Abstract

This dissertation explores the applicability of Model Predictive Control (MPC) for the purpose of set-point control and flood control of river systems. The first part of this work discusses the modelling aspects of river systems. The dynamics of a single reach can be described with the well known hydrodynamic equations of de Saint-Venant. Combining these hyperbolic Partial Differential Equations (PDEs) for every reach, together with the nonlinear equations modelling the hydraulic structures and the boundary conditions related to junctions, mathematical models can be constructed for a wide range of river systems. However, these models are typically too complex to be used directly in the design of a controller. A new type of approximate model is proposed in this dissertation. A significant reduction in computational complexity with respect to using the full hydrodynamic model while still achieving accurate results can be obtained by approximating the dynamics of every reach with a linear model in combination with the nonlinear gate equations. Model reduction techniques can be used to further decrease the computational complexity.

The main part of this dissertation focuses on the design of the predictive controllers. The key ingredient is to work with the gate discharges as optimization variables instead of the gate openings. A linear approximate model is sufficiently accurate in this configuration and the resulting optimization problem is a Quadratic Programming problem (QP). It is explained how this controller can be used for set-point control and flood control at the same time and how it can recover the used buffer capacity of the reservoirs in an efficient way. Attention is paid to minimize the computation time needed to solve this QP at every time step by decreasing the number of optimization variables and the number of inequality constraints. The use of a Kalman filter as state estimator is also discussed. All closed loop simulations are performed with the full hydrodynamic models.

Besides some academic test examples, a mathematical model of the Demer based on real field data is used to test the performance of the proposed control scheme. It is discussed how the controller can deal with the irregular bed slope and the irregular cross sectional profiles of the river system without having v vi ABSTRACT to rely on nonlinear advanced control techniques. The performance of the predictive controller is tested for the historical rainfall data of the Demer for the flood event of 2002 on the full hydrodynamic model and compared with the control performance of the current controller installed. The proposed predictive control scheme reduces significantly the number and the magnitude of floods, leads to a better set-point tracking and recovers the buffer capacity in a faster way than the current controller.