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Rainfall Forecasting using Neural Network Fitting Tool (NFTOOL)

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Abstract: ***Forecasting is the application of science and technology to predict the state of the atmosphere for a future time at a given location. Generating predictions of meteorological events is very complex process, because the atmosphere is unstable. Rainfall Forecasting has become a major tool in numerous applications in meteorology and other environmental areas. This paper investigates to forecast the monthly rainfall of monsoon period between June to September of Ahmedabad district of Gujarat state, India. using Neural network fitting tool. Data fitting is the process of fitting models to data and analyzing the accuracy of the fit. Eight models prepared using different number of Inputs. Meteorological data of 50 years were collected of Ahmedabad District. Neural network data fitting tool analysed models by regression using two-layer feed-forward network trained with Levenberg-Marquardt method and gives results to check accuracy of models. It is found that model-3 with 4 inputs (Wet day frequency, Humidity, Max temperature, Potantial Evapotranspiration,) gives least error. So it concludes that model-3 is the best predicted model and Neural networks fitting tool can be used for the prediction of rainfall for the study area.***

Keywords: Rainfall, Forecasting, Neural network, data fitting tool, Neural network MATLAB Mathworks

1. Introduction

Weather forecasting is application of science to predict and technology to predict the state of the atmosphere for a future time at a given location. Human kind has attempted to predict the weather since ancient times. Generating predictions of meteorological events is very complex process, because the atmosphere is unstable and the systems responsible for the events are the culmination of the instabilities and involve nonlinear interaction between different spatial scales from kilometers to hundreds of kilometers. The chaotic nature of the atmosphere limits the validity of deterministic forecasts, but the increasing economic cost of adverse weather events provides a strong reason to generate more accurate and updated weather forecasts.

Today, weather forecasts are made by collecting quantitative data about the current state of the atmosphere and using scientific understanding of atmospheric processes to project how the atmosphere will evolve. Some sources state that weather forecast accuracy falls significantly beyond 10 days. Weather forecasting is complex and not always accurate, especially for days further in the future, because the weather can be chaotic and unpredictable. The traditional weather forecasting approaches are based on:

Empirical approach: This approach is based upon the occurrence of analogues and is often referred to by meteorologists as analogue forecasting. This approach is useful for predicting local-scale weather if recorded cases are plentiful.

Dynamical approach: This approach is based on the equations and forward simulations of the atmosphere, and is often referred to as computer modeling. The dynamical approach is only useful for modeling large-scale weather phenomena

There are several types of weather forecasts made in relation to time:

Short-Range Forecast is a weather forecast made for a time period up to 48 hours are generally more accurate than the other types of forecasts.

Medium Range Forecasts are for a period extending from about three days to seven days in advance.

Long-Range Forecasts are for a period greater than seven days in advance but there are no absolute limits to the period. They are widely used in the energy industry. Long-term Prediction of rainfall has several benefits for efficient resource planning and management including agriculture, famine and disease control, rainwater catchment and ground water management.

Rainfall prediction is very important for countries whose economy depends mainly on agriculture, like many of the third world countries. Rainfall forecasting is one of the most imperatives, important and demanding operational tasks and challenge made by meteorological services around the world. There are two types of rainfall predictions:

Long term prediction, i.e. predict total monsoon rainfall a few weeks or months in advance.

Short term prediction, i.e. predict rainfall over different locations a few days in advance.

The most prevalent techniques used to predict rainfall is numerical and statistical methods. Although research in these

areas takes place for a long time, the successes of these models is rarely concrete because these models have been found to be very accurate in calculation, but not in prediction as they cannot adapt to the irregularly varying patterns of data.

Computational intelligence (CI) is the study of adaptive mechanisms which enable or facilitate intelligent behaviour in complex and changing environments. As such, computational intelligence combines artificial neural networks, evolutionary computing, swarm intelligence and fuzzy systems. In addition, CI includes broader fields such as image processing, data mining, and natural language processing.

Machine learning (ML) involves adaptive mechanisms that enable computers to learn from experience, learn by example and learn by analogy. Machine learning mechanisms form the basis for adaptive systems. The most popular approaches to machine learning are artificial neural networks and genetic algorithms.

