When Does the Point Cloud Become a Real Tool for a Landscape Architect? Teaching Experience with Bachelor and Master Student Programmes in Landscape Architecture

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Abstract: The paper concerns with the application of data obtained from UAV survey-based point clouds for teaching landscape architecture students. Easy accessibility of a point cloud predisposes its use in the analytical phase of the design process as well as for the presentation of the final design. The goal was to integrate this data into the creative process in two case studies and observe how students deal with data. The process was evaluated afterwards through an online survey and through interviews with students in the form of a focus group. From the case studies, there is still a preference for using "traditional data" such as orthophoto maps, plans and contours for the analysis and presentation. This challenged us to develop new approaches for including UAV survey-based point cloud data in the design process.

Keywords: Point cloud, UAV, case study, landscape architecture

1 Introduction

The motivation for this article stems from easy availability of technology for UAV sensing as well as for processing of scanned data into 3D models by photogrammetric methods (ABER et al. 2019, GERKE 2018) and their 3D representation by means of point-based graphics (GROSS & PFISTER 2007).

This method of capturing and displaying an area uses accurate representation of vegetation, buildings or other surfaces. It represents a new medium for documenting territory for architectural analysis between maps and photography. These properties make them also candidates for teaching landscape architecture, where they were used to analyse and represent large-scale architectural projects (LIN & GIROT 2014, REKITTKE et al. 2015). Point clouds have also been used as digital assets in design, e. g., trees (URECH 2019) or for creatively interpretation in the design process (FRICKER & MUNKEL 2015). In addition to representing and visualising the current state and design, point clouds offer great potential for evaluating the physical characteristics of a tree: height, perimeter, and crown diameter (LARSEN et al. 2011, TURNER et al. 2012).

Although the above examples confirm the gradual penetration of such technology into teaching, first-hand point clouds (i. e., data acquired by the student or lecturer) have not yet been formalised as a primary data source for the survey of topology in teaching landscape architecture at our university. The methods currently used for teaching purposes are mainly clas-

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sical ones such as analysis of various maps (historical, thematic, perpendicular aerial photographs – orthophoto maps, etc.), field surveys, the study of archival documents or sociological surveys (questionnaires, interviews with stakeholders and others). UAV aerial photography is often limited to 'top-down' photos that provide a new and critical perspective but are far from realizing their potential. This paper focuses on the experience of applying new technology to two model examples: Wakeboard Park in Cambodia processed by master students, and the revitalisation of a composed landscape in historical context prepared by bachelor students. The aim was to evaluate these methods by means of a structured questionnaire with the data being obtained using the focus group method (DEMING & SWAFFIELD 2011).

2 UAV Based Imagery and Point Clouds

2.1 UAV Based Imagery and Point Clouds from Technical Point of View

This paper deals with the use of point clouds obtained via photogrammetric methods, specifically, using imagery from UAV surveys. Point clouds obtained by UAV imagery are often referenced to as a photogrammetric point cloud (YURTSEVEN et al. 2019). Point clouds represent samples of surfaces – discrete points that do not provide information about adjacent points or connectivity. Points only carry information about their XYZ and surface reflectance properties (e. g. RGB colour). In 3D digital graphics, a point is displayed as a surfel. A surfel is a geometric primitive; sphere or rectangle, which renders the surface RGB colour or a colour ramp representing height (Z coordinate). The denser the points, the more realistic the surface looks. Point clouds in a web browser can be viewed using WebGL, allowing users to view the data in 3D, resize points, or measure distances and volumes. (REKITTKE et al. 2015). Known services are, for example, LidarView, Potree or PointBox. This method is used to represent scanned spatial data of both small objects and large areas; it is ideal for analysing areas for design work (GROSS & PFISTER 2007).

2.2 A 3d Point Cloud as a Form on Border Between Maps and Photography

In the beginning we faced the question of what a point cloud actually represents. The points represent a scanned landscape at a specific time, with specific conditions very similar to photography. The territory was different yesterday and will be different tomorrow, or even hours earlier or later. There is a philosophical argument that things or reactions are not the things themselves. In the case of maps and territories, according to Korzybski, models of reality should not be mistaken for the reality itself (PONTE 2011). We also need to consider that the point cloud is a representation with only a certain level of detail, or in other words with a certain level of abstraction.

