The Site Visit: Towards a Digital in Situ Design Tool

Benedikt Kowalewski[1], Christophe Girot[2]

[1]ETH Zurich/Switzerland, Chair of Landscape Architecture · kowalewski@arch.ethz.ch
[2]ETH Zurich/Switzerland

Abstract: Can a historical, analog site mapping tool be translated into a digital tool to change the way landscape is currently designed? This paper illustrates the path to the development of an on-site design tool and discusses its implications for landscape architecture. The presented field survey exemplarily illustrates an in situ design process from capturing georeferenced points, lines, and polygons in the field with a GNSS receiver and a tablet PC using the ESRI Collector app. By exchanging data with ArcGIS Online and translating the captured design parameters into three-dimensional outputs (in this case, trees) in ArcGIS Pro, visual feedback of the captured design points was generated while still in the field. The goal of this study is to strengthen the connection of landscape architectural design process to the site through the use of the in situ design tool. In the long term, the plan is to integrate the tool directly into CAD programs and to expand it to include applications in virtual and augmented reality.

Keywords: Geodesign, GIS, mapping, on-site design, remote sensing

1 Introduction

Modern technologies offer an increasingly rich trove of information as a foundation for landscape design. Most notably, technologies that give us a better understanding of the design site promise massive gains in knowledge. GIS and site surveys, however, often offer only abstract methods for analyzing the site, and are not inherently linked to it. Most digital tools lack a direct connection to the design site and the integration of the "human touch". The "human touch" refers to specific elements or inputs that can only be given by the designer and not by parametric inputs. In this paper, the first step of an approach will be presented to link the site indispensably with design tools, as well as to enable an interaction of the designer on site with the design result.

The location of a design is arguably the most central and complex component for landscape architecture: The genius loci determines the success or failure of a design. For landscape architects, the physical site visit has since become the method for experiencing the place and starting the design process. However, this proven method has not been developed further for decades and, apart from a few documentation tools (i. e. photography, video), has hardly benefited from digitalization. With regard to the elaborate documentation and drawing tools that landscape architects used a hundred years ago, it can be said that the site visit loses its importance. This paper will introduce a new digital tool to demonstrate how the site visit can be given meaning again and possibly even become the core of landscape architectural design. Specifically, it is about enriching parametric design methods with subjective information and precise design anchors that can be set directly on site.

Journal of Digital Landscape Architecture, 6-2021, pp. 258-266. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-705-2, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537705022.

2 Rediscovering a Design Workflow

The idea of turning the site visit into something richer is by no means new. Many contemporary as well as historic landscape architects have dealt with site-specific survey methods such as walking (BURCKHARDT & RITTER 2006; Fig. 1) or participatory workshops with local residents (SCHELLENBERGER et al. 2014). In recent years, Christophe Girot coined the term "Topology" for the holistic link between site, landscape design and designer (GIROT 2011). While this term is related but not identical with the mathematical and geometrical meaning of topology, it describes the interlinking of the morphologic, cultural and aesthetic dimensions of a landscape. His chair has therefore developed various techniques to map and document the site using point clouds, video and audio recordings, and other means.

Fig. 1:
Daniel Nikolaus Chodowiecki, Natürliche und affektierte Handlngendes Lebens. Der Spatzier Gang – La promenade, copper engraving, 1778

However, when the information gathered on site is translated into form, the greatest weakness of these methods becomes apparent: In most cases, the design information is only mapped in the mind of the person conducting the site visit and cannot be translated directly into a spatial reference or shape. About 200 years ago, Friedrich Ludwig von Sckell introduced a tool to establish this spatial reference and possibly even make the translation into a plan obsolete in his work "Contributions to the fine art of gardening" (VON SCKELL 1825).

