Human-Tool Assemblage: Designers in the Big Data World

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Abstract: Being able to create data is important for designers to frame problems and ask the appropriate questions in the big data world. In this paper, we present the Community-Centred Urban Sensing approach and introduce the DIY (Do-It-Yourself) urban sensing strategy. This strategy possesses great potential for designers to create multi-dimensional, multi-temporal and site-specific environmental data, but it also raises questions and concerns about the roles and agency of designers and community participants in urban sensing systems. By deploying the concept of the assemblage, we argue that framing urban sensing as a human-tool assemblage can conceptualize 1) the community's role in urban sensing, and 2) the designer's role in this technological system. The discussion helps to cultivate a sense of self-reflexivity − the ability to question the role and agency as data creators and the non-neutral qualities even of purely quantitative environmental datasets. This ability is important for designers who participate in the big data world through data creation.

Keywords: Urban sensing, data literacy, DIY, Arduino

1 Introduction

For years, some landlords in NYC have used a notorious *tenant blacklist* to turn down prospective renters.[1] The *tenant blacklist* is a database of renters who have been in court with their landlords in the past − regardless of the reason or the outcome, sometimes even if when the renter is suing the landlord for inhospitable conditions in an apartment. The database, developed by landlords, deploys data in a way that clearly perpetuates social injustice. In a potentially similar manner, spatial and environmental data are used by designers to frame design problems and propose design solutions; those who have authority over spatial and environmental data have the agency to define the discourse, thus to decide how the physical environment is categorized, represented, designed, and finally constructed. Such constructed environments are burdened with biases and prejudices even if the enumeration of the environment − data − is treated as neutral. An awareness of how these agencies during data creation can perpetuate bias and injustice should, therefore, be a critical part of data literacy for designers operating in a big data world. We use the Community-Centred Urban Sensing (CCUS) to open up a discussion of how the agency is distributed across technological tools, community members, and designers in the data creation process and address the challenges of data literacy among designers and community members.

Extensive literature addresses the concept of data literacy, and the term has been defined in various ways (KOLTAY 2016, GUMMER & MANDINACH 2015, MANDINACH & GUMMER 2013, SCHIELD 2004). Most literature describe the term as data related operations or skills such as collecting, organizing, analysing, and interpreting data, as well as making responsible decisions with the gathered data. To situate the concept within a design context, we define

[1] https://www.brickunderground.com/blog/2014/05/tenant_blacklist

Journal of Digital Landscape Architecture, 3-2018, pp. 397-405. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-642-0, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537642042.

data literacy as the ability to *create*, *process*, and *communicate* data *critically* with the awareness of how agency during these operations can perpetuate bias in design practices. With dedicated researchers and pedagogies, most of today's designers are able to use a variety of analysis tools to process data and use advanced visualization software to communicate data to a broader audience. However, often data is treated as neutral, and how to practice critically is rarely discussed. Moreover, compared to their ability to *process* and *communicate*, designers' ability to *create* data and take part in emergent "data science" linking big data and decision making remains overlooked and underdeveloped. We assert that among the three elements of data literacy, being able to create data is increasingly crucial, both because of growing numbers of data creators among designers and community members, and also because data creation frames problems in the first place and sets boundaries for the questions to be asked.

In today's digital landscape practices, most environmental and spatial data are downloaded or purchased in the form of public or quasi-public GIS data. The utility of these data for site design is in question because 1) the data are collected by public agencies with specific agendas in collecting them and those agendas may not be necessarily align with designer goals or community concerns; and 2) some of the environmental and spatial data simply do not exist for various reasons: political and technological constraints, or simply the excessive amount of manual labour required for data collection (SIEBER 2007). On the other hand, today's environmental design professions such as landscape architecture are still largely outside the mainstream of technological development and investment (CANTRELL & HOLTZMAN 2016), and as a result, there are few providers that design and manufacture tools for data collection or provide technical support specifically for a designer's purposes in data creation. Is it possible for designers to collect appropriate spatial data in the design practices? However, before successfully addressing this question, we argue that designers do not have the privileged knowledge of what the "appropriate" data is unless they make an effort to understand the power of data, their role as data creators in the technology progression, and the non-neutral qualities even of purely quantitative environmental datasets. How to cultivate this sense of self-reflexivity is another challenge that we address in this paper.

Using the CCUS as an exemplar, we present how collecting environmental and spatial data with low-cost, low-tech, Do-It-Yourself (DIY) sensing devices, can actively address data literacy challenges among designers as well as community members. Using the lens of assemblage theory (DELANDA 2016), the urban sensing technology used in the CCUS can be treated as a *human-tool assemblage*. As described below, the concept of the human-tool assemblage not only cultivates the sense of self-reflexivity of designers when working with digital tools but also opens possibilities for the development of strategies to adopt technologies creatively in the digital landscape practices.

