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A laser profilometry technique for monitoring fluvial dike breaching in laboratory experiments

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A challenging aspect for experimental modelling of fluvial dike breaching is the continuous monitoring of the transient breach geometry. In dam breaching cases induced by flow overtopping over the whole breach crest (plane erosion), a side view through a glass wall is sufficient to monitor the breach formation. This approach can be extended for 3D dam breach tests (spatial erosion) if the glass wall is located along the breach centreline. In contrast, using a side view does not apply for monitoring fluvial dike breaching, because the breach is not symmetric in this case. We present a non-intrusive, high resolution technique to record the breach development in experimental models of fluvial dikes by means of a laser profilometry (Rifai et al. 2016).

Most methods used for monitoring dam and dike breaching involve the projection of a pattern (fringes, grid) on the dam or dike body and the analysis of its deformation on images recorded during the breaching (e.g., Pickert et al. 2011, Frank and Hager 2014). A major limitation of these methods stems from reflection on the water surface, particularly in the vicinity of the breach where the free surface is irregular and rippled. This issue was addressed by Spinewine et al. (2004), who used a single laser sheet so that reflections on the water surface were strongly limited and did not hamper the accurate processing of each image. We have developed a similar laser profilometry technique tailored for laboratory experiments on fluvial dike breaching.

The setup is simple and relatively low cost. It consists of a digital video camera (resolution of 1920 $\times$ 1080 pixels at 60 frames per second) and a swiping red diode 30 mW laser that enables the projection of a laser sheet over the dike body. The 2D image coordinates of each deformed laser profile incident on the dike are transformed into 3D object coordinates using the Direct Linear Transformation (DLT) algorithm. All 3D object coordinates computed over a swiping cycle of the laser are merged to generate a cloud of points. The DLT-based image processing method uses control points and reference axes, so that no prior knowledge is needed on the position, orientation and intrinsic characteristics of the camera, nor on the laser position.

Refraction of the light and laser rays across the water surface needs to be taken into account, because the dike is partially submerged during the experiments. An ad hoc correction is therefore applied using the Snell-Descartes law. For this purpose, planar approximations are used to describe the shape of the water surface. In the presentation, we will discuss the resulting uncertainty and will detail the validation of the developed method based on configurations of known geometry with various complexity.

The presented laser profilometry technique allows for a rapid non-intrusive measurement of the dike geometry evolution. It is readily available for laboratory experiments and has proven its performance (Rifai et al. 2017). Further adjustments are needed for its application to cohesive dike material due to the reduced visibility resulting from the higher turbidity of water.

References

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