

Using Massive Field Data for Large-size Design Action

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Cogitation

For almost too long, we have tried to abide in the elusive academic satisfaction that we are really doing rather well concerning the *in situ* data capture and subsequent generation of highly detailed point cloud models of urban landscape reality. In our opinion, this approach affords an extensive physical overview of almost every kind of location in a landscape architectural or urban design related fieldwork operation. We continue to experiment with the use of portable tools to reconstruct three-dimensional digital landscapes while progressively improving upon the precision and density of geo-referenced data captured. Assertively, we postulate that the use of these tools and applied methods are conducive to the provision of visible, understandable, and designable spatial data within the academic context of urban landscape design studios. Now, we seek to address this demanding postulate with much consideration. The paper marks the beginning of the presumably tedious and challenging journey into what we call digging massive field data for large-size design action.

To date, we have achieved the ability to continually self-generate an infinite mass of digital sludge or virtual modelling clay for the landscape architectural designer. However, we have yet to demonstrate, in a convincing manner, the ability to put forth compelling designs which are yielded by our digital commodities. In other words, we have to make up the balance between the unassertive diggings of our remarkable field data, which has led to rather habitual design work. We began to settle this deficit by tackling a large-size academic studio project – a 26 kilometres long, abandoned railway line in Singapore that crosses the nation city. We politicize and popularize the design project by calling it *The National Mall*, as the expansive stretch of land is at risk of becoming real estate.

The design process began with a two-week fieldwork campaign, resulting in the complete coverage of the railway line. This was achieved through mixed digital landscape capture methods: photography from stroller's perspective, drone-based aerial videography, and terrestrial laser scanning. The package of digital data – manifold, difficult to handle, and computationally expensive – was used to realise this goal. The paper describes our concerted experimental efforts to exploit the data glut for sophisticated design outcomes.

1 Site and Assignment

Under British colonial rule, a railway line had been built to service Singapore, Malaysia and Thailand. After Singapore and Malaysia separated in 1965, the Malaysian federation

retained ownership of railway land, structures and train stations within Singapore. In May 2010, both countries agreed Malaysia would cede ownership of the land in exchange for real estate in two of Singapore's most expensive districts. The railway service between Tanjong Pagar Railway Station, situated in the centre of Singapore, and Woodlands Train Checkpoint was shut down on 1 July 2011. The fate of the fully intact, smooth, un-interrupted railway corridor that crosses the entire island from South to North remains unclear (Fig. 1). In a paper published by the Nature Society Singapore, titled 'The Green Corridor: A Proposal to Keep the Railway Lands as a Continuous Green Corridor', the authors write: "The least challenging and most unimaginative "solution" would be for policy makers, planners and developers to parcel the land out as real estate, dismantle the line, erase the rail-way and its memory from the public domain and relegate it to textbook history. That would be a costly mistake. [...] Rather, we feel that by exploring more creative, sensitive and inclusive ways to utilize the railway and its land we would be enhancing rather than reducing its value. In a country searching desperately for genuine icons, it would be a tragedy to destroy this potent symbol of connectivity and inclusive progress" (NATURE SOCIETY SINGAPORE 2010). In 2014, we dedicated a student design studio to the development of visions and designs for a major project which we name 'The National Mall' – a shadily outdoor promenade, not another shopping mall. The railway line crosses various urban quarters and different landscape types.

