International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-4, November 2019

An Intelligent Weather Monitoring System using Internet of Things

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Abstract*: With a drastic change in climate continuously it is very harmful to the people who are living in the disaster-prone areas. In some areas the people are not warned for the consequences of coming specifically in their areas, they are told about the average temperature and humidity of the city while the humidity and temperature vary at different altitude and changes at short distances. The system is a very cost-effective and efficient method for controlling and monitoring the weather, and it sends the data to the cloud so that it can be visible anywhere through internet. The temperature, humidity, and pressure play a significant role in different fields like agricultural, industrial and Logistical Field. Weather forecast is necessary for the growth and development of these industries. The Internet of Things (IoT) is the technology used in developing the proposed system, which is an efficient and advanced method for connecting the sensors to the cloud which can store real-time sensor data and connect the entire world of things in a network. Here things might be anything like electronic gadgets, sensors, and automotive electronic equipment. The system deals with controlling and monitoring the environmental conditions like Temperature, Pressure, Smoke, Relative humidity level and various other gases with sensors and sends the information to the cloud and then plot the sensor data in graphical form. An Intelligent prediction is to be done using machine learning. Machine learning is a branch of Artificial Intelligence (AI) which is a compelling method of Analyzing and predicting the given data-set. The data collected will be analyzed continuously. The real-time data which has to be sent through the sensor can be accessible throughout the world using the internet.

Keywords *: Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning, Weather Forecast.*

Manuscript published on November 30, 2019.

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I. NTRODUCTION

An IoT system contains smart devices which are connected to the internet and uses an embedded processor, sensors and communication hardware to save, transfer and perform an action on the data which they acquire from their

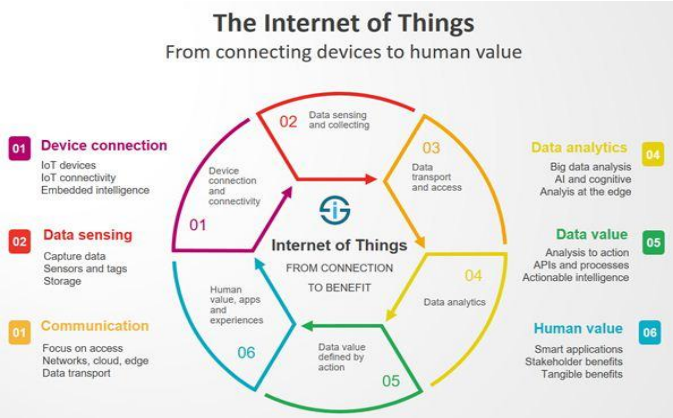

Fig 1: Internet of Things (IoT)

surroundings. IoT devices transfer the sensor data which they receive from connecting the IoT gateway or another edge device where data is transferred to cloud for analysis or being analyzed locally. Sometimes, these devices communicate with each other and take action according to the information collected from other devices. Fig 1 shows IoT devices can work without the help of people, although people can interact with the devices for performing tasks and getting more straightforward as well as accurate data, give them instructions or access the output.

II. WEATHER MONITORING & AIR POLLUTION CONTROL

Weather Monitoring System (WMAPC) is a system which monitors the humidity, temperature, pressure and various hazardous gases in the environment. It has various sensors like DHT11 which calculates the humidity and temperature, BMP180 which calculates the air pressure at different altitudes, MQ135 is used for measuring data at different levels. It is used in various areas like agriculture, disaster-prone areas people and day to day it will check the pollution in the environment. In this, we send the data to the cloud than using a machine learning algorithm prediction is carried out.

A. *Advantages of Weather Monitoring and Air Pollution Control*

- The WMAPC is a very cost-effective and efficient monitoring system. The sensors and
- microcontroller used in the system are very cheap and cloud to be used is also open source.
- It senses the temperature with error rate +-2^0 C.
- It senses the humidity which is range from 20% to 90%.
- It sends the data to the cloud so that we can check the data from anywhere 24*7.
- Using ML algorithms, it will predict the weather data.

