Investigation Using Artificial Neural Networks in Electric Power Sectors

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Abstract: This paper presents an initial survey of the uses of Neural Networks in the Electric Power Industry. The objective of the Electric Power Industry is to supply electricity at the least possible cost with a constant service quality. Among the factors that provoke difficulties in achieving this goal, the inherent variability of the load and the fast growth of the demand are foremost, followed by requirements of clean environment, weather, and quality fuels, and accelerated aging of the plants and fast changes in technology. Promising Artificial Neural Networks (ANN) approaches have been developed to solve problems in power plants and power systems --tuning of controllers, process identification, sensor validation, monitoring and fault diagnosis, in power plants, and security assessment, load identification, load modeling, forecasting and fault diagnosis, in power systems.

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1. Introduction

Artificial Neural Network (ANN) is an algorithm that imitates human being biological nervous systems. It has certain performance characteristics in common with biological neural networks. The key element of this algorithm is the novel structure of the information processing system [1-4].

It is composed of a large number of highly interconnected processing elements (neurons) working together to solve a specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist among neurons [5-9].

During last four decades, almost all the known methods of numerical analysis for solving a set of non-linear algebraic equations have been applied in developing load flow algorithms. One or more desirable features to compare the different LF methods can be the speed of solution, memory storage requirement, and accuracy of solution and the reliability of convergence depending on a given situation. Though, robustness or reliability of convergence of the method is required for all types of application, the speed of solution are more important for on-line applications compared to the off-line studies. For contingency selection, fast non-iterative approximate load flow methods such as DC load flow method, laniaries AC load flow, decoupled load flow, fast decoupled load flow methods are used, which provide results having significant inaccuracies. Full AC load flow methods are accurate but become unacceptable for on-line implementation due to high computational time requirements [10,11].

In this paper, standard neural network architecture, multi-layer perception model for the computation of power transfer capabilities and voltages of multi-area power system has been proposed. The repeated power flow method, which repeatedly solves power flow equations at a succession of points along the specified load/generation increment, is used in this work for transfer capability and voltage calculations necessary for the generation of input-output patterns for training the proposed artificial neural network. The effectiveness of the ANN based approach is demonstrated on a three area 30-bus system for different loading patterns [12-15].

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A trained neural network can be thought of as an "expert" in the category of information it has been given to analyze [16-20].

If the network is able to solve the problem by itself and the operation becomes unpredictable, then this can be a disadvantage of this method. On the other hand, it is common that a cognitive approach is used by computer to solve the problem. In this mechanism, problem must be known and stated in less unambiguous instructions. These algorithms are then converted to a high level language program and then compiled into machine code that the computer can understand. Artificial Neural networks and conventional computers are not in competition. They work together. There are tasks more suited to an algorithmic approach like arithmetic operations and tasks that are more suited to neural networks. Even more, a large number of tasks, require systems that use a combination of the two approaches (normally a conventional computer is used to supervise the neural network) in order to perform at maximum efficiency [21-23].

Interactive Voice Response (IVR) with pattern recognition based on Neural Networks was proposed by Syed Ayaz Ali Shah, Azzam ul Asar and S.F. Shaukat for the first time in 2009. In this case, after entering the correct pass word the user is asked to input his voice sample which is used to verify his identity. The addition of voice pattern recognition in the authentication process can potentially further enhance the security level. The developed system is fully compliant with landline phone system. The results are promising based on false accept and false reject criteria offering quick response time. It can potentially play an

effective role in the existing authentication techniques used for identity verification to access secured services through telephone or similar media [24,25].

A large number of load patterns are generated randomly by perturbing the load at all the buses in wide range, voltage magnitude at PV and slack buses and real power generation at PV buses. Single line outages are considered as contingencies. After training, the knowledge about the training patterns in form of voltage magnitudes at all the PQ buses and voltage angles at different PV and PQ buses in various contingency cases and different system operating conditions are stored in structured memory by the trained RBFNs [26,27].

