LOW FLOW AUGMENTATION CONTROL OF WUPPER RESERVOIR SYSTEM WITH MULTICRITERIA...

Jarosław Jan Napiórkowski
Institute of Geophysics, Polish Academy of Sciences

HYDRA 2000, Proc. XXVI Congress IAHR, London, 11-15 Sept., vol.4, The hydraulics of water resources and their development, edited by J.Gardiner, 72-73

LOW FLOW AUGMENTATION CONTROL OF WUPPER RESERVOIR SYSTEM WITH MULTICRITERIA MINIMAX OBJECTIVES

JAROSŁAW J. NAPIÓRKOWSKI
Institute of Geophysics, Polish Academy of Sciences, Warsaw, Poland

ANDRZEJ KARBOWSKI, TOMASZ UKLEJA
Institute of Automatic Control, Warsaw Institute of Technology, Warsaw, Poland

INTRODUCTION

An intelligent decision support system for real time operation during drought has been developed for a part of the Wupper Reservoir System in the Federal Republic of Germany (Napiórkowski et al., 1993). The reservoir system consists of two reservoir in series with additional inflow to the lower reservoir. The task of these reservoirs are flood control, recreation, hydropower and low flow augmentation in the city of Wuppertal which lies about 20 km downstream of the lower reservoir with the aim of water quality improvement. A two step procedure for managing droughts is proposed. In the first step operating rules are developed with the aid of simulation technique on the basis of a historical record of 39 years and ten synthetic records of 50 years (Schultz and Harboe, 1989).. These operating rules provide a good long range strategy for drought prevention. In the second step, discussed in the paper, special operating rules for damage reduction in case of drought are derived by applying the worst case approach.

PROBLEM FORMULATION

In the extreme case, when risk of system failure is high, we my be risk-averse. That is we want to eliminate completely risk of some events, if this entails a worse average performance of the system. We mean so-called worst case (min-max) approach, where we want to assure some quality of the system for all combination of inflows including the most unfavourable one from the point of view of the performance index.

We consider a periodic (seasonal), discrete-time dynamic systems described by the state equation. It is assumed, that the control vector (releases) is constrained to take values in a subset that depends on current state (storages) and is also a periodic mapping in time. The dynamics of inflows is represented by means of 39 year long historical sequences (*scenarios*). For the Wupper Reservoir System the following three objective functions are considered: maximum stage deficit, maximum length of continuos deficit period and total annual deficit. The maximum is taken with respect both to time and to all sequences of scenarios, that is the value of a criterion is the maximal cost for the worst possible sequences of inflows.

New operating rules in case of drought were derived by solving the above closed-looped control problem with minimax objectives. The method used is described in details in Soncini-Sessa and Karbowski (1994). This algorithm resembles the successive approximation algorithm for solving Stochastic Dynamic Programming because it also proceeds backward-in-time and the optimal control policy is obtained by successive iteration. The implemented technique is based on the reference point method and graphical interactive representation called ‘Pareto race’. The sequence of most desirable (reference) points in the space of performance indices is generated in a systematic way. These points lie on some lines having direction defined by the user. During calculations, every reference pointy is projected on Pareto surface and the result is shown in the form of bar graphs. Their lengths are changing, making the impression of ‘driving a car’ on the efficient (i.e. Pareto optimal) frontier (Korhonen and Laakso, 1986).

Acknowledgements:. This work has been supported by Polish Committee for Scientific Research, Grant No. PB0021/S4/94/06. The authors like to thank Mr. H. Kissler, Wuppertal Water Authority, for 39 historical scenarios.

REFERENCES

Korhonen P., Laakso J., A visual interactive method for solving the multiple criteria problem. European Journal of Operational Research, vol.24, no.2, 277-287, 1986.

Napiórkowski J.J., Wolbring F.A., Schultz G.A., 1993. Expert System Application for real-time management during drought. Extreme Hydrological Events: Precipitation, Floods and Droughts. IAHS Publ. no.213, 439-446.

Schultz G.A, Harboe R. 1989. Development of reservoir operation rules for Wupper Dam during floods and low flow periods. Wasserwirtschaft, 79, 1-4.

Soncini-Sessa R., Karbowski A., 1994. Design and Control of Water Systems in Presence of Inflow Scenarios, in L.Duckstein and E.Parent (eds.), Engineering Risk in Natural Resources Management, 305-320.