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# A Review on Modeling Techniques in Chaotic Soft Computing Systems using Forecasting

Sruthi Sreekumar
Mtech Electronics
S.B.Jain Institute of Technology, Management and Research, Nagpur,India
*shrutiskmr@gmail.com*

Sanjay Badjate
S.B.Jain Institute of Technology, Management and Research
Nagpur,India
*s_badjate@rediffmail.com*

***Abstract*****—**Time series prediction finds various applications in medicine, stock market, meteorology, geology, astronomy, chemistry, biometrics and robotics. In this paper we give a review on various modeling techniques in soft computing for various weather applications in presence of chaos if any. There are various prediction models which enhance the ability to reduce the after effects of the hazards created by such uncertainty. In local modeling approaches, the independent models which work on different nonlinear systems and processes are very successful in modeling, identification, and prediction applications. The results of such reviews of various methodologies are to get an efficient analogy to create a much better prediction model for chaotic neuro fuzzy or adaptive neural network systems.

***Index Terms*****—**modeling, prediction, chaos, soft computing

## I. INTRODUCTION

Predicting future behavior of chaotic time series is a challenging area in nonlinear prediction. The prediction accuracy of chaotic time series is extremely dependent on the model and learning algorithm. In addition, the generalization property of the proposed models trained by limited observations is of great importance.

In the past two decades, neural networks and related neuro fuzzy models as general function approximators [1], [2] have been the subjects of interest due to their many practical applications in modeling complex phenomena [3], [4]; but when the number of observations for training is limited they can neither reconstruct the dynamics nor can learn the shape of attractor. They may present the most accurate one step ahead predictions, but in larger prediction horizon their performance dramatically falls down [3]. The uncertainty of weather has repelled humans to make efforts for determining weather before time so that disasters and adverse situations may be tackled and managed prior to any vast spread demolition. If we predict real time geographical conditions in advance to be prepared for unsympathetic conditions.

In recent years, hydrological modeling has gained significant importance through Artificial Intelligence (AI) techniques for their ability to learn hidden patterns from historical data and predict highly non-linear systems. The hybrid Adaptive Neuro-Fuzzy Inference System (ANFIS) and Artificial Neural Network (ANN) are commonly used AI techniques which have been applied in variety of domains for such modeling [5] – [6].

Similarly, one of the crucial factors of an effective power system are load and energy production forecasting for proper system planning and operation. Almost all electric power companies are now forecasting power load based on traditional prediction methods[7]. Nevertheless, the relationship between power load and factors influencing power production is nonlinear; therefore it is difficult to identify its nonlinearity by using traditional prediction methods.

There are various optimization techniques and spectral analysis is to find some long term predictable components which describe the time series dynamics properly such as singular spectrum analysis which is one of the many to be mentioned.

For the total 80% water demand rainfall forecasting is imperative for rain-fed agriculture in arid and semi-arid regions of the world for agriculture [8].Over all, the gross development production is directly affected in regions all over the world where the harvest are dependent on irregular climatic conditions [9], making it necessary to know maximum about the future climatic conditions, specifically the rainfall forecast, for a correct management of resources.

Various optimized procedures such as a bio-inspired heuristic search technique are used to solve complex forecasting problems can be used to represent models on the concepts of biological neurons. This can be suitably applied to a neuro-fuzzy or simply an ANN system application in real time databases such as solar energy production and relative data are pre-processed using Fuzzy Logic techniques.

This paper aims at giving a comparison about the existing techniques for prediction of real time data which may or may not use chaotic time series. The paper also throws light over the ANFIS model which hybridizes soft computing techniques through which analysis of real time prediction can be done effectively.

## II. RELATED WORK

The problem of future real time data prediction using a pre-trained model consists in determining a suitable model given a set of meteorological variables which are the geographically measurable paramaters in a certain region. One of such techniques which are used for real time data prediction is Singular spectrum analysis (SSA) which is a new tool to extract information from short and noisy chaotic time series [10] and has been successfully used in predicting chaotic time series in [3], [4]. This tool of singular spectrum analysis lies on the Karhunen- Loeve decomposition of an estimate of covariance matrix based on M lagged copies of the time series. In this algorithm, the initial step is the embedding procedure which is applied to construct a sequence {Xi' (t)} of M-dimensional vectors from time series {X(t): t = 1 ....,N}

There are various networks and methodologies on which time series prediction has been implemented, some of which are listed below.