2.1 The Vision of Friedrich Ludwig von Sckell

In his book, von Sckell describes both a method and a corresponding tool for designing landscape directly on site. The designer (called draftsman by him) holds a stick with an iron tip to mark the ground (Fig. 2). The designer now moves with this stick through the landscape and marks and draws the course of paths, the outlines of flowerbeds, the points where trees are to be planted and all other elements relevant to the design. He is guided by his "imagination", which he has trained through intensive study. Through the markings, the construction workers directly receive the information necessary for the physical implementation of the design. The design is thus carried out directly in the landscape, without a detour via any graphic abstraction. This simple, but highly precise design method, can hardly be surpassed in terms of site specificity. However, this method of designing seems to have fallen into oblivion to a large extent. Currently there seems to be no digital translation of this method for designers. The following paragraphs describe how the technical requirements for this have existed for years and are just waiting to be embedded in the landscape architectural design process.

Fig. 2:
Friedrich Ludwig von Sckell and his "Zeichenstab" – drawing stick, 1825

2.2 Drawing Digitally in the Landscape

The rapid developments in surveying and GNSS (Global Navigation Satellite System) technology have turned the surveying industry upside down over the last decades. The architecture industry has only marginally noticed this and has rather focused on other digital developments. Through the appropriation of surveying technologies by landscape architects, it would be possible to translate von Sckell's old design method into the 21st century. The necessary technologies have existed for years and are in daily use by surveyors in the field and in the office; however, they have not yet made the leap into design practice. A GNSS receiver in combination with a recording device for various inputs such as points, lines and areas with direct feedback about the recorded elements would most closely resemble a modern version of von Sckell's design tool. Such a digital drawing tool for design within the landscape can rely on a variety of base data: All the data, which is available to us in the office for traditional design processes at the screen or using sketch paper, could be likewise consulted in the field and support the in situ design. Modern tablets and larger smartphones, in combination with the widely available 3G, 4G and 5G mobile data standards and with market-proven applications, can provide this feedback and additional data in real time in the field. In the following paragraphs describes one exemplary case study for the setup, configuration and integration of such digital design tool.

3 Development of an in situ Design Tool

The simplest example of an in situ design process is already in use by a variety of designers. Points of interest, photos, videos etc. taken in the field are used in the later design process to incorporate site-specific conditions. The next step towards in situ design inputs is the recording of locations in the field with GNSS receivers and thus locating them geographically. While some practitioners are already working with georeferenced data, design and visualization are still largely conducted ex situ. A feedback system on the points recorded in the field and the associated design implications could shorten the post-processing in the office and possibly even enable a design process that takes place entirely on site. The exemplary development of this feedback of an initial design using geographically located inputs in the field was the focus of the following survey.

3.1 From GNSS to GIS

The first challenge for the prototypical setup was to achieve a higher geographic precision for data recorded in the field than with the conventionally installed GNSS sensors of tablets or smartphones. An R8-3 GNSS receiver from Trimble was used for this purpose. This model was able to provide sub-meter accuracy in the context of this experiment. The position correction SBAS (Satellite Based Augmentation System) and the data format GGA (Global Positioning System Fix Data) were used to setup the receiver.

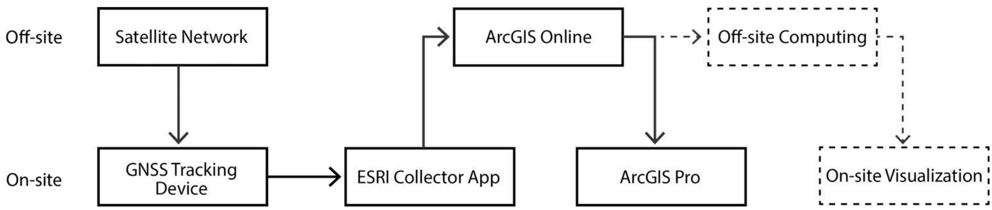

Fig. 3: Workflow diagram; divided into off-site and on-site elements. Dashed elements were not included in this study but are planned to be included in future studies.

The Trimble's Bluetooth interface connected it to a Microsoft Surface 7 Pro Tablet. While the GNSS receiver installed on a tripod about 1.4 meters high sent position data to the tablet, the tablet was to forward this data via ESRI Collector App and its G4 internet connection to the ArcGIS Online database.