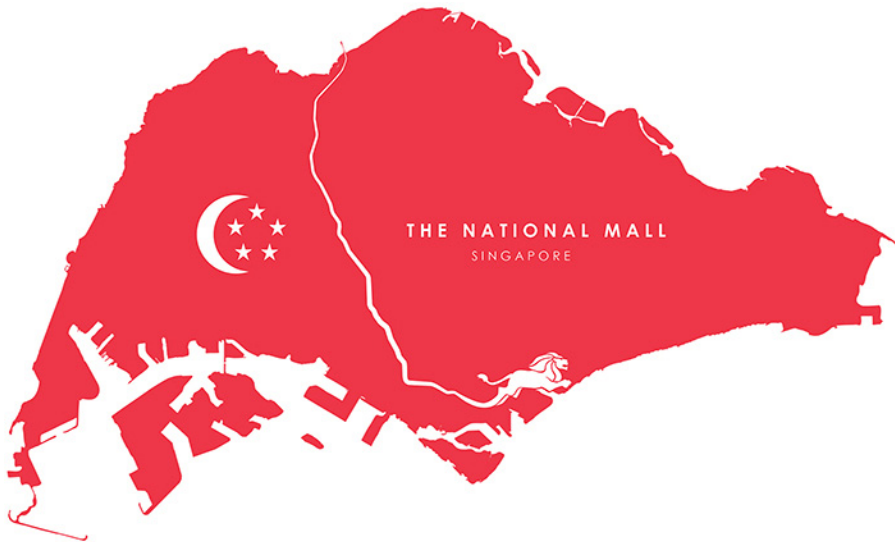


Fig. 1: Emblem of the 'National Mall' project. It shows the central location of the railway line and its nationwide dimension (Graphic: Feng Yuanqiu)

In its current state it already appears to be a nature park connecting a number of different green spaces with a unique mix of secondary forest, grasslands, and at times, guerrilla gardens on either side of the tracks. We recognise that should people be allowed to continue walking and cycling along the abandoned rails in the future, they would experience an uninterrupted 26-kilometre landscape corridor. This would be a unique feature for a city, fulfilling future requirements for recreational purposes including urban ecological quality

and green space availability. Our goal is to let *The National Mall* become a constant of the collective esteem, finally making the fragmentation, destruction and building development of the railway corridor an unthinkable act.

2 Fieldwork

Our maxim is to capture all design information in our own right and *in situ*, operating on foot and carrying all applied equipment with us (Fig. 2), all the time during fieldwork. Given these conditions a distance of 26 kilometres is rather large and challenging. Each of the twelve students had been equipped with a backpack, which contained: a) GoPro HERO3+ Black Edition (action camera, waterproof case, long-neck GoPro foot); b) GoPro LCD Touch BacPac (mounted on camera, in waterproof case); c) GoPro Suction Cup; d) GoPro Jaws: Flex Clamp; e) GoPro Handlebar/ Seatpost Mount; f) GoPro Rechargeable Battery; g) GoPro The Frame mount (2 frames (large & small), short-neck GoPro foot, screw); h) GoPro extra mounting joints; j) SanDisk micro SDHC UHS-I Card (32 GB). Two students operated a FARO Focus3D Terrestrial Laser Scanner (TLS), and a TRIMBLE GeoXH Handheld Global Navigation Satellite System (GNSS) for geo-referencing of the FARO scan data. Each of the three accompanying researchers (authors) carried the following tools: a) PHANTOM 2 Vision camera quad-copter, transported – together with extra batteries and spare parts – in a carrying case with wheels; b) iPhone; c) iPad. The Phantom 2 Vision shoots HD video at 1080p 30/60i and takes 14-megapixel still photos. All camera settings and the live imagery can be controlled and adjusted through the free 'Vision' app, for example on iPhone or iPad. Photos and videos are transmitted via the on-board Wi-Fi connection. The integrated GPS autopilot system offers position hold, provides altitude lock along with stable hovering, which allows for rather stable flights.



Fig. 2: Left: Content of a student backpack, with GoPro HERO3+ Black Edition. Right: PHANTOM 2 Vision camera quad-copter with carrying case (Photos: J. Rekittke).

The central aim of the fieldwork mission was the systematic and thorough *visual collection* of the diversified characteristics of tropical vegetation along both sides of the railway track. It is this vegetated buffer that makes the project site unique. Though moving through the middle of a densely built city-state, the stroller or biker undergoes a calming and almost surreal landscape experience. The students had been challenged to integrate the abundance and complexity of the existent vegetation structure into their design outcome. We decided to work in three different modes of site recording: 1) A complete photo shooting of the 26

kilometres long trail, from stroller's perspective with the 12 GoPro HERO3+ cameras; 2) A representative scan of 2.3 kilometres of the trail with the FARO Focus3D terrain scanner – a complete scan would have taken too much time; 3) A representative drone-based aerial video shooting of a part of the scanned 2.3 kilometres segment with the PHANTOM 2 Vision camera copters – given that we were operating in a categorical *No-Fly-Zone*.

