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Computer controlled water systems: electrifying or shocking?

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In a century where soon even your refrigerator may be on the internet and fuzzy logic washing machines are yesterday's news, can water management keep up? This is of course partially dependent on scale. It is easier to apply computer control to a drinking water preparation or waste water treatment than it is to automate an open channel irrigation system spanning hundreds of square kilometers. In the latter case we face the obvious problems of power supply and communication. Less obvious are some other problems. Long transport delays complicate controller design, as do operational limitations on the frequency of structure adjustments and measurements. Time delays due to the processing of measurements, calculation of control actions, and implementation of those actions may not be negligible. Sometimes we may even need to allow for control actions triggered by events in the system. It is not sufficient to be aware of these problems, we need assurances that a design will work. While simulations may provide part of the answer to that question, theoretical tools are that predict the behavior of a control system are essential. Given the current discussions on water and food shortages, an open channel irrigation system provides a good context to showcase the problems and demonstrate some tools. We need a control system that takes into account the state of the whole system if we wish to avoid letting more water into the system than is necessary. This introduces a non-trivial complications in the design of the automatic control system. To illustrate this we consider a primary canal that is split into reaches by remotely controlled structures. The reaches are modeled as a combination of a delay and a reservoir. We derive necessary conditions for stability of the resulting system. The system is a sampled data system with non-linear actuators. The analysis is based on the theory of non-monotonic Lyapunov functions.