

Hybrid Metaheuristic of Artificial Neural Network - Bat Algorithm in Forecasting Electricity Production and Water Consumption at Sultan Azlan Shah Hydropower Plant

S.N.H.S.Hussin^{1*}, M.A.Malek^{1,2}, N.S.Jaddi¹

¹ Civil Engineering Department

² Centre for Renewable Energy (CRE)

Universiti Tenaga Nasional

Selangor, Malaysia

Corresponding author *: Sharifahsyedhussin@gmail.com

Z.A.Hamid³

³ Performance & Diagnostic Unit, Asset Operation Dept.

Generation Division, Tenaga Nasional Berhad

Malaysia

Abstract— Hydropower is one of the technologies in renewable energy that is commercially viable on a large scale. A hybrid of metaheuristic Artificial Neural Network (ANN) technique with Bat Algorithm (BA), a bio-inspired algorithm is proposed to forecast future electricity production and water consumption at Sultan Azlan Shah Hydropower Dam located upstream of Perak river. In this study, both the ANN and Hybrid ANN-Bat Algorithm coding was designed and written explicitly to tailor the time series input data and assumptions used in this study. Comparison on results obtained from ANN and the proposed hybrid ANN – BA was conducted. Simulations conducted in this study exhibited that the proposed hybrid algorithm is much superior than the conventional ANN.

Keywords— Artificial Neural Network (ANN), Bat Algorithm, electricity production, water consumption, hydropower.

I. INTRODUCTION

Hydropower is a set up innovation that saddles the vitality moving from higher to lower heights [3]. It comes in different shapes and sizes from expansive supply tasks to little keep running off waterway offices. Hydropower utilizes common wellspring of water to create power and has low nursery gas emanations. It is a premium vitality source which gives a scope of administrations. These incorporate base and pinnacle load eras and backing different types of power era, especially renewables [5]. In spite of these qualities, hydropower advancements over the previous decades have been profoundly disputable because of the going with social and natural concerns. A test for hydropower engineers and administrators, and additionally legislative organizers and controllers, has been to create instruments that advance great practice and manageable hydropower ventures [3, 5]. In addition, other stakeholders namely financiers and developers share similar challenges.

II. FUTURE OF HYDROPOWER IN MALAYSIA

Hydropower has four points of interest, specifically it is renewable, it produces negligible amount of greenhouse gases,

it is the least costly way of storing large amount of electricity, and it can easily be adjusted on the amount of electricity produced to the amount demanded by consumers [3]. Hydropower represents around 17% of worldwide era limit and around 20% of the vitality created every year [3, 5]. Hydropower vitality is generally utilized all through the world, changing in size from little (smaller than usual hydro) to mammoth plans serving a few nations or districts. Industrialized nations have used their hydro potential to an impressive degree, in spite of the fact that in the creating nations, especially in the central and tropical belts, the utilization of hydropower plant is a choice with extensive potential to fulfill vitality needs [3, 5].

III. STUDY AREA

Sultan Azlan Shah Power Station, Bersia or known as Bersia Dam is one of the dams fabricated upstream of Perak river in Malaysia. The dam is located close to the town of Gerik, around 18 km toward the east by the East West Highway. The power plant is furnished with three turbines of 72MW in total capacity. The station supplies power to the whole state of Perak and Penang through the National Grid system. This study concentrates on the improvement of projection model utilizing Artificial Intelligence (AI), a science in making machine do things that would require insight if done by people. A cross breed insightful strategy is one that joins no less than two keen innovations. A decent mixture framework brings the upsides of both these advancements. The Artificial Intelligence (AI) technique chosen in this study is Hybrid Artificial Neural Network - BAT Algorithm [2].

IV. TECHNIQUE USED

AI technique proposed in this study is a creation of computer system that exhibits some form of intelligence and attempts to apply such knowledge to the design of computer based

systems. Programming, in programming advancement of AI requires the utilization of various sorts of information on the issue area. The programming space requires a wide range of ventures in consolidating these sorts of learning into one last arrangement [1]. In this study, both the ANN and Hybrid ANN-Bat Algorithm coding was designed explicitly to cater for data used as input to the proposed model. The pseudocode is not presented in this paper, due to Intellectual Property (IP) issues.