### A. THE EMBEDDED SPACE CONSTRUCTION

A chaotic time series generally exhibits stochastic characteristics which is non deterministic or random in time or frequency domain. Nevertheless, by using the coordinates with appropriate embedding dimension and time delay, a quasi periodic attractor in the phase space can be derived. Fig. 1 indicates a chaotic time series and its trajectories in the EPS. Consider a mathematical time series {x(1), x(2), x(3),…..x(N). An embedded phase vector given as y(i) is

$$y(i) = [x(i)\ \ x(i-T) \ldots\ x(i-(D-1)T)]$$

where i € [ 1+ (D-1)*T*, N], D is the embedding dimension, and *T* is the time delay, y(i) is a vector in the D-dimensional phase space RD. A trajectory Y in RD is defined as

$$Y=[y^T(i)\ \ y^T(i+1) \ldots\ y^T(i+m)]$$

In order to extract the behaviors of the time series in an efficient way, optimal values of D and *T* have to be determined accordingly.

### B. ARTIFICIAL NEURAL NETWORKS

Soft computation techniques play a vital role in most engineering applications in which the model optimization problems have to be solved. Many a times the complex and immediate nature of many practical problems involves an effective use of soft computing or Artificial Neural Networks to solve them. Without any a-priori assumption concerning the nature of these correlations, ANNs are useful tools when one needs to get into the complex and nonlinear relationships among data. As previously presented by the authors in [11], ANN is an effective computing method which is widely used in order to easily process the dynamic behavior of time-varying variable. An example of real time ANN is the human brain in which neural networks are simulated by such networks by capturing the features and behavior of the human brain. Adaptive neural networks consists of an interconnected group of artificial neurons which can be changed in accordance with requirement suitably processes information according to the strength of connections among each if the neuron. If looked at it in terms of practical aspects, the neural networks are non-linear statistical data modeling tools used to model complex relationships between inputs and outputs or to find patterns in data for any specified data.

### C. NEURO FUZZY LOGIC

Fuzzy logic [18-20] based logical mapping done provides an effective way to relate weather parameters and events primarily because weather parameters and events are fuzzy in nature [12]. Mamdani type of fuzzy inference model of Fuzzy rule based system has been used for predicting weather events of Lahore.

