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Day Wise Rainfall Prediction System Using Artificial Neural Networks

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Abstract ---- Rainfall plays an important role in the human life. Hence, prediction of Rainfall and associated factors are essential to the agriculture, house hold purpose, industries and construction of buildings. Any weather prediction is extremely complicated. This is because associated mathematical models are complicate, including many simultaneous non linear hydro dynamic equations. In many occasions such models do not give accurate predictions. Artificial neural network (ANN) are known to be good at problems where there are no clear cut mathematical models and so ANNs have been tried out to make predictions in our application. ANNs are now being used in many branches of research, including the atmospheric sciences. The main contribution of this project is the development of ANN to identify the presence of rainfall based on Automatic Weather Station data collected at ISRO weather Research Center, Tirupathi and pune.

Key words ----- Rainfall, cyclones, mesoscale, parsiel disdrometer, Microrain Radar, Automatic Weather Station, Laser disdrometer.

I. INTRODUCTION

Rainfall is a highly dependable factor of nature and the timely tracking of the rainfall is important to reduce the water problem and human casualties. Rainfall develops mainly due to intense convection and is accompanied by wind force, wind direction, humidity and pressure. Rainfall also depends on clouds, such as cumulus or cumulonimbus clouds of the convective origin and high vertical extent of a range .Kadapa region is a heavy draught area which contains very less rainfall. Most of the rainfall occurs due to monsoons and Cyclones. This area is completely depend on sea monsoons and Cyclones produced by sea environments such as Bay of Bengal and Arabian Sea.

Most of the rainfall recorded in the South-west Monsoon (June, July, August and September) period. The life cycle of the rainfall are categorized in to three phases on the basis of growth of the clouds. Cumulus stage marks the first stage of growth with the updraft persisting throughout the cell. N the mature stage there is the presence of both the updraft and the downdraft. The presence of upper level shear adds severity of the Rainfall since it differentiates the zone of the updraft from the zone of downdraft at this stage. The severe rainfall associated with Thunderstorms, Extreme Wind speed etc, which causes extensive losses in agricultural, damage to structure and also loss of life. The strong wind produced by the rainfall contact with the earth surface and spread out, which cause heavy rainfall and creates a threat to aviation. The highest numbers of aviation hazards are reported during occurrence of this Rainfall.

The Rainfall prediction system is a typical mesoscale systems dominated by intense convection. The understanding and prediction of these weather events is a challenge to the atmospheric scientists. Though, many studies are conducted to understand the dynamical and thermo-dynamical structure of this severe weather phenomenon, but are mostly in the form of case studies and are limited due to lack of observations. The micro-physical processes leading to the development of weather forecasting are also not well-understood due to lack of mesoscale observations. The improvement in prediction of these important weather phenomena is also highly handicapped due to lack of mesoscale observations and insufficient understanding. Non-availability of sophisticated instruments also did not help to improve the understanding earlier. Realizing the importance of improved understanding and prediction of these weather events and their socio economic impact, a research work has been done and developed. This is a comprehensive observational and modeling effort t to improve understanding and prediction of the rainfall. The artificial neural networks have been used to forecast meteorological events such as rainfall. The greater advantage in using ANN (Artificial Neural Networks) is their intrinsic non-linearity, which helps in describing complex meteorological events in a better way than linear methods. ANN are known to be good problems where there are o clear cut mathematical models and so ANN's have been tried out to make predictions in our application. ANN's are now being used in many branches of research, including the atmospheric sciences.

II. RESEARCH BACK GROUND WORK

Rainfall is a severe weather phenomenon, which develops mainly due to various factors such as humidity, temperature, wind-speed, wind-direction etc, it is very difficult to predict the position of clouds all over the Globe because it causes rainfall. Clouds keep-on moving , so there is a possibility of changing the weather due to wind-speed , wind-direction etc. It is very important to predict the rainfall, for agriculture and other requirements. Hence , we have developed ANN for predicting to short term Rainfall activity.

A. Problem Statement

To predict the Rainfall Activity or Metrological Activity super computers are needed and it requires huge budget. So hence the ANN is Robotics/Versatile and it can run in PC with C-language and/or Fortran. The prediction skills and sources are comparable with the super computer based model outputs.

