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HYBRID NEURO FUZZY-BASED RESERVOIR RE-OPERATION MODEL: CASE STUDY OF BHUMIBOL DAM IN THAILAND

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INTRODUCTION

Dam and reservoir systems have long been introduced to support the water resources planning and management through a variety of the single and multi-purpose water resources development projects. Because of the high variability of temporal and spatial climate data creating impacts on dam and reservoir's function, escalation of reservoir operating policy and adaptation measures have been highly recommended. The reservoir re-operation is considered as one of the best ways to achieve the water resource management activities particularly in views of the water allocation sustainability and the natural disaster risk management. Accordingly, this study aims to investigate the adaptation strategy through re-operating the reservoir using artificial intelligence tool. The hybrid neuro fuzzy-based reservoir re-operation model was proposed by aiming to increase long-term reservoir water storage of Bhumibol Dam (BB) located in the Ping River Basin, Thailand. To accomplish this research goals, the reservoir re-operation model was developed by applying Adaptive Neuro Fuzzy Inference System (ANFIS) in MATLAB. ANFIS is a novel hybrid approach of artificial neural network (ANN) and fuzzy logic system (FLS), which was developed based on Takagi–Sugeno fuzzy inference system. It is revealed that ANFIS model can help ensure more efficient operation of reservoir system than the classical model based on rule curve if the informative data was sufficiently provided [1]. ANFIS can generate a set of fuzzy IF–THEN rules with appropriate membership functions by identifying the input and output training dataset through a hybrid learning rule which combines the back-propagation gradient descent and a least squares method [1].

METHODOLOGY

The daily long-term reservoir data and hydrological data from 2000 to 2020 were used to develop the hybrid neuro fuzzy-based reservoir re-operation model of BB Dam. The seasonal water allocation plan in the Greater Chao Phraya Irrigation Scheme established by the Royal Irrigation Department (RID) and Electricity Generating Authority of Thailand (EGAT) was used to determine the daily target water demand of BB Dam. To develop ANFIS model, three main variables namely, initial water storage, reservoir inflow, and target water demand were determined as inputs and the current dam release was specified as output. The 80% of dataset was used for model training to generate the rule base relationship between the input and output variables and 20% of dataset was used for model testing to verify the model performance. The optimal reservoir release rules of BB Dam were then obtained from ANFIS model. The statistical performance metrics namely, Root Mean Square Error (RMSE) and R-squared (R^2) were evaluated to assess the ANFIS-based reservoir re-operation performances for both training and testing datasets. The ANFIS rule-based model were then applied in the water balance-based reservoir operation model developed by MATLAB Simulink Toolbox to re-operate the long-term reservoir operation of BB dam. In addition, the maximum and minimum water releases constrained by

the dam and reservoir systems in the Lower Ping River Basin were also assigned in the model. The last step was to evaluate the reservoir reliability performed by the ANFIS-based reservoir operation rules and compared the result with the current operation.

RESULTS AND DISCUSSIONS

The ANFIS-based reservoir operation rules were derived after the number of training epochs of 1,000 was reached and zero error tolerance was set in the model. The results show that the RMSE and R^2 between current release and simulated release accomplished by ANFIS are 6.52 and 0.70, respectively for the training dataset and 5.43 and 0.57, respectively for the testing dataset. When the water balance-based reservoir re-operation model was established and the ANFIS operation rules was embedded in the model, the long-term simulation run of BB Dam from 2000-2020 was accordingly conducted. The comparison of daily reservoir releases between current operation and simulated release by ANFIS-based reservoir operation rules is shown in Fig. 1. In addition, the reservoir re-operation performances quantified as the potential in increasing reservoir water storage during 2000-2020 and reservoir reliability are evaluated in Table 1. It can be evidently seen that ANFIS operation rule-based reservoir re-operation model can increase the reservoir storage throughout the year which is approximately 0.82% higher than current operation. The percent increase in reservoir water storage performed by ANFIS rule-based model is 0.45% in dry season (DS) and 1.26% in wet season (WS) which are higher than current operation. Moreover, the reliability index climbs up to 77% when ANFIS rule-based model was adopted which is much higher than those obtained from the current operation.

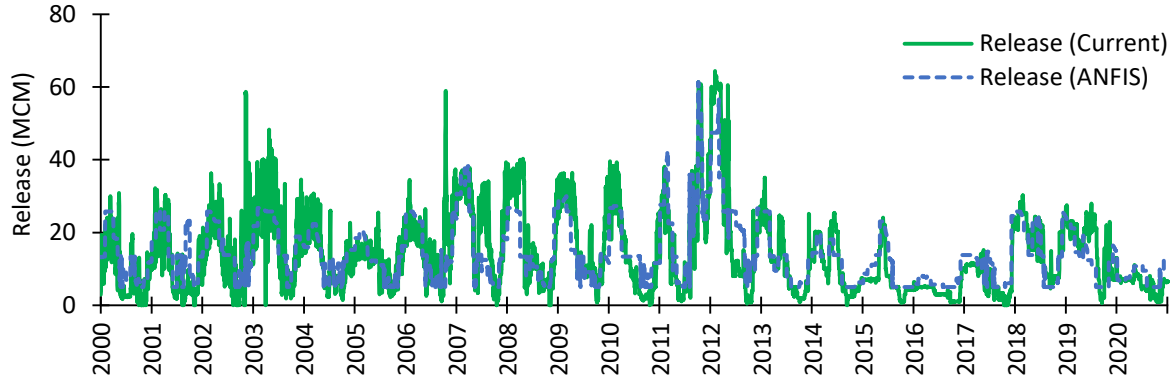

Fig. 1. Comparison of daily reservoir release simulated by ANFIS-based reservoir operation rules and current operation of BB Dam

Table 1. Average seasonal and yearly reservoir storages re-operated with ANFIS-based reservoir operation rules during 2000-2020 and reservoir reliability

Reservoir Operation	Reservoir Storage (MCM)			Reliability Index (%)
	DS	WS	Yearly	
Current operation	8,353	7,073	7,713	52
Re-operating with ANFIS rule	8,390	7,162	7,776	77
Δ% Increase	+0.45	+1.26	+0.82	+25

CONCLUSION

Hybrid neuro fuzzy-based reservoir re-operation model is a state-of-the-art technology and self-learning approach between the input and output linguistic variables that resembles the current operation in controlling complex reservoir operating systems. Research findings revealed that it can be effectively implemented in increasing reservoir storage and achieving better reservoir performance compared to the current operation.

REFERENCES

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