The students had to figure out the best way of a collective operation with the GoPro cameras. They tested out several constellations and finally decided on the best method of documenting the full length of the trail (Fig. 3).

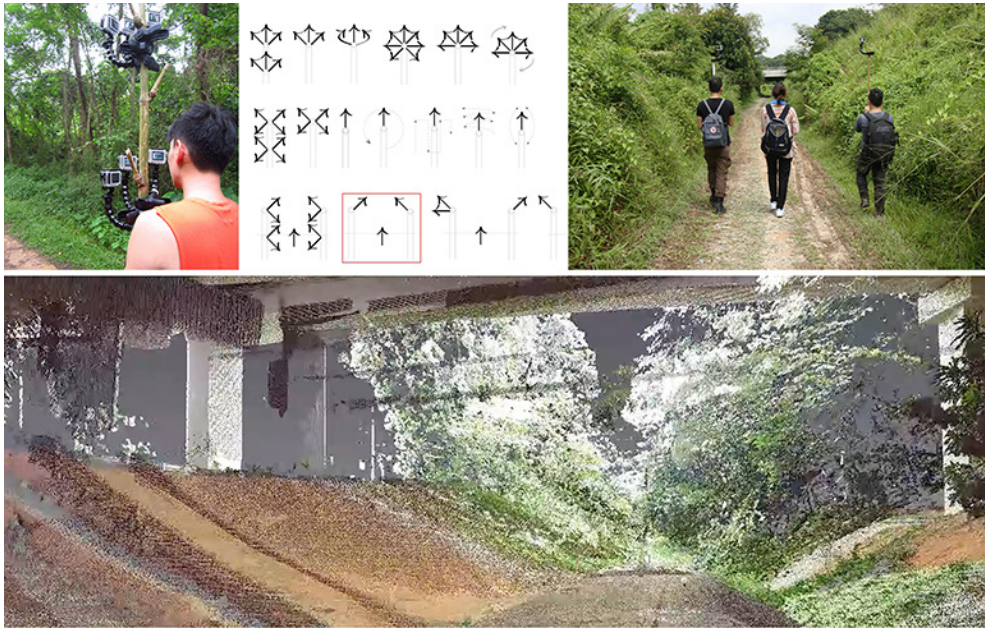


Fig. 3: Top left: First experiments with the GoPro HERO3+ cameras. Top mid: Systematic test series and selection of best method. Top right: Selected walking technique. Bottom: FARO terrestrial scan of the trail under a highway bridge (Material: MLA students / studio: Rekittke).

To maintain a steady walking speed, they used a metronome. The production of the 2.3 kilometres long terrain scan was a diligent but routine piece of work, as well as the flight survey with the camera quad-copters. The aerial documentation had been conducted in two directions at a time, and in two operating altitudes of 10-15 and 30-40 metres.

3 Design Work

In this paper, we will not discuss the creative quality of the design results as such. We will limit ourselves to the discussion of the design crafting process in the studio, based on the information and data gathered in the field. In connection with the fieldwork, the students had been taught to exploit the digital material via a certain workflow which includes the use

of advanced software programs such as VisualSfM and CPMVS – structure from motion (SfM) applications for 3D reconstruction of digital image material (HAVLENA et al. 2010, WANG 2011, WU 2011), Autodesk Recap for registration of point clouds, as well as Autodesk Revit, and 3DS Max for the creative manipulation of point clouds. In order to avoid unintended fixation on technical issues and to inspire the students to use a wide range of design techniques and media, we held a 'talent session', where every student could present a personal favourite way of creative making. Besides painting, drawing, sketching or photography, skills like dancing, cooking and plant breeding also came to the fore. Our invitation to use a maximum range of personal skills and preferences for the design process was complemented by the unconditional statement of a resolute utilisation of the comprehensive and valuable fieldwork data. After the midterm review, the student group arrived at an agreement on one collective design approach (project). Connective as well as framing element of *The National Mall* is a monumental avenue of lofty dipterocarp trees – native rainforest species, featuring massive columnar trunks – planted at intervals of 10 metres, framing a central promenade of 9 metres in breadth (Fig. 4).