The moment of capture applies to trees, shrubs, vegetation, their location and their colour, as well as other objects such as fallen wood or temporary objects (e. g. persons). If we compare a map to a 3d point cloud, we might view the map as a painting and the 3d point cloud as photography. This should also be taken into account when working with the data. On the other hand, there is also a more stable part of the data – the data providing information about buildings and terrain. The resulting precise topological information, when working with terrain, predisposes point clouds and their derivates to new approaches to the design process (GIROT 2017). The transient part – vegetation, shrubs and grassy lawns can contribute to the representation of proposed changes.

3 Case Studies

The basis of the whole process is to capture an area by automatic remote sensing and create a point clouds as the primary working medium from which other useful topological data is derived: altimetry, planimetry, digital surface model, orthophoto map. There are several advantages over the traditional assets – the process is up-to-date, accurate and allows for instant interactive viewing while moving around in a 3D environment.

The approach, in the application context, was evaluated in two study areas. The first example was a project by master course final year students focusing on the design of Wakeboard Park in Cambodia (Wakeboard Park – International Christian Fellowship (ICF) Cambodia Sustainability project). The second example is a studio class of students in the final year of bachelor study. Students obtained point clouds and their derivates from aerial photography, learned how to acquire them, and gained fundamental knowledge of their use. Subsequently, we evaluated their methods stressing the subjective opinions of students on the applicability, efficiency of work and any shortcomings in the approach. In addition, the aim was to provide the students with more accurate data for their work, and, finally, to spread knowledge and information about these technologies and their possibilities to the broader public.

Fig. 1:
Freely accessible but outdated orthophoto map of the case study area – the most accurate freely available asset (source: www.maps.google.com)

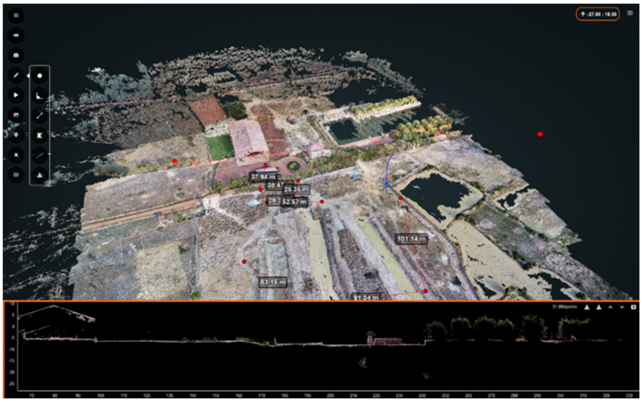

Fig. 2:
Point cloud in Pointbox web application – processed materials for students, showing coordinates and sections (source: www.pointbox.xyz)

The Wakeboard Park project was a part of the summer semester course Workshop II. A group of five students worked on designing a campus for Wakeboard in Cambodia. ICF Cambodia, a Christian organisation, intends to expand the range of activities in this area in order to obtain additional income to fund their other activities. The area will provide accommodation and facilities for wakeboarding. The investor provided only basic design requirements: a simple ground plan drawing of the site in pdf and several photographs. There was also no topographic data, no planimetry or altimetry were available, and map sources such as Open Street Maps and Google Maps showing the site were low resolution and outdated, therefore inapplicable for design work.

Moreover, not all the students could visit the site in Cambodia in person to obtain the data necessary for research analyses. At the time of the visit, the whole site was captured by automatic aerial photography using a drone. DJI Mavic Pro was used for the survey. The shooting took place over two mornings, in six take-offs, and the total shooting time was 106 min. In total 2891 pictures were acquired for postprocessing. Pix4D software was used for photogrammetric processing. The students could view and measure the point cloud using the Point Box web service. The service also allows simple analyses such as height and distance measurements, area measurements, and terrain cuts. The students also received a detailed orthophoto map with 1.89 cm/pixel resolution, a contour map and a digital surface model as a basis for further design work. All were in CAD and GIS formats.