III. LITERATURE REVIEW

Effective and cheap methods to monitor the quality of the air and prevent it from a potential hazard. The author collects the data from the app and analyzes the Air Quality Index (AQI) at different time intervals. They correlate CO and NO2 levels against humidity and temperature [1]. The embedded controller is designed to measure the temperature and humidity of the environment. The monitoring station sends the data through a wireless network on a web page. It uses the GPS module, Real Time Clock to measure real-time weather data at a particular location. The monitored data uploaded on the cloud using a mobile application. The sensor used is wind speed, wind pressure, temperature, and humidity [2].B.S.Rao et al.[3] have Created a wi-fi network by the client to get access the cloud services and microcontroller. The data is uploaded on the Thingspeak. The system used by the author is cost effective as it cannot use the DHT sensor which reduces the cost at a lesser extent. The author displays the result in the OLED display. It uses Wemos board instead of ESP8226 board which has inbuilt WIFI module.Kodali and his team [4] has developed a pressure monitoring system using CC3200 launch pad. The result obtained is compared with commercial thermometer and barometer. The sensors used are BMP085(Pressure Sensor), CC3200 and AT&TM2(cloud Technology). The average error in pressure measurement is 0.035%. In temperature measurement, the average error is 2.02%. The measured parameters are sent to the cloud services. The author works on Nodemcu which is also combined with different sensors like temperature, humidity, noise, CO and rain. The main advantage of this work is that it is low cost and less power consumption. It is installed anywhere to monitor the climatic changes. The system helps the user to select the best suitable environment. It uses various sensors like temperature, humidity, noise detector, and gas detector. Moreover, the data to be monitored on the website [5].The author S N Swamy and his team [6] uses repetitive data management to handle repeated data in IoT. RDMA algorithm is applied to data collected from different sensors like DHT11, Digital light sensor, pressure sensor, and rain detecting sensor. In this work, comparison between the repeated data and non-repeated data is presented successfully. The proposed algorithm reduces the 44.83% network load and eliminates the data processing overhead due to repeated data generated by different sensors in IoT. Durrani et al [7] have used various sensors like humidity, pressure, temperature, light, rain level sensor and Air Quality, and so forth are used. It acquires data from the different sensors and send data to the cloud and display the resultant data in the mobile App. It also predicts the next 24 hours data and forecast in the web. In this paper, the author also uses various machine learning algorithm like Recurrent Neural Network (RNN), Nonlinear Regressive Exogenous Neural Network, Time Delay neural network. It shows the data in various graphical forms like data show in ThingSpeak. It uses ThingSpeak as a cloud.Shakir and Rakesh have utilized Weka tool for clustering and regression. The dataset collected from the Karnataka pollution control board can be analyzed using Weka tool. It is very clear from the analysis that pollutants tendency is very high during working days. The author uses ZeroR classification method that depends on the target and ignores all the predictors.The authors Anandharajan et al [9] identified SVM used for prediction and works when there is a large number of features. The author uses various functions like cost function, hypothesis function, multiclass function, Gradient Descent. It uses the MATLAB tool by implementing vectorization concept.Various machine learning algorithms like Linear Regression, Multiple Linear Regression, SVM and ARIMA is used. Observed the characteristics of the various weather forecasting algorithms by applying the algorithms mentioned above. In this, the author collects data from various sensors and transfer the data to the various data centers or servers where processing and analysis are to be done [10].Ibhrahim et al [11] have used Micro-controller to monitor the weather characteristics like temperature, humidity, light, earthquake and air quality. It uses Raspberry Pi as a micro-controller. It uses various python libraries like pip, python-dev, python-eeml, RPI.GPIO and so forth. In this paper, the author provides monitoring and controlling the services in the remote areas and ad-hoc application which are usually not provided for the large system. It is an earthquake detection sensor which can save many lives. It takes information from the surrounding environment through the sensor and sends it to the internet. The author practices the NODEMCU as a microcontroller. It uses various sensors like BMP180 pressure sensor, DHT 11 temperature and humidity sensor, rain module, and light dependent resistor. This device is used for a particular place or surrounding Whenever the value is exceeding the threshold limit, it directly sends the alert SMS and emails to the owner about the alert that the level of the sensors is either above or below the predefined level [12]. Based on the above literature survey findings, We are proposing our new methodology in the next section.

