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Flow dynamics at a river junction using image processing technique

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The understanding of flow dynamics at a junction in a river-network system is paramount for bank restoration, flood control and management. Several studies have been reported over the time to understand the flow dynamics at a junction. But, the main limitation lies in the collection of high-resolution data such as flow depth and velocity which in turn are used to calculate parameters such as circulation, shear stress, Reynolds number, mass and momentum transfer. Hence, this paper presents a new approach based on image processing technique to comprehend the flow characteristics at a junction. The investigation is carried out in a laboratory setup of river-network-floodplain system that has multiple junctions. The study is divided into two major parts to acquire the required data: (a) spatial distribution of velocity and (b) water surface topography. The surface velocity is generated using the non-intrusive Large-Scale Particle Image Velocimetry (LSPIV) technique. The measurement of water surface (WS) topography is carried out using the automated close-range photogrammetry (CRP) technique. For LSPIV, non-specular tracer materials are introduced at the upstream of a channel junction. Video of the junction area is recorded from a single camera. The video is then converted into frames for further processing in FUDAA LSPIV package. The package calculates 2D velocity components by tracking the tracer particles in two consecutive frames. For comparison, ADV is employed to measure velocity at three cross-sections for 3D velocity profiles. The surface velocity is obtained by fitting the ADV data as ADV cannot measure surface velocity and is then compared with the LSPIV data. The WS and the junction bottom topography are generated in the form of super high-resolution DEM using the CRP technique. For CRP, simultaneous images are taken using two DSLR Nikon D5300 cameras from different orientations and altitudes with significant overlap of 80%. The images are taken prior to experiments to generate bed topography and during the experiments when tracers cover the junction area for WS. The ground control points (GCPs) and checkpoints are surveyed using two ultrasonic sensors with $\pm$0.5 mm vertical accuracy. The captured images are processed in PhotoScan package utilizing the GCPs and the DEMs of bottom topography and WS are produced. The accuracy of the DEMs is evaluated by comparing with the checkpoints. Eventually, water depths are estimated from DEM of difference. The measured velocity and water depth are then processed to calculate parameters such as circulation, shear stress, mass and momentum transfer at the junction. However, the accuracy of velocity and water depth is limited by the uniformity of non-specular materials over the region and stereo-matching discrepancies. Thus, the approach presented herein if applied to a river junction can significantly reduce the time, manual labour, cost of instrumentation and avoids human errors. The obtained highly accurate flow parameters can be used to understand the physics of flow at a junction in a better way and also to evaluate the suitability of 1D, 2D and 3D mathematical models in accordance with the required precision of engineering applications.