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A fuzzy inference model for short-term load forecasting

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ABSTRACT

This paper is concerned with the short-term load forecasting (STLF) in power system operations. It provides load prediction for generation scheduling and unit commitment decisions, and therefore precise load forecasting plays an important role in reducing the generation cost and the spinning reserve capacity. Short-term electricity demand forecasting (i.e., the prediction of hourly loads (demand)) is one of the most important tools by which an electric utility/company plans, dispatches the loading of generating units in order to meet system demand. The accuracy of the dispatching system, which is derived from the accuracy of the forecasting algorithm used, will determine the economics of the operation of the power system. The inaccuracy or large error in the forecast simply means that load matching is not optimized and consequently the generation and transmission systems are not being operated in an efficient manner. In the present study, a proposed methodology has been introduced to decrease the forecasted error and the processing time by using fuzzy logic controller on an hourly base. Therefore, it predicts the effect of different conditional parameters (i.e., weather, time, historical data, and random disturbances) on load forecasting in terms of fuzzy sets during the generation process. These parameters are chosen with respect to their priority and importance. The forecasted values obtained by fuzzy method were compared with the conventionally forecasted ones. The results showed that the STLF of the fuzzy implementation have more accuracy and better outcomes.

1. Introduction

Load forecasting is an important element for economically efficient operation and for effective control of power systems. The purpose of the short-term load forecasting (STLF) is to forecast in advance the system load, that represented by the sum of all the consumers' load at the same time. Also, precise load forecasting is required to avoid high generation cost and the spinning reserve capacity. Under prediction of STLF leads to insufficient reserve capacity preparation and threaten the system's stability, on the other hand, over prediction of STLF leads to the unnecessarily large reserve that leads to high cost preparation.

The following factors specify the pattern of the electricity consumption variation: (a) weather; (b) time; (c) historical data; and (D) random disturbances. The nature of parameters that affect the load forecasting includes many uncertainties. Fuzzy logic (FL) is characterized by generalizing classical two-valued logic for reasoning under nonlinear and uncertain conditions; it is therefore the most appropriate method in describing the human knowledge that contains vague concepts and huge amount of data. Load forecasting using fuzzy implementation is considered to be faster and more accurate than the conventional forecasting methods which deal with rigid data and have long processing time. Regression analysis is considered as a conventional way in power demand prediction. In statistics, regression analysis is the process used to estimate the parameter values of a function, in which the function predicts the value of a response variable in terms of the value of other variables (Tong, 2007); moreover, the method that based on "similarity" principle which use information of the day being similar to the weather condition is considered as a conventional method (Pandian et al., 2006).

Conventional load-forecasting systems in Jordan are normally based on statistical modeling techniques; they have limited chances in predicting accurate loads for abnormal days when some irregular events occur due to abnormal weather conditions or sudden temperature changes. They also need precise values in the forecasting process, while the fuzzy method uses interval of values like "high or low temperature". Such changeable conditions lead to the application of fuzzy implementations to be used instead of statistical schemes in the forecasting systems. And even though in the US, and most developed countries, the standard load-forecasting system uses a neural network. Fuzzy logic was used by Pandian et al. (2006) to achieve much closer results to the actual consumption than other conventional methods uses the similarity principle. And Li-Chih and Pan (2007) found that

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the adaptive network-based fuzzy inference gave better results than artificial neural-network model.

Many attempts by researchers (Jingfei, 2006; Chow et al., 2005; García, 2006; Gabbi and Zanotti, 2003; Negnevitsky, 2005) have been made to improve load-forecasting process in many worldwide regions. Khan and Abraham (2003) used a hybrid of artificial neural network (ANN) and fuzzy logic to forecast the load in Czech Republic. They found that hybrid fuzzy neural network and radial basis function networks are the best candidates for the analysis of the load in Czech Republic.

Another study has been carried out for power systems in India by Pandian et al. (2006). They used fuzzy approach for short-term load forecasting using the temperature and time parameters only as inputs for the system. They showed that with the aid of fuzzy logic, they can achieve much closer results to the actual consumption than the conventional methods which use the similarity principle.

Mamlook (2006) used fuzzy set methodology for evaluating energy production alternatives to compare between different power systems. He showed that the fuzzy method has faster learning technique than the neuro-fuzzy method. Fuzzy logic methodology has been utilized for wide range of evaluation applications, i.e., evaluation and comparison between different solar systems (Mamlook et al., 2001), evaluation of factors affecting solar still production (Mamlook and Badran, 2007), evaluation of parameters that affect leakage in infrastructure systems (Mamlook and Al-Jayyousi, 2003).

Li-Chih and Pan (2007) applied the adaptive network-based fuzzy inference system model to forecast the regional electricity loads in Taiwan, and demonstrated the forecasting performance of their model. They found that the adaptive network-based fuzzy inference gave better results than artificial neural-network model.