For the digital elements to be referenced, the choice fell on points, polygons and lines. The three elements correspond to the most common two-dimensional inputs used by architectural design programs. Thus, it should be possible to map all desired design inputs based on these three features. In the further course, they were to be used in ArcGIS Pro as the basis for parametric design inputs. For this purpose, the ArcGIS Online database was linked back to ArcGIS Pro installed on the tablet.

Up to the data input in ArcGIS Pro, the presented workflow is only a method for recording geo-coordinates. By linking it to very simple parametric design inputs in ArcGIS Pro, the potential of the workflow for landscape architectural design shall be exemplified.

3.2 Parametric Design Inputs

In parallel to the preparation of the GNSS receiver and tablet, the digital design framework was prepared in the ESRI program ArcGIS Pro Desktop. The ArcGIS base maps "World

Topographic Map" and "World Hillshade" as well as 3D building data in LOD2 provided by the municipality served as base layers for orientation and context. The file was configured as a local 3D scene; the "WorldElevation3D/Terrain3D" dataset from the ArcGIS Living Atlas served as the base terrain enabling a three-dimensional display of the site. As mentioned above, three different data types were to be recorded in this survey. The following feature classes and its associated design implications for points, lines and polygons are only to be understood as exemplary features. The desired outputs are freely selectable within the framework of the design program used.

To give the inputs generated with the GNSS receiver an exemplary design meaning, the generated feature classes should inform various ways of tree placement in ArcGIS (Fig. 4 & 5). The placement of trees in the 3D viewport of the GIS program would be fully automated after a feature is entered via the GNSS workflow. The feature class for points exemplarily represents single trees. Several European deciduous trees were selected as 3D symbols for this feature class from the ArcGIS symbol library. In addition to the basic feature class data, attribute columns were created for the tree species and tree height. Using these inputs, the designer could control which preset trees with which height should be visualized in the design preview on the tablet without having to select them manually.

The line inputs are automatically translated into tree rows. The density of the symbols distributed on the line was defined in advance, but could have been parametrized as well. In addition to the representation of a row of trees use of the line input for the virtual creation of a wall in the landscape was also tested.

Finally, the polygon data was used as input for an area randomly planted with trees. The random parameter could have been replaced by a meaningful parametric input, but seemed sufficient for the exemplary nature of this paper.

Prior to the survey, the site in close proximity to the Campus Hönggerberg at ETH Zurich was limited to a perimeter of about four square kilometers for performance purposes. Finally, all three feature classes were published to ArcGIS Online via the "Publish to Web Layer" function and combined into one map making the them ready for use by the ESRI Collector App.

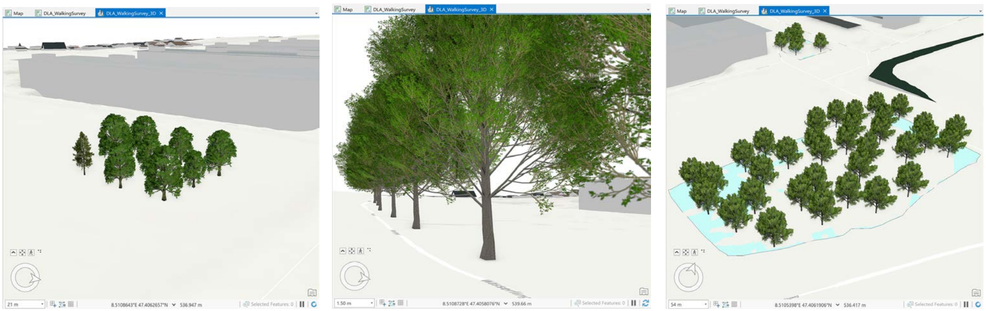

Fig. 4: Features of single points with 3D tree models as representations, as well as a line with a corresponding line of trees and two polygon features filled with trees. All three feature classes relate their Z-coordinate to the underlying 3D terrain model (in this case the ESRI World Elevation 3D terrain) and were informed by the on-site mapping with the GNSS Receiver.

