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APPLICATION OF WEATHER PREDICTION TOOL USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

In the modern world, weather forecasting is a vital occurrence. Even if weather prediction is entirely automated and made possible by technologies like Weather Research & Forecasting (WRF), Advanced Research WRF (ARW), and Weather Processing System (WPS), it's still a difficult and interesting topic because forecasts aren't always accurate. The process of forecasting weather is complex, dynamic, high-dimensional, and ongoing since it incorporates a wide range of atmospheric phenomena. The intricacy of the criteria needed to forecast the weather means that even short-term forecasts are problematic. Artificial neural networks are perfect for weather forecasting because of their ability to learn from past data in addition to analyzing it and generate forecasts for the future. It is possible to simplify weather forecasting. By using the data gathered at a certain station over a predetermined period of time to train artificial neural networks (ANN) with back propagation for supervised learning. They are used to forecast the weather after the model has been trained. The model is revealed to anticipate the values as unknown values as an experimental technique. The results show promise and encourage us to keep working toward this objective.

Keywords: Predictive Analytics, ANN, Regression Techniques, Machine Learning Techniques

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1. INTRODUCTION

A meteorologist's responsibility in weather forecasting is to anticipate the weather, including when and under what conditions it will change over a given period of time. In reality, predicting is a very complicated process that incorporates a lot of mathematics, thermodynamics, atmospheric physics, and laws of motion, energy conservation, hydrodynamics, and other concepts. The multidisciplinary scientific study of the atmosphere is called meteorology. As a result, meteorologists work hard to increase forecast accuracy. A meteorologist needs historical data in order to create an accurate forecast. It is necessary to comprehend the atmospheric processes that result in the current weather at a certain region, which is then contrasted with historical data. Making observations of the atmosphere, such as determining the mean sea level, temperature, atmospheric pressure, humidity, cloud cover, precipitation, rainfall, wind direction and speed, etc. The more comprehensive our measurements are of the earth's surface, both vertically and horizontally, the more accurate our forecast will be. A decent forecast may be made by tracking the changes in these elements over time

and contrasting the new patterns with the old ones. In order to visualize how the atmosphere is changing and will appear in the future, meteorologists need to understand how the atmosphere changes over time in response to various factors, such as the earth's surface warming due to solar radiation, advection, radiation cooling at night, latent heat release during condensation, El nine, etc.

Forecasters can utilize the results from these models to help them prepare their forecasts. The results produced by the computer models are far from flawless and are not to be the only source of information used. In summary, in order to forecast the future weather, the output models rely on the forecasters' astute knowledge based on the existing situation. A significant amount of research and development is being done to improve computer models and mathematical formulas as well as to find new ways to reliably and quickly deliver meteorological information to people across a variety of media in a variety of formats as needed and expected [1].

2. RELATED WORKS

Data Mining is the extraction of hidden knowledge from data warehouses. It is a powerful technology with a great scope to analyze and predict vital information from the databases. Meteorological data are voluminous, dynamic, complex and high dimensional. Some data mining techniques are ideal for making weather predictions. Many works have been done and it is still going on as researchers find it as a promising and fruitful. Research efforts on ANNs for forecasting are considerable. The literature is vast and growing. The idea of using ANNs of These applications can maintain public safety and welfare. Their future work includes building adaptive and dynamic data mining methods that can learn dynamically to match the nature of rapidly changeable weather nature and sudden events. Meghali A. Kalyankar and S.J.Alaspurkar, “Data mining technique to analyse the meteorological data” have tried to extract useful knowledge from weather data by using clustering technique i.e. k-means partitioning method.“Experimental Survey on Data Mining Techniques for Association rule mining” by Praveen Pappula, Ramesh Javvaji gives a survey on data mining techniques. More specifically, they discuss on basic data mining technique called association rule mining. Their survey provides the related research results and also explored the future directions about data mining in weather report, and it is a good reference for researchers on this topic.Imran Maqsood, Muhammad Riaz Khan and Ajith Abraham, “An ensemble of neural networks for weather forecasting” conclude that Neural networks based ensemble models were developed and applied for hourly weather forecasting of southern Saskatchewan. The experimental results show that the ensemble networks can be trained effectively without excessively compromising the performance. “Modeling and prediction of rainfall data using data mining” by Seema Mahajan and Dr. S. K. Vij discusses about Rainfall Prediction an important crucial a proposed model.