IV. METHODOLOGY

Our Proposed Methodology is developed using publish and subscribe software pattern [13]. It will have the following steps.

Step 1: NodeMcu is gathering information from different sensors which is based on the code dumped in the microcontroller NODEMCU and sends data to the cloud via ThingSpeak and it displays data both in web view and app view.

Step 2: All the sensors are connected to the NodeMcu. It sends send data to the cloud and data analysis is carried out and it displays the resultant data in web view. In Fig. 2, our proposed system architecture is shown where arrow defines the flow of data.

Step 3: The data is imported from the cloud in the form of csv file. Fig. 3 shows the processing of data. Firstly, it imports the data from the cloud in R Studio and secondly the data is processed through various algorithms.

Step 4: Linear regression and multiple regression algorithm is used to display the data of weather.

Step 5: The result is shown in Arduino IDE, Rstudio,ThingSpeak and Mobile App view.

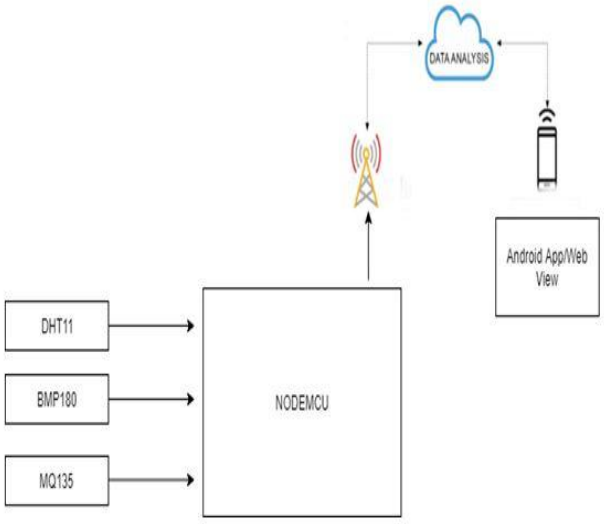

Fig 2 : System Architecture Diagram

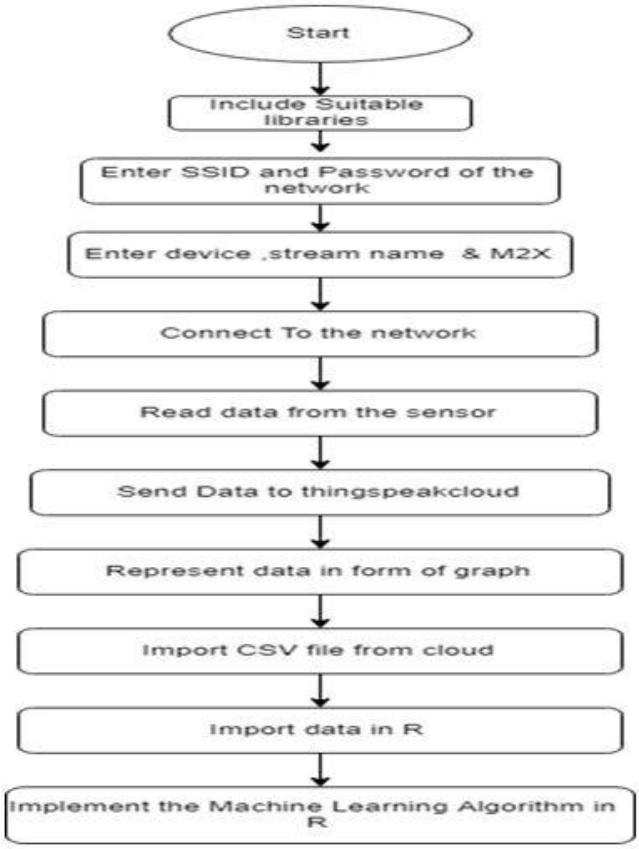

Fig 3: Processing Flow diagram

V. COMPONENTS USED AND ITS WORKING

NodeMCU: It is a microcontroller which has inbuilt Wi-Fi module. It supports bandwidth up to 2.4GHz. It has similar functionality like Arduino boards. It is a microcontroller very similar to Arduino UNO with the added benefit of inbuilt Wi-Fi Module. It has both analog and digital pins on its board. It ranges from D0 to D7.

