e-ISSN:2582 - 7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 4, Issue 8, August 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 5.928

International Journal Of Multidisciplinary Research In Science, Engineering and Technology (IJMRSET)

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 5.928|

| Volume 4, Issue 8, August 2021 |

|DOI:10.15680/IJMRSET.2021.0408019 |

Prediction of Air Pollutants Concentration by using Artificial Neuron Network

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ABSTRACT: Due to rapid increase in air pollution the curbing of pollution has become a mandatory step. The harmful pollutants like SO2, rspm, pm10 and pm2.5 affect the human health badly. It damages the respiratory system of humans and living creatures by causing respiratory diseases and cardiovascular problems. For public awareness and its protection for health the prediction of air pollutants concentration is necessary. For this purpose many forecasting tools are been used therefore, the most popular tool is Artificial Neuron network. The neural networks attempt to form the organic capabilities of the human brain. Thus, to carry out the process software like neurosolution is been used. The past 4 years old data is collected from Central pollution control board. Data is arranged accordingly and the values are trained, tested and validated through the software and the tool of ANN. The prediction is done for one day ahead and hence, we can do such predictions to save humans health from day to day increasing air pollution.

KEYWORDS: Artificial neural network, Generalized Feed Forward Network**,** PM2.5, PM10 , Multilayer Perceptron ,SO_2

I. INTRODUCTION -

Air is incredibly elementary for all the living creatures. While not air and water, the world would be unable to take care of life. Air pollution causes uneasiness to the health of humans and animals and causes damage to plants and materials. Within the days before the proliferation of enormous cities and trade, nature's own systems unbroken the air fairly clean. Wind mixed and spread the gases, rain washed the dirt and alternative simply dissolved substances to the bottom and plants absorbed carbonic acid gas and replaced it with Oxygen. With increasing urbanization and industry, humans began to unharness additional wastes into the atmosphere than nature might touch upon with additional pollution has been supplementary to the air by industrial, business and domestic sources. As these sources typically found in major cities, the gases that are focused within the air exceed protected limits then there arise pollution downside. Nature will not manage pollution while close air quality data processing could be a variety of data processing involved with finding hidden patterns inside mostly obtainable information, in order that information the data retrieve may be reworked into usable knowledge. The distribution of suspended particles like PM10, PM2.5, SO_2, NO_2 that contaminate atmosphere air are determined and function a vital reference for state agencies in evaluating gift and production future pollution policies.

II. BASIC FEATURES OF ANN

Many epidemiological research have verified the affiliation of air pollutants with a deterioration of human health. The neural networks attempt to form the organic capabilities of the human brain. These biologically stimulated techniques of computing are idea to be the following essential development withinside the computing industry.

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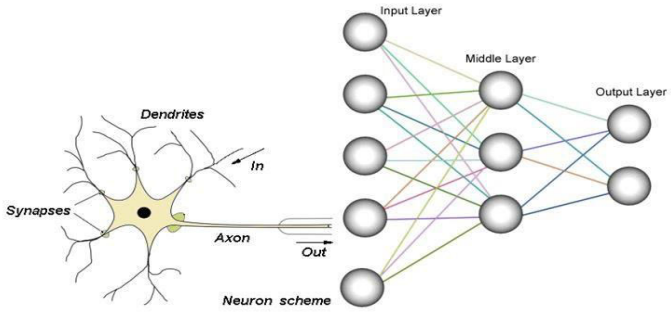

Fig1. Human brain versus Artificial neuron network

(source- https://www.google.com/url?sa=i&url=https%3A%2F%2Fmsatechnosoft.in%2Fblog%2Fartificial-neural-network-types-feed-forward-feedback-structure-perceptron-machine-learning-applications%)

Types of Artificial Neural Network

There are many types of artificial neural networks (ANN) for various applications. We have to choose proper one for desire output. An artificial neural network is a computational simulation of a biological neural network. These models mimic the real life behavior of neurons and the electrical messages they produce between input (such as from the eyes or nerve endings in the hand), processing by the brain and the final output from the brain (such as reacting to light or from sensing touch or heat). There are other ANNs which are adaptive systems used to model things such as environments and population. The systems can be hardware and software based specifically built systems or purely software based and run in computer models.

