Indonesian Journal of Electrical Engineering and Computer Science
Vol. 8, No. 2, November 2017, pp. 567 ~ 570
DOI: 10.11591/ijeecs.v8.i2.pp567-570

Hybrid Approach for Water Demand Prediction Based on Fuzzy Congnitive Maps

G. Jenitha
Department of Mathematics, AMET University, Chennai, India

Abstract

In this study, we propose a new hybrid approach for time series prediction based on the efficient capabilities of fuzzy cognitive maps (FCMs) with structure optimization algorithms and artificial neural networks (ANNs). The proposed structure optimization genetic algorithm (SOGA) for automatic construction of FCM is used for modeling complexity based on historical time series, and artificial neural networks (ANNs) which are used at the final process for making time series prediction. The suggested SOGA-FCM method is used for selecting the most important nodes (attributes) and interconnections among them which in the next stage are used as the input data to ANN used for time series prediction after training. The FCM with proficient learning calculations and ANN have been as of now demonstrated as adequate strategies for setting aside a few minutes arrangement anticipating. The execution of the proposed approach is exhibited through the examination of genuine information of every day water request and the comparing expectation. The multivariate examination of recorded information is held for nine factors, season, month, day or week, occasion, mean and high temperature, rain normal, touristic action and water request. The entire approach was actualized in a clever programming device at first sent for FCM forecast. Through the exploratory investigation, the value of the new mixture approach in water request forecast is illustrated, by computing the mean outright blunder (as one of the outstanding expectation measures). The outcomes are promising for future work to this bearing.

Keywords*:* ANN; Fuzzy Cognitive Map (FCM)

1. Introduction

Fuzzy Cognitive Maps (FCMs) work as recurrent neural networks, inheriting their main advantages. They model any real world system as a collection of concepts and causal relationships among concepts. They were initially relied on the human expert knowledge for a domain, making associations along generalized relationships between domain descriptors, concepts and conclusions. Neuro-fuzzy inference system (ANFIS) to estimate the biochemical oxygen demand (BOD) is explained by [1]. Based on the availability of the historical data, FCM can be constructed solely based on them through the use of efficient learning algorithms.

On account of multivariate time arrangement forecast, the FCMs with hereditary based learning calculations have been already proposed. Pattern-based model for water-demand forecasting is discussed by [2]. The contextual analysis of the water request expectation was chosen as an agent one to demonstrate the capacities of the proposed FCM calculation because of the accessibility of genuine information measured from the water supply system of Skiathos Island, Greece. The forecast of the water request is a vital issue that should be mulled over in the operation of water supply and conveyance frameworks. Fuzzy inference systems for water consumption time series prediction and fuzzy grey cognitive maps for the forecasting of multivariate, interval-valued time series are described by [3, 4]. The operation of these frameworks requires visit modifications because of varieties sought after keeping in mind the end goal to enhance its operation and limit dispersion costs. Water request incorporates family unit utilization; additionally organize spillage, since it is the consolidated sum that is put into supply. Hybrid model for medical diagnosis using Neutrosophic Cognitive Maps with Genetic Algorithms and time series based on fuzzy information granules are described by [5, 6].

To enhance exactness of choice emotionally supportive networks, half breed display joining different strategies can be utilized. An approach for time arrangement forecast in view of ARIMA and manufactured neural system is proposed. Hybrid wavelet artificial neural network model for municipal water demand forecasting is discussed by [7]. It takes focal points of both

Received July 11, 2017; Revised September 30, 2017; Accepted October 16, 2017

approachs in direct and nonlinear displaying. A HYBRID approach joining ANNs, fuzzy logic and hereditary calculation was proposed. In, another model was produced for water request anticipating in view of the discrete wavelet changes and manufactured neural system. Survey on fuzzy Petri nets for classification is discussed by [8]. The application of Fuzzy Cognitive Maps to time series modeling has been previously discussed by Homenda *et al*. A hybrid algorithm for fuzzy time series prediction based on fuzzy c-means clustering, fuzzy cognitive map and genetic algorithm is presented. Papakostas *et al.* proposed a model based on fuzzy cognitive maps and artificial neural networks for pattern classifying.

2. Fuzzy Cognitive Maps

Fuzzy cognitive map is a fuzzy-graph structure for representing causal reasoning as a set of concepts *X* significant for the analyzed problem and connections between them in the form of weights matrix *W*. The values of concepts can be calculated according to the selected dynamic model. The most commonly used models are described by the formulas (1), (2).

$$X_i(t+1) = F\left(X_i(t) + \sum_{j \neq i} w_{j,i} \cdot X_j(t)\right), \quad (1)$$

$$X_i(t+1) = F\left(\sum_{j \neq i} w_{j,i} \cdot X_j(t)\right), \quad (2)$$

where *t* is discrete time, *t* = 0, 1, 2, ..., *T*, *T* is end time of simulation, *wj,i* is the weight of the connection between the *j*-th concept and the *i*-th concept, taking on the values from the range [−1, 1], *Xi*(*t*) is the value of the *i*-th concept, transformation function, which can be chosen in the form:

$$F(x) = 1/1 + e^{-cx} \quad (3)$$

where $c > 0$ is a parameter.

