An IoT based Air Quality Monitoring with deep learning model System

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Abstract. Air pollution occurs when the environmental gases such as CO2, NH3 etc. concentration levels go above the optimum level. As the AQI is being calculated and as per the Central Pollution Control Board (CPCB), there is standard level of ranges for pollution level. This paper presents about monitoring the pollution level using Raspberry Pi 3 based on IoT technology. Here, the temperature, humidity, due point and wind speed parameters are also monitored and use of these parameters as data sets for prediction of pollution forecasting.
Then, the target of this project is applying the deep learning concept for the prediction and analysis of gas sensors pollution level so that we can analyze the pollution level due to the pollutant gases based on prediction analysis. Various experiments being performed validation of the development of the system for real-time monitoring. Here, We are discussing about the different methods used in deep learning i.e. Artificial Neural Networks (ANN), Multilayer Perceptron (MLP) and Recurrent Neural Networks (RNN) using LSTM model to analyze and predict the multivariate time series forecasting.

Keywords: Internet of Things (IoT) · Raspberry Pi 3 · Recurrent Neural Networks (RNN) · Long Short Term Memory (LSTM) · Air Quality Index (AQI).

1 Introduction

Pollution is the major concern in the current scenario. As we are moving forward towards smart city development, air pollution is one of the important concern for human health and other living beings. Any changes in the composition of air can cause sage harm to different life forms. Air pollution is the presence of one or more contaminants in the atmosphere such as pollutant gases in excess quantity that can harm human beings, animals and plants. Air pollutants are measured in percentage form or ppm.

1.1 Existing and Proposed Model

A gas sensor is a form of transducer that detects molecules of gas and transforms it into an electrical signal with a magnitude proportional to the concentration

level of the gas. Previously, the instruments using analytical techniques for monitoring the different gas sensor concentration were used. These instruments provide adequate accuracy but there are some disadvantages such as large size which become bulky, costly instruments and high maintenance cost, slow response time and the requirement of trained operators.

2 Literature Survey

Tajne K.M et al. [1] presented an idea of implementing air pollution monitoring system based on WSN to analyze air pollution in Nagpur city used for monitoring and controlling the air quality in Nagpur city providing alert message system. A. R. Al-Ali et al. [5] presented the monitoring system consisting of Mobile Data-Acquisition Unit integrating MCU, Sensors array, GPS module, GPRS module and a server. It gathers air pollutant levels, uploaded to GPRS modem and sent to server and is tuned to Google maps for displaying real time air pollutant levels. Khaled Bashir Shaban et al. [6] focused on applying the ML algorithms building forecasting models to analyze the concentration levels of O3, NO2 and SO2. The algorithms are ANN, SVM and M5P model trees and the performance measures are taken based on accuracy and root mean square error (RMSE). H. Khelifi et al. [7] presented to merge CNN and RNN with IoT and information centric networking. CNN is used to extract reliable data from the environment and RNN is integrated to model the data in real time applications. CNN is having four layer steps i.e. local receptive field, shared weights, pooling and activation. V. O. K. Li et al. [8] discussed about the M-BP algorithm to retrieve and fill the missing data. It proposed a big data framework based on deep learning taking urban dynamics data. The framework is comprised of the LSTM model to resolve for missing data.

3 Methodology

3.1 Architecture Model

The Proposed model of the system is as follows. Fig. 1 shows the architecture model of the whole system. The block diagram of the system depicts the hardware requirements and the working principle for a particular proposed system model [9]. The device will be set up to take the environmental data and there will be a base standard value. The device will collect data and based on the set values it will show the output.

3.2 Flowchart Model

The proposed system Comprises of Hardware and software section. The gas sensors are calibrated [2] before to sense the air pollutants accurately. The coding is done in python. The data is stored in cloud server using Firebase server database. Fig. 2 shows the flowchart model. Then, the data set is used for the prediction of pollution based on deep learning algorithms as here being used as LSTM based on RNN.

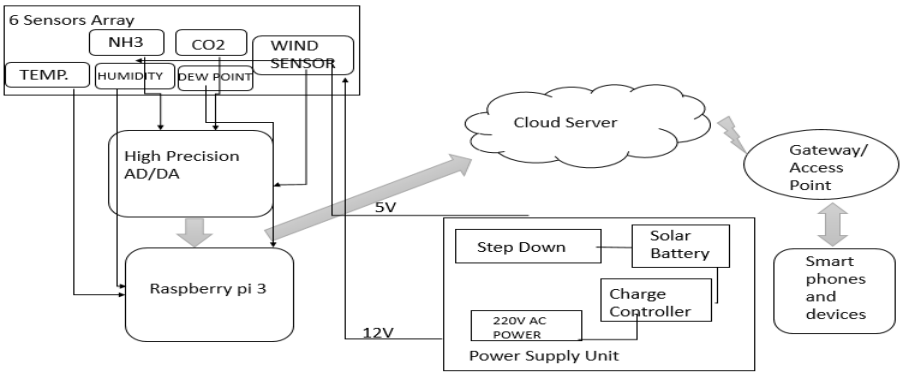

Fig. 1. System Architecture Model.

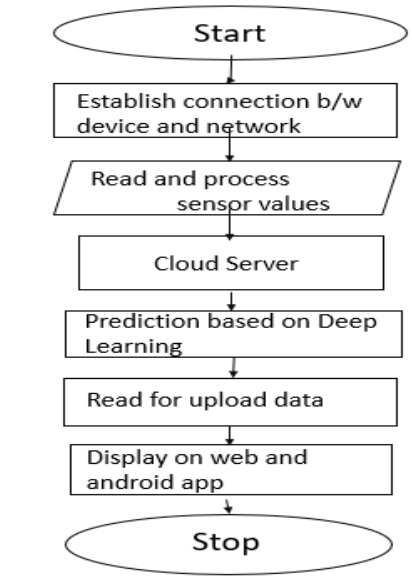

Fig. 2. Flowchart Model Diagram.