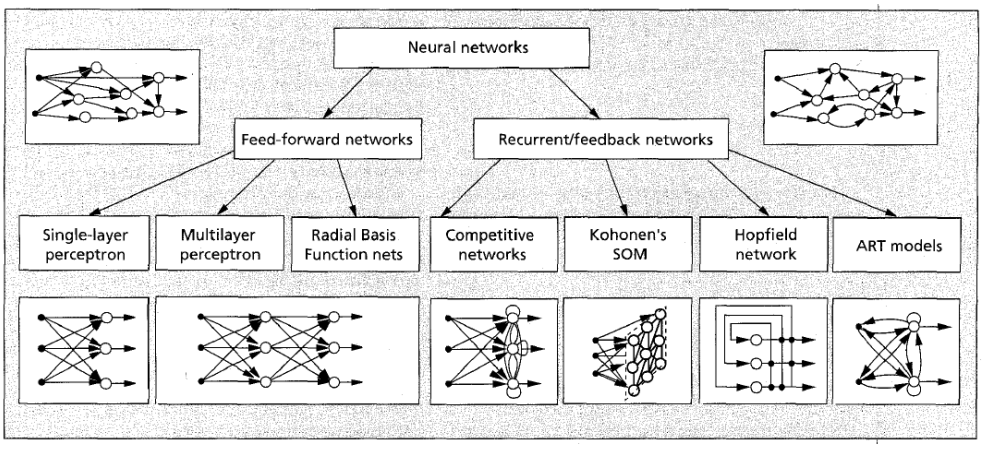

Fig. 1.2:-A taxonomy of feed forward network and recurrent network architecure

(Source-https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2F23-Taxonomy-of-Neural-Network-ArchitecturesJain-AK-MaoJ-and-Mohiuddin-K1996_fig17_331970420&psig=AOvVaw297FVD0Q0wA-LJn6u2-peB&ust=1630302162341000&source=images&cd=vfe&ved=0CA0Q3YkBahcKEwjQn9WAw9XyAhUAAAAAHQAAAAAQAw)

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Radial basis function (RBF) network

Radial basis functions are powerful techniques for interpolation in multidimensional space. A RBF is a function which has built into a distance criterion with respect to a center. Radial basis functions have been applied in the area of neural networks where they may be used as a replacement for the sigmoidal hidden layer transfer characteristic in multi-layer perceptron. RBF networks have two layers of processing: In the first, input is mapped onto each RBF in the 'hidden' layer. The RBF chosen is usually a Gaussian. In regression problems the output layer is then a linear combination of hidden layer values representing mean predicted output. The interpretation of this output layer value is the same as a regression model in statistics. In classification problems the output layer is typically a sigmoid function of a linear combination of hidden layer values, representing a posterior probability. Performance in both cases is often improved by shrinkage techniques, known as ridge regression in classical statistics and known to correspond to a prior belief in small parameter values (and therefore smooth output functions) in a Bayesian framework.

Feed forward neural network

The feed forward neural network was the first and arguably most simple type of artificial neural network devised. In this network the information moves in only one direction — forwards: From the input nodes data goes through the hidden nodes (if any) and to the output nodes. There are no cycles or loops in the network. Feed forward networks can be constructed from different types of units, e.g. binary McCulloch-Pitts neurons, the simplest example being the perceptron. Continuous neurons, frequently with sigmoidal activation, are used in the context of back propagation of error. The feed forward network is been classified into two types of network i.e single feed forward and multilayer feed forward network.

Single Feed forward neural network

The feed ahead neural community become the primary and questionably maximum easy sort of synthetic neural community devised. In this community the facts actions in handiest one path — forwards: From the enter nodes information is going via the hidden nodes (if any) and to the output nodes. There aren't anyt any cycles or loops withinside the community. Feed ahead networks may be made out of distinct varieties of units, e.g. binary McCulloch-Pitts neurons, the best instance being the perceptron.

