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Original article

Data assimilation for real-time estimation of hydraulic states and unmeasured perturbations in a 1D hydrodynamic model

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Abstract

Water management, in a variety of contexts and objectives, is a very important issue gaining increasing attention worldwide. In some places and during some periods, this is due to the scarcity of the water resource, and increasing competition for its use. In some others, it can be risk reduction due to flood events, or optimization of hydropower production along rivers. Hydraulic modeling, system analysis and automatic control are now parts of most water management projects. In order to operate hydraulic devices on irrigation canals or rivers, detailed information on the hydraulic state of the system must be available. This is particularly true when the control algorithms are based on Linear Quadratic Gaussian or Predictive Control approaches, using full state space models. Usually, the only known quantities are water levels, measured at limited locations. Sometimes, the discharge is known at specific locations (cross devices with gates, weirs, or hydropower turbines). The design of an observer is a very useful tool for reconstructing unmeasured data, such as discharges or water levels at other locations, unknown perturbations, such as inflows or outflows, and model parameters such as Manning–Strickler or hydraulic device discharge coefficients. Several approaches are able to provide such observers. The paper illustrates and compares the use of sequential Kalman Filter and sequential Particle Filter State Observer on these water management problems. Four scenarios have been selected to test the filters, based on twin experiences or using real field data. Both approaches proved to be efficient and robust. The Kalman Filter is very fast in terms of calculation time and convergence. The Particle Filter can handle the non-linear features of the model.

Keywords: Data assimilation; Kalman Filter; Monte Carlo; River; Canal

1. Introduction

Irrigation is well-known for being responsible of more than 70% of the fresh water withdrawal, in average in the world. But irrigated lands also contribute for more that 40% of the world food production with less than 20% of the cultivated area. Recent FAO figures indicate that for 2030 the food production will have to be increased by more that 80%, but with no more than 12% additional water extraction. Therefore, high levels of efficiencies of water uses are increasingly expected from the managers of irrigation canals or rivers used for irrigation. Hydropower production

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