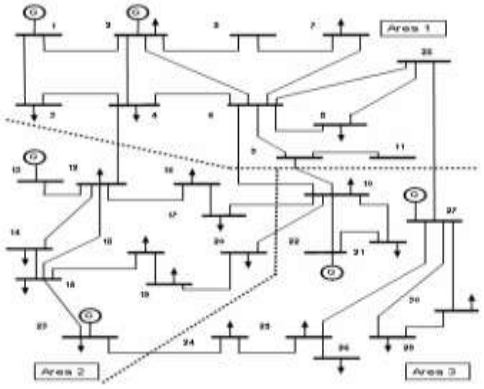

Figure 1: Three area 30-bus systems

An ANN is used to predict one or more of the sensor outputs. If there exist significant difference between the predicted and the actual outputs, then something in the components, system or instrumentation has changed. Topics described in the article: transient diagnostics, sensor validation, plant-wide monitoring, check valve monitoring, and analysis of vibrations. Interesting approach for sensor validation function and detection of incipient faults. Most of the works mentioned have been realized to demonstrate feasibility of some ANN approach [30].

The artificial neural network used in short-time load forecasting can grasp interior rule in factors and complete complex mathematic mapping. Therefore, it is worldwide applied effectively for power system short-term load forecasting. Short-term load forecasting has been useful in safe and economical planning operation of an electrical power system. It has been also used in start-up and shut-down schedules of generating units, overhaul planning and load management. One of the characteristics of electric power is that it can't be stockpiled, that is, the power energy is generated, transmitted, distributed and consumed at the same time. In normal working condition, system generating capacity should meet load requirement anytime [31,32].

If the system generating capacity is not enough, essential measure should be taken such as adding generating units or importing some power from the neighboring network. On the other hand, if the system generating capacity is of surplus, essential measure should be taken too, such as shutting-down some generating units, or outputting some power to neighboring network. Load variation trend and feature forecasting are essential for power dispatch, layout and design department of power system. Artificial Neural Network and Expert System methods belong to quantitative forecasting methods. In this approach, the ANN traces previous load patterns and predicts a load pattern using recent load data [28,29]. It also can use weather information for modeling. The ANN is able to perform non-linear modeling and adaptation. It does not need assumption of any functional relationship between load and weather variables in advance [30].

Newton-Raphson (NR) load flow program is run to generate training / testing patterns for different load scenarios and for all the single-line outage contingencies. Two RBF neural networks are developed in this work, one (RBFN1) for computation of bus voltage magnitude at all the PQ type buses, while the other (RBFN2) for computation of bus voltage angle at PV type and PQ type buses.

Monitoring, Fault Diagnosis and Predictions Ikonomopoulos, Tsoualas and Uhrig presented an approach based on ANNs and rule-based fuzzy expert system to monitor nuclear reactor systems. A model-reference approach was utilized. The expert system executes the basic interpretation and performs identification functions. The ANNs provide the model, classify general categories of system behavior and generate membership functions. These membership functions can be utilized as inputs to a fuzzy controller without the prerequisite of fuzzifying the measured input values. The system allows for monitoring of the equipment performance and inferring of process variable values (virtual measuring). Excellent robustness to noisy and faulty signals was reported. System description is suitable for control applications.

The results have been found very encouraging by Duke Power and EPRI. In the next phase, integrated software will extract the features from data files, run the neural net, compute the wear properties and place the results in a data base.

Interestingly, the application of ANNs proved its suitability for load forecasting according to the following remarks:

1-ANNs are able to approximate numerically any continuous function to the desired accuracy. ANNs could be seen as multivariate, nonlinear and nonparametric methods.

2-ANNs considered as data-driven method, i.e., their models' parameters are mainly estimated on basis of preprocessed forecasting data.

3- Given a sample of input and output vectors, ANNs are able to automatically map the relationship between them.