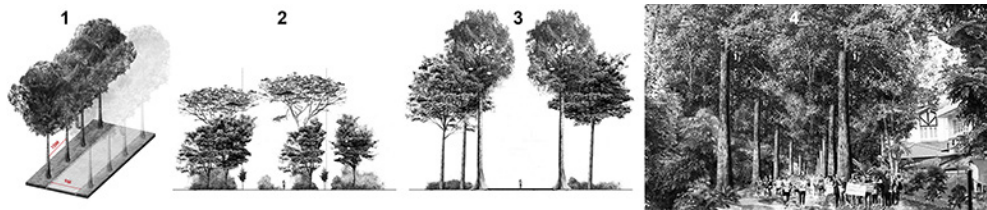


Fig. 4: 1) Dipterocarp tree framework of 10 x 9 m. 2) Initial planting of young dipterocarps. 3) Scheme of adult dipterocarp growth, forming a monumental avenue. 4) Perspective, showing the fully-grown trees in the context of existent, dense tropical vegetation along the promenade (Graphics: MLA students / studio: Rekittke).

The project area was roughly portioned into 500-metre intervals, resulting in a sequence of 50 cross sections, guiding the viewer through the entire distance of the project. While focusing on the core element of the *National Mall* (trail), all relevant details of the surroundings on both sides of the trail were included in the sections. They show future projects according to the current master plan, published by the Urban Redevelopment Authority Singapore (URA 2014), as well as the most relevant land use elements such as residential, public and commercial buildings and facilities, viaducts and flyovers, overhead bridges, existent park connectors, et cetera. At the beginning of the cross-sectional work, the students curiously used everything but the original field material, resulting in kind of lifeless, schematic sections without any tropical abundance of vegetation – the main formative factor of the fascinating as-is quality of the site. The students were obviously hesitant to take advantage of the massive data set. The breakthrough came when the group, which had carried out the terrain scan, was forced into the utilization of the gathered data. In collaboration with other members of the group, they started to develop an inspiring workflow. When a black-and-white point cloud section – with some *perspective depth* added – taken from the coloured terrestrial scan, was placed in a schematic section drawing of the site, suddenly the creative and aesthetic potential of the fieldwork material flashed up (Fig. 5).

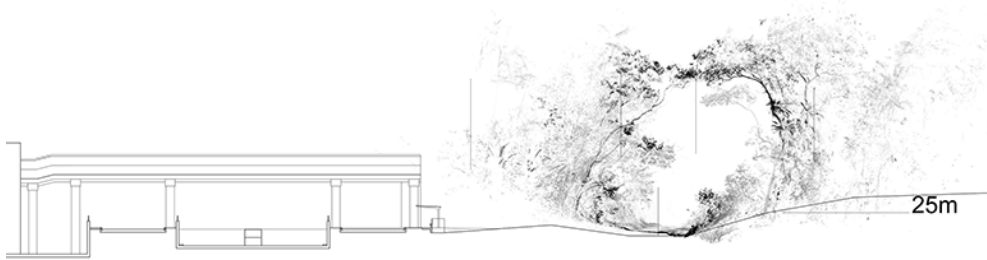


Fig. 5: Black-and-white point cloud section from terrestrial scan placed in a schematic section drawing of the site (Graphic: MLA students / studio: Rekittke).

It may not look like a great thing, but we regard the beautiful contrast of the organic landscape scan with the static architectural environment as being much more than an aesthetic effect. We appreciate the richness and complexity of the existing vegetation layer as main sales argument for the project – a narrow but unbuilt stretch of heavily vegetated land in the otherwise bleak city context. What we also appreciate is the fact that the high aesthetic quality of the machine generated landscape representation (scan/point cloud) invites the designer to include more traditional techniques like painting, drawing and photography in an almost self-evident way. This was what inspired the next steps for the students' work (Fig. 6).

