Co-UDlabs

Data Storage Report

CoUDlabs_WP8_T811_UDC_001

Analysis and assessment of new techniques to build-up the topography/geometry of Urban Drainage infrastructure with high resolution

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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_T811_UDC_001
Dataset title	Analysis and assessment of new techniques to build-up the topography/geometry of Urban Drainage infrastructure with high resolution
Data sources	Topographic surveys of several laboratory large-scale facilities made by different techniques.
Content	Survey data, images used for SfM technique and resulted DEMs.
Formats	csv, ply, jpg, tif
Volume	5 Gb

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Abstract

The aim of this document is to describe the dataset collected on the research activity “Analysis and assessment of new techniques to build-up the topography/geometry of Urban Drainage infrastructure with high resolution” performed under Joint Research Activity “JRA 3- Improving Resilience and Sustainability in Urban Drainage solutions” of Co-UDlabs project. The quality of the results obtained in hydraulic numerical models is strongly conditioned by the accuracy of the input data, especially in the case of shallow waters such as those occurring in urban floods. In addition, urban catchments have kerbs and other urban elements, such as ditches or grates, that condition the flow of the runoff generated during an event. This also occurs in the case of laboratory studies in large-scale facilities, with traditional elevation measurement techniques being too time-consuming to obtain not very high-resolution topographies. Therefore, this activity has analysed and evaluated three different devices and techniques to obtain accurate elevation maps with a high resolution: i) conventional camera with the Structure from Motion (SfM) photogrammetric technique, ii) Intel® RealSense™ LiDAR Camera L515 and iii) Depth camera Intel d435i. The measurements from cameras ii) and iii) were combined with a 3D reconstruction software. Finally, a topographic manual survey was used as a base for coordinate referencing and elevation comparison. Surveys data, including the images used during the SfM survey, and resulted DEM were included in this dataset.

1. Experimental facilities surveyed

The study was carried out in the two urban drainage facilities STREET and BLOCK located at the Hydraulics Laboratory of the Centre of Technological Innovation in Construction and Civil Engineering (CITEEC), at University of A Coruña (Spain). The two facilities are being offered as part of the Transnational Access Co-UDlabs programme. The first facility named BLOCK consists of a T-intersection of two concrete streets considering 1:1 scale elements such as curbs, manholes and gully pots (Figure 1a). This study was focused on an area of 20 m^2 (Figure 1a) that covers the different types of elements present in the facility, including one of the roofs (henceforth Roof survey) and a fragment of surface including roadway, pathway, and drainage elements such as manholes and gratings (henceforth Surface survey). On the other hand, STREET facility consists of a 36 m^2 full-scale street section with a permeable asphalt as roadway (Figure 1b). The two installations cover an interesting range of surfaces and textures to test the different methods and compare them with traditional manual surveying.

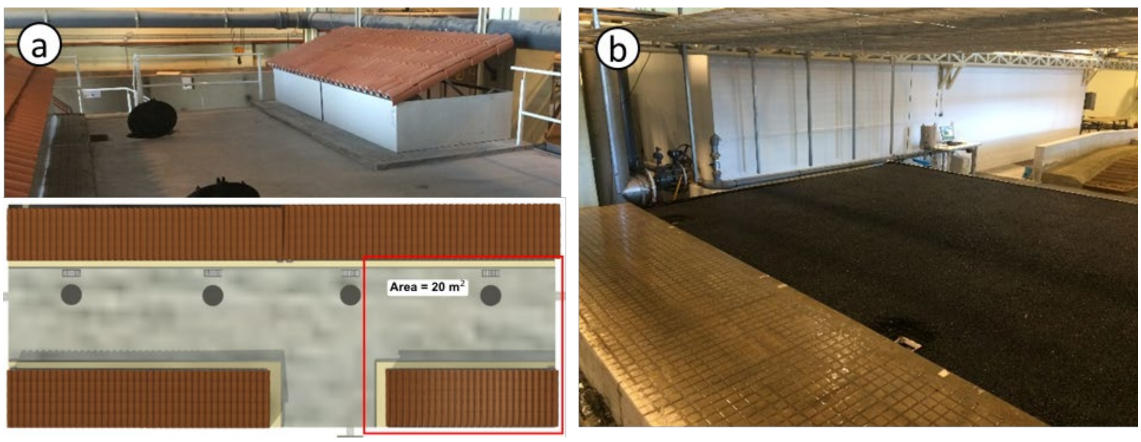

Figure 1. a) Urban drainage BLOCK facility and surveyed area. b) STREET facility.

2. Elevation measurement techniques

2.1. Topography survey

The XYZ coordinates of a grid of points marked at the different surfaces were obtained by a conventional topographic manual survey to be used as reference and validation points to compare the rest of techniques. Elevations were measured point-by-point in each surface. The X and Y coordinates were obtained by relative distances between points, and the Z coordinate was obtained as the distance of the different points to a reference laser plane. Table1 summarizes the number of points and the mean separation in each direction.

Part of the grid coordinates were used for the scaling and positioning of the topographies obtained by the LiDAR, depth camera and SFM techniques. The remaining validation points were used to assess the performance of the camera-based techniques.

Table 1. Points surveyed for each studied model (BLOCK surface, BLOCK roof and STREET).