Short Term Forecasting is for the range of one hour to one week ahead and is used to assist planning and market participants. It can help to estimate load flows and to make decisions that can prevent overloading. Appropriate implementations of such decisions lead to the improvement of network consistency and to the reduced occurrences of equipment failures and blackouts. Weather factors that include temperature, humidity, precipitation, wind speed, cloud cover, light intensity etc. often affect consumer's usage

of some appliances such as space heater, water heater and air conditioner. Forecasted weather parameters are the most important factors in short-term load forecasts. Various weather variables could be considered for load forecasting.

Very Short-Term Load Forecasting (VSTLF)

Very Short Term Forecasting is done to forecast the hours and minutes ahead. It is used to assist trading and eventually dispatch.

One of the major causes for power system outages is the failure of electrical equipment. Reliability, security, and availability of the system can be improved by having good detection and diagnosis systems.

ANNs are able to perform a nonlinear mapping of the load demand electricity series, which allows the extraction of more complex relationships. These characteristics often make it possible to obtain more precise forecasts [5, 18]. Most of the literature surveyed use multilayer perceptron (MLP) that might be classified into two groups, according to the number of output nodes. The first group is MLP that has several output nodes to forecast a sequence of hourly loads, typically 24 nodes, to forecast next day's 24 hourly loads (this is called the load profile) . The second group is the ones that has only one output node, used to forecast next hour's load, next day's peak load or next day's total load.

This paper will focus on Very Short-Term Load Demand Forecasting (VSTLF). Basically, the Artificial Neural Network (ANN) that will be used act as a behavioral model. Based on previous data such as Time, Temperature, Humidity and Load Demand as the output, a behavioral model using ANN will be constructed. Once the behavioral model is concluded it will be used as Load Demand Forecaster.

A simple feed-forward neural network model has been trained with different set of noisy data. The back-propagation method was used for learning in neural network. The range of applications includes postal code recognition, automatic data entry into large administrative systems, banking, automatic cartography and reading devices for blind.

Here the image processing time was significantly reduced while maintaining efficiency and versatility at the same time. But the complete system which encompassed all the features of a practical OCR system was yet to be realized. The key factors involved in the implementation are: an optimal selection of features which categorically defines the details of the characters, the number of features and a low image processing time.

It then explored the similarities and differences between matched filters and one type of artificial neural network, the 'associative memory', which was widely applied to pattern recognition and recall applications. Subsequently, a more promising approach based on 'multilayer perceptions' is investigated for the design of nonlinear filters and its application is examined for the filtering of distorted data from communications channels to equalize and reduce the distortion prior to a binary decision process. It was well recognized that the optimal filter for detecting a signal contaminated by white Gaussian noise is the matched filter. For a coded signal waveform the matched-filter function is achieved by correlating the received signal against a reference waveform to give the correlated output. This is achieved by multiplying together the two time series waveforms and performing the time integration. Two basic realizations of the receiver are possible: the active correlate and the linear matched filter.

Conclusion:

ANN model with the developed structure can perform good prediction with least error and finally this neural network could be an important tool for short term load forecasting. While investigating the works chronologically we have noticed that though there are some merits and demerits of each individual work the application of ANN in each pattern recognition case always performed better result than that of without implementing ANN. The results suggest that the Levenberg-Marquardt method is a powerful tool for neural network modeling. The accuracy level of forecasting on the basis of present data set (experience) was always better.

