Modeling Electricity Consumption using Modified Newton's Method

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ABSTRACT
In this paper we present modified Newton's model (MNM) to model electricity consumption data. A previous method to model electricity consumption data was done using forecasting technique (FT) and artificial neural networks (ANN). A drawback to previous techniques is that computations give less reliable results when compared to MNM. A comparative analysis is carried out for FT, ANN and MNM to investigate which of these methods is the most reliable technique. The results indicate that MNM model reduced mean absolute percentage error (MAPE) to 0.93%, while those of FT and ANN were 3.01% and 3.11%, respectively. Based on these error measures, the study shows that the three methods are highly accurate modeling techniques, but MNM was found to be the best technique when mining information. Experimental results indicate that MNM is the most accurate when compared to FT and ANN and thus has the best competitive performance level.

Keywords
Efficiency, modified newton's method, forecasting technique, artificial neural networks, reliability

1. INTRODUCTION
Growing demand for electricity consumption makes it imperative to strengthen capabilities in infrastructure and equipments. Energy efficiency is becoming an interesting area of research because there are constraints in terms of availability of electricity supply and distribution, hence the needs for efficiency in its use [1] . For this reason, energy analysts need a guideline to better choose the most appropriate technique in order to provide accurate estimates for electricity consumption problems. FT, as used in previous literature [1], [2], consists of a combination of time series, ARIMA and forecasting techniques to solve energy models. The research papers carry out a comprehensive review and computes different evaluation statistics for these techniques. It is discovered that the approach to the various techniques involved in FT are similar in their analytical solution process.

The problems entrenched in electric-efficient systems are diverse. Whereas electric generation, distribution and consumption have greatly improved in the society, efficient use of it is a growing problem. This has led to escalating costs for electricity consumption [3]. A novel regression technique, evolution local kernel regression (ELKR) was introduced by [4]. It is a kernel regression variant based on local Nadaraya-Watson estimates with independent bandwidths distributed in data space. The model uses a stochastic non-convex optimization method known as CMA-ES. The constraints in the research work consist of absence of parameter studies of (ELKR) on real power data and also a lack of experiments in regression problems. [4] investigates half-hourly ahead load predicting and half-hourly ahead price prediction applications. The method used in the research paper is artificial neural network (ANN) which uses historical data, load consumption, price and calendar data. It develops a multi-layer feed forward neural network trained with Back propagation (BP) algorithm. The technique considers only short-term load predicting or forecasting system. For an efficient electricity system, it is necessary to consider a long-term collection of data and also use of real-time data [5]. Proposed algorithms for minimization of the electric production costs of power is obtained by making a comparative study of genetic algorithms and Newton's method. The algorithms seem to be an effective technique in solving a great number of problems which are in constant evolution. However, there are limitations in the method. The technique does not present results of number of iterations involved in numerical solution of the problem for its rate of convergence, to determine its performance index. A simulation to model behavior of an electricity network, following the introduction of an electric vehicle fleet and high wind penetration, was described by [6] . In the vehicle model simulation, it takes into consideration the electrical model when vehicle is connected to the grid and the vehicle behavior model that determines timing and energy use of trips made by individual vehicles. It incorporates accurate wind speed data and measured corresponding grid load over a one-year period. A system to develop informed demand-side load management techniques to support and promote energy efficiency and economy in the residential/household sector was developed by [7]. The paper discusses the communication of real-time information to consumers through specific and ambient visualizations. A based game scenario that addresses the problem of energy consumption and possible learnability solutions is discussed by [8]. It proposes a novel way of using mobile Augmented Reality (AR) in combination with adaptive virtual gardens to raise awareness for reducing energy consumption through a game setup. Results from the study shows that the presented game motivates players to be aware of the presented problem.

The present study models historical electricity consumption data and utilizes Newton's method, which together with standard error estimates of data are used to obtain MNM. The study carries out a comparative analysis with a simulation of electricity consumption data based on FT in order choose a reliable method for modeling. Newton's method has previously been used to solve energy problems in the downlink of an orthogonal frequency division multiple accesses (OFDMA), [9]. It is applicable in the field of computational learning theory. The Newton's technique is very fast, considers multiple parameter constraint violations in its control task and possesses high speed computation [5].

This research work aims to estimate electric load in the system with the goal of modeling electricity consumption.

2. METHODOLOGY

This research is concerned with comparing solution techniques for modeling electricity consumption data. Efficient use of energy is becoming an important issue since the future world is dependent on today's decision. Identifying a reliable solution to electricity problems should help in achieving efficiency by the fact that forecasting for electricity consumption is done at a faster rate. The requirement for efficient use of electricity is proper allocation of available resources. This is made possible by accurate prediction of future needs, through its proper estimation process as shown in Figure 1. To determine the recommended technique for modeling electricity consumption data, an extensive review of literature was conducted on published literature related to the study. Specifically, the information compiled focuses on strengths and weaknesses of past techniques related to this study.

