Onsite Analysis: Developing a Flexible Software Field-kit for Landscape Architecture and Spatial Design

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Abstract: The site visit has played a vital role at the beginning of any spatial design project, yet despite developments in technology, has remained largely an act of observation and recording. This research proposes the synthesis of a software field kit and mode of working to allow efficient, affordable on-site landscape analysis to become a feasible part of the typical site visit. It develops the rationale behind an on-site analysis technique, its synthesis, application considerations, case studies of its application, and development potential and implications for the disciplines of landscape architecture and spatial design.

Keywords: Onsite computational design, landscape analysis, landscape sensing, realtime analysis, landscape tool development, hardware/software synthesis

1 Introduction

The humble site visit has always been a crucial early step in the understanding of a place and its potential – yet it often remains limited to a traditional ritual of observation and visual references, whether in photographic or sketch form. This research builds upon various previous research works into site scanning, sensing and analysis; and their potential impact on site selection, construction, and evolving landscape sites (FRAGUADA et al. 2013). It acts to support the contemporary project requirements for comfort, sustainability, and project development, which require early and accurate application of applicable site data in order to justify site interventions, design and maintenance decisions (REITER & DE HERDE 2011). In relation to landscape architecture, this fundamental and primary act of site investigation is often underestimated in its significance to the field. Despite research into certain site specific investigations into deeper scanning techniques (REKITTKE et al. 2013), the relevance of on-site sensing and analysis is absent in recent comprehensive publications on digital techniques and landscape architecture (WALLIS & RAHMANN 2016). While several specialised options exist for site appraisal using UAV technologies, and software pathways, high costs and complicated workflows serve to negate the usefulness of such techniques to typical landscape architecture project applications.

Through the synthesis of such techniques and the reduction of required infrastructure, a balance between a subjective and empirical understanding of site can be reached earlier in the design process. Potential impacts of the discipline include the transformation of the early landscape development phases, such as sketch-design, analysis (soil, geology, vegetation and hydrology) and related landscape processes. In cases which site selection or project positioning also plays a role, such techniques can be seen to be indispensable in landscape design practice.

Early on-site analysis, when applied as a diagnostic process, can quickly review both landscape potential and deficit, as well as call into question standardised understandings of site,

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such as those produced by planning, zoning, and cartography techniques, which tend to normalise the reading of site, and include their own cultural weighting of site-factors, ignoring subtleties of site (FRAGUADA et al. 2012). Parallel areas of research such as microclimate sensing, simulation and human comfort provide rich possibilities for interdisciplinary participation and site insight.

The software field-kit has been developed as a package of plugins and scripts within Grasshopper for Rhino, which provide the interface between on-site UAV applications (where necessary) terrain data, and real-time on-site analysis. This research paper documents the rationale behind such a technique, its synthesis, application considerations, case studies of its application, and development potential and implications for the disciplines of landscape architecture and spatial design.

2 Efficiency and Accuracy in On-site Analyses

In many cases, the time-frame of landscape review and analysis is paramount to a project. Particularly pertinent are such cases are those in which potential projects require initial site-feedback to refine design and intervention briefs, or where multiple sites are in question for landscape development. In most areas of the world, accurate, applicable site data is either prohibitively expensive to procure, or nonexistent. Due to industry efficiencies and varied interdisciplinary implications of landscape development, a shared, rich source of site data is of benefit to the launch of any development project. Nevertheless, increasing uncertainty and sheer scale of inherited site data often precipitates in the requirement for the acquirement of accurate, fresh data (PERALTA 2006).

Grasshopper analysis field-kit – definition typologies/tool grouping			
key applications:	*terrain*	*hydrology*	*vegetation*
* *mesh analysis* ** *energy plus modeling* *** *image based*	UAV path generation/ i/o*	–	–
	slope*	runoff analysis*	tree crown*/***
	aspect*	pooling*	solar exposure*/**
	typology/material***	erosion*/***	species***

Fig. 1: The grasshopper analysis definitions have been simplified into 3 main families, that are nested together. This allows the user to be less specialised, and simplifies both the operation and customisation/hybridisation of the tools by the user.

Landscape environments are dynamic environments going through continuous transformation, in comparison to controlled built and building interiors. The ease with which a site scan can be performed raises the potential for multiple site visits, allowing a site to be scanned at various times of day, season, or year, generating a deep understanding of vegetation change, weather event impact, agricultural cycles, and cultural program phenomenon.