Weather prediction expert system approaches (Ceng-568 Literature Survey) by Bulent kiskac and Harun yardimci tried to give readers an overview about weather prediction phenomena, expert systems approaches, main domain specific problems, and solution methodologies. They made this research about a local airbase short-term weather prediction implementation with Case Base Reasoning KNN algorithm, Fuzzy logic and Artificial Neural Network implementation.“Forecasting with artificial neural networks: The state of the art” by Guoqiang Zhang, B. Eddy Patuwo, Michael Y. Hu. Attempted to provide a more comprehensive review of the current status of research in this area. They mainly focused on neural network modeling issues. This review aims at serving two purposes. First, it provides a general summary of the work in ANN forecasting done to date. Second, it provides guidelines for neural network modeling and fruitful areas for future research.

3. ARTIFICIAL NEURAL NETWORKS

The word network in the term 'artificial neural network' refers to the inter connections between the neurons inthe different layers of each system. This system has three layers. The first layer has input neurons which send datato the second layer of neurons, and to the third layer of output neurons, via synapses. The synapses use weights tomanipulate the data in the calculations.

An ANN is typically defined by three types of parameters

- The interconnection pattern between the different layers of neurons.
- The learning process for updating the weights of the interconnections.
- The activation function that converts a neuron's weighted input to its output activation.

ANN adaptively changes their synaptic weights through the process of learning. A Feed forward NN with back propagation have been used in the past for modeling and forecasting [2] [3]. Choosing the number of hiddenlayers in a network depends on the training and validation of data. Each neuron in the network performs two operations:

- It makes a weighted sum of its input from the input layer.
- Then, it transfers the weighted sum to its output layer using its activation function.

3.1. THE BACK PROPAGATION ALGORITHM

It is training or learning algorithm also called as Feed forward Networks or multilayer perceptron's (MLP). Back propagation network learns by example. Here we train the network, by giving examples, change the network's weights and get the output (target).

i) The network is initialized by setting up all its weights to random numbers.
ii) The input pattern is applied to get the output (forward pass)
iii) Calculate the error of each neuron (target – actual value)
iv) Error is mathematically changed, to minimize it.
v) Repeat steps ii) to iv) such that target is closer to actual value (reverse pass)

Back propagation algorithm is a supervised learning method which can be divided into two phases: propagation and weight update. Until the performance of the network is satisfactory, the two phases are repeated.In this method, the output is compared with the target to compute the value of predefined error-function. This error is then fed back to the network. The algorithm then adjusts the weights of each connection in order to reduce the value of the error function. This process is repeated for a sufficiently large number of training cycles, until the network converge at a state where the error function is relatively small. At this juncture, one can conclude that the network model is ready for test phase.

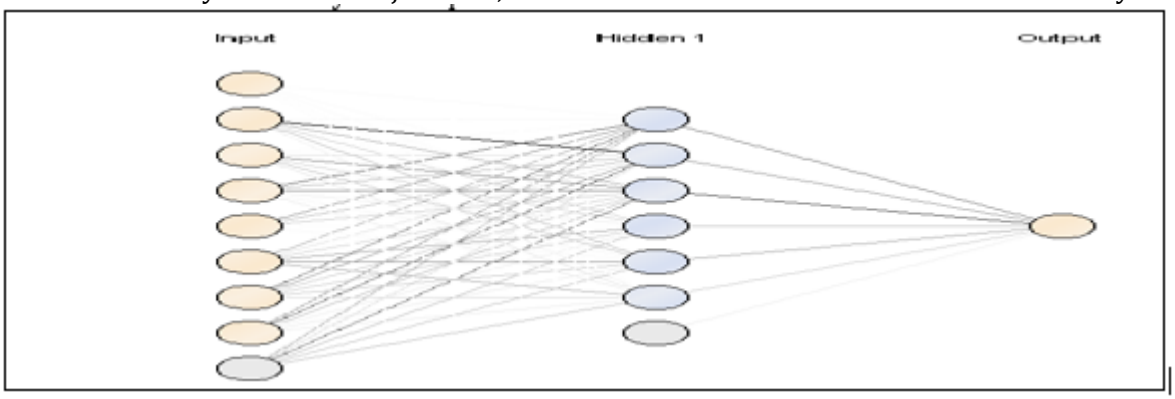

Fig. 1: Back Propagation Graph

Weather forecasting can be modeled as a standard data mining predictive analytics problem. Predictive analytics encompasses a variety of techniques from statistics, modeling, machine learning, neural networks and data mining that analyze current and historical facts to make predictions about future, unknown events.