B. Challenges

Occurrences of rainfall are a rare phenomenon and difficult to predict Most of the days are non-rainy days in the surroundings of Andhra Pradesh. The Rainfall can be predicted by the development, testing and training of ANN. The main contribution of this project is the development of ANN to identify the presence of Rainfall.

C. Method of Problem Solving

Extensive programming was made to execute the ANN calculations, the source programmers are developed and source codes are written in 'C' and the 'exe' files can work through C. the program gives a graphical display of process of testing and training of ANN with depiction of results on screen in graphical mode.

III. *Basic Introduction of ANN*

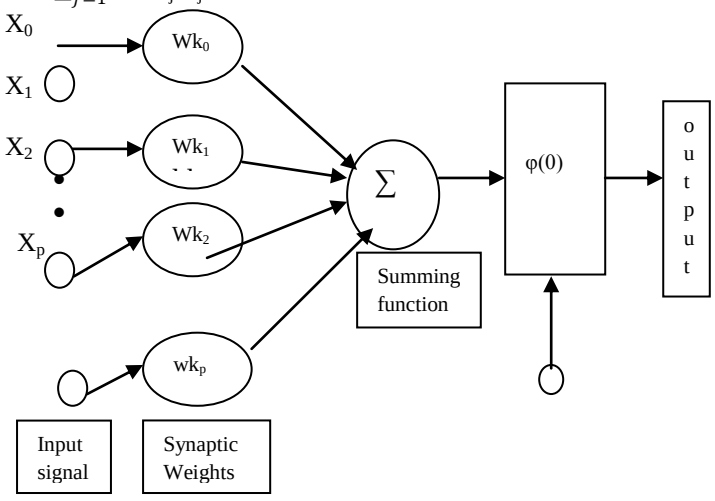
ANN is parallel distributed processor made up of simple processing units, which has a natural propensity for storing experimental knowledge ad making it available for use when required. It is an information processing paradigm that is inspired b the way biological nervous systems, such as the brain, process information. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems.[1]

Neural network is a machine designed to mode the way in which the brain performs a particular task or function of interest. The network is usually implemented by using electronics components or it is simulated in software on a digital computer[2].

An input is presented to the neural network and a corresponding desired or target response set at the output (when this is the case the training is called supervised) an error is composed from the difference between the desired response and the system output. This error information is fed back to the system and adjusts the system parameters in a systematic fashion (the learning rule). The process is repeated until the performance is acceptable. It is clear from this description that the performance hinges heavily on the data. If one does not have data that cover the significant portion of the operating conditions, or if they are noisy, then neuron network technology is probably t the right solution.

A. Model of Artificial Neuron

$\upsilon_k = \sum_{j=1}^{p} W_{kj} X_j$



B. Activation Functions

The activation function acts as a squashing function, such that the output of a neuron in 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 F (.). 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 value 1 if the summed input is greater than or equal to the threshold value.

$$\varphi(\upsilon) = \begin{cases} 1 & if \quad \upsilon \geq 0 \\ 0 & if \quad \upsilon < 0 \end{cases}$$

$$f(x) = \begin{cases} 1 & if \quad \upsilon \geq 1/2 \\ \upsilon & if \quad -\frac{1}{2} > 1/2 \\ 0 & if \quad \upsilon \leq -1/2 \end{cases}$$

$\varphi(\upsilon) = \tanh(\upsilon/2) = (1-\exp(-\upsilon)) / 1+\exp(-\upsilon)$

IV. *Introduction of weathers*

Weather variables constantly affect our daily business operations. Knowing in advance the expected weather enables decision-makers to plan effectively. For example, weather forecast would aid farmers better plan for planting and harvesting of crops, which would result I increased crop production; likewise, the forecasts would help facilitate airlines to schedule flights, which would lead to decreased number of weather-related accidents. We rely on weather forecasters to help us plan our daily routine life and prepare for life-threatening conditions[3].

A. Generally, two methods are used to forecast weather

- Empirical approach
- Dynamical approach

The first is based up on the occurrence of analogs and is often referred to by meteorologists as analog forecasting this approach is useful for predicting local-scale weather if recorded cases are plentiful[4]. The second approach is based upon equations and forward simulations of the atmosphere, and is often referred to as computer modeling. Because of the grid coarseness, the dynamical approach is only useful for modeling large-scale weather phenomena and may not predict sort-term weather efficiently [5].

