Geophysical Research Abstracts
Vol. 20, EGU2018-12159, 2018
EGU General Assembly 2018

Control of a water system with a partial time step delay in the feedback loop

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With increasing urbanization, climate variability, and population growth, higher demands are made of the management of modern water systems. One way to address this problem is the use of computerized control systems. These systems gather measurements and then adjust the structures (weirs, gates and pumps) in the system at fixed intervals. For practical reasons these intervals should not be too short. Very short intervals result in high demands on the communication system and increased wear and tear on the motors adjusting the structures. This introduces a problem. For a given system an interval of say 15 minutes could be acceptable from both operational and control viewpoint, except for the fact that using 15 minute old data would be problematical. The time taken to gather the measurements, pre-process them, calculate the control actions, and transmit the control actions cannot be neglected. So a careful analysis of the effects of both the time step and the delay in the control loop is needed. The controlled system is a sampled data system with a fractional time step delay in the application of the control action. There are standard analysis techniques for such systems when the delay between measurement and application of the resulting control action is a multiple of the time step. For the case of a fractional time step delay some more work is required. As an example a stability analysis is given for water level control in a reservoir using a non-linear actuator. The analysis is based on the theory of non-monotonic Lyapunov functions.