Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
July- December 2023 4(2), 960–965

PREDICTION OF CLIMATOLOGY USING NEURO-FUZZY TECHNIQUES

Ratnesh Kumar Namdeo[1], Dr. Omprakash Chandrakar[2]

[1]Research Scholar, MSIT, MATS University Raipur
[2]Professor, MSIT, MATS University Raipur

Corresponding Author
Ratnesh Kumar Namdeo,
ratneshnamdeo12@gmail.com

DOI
10.29121/shodhkosh.v4.i2.2023.1961

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

For social and economic activists, weather forecasting is the most talked about topic right now. Due to its applicability in a number of public and private industries, such as forestry, air traffic, agriculture, and maritime, it is also garnering widespread interest. Recent events have caused alterations in the climate. Occurat a rapid pace, rendering traditional weather forecasting techniques less accurate, more time-consuming, and erratic. To solve these, more advanced and effective weather forecast techniques are required. Challenges. Through actual evidence, we show that artificial neural networks generate significantly less deviations than GDAS assessment. Thus, almost exact weather forecast results are predicted. This article investigates the forecasting performance of neural networks in comparison to linear and polynomial approximations for a time series produced by the chaotic Mackey-Glass differential delay equation. There is one step ahead in the predicting horizon. A basic neural network with two neurons is used in a series of regressions with polynomial approximators, and the numerous correlation coefficients are compared. A nearly perfect forecast is produced by the neural network, a very basic neural network that outperforms polynomial expansions. Lastly, over a broad range of realizations, the neural network outperforms the other techniques in terms of precision.

Keywords: Artificial Neural Networks, AI Weather Forecast, Machine Learning, Weather Forecasting, Weather Prediction

1. INTRODUCTION

The use of technology and computer science to forecast the weather for a specific location at a future date is known as weather prediction. Informal weather forecasting has been an endeavor for a very long time. The process of making weather predictions involves obtaining quantitative information about the atmosphere's current condition and applying scientific knowledge of weather evolution processes to predict how the atmosphere will change over time. To obtain the best possible prediction model which includes pattern recognition tasks, knowledge of model performance, and accuracy manual input is still necessary. The applications of weather prediction are diverse. Because they are intended to save lives and property, weather warnings are significant forecasts. Temperature and pressure forecasts are crucial to farmers and, consequently, to dealers in commodities markets. Utility providers use temperature forecasts to project demand for the upcoming days. Weather forecasts are used by people to plan their outfits for the upcoming day. Since wind, snow, and heavy rain drastically limit outside activities. Additionally, weather forecasting can be utilized to plan events surrounding them, as well as to prepare ahead of time and withstand them. Essentially, there are just two ways to forecast weather: the dynamical and empirical approaches [18]. The empirical method is predicated on the fact that meteorologists as "analog forecasting," using analogs. This method works well for forecasting localized weather if there are many cases that have been reported. The dynamical method relies on formulas and forward models of the environment and known as computer modeling. This method works well for simulating large-scale meteorological phenomena. Practically speaking, most weather prediction algorithms combined empirical and dynamic methods.AI faces enormous problems when it comes to weather forecast. The weather is constant, and there is a wealth of diverse, lively and disorganized. Regarding these attributes, meteorological forecasting served as a test bed for AI prediction systems. The Using operational weather forecasting entails using extensive knowledge of people. Three facets of forecasts that have to be taken into account when creating systems with intelligence for working meteorologists. Initially, Predicting is based on multiple methods. Secondly, specialists use ambiguous language to express their understanding, thirdly, information is frequently vague.

Learning quick dynamics (high frequencies in the linear case) while simultaneously canceling noise is a challenge in time series prediction. This problem closely relates to the trade-off between overfitting and underfitting. It is true that forgetting fast dynamics results in under-fitting, whereas learning noise may lead to over-fitting. Time series prediction is a significant practical issue with a wide range of applications, including signal processing, control, and economic and commercial planning. One problem with a chaotic series is that regularities cannot be captured by linear models, such time series or regressions. Short-term predictability should be present in data if it is not produced by a high-dimensional process, but not when using linear forecasting models. A non-linear model, such a neural network, is suitable in this situation. The most challenging aspect of forecasting is modeling the chaotic time series.

