Urban Air Pollution Monitoring System with Forecasting Model

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Abstract— In this paper a system for monitoring and forecasting urban air pollution is presented. The system uses low-cost air-quality monitoring motes. The model are prepared form receiving and storing the data, preprocessing and converting the data into useful information, forecasting the pollutants based on historical information. The focus of this paper is on the monitoring system and its forecasting model. Machine learning algorithm are used to build accurate forecasting models for concentrations of sulfur dioxide (SO2), nitrogen dioxide (NO2), Respirable Suspended Particulate Matter (RSPM), Air quality index (AQI). This paper focus on the prediction possibilities in urban air pollution monitoring system by using neural network using MATLAB program. A system for monitoring and forecasting urban air pollution was presented. The data was collected from government owned installations i.e. Maharashtra Pollution Control Board. This data was then subjected to intelligent processing and the ML algorithm was designed to present a model which is able to forecast. It is intended to develop a system which is able to forecast concentration values of sensors some hours ahead. The outcome of this paper can be useful for alarming applications in areas with high air pollution levels.

Key words: Neural Network, Forecasting, Air Quality Index (AQI), Respirable Suspended Particulate Matter (RSPM), Machine Learning

I. INTRODUCTION

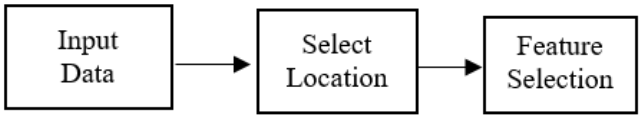
A system for monitoring and forecasting urban air pollution is presented. Urban air pollution has a direct impact on human health especially in developing and industrial countries, where air quality measures are not available. Recent studies have shown substantial evidences that exposure to atmospheric pollutants has strong links to adverse diseases including asthma and lung cancer. Urban air pollution means the pollution of large industrial city and nearby area. More and more large-size factories will be built during the development of these industrial cities, and a large number of exhaust gas will be discharged because of the daily production of iron and steel industry, petrochemical industry, foundry industry, machinery industry and thermal power industry, etc. Therefore, how to forecast the discharged exhaust gas scientifically becomes a pressing problem. In order to offer better environments for the residents, many developed countries have launched some relevant researches. It is important to realize that no single method is universally applicable. Neural networks are currently applied to wide range of applications, in addition to traditional areas such as pattern recognition and control systems. Its nonlinear learning and interpolative smoothening capabilities have proven superior to conventional methods in solving certain capable of predicting the future values of time series by extracting knowledge from the past. Neural network have to be proven to traditional techniques for forecasting model. Prediction sometimes based on facts or evidence, but categories of problems, one of which is time series predictions. Applying neural networks are not always. It is actually what would happen assumes that future occurrences are based, at least, on presently observable or past events. Moreover, it assumes that some aspects of the past pattern will continue into the future. Past relationships can then be discovered through study and observation. Forecasting the future values of an observed time series is an important problem in many areas, including economics, production planning, safety, diagnostics, and signal processing. Over the last thirty years, many approaches to forecasting have been developed. A wide variety of different forecasting methods are thus available.

Here we have predict four main gaseous that will affect the environment that are So2, No2, RSPM, AQI with the help of neural network. Neural network is used here because these are learning techniques that will predict the data from historical data. The work presented in this paper focuses on the development of accurate forecasting models for predicting future average concentrations of some urban air pollutants, namely: SO2, NO2, RSPM and AQI all of which are mentioned as being harmful in the WHO's guidelines.

II. BLOCK DIAGRAM

In training, data with known target values are collected from the Government owned installation .i.e. Maharashtra Pollution Control Board. Then we will select the location here we have selected Nagpur. A subset of feature is selected, we have selected here So2, No2, RSPM, AQI and then used to construct a forecasting model. There are many subsets of features selected and various neural network algorithm used; therefore, there are various predictors that can be trained.

A. Training



B. Testing

Fig. 1: Block Diagram of ML- based Prediction Model

In testing, data is divided into three parts i.e. training, testing and validation. Training is 70%, testing is 15% and validation is 15%.Neural network is training with the help of Autoregressive method and we get the predicted accuracy data.