DHT 11: The DHT 11 is a humidity and temperature sensor which is used in weather and environment monitoring of data. This is a very efficient and cost-effective sensor. It is widely used in cheap sensor. Its supply voltage is +5 volt. It senses the temperature which is range from 0^0 C to 50^0 C which has chances of error +-2^0 C. It senses the humidity range from 20% to 90%. It is one of the sensors of DHT series. dht.read is one of the function of DHT and it is used for reading the humidity and temperature from the sensor. Where pin number is the digital pin number from which output of DHT sensor is to be read.

BMP180: The BMP180 is a pressure sensor which is created by the BOSH sensor tech Pvt. ltd. Company. It is a high performance, cost effective and efficient device which enable the application in the new generation mobile phones like Tablet, Smartphones and other devices. It is same as BMP085 and takes many changes. It is very smaller in size. The ultra-low power consumption decreases to 3uA make BMP180. BMP180 is known for its stable behavior with reference to independency in supply of voltage. The BMP180 is also used for reading the temperature and it uses bmp.read() function for reading the data from the BMP180 sensor.

MQ135: The MQ135 gas sensor is a air quality sensor which senses various gases like oxygen, smoke, ammonia, sulphide and nitrogen etc. Operating Voltage of MQ135 ranges from 2.5V - 5V.The MQ135 gas sensor has low conductivity to clean the air. In environment we can easily find the pollutants or particles of pollutants but the conductivity of the gas sensor is high when the concentration of the pollutants in the air increases. It is used to detect various harmful gases benzene, smoke and other harmful and toxic gases which are available in the environment. It is very cheap, cost effective and efficient which can last for years. There are various types of sensors in the series of MQ like MQ2, MQ3, MQ6 and MQ135 etc. these are all used for checking various types of gases.

VI. LIBRARIES USED

DHT Library: The DHT11 library is used for connecting the DHT11 sensor to the Arduino IDE or microcontrollers. It contains 4 files DHT.cpp, DHT_U.cpp,DHT.h, DHT_U.h. It is used for connecting all the DHT series sensors to the Arduino IDE. It is created by the Adafruit.

ThingSpeak: This library is used for connecting various microcontrollers to the ThingSpeak cloud so that we can easily read, write and store data in graphical form. It easily converts the data to be stored into .xlsx file format. It has 2 files ThingSpeak.h and ThingSpeak.cpp.

Adafruit: Adafruit sensor library is a library which contains the drivers of the unified sensors. It is used for connecting the NodeMcu. It also contains files Adafruit_ESP8226.h and Adafruit.cpp for the connectivity process.

BMP: The BMP library is used for connecting the BMP series sensors to the different kind of microcontroller. This library contains 2 library files which is BMP180.cpp and BMP180.h. It is used for connecting the BMP 180 Sensor.
MQ135: The MQ135 library is used for connecting the MQ135 Air quality sensor to the NodeMcu or various micro controller. It contains two files MQ135.cpp and MQ135.h.

VII. SOFTWARE USED

A. *Arduino IDE*

The Arduino IDE [14] is a software which is act as an interface between the microcontroller board and the computer. The integrated development environment (IDE) is an inter-platform application (for UNIX, Windows, Mac and Linux operating systems) which is coded in language Java. It is widely used in writing & uploading the code in different kind of Arduino UNO boards and microcontrollers like NodeMcu and Wemos board and so forth. It has a set of libraries which is used for connecting various sensors and libraries. It provides the facility of the serial monitor through which we can see the output of the code and it can be dumped in the microcontroller. It compiles the code before it is been uploaded into the microcontroller and checks all the errors which are either of the library error or syntactical error. It is an open source software in which source code is to be written and debug and it is supported by arduino.cc. It saves the file under the .ino extension.

B. *R Studio*

R studio is an open source software which is used in place of R software. It makes the R more comfortable to use, code and ease to understand. It includes text editor, debugger and various other visualization tools. Though we can easily install R packages and we can also run the command efficiently. It is an active member of the R Community. It is the same as but it provides a platform which is easy to understand and code can be written quickly.

