Co-UDlabs

Data Storage Report

CoUDlabs_WP8_T831_AaU_001

Application of Large-Scale Particle Image Velocimetry (LSPIV) technique in Aalborg retention pond

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DATASET DETAILS

Project acronym	**Co-UDlabs (www.co-udlabs.eu)**
Project title	Building Collaborative Urban Drainage research labs communities
Call identifier	H2020-INFRAIA-2020-1
Grant Agreement No	101008626

Dataset Information	
Activity	Joint Research Activities
Dataset ID	CoUDlabs_WP8_T831_AaU_001
Dataset title	Application of Large-Scale Particle Image Velocimetry (LSPIV) technique in Aalborg retention pond.
Data sources	Data from water surface velocities measurements in Aalborg retention pond using LSPIV and low-cost cameras.
Content	Raw and processed images of surface runoff and surface velocity maps resulted.
Formats	jpeg, txt.
Volume	16 Gb

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Abstract

This document describes the dataset 'Application of Large-Scale Particle Image Velocimetry (LSPIV) technique in Aalborg retention pond' which is a result from the Joint Research Activity 3 (WP8, Improving Resilience and Sustainability in Urban Drainage solutions), Task 8.3.1. (Hydrodynamic design for stormwater detention ponds optimized for cost-efficient maintenance) within Co-UDlabs project, funded under the European Union's Horizon 2020 research and innovation program under grant agreement No 101008626.

This dataset includes the data obtained during the installation of a camera system to determine the surface velocities in a retention pond monitored by Aalborg University (AAU). The dataset consists of raw and processed images and surface velocity maps obtained during preliminary experiments when the retention tank was being filled and emptied. The objective is to assess the feasibility and usefulness of this type of measurement for the calibration of CFD models to optimize the operation of the installation. The data presented may help to improve and assess imaging techniques in real conditions in urban environments.

1. Experimental setup

The retention pond of Aalborg is a pilot facility monitored by AAU team were stormwater drained from a small residential area catchment is storage before being pumped into a natural pond. The main objective of the research carried out by AAU team is to analyse and optimize the removal of sediments and pollutants by deposition during the retention of the stormwater in order to improve the performing and design of this kind of solution in future applications. The required equipment to record videos and apply the LSPIV technique in the retention pond consisted of 3 NOIR Picameras V2.1 controlled by Raspberries Pi 4. The raspberries record, store, and transmit the videos to be processed via Wi-Fi. To do this, hermetic protective boxes were adapted with 3D-printed pieces to mount the cameras and keep the Raspberries Pi inside. A metal cover has also been added to prevent rainwater on the lens of the cameras. The raspberries have been installed on the lateral of the main basin of the facility: one recording the inlet section and the others capturing the outlet section of the tank. The raspberries and the cameras were installed inside the boxes assembled. Power supply has been provided through outdoor electrical boxes.

Figure 1: Installation of the equipment at the Experimental SUDS facility.

2. Video recording

- Inlet test: The first experiment performed was focusing on the inlet section of the retention tank. The first camera was used, and a video of 5 minutes was recorded while 800 L of water – previously storage before the inlet gate of the facility – were introduced to the facility. Sawdust was used as tracer particles and distributed on the water surface before the experiment started.

- Outlet test: Cameras 2 and 3 were used to record the movement of the particles used in the emptying of the retention tank at the outlet section. The pumps of the facility were used and videos of 1 minute were recorded during the time of emptying. When the water depth of the tank decreased, two additional videos of 5 minutes were recorded to better register the last part of the process in order to analyse how velocities increased and sediment deposited may be resuspended. Since the emptying of the tank is slow, the following 9 videos have been recorded considering t=0 when the pump is turned on (t=-17 minutes, t=7 minutes, t=-12 minutes, t=17 minutes, t=27 minutes, t=41 minutes, t=46 minutes, t=51 minutes, t=58 minutes).