The methods and strategies used to conduct predictive analytics can broadly be grouped into

A. Regression Techniques [4] [6]
B. Machine Learning techniques (MLT)

And our work focuses on MLT mainly because it emulates human cognition and learn from training examplesto predict future events. In the learning process, each neuron changes its weights according to specific rules and produces result closer to the expected result [7]. ANN falls under MLT, where we use historical weather data, train the model with the known data set to predict the unknown parameters [13].

4. TOOLS AND TECHNIQUES

We have use Rapid Miner is a commercial popular data mining open source tool, developed by Rapid –I, GmbH of Dortmund, Germany. Rapid Miner, formerly known as YALE (Yet another Learning Environment), was developed. Rapid Miner is a software platform that provides an integrated environment for machine learning, data mining, text mining, predictive analytics and business analytics. It is used for business and industrial applications as well as for research, education, training, prototyping, and application development and integrates all steps of the data mining

process including results visualization, validation and optimization. It is an easy-to-use visual environment for predictive analytics. It is the most powerful and intuitive graphical user Interface for the design of analysis processes. It can easily integrate our specialized algorithms by leveraging its powerful and open extension APIs, 3-D graphs, scatter matrices, self-organizing maps. Rapid Miner's advanced engine allows turning data into fully customizable, exportable charts with support for zooming, panning, and rescaling for maximum visual impact.

- Open and extensible.
- Advanced analytics at every scale perfect for big data.
- Start making predictions in 5 minutes or less with application templates.
- Rapid Miner Studio runs on every major platform and operating system.
- Strong Visualizations.
- Multiple Interfaces.
- Accurate Preprocessing.
- Complete Toolbox [12].

5. IMPLEMENTATION IN RAPIDMINER

Here, we consider weather data set (2023 Jan, Feb data) collected at US international airport

Table I. 2023 Jan, Feb Weather Data Set

Month	Day	Dew Point	Humidity	Pressure	Tmp High	Tmp Low	Visibility	Wind Direction	Wind Speed
1	1	19.4	0.861	1017.1	25.6	22.2	15.2	31.7	5
1	2	20	0.831	1018.1	27.2	22.8	15.9	57.6	6.4
1	3	20.6	0.862	1019	26.1	22.8	15.5	72.9	6.9
1	4	21.1	0.841	1018.8	26.7	22.8	15.8	118	6
1	5	22.2	0.857	1019.1	28.3	23.3	15.8	154.7	3.3
1	6	21.7	0.877	1019.9	28.3	22.8	14.3	89.5	3.2
1	7	22.2	0.817	1017.9	28.9	24.4	14.7	138.3	4.2
1	8	22.2	0.814	1014.3	28.3	24.4	15.6	183.5	6.8
1	9	17.8	0.889	1014.3	26.1	19.4	9.9	98.8	6.2
1	10	20	0.854	1018.2	28.9	22.2	15.8	121.3	3.9
2	20	9.4	0.665	1019.5	23.9	15.6	16.7	86.7	4.8
2	21	15	0.716	1017.4	26.7	21.7	16	151.3	5.1
2	22	20	0.857	1013.9	27.2	22.2	10.9	178.5	3.9
2	23	16.1	0.819	1014.2	25	21.1	14.3	329.6	5.6
2	24	12.2	0.651	1019.5	23.9	18.9	16	52.4	7.9
2	25	12.8	0.624	1019.8	23.9	19.4	16	114.1	8.1
2	26	16.7	0.784	1017	26.1	22.2	16	164.6	5.7