While these benefits can be clearly argued, it is rather the accessibility and efficiency of implementing such techniques which is of key interest to this research. Due to the infrastructures afforded most landscape architecture offices, early site analysis is often deemed beyond the scope of capabilities, and either delayed to later stages of the project, and other specialists.

Two recent key developments have facilitated the work in the research – those of affordable and flexible aerial UAV photogrammetry packages, and the advent of easily accessibly parametric interfaces to landscape architecture design software, such as Rhino/Grasshopper. Through the closing of the loop of separating site scanning, landscape analysis and appraisal to a tight circle within the scope of the typical designer, the research serves to facilitate a new instrumentalisation of the humble site-visit, and its role within landscape architecture.

This research has chosen to focus on expanding the potential of the discrete site visit in 3 key ways: when applied efficiently one larger area can be scanned in efficient sectors (scale), or several sites compared where site selection is of key importance (comparison), or the technique can efficiently be repeated on a discreet, evolving site (repetition).

Fig. 2: While on an extended site visit (left) the on-site generation of UAV flight paths, generated from Grasshopper script and exported to the UAV, (centre) to generate the required data in the hills above Barcelona, Spain, (right), being processed remotely for additional speed and data fidelity (ETHZ/IAAC)

Accessibility remains of key importance, whether in the range and location of sites able to be surveyed, the flexibility of the site visit, or the cost and simplicity of the site-based tasks. Commonly defined in this research as criteria of both (site-) access & ability (to perform), the priority of the research was on the flexible access of multiple site typologies in varied locations, and the ability of one participant to carry out the given tasks in their entirety alone, should that be necessary, although the case studies, as with many professional scenarios would allow for group work and shared roles and tasks. The terminology also applies well to both the scanning/sensing and analysis roles, also in terms of availability, ease of use and cost (WALLIS & RAHMANN 2016).

The synthesised sensing and analysis tasks can best be characterised through their efficiency, achieved by either using a simplified large scale dataset, or a specific area in high resolution.

This can best be achieved through their combination/hybridisation, and through borrowing from related earth-science fields, such as Geomorphometry, which seeks to streamline digital landscape analysis processes (PIKE et al. 2009), and remote sensing, which has developed efficient techniques of detailing efficiently with the territorial scale (PIROKKA et al. 2015). As can be seen in the case study review, such analysis and mapping techniques have relevance at all site scales and contexts, and combined with on-site analysis, generate the potential for site readings and landscape morphologies that would otherwise remain undetected, improving the depth of understanding afforded by the site visit.

3 Case Studies

The two case studies involved student groups on varied and unfamiliar sites. These continue and refine the research of discrete site-process techniques (GIROT et al. 2015). While both apply the field-kit in a similar method, the first best demonstrates the specialised application of UAVs on an unknown site, and the second the potential for analysis and communication of landscape site.

The techniques deployed during our various on-site research campaigns were aimed at specific landscape analyses and determined to have varied potential for accessible site-visit application, specifically focussing on terrain and vegetation characteristics. The hardware ranged from photographic/video recording, low cost sensors, distance measuring devices, UAV photogrametry, and Terrestrial Laser Scanning, with an increasing and direct relation to complexity and cost. For this reason, a limited scope of hardware and software where considered for this targeted research. Analysis and control ranged from on-site access of open data, to simple analysis of terrain aspect/slope, exposure, hydrology, vegetation variation/density, hardscape/softscape, sensor data visualisation, photogrammetry and point cloud filtering, in order of complexity.

The first study consisted of a discrete student workshop carried out in a national park in the forest above Barcelona, Spain, focusing on UAV scanning and direct landscape analysis run in collaboration between IAAC, Barcelona and ILA, ETHZ. The second case study forms the beginning of a year-long design program on the Zurich lakeshore by the students from ETH Zurich, MAS LA program, involving scanning, sensor integration, and the following implementation of sustained, project-specific site enquiry. The two case studies, carried out between 2015 and 2016, clearly demonstrate the potential of a considered hybridisation of landscape surveying and sensing tools for direct and nuanced understanding of site and context.

The Barcelona workshop was a case study example featuring dense vegetation and complex topography, and lacking any descriptive contemporary maps of the area. In this case, standardised UAV photogrammetry techniques were deemed as inapplicable, due to the 60 m height difference within the 20 hectare large scan area. Within Grasshopper/Rhino, we developed a UAV flight path interpreter/publisher, allowing the students to define the landscape scan area and directly export the flight paths, and heights, crucial for a consistent photogrammetric result (Fig. 2). The research team produced detailed flight paths in minutes using basic Google Earth terrain and tree height data sourced dynamically on site. This allowed the UAV to then collect a minimum number of well-spaced images for an efficient and accurate processing set for the photogrammetry task.