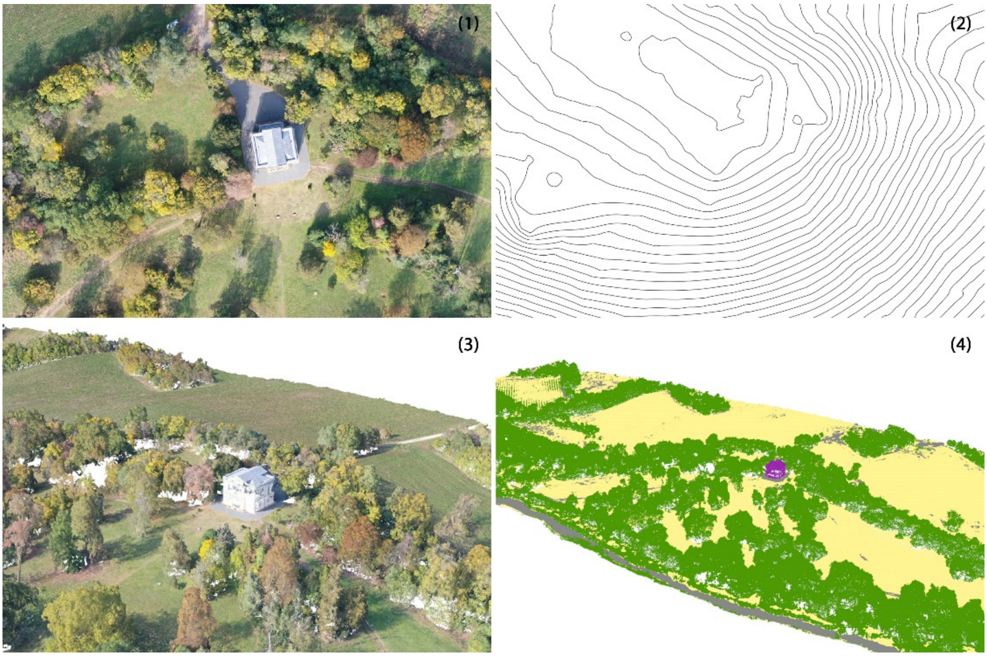

Fig. 3: Bachelor students received following data: (1) Detailed orthophoto map, (2) Contour line from DTM, (3) Raw point cloud data, (4) Classified point cloud via Pix4D

The second example deals with one specific area within the design study, through all levels of documentation necessary for the approval of building authorities. A group of 21 students worked in an area that was easily accessible to them. The winter semester 2019/2020 dealt with revitalisation of designed landscape in a historical context. The UAV survey took place over two flights, and the total imaging time was 35 min, with 778 pictures acquired for post-processing. Part of the area was surveyed with a Sequoia multispectral camera, so that the NDVI index showing differences in vegetation vitality for the core area could be determined. Pix4D software was used for photogrammetry processing, including the NDVI index. The students received raw point cloud data and were advised to use CloudCompare software for viewing, measuring and creating slices. They also received a detailed orthophoto map with a resolution of 2.86 cm/pixel, a digital surface model, a derived digital terrain model, contour lines, mesh for working in 3D software — all in formats suitable for CAD, GIS, Sketchup (mesh) or other 3D products.

4 Survey Evaluation

To obtain information and feedback about the case studies from students, we used an online survey via Google forms and focus groups interviews. The purpose of the focus group was to clarify and interpret the results of the questionnaire (online survey) and gain new insights. The survey and the focus group interviews were divided into three blocks of questions. The first part focused on obtaining information about the respondents, their previous knowledge about the possibilities of using drones for landscape architecture, their relation to technologies and what methods and software they use for their standard work. The second part of survey focused on which of the data they had received for their work they had actually used, how much of it, which tools (software) they worked with and in what part of the work process they used it (analysis, design process, presentation). The third part focused on identifying the problems that the students faced during their work, whether they found the topic (UAV, photogrammetry etc.) interesting, whether they would appreciate its inclusion in teaching and, if so, in what form.

