Rainfall forecast of Tongjiqiao reservoir

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Abstract. The dam site of Tongjiqiao reservoir is located in Puyang River, a tributary of Qiantang River. Tongjiqiao reservoir is the backbone flood control water conservancy project in Puyang River Basin and an important source of ecological and environmental protection tourism. It is also a reserve water source protection area for the future development of Pujiang County. The reservoir not only provides most of the industrial and agricultural production and domestic water for several major towns (streets) and economic development zones of Pujiang County, but also undertakes the ecological water supply task of Puyang river. For a long time, Tongjiqiao reservoir has played an important role in the economic and social development of Pujiang County. In this paper, the model of adaptive neural fuzzy inference system is used to predict the rainfall of Tongjiqiao reservoir. The results show that the rainfall of the reservoir area is in the average level of many years from 2020 to 2025.

1. Brief introduction of tongjiqiao reservoir

The dam site of Tongjiqiao reservoir is located in Puyang River, a tributary of Qiantang River, about 4.0km upstream of Puyang Town, Pujiang County, with a drainage area of 104.5km². The normal water level of the reservoir is 108.60m, the corresponding storage capacity is 58.8 million m³, and the total storage capacity is 80.97 million m³. It is a medium-sized reservoir mainly for flood control and irrigation, combined with power generation and other comprehensive utilization. The original main works of the reservoir are designed according to the 100 year flood, checked by the 500 year return flood, and all the reservoirs are impounded for the 20-year flood. After the completion of the dam protection project in the 1980s, the reservoir check standard has reached 10000 year return period.

Tongjiqiao reservoir is the backbone flood control water conservancy project in Puyang River Basin and an important source of ecological and environmental protection tourism. It is also a reserve water source protection area for the future development of Pujiang County. The reservoir nurtures 107100 mu of arable land in the downstream Tongjiqiao reservoir irrigation area. The irrigation area covers Puyang, Punan, Xianhua three sub district offices and Yantou, Zhengzhai and Huangzhai towns, with a population of 219000, accounting for 57% of the total population of the county. The reservoir not only provides most of the industrial and agricultural production and domestic water for several major towns (streets) and economic development zones of Pujiang County, but also undertakes the ecological water supply task of Puyang river. For a long time, Tongjiqiao reservoir has played an important role in the economic and social development of Pujiang County.
2. Rainfall forecast method

There are many non-linear forecasting methods for rainfall, but the accuracy of each method is difficult to reach the ideal level due to the complexity of rainfall. In recent years, in order to improve the prediction accuracy, the hybrid algorithm of various methods has been gradually applied to runoff prediction. In the early 1990s, S. R. Jang proposed an adaptive neuro fuzzy inference system (ANFIS) based on TS model [1-2]. It uses neural network to realize three basic processes of fuzzy control: fuzzification, fuzzy reasoning and anti fuzziness. The conclusion part of TS (Takagi Sugeno) model is composed of linear functions, that is, multiple linear models will be used to fuzzy approximate a nonlinear model, so that the identification of conclusion parameters is simple, fast and effective[3-4]. Based on the information storage and learning ability of neural network, the adaptive neuro fuzzy inference system of S model can initialize fuzzy rules independently through the structural identification and parameter identification of the system, and adaptively adjust the premise (non-linear) parameters and conclusion (linear) parameters, and optimize the control rules, membership functions and output functions, so as to realize the effective control of the system Therefore, the prediction accuracy is much better[5-6].

For a system with multiple inputs corresponding to one output, the input vector is $x = [x_1, x_2, ..., x_n]^T$ assumed to be a fuzzy linguistic variable. Design:

$$T(x) = \{A_1, A_2, ..., A_n\}, \quad i = 1, 2, ..., n \quad (1)$$

Where $A_j^i (j = 1, 2, ..., m_i)$ is $j$th language variable of $x_j$, which is a fuzzy set defined on $U_j$. The corresponding membership function is $\mu_{A_j^i}(x_j) (i = 1, 2, ..., n; j = 1, 2, ..., m_i)$.

The consequence of the fuzzy rule proposed by Takagi Sugeno model is a linear combination of input variables, i.e. $R_j$. If $x_j$ is $A_j^i$ and $x_k$ is $A_j^k$ and $x_n$ is $A_j^n$, then

$$y_j = P_{j0} + P_{j1}x_1 + ... + P_{jn}x_n \quad (2)$$

Where $j = 1, 2, ..., m, m \leq \prod_{i=1}^{n} m_i$.

If the input is fuzzified by a single point fuzzy set, then for a given input $x$, the fitness of each rule can be obtained as follows:

$$\alpha_j = \mu_{A_j^i}(x_1) \mu_{A_j^k}(x_2) ... \mu_{A_j^n}(x_n) \quad (3)$$

The output of fuzzy system is the weighted average of the output of each rule, where

$$y = \sum_{j=1}^{m} \alpha_j y_j / \sum_{j=1}^{m} \alpha_j = \sum_{j=1}^{m} \bar{\alpha}_j y_j \quad (4)$$

Where $\bar{\alpha}_j = \alpha_j / \sum_{j=1}^{m} \alpha_j$, It is composed of antecedent network and consequent network. The antecedent network is used to match the antecedent of fuzzy rules, and the consequent network is used to generate the consequent of fuzzy rules.

3. Prediction and analysis of annual maximum daily rainfall of Tongjiao reservoir

The time series of rainfall from 1955 to 2011 in Tongjiao rainfall station is selected to forecast and analyze. The data of T and T + 1 are used to predict the data of T + 2 years, and the prediction analysis model is established. The data from 1955 to 2009 were used for simulation calculation, and the data from 2010 to 2011 were used as the test. The membership function of hidden layer is selected
as gbellmf with three numbers. Observe the change process of the error curve, and finally choose to train the sequence for 500 times, and take the network after 500 times training as the original sequence simulation and prediction network. After inverse normalization and denormalization of the simulation and prediction results, the comparison between the simulation results and the original data is shown in the following figure:

![Figure 1. Simulation and prediction results](image)

This calculation takes 5 seconds and the calculation time is very fast. It can be seen from the above figure that the trend of the original series and the predicted series is basically similar. The results show that the rainfall from 2020 to 2025 is in the level of multi-year evaluation.

4. Epilogue

In this paper, the model of adaptive neural fuzzy inference system is used to predict the rainfall of Tongjiqiao reservoir. Using the model after 500 training as the prediction analysis model, the simulation results of the model are basically similar to the results of the original sequence. Therefore, the simulated network can be used to predict the future rainfall. The forecast results show that the future rainfall in this area will be at the average level for many years.

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