REAL-TIME STREAM MONITORING USING MOBILE LARGE-SCALE PARTICLE IMAGE VELOCIMETRY

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Emerging cyberinfrastructure-based decision-support systems for aquatic environments assume coupling of real-time monitoring instruments with data-driven models covering spatial and temporal scales from microhabitat to watershed levels. This paper describes a Mobile Large-Scale Particle Image Velocimetry (MLSPIV) that allows visualization and quantitative measurements of instantaneous and averaged flow characteristics in rivers over large areas. The unmatched spatial resolution along with the remote, real-time, and fully digital nature of MLSPIV makes it an ideal cybertool either as a stand-alone instrument, as presented in the paper, or integrated in large-scale networks. Preliminary tests with similar stationary LSPIV configurations proved that the technique is reliable, flexible, and efficient for monitoring, design, hazard warning, and decision-making in riverine ecosystems.

MLSPIV holds considerable promise for filling the gaps in our ability to collect data in natural streams in a non-intrusive manner. The MLSPIV has capabilities to measure discharges and free-surface velocity distribution in streams during normal and extreme flow conditions at any river site. The most important impact of such a measurement system is its potential to measure during flows hazardous to immersed equipment (flooding), and in situations where the interior of the flow is, for one reason or another (low flows, flows over rock beds and submerged control structures) is inaccessible or difficult to reach. In these situations the need for data is greatest because there are no alternative measurement techniques available. The system provides a cost-effective means to measure discharges at ungaged sites, and also can expand rating curves at existing gaging sites during flood events. The relatively high frequency of the MLSPIV measurements can reliably document the kinematics of the flood wave propagation, providing event-based observations that have not been documented before. The newly-acquired information will eliminate current practice of extrapolating rating curves

obtained with direct measurements during quasi-uniform flow conditions. Improvement of rating curves will benefit routine monitoring programs, and also load estimation for a range of transported solute and suspended substances.

The MLSPIV is a truck-based system that incorporates successive advancements gained over several years of LSPIV development conducted at IIHR. MLSPIV is an imaging device (video or digital camera) mounted to a telescopic mast which can position the camera up to 14m height. Camera positioning and control is accomplished remotely using in-house developed software installed on a laptop. Image processing for obtaining the measurements is conducted real-time on the same laptop computer. MLSPIV is self-powered, can be deployed conveniently in the vicinity of streams, and allows measurements with relatively little preparation. These capabilities make MLSPIV as a good measurement alternative for measurements in small ungaged streams or for capturing flow characteristics near stream boundaries or in the vicinity of hydraulic structures to document scour processes.

The case study reported in this paper was conducted on the Clear Creek near Coralville, IA where a USGS sreamgaging station (USGS 05454300) exists. The stream has 20m width and 0.5m depth at the location of the measurements. Images were captured using both digital camera and video camera using natural illumination. Hay, used for cattle feeding, was spread in small quantities over the stream water surface to improve the flow visualization. Images with the two systems were collected for 3 minutes, with the discharge measurements converged to the average in less than 1 minute. The purpose of the measurements was to document the MLSPIV overall performance and the improvement in the accuracy of the measurements by using higher spatial resolution for the imaging device. The results obtained with both cameras showed good agreement with the reference measurements, with differences in the discharge no larger than 4.5%. Reference measurements were those provided by the USGS real-time stream gaging data. As expected, the higher spatial resolution of the digital camera improved the accuracy of the discharge approximately 2%. The overall comparison of the three measurements is provided below.

	USGS	Digital camera	Video camcorder
Discharge (m^3/s)	2.435	2.374	2.544
Error (%)	reference	-2.53	4.46

Keywords: Mobile Large-Scale Particle Image Velocimetry; Discharge measurement; Surface velocity fields

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