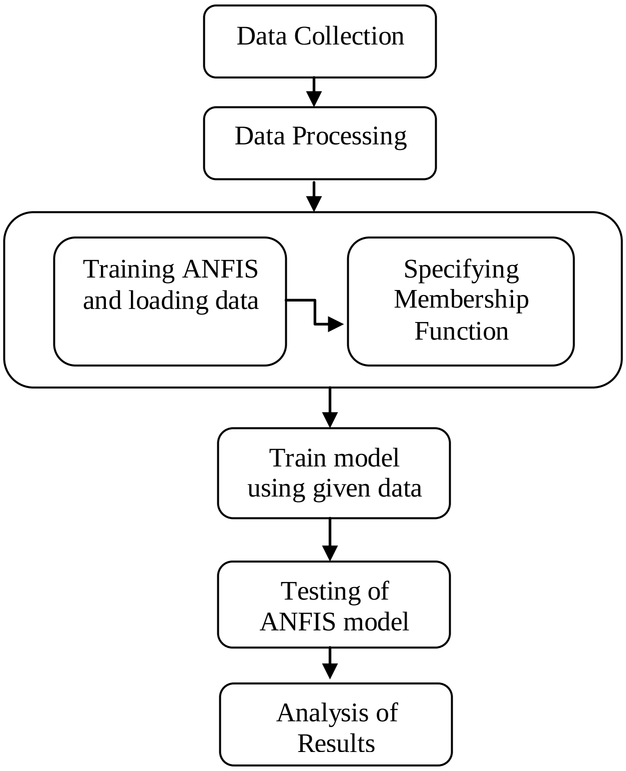


Figure 1. Sugeno FIS methodology

The results of the fuzzy system of the Mamdani fuzzy inference system have been compared with decision tree (DT) based model and partial least square based regression (PLSR) model as in [13]. Novel data mining techniques along with computational neural networks which are part of soft computing was used for the prediction of frost [14]. A regression tree algorithm (cubist) was used for soil temperature and moisture prediction [15]. For the prediction of real time data such as dew point temperature and flood forecasting artificial neural network (ANN) models are used [12][16]. Multi-Layer Perceptron (MLP) is used [17] to model short-term temperature forecasting (STTF) Systems Important structural design of neural networks. Similarly, in ref. [18] ANN is used for air temperature prediction. In neural networks atmospheric temperature is predicted by using Support Vector M achine (SVM) [9]. Moreover, a priori based association rule algorithm is used for tropical cyclone intensity prediction [19] such as T-Apriori algorithm which is used to show close association between environmental factors and ecological events [20]. The logical node mapping of the fuzzy inference system provides a basis from which decisions can be made, or patterns discerned. [21]. As contrast to the other fuzzy inference systems observed, Adaptive Neuro Fuzzy Inference System (ANFIS) is more composite,rugged and is not offered for all of the fuzzy inference system options.

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Anfis is explicitly used for Sugeno type systems [21] because of its compositeness.

## IV. COMPARISON OF VARIOUS PROPOSED SYSTEMS

There are various methods proposed for the real time data analysis. Here we will be discussing a few techniques being proposed.

### A. WEATHER ANALYSIS

In a specific system, an analysis was conducted in a city in Pakistan where data collection had been done and the data comprised of input weather parameters i.e. temperature levels, humidity levels rainfall, clearity of vision, speed of the wind, wind speed limits, dew levels, heat days over the period (7 years ) January 2003 to December 2010. The weather events encompassed in this duration for that city were rain, fog, clear, thunderstorm, rain & thunderstorm.

Some abnormalities were found in the encompassed data with the weather data collected [22] which was a representative experience of five seasons in the city. Missing values in the input space have been filled with the average of the previous and next value. Standard deviation to note the error rate from the standard value of all input parameters was taken and parameters with low standard deviation were skipped in second experiment to reduce the data set. The whole sample space for the training comprising of 2100 instances. About 70% of the sample space was used for training ANFIS, while the remaining 30% of the sample space was for testing of neural network in error rate and the accuracy of the trained ANFIS. The model is depicted in Figure 1.

### B. WIND POWER FORECASTING

Another technique proposed is of a short-term wind power forecasting based on neuro-fuzzy networks. This wind power forecasting system mainly uses numerical weather predictions (NWPs) as inputs to forecast or predict the future wind power production of the entire wind farm or any other geographic area. Fig.2 shows an outline of the forecasting system proposed. The meteorological forecast which is to be done of the NWP model applied is provided specifically for a geographical reference point inside the area of the wind farm. The Wind Turbine Models, WTM(i), represent the transfer function mathematically between the meteorological variables from the NWP model and the corresponding electric power production of the ith wind turbine of the proposed system. Each WTM is modeled by a neuro-fuzzy network and therefore is hybrid. The neuro-fuzzy system can represent each transfer function correctly, when the neuro-fuzzy network has been trained, and the pattern differences of electric power production due to terrain characteristics, wake effect and power curve characteristics of each wind turbine have been taken into

| m1i | ∂1j | . | mij | ∂ij | …. | w1j | w2j | . | wmj |
|---|---|---|---|---|---|---|---|---|---|

account and modeled automatically. As shown in Fig.2,the neuro fuzzy system which has the inputs of the WTM models are meteorological variables forecasted by NWP model. The monitored parameters are forecasted mean wind speed values, forecasted mean wind direction values, forecasted mean humidity values, forecasted temperature values and forecasted atmospheric pressure values.