	STREET	BLOCK Roof	BLOCK surface
Number of points	132	8	45
Mean spacing X-axis	0.5 m	0.3 m	0.7 m
Mean spacing Y-axis	0.5 m	0.2 m	0.5 m

2.2. Structure from Motion (SfM) photogrammetric technique

SfM is a computer vision technique used to reconstruct 3D structures from a collection of two-dimensional 2D images or photographs. By analyzing the patterns of visual features and their positions in multiple images taken from different viewpoints, SfM algorithms can estimate the 3D geometry of objects and scenes. The technique was used in this work to generate the 3D model of the BLOCK surface, the BLOCK roof, and the STREET facility surface. To do this, a series of images around each area were taken without any reference and with degrees of overlapping greater than 60% as recommended in the literature.

The VisualSfM software was used to process the images and reconstruct the 3D models resulting in a point cloud. In the case of the BLOCK facility, it was necessary projecting an image to introduce texture heterogeneity that allowed the software to obtain references to reconstruct the model (Figure 2). With the same purpose, some drawings were performed in the uniform asphalt black surface of the STREET facility. MeshLab software was then used to process these point clouds positioning and scaling by means of reference points with known coordinates (topography survey) and removing outliers. Finally, meshes were built using the Screened Poisson Surface Reconstruction function, which simplifies and smoothes the raw point clouds by fitting polynomial functions between the points.

2.3. Light Detection and Ranging (LiDAR)

The 3D LiDAR point clouds were obtained using the Intel® RealSense™ LiDAR Camera L515. LiDAR cameras capture simultaneously visual imagery and depth information, by sending out laser pulses and measuring their return time, offering a comprehensive view of the environment. The software RecFusion was simultaneously used to process the LiDAR data captured by the L515 sensor and reconstruct the 3D models.

The postprocessing of the reconstructed 3D models included the use of the built-in post-processing library OpenMesh: Mesh Decimation Framework to remove small-connected elements, cropping the mesh and specify the exported mesh size. Finally, the meshes were scaled and positioned using reference points of the topography survey using MeshLab software.

2.4. Depth Camera

The Intel RealSense Depth Camera D435i is an advanced depth-sensing camera that combines RGB imaging with accurate depth perception. Equipped with depth sensors and an inertial measurement unit (IMU), it captures detailed 3D depth maps and motion data simultaneously. The 3D reconstruction of the models was performed through the software RecFusion and the postprocessing was carried out applying the same methodology as the data from LiDAR camera.

3. Data and result files organization

Data is structured in three different folders:

- The folder *'01_Survey_data'* contains images and raw reconstructed models of the facilities surveyed.
- The folder *'02_Postprocessed_data' includes* filtered, scaled, and referenced models.
- The folder *'03_Digital_Elevation_Model' collect* Digital Terrain Models resulted for BLOCK surface and roof and STREET surface.

	01_Survey_data Images and raw reconstructed models of the BLOCK surface and roofs, and STREET surface.	JPEG, PLY, CSV
	02_Postprocessed_data Filtered, scaled, and referenced models of the BLOCK surface and roofs, and STREET surface.	PLY
	03_Digital_Elevation_Model Digital Terrain Models of the BLOCK surface and roofs, and STREET surface.	TIF

The 3D model reconstructions obtained for each of the methodologies and each of the areas are presented in Figure 2 as an example. The 3D reconstruction model of the STREET facility could not be obtained with the LiDAR camera because these cameras perform poorly in capturing surface with low reflectivity, such as black asphalt pavements.

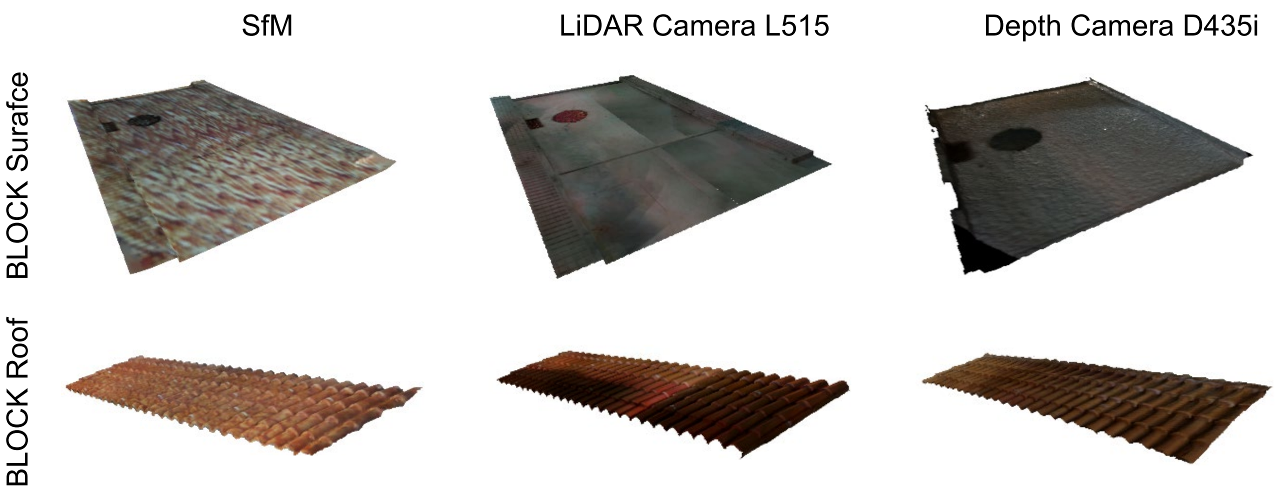

Figure 2: Example of the 3D models resulted from the three techniques (SfM, LiDAR and depth camera) for BLOCK surface BLOCK roof.