References:

1. E. I. Amoiralis, M. A. Tsili, A. G. Kladas, "Transformer Design and Optimization: A Literature Survey," IEEE Trans. on Power Delivery, vol. 24, no. 4, 2009, pp. 1999-2024.
2. Rehman, A. and Saba, T. (2014). Evaluation of artificial intelligent techniques to secure information in enterprises, Artificial Intelligence Review, vol. 42(4), pp. 1029-1044, doi. 10.1007/s10462-012-9372-9.
3. Rehman, A. and Saba, T. (2012). Off-line cursive script recognition: current advances, comparisons and remaining problems, Artificial Intelligence Review, Vol. 37(4), pp.261-268. doi. 10.1007/s10462-011-9229-7.
4. Mohsen H., and Yazdan S. (2007): Artificial Neural Network Approach for Short Term Load Forecasting for Illam Region. published at World Academy of Science, Engineering and Technology, 28.
5. Saba, T. Rehman, A. Elarbi-Boudihir, M. (2014). Methods And Strategies On Off-Line Cursive Touched Characters Segmentation: A Directional Review, Artificial Intelligence Review vol. 42 (4), pp. 1047-1066. doi 10.1007/s10462-011-9271-5
6. Rehman, A. and Saba, T. (2011). Document skew estimation and correction: analysis of techniques, common problems and possible solutions Applied Artificial Intelligence, Vol. 25(9), pp. 769-787. doi. 10.1080/08839514.2011.607009
7. Saba, T., Rehman, A., and Sulong, G. (2011) Improved statistical features for cursive character recognition" International Journal of Innovative Computing, Information and Control (IJICIC) vol. 7(9), pp. 5211-5224
8. Muhsin; Z.F. Rehman, A.; Altameem, A.; Saba, A.; Uddin, M. (2014). Improved quadtree image segmentation approach to region information. the imaging science journal, vol. 62(1), pp. 56-62, doi. http://dx.doi.org/10.1179/1743131X13Y.0000000063
9. Neamah, K. Mohamad, D. Saba, T. Rehman, A. (2014). Discriminative features mining for offline handwritten