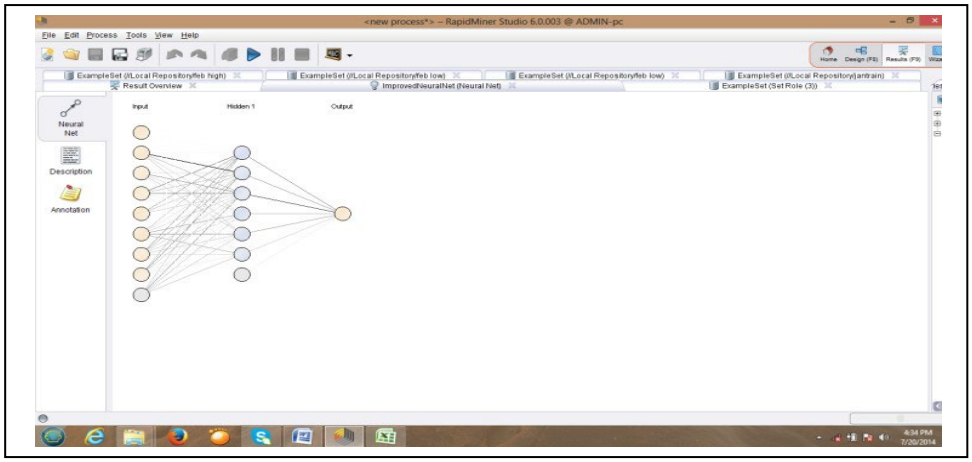

Fig. 2: A Graphical view of NN for weather prediction model

refer Table 1. As a case study for training the model, we used January months' data with all the prime weather attributes [8] and tried to predict February months' maximum and minimum temperature. The model is designed using Rapid Miner tool, which is a basic data mining busines and predictive analytical tool. While running the model, to our surprise

we find that it more or less coincided with the real/actual data.

NN uses hidden layer to compare all attributes in a data set to all other attributes. The circles in the graph are nodes, and the lines between the nodes are neurons. The thicker and the darker the neuron is between the nodes that exhibit the strong affinity. The graph begins on the left, with one node for each predictor attribute. Stronger neurons equate to a stronger ability by that attribute to predict [9] [10] [11].

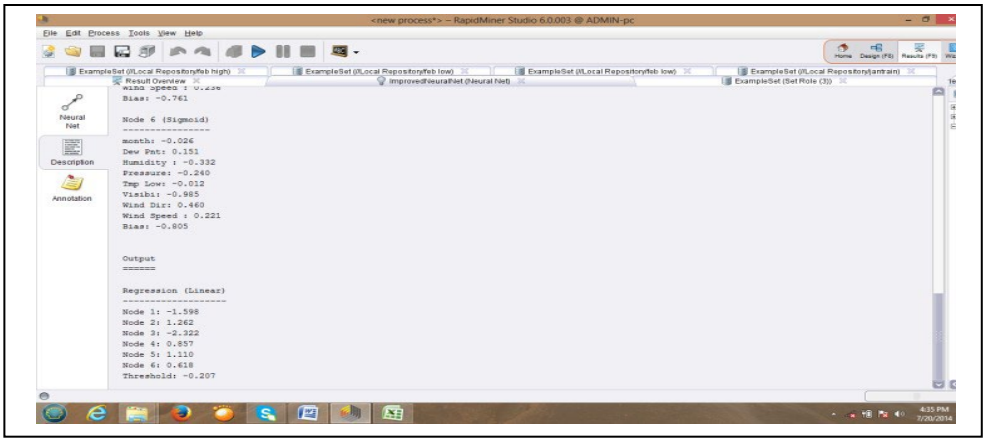

Fig.3: Experimental Result 1

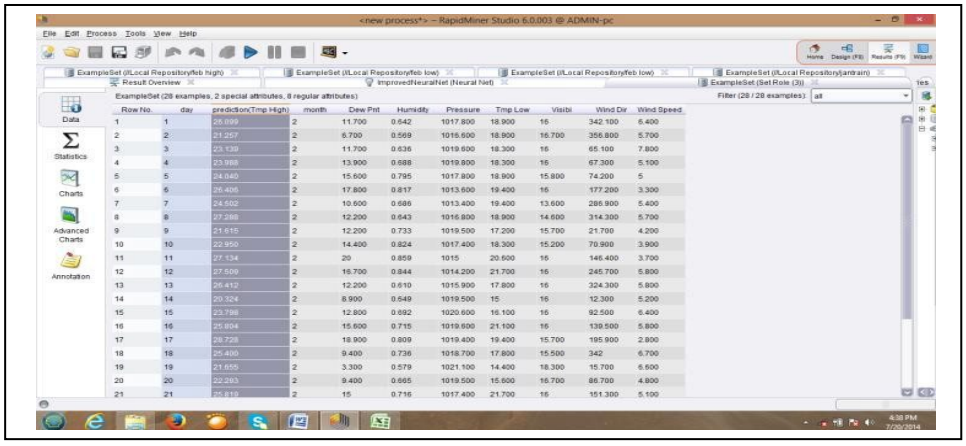

Fig. 4: Screen Shot Predicting Max Temperature of Feb

The above figure is the result of running the model predicting the max. Temperature of Feb' 2023. Figure 4 screen shot depicts example set of 28 examples, 2 special attributes and 8 regular attributes. It displays all the attributes given as input and one field called prediction (tmp high) which is highlighted. This output / target / predicted value generated is compared with the acutal values and it is plotted as graph, comparing both minimum and maximum values of Feb. From figures 5 and 6 one can find that the deviations are narrow.