On the foundation of the theory of dynamic reconstruction from a scalar time series, numerous forecasting methods have been constructed. It is easy to discover that nearly all methods for forecasting chaotic time series—such as radial basis functions, polynomial approximations, local linear approximations, and neural networks—were first created for approximating generic continuous functions. Numerous cases have been tested to confirm the efficiency of these strategies. Of course, there are drawbacks to every method; in particular, prediction accuracy is still very low. It is obviously connected to chaotic systems' sensitive dependency on initial conditions. A decent prediction is also somewhat hampered by computational resources. Actually, chaotic behavior is so erratic that it may not be possible to predict it using the conventional, mature methods. The reason for the irregularity is that chaotic attractors have extremely intricate geometric structures.

2. RELATED WORK

Over the years, a number of techniques were used for weather prediction, including both traditional and sophisticated methods [Fig. 1]. We have using techniques of climatology.

There are divided into two techniques first one is classification techniques and second one is intelligent Techniques. The classification Techniques divided into two subpart that is Regression models and Time series module and intelligent Techniques divided also sub two part that is memory system and Hybrid system

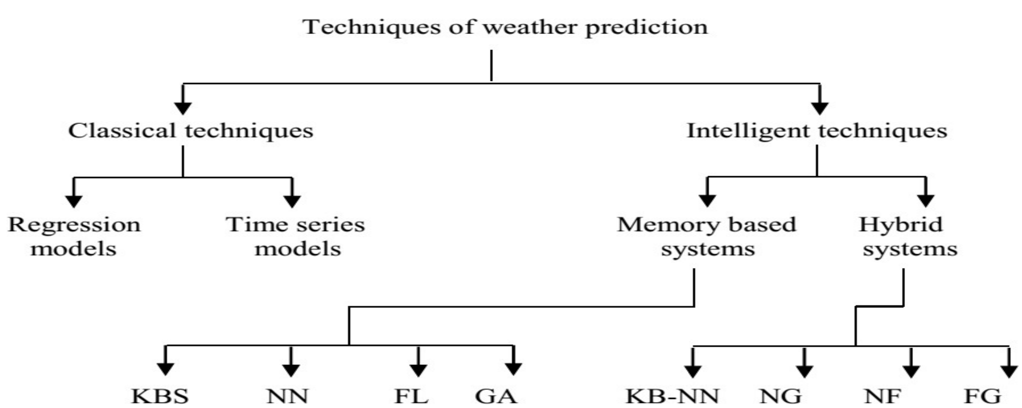

Fig: 1. Techniques of weather prediction

Neuro-fuzzy systems provide a potent trade-off between a human-like model representation and a quick learning technique in terms of efficiency and reliability, as demonstrated in [6]. But the major feature that sets Neuro-fuzzy estimators apart from other types of nonlinear approximates is their ability to integrate data-driven modeling methodologies with pre-existing a priori first principle models. In actuality, fuzzy design enables a simple integration of existing knowledge about the process to be represented into the system, whereas learning approaches enable the inference system to adapt to the observed data. Neural networks have also been demonstrated in [12] to be utilized for long-range rainfall forecasts in the Matron region of Egypt. They concluded that the information anticipated by using the algorithms for back propagation are more accurate than the data established by using the statistical model. In [24], the writers determined that searching through a big database of weather observations for weather instances in the past that are comparable to this one Employing a fuzzy similarity metric can improve the precision of forecasts for an airport's visibility and cloud cover. [21] Employed the Nearest Neighbor Based Fuzzy Model [NNFM] based on membership data to predict Delhi's daily maximum temperature. He discovered that this approach is promising in terms of practical use.

Successful grid-based environment for addressing problems that genuinely expands and accepts the conventional tools of a computational scientist include Multiple times. They have concentrated on the most difficult clients. Of numerical forecasting for the weather. In order to establish climate relationships over time and space, it was suggested in [22] that a spatially explicit seasonal forecasting method be used. This method would be based on the fuzzy classification of long-term [40 years] daily rainfall and temperature data. According to [7], throughout the past few years, a number of operational numerical weather prediction centers have produced global weather forecasts that have improved gradually in ability and quality to an astounding degree. It was demonstrated in that Mount Everest's meteorological features during the 10-minute mean and daily records temperature, minimum temperature, maximum temperature, wind, pressure, and relative humidity.

