Hybrid Genetic Algorithm and Local Search for Energy Demand Prediction Model

Wahab Musa[1], Ku Ruhana Ku-Mahamud[2] and Azman Yasin[3]

**[1] Electrical Engineering Department, Universitas Negeri Gorontalo
Gorontalo, 96125, Indonesia**

**[2] College of Arts and Sciences, Universiti Utara Malaysia
Sintok, Kedah, Malaysia**

**[3] College of Arts and Sciences, Universiti Utara Malaysia
Sintok, Kedah, Malaysia**

Abstract

Energy demand pattern have many variables related to uncertainty behavior. These lead to a higher estimation rate of energy demand forecasting. However, two problems need to be overcome. The first problem is the fitness evaluation in energy demand forecasting model in which more than one variable are included, and the second problem is the local optimality that single algorithm fails to solve. The objective of this research is to develop energy demand forecasting model that reflects the characteristics of energy demand. A local search is used to assist the genetic algorithm in overcoming uncertainty in demand and the local optima problem and thus producing a higher estimation rate. To evaluate the performance of energy demand model, the actual demand was compared to estimation results. The findings indicate that the solution obtained using the proposed model was an improvement in quality over that obtained by a single genetic algorithm and can be applied to forecast future energy demand with higher approximation accuracy.

Keywords: *Hybrid genetic algorithm, Energy demand forecasting, Higher approximation accuracy.*

1. Introduction

A genetic algorithm is a famous algorithm that has been used in many fields to solve many problems because of its suitability to nearly any function. It simulates the mechanism and the process of evolution, as unique biological features. An algorithm generated from a genetic algorithm, namely the estimation of distribution algorithm (EDA), becomes a hot topic because it is superior. Estimation of distribution algorithms replace some operations in a genetic algorithm, such as learning and sampling of the best individuals of the population, replacing the crossover and the mutation in each iteration of the algorithm [1].

The applications of a genetic algorithm are useful for estimations such as; (i) parameter estimation, (ii) cost estimation, and (iii) energy demand estimation. Parameter estimation using a genetic algorithm has attracted great attention from many researchers. A method for parameter pattern estimation using an adaptive hybrid genetic algorithm was proposed by [2]. The hybrid algorithm is applied to the third-order induction motor. To prevent early convergence in the genetic algorithm, the mutation probability and crossover are changed according to the fitness values of the population at each generation. Their method is successful in solving the problem of parameter estimation in an induction motor.

The study by [3] for parameter estimation of speed governor used a genetic algorithm for optimizing the measurement of frequency and active power variation during transition operation. A real-coded genetic algorithm is applied in all system generators simultaneously to estimate their parameters. It is fully in line to treat and study the comprehensive behavior of a whole electric power system.

An approach for cost estimation has been proposed by [4]. This approach is applying a genetic algorithm to alleviate the drawback of the previous study approach in terms of low prediction accuracy. A previous study proposed effective methods to optimize the weights of the features to estimate the cost with a current project by referring to data collected from past projects. The results of a study by [4] indicated their methods were more effective for software cost estimation than other methods.

The study by [5] for energy demand estimation used a genetic algorithm for optimizing an objective function of electricity demand. When economic growth increases,

IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 5, No 1, September 2013
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

more needs are created to accompany the higher standard of living, more energy is needed to satisfy energy consumption. The absence of electricity has a negative effect on economic development. During economic boom, a large number of projects for power resources should be constructed. This places heavy pressure on natural resources, the environment and the economy because it is beyond the allowable extent of the national economy [5].

A vital problem in economic development is a study about how to harmonize the fluctuation relationships between electricity construction and economic national development. It also requires scientific demand forecasts for future projections [6]. Such a relationship is a difficult task and some specialists argue that it requires too many inputs and is circular. Causal factors of energy consumption include gross domestic product, oil prices and population growth rate.

Our study proposed a methodology that used population growth, gross domestic product, import, and export as the input variables to determined electricity energy demand as the output of the proposed hybrid genetic algorithm (HGA) for energy demand model. Thus, in the proposed model, energy demand is the function of population, gross domestic product, import and export. Estimation of the relationship between energy demand and independent variables used a HGA is measured by using historical data over a long-term period.