DataFit is a science and engineering tool that simplifies the tasks of data plotting, regression analysis (curve fitting) and statistical analysis. Data fitting is the process of fitting models to data and analyzing the accuracy of the fit. Engineers and scientists use data fitting techniques, including mathematical equations and nonparametric methods, to model acquired data. **Neural networks** are good at fitting functions. In fact, there is proof that a fairly simple neural network can fit any practical function.

2. Litrature Review

Agboola A.H. et al (2013) Investigated the ability of fuzzy rules/logic in modeling rainfall prediction for South Western Nigeria. The developed Fuzzy Logic model is made up of two functional components; the knowledge base and the fuzzy reasoning or decision-making unit.

Nayak .D et al (2013) carried a detailed survey on rainfall predictions using different neural network architectures over twenty-five years. This survey reports that rainfall prediction using ANN technique is more suitable than traditional statistical and numerical methods.

Goswami. S and Gaur. A (2014) carried a study about weather prediction. In this paper the application of artificial neural networks to predict the Weather of Delhi city has been proposed using knowledge base in the Neuro-Fuzzy Inference system.

Pallavi and Singh .G (2016) focused on giving different ways to forecast the weather in different regions. The paper presents the review of Rainfall Forecasting using different techniques and studies the benefit of using them. It provides a survey of available literatures of some techniques given by different researchers.

3. Neural Network Fitting Tool

DataFit is a science and engineering tool that simplifies the tasks of data plotting, regression analysis (curve fitting) and statistical analysis. What sets DataFit apart from similar curve fitting and regression programs is its ease of use. With the combination of the intuitive interface, online help and wide range of features, it is a tool that is used effectively by both beginners and experts.

A two-layer feed-forward network with sigmoid hidden neurons and linear output neurons (newfit), can fit multi-dimensional mapping problems arbitrarily well, given consistent data and enough neurons in its hidden layer.

The network will be trained with Levenberg-Marquardt back propagation algorithm (trainlm), unless there is not enough memory, in which case scaled conjugate gradient back propagation (trainscg) will be used.

In fitting problems, you want a neural network to map between a data set of numeric inputs and a set of numeric targets. The Neural Network Fitting Tool will help to select data, create and train a network, and evaluate its performance using mean square error and regression analysis.

Suppose, we have 200 numbers of data with 3 or 4 inputs and 1 output.

We can solve this problem in two ways:

- Use a graphical user interface, nftool, as described in Using the Neural Network Fitting Tool.
- Use command-line functions, as described in Using Command-Line Functions.

It is generally best to start with the GUI, and then to use the GUI to automatically generate command-line scripts. Before using either method, first define the problem by selecting a data set. Each GUI has access to many sample data sets that we can use to experiment with the toolbox (see Neural Network Toolbox Sample Data Sets). If we have a specific problem we want to solve, we can load our own data into the workspace.

4. Study Area and Data collection

Ahmedabad district is consider as study area for this study. Ahmedabad is the fifth most populous city and seventh most populous urban agglomeration in India. it was rated India's best megacity to live in by leading market research firm IMRB. Ahmedabad lies at 23.03°N 72.58°E in western India at 53 metres (174 ft) above sea level on the banks of the Sabarmati river, in north-central Gujarat. It covers an area of 464 km2 (179 sq mi). The Sabarmati frequently dried up in the summer, leaving only a small stream of water, and the city is in a sandy and dry area. Three lakes lie within the city's limits—Kankaria, Vastrapur and Chandola. Kankaria, in the neighbourhood of Maninagar, is an artificial lake developed by the Sultan of Delhi, Qutb-ud-din Aybak, in 1451.

Figure 1: Study Area

Ahmedabad has a hot, semi-arid climate with marginally less rain than required for a tropical savanna climate. There are three main seasons: summer, monsoon and winter. Aside from the monsoon season, the climate is extremely dry. The weather is hot from March to June; the average summer maximum is 43 °C (109 °F), and the average minimum is 24 °C (75 °F). From November to February, the average maximum temperature is 30 °C (86 °F), the average minimum is 13 °C (55 °F), and the climate is extremely dry. Cold northerly winds are responsible for a mild chill in January. The southwest monsoon brings a humid climate from mid-June to mid-September. The average annual rainfall is about 800 millimetres (31 in), but infrequent heavy torrential rains cause local rivers to flood and it is not uncommon for droughts to occur when the monsoon does not extend as far west as usual. The highest temperature in the city was recorded on May 18 and 19, 2016 which was 50 °C (122 °F).