Multilayer Feed Forward Network.-Multi layer perceptron (MLP) is a complement of feed ahead neural community. It includes 3 varieties of layers—the enter layer, output layer and hidden layer, The enter layer get hold of the enter sign to be processed. The required assignment along with prediction and class is carried out with the aid of using the output layer. An arbitrary quantity of hidden layers which might be located in among the enter and output layer are the real computational engine of the MLP.

Recurrent neural network (RNN)- Contrary to feedforward networks, recurrent neural networks (RNNs) are models with bi-directional data flow. While a feedforward network propagates data linearly from input to output, RNNs also propagate data from later processing stages to earlier stages. RNNs can be used as general sequence processors.

Activation functions

The activation function acts as a squashing function, such that the output of a neuron in a neural network is between certain values (usually 0 and 1, or -1 and 1). In general, there are three types of activation functions, denoted by Φ (.). First, there is the Threshold Function which takes on a value of 0 if the summed input is less than a certain threshold value (v), and the value1 if the summed input is greater than or equal to the threshold value.Secondly, there is the Piecewise-Linear function. This function again can take on the values of 0 or 1, but can also take on values between that depending on the amplification factor in a certain region of linear operation.Thirdly, there is the sigmoid function. This function can range between 0 and 1, but it is also sometimes useful to use the -1 to 1 range. An example of the sigmoid function is thehyperbolic tangent function.The artificial neural networks which we describe are all variations on the parallel distributed processing (PDP) idea. The architecture of each neural network is based on very similar building blocks which perform the processing. In this chapter we first discuss these processing units and discuss different neural network topologies. Learning strategies as a basis for an adaptive system.

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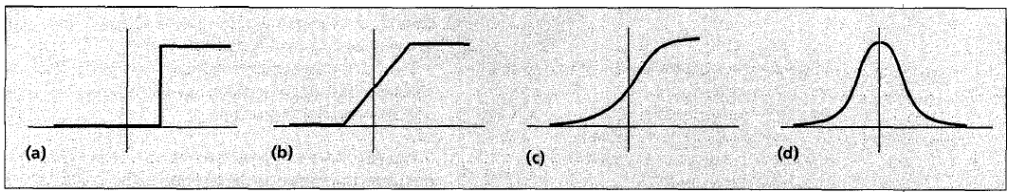

Fig. 1.3:- Different types of activation function
(a) threshold, (b) piecewise liner, (c) sigmoid, (d) Gaussian.

(Source-https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FCommon-activation-functions-in-ANN_fig3_314972496&psig=AOvVaw3Rh2vNWP3ehmQn2YdTxoJw&ust=1630302284421000&source=images&cd=vfe&ved=0CA0Q3YkBahcKEwjYi_--w9XyAhUAAAAAHQAAAAAQCA)

A framework for distributed representation

An artificial neural network consists of a pool of simple processing units which communicate by sending signals to each other over a large number of weighted connections. A set of major aspects of a parallel distributed model can be distinguished: a set of processing units ('neurons,' 'cells');a state of activation yk for every unit, which equivalent to the output of the unit;Connections between the units. Generally each connection is defined by a weight wjk which determines the effect which the signal of unit j has on unit k;a propagation rule, which determines the effective input sk of a unit from its external inputs;an activation function Fk, which determines the new level of activation based on the effective input sk(t) and the current activation yk(t) (i.e., the update);an external input (aka bias, offset) øk for each unit;a method for information gathering (the learning rule);An environment within which the system must operate, providing input signals and if necessary error signals.

Transfer functions in ANN

Transfer functions may be used in the input pre-processing stage or as an integral part of the network. In the last case, transfer functions contain adaptive parameters that are optimized. The simplest approach is to test several networks with different transfer functions and select the best one. Using heterogeneous functions in one network may give better effects. Starting from a network with several types of transfer function one may train it, possibly using pruning techniques to drop functions that are not useful. Constructive methods may also be used, training several candidate nodes and selecting the one that is the best performer. These possibilities are briefly discussed below.