2. Hybrid Genetic Algorithm

There are various applications of hybrid genetic algorithms in solving optimization problems and NP-hard problems. The application of hybrid genetic algorithms can be categorized into three types of hybridization; application of hybrid genetic algorithms with other methods, application of hybrid genetic algorithms with local search and application of hybridization genetic algorithms with parameter adaptation [7].

Genetic algorithms are efficient heuristics and stochastic global search methods that have the ability to handle complicated problems. Unfortunately, these results can only be achieved at the expense of intensive computational requirement. This ability decreases in searching the point that is close to the optimal solution [8]. It can be increased by using a local search capability, which is good at converging at the local optima from nearby starting points. Hybridization of genetic algorithms with other appropriate local search methods would also increase the performance of genetic algorithms in solving global optimization of continuous multimodal functions [9].

Hybridization genetic algorithms with local search are commonly implemented in solving many complex problems where each new generated offspring follows local optimization procedures to lead the solution towards a local optimum area before continuing to the next generation. The local search performs local exploitation around individuals in the local neighborhood, while genetic algorithms make global explorations in a population.

Hybridization of genetic algorithms with local search has proven to provide significant improvement, which was able to explore ability and enhance exploitation towards feasible and highly accurate solutions in solving combinatorial problems [8]; [9].

Therefore, our study aims to apply a hybridization approach in an energy demand pattern forecasting problem and combines local search with genetic algorithms to guide the search towards a feasible solution that minimizes the run time.

3. Proposed HGA Technique

Figure 1 shows the main phases of the proposed hybrid genetic algorithm and the local search algorithm.

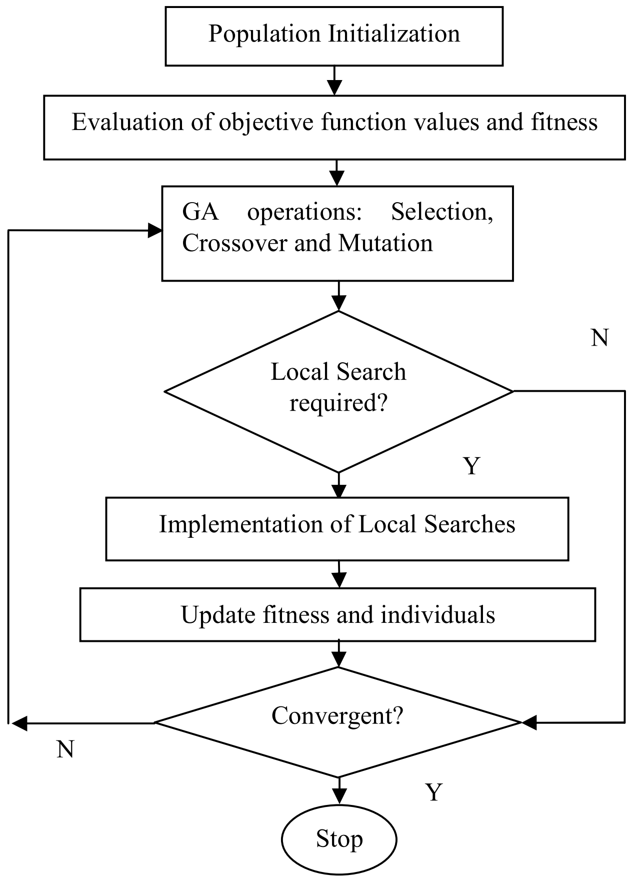

Fig. 1 Proposed HGA Technique

IJCSI International Journal of Computer Science Issues, Vol. 10, Issue 5, No 1, September 2013
ISSN (Print): 1694-0814 | ISSN (Online): 1694-0784
www.IJCSI.org

The technical aspect combining a local search algorithm and a genetic algorithm is referred to as the HGA approach. The combining process starts by running GA with small iterations in order to be effective in computational time. During the process, the capability of GA to find a solution quickly in exploring the area of solutions is the main consideration [10].

The process of the proposed HGA starts from the initial population of parameter values. Their objective function values are calculated using an objective function through a genetic algorithm process.

Step – 1. Population Initialization; the population initialization is the process of generating the initial population of *N-pop* chromosomes where *N-pop* is the population size. Heuristic methods and random methods can be used to initiate the population. The commonly used random methods generated N_{Pop} x N parameter values between 0 and 1 and then all of these values are scaled to their feasible ranges. However, the heuristic method requires some prior knowledge about the parameter set. One way is take default values as one chromosome and other chromosomes are generated randomly.