III. NEURAL NETWORK

The term neural network (NN) has been conducted right after the recognition of the way the human brain computes. The human brain computes in an entirely different way from the conventional computer, the brain is a highly complex, nonlinear and parallel information processing system. The brain computing process to perform a certain computation is many times faster than the fastest digital computer in existence today, due to the capability to organize its structural constituents, known as neurons. The brain accomplishes perceptual recognition tasks routinely, e.g. recognizing familiar face embedded in an unfamiliar scene. A neural network is a machine that is designed to model the way in which the brain performs a particular task. The network is implemented by using electronic components or is simulated in software on a digital computer. A neural network is a massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experimental knowledge and making it available for use. It resembles the brain in two respects:

1) Knowledge is acquired by the network from its environment through a learning process.
2) Interneuron connection strengths, known as synaptic weights, are used to store the acquired knowledge. The procedure used to perform the learning process is called a learning algorithm, the function of which is to modify the synaptic weights of the network in an orderly fashion to attain a desired design objective.

IV. FORECASTING USING NEURAL NETWORK

Designing a neural network that predicts urban air pollution time series require a well thought through process for picking the large number of parameters that needs to be decided upon. The eight-step procedure has presented below:

1) Step 1: Variable selection the input parameters used in the neural networks has been technical as well as fundamental. Although one would believe that the more inputs the better, studies show that the predictive power was decrease if too much information is fed to the system as increased noise eventually will confuse the network FORECASTING USING NEURAL NETWORKS. A review of metrics used for prediction in previous research followed by a data selection model has consequently be introduced to find the set of input parameters that maximizes the predictive power of the network.
2) Step 2: Data collection Data of the financial assets as well as the fundamental data has been collected via Maharashtra Pollution Control Board database.
3) Step 3: Data preprocessing the data collected from the MPCB database has been preprocessed to be suitable for the networks.
4) Step 4: Training, validation and testing sets. The data set has been partitioned into different subsets to fulfill different purposes in the design of the neural networks. One set has been used for training the network to recognize patterns in the data. A second set has been used for the model selection algorithm, and hence generate data that has act as decision basis to choose the configuration that has best predictive power on the specific time series. A third set was used to provide a final evaluation of the model. It is important to leave this third set truly untouched in order to not bias the design of the networks.
5) Step 5: Neural network paradigms a common method to describe a neural network is to introduce it as a node network. The five types of neural network are used as forecasting models today. In addition to different types of network there are lot of design parameters to choose between as well, which means that a neural network can be constructed in an infinite number of ways. The architecture of the neural network refer to how the network is organized. The network can be divided into three vital sets of layers: input layer, hidden layers and output layer. Choosing the number of layers and the number of nodes within each layer is crucial parameters. Within neural network terminology these are called hyper-parameters. Increasing the number of hidden layers provides the ability to generalize, but in practice a network with only one or perhaps two hidden layer(s) and sufficient number of nodes is enough and have historically shown good performance. Several architectures will be tested for every forecast, and then a model for selecting the number of hidden layers and the number of nodes with the highest performance was defined. Further, an important design parameter is the activation function, which specifies how the data is transformed between nodes. The choice of this function has been based on the form of the output data.
6) Step 6: Neural network training In order for a network to be able to recognize patterns it needs to be presented with observations from the training data set as paired inputs and outputs, called supervised learning. This allows computation of the optimal weights between the neurons. Training was carried out with an optimization heuristic to find the set of weights that minimizes the error function.
7) Step 7: Evaluation criteria Once the networks are trained them has been tested on validation data sets. This allows comparison of estimated out-of-sample predictive performance of different architectures. The network that has the best predictive performance on the training sets for every time series respectively has been assumed to have the best generalization ability. This network was used for evaluating the neural network technique on the test set.
8) Step 8: Implementation The actual implementation of the neural network.

V. EXPERIMENTAL RESULTS

Prediction with time is done. The air pollution data of one year is used as input to predict the air pollution of the next year as output. The final approach of the suggested air pollution prediction model. This station measures SO2, NO2, RSPM, AQI.

Location	Parameters	Actual value	Predicted value	Accuracy
Civil lines	So2	10	95	15%
	No2	32	89.54	42.46%

	RSPM	104	98.65	94.65%
	AQI	103	97.99	94.99%

Fig. 3: Table for Result of So2, No2, RSPM, AQI at Location Civil Lines

Location	Parameters	Actual value	Predicted value	Accuracy
Divisional Commissioner Office	So2	10	98.38	11.62%
	No2	59	98.38	60.62%
	RSPM	86	103.31	82.69%
	AQI	86	91.10	94.9%

Fig. 4: Table for Result of So2, No2, RSPM, AQI at Location Divisional Commissioner Office