A timestamp was created for each video with the time taken to record each frame, which is used for the estimation of velocities and the result timestamps. Figure 2 includes an example of raw frames for each of the cameras installed.

Figure 2: Example of raw frames recorded by each camera.

3. LSPIV methodology

The videos recorded were first rectified using four points with known coordinates placed at the corners of the frame and measured during the installation of the cameras. A median filter of the image is then applied to highlight particles in order to be better recognized by the OpenPIV software (Liberzon et al., 2022), which is applied to the rectified and filtered images. Example of rectified and filtered frames is included in Figure 3.

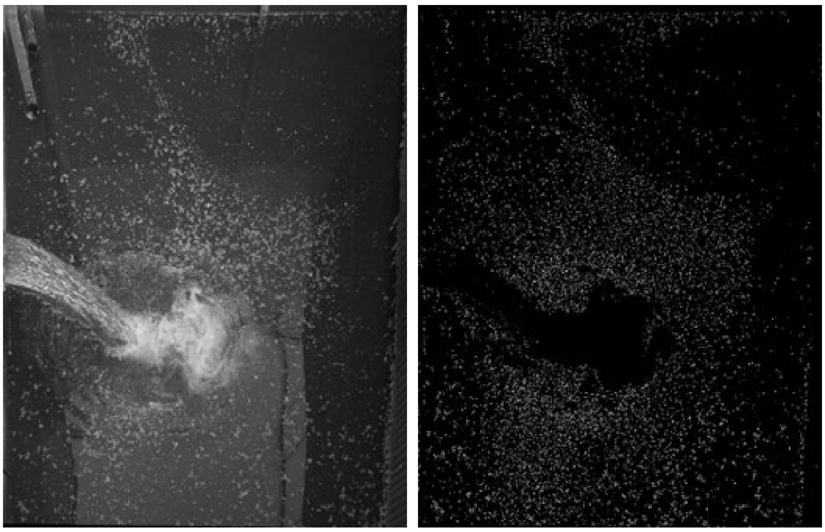

Figure 3: Example of rectified (left) and filtered (right) frames for camera 1.

Raw surface velocity results obtained were filtered to remove erroneous vectors using the noise ratio from cross-correlation function, median spatial filter, minmax filter, and median temporal filter for mean results from several instantaneous velocity results. Finally, the velocities are scaled to obtain water surface velocities in m/s. Calibration, preprocessing and postprocessing parameters were optimized and kept common to all the experiments. A timestamp 'txt' file was created to be stored with each result folder to associate each result to a specific time instant. An example of raw and filtered velocity map is included in Figure 4.

