HIM: A Linear Free-Surface Model for Irrigation Canals Operating in Real Time

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Abstract

One of the most significant contributions in the paper is the concept of the Hydraulic Influence Matrix (HIM) and its use as a linear model for complex open-flow canals. In the context of canal flow, the HIM serves as a parameter sensitivity matrix. Given its physical interpretation, the HIM can characterize free-surface flow behavior in canals. Specifically, it helps analyze the dependence domain of a canal setpoint and the influence domain of a gate movement.

The matrix is populated with derivatives typically calculated using numerical flow models, but this approach is impractical when there are many parameters to identify or when the performance index is challenging to evaluate common issues in canal control systems. Therefore, the HIM has been derived analytically. A primary contribution of the HIM to open-flow canals and canal controllers is its ability to quickly and accurately compute water level and velocity perturbations in response to gate movements in real-time. This model provides watermasters with the ability to apply this linear surface model in both unsteady and steady states, enabling real-time applications in control algorithms. Model testing showed that, for gate movement disturbances ranging between 10% and 0.5%, equivalent to a maximum incremental discharge of over 70%, the linear model maintains an acceptable error margin, supporting its application as a real-time control model. Furthermore, this model fully supports real-time control applications, as larger gate movement disturbances (exceeding 10%) should be planned in advance rather than managed in real time.

Keywords

Optimization algorithms, real time control, mathematical flow models, irrigation canals.