signature verification, 3D Research vol. 5(3), doi. 10.1007/s13319-013-0002-3
10. Saba T, Al-Zahrani S, Rehman A. (2012) Expert system for offline clinical guidelines and treatment Life Sci. Journal, vol.9(4), pp. 2639-2658.
11. Mundher, M. Muhamad, D. Rehman, A. Saba, T. Kausar, F. (2014) Digital watermarking for images security using discrete slantlet transform, Applied Mathematics and Information Sciences, Vol. 8(6), PP: 2823-2830, doi.10.12785/amis/080618.
12. Norouzi, A. Rahim, MSM, Altameem, A. Saba, T. Rada, A.E. Rehman, A. and Uddin, M. (2014) Medical image segmentation methods, algorithms, and applications IETE Technical Review, vol. 31(3), doi. 10.1080/02564602.2014.906861.
13. Haron,H. Rehman, A. Wulandhari, L.A. Saba, T. (2011). Improved vertex chain code based mapping algorithm for curve length estimation, Journal of Computer Science, Vol. 7(5), pp. 736-743, doi. 10.3844/jcssp.2011.736.743.
14. Rehman, A. Mohammad, D. Sulong, G. Saba, T.(2009). Simple and effective techniques for core-region detection and slant correction in offline script recognition Proceedings of IEEE International Conference on Signal and Image Processing Applications (ICSIPA'09), pp. 15-20.
15. Selamat, A. Phetchanchai, C. Saba, T. Rehman, A. (2010). Index financial time series based on zigzag-perceptually important points, Journal of Computer Science, vol. 6(12), 1389-1395, doi. 10.3844/jcssp.2010.1389.1395
16. Rehman, A. Kurniawan, F. Saba, T. (2011) An automatic approach for line detection and removal without smash-up characters, The Imaging Science Journal, vol. 59(3), pp. 177-182, doi. 10.1179/136821910X12863758415649
17. Saba, T. Rehman, A. Sulong, G. (2011) Cursive script segmentation with neural confidence, International Journal of Innovative Computing and Information Control (IJICIC), vol. 7(7), pp. 1-10.
18. Rehman, A. Alqahtani, S. Altameem, A. Saba, T. (2014) Virtual machine security challenges: case studies, International Journal of Machine Learning and Cybernetics vol. 5(5), pp. 729-742, doi. 10.1007/s13042-013-0166-4.
19. Meethongjan, K. Dzulkifli, M. Rehman, A., Altameem, A., Saba, T. (2013) An intelligent fused approach for face recognition, Journal of Intelligent Systems, vol. 22 (2), pp. 197-212, doi. 10.1515/jisys-2013-0010,
20. Joudaki, S. Mohamad, D. Saba, T. Rehman, A. Al-Rodhaan, M. Al-Dhelaan, A. (2014) Vision-Based Sign Language Classification: A Directional Review, IETE Technical Review, Vol.31 (5), 383-391, doi. 10.1080/02564602.2014.961576
21. Saba, T. Rehman, A. Altameem, A. Uddin, M. (2014) Annotated comparisons of proposed preprocessing techniques for script recognition, Neural Computing and Applications Vol. 25(6), pp. 1337-1347 , doi. 10.1007/s00521-014-1618-9
22. JWJ Lung, MSH Salam, A Rehman, MSM Rahim, T Saba (2014) Fuzzy phoneme classification using multi-speaker vocal tract length normalization, IETE Technical Review, vol. 31 (2), pp. 128-136, doi. 10.1080/02564602.2014.892669
23. Al-Ameen, Z. Sulong, G. Rehman, A., Al-Dhelaan, A., Saba, T. Al-Rodhaan, M. (2015) An innovative technique for contrast enhancement of computed tomography images using normalized gamma-corrected contrast-limited adaptive histogram equalization, EURASIP Journal on Advances in Signal Processing, vol. 32, doi:10.1186/s13634-015-0214-1
24. Saba,T., Rehman, A., Al-Dhelaan, A., Al-Rodhaan, M. (2014) Evaluation of current documents image denoising techniques: a comparative study , Applied Artificial Intelligence, vol.28(9), pp. 879-887, doi. 10.1080/08839514.2014.954344
25. Nodehi, A. Sulong, G. Al-Rodhaan, M. Al-Dhelaan, A., Rehman, A. Saba, T. (2014) Intelligent fuzzy approach for fast fractal image compression, EURASIP Journal on Advances in Signal Processing, doi. 10.1186/1687-6180-2014-112.
26. MSM Rahim, SAM Isa, A Rehman, T Saba (2013) Evaluation of Adaptive Subdivision Method on Mobile Device, 3D Research 4 (2), pp. 1-10
27. Rehman, A., and Saba, T. (2013) An Intelligent Model for Visual Scene Analysis and Compression, International Arab Journal of Information Technology, vol.10(13), pp. 126-136
28. Harouni, M., Rahim,MSM., Al-Rodhaan,M., Saba, T., Rehman, A., Al-Dhelaan, A. (2014) Online Persian/Arabic script classification without contextual information, The Imaging Science Journal, vol. 62(8), pp. 437-448, doi. 10.1179/1743131X14Y.0000000083.
29. Husain, NA., Rahim, MSM Rahim., Khan, A.R., Al-Rodhaan, M., Al-Dhelaan, A., Saba, T. (2015) Iterative adaptive subdivision surface approach to reduce memory consumption in rendering process (IteAS), Journal of Intelligent & Fuzzy Systems, vol. 28 (1), 337-344, doi. 10.3233/IFS-14130.
30. Saba,T. Almazyad, A.S., Rehman, A. (2015) Language independent rule based classification of printed & handwritten text, IEEE International Conference on Evolving and Adaptive Intelligent Systems (EAIS), pp. 1-4, doi. 10.1109/EAIS.2015.7368806.
31. Elarbi-Boudihir, M. Rehman, A. and Saba, T. (2011). Video motion perception using optimized Gabor filter. International Journal of Physical Sciences, vol. 6(12), pp. 2799-2806.
32. Saba, T. Rehman, A. Al-Zahrani, S. (2013) Character segmentation in overlapped script using benchmark database, pp. 140-143, ISBN: 978-1-61804-233-0

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