VIII. TECHNOLOGIES USED

A. *ThingSpeak*

ThingSpeak is an analytics platform for IoT devices which provide service from Math Works, the creators of MATLAB and Simulink. It allows us for graphical visualization, aggregation, storing and analyzing real-time data in the cloud. The architecture of ThingSpeak is shown in Fig 4. It provides instant picturization of graphical data uploaded by our sensors or devices. The User can execute MATLAB code in the ThingSpeak cloud. It processes the data and shows the result in graphical form. It increases the development of proof of concept of IoT systems, especially those that need analytics. We can quickly build an IoT application without the development of any web-based software or setting up of any server.

The Feature of ThingSpeak is:

- It is easy to send the data to thingspeak as it uses various IoT protocols.
- It visualizes the live sensor data streams
- Aggregate data on-demand from third-party sources.
- It uses MATLAB for the analysis of real-time data.
- Run our IoT analytics platform directly based on events and Schedules.
- We can quickly build the IoT application without the development of web-enabled application and set up the servers.
- Directly act on our data and communicate by third-party services like email, SMS Twitter, and soforth.

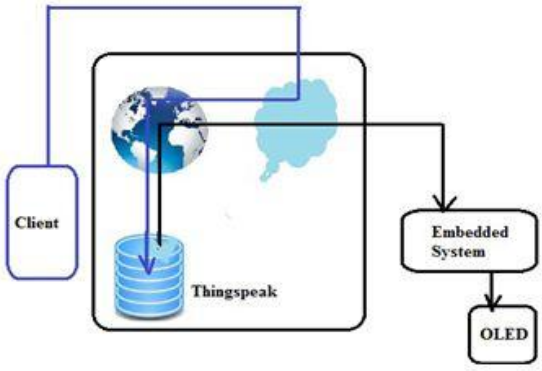

Fig 4: Architecture Of ThingSpeak

IX. ALGORITHMS USED

A. *Linear Regression*

Linear Regression is one of the machine learning algorithms which is used for identifying the relationship between a dependent variable and independent variable. It determines whether one variable expressed its relationship with the other variable or not. Linear regression used for identifying the relationship between temperature, humidity and Predict the humidity based on the temperature. In linear regression, we have used two variables, one is Dependent variable whose value we want to predict, and the Independent variable is a variable through which we can predict the value. In this, first we have to take training dataset and to use training dataset we will obtain a regression line which will give a minimum error. The prediction is to be done using the equation

$$Y=b0+b1*X \quad (1)$$

In the above equation, b0 and b1 are constant, and x is an independent variable and y is a dependent variable, the value of b0 and b1 is to be taken for minimizing the error.
If b1>0, then x and y have a positive relationship and If b1<0, then x and y have an inverse relationship or negative relationship.
It is the linear method for identifying the relationship between two variables in which one is dependent, and one is Independent.

B. *Multiple Regression*

Multiple Linear Regression is similar like linear regression or an updated version of linear regression as in linear regression has one independent variable, and in multiple regression, it has multiple independent variables. It is used to identify the relationship between the dependent variable with two more Independent variables. In Multiple regression, we will predict the value of the dependent variable, and the value which will predict is based on Independent variable. We have used Humidity as a dependent variable. The prediction equation is: -

$$Y=a+b_1*x1+b_2*x2+\ldots. bq_*Xq \quad (2)$$

In the above y is a dependent variable, a is a constant and x is an independent variable. Multiple Regression requires two or more independent or predictor variables. The multiple regression is used to identify the power and effectiveness of the independent variable. Multiple Regression is used for analyzing future trends and predicts future values.

X. RESULTS

System modelling [15] is done and the results of temperature, humidity, pressure, air quality data of weather reporting and air pollution control is shown in Arduino IDE, Rstudio, Mobile Appview, Think speak web view. In the Fig 5, Fig 6, Fig 7 and Fig 8 shows the result of weather reporting.

