**Publications of the Institute of Geophysics, Polish Academy of Sciences**
Geophysical Data Bases, Processing and Instrumentation
vol. 434 (E-11), 2021, pp. 79-81
DOI: 10.25171/InstGeoph_PAS_Publs-2021-024
Webinar on Experimental Methods and Laboratory Instrumentation in Hydraulics, 13-15 April 2021

# Laser Profilometry Technique for Nonintrusive and Subaquaous 3D Geometry Reconstructions

Ismail RIFAI[1,✉], Lydia KHELOUI[2], Sébastien E. BOURBAN[2], Sébastien ERPICUM[3], Pierre ARCHAMBEAU[3], Michel PIROTTON[3], Damien VIOLEAU[2], Benjamin DEWALS[3], and Kamal EL KADI ABDERREZZAK[2,✉]

[1]Egis, Flood Risks and Water Resources, Strategy and Innovation, Guyancourt, France
[2]EDF R&D, National Laboratory for Hydraulics and Environment, Chatou, France
[3]University of Liège, Hydraulics in Environmental and Civil Engineering, Liège, Belgium
✉ ismail.rifai@egis.fr; kamal.el-kadi-abderrezzak@edf.fr

Abstract

Laser Profilometry refers to a surface measurement by laser sheet projection on the geometry of interest. This technique is routinely used in industrial and in hydraulics laboratory applications. In this paper, we present a development of this technique for overtopping induced dike breaching experiments. The Laser Profilometry Technique (LPT) presented hereafter allows for high resolution continuous monitoring of the three-dimensional (3D) evolving breach in laboratory models of fluvial dikes. The reconstructions of submerged parts of the dike were allowed by use of a dedicated refraction correction module. The LPT was selected for this application as it is compatible with commercial cameras and standard sheet projecting lasers while offering accurate and sufficient spatiotemporal resolution of the 3D reconstructions. The method has also advantages in terms of flexibility and compatibility with different experimental configurations and could be used on different scale models.

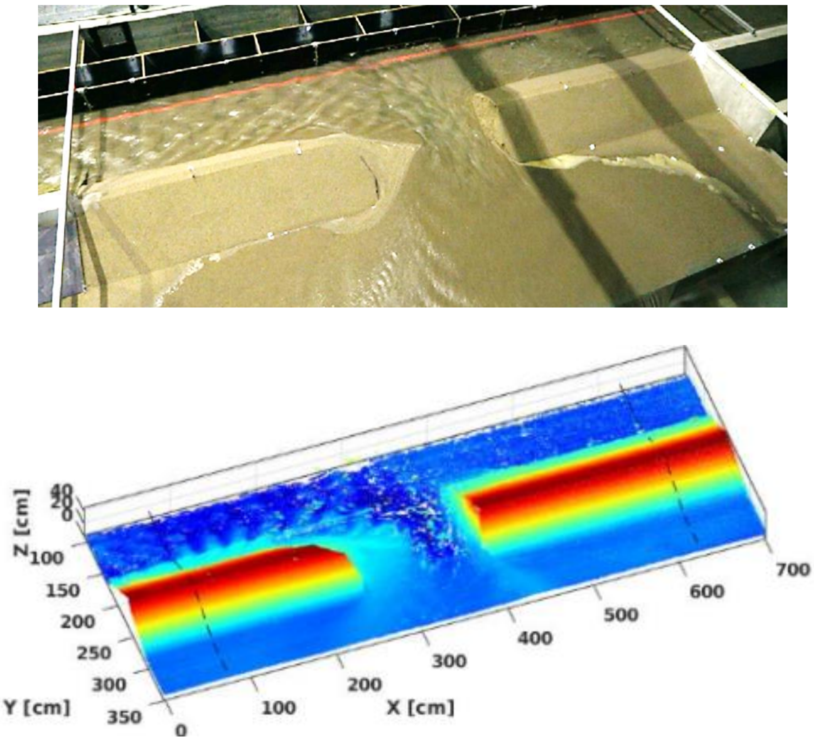
**Keywords:** profilometry, DLT, subaqueous, dike breaching, nonintrusive.

## 1. INTRODUCTION

Nonintrusive reconstruction of highly evolving surfaces is a challenging task and a highly valuable feature in experimental setups, especially in erosion, scouring and morphodynamics related experiments. Recent advances in digital imaging and processing capabilities promoted development of image processing based measurement technique. The Laser Profilometry Technique (LPT) presented in this paper is one of them as almost all the information needed for the geometry reconstruction is encapsulated in recorded images.

## 2. OVERALL ALGORITHM

The LPT applied to dike breaching experiments is structured in three main modules: (1) image processing, (2) reconstruction, and (3) refraction correction. The image processing module consists of a series of filters allowing to segregate the laser profile incident on the measured geometry (Fig. 1a). The reconstruction module transforms the laser profiles defined in image coordinates into 3D coordinates. This step is performed using the Direct Linear Transformation (DLT) algorithm (Abdel-Aziz and Karara 2015) (Fig. 1b). The refraction correction module allows for refraction bias correction for submerged reconstructed surfaces. The refraction correction is applied using the Snell-Descartes law (Glassner 1989) and assuming simplified planar approximations of the water surface. Detailed description of the algorithm is presented in Rifai et al. (2020).




(a)

(b)

Fig. 1. Reconstruction of the breach geometry for a fluvial dike breaching test with erodible bottom.

## 3. LIMITS AND PERSPECTIVES

Although the method has proven its performance and allowed for satisfactory results on overs 50 dike breaching tests (Rifai et al. 2019), several limits were pinpointed and restricted the range of experimental configurations that could be studied.

Issues related to laser visibility, such as blind spots and water turbidity, can result in missing data in the reconstruction. Adding cameras with different point of views and different colour lasers can be a workaround of the first issue. Adaption of the laser power and enhancement of the image processing algorithm can allow improvement of the accuracy of reconstructions in high turbidity cases.

Other adaptations of the overall algorithm can be explored and can allow for complementary measurements. For hydraulics and/or morphodynamics related experiments, this enhancements could be particle tracking for flow trajectories and velocities, water height deduction from laser refraction measurements, colorized and texturized reconstructions allowing for tracking of bed forms migration, etc.

## References

Abdel-Aziz, Y.I., and H.M. Karara (2015), Direct linear transformation from comparator coordinates into object space coordinates in close-range photogrammetry, *Photogramm. Eng. Remote Sens.* **81**, 2, 103–107, DOI: 10.14358/PERS.81.2.103.

Glassner, A.S. (ed.) (1989), *An Introduction to Ray Tracing*, Morgan Kaufmann Publ., San Francisco.

Rifai, I., K. El Kadi Abderrezzak, S. Erpicum, P. Archambeau, D. Violeau, M. Pirotton, and B. Dewals (2019), Flow and detailed 3D morphodynamic data from laboratory experiments of fluvial dike breaching, *Scien. Data* **6**, 53, DOI: 10.1038/s41597-019-0057-y.

Rifai, I., V. Schmitz, S. Erpicum, P. Archambeau, D. Violeau, M. Pirotton, B. Dewals, and K. El Kadi Abderrezzak (2020), Continuous monitoring of fluvial dike breaching by a laser profilometry technique, *Water Resour. Res.* **56**, 10, e2019WR026941, DOI: 10.1029/2019WR026941.

Received 22 March 2021
Accepted 12 April 2021