Step – 2. Evaluate Objective Function: the model outputs are passed to the objective function to calculate the objective function value associated with the chromosomes, a fitness value is calculated and assigned to each chromosome based on its objective function value.

Step – 3. GA operation: In the execution of a genetic algorithm, one generation is formed by the process of evaluation, selection, crossover and mutation. A new generation of chromosomes is produced after the process is complete. However, there is no guarantee that the best chromosome is carried through to the next generation, the new generation might not be better than the previous one. The genetic algorithm terminates if conditions are satisfied. First, if the objective function value is below the prescribed threshold, the genetic algorithm terminates with an optimal solution. Second, if the maximum number of prescribed generations has been reached, the genetic algorithm terminates without an optimal solution.

Step – 4. Local Search process: The local search process is required based on the objective function values after the genetic algorithm operations. Several options can be taken after the GA operations. If the genetic algorithm process is convergent, then stop: otherwise, return to the GA operations. If a local search is required, carry out the local search. Update fitness and individuals. If the local search process is convergent, then stop: otherwise, continue the GA operations. This process is continuous until convergence is achieved.

4. Performance of Proposed HGAED

Several experiments were done to obtain the appropriate method for solving the energy demand problem. This includes experiments on a single algorithm for energy demand pattern, application of pre-processing and the local search method, and comparison between the proposed HGAED and others method.

Table 1.Comparison of single genetic algorithm, pre-processing and local search

Data	1	2	3	4	5
Average errors (%)					
GA	29.8392	13.369	8.4727	12.5832	8.6511
GA + Prep	25.5609	9.7307	7.2525	9.5239	8.3136
GA+ LS + Prep	6.6571	4.389	3.3004	1.7370	3.464

The experiments in first section are results compared from the single GA with and without pre-processing data, the GA with local search, and the GA with local search and pre-processing data for the energy demand model using the available historical data. The experiments in the second section compared the performance of the proposed HGA model with others models.

This study was to investigate single GA performance by measuring the average error using available data of energy demand, testing the effect of using pre-processing data, testing the effect of using local search when combined with GA and testing the pre-processing data in the HGA. Table 1 and Figure 2 presented the findings from the experiments

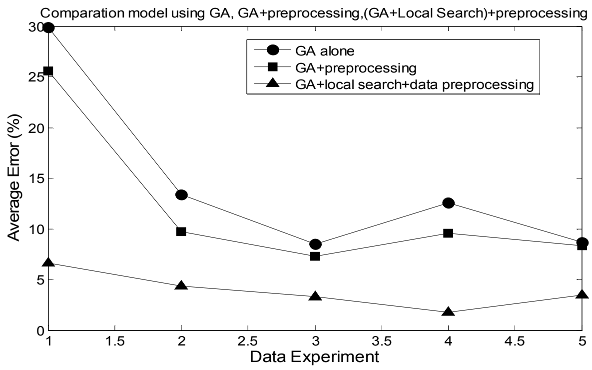

Fig. 2. The average error of single GA and hybrid GA with pre-processing data

Through experimental analysis, results indicated that the hybrid genetic algorithm and local search algorithm using pre-processing data obtained the best solutions. The application of local search combined with genetic algorithms resulted in good solution quality in solving the energy demand pattern problem. Table 2 and figure 3 illustrated the experiments results in the second section. Figure 3 show the performance of the energy demand model, which are measured by the goodness of fit between model outputs and the required target (actual energy demand). It can be seen that the proposed HGAED using the hybrid genetic algorithm and local search approach has better performance.

Table 2. Estimation rate by proposed HGAED and other models

Years	**Actual Demand**	GAED	Linlog	Proposed HGAED
2001	**84.5**	79.521	81.022	75.9079
2002	**87.1**	82.566	76.879	78.7989
2003	**90.4**	88.774	78.544	84.7533
2004	**100.1**	103.651	86.676	92.355
2005	**107.0**	122.129	102.063	105.5662
2006	**112.6**	138.873	116.901	123.0078
2007	**121.2**	155.497	124.667	134.0135
2008	**129.0**	187.313	131.086	137.4572
2009	**136.1**	174.726	111.161	138.4144
Average-Err(%)		**15.293**	**6.426**	**4.389**

