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ScienceDirect

Procedia Engineering 186 (2017) 491 – 498

Procedia Engineering

www.elsevier.com/locate/procedia

XVIII International Conference on Water Distribution Systems Analysis, WDSA2016

Hybrid optimization method for strategic control of water withdrawal from water reservoir with using support vector machines

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Abstract

The aim of strategic control is the effort to achieve optimal water resource management (water reservoir). Classic strategic control of water withdrawal from water reservoir are based mainly on the rules and rules curves, which are created by generalization of historical data of water inflows to the reservoirs and water demand. Discharge series are changing in the time due to expected climate change. It is necessary to looking for intelligent water withdrawal control, which will allow to react on these hydrological changes and contribute to the efficient use of accumulated water for ensure water demand. The paper will describe the algorithm based on adaptive control. The normal adaptive control required knowledge of the water flow medium-term prediction into the reservoir. The created algorithm of intelligent water withdrawal control does not require knowledge of hydrological predictions. This control method is based on a suitable combination optimization method with the Support vector machines method. The control algorithm is one of the possible measures to mitigate the negative impacts of droughts and water scarcity. The algorithm of adaptive control is applied to the control of water withdrawal from selected single-reservoir. The results are compared with usual rules for water withdrawal control.

Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems

Keywords: Adaptive; Evolution Algorithms; Operative Control; Reservoir; Strategic Control; Optimization; Support Vector Machines; Water Demand; Water Resource; Water Withdrawal

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Peer-review under responsibility of the organizing committee of the XVIII International Conference on Water Distribution Systems
doi:10.1016/j.proeng.2017.03.261

1. Introduction

Over the last few years we have been able to observe more frequent occurrence of hydrological extremes. Floods have become more frequent and droughts have become more severe. Expert studies in the field of climate science have been pointing out the occurrence of these extreme events for a long time now. As an example, the years 2011 and 2012 are worth mentioning, which in terms of hydrology were evaluated as extremely dry [1], as was also the last year 2015 [2]. It may be anticipated in the near future that such events will occur more often, and their negative effect will show a progressive trend.

In reality it is possible in the case of a sequence of occurrences of several droughts of longer duration that the storage function of some water sources may become jeopardized. Supposing that this threat will become reality and the water storage in water reservoirs will not be sufficient for operating them, a possible solution will lie in a change of the operating hydraulic structures. Such changes will be mainly based on alterations of the method of manipulation with controlled outflow. In an extreme case, if all other options of adaptation measures to ensure water management services are exhausted and when climate changes can no longer be solved by other means for their unfeasibility or disproportionate costs, it will be possible to extend the existing reservoirs by new ones.

The existing state of the active storage capacity control is sufficient but considering the climatic developments, it may soon become insufficient. Classical control of the storage capacity of water reservoirs is predominantly based on control rules [3] or rules curves [4]. The establishment of the above mentioned guidelines was influenced by the performance of the computer technology of that time, resulting in their considerable simplification. The guidelines are based on historical discharge series. The use of historical discharge series does not allow for the guidelines to respond adaptively to actual hydrological conditions. For this reason, the existing control guidelines may collide with limitations due to the changing hydrological conditions which cannot be included in the historical discharge series. Modern computer technology performance allows for the control methods used to be enhanced by the so called intelligent control methods. Intelligent control allows appropriate manipulation on hydraulic structures. Appropriate manipulation allows to prevent system failures such as lack of water supply, and also allows effective water management for hydropower purposes.

The commonly used control methods can be enhanced by intelligent control methods. The intelligent control method is based on the principle of adaptivity. An adaptive approach can respond to the continuously changing hydrological conditions. Such control usually requires the knowledge of prediction of the water flow into the reservoirs. In practice, it is possible to partly eliminate prediction inaccuracies using the adaptivity principle. Although the results of such control show a high potential [5], [6], [7] the successfulness of reservoir control is significantly dependent on the prediction accuracy. One of the possibilities of how to achieve greater success in reservoir control is to improve the prediction model. Another possibility is creating such intelligent control that would be able to respond dynamically to the changing hydrological conditions, and the control process itself would not be dependent on water flow predictions. Such algorithm of intelligent reservoir control not requiring the knowledge of water flow predictions is presented in this paper. This control method is based on an appropriate combination of the optimization model and the Support Vector Machines method [8]. Support Vector Machines (SVM) is a relatively new method belonging among the methods of machine learning. The proposed control algorithm may be used as a support tool for the water management control department, providing it with suitable support in the decision making process when controlling more complex systems with a number of reservoirs and considering a number of water management purposes. The presented control algorithm provides one of the possible measures for mitigating the negative impacts of droughts and water scarcity.

2. Methods

The hybrid optimization method for controlling the storage function of water reservoirs is based on the proposed algorithm combining the optimization model and the SVM method. Detailed descriptions of the optimization model and the SVM method are provided in the following text.