a machine learning algorithm called Recurrent Neural Network more specifically Long Short Term Memory (LSTM).**

Keywords—Deep Learning; IoT; LSTM; Real time; RNN;

I. INTRODUCTION

It is obvious that those who work in a factory or plant will be far more at risk of inhalation of harmful chemicals and gases due to their prolonged exposure to emissions. Air pollution adds to the harmful condition that makes unfavorable impact on living things.It is one of the real concern for the entire world. Air pollution is a worldwide issue including international organizations, governments, and the mass media. Any utilization of natural assets at a higher rate than the nature's ability to reestablish itself can bring about contamination of plants, air, and water. Other than human exercises, there are a couple of intermittent characteristic cycles that additionally result in release of risky stuff. Beside human made activities natural disaster such as volcanic eruption may result in the contamination of air. Globalization is significant reason for contamination. In most cases air pollutants can be:

- Carbon Monoxide: A gas that originates from the consuming of burning of fossil fuels, generally in autos. It can't be seen or noticed. It affect human beings feeling dizzy and tired and gives them headaches.
- Toxic air pollutants: are created in chemical plants or are emitted when fossil fuels are burned. They are the causes for cancer. Other toxics can also cause birth defects.
- Ozone (O_3): Secondary toxin framed by synthetic response of unstable natural compounds within the sight of sunlight. It minimizes the lung function and causes breathing symptoms, such as coughing, asthma, and breathing related problems.
- Nitrogen Dioxide (NO_2): Fuel ignition such as vehicle fuel, electric utilities, wood burnings and industrial boilers. It is the cause for lung related diseases.
- Sulfur Dioxide (SO_2): It comes from combustion of high sulfur fuel as well as natural disaster such as volcanoes.

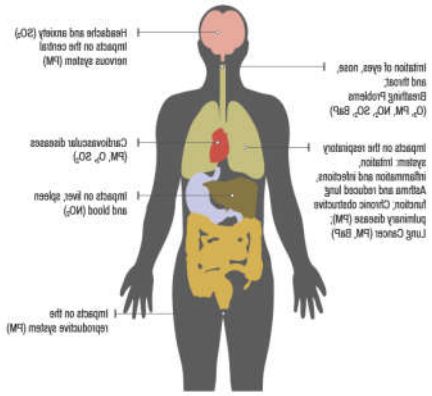

Fig 1. Effects of air pollution in human health[14]

Technology is passing around its wing in almost every walk of human life activities. Now a day it is better if every action is done using new technology in order to satisfy the demand of human being, Organization, Enterprise etc. Internet of Things (IoT) is one of the main communication development in the last decade. Through this concept, it is possible to connect countless low-powered smart embedded objects to each other and to the Internet. The pervasive presence around us of various wireless technologies such as Radio Frequency IDentification (RFID) tags, sensors, actuators and mobile phones constitutes the cornerstone of the IoT concept. These objects can send and receive data autonomously, thus opening new horizons for home, health, and industrial applications. In fact, technology advances along with increasing demand will foster a widespread deployment of IoT services, which would radically transform our corporations, communities and personal lives. [9]

Internet of things is going to connect things with each other via internet that mean each thing will be having communication ability.

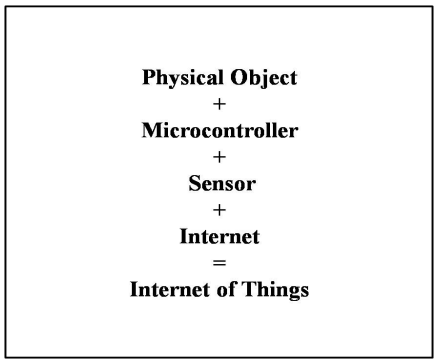

Fig 2. IoT basic components

Basically there are four key layers in IoT, include:

i. **Application layer:** Comprises of the different applications and services that the IoT provides.
ii. **Perception Layer:** Composed of different forms of sensors such as alcohol sensor, temperature sensors, vibration sensors.
iii. **Network Layer:** includes network communications software as well as physical components.
iv. **Physical Layer:** this layer includes the main hardware such as smart appliances and power supplies.