Previously, most weather prediction systems used a combination of empirical and dynamical technique. However, a little attention was paid to the use of artificial neural networks in weather forecasting utilizing state-of-the-art neuro-computing tools, and the weather forecaster can accurately predict the future weather conditions in order to provide the most up-to-date forecasting information.

B. Meteorological Instruments

- Laser Disdrometer
- Automatic weather station
- Micro Rain Radar
- OTT- Parsivel Disdrometer

C. Rainfall factors Measurement

- Thermometer for measuring temperature
- Anemometer for measuring wind speed
- Wind vane for measuring wind direction
- Hygrometer for measuring humidity
- Barometer for measuring pressure

D. Meteorological Instruments

i. Micro Rain Radar (MRR):

The Micro Rain Radar is compact 24-GHz FM-CW-radar for the measurement of profiles of drop size distributions and derived from this rain rates, liquid water content and characteristic falling velocity resolved into 30 ranges gates. Due to high sensitivity and fine temporal resolution very small amounts of precipitation below the threshold of conventional rain gauges are detectable. Due to the large scattering volume statistically stable drop size distributions can be derived within few seconds. The droplet number concentration in each drop diameter bin is derived from the backscatter intensity in each corresponding frequency bin. In this procedure the relation, between terminal falling velocity and drop size is exploited[6].

ii. Parsivel Disdrometer

Parsivel is a laser based optical for complete and reliable measurement of all types of precipitation. The size range of measurable liquid precipitation particles is from 02 to 25mm. the precipitation measurements are carried out using special sensor head that was developed for this particular purpose. It detects precipitation optically. the use of this to find the raindrop each size distribution.

iii. Automatic weather Station (AWS):

An automatic weather station (AWS) is an automated version of the traditional weather station, either to save human labor or to enable measurements from remote areas. The system may report in near real time via the Argos System and the Global Telecommunications System, or save the data for later recovery.
The automatic weather station has

- Thermometer for measuring temperature.
- Anemometer for measuring wind speed
- Wind vane for measuring wind direction.
- Hygrometer for measuring humidity.
- Barometer for measuring pressure.

a. Temperature

Temperature is the manifestation of heat energy. In meteorology, temperature is measured in free air, in shade, at a standard height of 1.2 m above the bound. Measurement is made at standard hours using thermometers. The unit of measurement is degree Celsius (^{0}C). Ambient temperature is referred to as dry bulb temperature. This is different from wet bulb temperature, which is obtained by keeping the maturing thermometer consistently wet. The wet bulb temperature or due point provides a measure of the moisture content of the atmosphere. We have used dry bulb temperature in our study.

b. Pressure

Atmospheric pressure is defined as the force excited by a vertical column of air of unit cross section at a given level. It is measured by a barometer. The unit of pressure is milli bar (mb) . Atmospheric pressure varies with time of the day and latitude as also with altitude and weather conditions. pressure decreases with height. This is due to the fact that the concentration of constituent gases and the depth of the vertical column decrease as we ascend.

c. Wind (Speed and Direction)

The atmosphere reaches equilibrium through winds. Wind is air in horizontal motion. Wind is denoted both the direction from which it blows and is specified by the points of a compass or by degrees from True north (0 to 360º).wind direction is hon by the wind vane and wind speed is measured by anemometer. In our study, for computational purposes, values are assigned to the various directions.

d. Relative Humidity

The measure of the moisture content in the atmosphere is humidity. Air can hold only a certain amount of water at given time. When the maximum limit is reached, air is said to be saturated. The ration of the amount water vapor presented in the atmosphere to the maximum it can hold at that temperature and pressure, expressed as a percentage is the relative humidity[7].

V. *DATA COLLECTION*

The data related to rainfall occurrence was collected from the ISRO research center –Tirupathi , meteorological department pune, and various rain gauge stations. We have collected huge set of data sets, of which 45% were used for training and 51% for testing. Each set consist of 5 input parameters and a corresponding output parameter. This output parameter specifies whether rainfall occurred or not.