An integrated evolving fuzzy neural network and simulated annealing for load-forecasting method is presented by Liao and Tsao (2004) to reduce the error of conventional load forecasting. Their load-forecasting scheme was tested using data obtained from a sample study includes 1 year, 1 month, and 24 h time periods. They showed that their method gave good accuracy.

Another study by Kodogiannis and Anagnostakis (1999) discussed the development of improved neural-network-based short-term electric load-forecasting models for the power system of the Greek island of Crete. The performance was evaluated through a simulation study, using metered data provided by the Greek Public Power Corporation. Their results indicated that the load-forecasting models developed provided more accurate forecasts than the conventional methods.

Maia and Gonçalves (2008) proposed an approach for next day peak load forecasting for electrical companies. A nonlinear model for the peak load is proposed taking into account the historical load and the temperature, each of which was estimated using an on-line recursive algorithm.

Hobbs and Nelson (1992) used a bilevel programming in the electric utility industry. The model is nonlinear and is used to analyze various economic issues that affect electric utility planning. The electric utility at the upper level of the model seeks to minimize costs or maximize benefits while controlling electric rates and subsidizing energy conservation programs. Customers at the lower level attempt to maximize their net benefit by consuming electricity and investing in conservation.

Gribik et al. (2007) suggested that the electricity market models require energy prices for balancing, spot and short-term forward transactions. For the simplest version of the core economic dispatch problem, the formulation produces a well-defined solution to the pricing problem in the usual intersection of the supply marginal cost and the demand bids. This pricing supports the equilibrium solution and satisfies a no arbitrage condition. In the more general economic unit commitment and dispatch models, there may be no corresponding uniform energy price vector that supports the solution. This introduces a need both define the appropriate energy prices and determine the

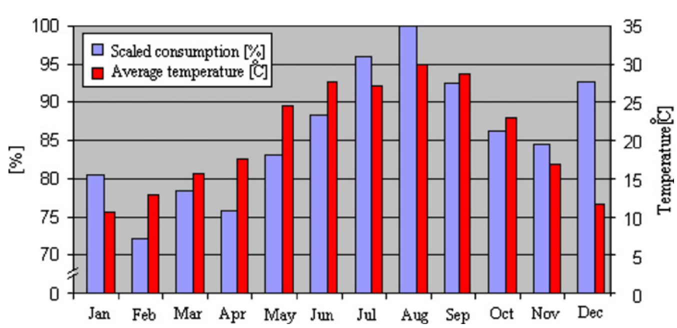

Fig. 2. Monthly variation of electricity consumption in year 2006.

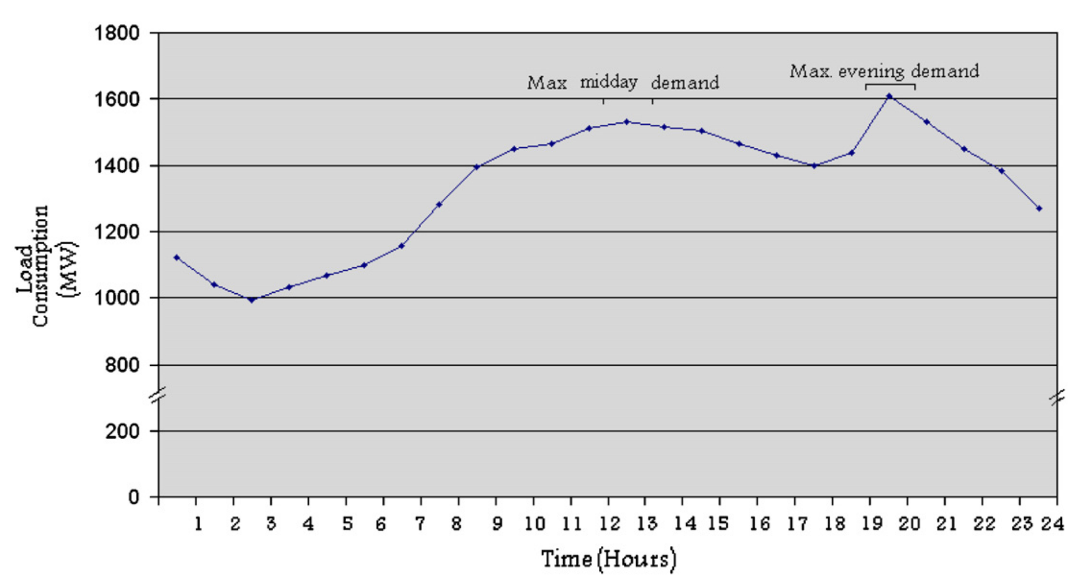

Fig. 1. Typical consumption curve pattern for a normal day.