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A HYBRID MODERN AND CLASSICAL ALGORITHM FOR INDONESIAN ELECTRICITY DEMAND FORECASTING

Wahab Musa
Department of Electrical Engineering, Universitas Negeri Gorontalo, Kota Gorontalo, Indonesia
E-Mail: wmusa@ung.ac.id

ABSTRACT

In this paper, we would investigate a hybrid modern and classical algorithm (HMCA) in parameter optimization of electricity demand forecasting. Genetic algorithm (GA) has been successfully applied in optimization problems. As a modern algorithm, GA has a capability to explore the solutions in the global search area, but its drawback is the slow rate of convergence and high number of iterations. The Nelder-Mead is one of the classical algorithms using simplex search methods. This technique, when combining with a modern algorithm can be used for faster optimization processing. The test performance of the hybrid algorithm model (HAM) is conducted using data for Indonesian electricity demand. Results have shown that HMCA is better than GA in term of accuracy and number of iterations.

Keywords: electricity demand forecasting, hybrid algorithm, optimization, genetic algorithm.

1. INTRODUCTION

Premature convergence is a major problem, especially in the optimization process that uses a single algorithm both classical and modern. This problem occurs when the predictions, it will affect the accuracy of forecasting results. Model development of computational intelligence conducted in this research is to exploit the advantages of classical algorithms and the ability of modern algorithms to explore the optimal solutions.

The hybrid method combines the classical exploitation optimal solutions through local search and the modern exploration optimal solutions in the global search area. The proposed hybrid algorithm is examined by benchmarking some hybrid based model. The average prediction error will be a reference in choosing the right model for planning the Indonesian electrical energy demand in several years.

2. PROBLEM IN FORECASTING

The aim of this study is to improve the accuracy of prediction of the electricity demand forecasting through the use of hybrid optimization algorithm. Model development of computational intelligence conducted in this research is to exploit the advantages of classical algorithms and the ability of modern algorithms to explore the optimal solutions in the global search area.

Genetic Algorithm Electricity Demand (GAED) exponential for forecasting total electricity demand and quadratic for forecasting the industrial electricity demand are two examples of models in forecasting electricity demand of Turkey. The exponential model using 9 parameters while the quadratic model using 15 parameters. However, the performance of these models is far from ideal and needs several attempts to improve it in terms of the estimation error.

2.1 Estimation error

The estimation error can quickly escalate into a single algorithm predictive model-based when the number of variables increases. A hybrid method seems to be the right approach to improve the performance of long-term energy demand forecasting model because it offers the opportunity to discover the best solution (the global optimum) to improve the accuracy. The slight increase in the accuracy of the electricity demand forecasting model, could affect billions of dollars in operational cost savings of electricity procurement.

2.2 Computational time

The ability of a single algorithm decreased when the search close to the optimal solution. Stagnation in the solution is not appropriate in a single algorithm contribute to increase the computational time. Modern or classic algorithm if separate or stand alone, it cannot guarantee to achieve the best optimal solution [1].

The solution that has been found by the modern algorithm will be used as a starting point by the classical algorithm to find a globally optimal solution. This can cause the hybrid algorithm is more efficient in terms of computing time.

2.3 Number of iterations

The accuracy of the model forecasting electricity demand is strongly associated with high computational costs due to the slow rate of convergence [2], [3]. These problems, if not handled properly can lead to inaccurate predictions. In modern algorithm, many iterations required to achieve a global optimum because the search is not running in the right direction. This requires new techniques to guide the direction of the search by the local search algorithm in the right direction.

3. HYBRID METHOD AS A SOLUTION

The hybrid genetic algorithm (modern) and local search (classical) is an example of hybrid method that can offer an opportunity to find a global optimum solution for electrical energy demand forecasting model. For most of the electrical energy demand forecasting models which use evolutionary algorithms (e.g. Genetic algorithms); the objective function can not obtain a good result because it can be trapped in a local optimum solution. This problem cannot be solved even though operating a single genetic algorithm repeatedly applied [4].