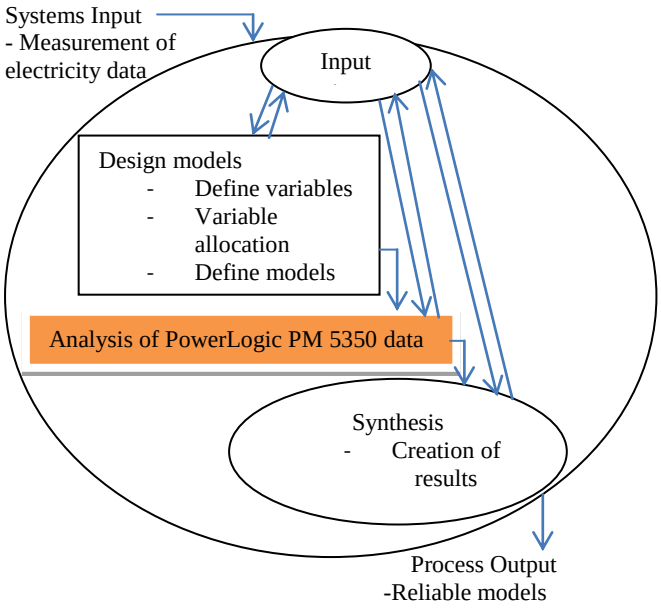

Fig. 1: Computation of estimates for electricity consumption

MNM was selected based on the fact that it has the most accurate results based on the techniques considered in this research and has a proven high performance level. In order to make comparisons between MNM, FT and ANN methods, there is a need to formulate respective models, simulated from electricity consumption data, f(x), where $x = x_1, x_2, x_3, \ldots\ldots x_n$ are occurrences at time x.

Fig. 2: The PowerLogic PM 5350

The electricity consumption data used in the analysis and computations of this research work consists of historical weekly aggregate power consumption data taken from daily recordings using the PowerLogic PM 5350, shown in Figure 2. The data samples were drawn from the Universiti Malaysia in Sarawak, Malaysia. Models obtained in this paper are applied in the power industry for forecasting electricity consumption. It should be noted that weekly consumption pattern can sometimes vary, depending on some factors such as a breakdown in the air-conditioner units, which results in a reduction in electricity consumption. For the estimation process, four years historical data i.e. a weekly aggregate of 1460 average daily data sets of the years 2009-2012 are used for training the forecasting models and the weeks in January and February 2013 month samples are used for testing these models. To illustrate the behavior of the propose technique, results comparing four weeks corresponding to the months of January and February for the previous years are presented. In this manner, representative results for this study are provided. For the sake of a fair comparison, four weeks in each of the months of January and February are selected. To build the forecasting models for each one of the considered weeks, the information available includes average daily consumption data of the weeks previous to the week whose data are to be predicted.

The FT method was evaluated using Box-Jenkins (BJ) approach. This is because the study considers univariate time-series method, i.e. only weekly electricity consumption forecasts are required. This is because univariate methods predict the future value of a time series solely from its past historical data. The STEPWISE variable selection procedure, available on the SPSS for Windows 21.0 statistical package was used to obtain models. Once models are obtained, these are used as independent and input variables using multiple perception in ANN techniques. Forecasts were generated from Newton's method using MATLAB programming techniques, where prediction errors are computed and added to these forecasts to compute new forecasts for MNM method. Once forecasts were generated from these techniques, the mean absolute percentage error (MAPE) were computed and compared. Relative measures dealing with percentage errors were used to compare the ex post forecasting accuracy of the different techniques. Comparisons of results obtained from simulating electricity consumption data using MNM, ANN and FT methods with actual data are used to check for reliability and accuracy of the methods.

The following solution techniques were considered:

2.1 Forecasting Technique

In this research, modeling of electricity consumption data is undertaken using FT technique. A similar study to obtain forecast of energy consumption to promote sustainable energy development was carried out using a combination of grey and FT [10].

A forecasting technique relates Y to a function of X and β and can be represented as:

$$Y_n \approx f(X_n, \beta) \quad (1)$$

where Y_n consists electricity consumption data for a given week n. X_n is weekly data bill for week n. β is the unknown parameter. It has been applied to solve non-linear problems [11]. Hence, we obtain a model from given electricity consumption data bill. This would be used to predict weekly electricity consumption based on a 1460 daily set of data covering 4 years.