3. CLIMATOLOGY

Fundamentally, climatology is the scientific study of climate, or the factors that dominate temperature, humidity, precipitation, and patterns of air circulation over a long period of time. Climatology explores the underlying rhythms and shifts that characterize Earth's climates over decades, centuries, and millennia, in contrast to meteorology, which deals with daily weather forecasts. The study of the Jabalpur atmosphere as an integrated system made up of the atmosphere, land, and ocean is known as climatology. The three fundamental components of meteorology are weather observation, comprehension, and interpretation. Jabalpur weather observations are made using basic devices such as thermometers and anemometers, and they are plotted on weather charts for meteorologists at Jabalpur weather stations to evaluate. Notable advancements in the study of meteorology have been made possible by recent developments in supercomputers, radars, satellites, and contemporary computers. Weather forecasters' jobs vary in that their Daily forecasts are analyzed and issued by an operational forecaster. A meteorologist specializing in catastrophic occurrences such as earthquakes, tsunamis, landslides, flash floods, and unpredictable climate shifts. In the military, for the country's security and safety. Airlines provide pilots with weather updates during takeoff, landing, and transitions. In agriculture, climatology is essential for crop yield, seeding timing, soil moisture content, pest migration, and other aspects of agricultural cultivation. Because

Of this, meteorology and Jabalpur weather forecasting are intimately related and essential to the survival of humanity and all other living things on Earth. This led us to the conclusion that applying data mining techniques was appropriate. Changes in the weather and climate have an impact on most economic, industrial, agricultural, social, commercial, and transportation-related processes, either directly or indirectly. People, animals, pests, insects, and microorganisms, as well as plants, trees, forests, and marine life, all have an impact on and sustain the atmosphere throughout their existence. Thus, meteorology plays a significant role in every aspect of contemporary human existence. Neuro-fuzzy modelling has been recognized as a powerful tool which can facilitate the effective development of models by combining information from different sources, such as empirical models, heuristics and data. Neuro-fuzzy models describe systems by means of fuzzy if-then rules, such as ‘If x is small then y is large’ represented in a network structure, to which learning algorithms known from the area of artificial neural networks can be applied. Neuro-fuzzy models are to a certain degree transparent to interpretation and analysis, i.e., can be better used to explain solutions to users than completely black-box models such as neural networks.

Jabalpur is a district of Madhya Pradesh state in central India. The city of Jabalpur is the administrative headquarters of the district. The city has an average elevation of 411 meters (1,348 feet). Geographically as depicted in the following Figure 1. The area of the district is 5,198 km^2 with populations of 2,463,289 (2011 census). As of 2011 it is the second most populous district of Madhya Pradesh (out of 50), after Indore. The region is geographically located at 23° 10′ 0″ N, 79° 56′ 0″ E. Jabalpur has a humid subtropical climate typical of north-central India (Madhya Pradesh and southern Uttar Pradesh). Summer begins in late March, lasting until June. May is the hottest month, with the average temperature exceeding 45 °C (113 °F). Summer is followed by the southwest monsoon, which lasts until early October and produces 889 mm (35 in) of rain. From July to September. Average annual precipitation is nearly 1,386 mm (54.6 in). Winter begins in late November, and lasts until early March. January is the coldest month, with an average daily temperature near 15 °C (59 °F).

4. METHODOLOGY

Data gathering and preprocessing: gathering and preparing the Jabalpur region's meteorological data set. Examining ANN methods: Finding the best ANN technique that is effective enough to learn the chaotic behavior of time series data. Determining the meteorological parameters that are useful for the meteorological system's dynamic behavior. Define fuzzy rules to detect chaotic behavior in time series meteorological data. Using climatologic data, a neuro-fuzzy model is developed to identify the internal dynamics of time series containing non-linear data.

We have categories four part of methodology from stage one to stage four that is our prediction

4.1. STAGE OF PREPARING THE DATA

This stage carried out during the following steps:

- Calculate the arithmetic mean for every month for every year of weather observations temperature, relative humidity, wind speed and rainfall.
- Compute the standard deviation for previous data.
- Calculate the sum of pollen grains for every month during the year. Divide its value for every month by this sum to obtain the percentage of month with respect to year.
- Obtain the maximum and minimum values of weather observations and pollen grains for every year
- Calculate the arithmetic mean for the four seasons [winter through autumn] during year of weather observations.
- Classify the data into 12 sets, each set consist of four means for one month of 12
- Transpose these sets into 10 columns each column contains 48 values represent one year
  The first 9 columns for training. The 10th column will be used to compare