A. Artificial Neural Network (ANN)

The AI method commonly used includes neural network, fuzzy logic and evolution algorithm. Nevertheless, Artificial Neural Networks (ANN) is not universal in solving all problems since it is an alternative mathematical device to rapidly process information on data [15].

In this study, a technique based on ANN is proposed for the scheduling of hydroelectric generations. The purpose of hydroelectric generation scheduling is to estimate the optimal amount of generated power of hydro units in the system for the next N ($N=24$ in the work) hours in the future. Input data used in this proposed ANN technique includes actual system hourly loads and actual water used at the study area, in order to forecast future electricity generation. In the ANN approach used, a clustering ANN was first developed in order to identify the days with similar hourly load patterns and actual water used. ANN models are increasing being applied in many fields of science and engineering. These networks are found to have the best performance with regard to input-output function approximation. The training method used for this model is back-propagation variation and known as extended-delta-bar-delta [16].

In this study, ANN is used to predict separate features such as demand on weekdays or weekends. It produced minimum error as compared to using fuzzy logic, knowledge-based and case-based reasoning (CBR) [17]. However, the performance of these ANN models can be evaluated using several statistical tests that described the errors associated with the model [18]. The purpose of error assessment of the model is to recognize and reproduce the training data set. It is also used to check the ability of the developed model in order to predict water consumed using the calibrated coefficients.

B. Bat Algorithms

Metaheuristic algorithms are instantly turning into the exceptional systems for highly challenging for optimization problem. Bat algorithm (BA) is a created by Xin-She Yang in 2010 [14]. BA has been seen to be an outstandingly compelling system in perspective of the echolocation behavior of bat [14]. The capacity of echolocation of smaller scale bats is interesting as these bats can find their prey and separate particular sorts of dreadful little creatures even in complete murkiness. Bats discharge an uproarious sound heartbeat and pay consideration to the echo that returns from objects [11, 12].

V. RESULTS AND DISCUSSION

A. Validation of Proposed Model

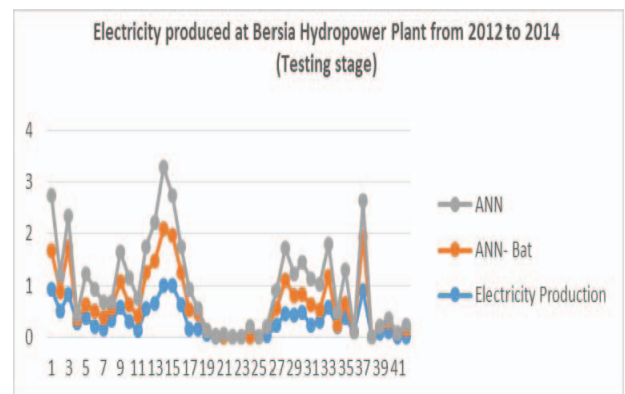
In order to use the proposed method to forecast future electricity production and water consumption in hydropower generation at Sultan Azlan Shah Power Station, validation on the proposed model were conducted by performing comparisons on the results generated from the proposed Hybrid ANN-Bat model, ANN model and actual historical electricity production values at year 2012 to 2014 during model testing as exhibited in Figure 1(a). These values were also presented in Table 1, where various statistical tests namely RMSE, MAE and MAPE were used to assess the strength of synthetic data generated.

Similar comparisons were conducted on water consumption at year 2012 to 2014 during model testing as exhibited in Figure 1(b). These values were also presented and tested at various statistical tests as shown in Table 2.

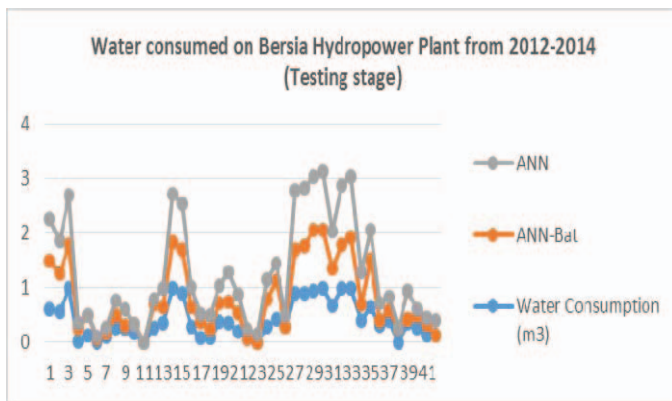
Based on the results obtained, it shows that even though both proposed models produced similar trending as compared to actual data, Hybrid ANN-Bat Algorithm model has managed to produce electricity production values that are closer to the actual historical electricity production values. This finding is also compared to the values generated by the standalone ANN Algorithm model.

