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Non-contact, Low-cost Sensor Network for River Stage Monitoring and Dynamic Discharge Estimation

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Long series of river discharge data are essential for developing improved river and water management strategies and for coping with water-related hazards such as floods. However, continuous direct measurement of river discharge is practically infeasible. Recently developed electromagnetic and ultrasonic methods can be used for automated (or direct) river discharge measurements; however, they are not widely used because they are expensive and are prone to damage during high flows.

At most gauging sites around the world, a rating curve is used to convert the measured stage into discharge. However, using rating curves is fraught with difficulties, including (a) hysteresis effect during unsteady flow, (b) extrapolation error during high flows, (c) need for regular updating due to change in hydraulic resistance and channel geometry. More recently, methods have been developed for dynamic river discharge estimation by solving governing equations of river flow i.e., shallow water equations (SWE). However, these methods (a) solve SWE in its conservative form, (b) are most suitable for prismatic channels with no lateral flow, (c) require one flow value, and (d) assume channel roughness or calibrate it by using observed stage data from two or three gauging locations. Although, stage data from two or three gauging locations are theoretically sufficient to calibrate channel roughness, in practice error margins are still high due to sub-optimal positioning of gauging stations, and coarse temporal resolution of existing measurement networks.

Therefore, motivated by a need to surmount the limitations in existing methods, we have developed a non-contact, robust, and cost-effective approach for dynamic river discharge estimation. We use an array of bespoke sensors to monitor the river stage at high resolutions and use these stage data to estimate river discharge. We present a methodology to calibrate a hydraulic model of a river reach by only using stage data from a network of such sensors. We use freely available HEC-RAS software as the solver for SWE. We have developed python scripts to control and automate HEC-RAS simulations and estimate river discharge dynamically.