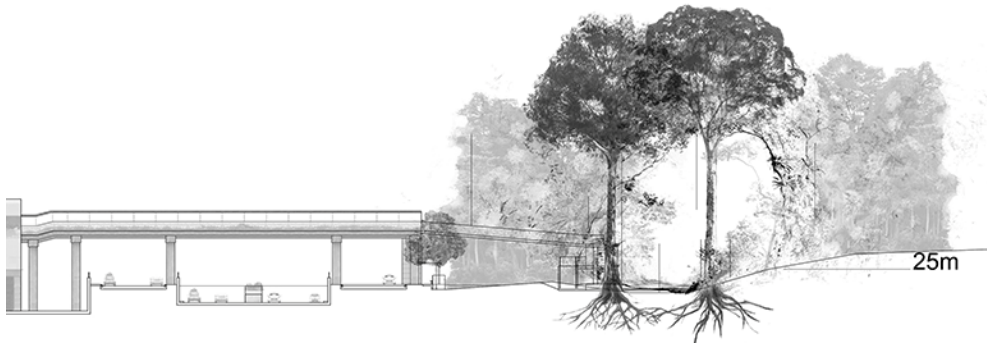


Fig. 6: Insertion of projected dipterocarp species in form of drawings, and of contextual information in form of photography (Graphic: MLA students / studio: Rekittke).

After subsequent experimentation with multitudinous forms of representation, abstraction and accentuation in respect of content and purpose, the 50 project cross sections were produced and underwent a final artistic finish by skilled studio participants (Fig. 7).

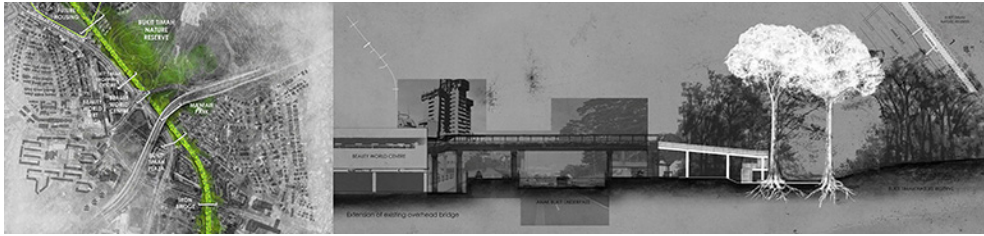


Fig. 7: Example of a final cross-section (displayed on an 8 m wide screen) with artistic *charcoal finish* referenced to plan (Graphic: MLA students / studio: Rekittke)

The overall studio result is a strong piece of work, which shows how convincing the cultivation of a bold contrast of big city development with a designed luxuriant landscape project can be. The students engaged in the fieldwork data set through a conventional cross-sectional approach but took advantage of the precision, measurability (FRITZ et al. 2013) and scalability of the digital material for an accurate anchoring of their design work. The point clouds considerably influenced the complexity (NEBIKER et al. 2010) and aesthetic quality of the final outcome. While the digging of massive field data merely led to a chary utilisation of them, it should be mentioned that there are few references for this kind of technology integration in landscape design schools as yet (FRICKER et al. 2012).

4 Room for Manoeuvre

The point cloud – in steadily increasing density – seems to be a well-nigh *ideal* form of landscape representation and design feedstock. Its three-dimensional precision, detail and theoretic spatial infinity can disengage the designer from two-dimensional postcard views (Fig. 8). The point cloud dataset is a by-product of the measurement of physical environments via digital media, exemplified by image-based modelling and range-based modelling methods (REMONDINO & HAKIM 2006).