3.3 The Site Survey

The goal of the survey was to collect the inputs for points, lines or polygons using only the Collector App. Consequently, no manual corrections were made within the GIS during the entire survey except for changes to the viewport.

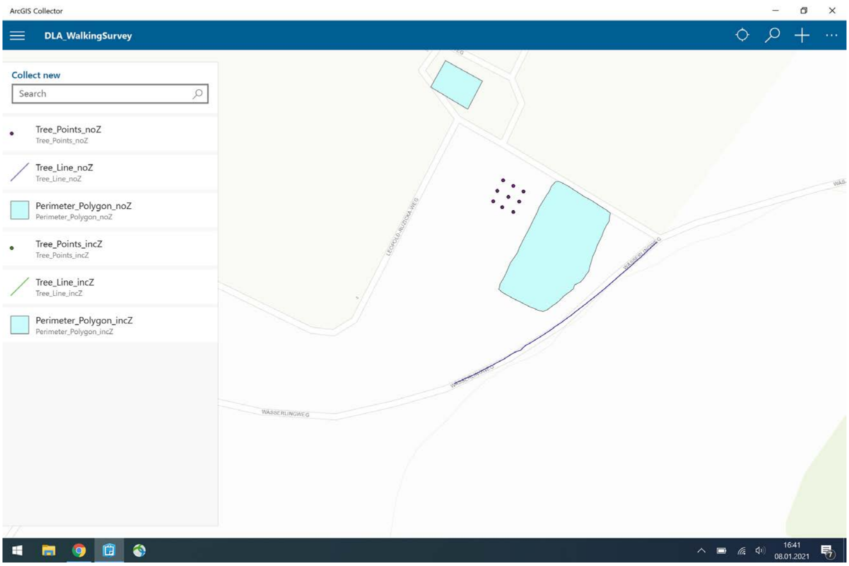

Fig. 5: Final input data in the Collector App showing one line object, nine point features and two polygons. The points constructing the features have been mapped by geo-locating them in the field.

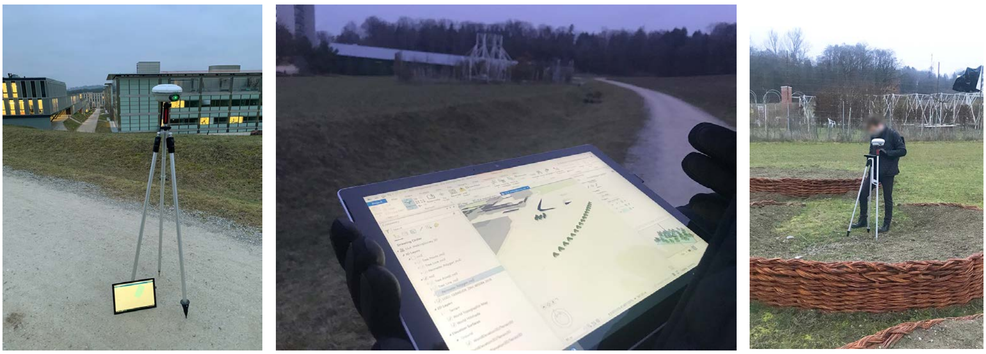

Fig. 6: Survey equipment with GNSS receiver and tablet; Visual design feedback in ArcGIS Pro on the handheld tablet; Process of georeferencing point data in the field

The ESRI Collector App provided access to the previously uploaded maps and contained feature classes in ArcGIS Online. New features were added by connection to a GNSS source at the geographic coordinates thus determined. Using the streaming function of the Collector App, data points for lines and the edges of polygons were continuously recorded at a varying frequencies (i. e. every second, every 10 seconds, every 30 seconds) to test the mapping accuracy. This made it possible to document the movement live with the GNSS receiver in the field and visualize it with only a short delay. Similar to von Sckell's movement through the landscape with his drawing stick.