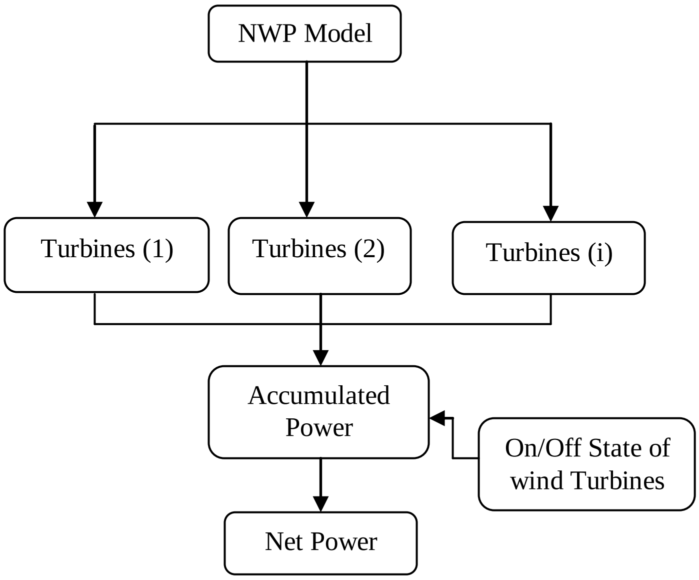


Figure 2. Wind power forecasting system

The "Power Aggregation" module is used to produce the total electric power production forecast. All the individual electric wind power production forecasts corresponding to each wind turbine are aggregated by the same. Their on/off state during operation is indicated by a schedule of the availability of all the wind turbines. The schedule of wind turbines is inputted by operators of the wind farm geographically, usually based on expected times for routine outages.

### C. CLUSTER BASED TRIBES OPTIMIZATION ALGORITHM

There is yet another scheme of hybrid soft computing which propose the CTOA (cluster based tribes optimization algorithm) which adopts a self-clustering algorithm (SCA) [23] for swarm of particles to divide into multiple tribes. complexity is very low in order to facilitate tribes optimization algorithm in re-construction tribe's links can more rapidly. To achieve intra tribe communication and inter-tribe communication, the proposed CTOA is used for the revolving state of each particle to use three different displacement strategies

| Rule 'a' | Rule 'b' | …….. | Rule 'n' | ………. | Rule 'r' |
|---|---|---|---|---|---|

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Figure 3.CTOA using NFS model

Here, in this algorithm in whole search space, a swarm of particles is initialized randomly. Each particle has its own position in search space in this algorithm. In this study, we use the SCA [23] to create multiple swarms which make the swarm ultimately. Unlike the traditional clustering techniques, the SCA is an online and distance-based connectionist clustering algorithm. The tendency of the traditional clustering techniques is to consider the total variations or deviation in all dimensions of the samples that will cause clusters to extend too fast. According to the above mentioned problems, the SCA method considers the variation or deviation of each dimension for the samples from the original positions. This technique in which SCA is used is a fast, one-pass algorithm that dynamically estimates the number of clusters in a set of data and finds the current centers of clusters in the sample space. In any cluster within the algorithm, the maximum distance between an example point and the cluster center is less than a threshold value. Clustering parameters in accordance with the deviation of the particles are set by this clustering algorithm and affects the number of clusters to be estimated. Figure 3 above shows a swarm which is divided into multiple tribes. The next step in the algorithm is that it determines the status of each particle to select displacement strategies for updating the particle followed by evaluation and updation of each particle.

## V. COMPARITIVE RESULTS

Enlisted below is the effective analysis of each scheme discussed above. Neuro-fuzzy networks are adaptive models, so then changes during the life time in any geographical territory like a wind farm occur (like extension of the wind farm, maintenance or availability of the machines that is usually not available through SCADA), the proposed adaptive forecasting model can fine-tune its parameters. It will become easy to track the real wind farm and represent it correctly during the operation in a wind farm.

Other neuro fuzzy systems which use algorithms such as CTOA (cluster based tribes optimization algorithm) method converges quickly and yields a lower RMS error than the other method. Computer simulations of this algorithm indicate that the proposed CTOA method surpass all other method in terms of accuracy and speed.

Using different meteorological input parameters of a particular city, the entire process of generating the Sugeno FIS consists of five stages like training, testing the network, overall evaluation, updation of the network from time to time, analysis through which weather forecasting of real time data of a city can be possible effectively. Experiments reveal that an increase in the number of membership functions in the fuzzy inference system also follows increased accuracy.

## VI. CONCLUSION

The comparative analysis of various schemes indicates that the hybridization of the soft computing techniques give optimum results in combination with fuzzy rules. The algorithm CTOA shows even better results due to the updation of variation of each particle within the system by their deviation.

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