2 Background

The past decade has seen an explosion of interest in collecting real-time spatial and environmental data by using sensing and Web technologies and relying on volunteers' participation in data collections. Numerous research entities[2] have developed many urban sensing pilot

[2] For example, The MIT-based Senseable City Lab: http://senseable.mit.edu/, a European Research Council funded project Citizen Sense: https://citizensense.net/, etc.

projects (CUFF et al. 2008, MARTINO et al. 2010, GABRYS 2014), which have shown a great potential for the application of the sensing technology in the environmental design professions. GOODCHILD (2007) uses the term VGI − *volunteered geographic information* − to characterize the spatial information that has been generated by distributed authors. Other scholars in the engineering fields may call it *people-centric sensing* (CAMPBELL et al. 2009), for which the data collections are achieved by people carrying mobile sensors (smartphones) and uploading the data to the urban sensing system actively or passively. Based on the custodian awareness and involvement, LANE and his colleague (2008) have conceptualized the passive and active participation into two types of people-centric sensing strategies − *participatory* and *opportunistic*. When user-generated spatial information relies on a real-time processing mechanism, similar practices can also be termed as *Live Geography* (RESCH et al. 2011).

These works lay a solid foundation for the development of urban sensing projects such as CCUS. However, the concepts of people-centric sensing and VGI, do not necessarily address participation in the technological development of a sensing initiative. Typically, even in participatory sensing, technological development is controlled by those with authorities and specific agendas − institutions, corporations, and governments. At a minimum, VGI and people-centric sensing do not take a clear stance on the technological component of urban sensing. Rather than empowering people with an *ability* to sense their environment, the top-down approaches turn people into sensors of the sensing system for the institutional interests; the data collected by the top-down approaches may not align with what people really care about their environment, and thus the data is not site-specific. Compounding the problem, people's concerns cannot be actively expressed through a top-down sensing system since there is no pathway for these concerns to be communicated as data and the system itself sets boundaries around environmental inquiries. In fact, GABRYS (2016) uses the concept of "idiot" to tease out those human or non-human components that fail to participate or act in "smart" urban sensing systems. How to avoid the creation of "idiots" in a "smart" system, during the process of site-specific data collection, is one of the primary theoretical objectives of the CCUS. With the premise that the people have invaluable knowledge about their neighbourhoods, the CCUS integrates top-down and bottom-up approaches for data collection and our team has sought to incorporate community voices in the technological development. To further illustrate this point, we return to the definition of technology as well as the relationship between human and tools.

"Technology is the practice of making the tools that enable further making. It is also the realm of ideas behind those endeavours, the expanse of knowledge and expertise. At once material, intellectual, active and social, technology is the purposeful organization of human effort to alter and shape environments" (LEE & HELPHAND 2014). But one may use Heidegger's famous essay *The Questions Concerning Technology* originally published in 1954 to critique modern technology including the urban sensing technologies. HEIDEGGER (1977) argues that the essence of *modern technology* is *enframing,* or *Gestell*, which places humans in *standing-reserve*. Indeed, the logic of the big data and urban sensing turns citizens into sensors in the urban sensing system and sets frames for designers' questions to be asked and the answers to be found. However, NEIL LEACH (2002, 2016) critiques Heideggerian approach to modern technology, especially for the application of digital technology in the design profession, for "what Heidegger fails to address…is the progressive way that we come to appropriate technology in general, and tools in particular, and absorb them within our horizon of consciousness" (LEACH 2016). Drawing on this notion of "absorbing" technology, we reject the binary between human and tool and argue that the Community-Centred Urban Sensing approach relies on treating urban sensing technology as a type of *human-tool assemblage.* In his recent work *Assemblage Theory* in 2016*,* Manuel DeLanda offers a close reading of the concept of assemblage in *A Thousand Plateaus* by Deleuze and Guattari: assemblages emerge from the interactions between the heterogeneous components and the properties of the assemblages are emergent and irreducible (DELANDA 2016). In a similar strand, LEVI BRYANT (2014) uses the concept of the *machine* to describe a thing (an idea, a person, or a tool) that operates, and the coupling of the machines (the assemblages) to enable the flows across the systems. Now, we can further illustrate how these ideas help to understand the role of a community member in the CCUS and the role of a designer in this human-tool assemblage.

3 Community-Centred Urban Sensing (CCUS) and DIY Sensing Devices

CCUS is an on-going project. In this paper, we only present preliminary findings and lessons learned from Phase One (Summer 2017). CCUS uses a series of customized digital tools to collect environmental data, visualize the data with an interactive web-based map, and collect feedback from community members by allowing them to participate online and in the data collection process in two neighbourhoods in Charlottesville, Virginia, United States (Fig 1). The end product is a customized digital infrastructure that empowers communities with the ability to better sense their environment, express their voices in the form of data through digital infrastructure, and feed the community data into the city's decision-making processes. In phase one, there were three student research assistants and one volunteer from one of the neighbourhoods who helped with the data collection by walking with the devices. Our three core members also participated in the data collection processes by mounting the devices on two vehicles.

Fig. 1: Screenshot of a version of CCUS web maps. The radius of the white dots represents the light level. Users can overlay other information such as income, race, etc. to examine intersections between the environment and social issues.