3. Hybrid Method For Multivariate Time Series Prediction Based On FCM With Soga And ANN

This paper presents a new hybrid approach based on the structure optimization learning algorithm for fuzzy cognitive maps learning and artificial neural networks. It is called SOGA-FCM-ANN. Figure 1 illustrates the proposed method for multivariate time series prediction.
Ventures of the proposed technique:

1. Initialize the FCM display in light of every accessible dat.
2. Input the standardized recorded learning information.
3. Select the most noteworthy information qualities (ideas of the FCM) and manufacture the unmistakable and lucid FCM demonstrate utilizing the SOGA calculation:

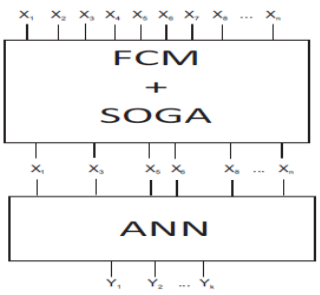

Figure 1. Hybrid Approach for Multivariate Time Series Prediction

- determine selection strategy, crossover and mutation operators,
- initialize population,
- generate new population on the basis of genetic operators,
- evaluate population,
- check stop condition.

4. Test the resulting fuzzy cognitive map with the use of selected normalized historical testing data.
5. Increase the prediction accuracy by using the selected input attributes (concepts of the resulting FCM model) as an input data for artificial neural network.
6. Learn ANNs with the utilization of back proliferation technique with energy and Levenberg-Marquardt calculation on the premise of chose information.
7. Test the subsequent ANN and ascertain forecast exactness measures. Recreation examination of the gave approach was done the utilization of ISEMK programming device. The fundamental components of ISEMK are depicted beneath.

4. Simulation Analysis

The hybrid approach was contrasted and NNs and FCMs beforehand proposed in a comparative dataset of Skiathos. Just a couple of past works have been explained with other referred to forecast calculations, for example, ARIMA and ANFIS for this contextual investigation. Nonetheless, on account of ARIMA, univariate time arrangement were utilized just for expectation of monthy information of Skiathos water request, as this technique as not proficient for multivariate examination of times arrangement in water request as appeared in Figure 2 . ANFIS was beforehand actualized in a littler dataset of Skiathos contextual investigation considering 4 contributions for expectation, nonetheless, because of ANFIS constraint to work with more than 5 inputs, it was unrealistic to make specifically examination with the proposed approach. The utilization of more expectation measures and in addition the correlation with other known anticipating techniques for urban water request is one without bounds steps.

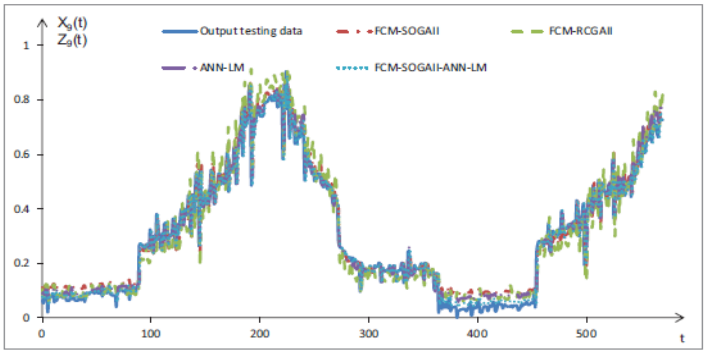

Figure 2. Exemplary Results of Testin

5. Conclusion

In this paper, we translated the urban water request designs through a right around five-year time arrangement for Skiathos Island, a delegate Greek touristic resort. The mid year request pinnacle is six times numerous the winter level and request designs generally comprise of a rising spring summer incline, a plummeting summer-fall slant and a practically steady winter part. We directed a multivariate examination exploring the favorable circumstances and detriments of the proposed approach with ANN-based estimating techniques. Among factors, touristic flood to the island is distinguished as the most imperative indicator of water request and is discovered very decidedly associated. The temperature is likewise decidedly corresponded to the request, dissimilar to precipitation, which is discovered contrarily related. The proposed FCM-SOGA-ANN-LM approach demonstrates to have sufficient fitting and determining limit, contrasting and the other benchmark ANN models.

References

[1] Ahmed AM, Shah SMA. Application of adaptive neuro-fuzzy inference system (ANFIS) to estimate the biochemical oxygen demand (BOD) of Surma River. *Journal of King Saud University-Engineering Sciences.* 2015.
[2] Alvisi S, Franchini M, Marinelli A. A short-term, pattern-based model for water-demand forecasting. *Journal of Hydroinformatics*. 2007; 9(1): 39-50.
[3] Firat M, Turan ME, Yurdusev MA. Comparative analysis of fuzzy inference systems for water consumption time series prediction. *Journal of hydrology*. 2009; 374(3): 235-241.
[4] Froelich W, Salmeron JL. Evolutionary learning of fuzzy grey cognitive maps for the forecasting of multivariate, interval-valued time series. *International Journal of Approximate Reasoning*. 2014; 55(6): 1319-1335.
[5] Kumar M, Bhutani K, Aggarwal S. Hybrid model for medical diagnosis using Neutrosophic Cognitive Maps with Genetic Algorithms. In Fuzzy Systems (FUZZ-IEEE). 2015. IEEE International Conference (pp. 1-7). IEEE.
[6] Lu W, Pedrycz W, Liu X, Yang J, Li P. The modeling of time series based on fuzzy information granules. *Expert Systems with Applications*. 2014; 41(8): 3799-3808.
[7] Mohammed JR, Ibrahim HM. Hybrid wavelet artificial neural network model for municipal water demand forecasting. ARPN Journal of Engineering and Applied Sciences. 2012; 7(8): 1047-1065.
[8] Taj SM, Kumaravel A. Survey on fuzzy Petri nets for classification. Indian Journal of Science and Technology. 2015; 8(14): 1.