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Landscape architectural foot soldier operations

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ABSTRACT

The main objective of this paper is to propose a systematic fieldwork approach in order to describe the ground condition of dense urban riverine settlements. The proposed approach supplements aerial-view acquired digital elevation models that are unable to describe the ground conditions that are obstructed by urban and vegetative canopies. After three years spent developing this approach, we can compare and identify synergies between three ground-view acquisition methods: an action-, digital single lens reflex (DSLR)-camera, and terrestrial laser scanner (TLS). This paper consists of a two-part study, which uses the visual quality and accuracy of the data sets produced as criterion for appraisal. Although norms would suggest a hypothetical best operational workflow as an outcome of this paper, we instead argue that the identification of circumstances in which different methods are combined to complement the limitations of another is more beneficial. As such, through the appraisal of visual quality and accuracy obtained by the approaches described above we can draw better insights to make the most out of typically laborious fieldwork. Given the labour-intensive process, an economy of work is necessitated in order to capture the best description of landscape elements with the given equipment and time, allowing the greatest area of coverage.

1. Introduction

Increasingly, the application of ground-view acquisition methods has been used to supplement aerial-view acquired digital elevation models (DEM) (Müller Arisona, Zhong, Huang, & Qin, 2013). The acquisition of fine-grain spatial information within densely settled areas with thick tropical vegetation remains a challenge. Furthermore, aerial-view applications are more commonplace in rural and suburban areas (Gruen, Zhang, & Eisenbeiss, 2012) and few projects have been noted to map urban areas with the use of UAV. Gruen et al. (2013) also proposed the integration of mobile laser scanning (MLS) data with UAV imagery in improving the accuracy of data registration by utilising features from both data sources and reports an average deviation of 0.4 m in planimetry and 0.6 m in height, with a maximal height deviation of 1.3 m when integrating the two data sources for 3D city modelling within the densely vegetated tropics. However, the use of MLS-derived data set is limited to the width of accessible streets.

For the context of dense urban settlements, a systematic ground-view structure-from-motion (SfM) method is proposed as an alternative. SfM addresses the problem of determining the 3D location of matching features in multiple photographs, taken from different angles. The solution used is manifested in methods that identify features within the image (Snavely, Seitz, & Szeliski, 2006) which in turn, provide for use in augmented reality, autonomous navigation, motion capture, hand–eye calibration, image/video processing, image-based 3D modelling, remote sensing, image browsing, segmentation and recognition, and military applications (Wei, Kang, Yang, & Wu, 2013). We are interested in the image-based 3D modelling application used for the reconstruction of urban environments, specifically of urban landscapes. The output consists of sparse to dense point clouds, which is a result of surface reconstruction of the object. The information may be interpolated into a high-density mesh, or be used directly as a point cloud model (Remondino & El-Hakim, 2006).

In the context of urban river rehabilitation (Findlay & Taylor, 2006), we take advantage of the dimensional attributes of captured objects to understand site conditions. The interpretation of the SfM-derived data set can be explored through automatic feature extraction algorithms and user-assisted feature extraction approaches, which are used to identify objects within the point cloud. However, algorithms used to process the point clouds are still in their infancy when it comes to automatic feature extraction

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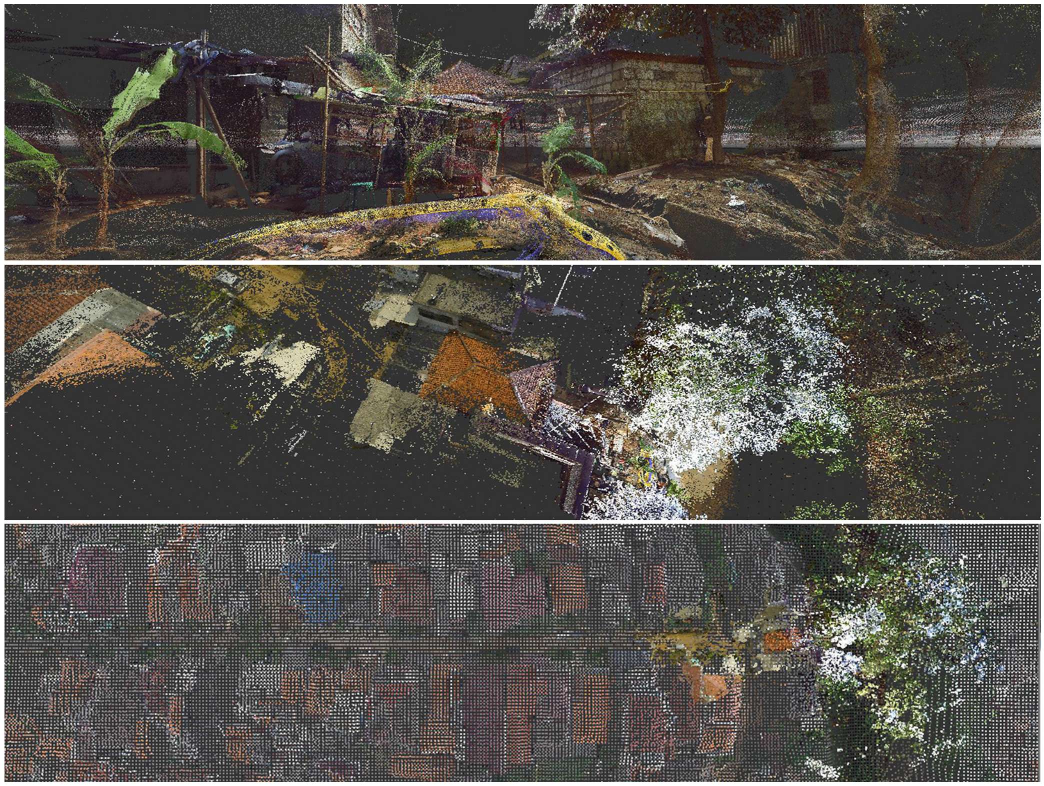