The same Grasshopper file used for the preparation of the photogrammetric site scan is supplemented with several grasshopper definitions for terrain analysis, allowing the basic Google Earth data to first be appraised, then a rough photogrammetric model, and finally a high resolution site model. This iterative process allows the site focus area and scale to shift, based on the analysis of each level of detail. By the time each student group received the final high resolution terrain data, the ideal site choice was already made, and able to be agreed and refined. Grasshopper definitions analyze terrain slope, aspect, and type, based on colour information, allowing typological, hydrological flow, pooling, potential erosion and ground cover analysis. The inclusion of the forest tree crown allows solar exposure, shadow calculations and seasonal variation to be shown in realtime (Fig. 1).

By using a cloud-based service (Fig. 2), the processing-intensive photogrammetry solution can be solved off site through the uploading of images, and downloading of textured meshes and pointclouds. This process is well documented elsewhere and need not be expanded upon in this paper. The key balance is the site size and target resolution, for maximum efficiency on site. Within the frame of this case study the image processing took place within the time it took to survey the site by foot, taking soil and vegetation samples, setting and collecting GPS markers, and making key measurements and local, object based photogrammetry (in the case of this project, scanning details of ancient agricultural terracing and retaining walls). Aside from typical site photography, a catalogue of terrain surface types and vegetation species further empower the potential of the image analysis techniques conducted within grasshopper to detect patterns and subtle landscape traces.

The combination of these analyses lead to the digital reconstruction of the now partially erased agricultural terraces, an understanding of the original hydrology of the site and likely irrigation techniques, and even traces of invasive species and wild agricultural species that can still be seen to thrive in certain terraced orientations of the valley (Fig. 3). These could then be further investigated, while still on site, allowing for an iterative and immersive understanding of the site context. This case study also served as a relevant complex, large-scale example to define the balance of data processing/accuracy for relevant on-site feedback. After the conclusion of the workshop, the site data was further refined to confirm and control the accuracy of the original on-site data. The second case study, based on the Zurich lakeshore involved the same basic parts, capitalising on specialised UAV deployment and on-site computation and analysis. The key differences relate specifically to the site differences: the Zurich site was relatively data rich compared to the Barcelona site (terrain), so UAV usage was deployed in a seasonally specific manner over several visits, and the on-site analysis focused on vegetation and key urban features, rather than terrain. In addition, the application of moving sensors for local microclimate detection, detecting soil moisture, air humidity, temperature, light spectrum, and sound frequency and intensity (Fig. 4). While the sensor readings interfaced in realtime with the same analysis tools, and were visualised in Rhino via grasshopper, such techniques have been previously documented by the research team and can be considered as providing a separate and parallel potential those within the specific scope of this research paper.

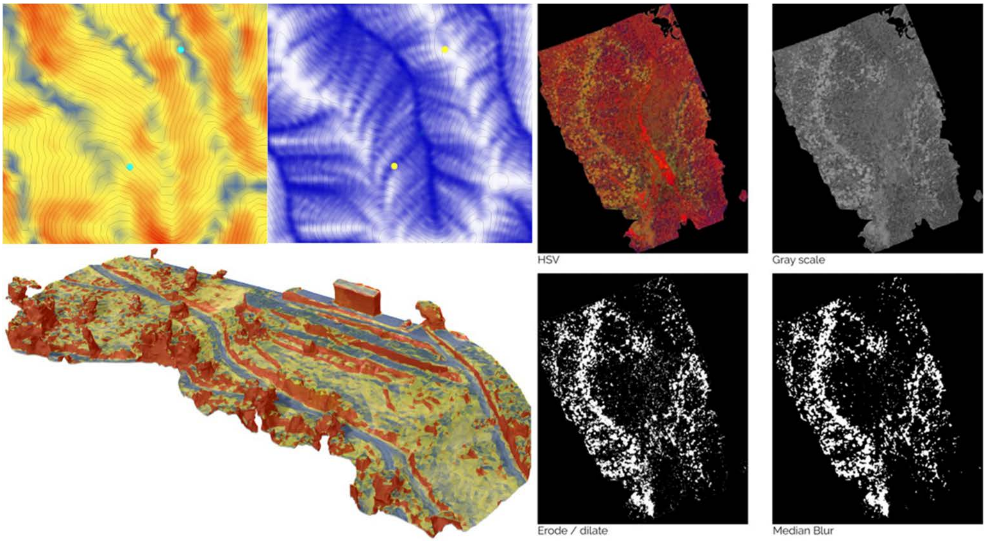

Fig. 3: Site analysis of the Barcelona forest site, with initial terrain and waterflow analysis (upper left), the detailed terrain terracing (lower left) and vegetation analysis (right) revealing historical agricultural landscape structure

Fig. 4: Sensor deployment (l), on-site landscape analysis on laptop & tablets (m), used in aiding the optimal placement of soil moisture sensors. Resulting in local terrain visualisations (r) combining open space network analysis and microclimate data.

