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1 Operative prediction and control of the flood passage

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The complexity of rainfall/runoff process is in the recent years powered by expected and partially already existing influence of the climate change, connected with the changes of capacity and temporal distribution of water sources. This, in connection with the influence of long periods of climatic and hydrological quantities changes, results not only in catastrophic floods, but also dry periods.

The problem mentioned above often force water management specialists to solve the situations, which sometimes lack sufficiently worked out methods and tools. It is necessary to develop non structural measures in river basis,, connected with operative hydrology, i.e. operative prediction and operative control of water runoff from river basin. An operative control of water runoff from the river basin can be carried out only in those river basins, which contain existing suitable regulation elements, i.e. water reservoirs. It was proved that these measures can significantly increase effects from operation of reservoirs.

Large water reservoirs are nowadays controlled by existing manipulation orders, which are based on the dispatcher graphs. Eventually the rules, based on the experience with historic flood courses are used. The recent flood situations though, start to be so atypical, that such way of the control does not always fulfill the expectation. The operative control is a possibility to decrease extreme runoff from the river basins significantly even during such flood situations. Every existing reservoir potentially offers such possibility, but it is not mentioned in any project documentation of the reservoirs,

nor in operation rules. There is the reserve.

The solving of problems mentioned above is carried out in considerable conditions of uncertainty. Uncertainty is the property of some events and processes, characterized by randomness. Uncertainty means that during the control of water management system, we don't know the exact course of control inputs (precipitation above river basin, system inflows). Inputs are random processes most of all, their course in the past contains a random error of measurement and predicted future course of input hydrological quantities contains, in addition, prediction model error. Simplifying of the solution is a part of mathematical models, used for operative control (system schematization, selection of method of mathematical model numeric solution, determination of model parameters by calibration). Uncertainty is in the scale selection of used models for prediction of rainfall above the river basin and rainfall-runoff models.

During the control in real time the rainfall-runoff models have to be considerably simplified to achieve acceptable calculation speed. The computing speed is in operative hydrology a limiting quantity for practical use of the models. The model reflects only part of reality and only the results achieved in practice decide about acceptability of used simplification.

Recently the research in the area of artificial intelligence methods development is aimed at the solution of decision problem under the conditions of uncertainty (intelligent control). The controlling systems have to be equipped with ability to use experience and knowledge described only vaguely and to react to uncertain and unknown situations (Zadeh, 1965), (Jang, 1993). The adaptive approach, used in operative control for the construction of controlling algorithms, is a way to eliminate uncertainty to a certain degree (Nacházel, Starý, Zezulák, 2004). The results achieved in practice univocally confirm the advantage of adaptive approach to the control (in connection with the classic controlling algorithms, based on optimization principles only, or in connection with controlling algorithms using methods of artificial intelligence (neural network, fuzzy regulators, neuro regulators, genetic algorithms, etc.)

The problem of operative prediction of water runoff from the river basin is a lower step of the solution of a given problem. It is a temporal extrapolation of the system behavior, using the knowledge of predicted future temporal and spatial distribution of rainfall above the river basin (or knowledge of predicted future water inflows into the river inter-basin). If there are reservoirs in the river basins, the reservoirs outflows in predicting models are set with the use of manipulation rules, imitating operation rules (rules used in practice). The prediction models of this type are relatively often used in practice. Therefore it is possible to use almost every simulation model of rainfall-runoff process in the river basin, which enables to include reservoirs into the modeled

river basin and to adjust the way of their control. There are many available models, such as AQUALOG (1995-2006) and MIKE with additional NAM modules (1991-2006), HYDROG (1991-2006).

The availability of rainfall-runoff models, containing controlling modules of water outflow from the reservoirs, which enable operative control of river basin runoff during the flood situations, is completely different. These models are, in most case, in the stadium of research (Drbal, 1999), (Fošumpaur, Nacházel, Patera, 2002) and verification (Starý, 1991-2006).

The substance of this contribution is the description of construction and application of controlling algorithms, which in maximum possible way enable to influence effectively, with operative runoff control, the natural rainfall – runoff process in river basin during flooding and to prevent, or to reduce flood flows and flood damage. For the construction of controlling algorithms the combination of optimal programming methods and selected methods of artificial intelligence is used (principle of adaptability, fuzzy–regulators and neural networks).

The advantage of fuzzy regulators, tested on the number of applications of operative control simulation, is their simplicity at fuzzy inference system (FIS) construction and considerable stability of regulation circuit. Their weak point, with the use of MATLAB environment with Fuzzy Logic Toolbox, is their use is time consuming, which reduces the possibility to use constructed controlling algorithms for operative control of complicated systems in practice. Therefore it was decided to assess the possibility of the fuzzy inference system with the neural network, which can be easily used in programming of the same controlling algorithm in other programming language (transfer of topology, weight and transmission biases) and simple use of FIS approximation matrix for linear interpolation between outputs corresponding with periodically spaced inputs in input space.

Part of this contribution presents the results of controlling algorithm application based on combination of non-linear programming and approximation matrix - regulation method or non-linear programming and neural network - regulation method. The programme was successfully used for the simulation of operative control of water discharge through system of five reservoirs on the Dyje River during the flood in August 2002.

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1.0.1 References

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