With the problems noted above and the opportunity to find a solution, then the question to be answered in this study can be formulated as follows: 1. How to make the formulation of the objective function of a hybrid algorithm model (HAM) with a new technique that could affect the accuracy. 2. How to avoid the causes of problems in models built based on single algorithm in a model of electricity demand forecasting based on a hybrid genetic algorithm (modern) and local search algorithm (classic). To achieve this, two specific objectives are listed below: 1. To formulate the objective function in a hybrid genetic algorithm that can minimize mistakes electricity demand forecasting using linear and nonlinear models. 2. Propose a new technique that can overcome the premature convergence and local optimality problem through a combination of genetic algorithms and local search extension (extended local search).

Hybrid optimization algorithm is divided into methods of global search and local search. The local search method usually converges to local optima.

In case the information needs of the derivative of the function to be optimized, local search methods can be further classified into two categories as non-gradient based method and gradient-based.

Gradient-based methods using information derived from the objective function to calculate and update the values of the decision variables. However, the gradient-based method is subject to two major limitations. First, the objective function is often difficult to achieve convergence with the gradient-based method. Second, the gradient-based methods often converge on optimal local rather than global search for the optimal solution.

Non-gradient based methods only require an evaluation of the value of the objective function, but not the partial derivative of the function and hence are also called a direct search method. Gradient-based method not only requires the calculation of the values of the function, but also the first derivative and in some cases even require the second derivative of the objective function or the gradient vector. Error measured by the objective function has depended on the values of the parameters. Although the general objective function is continuous and differentiable to the parameters, it is usually difficult to calculate the derivative of the objective function analytically except for a very simple model.

In [5] and [6], GA is used as optimization tools for complex problems involving many variables or involve a combination of linear and nonlinear equations. As an optimization tool, GA attempted to improve performance, which leads to the optimal solution. However, these models still have not found the best solution which is marked with the prediction error rate is still relatively high and large enough number of iterations cause high computational costs and a long operating time.

Although GA can quickly locate the area where the global optimum is, the algorithm takes a relatively long time and the number of iterations that is a lot more to find the right local optimum solutions in the area of convergence. GA with some additional heuristics can increase the rate of convergence of the algorithm and find a better solution. The combination of GA with a local search can speed up the search to find a global optimum solution.

3.1 Research Steps

There are at least six steps can be taken which is divided into two stages, namely:

Phase I: Try and simulate the model with the old technique.

i) Selecting the best possible forecasting tool

ii) Collect the necessary data

iii) Data processing with existing techniques

Phase II: Undertake the development, simulation and evaluation models with new techniques.

Activity in the second phase will include three steps namely:

iv) The development of the objective function,

v) The design of hybrid algorithm development

vi) The performance evaluation.

- The first step in the proposed research methodology is to choose the right forecasting tool. Selection will depend on the time horizon estimates, data are available, time available, and the estimated operating costs with poor or inadequate. In this research, forecasting electricity demand long term being suitable for application in planning and decision making. Forecasting models are selected using available data collected for the electricity consumption of the world's energy agency, the model variable data from the Office for National Statistics. In addition, the proposed benchmarking forecasting model also uses data from previous studies. A reliable forecasting tool derived from the simulation must have a higher accuracy than other estimation models. The model shows a good estimate of the prediction will be elected as the development model used to forecast future demand for electricity by using economic scenario.
- The second step is the collection of data. In developing the model of electric energy demand forecasting, simulation and processing of each model

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with the available data are needed to obtain a better distribution of electricity demand forecast. Every electricity demand forecasting method is then tested by a special way of relating to the request variables above. Zhang and Ye [7] uses historical data to predict the burden of future demand.