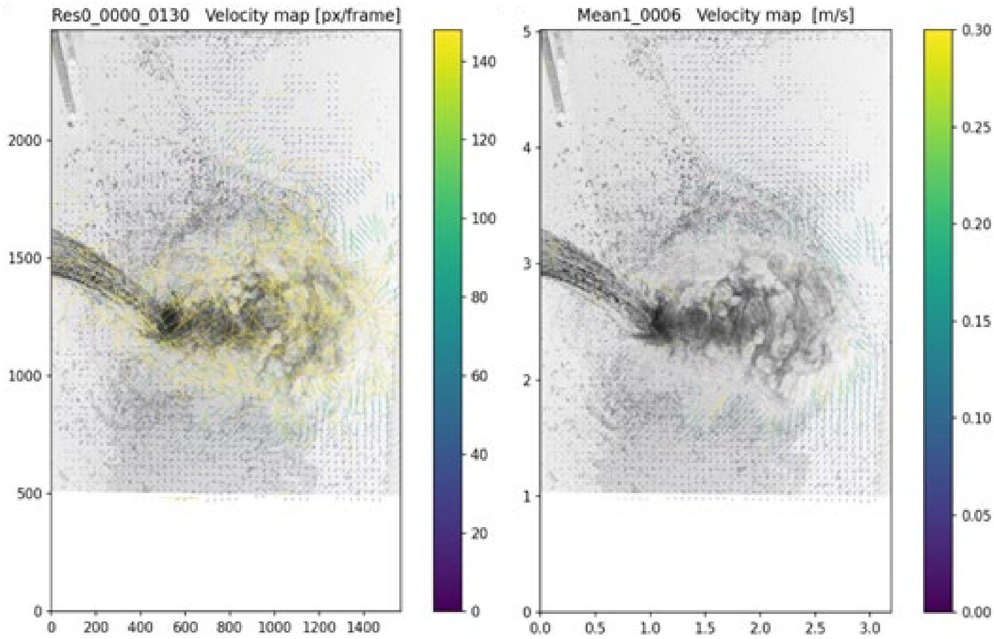

Figure 4: Example of raw surface velocity map (left) and filtered, scaled and mean results (right) for camera 1.

The raw and processed videos included in this dataset are listed in Table 1, corresponding to one video for the inlet test and 9 videos for the outlet test in different times from the start of pumping. Due to the velocities developed during the outlet test, not all the recorded frames were considered to estimate surface velocities. Taking one each 10 frames increases the displacement of particles between consecutive frames considered improving the PIV correlation accuracy. The number of instantaneous results used for obtaining each mean final result were also adapted for each video following table 1. Water depths were too low for test Out09 and it was not possible to apply LSPIV.

Table 1: Available videos and parameters used to estimate surface velocities by LSPIV technique.

Videos ID	Test	Cameras	Time from test start (min)	Duration (s)	Frames used	Results for mean velocity
In01	Inlet	Camera 1	0	300	All	10
Out01	Outlet	Cameras 2	-17	60	1 each 10	70
Out02	Outlet	Cameras 2 and 3	7	60	1 each 10	70
Out03	Outlet	Cameras 2 and 3	12	60	1 each 10	70
Out04	Outlet	Cameras 2 and 3	17	60	1 each 10	70
Out05	Outlet	Cameras 2 and 3	27	60	1 each 10	70
Out06	Outlet	Cameras 2 and 3	41	60	1 each 10	70
Out07	Outlet	Cameras 2 and 3	46	60	1 each 10	70
Out08	Outlet	Cameras 2 and 3	51	300	1 each 2	70
Out09	Outlet	Cameras 2 and 3	58	300	-	-

4. Data and result files organization

The dataset is stored based on the three existing measurement points, which corresponds to each camera installed: AA1 (inlet, right side), AA2 (outlet, right side) and AA3 (outlet, left side). An additional folder with the joined velocity results from AA2 and AA3, which cover together all the outlet section is also included in the dataset. Then, inside each camera folder, there is one folder per each video recorded which contains all the raw and processed data associated with that video. For each test folder for each camera, the results saved are:

Camera folder:

Video folder:

- 0_Frames: Original frames
- 1_Rectification: Rectified frames (only saved for some cases as an example)
- 2_FilterM: Filtered rectified frames (only saved for some cases as an example)
- 3_Results: Partial and final results saved
    - Pair_0: Raw instantaneous results (pixel/s). Only saved for some cases.
    - Pair_1: Algorithm noise filtered results (pixel/s). Only saved for some cases.
    - Pair_2: Instantaneous postprocessed results (pixel/s). Only saved for some cases.
    - Pair_3: Instantaneous postprocessed results (mm/s). Only saved for some cases.
    - Mean_0: Mean results without additional filtering (mm/s). Only saved for some cases
    - Mean_1: Mean results applying a temporal median filter (mm/s).

Each result folder contains: Plot images with vectors (jpg), 'Res' txt files with coordinates and velocity components (x,y,u,v) for each measured velocity vector and a 'Timestamp.txt' file with the time corresponding for each result obtained. The rest of folders corresponding to image processing contain raw and processed images (jpg) and timestamp files (txt). Some examples of the results included in this dataset can be consulted in Figure 5 and 6 for inlet and outlet test, respectively.