VI. *ALGORITHM*

Step: 1- Sample data file at least 516 datasets with No Rainfall and Rainfall events.

Step: 2- Initial weights & subjected to the ANN.

Step: 3- If it convergence the loop will proceeds to the Multi layer and if it diverge then it will send to the step1.

Step: 4- After the completion of execution in Multilayer, if errors occurs it goes to the step-1 and again it will subjected to Hidden layers and process will occur vice versa from step 1 to step 4.

Step: 5- If the Training of ANN and Multilayer is successful the program will executes the output file and it shows Graphical representation.

Step: 6- Finally the Rainfall Occurrence is verified/forecasted for next 24 hours.

With the help of above algorithm and implemented the following data items inorder to predict the rainfall basing on various weather parameters. The Data has been divided into 2 types

1) Clear Sunny Day (NO Rainfall)
2) Rainfall Occurrence

Finally the Rainfall presence is verified.

VII. *DATA SETS*

A. Clear Sunny Day (NO Rainfall)

Time	Temperature	Humidity	Wind Speed	Wind Direction	Barom
0.2	18.6	112	3.36	WNM	739.1

	6	.8			6
0.28	22.63	84.3	3.36	NNE	738.04
0.32	23.06	82.3	4.93	NNE	737.1
0.4	23.81	82.7	2.37	NNE	737.78
0.421	23.94	82.7	3.55	ESE	737.7
0.5	24.19	82.8	5.13	NNE	737.59
0.55	24.88	82.3	5.13	NNE	737.59
0.6	25.75	77	6.71	NNE	736.51
0.86	24.88	82.3	3.75	NE	736.8
9.08	25.75	77	6.71	NNE	736.51
9.3	26.19	72.7	2.37	NNE	736.12
9.51	27.5	67.9	3.55	NNE	735.4
9.73	28.28	63.7	4.15	WSW	735.2
9.95	28.13	63.5	2.57	NNE	735.2
10.16	28.5	61.3	0	NNE	734.37
10.38	28.97	52.6	4.74	NNE	733.7
10.6	29.53	50.9	1.58	ESE	732.83
10.81	30.72	46.3	1.97	ESE	731.81
11.03	31.5	40.7	2.37	NNE	731.46
11.25	31.59	40.1	3.75	NE	731.02
11.46	31.34	35.9	4.15	NNE	731.26
11.68	31.06	38.1	8.68	ESE	731.15
Time	Temperature	Humidity	Wind speed	Wind Direction	Barom
11.9	30.13	39.8	7.9	ESE	732.01
12.11	30.97	42.4	3.55	NNE	730.95
12.33	32.06	39	2.96	NNE	730.95
12.55	31.91	41.9	5.13	WSW	731.11
12.76	31.91	40.9	2.17	NNE	730.91
12.98	32.09	40.1	2.57	NNE	730.63
13.2	30.91	44	2.57	NNE	730.63
13.4	30.5	46.	2.76	NNE	732.2

1	9	7			3
13.63	30.09	50.2	2.57	NE	71.61
13.85	29.95	50.3	6.12	NNE	731.8
14.06	28.5	50.7	5.92	ESE	732.18
14.28	28.28	51	3.16	NNE	733.56
14.5	27.69	52.6	4.54	ESE	733.3
14.71	27.31	54.8	3.95	NNE	733.56
14.93	27.19	56.6	2.17	NE	733.86

B. Directions description

Sl. No	DIRECTION
1	NORTH (N)
2	NORTH NORTH EAST(NNE)
3	NORTH EAST (NE)
4	EAST NORTH EAST (ENE)
5	EAST (E)
6	EAST SOUTH EAST (ESE)
7	SOUTH EAST (SE)
8	SOUTH SOUTH EAST(SSE)
9	SOUTH (S)
10	SOUTH SOUTH WEST (SSW)
11	SOUTH WEST (SW)
Sl. No	DIRECTION
12	WEST SOUTH WEST (WSW)
13	WEST (W)
14	WEST WEST NORTH (WWN)
15	NORTH WEST (NW)
16	WEST NORTH WEST (WNW)

In our study 16 different directions has been implemented in order to collect the data on both clear sunny days and rainfall occurrence day. The data collected during the rainfall day as follows.