While the ESRI Collector App also allows a limited two-dimensional viewing and modification of the collected geo-data, this preview was not sufficient for a meaningful design evaluation in the field. Therefore, the visualization and review of the collected data was performed in ArcGIS Pro. To establish a live feedback, the data collected with the Collector App was continuously synchronized with ArcGIS Online; while ArcGIS Pro running on the tablet was also linked to the corresponding ArcGIS Online map to visualize the collected data.

4 Results

The data collected during the exemplary survey described in this paper includes point data from existing tree rings to test the placement of trees in these sites, several polygons of landscape architectonic features not recorded in the basic data, and a line along a farm (Fig. 5). The data was collected both point by point (i. e. points and first polygon) and by walking along the shape to be recorded (i. e. line and second polygon). The feasibility of making live adjustments in the field was also tested (i. e. change of tree heights and tree species, correction of individual points within the Collector App).

A satisfactory workflow for all three feature classes from setting points in the Collector App using the GNSS receiver to ArcGIS Online to a visualization of the inputs in ArcGIS Pro in 3D could be established during the survey.

Although the conduction of this survey overall demonstrated the general feasibility of the method discussed at the beginning of this paper, there remain some challenges and redundancies to overcome before this tool can be efficiently deployed in the field.

Firstly, the precision of the GNSS receiver used was not fully satisfactory. Modern devices can achieve accuracies in the centimeter range (LI et al. 2015). In particular, the elevation data measured in the survey was unusable due to the inaccuracy and had to be replaced by an abstract predefined terrain model. In addition, the weight of the currently used receiver is not suitable for a lengthier survey. In the long term, a lighter and more precise model would be ideal. During the survey, it also became apparent that precision decreases rapidly in partially covered areas (e. g. forest) or narrow areas (e. g. between buildings). Since landscape architecture design does not only take place on the open field, but also in more complex environments, the device should also be able to deliver satisfactory results in urban or covered areas in the future with the help of further localization mechanisms (e. g. indoor WiFi localization; SALAMAH et al. 2015).

The field survey also showed that both the usability and processing power of the tablet used are not ideal, especially for desktop applications such as ArcGIS Pro. On the one hand, desktop applications require at least two different cursor inputs for full functionality and possibly even further inputs from the keyboard. Visualizations on a landscape scale quickly exceed the capacities of the tablet PC. One conceivable solution would be the use of off-site computing: While the tablet marks and uploads data points with GNSS as demonstrated in the survey, the inputs are visualized on an off-site computer or server and only the visual output is sent back to the tablet. With the 5G mobile communications standard currently under development, such real-time transmission could become possible. Also, the redundancy of upload and download to the same device be solved this way.

In addition, ArcGIS Pro is not a design software in the true sense and can only be used as such in an impractical way. Scale, response time and handling do not correspond to CAD programs used for landscape architecture. Nevertheless, ArcGIS was helpful as the first program for testing the in situ design tool due to its direct relation to geo-coordinates. In particular, the workflow to connect GNSS, tablet, ArcGIS Online and the visual feedback in the desktop program was seamless. ESRI has perfected the embedding of online data in desktop applications; a problem that not many CAD programs can yet solve satisfactorily.

Finally, the price of the whole setup tested in this site survey is not feasible for use by landscape architecture practices. Both the costs for GNSS receivers and for possible licenses for the data-recording program have to be significantly reduced in the further course of development.

5 Discussion

5.1 Towards Real-Rime in situ Design with CAD

In the future, it is planned to improve the presented tool functionally with the comments presented in the previous section and to embed it into a more meaningful design process. The aim is to reduce the use of proprietary software to the minimum. In order to minimize the cost factor of GNSS receivers, the possibility of using RTK (Real-Time-Kinematic) receivers will be examined. In this context, the use of multiple receivers for collaborative design will be tested, where multiple receivers in the field can access the same database.