II. RELATED WORK

Paper 1 – Urban air pollution monitoring system with forecasting models[4]
Authors- E. Rezk, A. Kadri, K. B. Shaban,
Conference/journal – IEEE journal, 2016
In this paper they applied three machine learning (ML) algorithms are investigated to build accurate forecasting models for one-step and multi-step ahead of concentrations of ground-level ozone (O_3), nitrogen dioxide (no_2), and sulfur dioxide (SO_2). This ML algorithms are support vector machines, M5P model trees, and artificial neural networks (ANN). Two types of modeling are pursued: univariate and multivariate. The results show that using different features in multivariate modeling with M5P algorithm yields the best forecasting performance[4].

Paper 2– IOT- Based Air Pollution Monitoring and Forecasting System [8]
Authors Liu Xianpeng, XuPeng,Chen Xiaojun
Conference/journal – IEEE conference, 2015
In this paper a large number of field data provided by front-end sensor network makes big data analysis in background application layer more direct and effective, providing a real and effective decision-making[8]. The algorithm can be further improved which can increase number of input layer.

Paper 3– IoT for environmental variables in urban areas [1]
Authors: Jorge E. Gómez, Fabricio R. Marcillo, Freddy L. Triana, Victor T. Gallo,Byron W. Oviedo, Velssy L. Hernández
Conference/journal – ELSEVIER International Conference, 2017
In this paper a listener sensors were used to collect information and the management used as a mediator to the storage to retrieve and delivery information. Machine learning algorithm can be used to predict for the future air condition to deliver accurate information so as to take quick measurements.

Paper 4– A Comprehensive Evaluation of Air Pollution Prediction Improvement by a Machine LearningMethod [7]
Authors: Xia Xi, Zhao Wei, RuiXiaoguang, Wang Yijie, BaiXinxin, Yin Wenjun, Don Jin
Conference/journal – IEEE conference, 2015
In this paper the air pollution prediction works by air quality index using the machine learning algorithms. From experiments, for different city, the best result can be obtained by different group of feature selection and model selection[7]. I personally suggest that it is better to use real time sensors.

Paper 5– Wireless Sensor Network Based Pollution Monitoring System in Metropolitan Cities [6]
Authors: ShwetalRaipure. Deepak Mehetre
Conference/journal – IEEE International Conference, 2015
In this paper the uses AVR ATmega-32 Microcontroller and sensor grid to detect the sensor values from different sensor like parameters MQ5, MQ7, temperature and humidity dataset. The simulation results shows that performance of the quality of service increased in the network.

Paper 6–Distributed System as Internet of Things for a new low-cost, air pollution Wireless Monitoring on Real Time[5]
Authors: Walter Fuertes, Diego Carrera, César Villacís, Theofilos Toulkeridis, Fernando Galárraga, Edgar Torres, and Hernán Aules
Conference/journal – IEEE International Conference, 2015
In this paper low-cost wireless monitoring system, that enables air quality referential parameters measurements based on a multilayer distributed model. The used agile methodologies such as Scrum and extreme programming[5].

Paper 7– A smart environmental monitoring system usinginternet of things[9]
Authors: Dr. A. Sumithra, J.Jane Ida, K. Karthika, Dr. S. Gavaskar
Conference/journal – IJSEAS Journal, 2016
In this paper they applied IoT monitoring air or water quality, atmospheric or soil conditions to monitor air pollution using sensors along with cloud storage and big data analytics. I personally suggest that to include future prediction.

Paper 8– Machine Learning Approach to Forecasting Urban Pollution [2]
Authors: Yves Rybarczyk, Rasa Zalakeviciute
Conference/journal – IEEE 2016
In this paper they tried to address the question of how to predict fine particulate matter given a combination of weather conditions by Predicting the air pollution with 2223 dataset using decision tree algorithm.

Paper 9– IoT enabled Environmental Monitoring System forSmart Cities[10]
Authors: Jalpa Shah, Biswajit Mishra
Conference/journal – IEEE 2016
IoT enabled environmental monitoring systemf or monitoring temperature, relative humidity and CO2.