- The third step is processing the data. Representation of the objective function of each model is a fitness function representing the relationship between the demand for electricity as the dependent variable and independent variables. In this study, the independent variable is the population, the gross domestic product, imports and exports in the form of linear and nonlinear. In this method, the objective function are models of linear, logarithmic, exponential, and quadratic. Each model was tested using electric demand data with and without a process of normalization, with and without local search.
- The fourth step is to develop an objective function. The objective function is a formula expressing the relation between the demand for electricity with a variable. This relationship is expressed by a mathematical formula. The influence of each variable on the magnitude of the demand for electricity is calculated by an algorithm. This mathematical relationship is expressed in the form of linear and nonlinear. Each model was tested using data already collected in the previous stage. The test results will be considered for future development.
- Step five is to develop algorithms. Local search algorithm (LS) that have been upgraded are used to exploit the solution around the individual in the local environment, while the genetic algorithm makes exploration in the global population. The proposed approach is known as a hybrid of classical and modern algorithms (HMCA).
- The sixth step is to evaluate the performance of the hybrid algorithm model. To evaluate the performance of the electricity demand forecasting model based on the proposed hybrid algorithm, the actual value of electricity demand and the results of the simulation estimation of each model was compared. After the approximate results of the proposed model are obtained, then it needs to be validated for accuracy. Selection of models for the study was based on several criteria.

3.2 Experiment results

When evaluating the different forecasting techniques, an important consideration that the purpose of any forecasting activities is to provide an estimate with sufficient accuracy at the lowest possible cost. In this methodology, a model with a sufficient degree of accuracy would be a candidate for the chosen model for forecasting future demand.

Based on the experimental results, obtained results showed that the HMCA is more accurate than other approaches. HMCA faster in processing the available data and more influence on the process of forecasting and has the best accuracy.

In order to take advantage of both, the solution obtained from the MA is used as the initial solution for the CA. Individual solutions will experience the evolution of both the MA and the exploitation of local environmental solutions from CA in each iteration.

HMCA excellence can be seen in the number of iterations and the percentage of error is much smaller than the results of other methods of approach. The number of iterations in the process and the percentage of errors can be seen in the following figure.

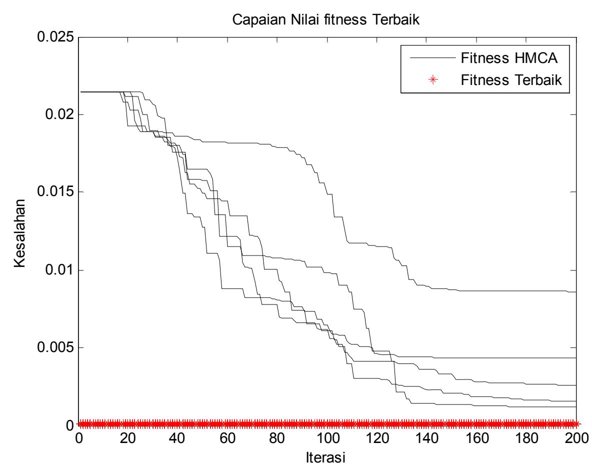

Figure-1. The percentage of error (kesalahan) vs. the number of iterations (iterasi).

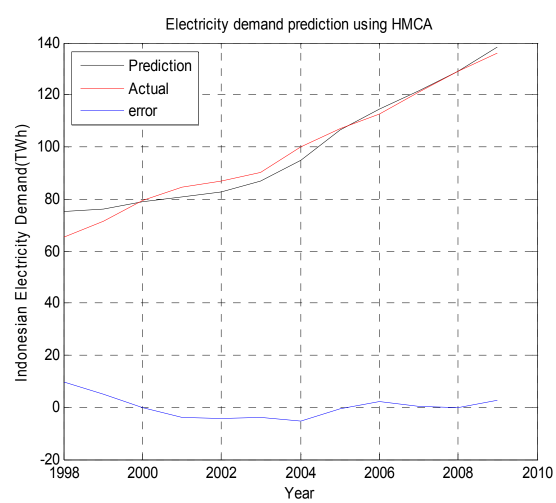

Figure-2. Electricity demand prediction and error.