In order to enable the integration of CAD programs into the in situ design process the current workflow has to be redefined once more. Already now, the feature classes in ArcGIS allown an export as e. g. dwg-file for the use by CAD programs. ArcGIS Pro as well as the Collector App will have to be replaced by a slimmer data workflow to load the mapping data directly from the receiver into a CAD. Some programs (e. g. Rhinoceros 3D), would be especially suitable for the setup of parametric design processes based on in situ inputs.

In the long term, the in situ design tool has to be integrated into a real-life design process. It would be particularly interesting to embed it in a fully automated fabrication process for landscape, as is currently being developed by the Robotic Systems Lab for an autonomously operating excavator (JUD et al. 2017).

As handheld devices like the tablet used in this study are limited in their ability to perform a detailed design review on site, it might in the future be feasible to combine augmented reality applications with the in situ design tool in order to verify and adjust a design on. In a further step, even an uncoupling of the physical site and the site visit could be considered, in which the site is made accessible with the help of virtual reality. In this way, even inaccessible or dangerous sites could be designed with the same sensitivity and site specificity.

5.2 Vision

The vision of this research is to rediscover the site visit as a treasure trove of design inputs and make it available to landscape architects. Especially with regard to new fabrication methods, such as described above, the design with in situ design tools might be the possibility to design landscape completely in the field instead of in the office. Just as von Sckell gave his markings carved into the ground directly as instructions to his workers, the tool described in this paper can serve as a direct input for robotic landscape fabrication. Without a detour via an execution plan. If the entire design process would be digital and the abstraction to the two-dimensional plan could become unnecessary, current problems such as the meaningful translation of point clouds to CAD plans may also become obsolete, as they could be smoothly embedded into the design environment without having been simplified or trans-formed beforehand (URECH et al. 2020). In the sense of Christophe Girot's "Topology", the inseparable link between site and design via the in situ tool would make a holistic and highly site specific approach to the design of landscape architecture inevitable.

References

BURCKHARDT, L. & RITTER, M. (2006), Warum ist Landschaft schön. Die Spaziergangswissenschaft. Berlin, 22008.

GIROT, C., HURKXKENS, I., KAPELLOS, A., MELSOM, J. & WERNER, P. (2011), Scales of Topology in Landscape Architecture. Scales of the Earth, 4, 156-163.

JUD, D., HOTTIGER, G., LEEMANN, P. & HUTTER, M. (2017), Planning and control for autonomous excavation. IEEE Robotics and Automation Letters, 2 (4), 2151-2158.

LI, X., GE, M., DAI, X., REN, X., FRITSCHE, M., WICKERT, J. & SCHUH, H. (2015), Accuracy and reliability of multi-GNSS real-time precise positioning: GPS, GLONASS, BeiDou, and Galileo. Journal of Geodesy, 89 (6), 607-635.

PENROSE, R. (1989), The Emporer's New Mind: Concerning Computers, Minds, and the Laws of Physics. London. Vintage.

SALAMAH, A. H., TAMAZIN, M., SHARKAS, M. A. & KHEDR, M. (2016), An enhanced WiFi indoor localization system based on machine learning. In 2016 International Conference on Indoor Positioning and Indoor Navigation (IPIN) (pp. 1-8). IEEE.

SCHELLENBERGER, S., HAAS, R., WITSCHI, F., ROBERT, Y. & BEUTLER, M. (2014), Biodiversität im urbanen Siedlungsraum. Pilotprojekt Fröschmatt. Schlussbericht. Bern. https://www.aramis.admin.ch/Default.aspx?DocumentID=3809&Load=true (14.11.2020).

URECH, P. R., DISSEGNA, M. A., GIROT, C. & GRÊT-REGAMEY, A. (2020), Point cloud modeling as a bridge between landscape design and planning. Landscape and Urban Planning, 203, 103903.

VON SCKELL, F. L. (1825), Beiträge zur bildenden Gartenkunst: für angehende Gartenkünstler und Gartenliebhaber. Jos. Lindauersche Buchl.