Transfer functions and their parameterization

Transfer functions should provide maximum flexibility of their contours with small number of adaptive parameters. Large networks with simple neurons may have the same power as small networks with more complex neurons. Recently a detailed survey of transfer functions has been published, containing all relevant references. Here a new taxonomy of these functions, based on their flexibility, is proposed, starting from the simplest functions and building more flexible functions with reasonable number of adaptive parameters. Two functions determine the way signals are processed by neurons. *The activation function* acting on the input vector $I(\mathbf{x})$ determines the total signal a neuron receives, and *the output function* $o(I)$, operating on scalar activation, determines the scalar output. The composition of the activation and the output function is called the *transfer function* ($I(\mathbf{x})$). For some transfer functions there is no natural division between activation and output functions.

Assessment parameters of ANN by Software

Out of large number of ANN models developed for the data sets, best ANN model is investigated in detail. The goodness-of-fit measures considered in the present study to evaluate the developed models are mean square error (MSE) and coefficient of correlation (R) between the forecasted and observed inflows. A typical artificial neural network consists of an interconnection of computational elements called neurons. Each neuron basically carries out the task of combining the input, determining its strength by comparing the combination with a bias and firing out the result in proportion to such a strength. The forecasting software used is Neurosolutions 7 by Neurodimensions. It is an

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efficient software used forf orecasting and analysing. It analyses input data in Excel format and creates various networks. These networks are formed by various training-testing patterns and various learning algorithms.

Basic terms of Artificial Neuron Network

1. Learning rule- It is the method or a mathematical logic and it improves ANN performance which applies rule over the network and updates the weight.
2. Weight – the parameter within the a neural network data which transforms input data inside the hidden layers is called as weight where as negative weight reduces the value of output.
3. Epoch – One epoch means that each sample in training dataset has an opportunity to revise the internal model parameters.
4. Cross validation- it is basically used to test the model's ability to predict new data that was not used to estimate it .
5. Routing algorithm – Procedure that lays down the route or path to transfer data from source of destination.
6. Linear regression- it attempts to model the relationship between two variables by fitting a linear equation to observed data.
7. Training set- A set of pairs of input patterns with corresponding desired output pattern.
8. Pm- it is a complex mixture of extremely small particles the unit used to measure pm is cubic meter of air
9. Learning neural network- a neural network without an activation function in any of its layer is called linear network.
10. Transfer function- it translates the input signals to output signals.
11. RSME-The root-mean-square deviation (RMSD) or root-mean-square error (RMSE) is a frequently used measure of the differences between values predicted by a model or an estimator and the values actually observed. Basically, the RMSD represents the sample standard deviation of the differences between predicted values and observed values.
12. MSE-In statistics, the mean squared error (MSE) of an estimator measures the average of the squares of the "errors", that is, the difference between the estimator and what is estimated. MSE is a risk function, corresponding to the expected value of the squared error loss or quadratic loss. The difference occurs because of randomness or because the estimator doesn't account for information that could produce a more accurate estimate.

Criteria for Selection of ANN Architecture

The number of input ,output and hidden layers,are defined in the architecture of ANN with interaction between neurons.The complexity is depended upon the number of hidden layer and number of neurons in each hidden layer. Without training and validation its impossible to determine the best number of hidden layer and neurons.Due to under fitting a very few neurons in hidden layer will get high training error and validation error. Thus, for selection of number of neurons in hidden layer certain thumb rules are used which may be useful in providing the exact solution.