Paper 10 – Predicting Trends in Air Pollution in Delhiusing Data Mining[12]
Authors: ShwetaTaneja, Dr. Nidhi Sharma, Kettun Oberoi,Yash Navoria
Conference/journal – IEEE 2016
In this paper they tried to utilize data mining tool WEKA to predict future along with algorithm i.e linear regression and multilayer perceptron.

III. METHODOLOGY

A. Overview of proposed work

The internet of Things (IoT) is fundamentally connecting devices with an on and off switch to the Internet (and/or to each other). This incorporates everything from mobile phones, cooking machines, lights, wearable devices and practically everything. IoT comprises of all the web- enabled devices that gather, send and follow up on information they obtain from their encompassing surroundings utilizing installed sensors, processors and correspondence equipment. These " connected " or " smart " devices, can in some cases communicate with other related devices and follow up on the data they get from each other.

New IoT advances guarantee all the more fine-grained information,, better accuracy, and adaptability. Effective forecasting requires high detail and flexibility in range, instrument type, deployment, and arrangement. This enables early recognition , detection and early responses to prevent loss of life and property. In this work the required parameters are observed remotely using internet and the information collected from the sensors are kept in the cloud and to expand the assessed drift on the browser so as to forecast the pollution rate using a machine learning algorithm called recurrent neural network (RNN).

B. Proposed workflow

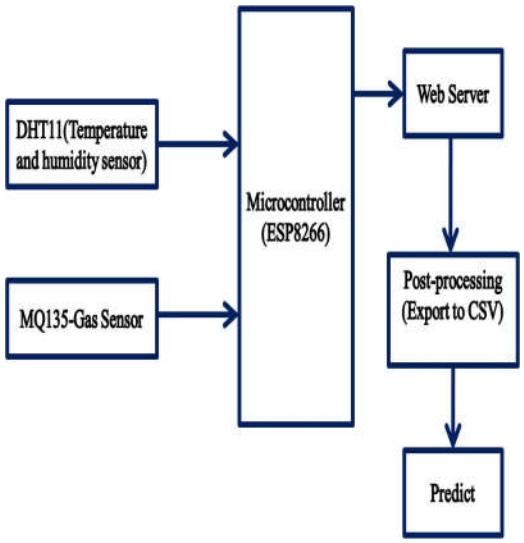

Fig 3.Flow of the proposed work

C. Real-time dataset

The data used in this work is collected from the DHT11 sensor for generating real-time digital temperature and humidity.

DHT11 and MQ135 sensor data

ID	Date and Time	Humidity	Temperature	Gas(PPM)
4330	2018-03-01 21:46:06	14	30	513
4331	2018-03-03 07:01:17	16	32	514
4332	2018-03-01 20:37:26	16	30	513
4333	2018-03-01 20:37:28	15	30	510
4334	2018-03-03 07:01:22	15	29	510
4335	2018-03-01 20:37:30	15	30	510
4336	2018-03-03 07:01:31	14	30	510
4337	2018-03-03 07:01:27	15	31	509
4338	2018-03-01 20:37:34	15	30	509
4339	2018-03-01 20:37:36	15	30	509

First << 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 >> Last

Fig 4. DHT11 and MQ135 sensor Dataset

IV. RESULT AND DISCUSSION

In this section the detailed implementation is presented. The experiment simulation is done by python 3.6.3 with tensorflow backend.

