Editorial: Water prediction and control technology

INTRODUCTION

The domain of hydroinformatics stretches over a wide range of fields, all with water as the common denominator. The domain involves technical aspects such as hydraulics, hydrology, water quality, as well as more social ones, such as economics, stakeholder involvement and decision support. The topic of this special issue of the *Journal of Hydroinformatics* is 'Water Prediction and Control Technology', or WaterPaCT. This topic touches upon each of the mentioned fields, with a particular emphasis on one particular field: control of real-time operations.

Nowadays, real-time operations are from a technical perspective realized in an open-loop fashion; human operators typically decide on which actions to take. The human operators for this gather information from different sources, and in particular use their experience and decision support systems to make decisions. The techniques proposed in this special session go a step beyond the current technologies, assuming that the information that the human operator uses is in fact all available digitally. From a technical perspective, this situation enables the operational control loop to be closed, i.e., the human operator can be taken out of the direct real-time operations, taking on instead a more supervisory role.

Technologies for the real-time control and short-term optimization of water resources systems represent a branch of the hydroinformatics tree that is gaining increasing attention as digital information availability and sensing technologies continue to find their way from theory into practice. Although it does not solve all water related problems, it does provide opportunities that should be discussed with experts from the related water domains.

ONGOING DEVELOPMENTS LEADING TO WATERPACT

Two lines of developments can be distinguished that explain how WaterPaCT has emerged:

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- The *first line of developments* emerges from the practical need for societies to use water systems for multiple goals. In order to direct the water system towards a state where the water flows, volumes, and quality satisfy those societal needs as well as possible, adjustable hydraulic structures have been constructed. These structures can be adjusted locally based on measurements and forecasts. As the effect of the adjustments can influence large parts of the water network, a multi-variable control problem emerges in which the actual and predicted states need to be kept as close as possible to the states demanded by society. The Systems and Control community has profound theoretical knowledge and technology for dealing with such kinds of multi-variable problems. In order to be able to benefit from this, ways have to be found in which the domain specific knowledge regarding water dynamics in the water community can be rewritten in the Systems Theory 'language'.
- The *second line of developments* emerges from the water community, which over the past decades has put tremendous efforts into making accurate models for describing the dynamics of water systems. These models are typically used in off-line studies for the design of water systems, for studying the effects of infrastructural measures, for investigating the effects of climate change, etc. Presently, computer technology has advanced to such an extent that running these models can simulate detailed dynamics in real time. The ratio between the time being simulated and the time required for making the simulation has to be in the order of 100 in order to be useful: In that case possibly predicted problems can still be anticipated. At that moment the question arises: 'What should we do now, now that things are likely to go wrong?'. This is the point where the Control Technology can provide answers.

The WaterPaCT community consists of researchers from both the control and the water community. With this collaboration, they join forces in stressing the importance of this combined approach and the need for exchanging knowledge on this emerging field. They work on combining control and predictions in particular for those water systems that are exposed to weather influences and that have sufficient controllability using adjustable structures and storages. Examples are drainage systems in low-land areas, multiple-purpose reservoirs, and irrigation canals. The techniques developed allow, among others, to anticipate upcoming water-related problems using the ever improving weather forecasts, and can be adopted to use measurements to react to deviations from the desired state in order to correct for unpredicted influences.

CONTRIBUTIONS IN THIS SPECIAL ISSUE

In this special issue the state-of-the-art of Water Prediction and Control Technology come together. This special issue features the following 10 contributions:

- Aguilar *et al.* (2013) present a study into improved predictions of high water levels in a river in Spain using data-assimilation techniques;
- In Liu *et al.* (2013) and Fovet *et al.* (2013), feedback controllers are designed to deal with water quality issues in canals, in this case freezing of water in China and algae attachment to a canal bed in France, respectively;
- Anand *et al.* (2013) concerns an offline optimization method for finding optimal controllers for a reservoir;
- Nederkoorn *et al.* (2013), Pianosi *et al.* (2013), Anand *et al.* (2013), Maestre *et al.* (2013), Wagenpfeil *et al.* (2013) and Romera *et al.* (2013) propose applications of model predictive control for control of various types of water systems: Nederkoorn *et al.* (2013), van Ekeren *et al.* (2013) and Romera *et al.* (2013) present so-called hybrid Model Predictive Control approaches, which take into account the presence of both continuous and discrete dynamics. Nederkoorn *et al.* (2013) and van Ekeren *et al.* (2013) consider test cases in The Netherlands (a polder system and an entire delta system, respectively). Romera *et al.* (2013) considers a test case in Spain;
- Anand *et al.* (2013) and Maestre *et al.* (2013) apply distributed model predictive control for a test case in Singapore and for controlling a drainage water systems, respectively.
- Wagenpfeil *et al.* (2013) uses model predictive control for controlling a navigation canal system in Germany.

CONNECT

The international WaterPaCT community meets at conferences that either relate to control or to water, such as the 2011 IEEE International Conference on Networking, Sensing, and Control, in Delft, The Netherlands, and the 2012 HydroInformatics Conference in Hamburg.

For information on joining this knowledge exchange initiative contact us directly, or visit http://www.waterpact.org/.

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