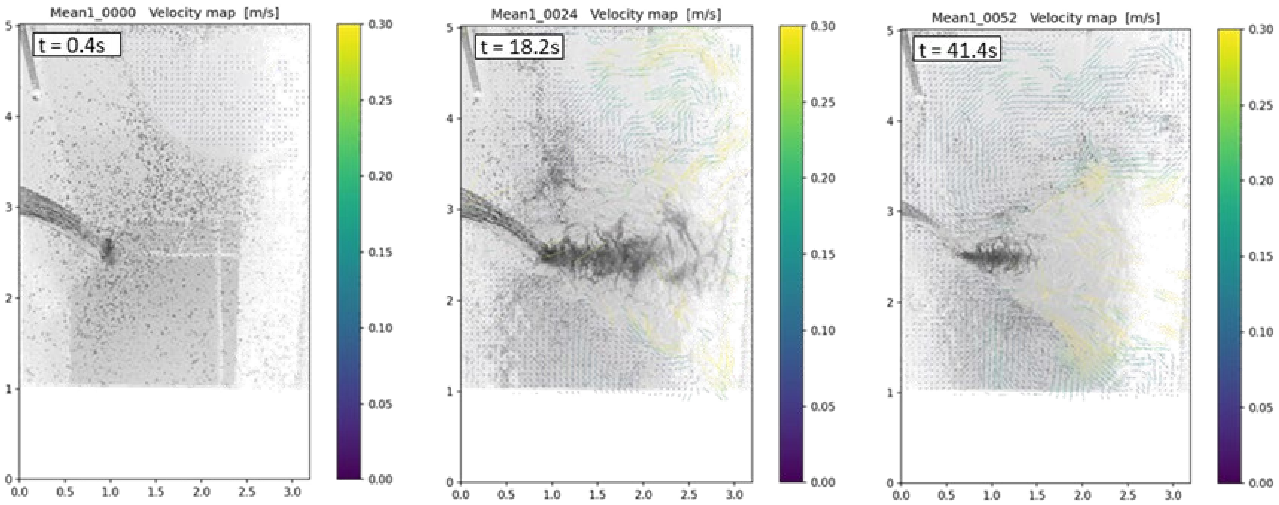

Figure 5: Surface velocity maps obtained from camera 1 at different times of inlet test.

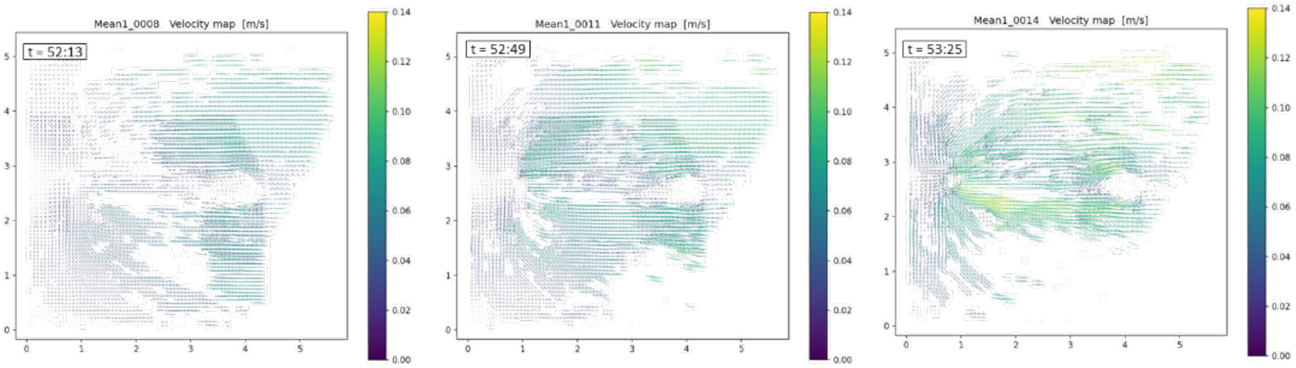

Figure 6: Combined surface velocity maps obtained from cameras 2 and 3 at different times of outlet test.

5. REFERENCES

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