C. Typical Metrological Data observed during Rainfall event:

Time	Temperature	Humidity	Wind Speed	Wind Direc tiion	Barom
17.1	21.9	89	0	NNE	737.27
17.31	20.75	90.9	0	NNE	737.67
17.53	20.34	94.4	0	ESE	737.95
17.75	20.03	95.3	0	NNE	737.27
17.96	19.94	97.8	0	NNE	738.93
18.18	19.84	95.3	0	ESE	739.16
18.4	20.09	93.8	0	NNE	739.1
18.61	20.16	93.2	0	NNE	739.1

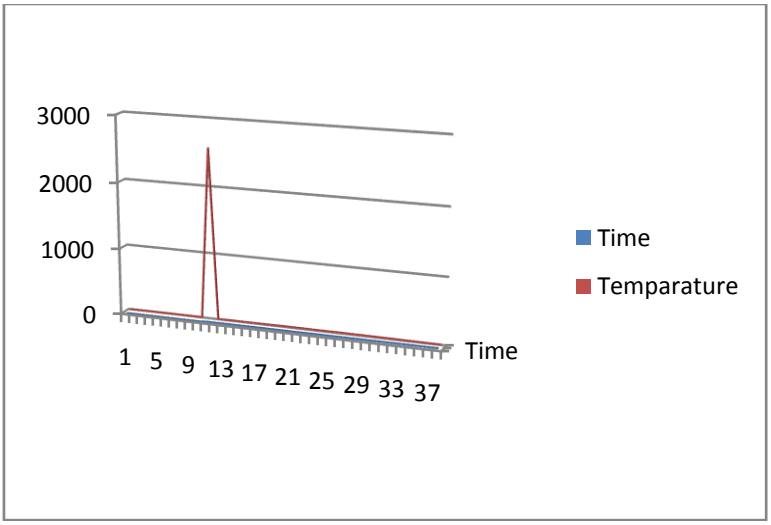
18.83	19.81	94.1	0	NNE	739.16
18.4	20.9	93.08	0	NNE	739.24
18.61	20.16	93.2	0	NNE	739.1
18.83	19.81	94.1	0	NNE	739.16
19.05	19.97	91.6	0	WSW	739.27
19.26	19.88	91	0	NNE	739.16
19.07	19.97	87.4	0	WSW	739.09

VIII. *CONCLUSION :*

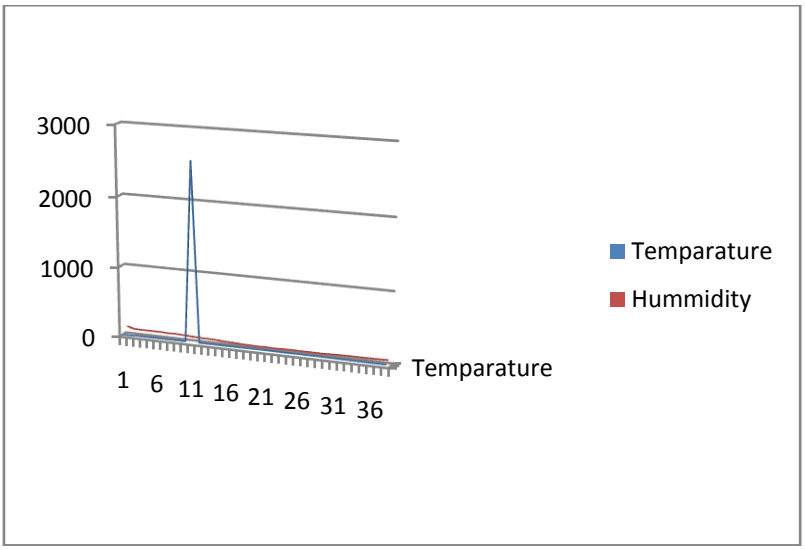
Day wise rainfall prediction has been implemented based on various weather attributes and 16 different directions were implemented to collect the data. With the help of Artificial Neural Networks, prediction strategies are implemented and define the result in the form of Graphs .Finally the occurrence of rainfall has been identified for various weather attributes. The Graphs show the relationship, between various attributes and finally display the rainfall occurrence.