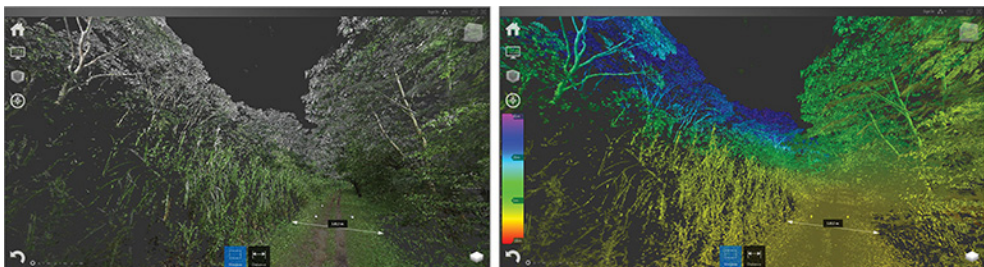


Fig. 8: Reading of and designing with dimensions in Autodesk Recap. Terrestrial laser scan data allow precise information by point-to-point measurements (left) and display RGB values of each point (right) within the dataset (Screenshot).

Image-based modelling, using cameras, is mainly used to reconstruct geometric surfaces and objects. Range-based modelling, using terrestrial laser scanners, is often used to record

basic shapes and fine details. For the comprehension and design of the complex landscape along the railway line, we proposed to utilize a combination of image- and range-based modelling methods. What went by the board at the end was the material captured via the drone-based aerial video shooting with the PHANTOM 2 Vision camera quad-copters. The benefit of the fantastic overview – suited to be used as conjunctive context information for the particular sections – was superseded by the technical effort to handle the computationally expensive data packages. The design students showed little patience for the post-processing of the images extracted from the flight videos. Furthermore, the gathered point clouds were rather sparse compared to the high resolution terrestrial scanning. We apprehend the range-based acquisition of landscape data proving to be the most successful method in capturing the subtleties of plant cover. Nevertheless, the material at hand certainly featured more room for creative manoeuvre than had been capitalised on during the design studio. In line with the outcome of the information produced by the students, we continue to explore the possibility of embedding the information captured from image- and range-based acquisition (Fig. 9, Fig. 10, Fig. 11).

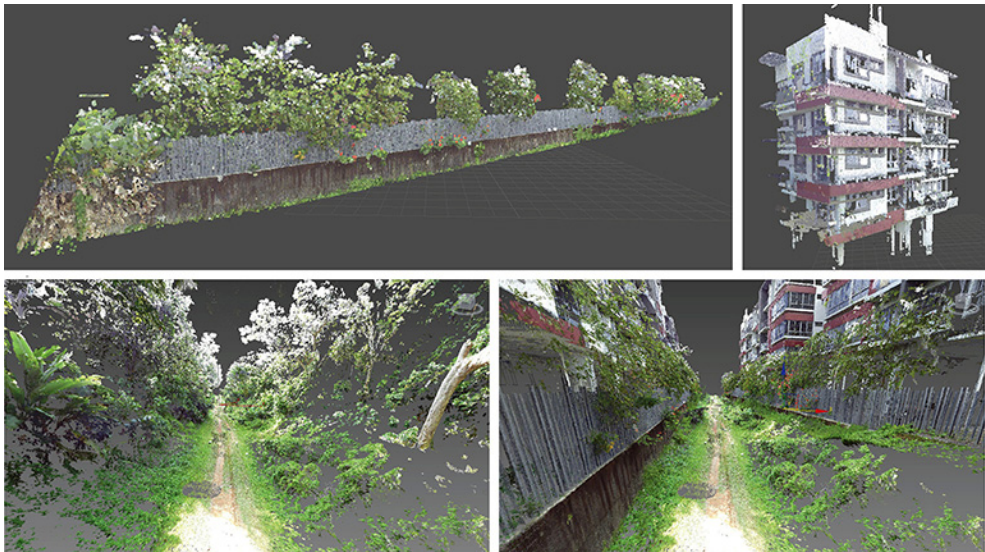


Fig. 9: Designing in the point cloud. Example of manual extraction of elements like fences (top left) or housing estates (top right) from an unstructured point cloud, and insertion of these elements into the original site scan (bottom left) via an interactive design act (bottom right) (Screenshot).



