Annual natural runoff forecast of Panjiakou Reservoir

Zhe Wang\textsuperscript{1}, Huifang Guo\textsuperscript{2,*}, Taotao Li\textsuperscript{3}, Jingsi Zhu\textsuperscript{1}

\textsuperscript{1}Hydrology Bureau of Haihe River Water Conservancy Commission, the Ministry of Water Resources, Tianjin, China
\textsuperscript{2}Zhejiang Tongji Vocational College of Science and Technology , Hangzhou, China
\textsuperscript{3}Tianjin Water Conservancy Survey and Design Institute, Tianjin, China

*Corresponding author e-mail: 32970400@qq.com

Abstract. Haihe River Basin is an area with frequent droughts and floods in China. There is a serious shortage of water resources in the Haihe River Basin. The average annual water resources in the basin are 37.2 billion cubic meters, with a per capita share of 305 cubic meters, 1/7 of China, which is one of the serious water shortage areas in China. Panjiakou Reservoir is a large reservoir in the Haihe River Basin, with a water storage capacity of 2.93 billion cubic meters. It is responsible for the water supply of Tianjin, Tangshan and other large and medium-sized cities. The reasonable operation of Panjiakou Reservoir plays an important role in Haihe River Basin. In this paper, the support vector machine model is used to predict the runoff of Panjiakou Reservoir. The prediction results can provide reference for the reasonable operation of Panjiakou Reservoir.

1. Introduction

Haihe River Basin is an area with frequent droughts and floods in China. The annual and interannual distribution of precipitation is uneven, and the precipitation concentration is strong. The special geographical characteristics determine that a rainstorm often changes from drought to waterlogging. Haihe River Basin is seriously short of water resources. The average annual total water resources in the basin is 37.2 billion cubic meters, with a per capita share of 305 cubic meters. One seventh of China, it is one of Chinese serious water shortage areas, and the problem of water shortage is very prominent. At the same time, Haihe River Basin is also the political and cultural center of China. With developed economy and dense large and medium-sized cities, urban water supply and flood control are equally important. Panjiakou Reservoir is a large reservoir in the Haihe River Basin, with a water storage capacity of 2.93 billion cubic meters. It is responsible for the water supply of Tianjin, Tangshan and other large and medium-sized cities. The reasonable operation of Panjiakou Reservoir plays an important role in Haihe River Basin. The runoff is the basis of reasonable reservoir operation.

The amount of runoff is related to the occurrence and development of natural disasters such as drought and flood, and it is closely related to the development and utilization of water resources. The accuracy of runoff prediction is directly related to the water resources development and utilization strategy of the studied area, and has a very important relationship with the long-term sustainable development of the study area. There are many methods of runoff prediction at home and abroad [2], but the accuracy of runoff prediction has been plagued by many scholars.
2. Runoff forecasting method

Support vector machine is a pattern recognition method based on statistical theory, which has advantages in solving small sample, nonlinear and high-dimensional pattern recognition. At the same time, it has the characteristics of global optimization, strong generalization ability and fast convergence speed. The kernel function in SVM model is radial basis function. There are two important parameters in support vector machine model using radial basis function kernel function: penalty factor C and kernel parameter need to be determined. The choice of these two parameters has an important impact on the model structure of support vector machine. However, their selection range is generally wide [5], and it is difficult to accurately find the parameters suitable for the model.

PSO algorithm is a global optimization search method [6], which can be combined with many intelligent algorithms, so as to improve the convergence speed of intelligent algorithm. Therefore, PSO algorithm is introduced into the parameter optimization of support vector machine to improve the accuracy of the model. The algorithm flow of PSO optimization support vector machine is as follows:

1. Set the number of iterations \( n = 1 \), initialize the particle swarm randomly, set the position vector of the \( i \)th particle as \( x^i_1 \), and the velocity vector as \( v^i_1 \) (\( 1 \leq i \leq m, 1 \leq d \leq D \)), which \( m \) is the population size of the particle swarm; \( D \) is the dimension of the search space;

2. The position vector \( x^i_1 \) of each particle is taken as the parameter \( C \) and \( \sigma \) of the support vector machine, and then the estimated output \( f \) of the support vector machine is calculated, and the mean square error \( RMSE \) is calculated as the fitness value of the particle \( RMSE^i_1 \).

3. Compare the current fitness value \( RMSE^i_1 \) of each particle with its own best fitness value \( pbest_1 \), if \( RMSE^i_1 < pbest_1 \), then \( pbest_1 = RMSE^i_1 \), \( p^i_1 = x^i_1 \).

4. Compare the current fitness value \( RMSE^i_1 \) of each particle with the best fitness value \( gbest \) of the particle swarm, if \( RMSE^i_1 < gbest \), then \( gbest = RMSE^i_1 \), \( p^i_1 = x^i_1 \).

5. According to the update equation of particle swarm optimization algorithm, the position vector \( x^i_{d+1} \) and velocity vector \( v^i_{d+1} \) of particle swarm optimization are updated; \( n = n + 1 \), and (2) is returned until the maximum number of iterations.

3. Analysis and prediction of natural runoff of Panjiakou Reservoir

The data collected this time is the natural runoff data from 1955 to 2016 after the reduction of Panjiakou reservoir. The trend of natural runoff is shown in Figure 1.

![Figure 1. Natural runoff data of Panjiakou Reservoir from 1955 to 2016](image-url)
From the above figure, we can see that the Runoff Trend of Panjiakou reservoir fluctuates greatly. In order to reduce the influence of dimension on the prediction results, the paper adopts the normalization of runoff. 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 2014 are used for simulation calculation, and the data from 2015 to 2016 are used as test. Let the population size m of the particle swarm optimization be 100, the inertia weight w change linearly from 1 to 0.5, \( V_{\text{max}} \) is set for 0.5, set the sum of acceleration constants \( c_1 \) and \( c_2 \) to 2, and set the number of iterations to 100. The results of simulation and prediction are compared with the original sequence, and the comparison results are shown in the following figure:

![Simulation and prediction results](image)

4. Conclusion

In this paper, the particle swarm optimization algorithm is used to optimize the two parameters of support vector machine: penalty factor C and radial basis function. The particle swarm optimization (PSO) support vector machine (SVM) model is introduced into the runoff prediction of Panjiakou Reservoir. According to the calculation, Panjiakou Reservoir will be at the average level for many years after 2020.

5. Acknowledgments

This work was financially supported by National key R & D plan (approval No.2016YFC0402705).

References

[1] Hu Junhua, Tang Deshan. Application of time series model in runoff long-term forecast [J]. Renmin Changjiang River, 2006, (02).
[2] Chen Shouyu. Theoretical model and method for comprehensive analysis of medium and long term hydrological forecast [J]. Journal of water resources, 1997, (8):15-21.
[3] Lu Min, Zhang Zhanyu. Application of support vector machine in runoff prediction [J]. China Rural Water Conservancy and hydropower, 2006, (02).
[4] Mei song, Cheng Weiping, Liu Guohua. Preliminary study on flood forecasting model based on support vector machine [J]. China Rural Water Conservancy and hydropower, 2005, (3): 34-36.
[5] Lin Jianyi, Cheng Chuntian. Application of support vector machine in medium and long term runoff forecast [J]. Journal of water resources, 2006,37 (6): 681-686.
[6] Ding genhong. Research and application of intelligent optimization algorithm for reservoir flood control operation [D]. Hohai University, 2008.