While the sites differed greatly, the key analysis techniques were applied thoroughly on site in each of the thematic categories. The key areas of topographical interest and analysis on-site were the street connectivity system, inclination, accessibility and resulting open space network and barriers. The large-scale vegetation network and species distribution was also quickly determined through on-site analysis (as well as its detailed relationship to the local microclimate, through sensor work not documented in detail here). Basic hydrological and shading analysis was conducted, yet it was not deemed necessary to carry this out on-site, in lieu of other analysis tasks.

Key on-site findings included the role of train infrastructure on-site as movement barrier and site-structuring element, despite having a minor visual impact, and a detailed understanding of potential movement routes, which were then mapped by the research participants (Fig. 4). A similar surface-typology mapping technique to that used in Barcelona allowed large scale analysis of the soft and hardscape surfaces to be made, predicted areas of infiltration and runoff, and identify zones for further investigation while on-site.

In contrast to the single Barcelona site visit, the efficiency of the analysis process on the Zurich site facilitated repetitive site-visits and sensing expeditions in the following months, yielding rich on-site data with minimal site contact time, and direct analysis feedback for refinement and site enquiry. Most notable for the site in question were variations in vegetation colour, density, and opacity, and in winter the snow coverage, distribution and depth on site. Given the lakeshore site's large open spaces, its performance as event an event-space could be mapped and programatic shifts recorded.

4 Discussion

The two case studies were used both to test the synergies of hardware and software on-site during two site visits of varied application and scope. Through this process, the key aspect of adjustment was to refine the computing complexity and intensity required, to a point where the field-kit augments the work of the landscape designer and not a hindrance.

Between the two studies, the clear positive implications for both the potential of the discrete site visit, and strategic site-re-visits can be clearly shown, as well as optimisations and refinements to a resulting discrete set of tools. In addition, the difference between the two sites and their contexts further reveals areas in which the toolsets and applications require flexibility, rather than standardisation, to form an ideal balance of applicability and efficiency. A marked improvement in the understanding of vegetation distribution was determined on both case-study sites, and in the Barcelona site, historical traces which were otherwise undetectable.

Due to the familiarity and embedding of the approach within their design software, the students were quickly able to integrate the analyses into their site-specifics approach, without extensive experience in the field. The results directly influenced the later design work of the students, and were generally agreed to be greatly beneficial to the process, facilitation insights that were not available through other sources.

Key potential for the approach revolves around the limitations of employing a laptop computer and adjusting analysis parameters on-site. To this end, further updates have involved further simplification of the user interface, such that the user need not interact with the Grasshopper definition at all, but instead with a simplified GUI. This also allows the analysis software to run on a tablet PC on site, further raising its accessibility in the field. Our latest field-kit setup successfully runs Rhino/Grasshopper and our custom analysis components on a 7-inch generic Windows 8.1 tablet: Intel quad-core, 16gB (Fig. 4) now available for around the cost of a 16gB USB flashdrive, a key consideration of accessibility, which shall only improve with computational performance and cost development.

5 Conclusion and Outlook

The implications of early analysis tools for the discipline of Landscape Architecture and spatial design are clear in terms of the empowerment of the designer and the design process, but also the role of Landscape Architecture early on, in any form of project requiring spatial understanding and transformation. Rather than a prescriptive or one-toolkit approach, the flexibility to integrate local data sources or develop one's own is a fundamental one. The increasing prevalence of data is a trend that on one hand has genuine benefits, yet can also be approached skeptically, in regards to accuracy (EKBIA et al. 2014).

A flexible yet well-structured sensing/analysis field-kit and site-specific deployment allows the spatial designer to augment their knowledge of the site as required, without obscuring their first impressions and phenomenological understanding of place. The opportunity to apply an early version of this field-kit in various parts of Europe has raised a clear interest from several research and industry partners, and demands further research and development. Furthermore, its development and research has led to a greater integration in the related natural sciences, resulting in shared tools, vocabulary, and potential for interdisciplinary exchange and mutual technique development.

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