ANN applications to Dam Operation Improvement

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Abstract

The dam plays essential role in long-standing strategy to secure a reliable source of water for a wide variety of human activities. Although numerous extensively studies have been done on optimal dam operation via stationarity and past hydrological experience, the effective decision making of release becomes more challenge under the effects of both climate variability and human responses since severe floods and droughts occurred more frequently. Besides, the prediction of real-time dam operation still remains obstacle in effective transmission of precipitation information, consuming computation time and memory capacity

. To improve adaptive dam operation, this study attempted to develop new tools for dam release decision making by generating the inflows and release of the Bhumidol Dam, Thailand by two separate ANN model utilized the upstream rain gauge stations in the past 10 years daily rainfall data.

Definition and methodologies

Since ANN with one hidden layer is sufficient to solve all problem of the hydrologic process , the architecture of each ANN for hydrology process model consists one input layer, one hidden layer, and one output layer (Figure 1). The best network's configuration (number of nodes, weights, biases) was defined through the performance of fitting among the neural network predicted values and the desired outputs. The training of the neural network models was stopped when either the goal of error was achieved or the number of iterations exceeded a prescribed value

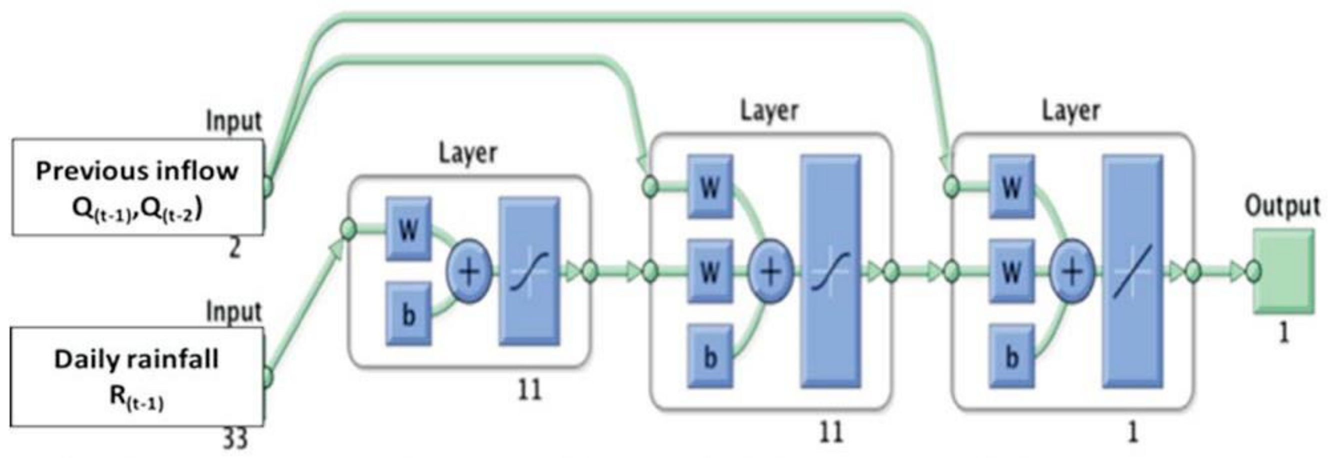

Figure 1. Structure of ANN with conveniently input layer for rainfall-runoff

Rainfall- Dam inflow

According to statistic performance form six combinations of input variables, the combination previous rainfall and two consecutive days of inflow is suitable for rainfall runoff in this study area.. To illuminate this problem, the precipitation was connected to conveniently input layer before transfer to hidden layer (see Figure 1). The performance of ANN was improved when the output was close to peak flow (see Figure 2). The RMSE of ANN with conveniently input layer for calibration and validation are 5.3 and 3.9, respectively. The R^2 is 0.92 for training process and is 0.89 for validating process.