III. LITERATURE REVIEW

Adharsh et al. (2019) concluded the study focuses on the chance of statement stream water quality parameters victimisation Artificial Neural Network expected future stream water quality parameters will be used as a baseline for characteristic unprecedented changes within the stream water(1).**Mane et al. (2018)** used artificial neural network to predict SO2 concentrations for Pune city, the major urban industrial areas of Maharashtra, India. . The developed model is based on three-layer neural network trained by a back-propagation algorithm with number of epoch. It was found that the models accurately match the trend of SO2 concentrations for one day ahead upto 86.9%(2). **Mane et al (2017)** used Artificial Neuron Network for the prediction of RSPM concentrations for Pune city, the major urbanized area of Maharashtra, India. . The developed model accurately match the trend of RSPM concentrations for one day ahead upto 90.5%(3).**Kumar et.al (2019)** stated that $PM_{2.5}$ is dangerous as part of the pollution due its adverse effects on humans additionally as alternative living things. He aimed at predicting air quality by victimisation Random forest algorithmic program with air quality index provided by the revered government agencies during this work he tend to create use of feature analysis for prediction method to supply simpler and general model(4). **Heidar Malek et.al(2019)** Malekh et.al concluded that authorities of urban air quality, practitioners, and call manufacturers will apply ANN to estimate spatial–temporal profile of pollutants and air quality indices more analysis is suggested to match the potency and efficiency of ANN with numerical, machine and applied math models to change managers to pick an applicable

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toolkit for higher cognitive process in field of urban air quality(5). **Adke et al (2019)** concluded Most of the cities facing problem of poor air quality which fails to fulfill standards of air permanently health. Its was necessary to develop ANN pollution measure and prediction system for sensible town. For rising rectilinear regression algorithmic rule with most accuracy, we tend to square measure victimisation neural network . During which it uses Multilayer Perceptron algorithmic rule(6). **Bhavsar et al. (2019)** was concerned to foremost necessary step in prediction, to develop a prophetical model of air quality standing, which is able to facilitate in management of the atmosphere and conjointly to make a way of awareness among individuals. He also stated that the Air quality prediction is becoming the key issue for observance pollution(7). **Tiwari et.al (2019)** concluded that study he aims to develop a man-made neural network for air quality prediction which may perform with unnatural dataset with extremely strong feature so as to handle the info together with noise and errors. He tends to use prediction models like ARIMA etc. to validate our foretold AQI. This AQI analysis helps in telling the standing of gift pollution and forecasted pollution levels in returning time(8). **Ruchi Raturi et.al (2018)** Raturi et.al concluded due to a significant increase in pollution day by day therefore it's needed to predict pollution of subsequent date, next months, next year victimization some previous air connected information. Several systems area unit designed to support pollution information storing, inventory management and generation of easy statistics among which ANN has been found beneficial in predicition of next months and next year pollution(9) **S. Sankar Ganapati et.al (2019)** Ganapati et.al summarized For the ultimate forecast, many ensemble models of individual neural network predictors and individual regression predictors area unit conferred. This projected approach performs with the very best potency in terms of prognostication air quality index(10) . **Xiao Feng et.al (2015)** Feng et.al within the paper used prediction strategy applied to daily meteoric forecast variables furthermore because the various waste matter predictors were used as input to a multi-layer perceptron (MLP) form of back-propagation neural network(11).**Madhavi Anushka Elangasinghe et.al (2014)** Elangasinghe et.al used methodology tested by modelling of NO_2 concentrations, the fundamental model consists of ANN model for predicting NO_2 concentrations victimization eight predictor variables(12).

IV. CONCLUSION

This paper mainly focuses on the most popular forecasting tool called ANN for the various air pollutant concentration like PM2.5, PM10 ,Rspm, SO_2,NO_2 etc. In recent years forcastig ANN with back propagation have become a popular and useful to predicting, data interpretation and monitoring tool for modeling various tools. Use of ANN application area increased effectively due its suitability for modeling complex system.By using user friendly approaches like GUI, ANN techniques will be attractive alternate tool to numerical modeling and real-time prediction.This is very important to get RSPM values for real time as application in following:Fog prediction i.e. Smog Visibility at transportation,Control vehicular emission as to control first to predict.

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