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Evaluation and improvement of image-based surface velocity method

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Velocimetry methods using image sequence analysis have become increasingly popular in the last ten years for measuring velocities and discharges in open-channel flows. The incentive of these nonintrusive methods is the measurement of the two-dimensional instantaneous velocity field over a relatively large area, sometimes filmed from an aircraft, without disturbing the flow or endangering operators and equipment. However, the integration of usual velocimetry methods such as the classical LSPIV (Large-Scale Particle Image Velocimetry) in operational measurement chains is still hindered by some limitations: validation in real conditions is difficult, results are sensitive to multiple choices submitted to the expertise of the operator, orthorectification surface is assumed to be flat, a complete method for computing velocity and discharge uncertainty still lacks. The developments carried out in this PhD aim to propose practical solutions to these main limitations. LSPIV as implemented in the open-source software Fudaa-LSPIV is used as a representative case study but most of the proposed methods can be applied to other velocimetry algorithms. In particular, an original method based on powerful computer graphics tools has been developed to create synthetic videos of realistic flows with precisely known reference velocities. In this way, important sources of environmental error can be simulated and their impact on the velocimetry results can be precisely quantified. The sensitivity of the results to the options and parameters defined by the operator could be systematically studied thanks to an LSPIV intercomparison involving twenty operators and eight videos representative of operational gauging with discharge references with quantified uncertainty. The variability of the results was greatly reduced thanks to new assisted setting tools and velocity filtering tools. Finally, the application of conventional image velocimetry (with a single camera) to flows on curved surfaces such as spillways or waterfalls on weirs is made possible by a new orthorectification method for straight cylindrical surfaces of known geometry (Orthocyd method). Prospects are proposed to prepare a quantification of the uncertainty of velocity measurements by LSPIV and thus to develop a complete uncertainty framework similar to those developed for other streamgauging techniques. These various methodological developments will significantly increase the reliability and applicability of LSPIV and other image velocimetry techniques.