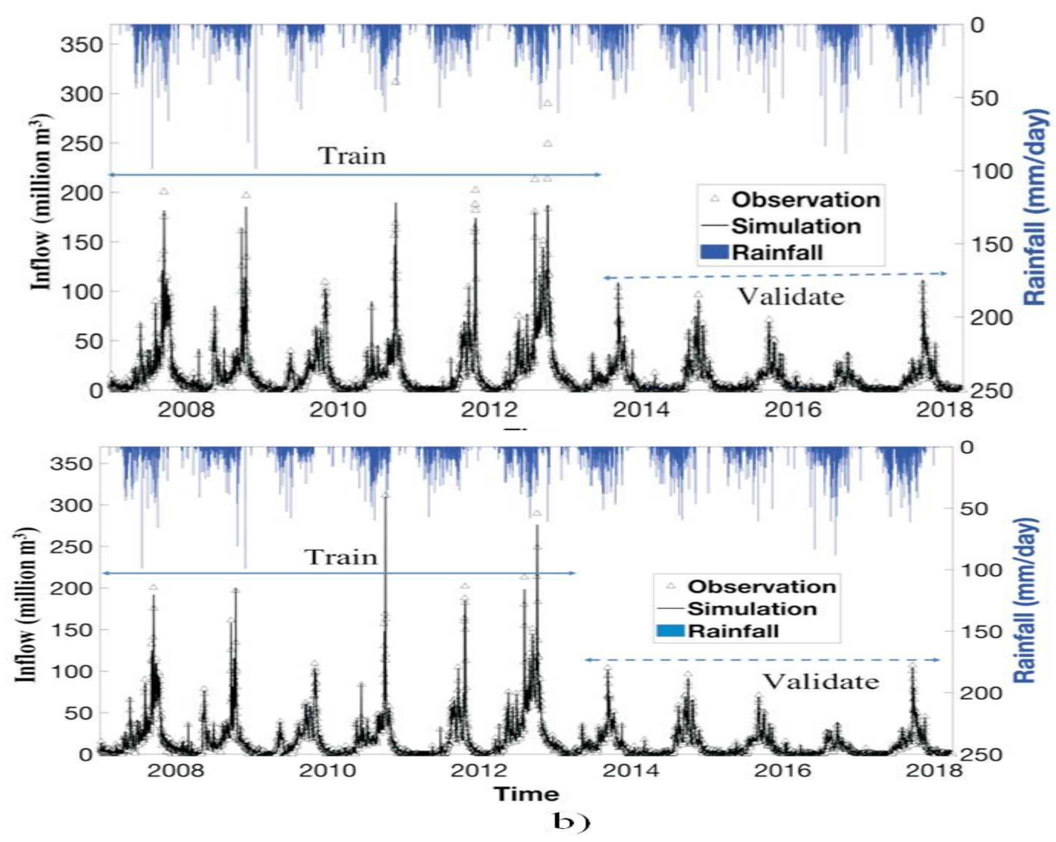

Figure 2. Results inflow of ANN with conveniently input layer

(Note The material is distributed in the session of Water-related Decision-Making in the UNESCO International Water Conference during 13 and 14 May 2019 at UNESCO Headquarters in Paris, France).

Inflow and Dam Release

The combination of two consecutive days of capacity and inflow presented the best performance from six combination variability inputs. The RMSE of calibration and validation are 5.33 mcm, and 3.912 mcm, respectively. The R2 of calibration and validation are 0.92 and 0.95, respectively. Although the simulate could not clarify some immediately high release dam, the ANN is possibility to predict dam release following the current rule curve.