Fig. 1. Local site scale data set acquired from TLS-, DSLR- and pole-mounted action-camera derived data set (top), extent of the ground view data set collected sitting on the 1 m × 1 m digital terrain model (DTM) (middle), and data set embedded in 1 m × 1 m UAV derived point cloud which describes the digital surface model (DSM) (bottom).

and are not robust enough for identifying complex landscape driven data sets (Brodu & Lague, 2012). Existing methods look at shape recognition within the urban environment but are limited to geometrically well-defined man-made street features (Golovinskiy, Kim, & Funkhouser, 2009). Existing classification techniques are inadequate to segment complex three-dimensional environmental data, for example, the separation of riparian vegetation from ground surfaces (Lague, Brodu, & Leroux, 2013). In the management of the data set, user interactivity is proposed and a set of digital tools are used to manipulate the point cloud for landscape architectural visualisation and manipulation (Lin & Girot, 2014).

The paper reflects on a fieldwork method that we have described previously as 'Aviator' and 'Foot Soldier' operations (Rekittke, Paar, & Ninsalam, 2012). This work has been carried out since January 2012 with the utilisation of commercial-grade equipment in the context of understanding the topography for river rehabilitation purposes. We distinguish two main groups of users of electronic tools being deployed by landscape designers and researchers in fieldwork operations. The first group we refer to as aviators, profiting from satellite data and all sorts of sophisticated aerial imagery. The wide distribution of low-cost drone technology has seemingly made designers and landscape architects amateur drone operators. Their fieldwork operations are primarily equipped with fleets of flying devices such as fixed-winged or multi-rotor aircraft. These devices carry professional-grade cameras and sensors that deliver geographically referenced images for 2D imagery, mapping, and 3D modelling. The second group we refer to as foot soldiers. The equipment of the foot soldier is related to satellites, radio, and data networks as well – but it has to be light and portable – their mission is to provide for information that cannot be gathered by any aviator. Despite all technical progress, in landscape architecture and urban design the direct contact to ground and detail will remain indispensable. This is why the laborious craft of the foot soldier delivers unique results concerning detail and truthfulness of the visualisation.

This work sites itself in the context of a landscape driven project, which looks into the rehabilitation of a tropical urban river in Jakarta (Girot & Rekittke, 2011). It uses spatial terrain models, in the form of a point cloud, of varying scales as the unifying method amongst landscape architecture and engineering research. Vollmer, Costa, et al. (2015) outline two goals for which the point cloud model is applied within the multi-scale multidisciplinary work (Fig. 1). These goals seek to understand the landscape by (1) generating scenarios driven by hydrodynamic simulations, and (2) through landscape architectural design scenarios. The authors acknowledge, but 'do not discuss' the existing statistical issues regarding the synthesis of spatial data obtained at different scales, spatial locations and dimensions (Gotway & Young, 2002). Gotway and Young emphasize that the choice of an appropriate scale for the study of spatial processes is pivotal, observing that 'the mechanism vital to the spatial dynamics of a process at one scale may be unimportant or inoperative at another.' As such, the discussion of landscape architecture design interventions necessitates the use of ground-derived spatial models, in addition to satellite and UAV-derived spatial data sets. The foot soldier approach is presented as a method to address working at such a scale.

The main objective of this paper is to propose a systematic fieldwork approach in order to describe the ground condition of dense urban riverine settlements. After three years spent developing this approach, we can compare and identify synergies between three ground-view acquisition methods. In this paper, we first describe the physical constraints of acquiring spatial data sets within the study site. We summarise the limits of using the equipment through past work done by the authors. After which, we assess (1) the visual fidelity of vegetation, terrain and built form within data acquired in these methods and (2) accuracy of the terrain data set acquired by the consumer-grade cameras in comparison