Overall, five of five students from Cambodia group and ten of twenty-one students from the other group responded to the online survey. Four master students from the Cambodia group participated in the focus group together with six bachelor students from the other group plus one of the lecturers. The interview was held with the master students approximately three months after they submitted their project. The session of the focus group took 35 minutes with the master students and 40 minutes with the bachelor students.

The results were very similar for the two surveyed groups (two case studies). The results show that the students were interested in new technologies and had already encountered the topic marginally before the assignment. Almost all of them have worked with CAD, GIS, Sketchup, and Photoshop tools as a regular part of their training. On the other hand, they reported only marginal use of other digital technologies or software such as graphic tablets, visualization programs (e. g., Lumion 3D), and others (BIM, photogrammetry).

Approximately 80% of the interviewed students used some of the provided data for their work. Most of the students worked with a ground plan, contour lines and orthophoto map. During the focus group sessions, the students commented on the detailed contours for modelling terrain works. “The contours were great, but first of all we had to redraw (smoothen) them once again in CAD to make them easier to work with.” The students used them in all stages of their project (analysis, design process, presentation). Only a few of them used the

3D model (mesh) and point cloud. They used CAD and GIS tools to work with data. The recommended tools for working with the point cloud (Cloud Compare and PointBox) were used only sparsely. During the focus group sessions, the interviewees appreciated the possibility to use sections in the point clouds in the PointBox application in order to eventually employing them as a source for sections through the design (Fig. 4.).

It remains unclear why so few people used point cloud and mesh for processing their projects. The biggest problem was and overall lack of knowledge of the technologies required for the work. One response aptly formulated the opinions from both groups: "Unfortunately we didn't fully use the data from the drone as it was less time-consuming to use other (familiar) approaches to processing the project." Other significant problems included low performance of their PCs for working with the given software, and the fact that both the understanding of the problem and working with the given data was also significantly time-consuming. During the focus group session, one of the lecturers referred to this as follows: "3D point clouds offer a great potential for landscape architecture, but at the moment this technique is hindered by the poor performance of the computers and the software, which struggles with processing larger areas over 10 ha. A 3D scan is great for 3D designing of smaller areas, e. g. up to 500 square metres. The current computers (equivalent of NVidia 1080 Ti graphic card) can also cope with areas of this size."

All respondents appreciated the introduction of new technologies into teaching and would have appreciated their inclusion in the main subject as well as the optional ones. This is how one of the lecturers involved in the focus group summarized the new methods: "Nowadays it is already possible to use 3D models for detailed analysing of visual links within an object, for comparing current layouts with the proposed designs, or just for capturing real situations in a 3D dimension, which is very important e. g. for heritage sites. We never had such an opportunity before."

Fig. 4:
Plan and the section of the final proposal for ICF project

5 Results

In the analytical phase of the design process, traditional datasets such as contours and orthophoto maps, derived from high precision point cloud datasets, were among the most utilised by the students. Point clouds datasets were used for direct measurements, for displaying sections, and were appreciated for their provision of instant 3D view in a web viewer.

Although point clouds represent a new method for representing a space (current or proposed), in the case study of Cambodia, the whole design was modelled from scratch using 3d modelling in SketchUp. The point clouds were criticised for the imperfect look of buildings and vegetation, which, on close inspection, show holes in a surface. Another drawback is the non-intuitive point cloud editing, since there is no dedicated software that allows easy modification (CloudCompare allows adjustment to some extent, but it is far from perfect).

Although point clouds offer a wide variety of application, in our case they were simply a precursor to obtaining more precise two-dimensional data. Keeping this in mind, we intend to carry on testing workflows to determine how to get the best use from the precision data. To use point clouds directly, software developers may need to bridge the workflow gap by developing a tool that could embed a point cloud deeper in GIS and CAD tools.

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