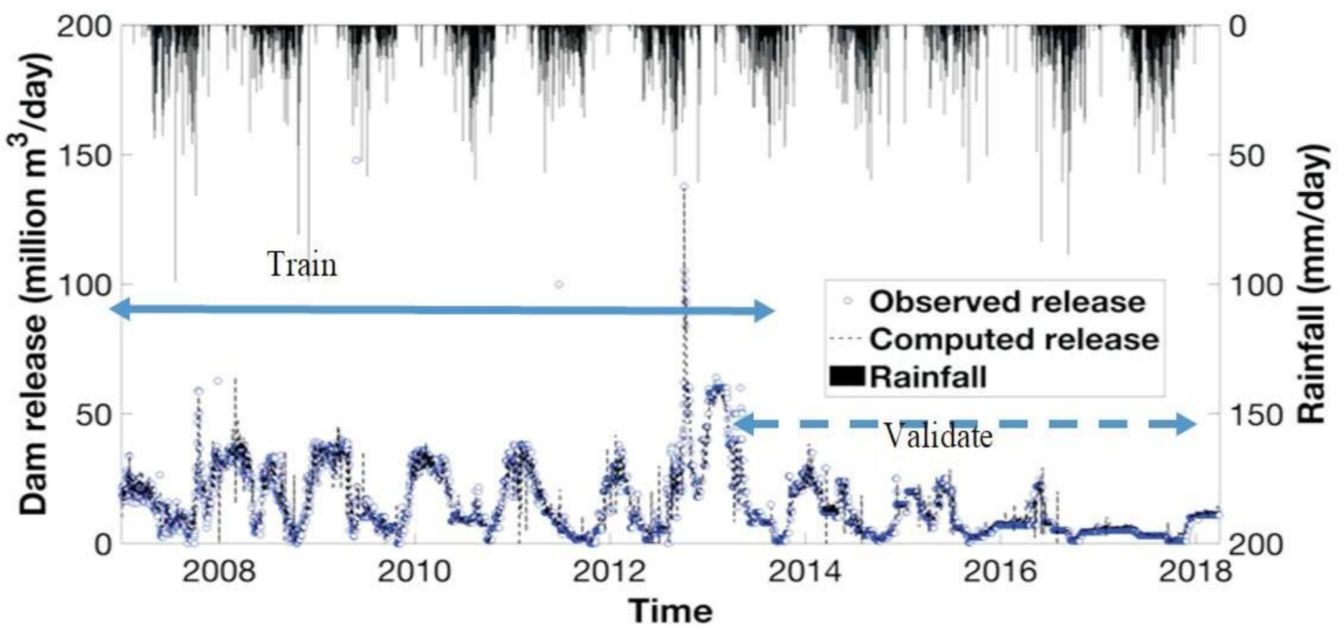

Figure 3. Results dam release following the current rule curve

Possible Improvements for decision making

According to potential application of ANN in hydrologic process, this study propose possible approach to improve water release decision making. The improved water release decision making will be generated from dynamic water demand and optimal ANNs making decision. The procedure shows as following:

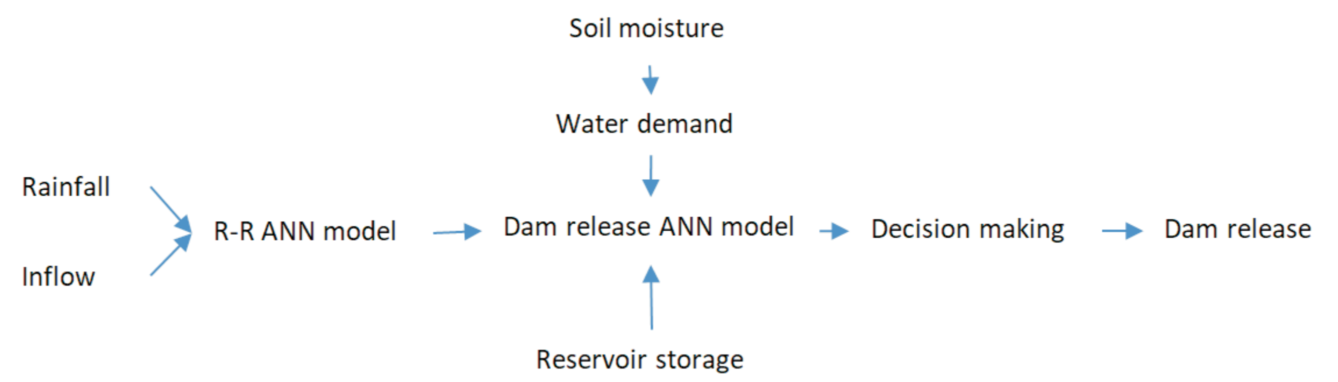

Figure 4. Improved water release decision making will be generated from dynamic water demand and optimal ANNs making decision

Conclusions

This study showed potential ANN applications to Dam Operation Improvement. The water release decision making could be developed more adaptive with climate variability and human responses by integrating dynamic water demand and optimal ANNs making decision. However, the inputs of ANN hydrologic process need to be clarified the reliable source water contributions to the inflow and consider scale impact of water demand to avoid redundant parameters which provide inappropriate release decision making.

References

De Vos, N., Rientjes, T., 2005. Constraints of artificial neural networks for rainfall-runoff modelling: trade-offs in hydrological state representation and model evaluation. Hydrology Earth System Sciences Discussions 2, 365-415.
Kolmogorov, A.N., 1957. On the representation of continuous functions of many variables by superposition of continuous functions of one variable and addition. Doklady Akademii Nauk. Russian Academy of Sciences, pp. 953-956.
Vuckovic, A., Radivojevic, V., Chen, A.C., Popovic, D.J.M.e., physics, 2002. Automatic recognition of alertness and drowsiness from EEG by an artificial neural network. 24, 349-360.

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