Location	Parameters	Actual value	Predicted value	Accuracy
Hingna Road	So2	16	105.2	10.8%
	No2	50	101.9	48.1%
	RSPM	166	101.4	35.4%
	AQI	144	93.33	49.53%

Fig. 5: Table for Result of So2, No2, RSPM, AQI at Location Hingna Road

Location	Parameters	Actual value	Predicted value	Accuracy
Sadar	So2	11	92.09	18.19%
	No2	35	97.17	37.83%
	RSPM	144	98.38	54.38%
	AQI	29	97.17	31.83%

Fig.6 Table for Result of So2, No2, RSPM, AQI at Location Sadar

Location	Parameters	Actual value	Predicted value	Accuracy
North Ambazari Road	So2	14	92.09	21.9%
	No2	48	97.17	50.83%
	RSPM	144	98.38	54.38%
	AQI	29	97.17	31.83%

Fig. 7: Table for result of So2, No2, RSPM, AQI at location North Ambazari Road

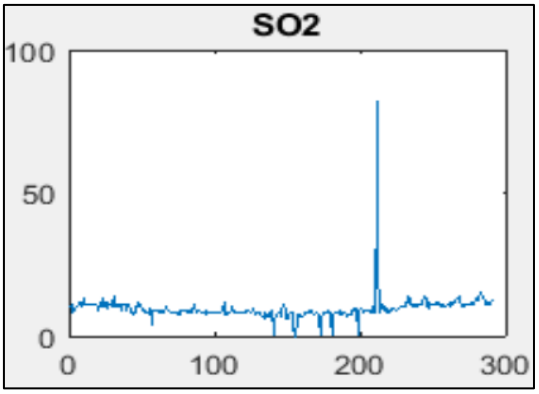


Fig. 8: Graph of Actual Value of SO2

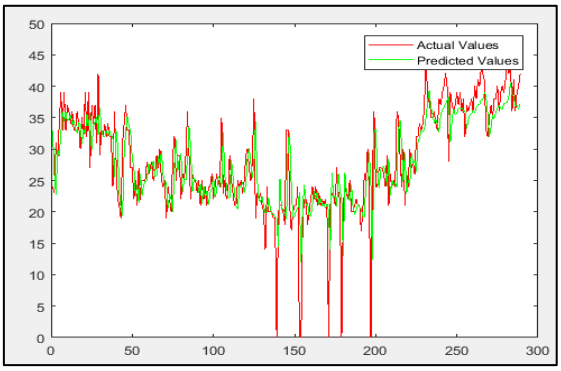


Fig. 9: Graph of Predicted Value for SO2 at Civil Lines

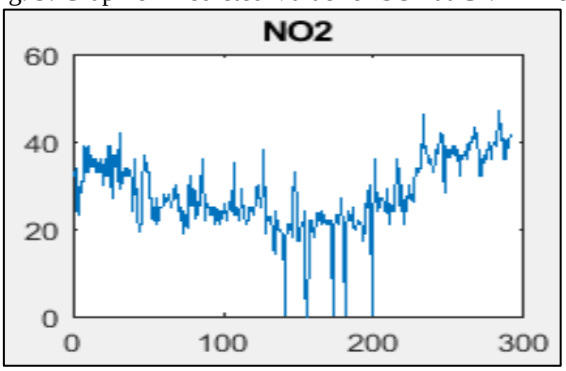


Fig. 10: Graph of Actual Value of NO2

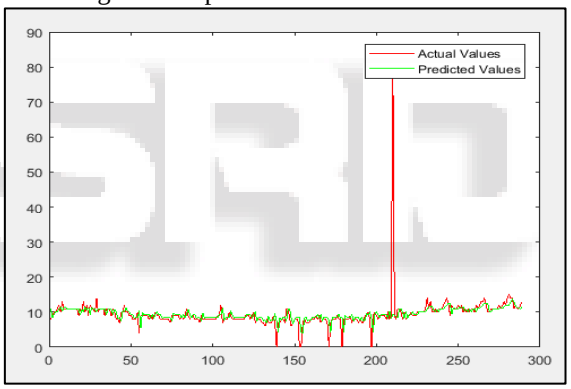


Fig. 11: Graph of Predicted Value for NO2 at Civil Lines

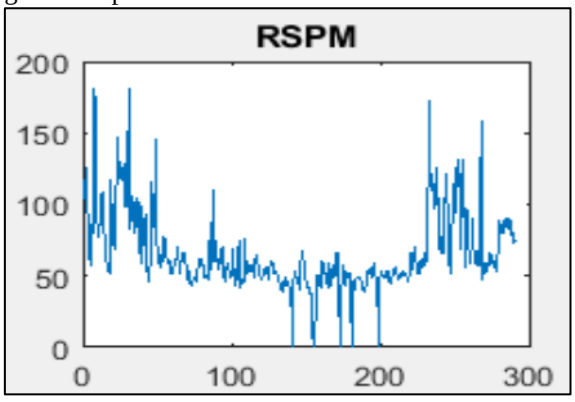


Fig. 12: Graph of Actual Value of RSPM

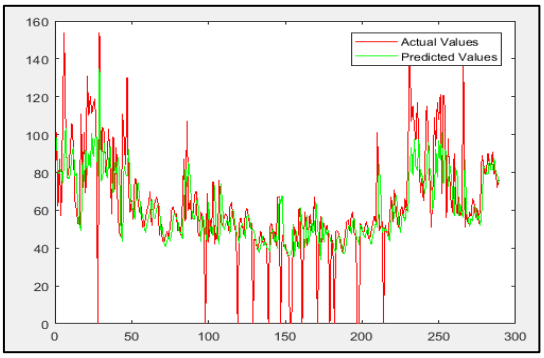


Fig. 13: Graph of Predicted Value for RSPM at Civil Lines

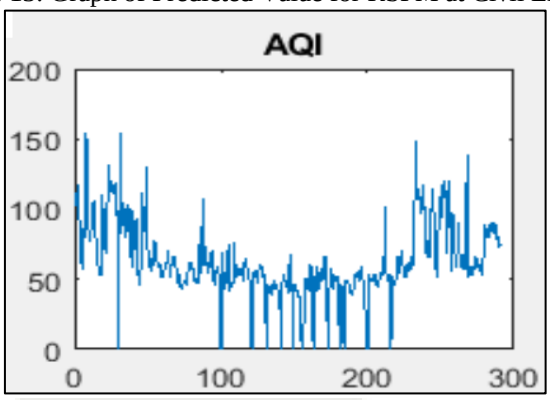


Fig. 14: Graph of Actual Value of AQI

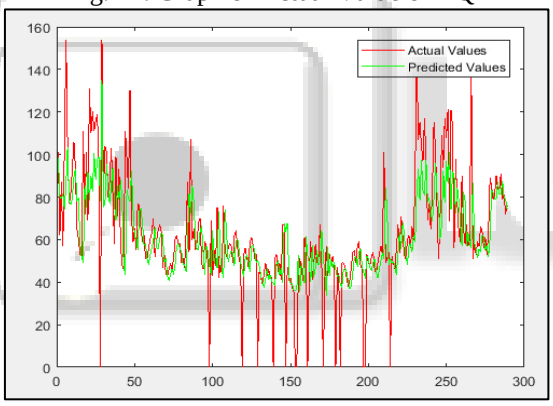


Fig. 15: Graph of Predicted Value of AQI at Civil Lines

VI. Conclusion

Air quality is a measure problem of the environment that directly effects human health. Air quality measures are collected from government installation and this data is analyzed to forecast concentration values of pollutants using neural network. In this work we collect real time data from different locations and provide detailed pollution map to maintain data accuracy**.** These models predict 24 hours ahead of concentration values.

VII. Future Scope

Air pollution is responsible for an increasing number of mortality and morbidity cases in Indian cities. In a recent study, based on published information on air quality monitoring from the Central Pollution Control Board (Delhi, India) and hospital admissions records from cities across India, the city of Delhi was declared the "Asthma Capital" of India. Air pollution is a complex issue, fueled by multiple sources ranging from – vehicle exhaust, re suspended dust on the roads due to vehicle movements, industrial flumes, construction debris, garbage burning, domestic cooking and heating, and some seasonal sources such as agricultural field residue burning, dust storms and sea salt (for coastal areas). While state and national authorities are taking necessary action and introducing interventions in varying capacities to curb these emissions and reduce ambient pollution levels, a lack of coherent policy as well as unplanned growth across sectors (construction, transport, industry) is hindering these efforts. Hence we intend to Urban Air Pollution Monitoring System with Forecasting Models (UAPMSF) with the help of which we are able to mitigate or help towards mitigating the effects of Air pollution monitoring in urban areas. In future we can apply ML and artificial Intelligence techniques like deep nets in order to improve the prediction accuracy.

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