IX. *Graphical Representations:*

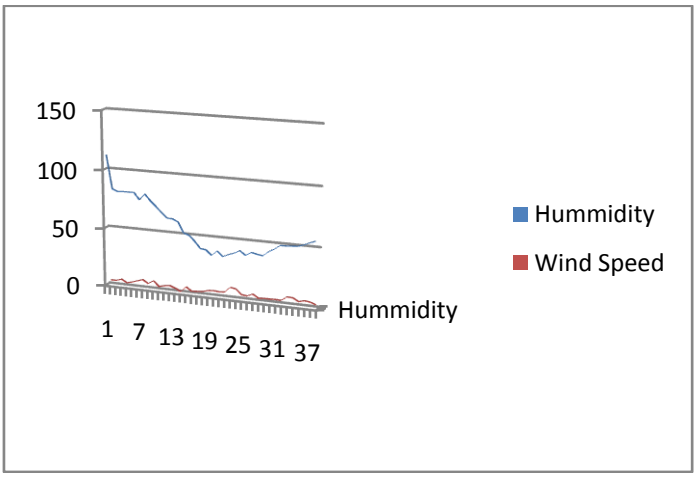
A. Clear Sunny Day (No Rainfall)



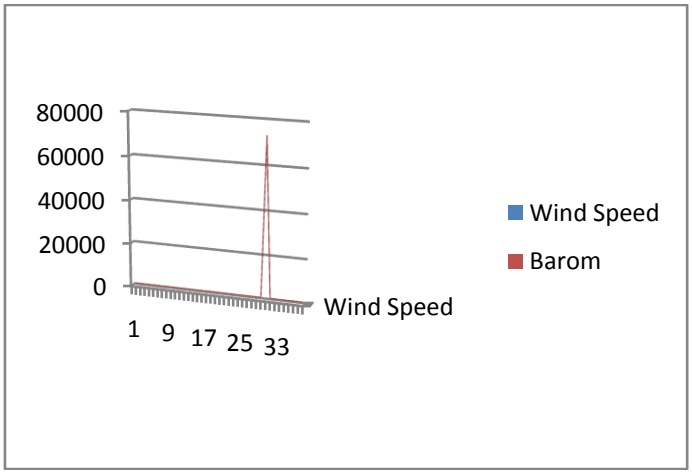
i. Time and Temperature Graph



ii. Temperature and Humidity

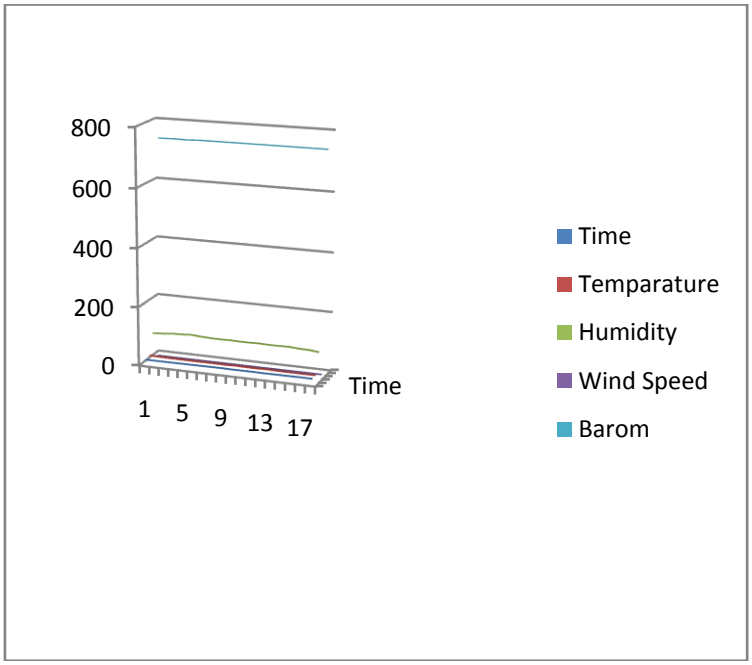


iii. Humidity and Wind Speed



iv. Wind Speed and Barom Graph

B. Rainfall Day (Occurrence of Rainfall)



i. Rainfall Day Graph

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