5. MODEL DEMONSTRATION

The following Mackey-Glass (MG) time-delay differential equation generates the time series that is predicted by the chaotic time series model that is put forth in this work.

$$x(t) = \frac{0.2\, x\,(t-\tau)}{1+\ x^{10}(t-\tau)} - 0.1x(t)$$

There is no distinct era in this time series because it is chaotic. The trajectory is very sensitive to initial conditions, and the series will neither converge nor diverge. In the fields of fuzzy modeling and neural networks, this is a standard problem. The fourth-order Runge-Kutta method is used to determine the numerical solution in order to acquire the time series value at integer locations (Figure 1). Its algorithm demonstrates the superiority of neural networks over polynomial and linear approximations. A basic neural network with two neurons and a series of regressions using polynomial approximators are used to compare the numerous correlation coefficients.

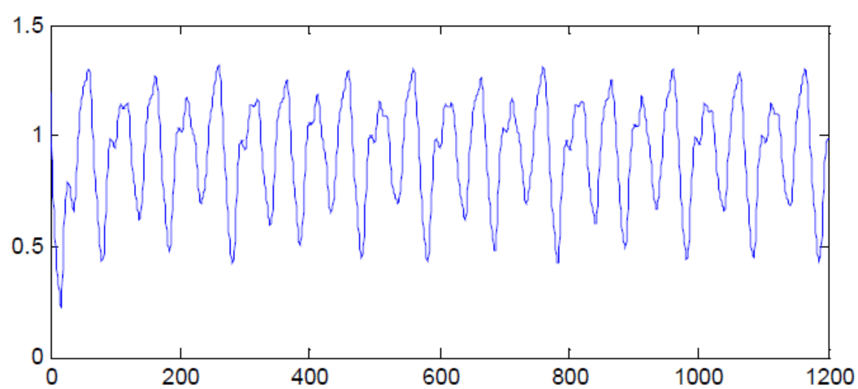

Fig. 2. Chaotic method model

Given that it uses genetic algorithms for training, the neural network is a product of genetic evolution. Time-series prediction uses the known values of the time series up to that moment in order to forecast the value at a later period.

6. RESULT

The goodness of fit or R 2 statistics results for this basic set of realizations are shown in Table 1. We compare second-order polynomials with a two-neutron simple network.

Table 1: Result

S. No.	Approximation	R^2
1	Linear	0.76
2	Polynomial-Order 2	0.87
3	Tehebeycheff Polynomial Order 2	0.87
4	Hermite-Order 2	0.87
5	Legendre-Order 2	0.87
6	Laguerre-Order 2	0.87
7	Neural Network: FF, 2 Neurons, 1 Layer	0.97

This table displays a number of significant findings regarding the prediction of a chaotic time series. First, giving up on pure linear approximation has clear advantages. Second, the predictions made by the power polynomial and the orthogonal polynomials are identical. There's no good reason to pick one over the other. Third, the genetically evolved neural network, which is a very basic neural network, outperforms polynomial expansions and produces extremely good results. In conclusion, the neural network exhibits significantly greater precision than the other approaches over a broad range of realizations.

7. CONCLUSION

By comparing the different cases of results from neuro-fuzzy model with the observed meteorological data and the accuracy of forecasting. The prediction of meteorological parameters such as temperature, relative humidity, wind speed, and rainfall using hybrid systems such as neuro-fuzzy model seemed to be promising method with successful test results. Testing the models of prediction for climate changes is essential to verify the prediction process. It is logic to find climatically sensitive biological indicators such as pollen dust grains. Pollen dust was used in the Current study to support the hypotheses of relativity of the pollen dust and the data of the climatic parameters. It was clear from the results that there is reverse relationship between pollen dust and rainfall, on other words any rise in rainfall rates leads to decrease on atmospheric free pollen dust. Also, there is relationship between pollen dust and wind speed, temperature, i.e. in case of increasing the wind speed and temperature this may leads to an increase on atmospheric free pollen as is evident from the foregoing, the estimate problem becomes significantly more difficult and time-consuming when nonlinearity is introduced compared to the basic linear model. However, it also adds a great deal of intrigue to the estimation process. We need to figure out how to distinguish between a set of estimates that is better or worse than another, as we can converge to a wide range of findings or parameter values. This research aims to model a time series without falling into the high danger of locally optimum solutions by applying an existing globally evolved search approach for neural network estimation.

CONFLICT OF INTERESTS

None

ACKNOWLEDGMENTS

None

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