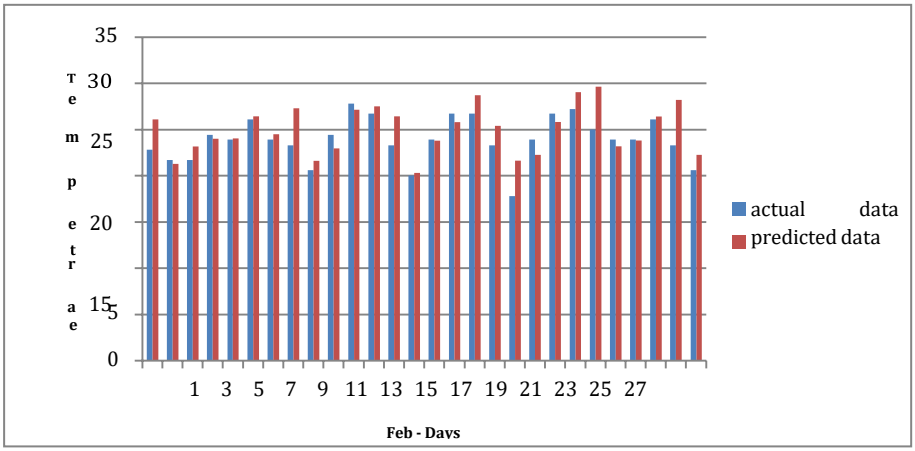

Fig. 5: Graph comparing max. Temperature of Feb

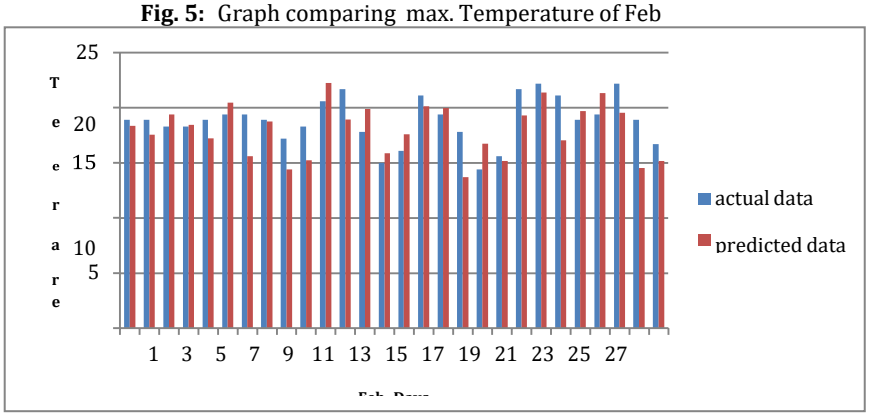

Fig. 6: Graph comparing min. temperature of Feb

The above graph shows the difference between the actual and predicted values. The difference can still be reduced by improving the model with increasing the training cycles, and by other parameters namely learning rate and momentum. In results perspective, we can find both a graphical model and numerical predictions.

4. CONCLUSION

We may infer from the model that artificial neural networks can help simulate a weather forecasting system that predicts the highest and lowest temperatures. Training 1000 cycles with a learning rate of 0.3 and momentum of 0.2 led to an accuracy of 81.78%. The correlation coefficient, or root mean square error, or RMSE, is used to quantify performance. ANN are more adept at determining the degree of correlation between attributes, are capable of learning from experience, and demonstrate intelligence when making predictions, despite the existence of numerous data mining techniques. In summary, even in the face of some data uncertainty, the suggested model updates or modifies attribute values, trains them, and creates nodes with higher levels of confidence percentages. The 81.78% accuracy rate shows that a An effective ANN model is created. In addition, the model can be expanded to forecast additional meteorological characteristics such as precipitation, tornadoes, hurricanes, cyclonic storms, and snowfall.

CONFLICT OF INTERESTS

None

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None

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