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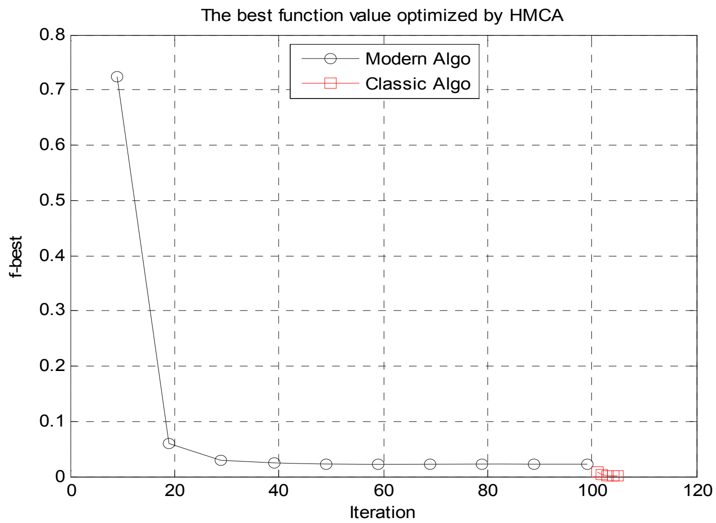

Figure-3. Optimization by HMCA.

Table-1 shows the simulation output of the hybrid modern algorithm and the classical algorithm (HMCA). Modern algorithm was set to 100 iterations and the obtained best value of the objective function is 0.021467. Its value is used to initiate the classical algorithm to explore the solutions in neighborhood search areas to find a better solution. The CA was successful in 5 iterations to obtain the best one that 25 times less than MA result and 20 times faster in computation timing.

Table-1. f_best value vs. iteration for modern algorithm and HMCA.

Iteration	f_best Mod-Algo	Iteration	f_best Mod-Algo	Iteration	f_best HMCA
1	19.164611	19	0.058704	100	0.008617
3	16.27921	29	0.029847	101	0.004345
4	12.769396	39	0.023729	102	0.002612
5	12.769396	49	0.02314	103	0.001546
6	8.516074	59	0.02314	104	0.001225
7	8.516074	69	0.022527	105	0.000843
8	6.648108	79	0.021654		
9	0.722904	89	0.021654		
10	0.237073	99	0.021467		

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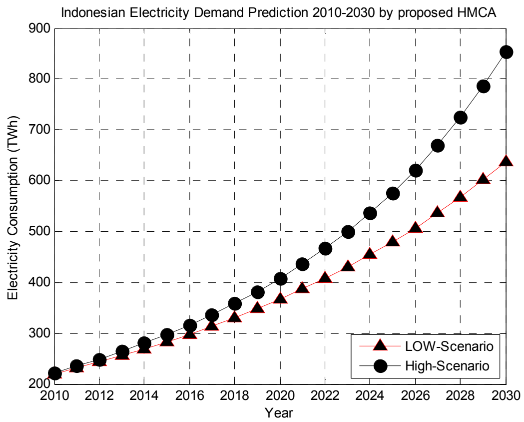

Figure-4. Indonesian electricity demand projection by HMCA.

4. THE DEMAND PROJECTION

The projection of Indonesian electricity demand by 2030 using the proposed HMCA is illustrated in Figure-4. During the period of 2010 to 2030, the electricity consumption of Indonesia has increased 2.895 times, from 220.0877 TWh (low scenario) in 2010 and in 2030 has reached 637.5702 TWh. The average growth of electricity consumption during those periods is 5% and 7% per year for low and high scenarios.

5. CONCLUSIONS

Based on the above results, it has been shown that the integration of modern and classic algorithm method is applicable for the long-term electricity demand forecast with high approximation accuracy and fast convergence time capability to reach the global optimal solution. The hybrid model has been developed in such a way that outputs for different socioeconomic scenarios can be obtained.

The output of the research activities is to obtain a forecasting model more reliable, accurate and can be applied to estimate the electricity demand of Indonesia in the next few years.

The annual growth of electricity demand projection is realistic compared to the average annual growth of electricity demand is 6.2% during the period of 1970 to 2009. Final energy consumption for the period of 1971 to 2009 had significant growth; it increased with the annual average growth of 7.3% from 6.78 MTOE in 1971 to 97 MTOE in 2009 [8].

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