Following meteorological data (For 50 years of monsoon season june to September) of ahmedabad district has been collected for the study.
• Rainfall (mm)
• Max temperature (˚C)
• Wet day frequency
• Average temperature (˚C)
• Vapour pressure (pa)
• Humidity (gm/m3)
• Potential Evapotranspiration (mm)
• Cloud cover

5. Methodology

Syntax: nftool
nftool opens the neural network fitting tool GUI.

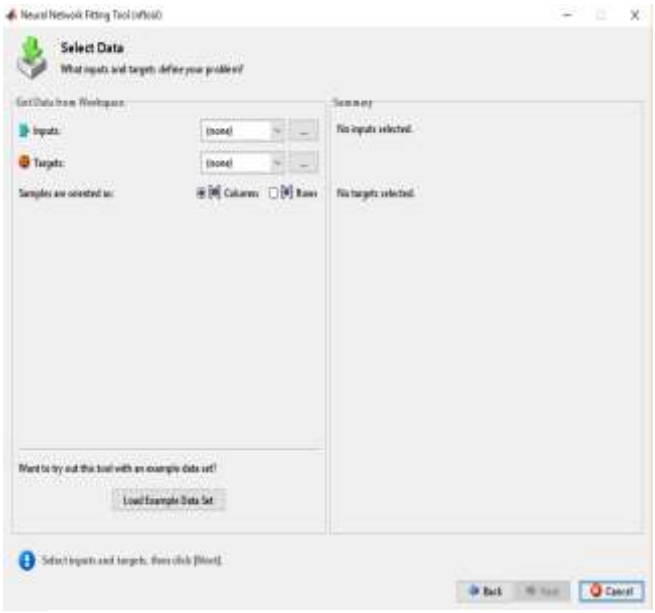

Figure 2: Neural network fitting tool GUI

Algorithms : nftool leads you through solving a data fitting problem, solving it with a two-layer feed-forward network trained with Levenberg-Marquardt.

Inputs and Targets will add first. Data samples are oriented as rows. Data will be divide in 3 parts to Train data in Neural network Data fitting. 70% Data used for Training, 15% Data will used for validation and remaining 15% Data will used for Testing. Add the numbers of hidden neurons as 20 default value. After Training the dataset, the Inputs and Targets will added again for testing.

Model Preparations: Total 8 models prepared for the prediction of Rainfall for Ahmedabad district. Models were prepared using different number of Inputs as shown in below table.

Table 1: Description of models using different inputs

Particular	inputs	No. of neurons
Model 1	Wet day frequency + humidity + Potential evapotranspiration + cloud cover	20
Model 2	Wetday frequency + humidity + Max temp + Vapour pressure	20
Model 3	Wet day frequency + humidity + Max temp + potential evapotranspiration	20
Model 4	Wet day frequency + humidity + Potential evapotranspiration + Vapour pressure	20
Model 5	Wet day frequency + humidity + Max temp	20
Model 6	Wet day frequency + humidity + Potential evapotranspiration	20
Model 7	Wet day frequency + humidity + Cloud Cover	20
Model 8	Wet day frequency + Humidity + Vapour pressure	20

6. Result and Analysis

Below Table shows that model 3 with 4 inputs (wet day frequency, Humidity, Max temperature, Potantial

evapotranspiration,) has least error so model 3 gives most accurate results than other models.