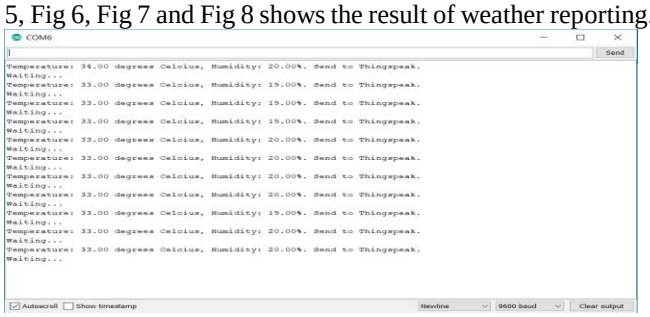

Fig 5:Temperature and Humidity using Arduino IDE

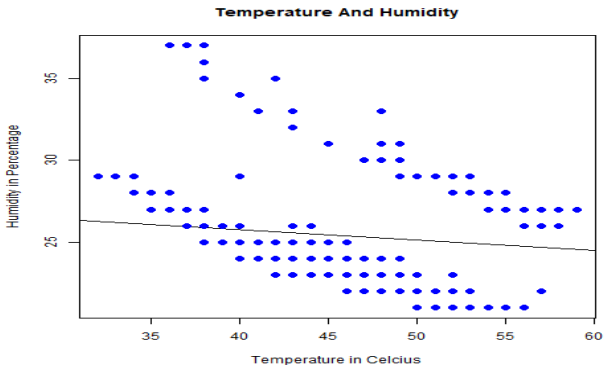

Fig 6 : Temperature and Humidity using R Studio

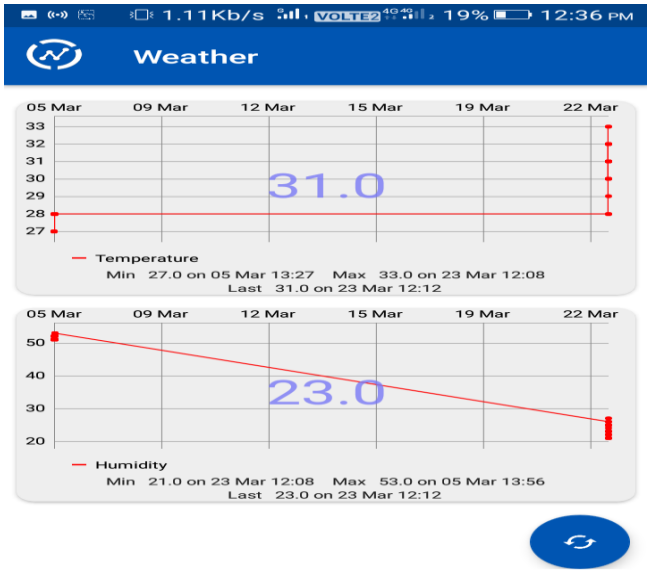

Fig 7: Mobile app view of weather

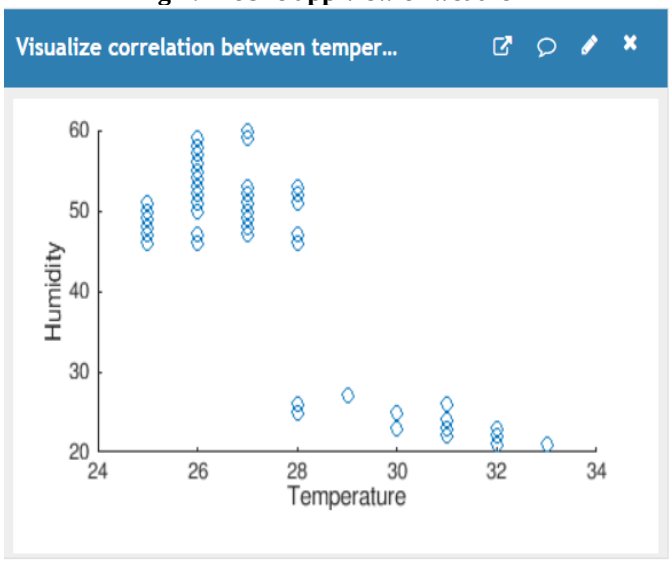

Fig 8: Correlation between Humidity and Temperature using Thing Speak Web View

XI. CONCLUSION & FUTURE WORK

There is many weather monitoring system and air pollution control system, but now they become obsolete and expensive as they are used for the whole city, not for a particular location. Now we have to make a system which is both cost-effective and efficient.