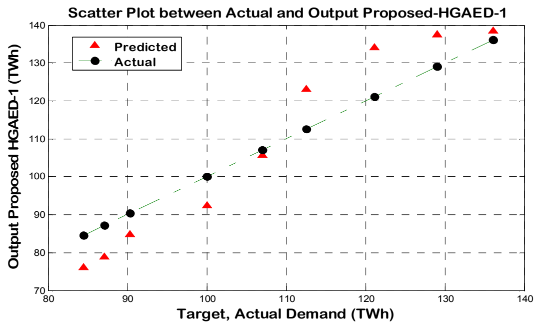

Fig. 3 The goodness of fit to actual demand by proposed HGAED model

5. Conclusions

Based on extensive experiments and obtained results, it appears that the proposed HGAED is more accurate than the conventional genetic algorithm approach. In the proposed HGAED, pre-processing of available data is done before estimation processing, therefore, obtained result proved to have the best accuracy. The performance of the proposed HGAED model was evaluated in terms of error using real energy data with pre-processing. It also was used to predict future demand using a scenario analysis of economic growth.

References

[1] Qiu, Y., Liu, Feng, & Huang, X. "Network Optimization based on Genetic Algorithm and Estimation of Distribution Algorithm". International Conference on Computer Science and Software Engineering, 2008 , Vol. 4, pp. 1058 -1061.

[2] Zhou, X., & Cheng, H. "The induction motor parameter estimation through an adaptive genetic algorithm". 39th International Conference on Universities Power Engineering, 2004, Vol. 1, pp. 494 - 498.

[3] Stefopoulos, G. K., Georgilakis, P. S., Hatziargyriou, N. D., & Sakis Meliopoulos, A. P. "A Genetic Algorithm Solution to the Governor-Turbine Dynamic Model Identification in Multi-Machine Power Systems", 44th IEEE Conference on Decision and Control, 2005, pp. 1288 - 1294.

[4] Li, Y. F., Xie, M., & Goh, T. N. (2007). "A study of genetic algorithm for project selection for analogy based software cost estimation". International Conference on Industrial Engineering and Engineering Management, IEEE, 2007, pp. 1256 -1260.

[5] Ozturk, H. K., & Ceylan, H. "Forecasting total and industrial sector electricity demand based on genetic algorithm approach: Turkey case study". International Journal of Energy Research, No.29, 2005, pp.829-840.

[6]Jian-Chao, H., Zhong-Fu, T., & Xiao-jun, L. "Electricity Consumption and Economic Growth in China: Multivariable Cointegration Analysis and Electricity Demand Forecasting". International Conference on Wireless Communications, Networking and Mobile Computing, 2008. Vol. 8, pp. 1-4.

[7]Asyikin, S.N. "Menu planning model for Malaysian boarding school using self-adaptive hybrid genetic algorithms". PhD Dissertation, College of Arts and Sciences, Universiti Utara Malaysia, Kedah, Malaysia, 2011.

[8] Musa, W., Ku-Mahamud, K.R., & Yasin, A. "Long term energy demand forecasting based on hybrid, optimization: comparative study". International Journal of Soft Computing and Software Engineering, 2012a, Vol. 2, No. 8, pp. 28-36.

[9] Musa, W., Ku-Mahamud, K.R., & Yasin, A. "Hybrid optimization approach to estimate random demand". International Conference on Computer Information Science, 2012b, Vol. 1, pp. 474-479.

[10] Ahmed I, Beg, M.R, Gupta, K.K, & Mansoori, M.I. "A Novel approach of query optimization for genetic population". International Journal of Computer Sciences Issues, Vol. 9, No. 1, 2012, pp. 85-91.

Wahab Musa is a senior lecturer at Electrical Engineering Department, Faculty of Engineering, Universitas Negeri Gorontalo, Indonesia. He received Master of Engineering degree (Electrical Engineering) from ITB Bandung, Indonesia. His research interest includes electricity energy planning, digital signal processing, hybrid genetic algorithm and computational intelligence applied in demand forecasting.

Ku Ruhana Ku-Mahamud is a Professor in the School of Computing at the College of Arts and Sciences, Universiti Utara Malaysia. As an academic, her research interest include computer systems performance modeling, ant colony optimization and computational intelligence.

Azman Yasin is an Associate Professor in the School of Computing at the College of Arts and Sciences, Applied Science Division, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah. Malaysia. His research interest includes software engineering education, information retrieval specifically scheduling and timetabling using artificial intelligence techniques.