Table 2: Neural network data fit Result

Model			MSE	R
Model 1	Train	Training	1023.96	0.9419
		validation	2503.1086	0.8687
		Testing	4179.16	0.8220
	Test	Testing	1719.11	0.9058
Model 2	Train	Training	1083.39	0.9383
		validation	2082.58	0.8852
		Testing	4102.73	0.8220
	Test	Testing	1686.12	0.9081
Model 3	Train	Training	884.5	0.9481
		validation	2042.69	0.8766
		Testing	3926.63	0.9392
	Test	Testing	1514.55	0.9249
Model 4	Train	Training	771.93	0.9589
		validation	2321.181	0.8709
		Testing	9593.7	0.6295
	Test	Testing	2327.589	0.8720
Model 5	Train	Training	2607.71	0.8715
		validation	1412.26	0.9378
		Testing	2392.11	0.8735
	Test	Testing	2396.05	0.8820
Model 6	Train	Training	1486.00	0.9164
		validation	3005.60	0.8641
		Testing	2383.51	0.8749
	Test	testing	1848.57	0.8915
Model 7	Train	Training	1139.90	0.9371
		validation	1008.19	0.9549
		Testing	3060.24	0.8092
	Test	Testing	1408.19	0.9233
Model 8	Train	Training	1353.58	0.9255
		validation	1389.62	0.9371
		Testing	1806.52	0.9041
	Test	Testing	1426.93	0.9232

Below two figures shows results of monthly rainfall prediction by data fitting neural tool. It shows the value of correlation coefficient R of training and Validation phase.

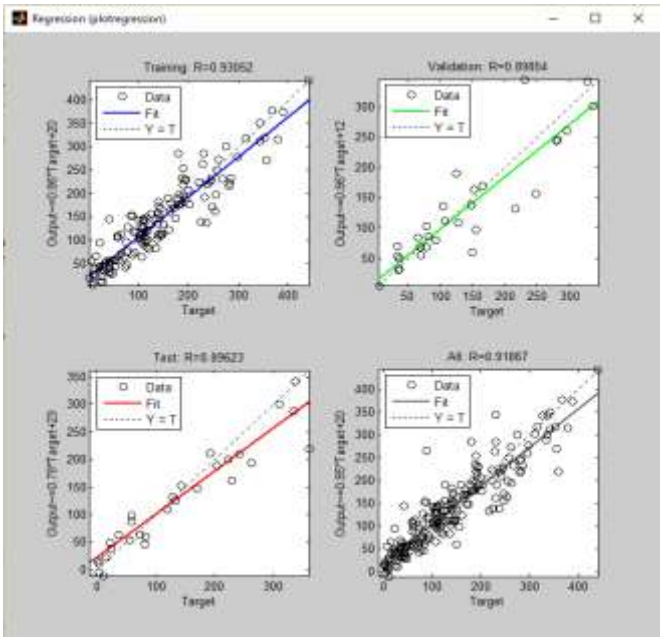

Figure 3: Regression Analysis of models for all phases

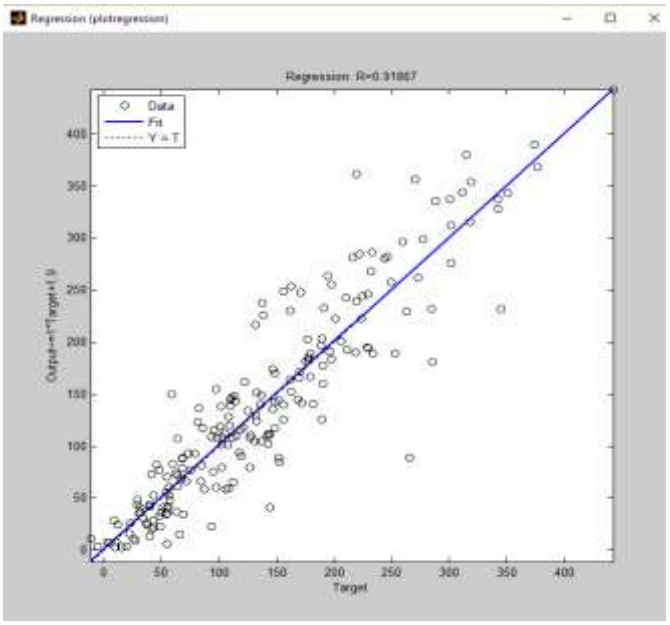

Figure 4: Regression analysis of model for testing phase

7. Conclusion

Neural network data fitting tool analysed models by regression using two-layer feed-forward network trained with Levenberg-Marquardt method and gives results to check accuracy of models. It is found that model-3 with 4 inputs (Wet day frequency, Humidity, Max temperature, Potantial Evapotranspiration,) gives least error. So it concludes that model-3 is the best predicted model. Neural network fitting tool gives the value of R (correlation coefficient) and MSE as 0.9481 and 884.5 of Training data set and 0.9249 and 1514.55 of Testing data set respectively.

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