3.3 Deep Learning

It is a subset of machine learning in AI [7] that makes unsupervised learning from unstructured data. Here, the network is built as neurons connected to each other same as in case of human brain. It makes the hierarchical approach to process and analyze linear as well as non linear data. There are number of algorithms based on deep learning i.e. Recurrent Neural Networks, Recursive Neural Networks etc. RNN algorithm is designed to process the speech signal and text based data sets which makes use of feedback loop from the output of hidden layer back to the input of same layers.

Recurrent Neural Networks (RNN): RNN is a type of neural networks which is very useful in processing a huge data sets which makes use of training and testing the data sets making use of recurrent i.e. feedback given back to the hidden layers to optimize the training model based on which the prediction of data can be made near to accurate. It uses LSTM model for making as a feedback loop where output from previous step is fed is feed to the input of current step. It is useful in prediction for real time series forecasting model [6].

Recurrent Neural Network Algorithm: Fig.3 shows the algorithm of deep learning for prediction and forecasting is done using RNN using LSTM i.e. long short term memory [8]. In the given algorithm, first the data is being loaded as the data sets contain parameters being used for forecasting. Then, the scaling of data is done. The data set is prepared for learning by splitting the data set into training and testing data sets. Then, the LSTM model is created for training the model based on which the loss vs epoch graph plot is obtained.

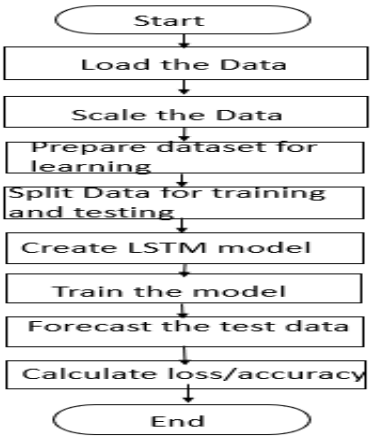

Fig. 3. RNN Algorithm Diagram.

4 Results

4.1 Firebase Server Database

In the proposed work, some of the real time parameters like temperature, humidity, dew point, wind speed, NH3 and CO2 gas sensor values is stored in firebase database.

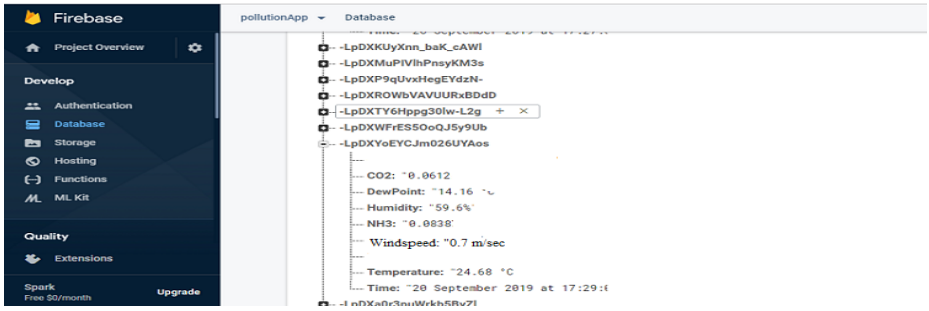

Fig. 4. Real time Data Packets in Database.

4.2 RNN Model loss vs epoch graph output

The RNN algorithm uses LSTM. The data sets include parameters of pollution level, temperature, humidity and wind speed based on the model is being trained and testing data sets is validated by plotting loss vs epochs that concludes about minimum error in testing data sets over training data sets as number of epochs increases. The test RMSE obtained is 23.714%

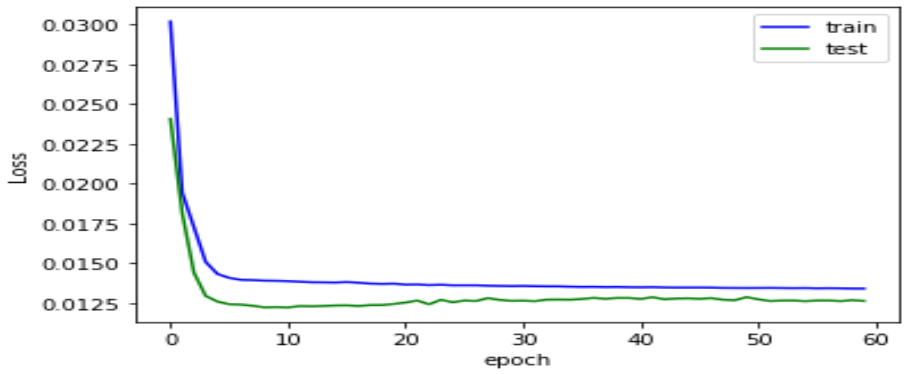

Fig. 5. loss vs epoch graph.

5 Conclusion

In this paper, the air pollution monitoring system is being developed to monitor and analyze the real time air pollutant concentration level and calculating the AQI level in the environment. The real time data is then stored in cloud server and can be retrieved on web services with deep learning model being used to understand the prediction problem in time series forecasting model.

6 Scope for Future Work

Prediction and analyzing the AQI/Pollution level using Deep Learning with different techniques and comparing the accuracy of prediction. The end node hardware is to to be completed for routing with 3D modelling printing. One can also implement data analytics to classify the pollution data into an area based on various pollutants and their effects on human health's.

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