Fig. 10: Example of the effective embedding of range-based site information in combination with site design in Rhino 5.0 (Screenshot)

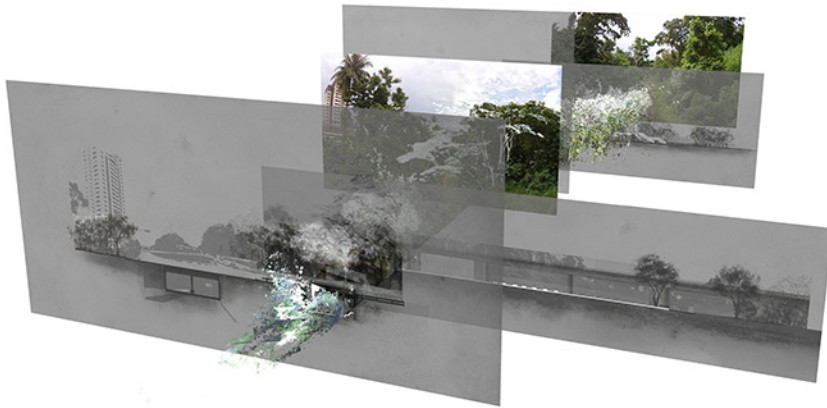


Fig. 11: Example of the embedding of range-based site information, site design and over-view images in form of picture frames in Rhino 5.0 software (Screenshot)

5 Reflection

We prefaced the paper with the aim of having yet to demonstrate the ability to put forth compelling designs that are yielded by our digital commodities. The presented progress is not spectacular – in long years of steady experimentation we have never performed any miracle – but we regard it as a move in the right direction. Finally the plethora of data from different sources and sensors led to a design noticeable informed by geographic context, charily introducing existent landscape and vegetation in their original complexity, beauty and fuzziness – instead of fully substituting it via inept placeholder, excogitated by creative genius. In the end, our subjective impression is – as the design teachers we are deeply in-

volved – that the applied tools, techniques and available field data did result in a design that is more systematic and informed by local context – thus maybe *better* – than without these conditions. We regard further teaching of skills in gathering and handling massive field data as vital for improved design competence in the future.

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References

- FRICKER, P., GIROT, C., MELSOM, J. & WEMER, P. (2012), From Reality to Virtuality and Back Again – Teaching Experience within a Postgraduate Study Program in Landscape Architecture. In: BUHMANN, E. et al. (Eds.), Peer Reviewed Proceedings of Digital Landscape Architecture 2012 at Anhalt University of Applied Sciences. Wichmann, Heidelberg, 130-140.
- FRITZ, A., KATTENBORN, T. & KOCH, B. (2013), UAV-based Photogrammetric Point Clouds – Tree Stem Mapping in Open Stands in Comparison to Terrestrial Laser Scanner Point Clouds. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XL-1/W2, 141-146.
- HAVLENA, M., TORII, A. & PAJDLA, T. (2010), Efficient Structure from Motion by Graph Optimization, in: Computer Vision – ECCV 2010. Springer, Berlin/Heidelberg.
- NATURE SOCIETY SINGAPORE (2010),
<http://nss.org.sg/documents/TheGreenCorridor101103.pdf> (12.12.2014).
- NEBIKER, S., BLEISCH, S. & CHRISTEN, M. (2010), Rich point clouds in virtual globes – A new paradigm in city modeling? Computers, Environment and Urban Systems Journal, 34, 508-517.
- REMONDINO, F. & EL-HAKIM, S. (2006), ‘Image-Based 3D Modelling: A Review’. The Photogrammetric Record, 21 (115), 269-291.
- URBAN REDEVELOPMENT AUTHORITY SINGAPORE, Masterplan 2014.
<http://www.ur.gov.sg/uol/master-plan.aspx?p1=View-Master-Plan&p2=master-plan-2014> (20.12.2014).
- WANG, Y.-F. (2011), A Comparison Study of Five 3D Modeling Systems Based on the SfMPrinciples (Technical Report No. VisualSize Inc. TR 2011-01), Goleta, USA, 1-30.
- WU, C. (2011), “VisualSfM: A Visual Structure from Motion System”.
<http://homes.cs.washington.edu/~ccwu/vsfm/> (03.11.2012).