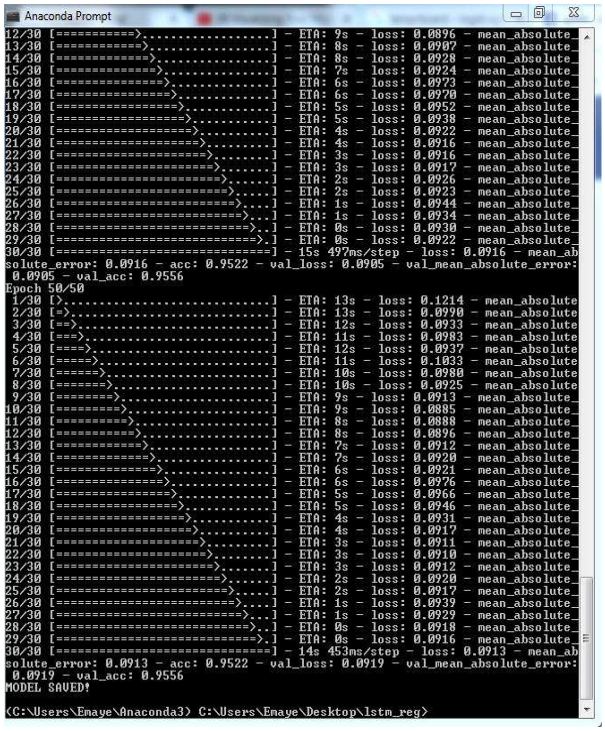

Fig 5. Training the LSTM model

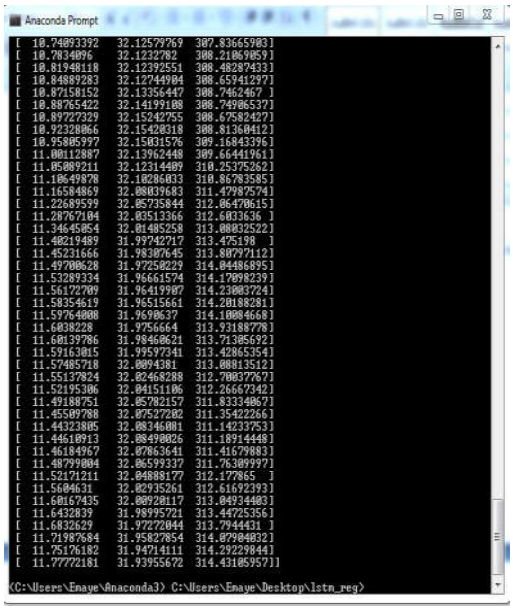

Fig 6. Making prediction using LSTM

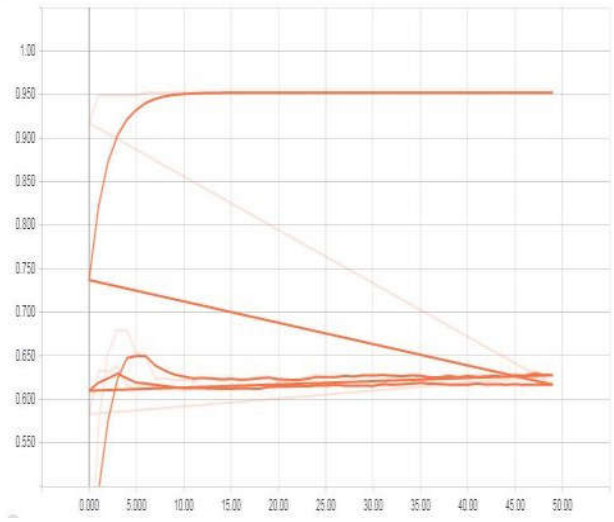

Fig 7. Curve of LSTM model accuracy

V. CONCLUSION

Now a day the air pollution in urban areas is a major issue in developed cities due to significant impacts of air pollution on public health, global environment and the whole worldwide economy. The proposed work on an air pollution monitoring and prediction system is enables us to monitor air quality with the help IoT devices. The system utilizes air sensors to detect and transmit this data to microcontroller. Then the microcontroller stores the data into the web server. For predicting the LSTM is implemented. It has a quick convergence and reduces the training cycles with a good accuracy.

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First and foremost I would like thank almighty GOD with his mother Saint Virgin Mary for everything that happens for me and make me patient, dedicated and courage to my work. I wish to warmly thank my guide**,** Asst. Prof. Rutvik Mehta for all his diligence, guidance, encouragement, inspiration and motivation throughout. Without his treasonable advice and assistance it would not have been possible for me to attain this landmark**.** He has always been willingly present whenever I needed the slightest support from him. Finally I am very grateful to my entire family and specially to my mother Mrs. Banchayehu Mekonen Awoke and my sister Ms. Etenesh Walelign Ayele.

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