The proposed system monitors the temperature, humidity, pressure and Air Quality. Through this proposed system, we observe that there is a positive relationship between temperature and humidity. In future, we can also add various sensors like earthquake detection sensor, light sensor, rain level sensor, light sensor and send data to the cloud and the user can interact with the system through the app.

In future, we can also add various machine learning and artificial intelligence algorithms like Artificial Neural Network (ANN) and Backward Neural Network (BNN) for predicting the future weather and its effects on the surroundings.

ACKNOWLEDGMENT

I express my sincere gratitude to Vellore Institute of Technology, Vellore, Tamil Nadu for the support provided.

REFERENCES

1. H. Aamer, R. Mumtaz, H. Anwar and S. Poslad, "A Very Low Cost, Open, Wireless, Internet of Things (IoT) Air Quality Monitoring Platform," In 2018 15th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT (HONET-ICT), IEEE, pp. 102-106, October 2018.
2. S. Halder and G. Sivakumar, "Embedded based remote monitoring station for live streaming of temperature and humidity," In Electrical, Electronics, Communication, Computer, and Optimization Techniques (ICEECCOT), IEEE, pp. 284-287, December 2017.
3. B.S Rao, D. K. S Rao and M.N Ome, " Internet of Things (IOT) Based Weather Monitoring system," International Journal of Advanced Research in Computer and Communication Engineering, vol. 5, pp.312-319, September 2016.
4. Iyapparaja M et.al. 2012 Coupling and Cohesion Metrics in Java for Adaptive Reusability Risk Reduction IET Chennai 3rd International Conference on Sustainable Energy and Intelligent Systems (SEISCON 2012),52-57.
5. D.V Palle and R.R Kanchi, "Cloud-Based monitoring and measurement of pressure and temperature using CC3200," In Intelligent Systems and Control (ISCO), 2017 11th International Conference, IEEE, pp. 393-397, January 2017.
6. S.N Swamy and C.N Sowmyyarani, "Repeated data management framework for IoT: A case study on weather monitoring and forecasting," In 2018 4th International Conference on Recent Advances in Information Technology (RAIT) ,IEEE, pp. 1-7, March, 2018.
7. Iyapparaja M, Bhanupriya Sharma, Augmenting SCA project management and automation Framework, IOP Conf. Series: Materials Science and Engineering 263 (2017) 042018 doi:10.1088/1757-899X/263/4/042018,pp-1-8
8. M. Shakir and N. Rakesh, "Investigation on Air Pollutant Data Sets using Data Mining Tool," In 2018 2nd International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC) I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC), 2018 2nd International Conference on IEEE, pp. 480-485, August 2018.
9. T.R.V Anandharajan, G.A Hariharan, K.K Vignajeth and R.Jijendiran, "Weather monitoring using artificial intelligence," In 2016 2nd International Conference on Computational Intelligence and Networks (CINE), IEEE, pp. 106-111, January 2016.
10. G. Chavan and B. Momin, "An integrated approach for weather forecasting over Internet of Things: A brief review," In 2017 International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC) ,IEEE, pp. 83-88, Feburary 2017.
11. Iyapparaja M, Tiwari. M, Security policy speculation of user uploaded images on content sharing sites , IOP Conf. Series: Materials Science and Engineering 263 (2017) 042018 doi:10.1088/1757-899X/263/4/042019,pp-1-8
12. R.K Kodali and S. Mandal, " IoT based weather station," In 2016 International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT), IEEE, pp. 680-683, December 2016.
13. P. M. Jacob and P. Mani, "Software architecture pattern selection model for Internet of Things based systems," in *IET Software*, vol. 12, no. 5, pp. 390-396, 10 2018. doi: 10.1049/iet-sen.2017.0206
14. P. M. Jacob and P. Mani, "A Reference Model for Testing Internet of Things based Applications", *Journal of Engineering, Science and Technology (JESTEC)*, Vol. 13, No. 8 (2018) ,pp. 2504-2519.
15. P. M. Jacob, Muhammed Ilyas H, J. Jose and J. Jose, "An Analytical approach on DFD to UML model transformation techniques," *2016 International Conference on Information Science (ICIS)*, Kochi, 2016, pp. 12-17.

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