Therefore, it is proven that the electricity production values generated by Hybrid ANN-Bat Algorithm model are better than the traditional standalone ANN Algorithm model. It was also found that the percentage error in Hybrid ANN-Bat Algorithm model is lesser than the ANN Algorithm.

Therefore, through this validation process, we can conclude that the proposed Hybrid ANN-Bat Algorithm is suitable to be used for forecasting of future electricity production and water consumption at the hydropower plant.



(a) Electricity produced

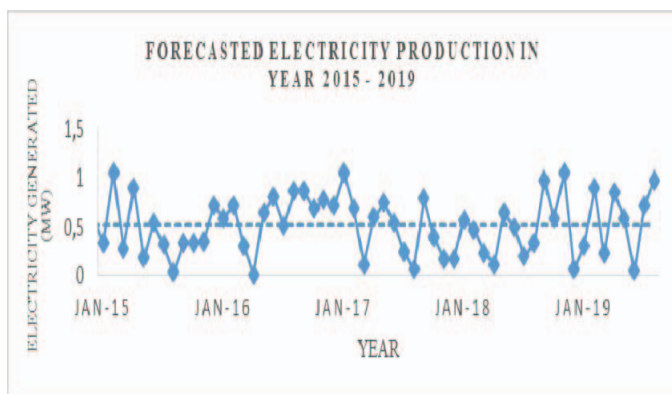


(b) Water consumption

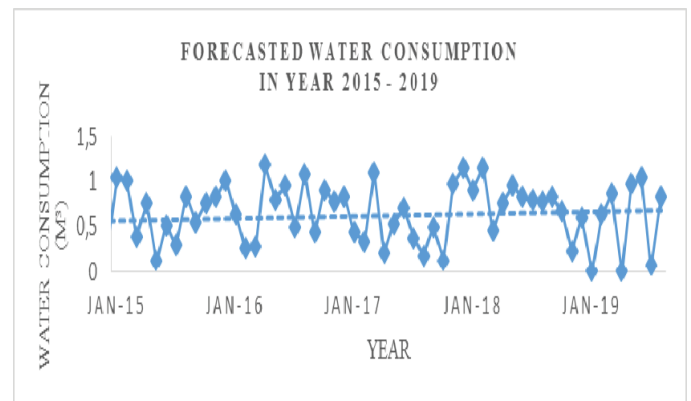
Fig. 1. Comparison between Hybrid ANN-Bat Algorithm and ANN model

B. Forecasting Electricity Production and Water Consumption at Sultan Azlan Shah Hydropower Plant. Validation of Proposed Model.

Based on model validation conducted in this study, the proposed Hybrid ANN-Bat Algorithm is proven to produce enhanced results as compared to the traditional standalone ANN Algorithm. Therefore, this study further proceeds to use Hybrid ANN-Bat Algorithm in forecasting of future synthetic values for both electricity production and water consumption at Sultan Azlan Shah Hydropower Plant. Figure 2 shows the graphical presentation of forecasted electricity production and water consumption at the study area for year 2015 to 2019. Using historical electricity productions data as an aid to develop the forecasted model, Figure 2(a) exhibited that future electricity productions are estimated to fluctuate till about 1.2MW at early 2017 and at the end of 2018. It is also found that between mid-2016 till early 2017, the forecasted electricity productions are generally generated above 0.5MW. On the other hand, as exhibited in Figure 2(b), it is estimated that there is a reduction of water consumption starting from early 2019. This is probably achieved by the effective usage of recycled water in the system.



(a) Electricity Production Year 2015-2019



(b) Water consumption Year 2015-2019

Fig. 2. Forecasting for Year 2015 - 2019

VI. CONCLUSION AND RECOMMENDATION

Based on the superiority of Hybrid ANN-Bat Algorithm, it is proposed that this technique is to be used in the development of projection model at other Hydropower Plants in Malaysia in generating future electricity production values and water consumption. The proposed hybrid technique is able to assist in the operational planning of various existing Hydropower Plants currently in operation.

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