CCUS was initially developed primarily with guidance from the City of Charlottesville, seeking to collect street light data at night. The City plans to improve its street lighting systems, and there is no adequate dataset that maps existing city-wide lighting conditions. While our team believed that "street lighting data" in the City should be far more complex than quantifying nighttime light levels to identify gaps in the light grid, the meeting with the community members confirmed this assumption. In the community meetings, we also learned that compared to light data, which was the city's interest, the communities were, in fact, more concerned about other environmental issues such as noise pollution, and these concerns vary across different neighbourhoods. This finding resonated our team's initial concept that CCUS project should not be a one-time investment data inquiry, but a framework through which different communities can sense, visualize, and ask questions about the environment from different aspects based on their concerns and knowledge about the place that they call home. In this framework, the urban sensing technology no longer manifests as a tool that can be used by governments, designers, or community members to collect data, but a *human-tool assemblage* in which designers, community members, governments and sensing devices are all important components, and the interaction of them enabled the capacity of the CCUS to collect site-specific data that reveals the real issues of the place.

CCUS uses DIY sensing devices. Many successful projects such as Safecast radiation monitoring[3], senseBox citizen environmental sensing[4], and Blitzortung real-time lightning monitoring[5] have proven the reliability and potential of the DIY approach. Indeed, DIY approaches (including hacking existing technologies, and fast prototyping) have significantly contributed to technological development in the design professions (CANTRELL & HOLTZMAN 2016). We believe that including inputs from the community during technological development is best characterized as a DIY approach. This DIY approach allows our team to work with the community to sense their environment. Inspired by an open source tutorial on the Instructables,[6] the team has revised the original design by adding more sensors to the devices and optimizing the Arduino codes to meet the goals of the project. The devices can be further illustrated in Table 1 and Figure 2.

Table 1: Parts and specifications of one DIY sensing device

Part	Model	Price*	Function
Microcontroller	Arduino Uno Rev3	$22.00	Execute the program to control the input/output peripherals, such as sensors, servomotors, LEDs, etc.
Light sensor	TSL2561	$5.95	Measure the illuminance (light level) in lux.
Colour sensor	TCS34725	$7.95	Measure the colour temperature in Kelvin to determine the colour of the street light.
Sound sensor	MAX4466	$6.95	Measure the decibel levels.
GPS	MTK3339 breakout V3	$39.95	Provide geographic locations (longitude and latitude) and GPS times.
Data Logger	MicroSD card breakout	$7.50	Log the data onto a microSD card in the CSV (comma separated value) format.
CO_2 sensor	SKU: SEN0159	$56.00	Measure the CO_2 concentrations in ppm (parts per million).
Enclosure	Custom made	N/A**	Protect the device.

*The price listed is in US dollars without taxes.
**The enclosures are custom designed and are made of recycled acrylic sheets.

3 https://blog.safecast.org/
4 https://sensebox.de/
5 http://en.blitzortung.org/live_lightning_maps.php
6 http://www.instructables.com/id/Darkness-Map-Data-Collection-Device/

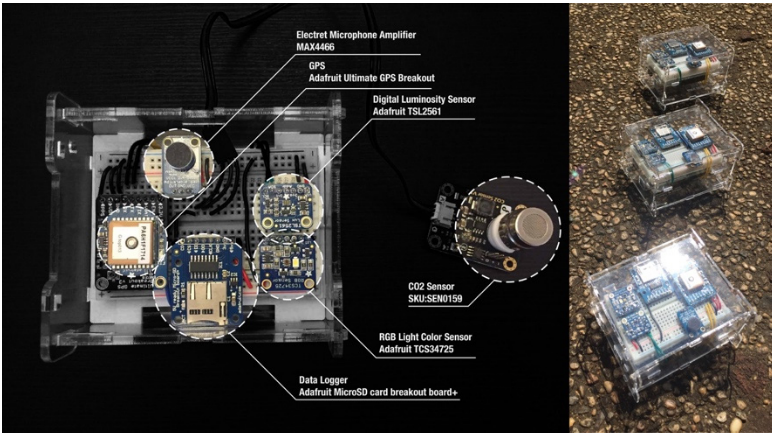

Fig. 2: Sensing devices. Model A can collect light, sound, colour, location data. Model B can also collect CO_2 data.

The sensing devices are flexible, low-cost, and relatively easy to build. First, the devices are able to collect multiple environmental features, and they are flexible enough so that the sensors can be easily added or removed based on the different needs of the community. Second, the cost is another concern if the approach can be replicable. The cost of the devices ranges from $ 80 to $ 130 US dollars depending on the capability of the devices. Since the devices are designed to be flexible, all of the sensors and boards can be disassembled and reused for other projects. Last, designing and building the devices do not require professional knowledge in engineering and computer science. There are numerous tutorials and open source examples to follow, and only basic physical computing and coding knowledge[7] are needed. With the increasing number of design programs offering courses on these topics in the United States, it is likely that in the near future designers with the interests to develop their own sensing devices will be able to easily find their needed resources.

4 Discussion: Human-Tool Assemblage

The CCUS project introduced above shows a great potential for application of DIY sensing strategy in the landscape profession, but it also raises some questions concerning the role of designers and community participants in a sensing system, and the agency of the designers and community members in the development of technological systems when working in a data science context. The *human-tool assemblage* presents a critical lens to provide a constructive analysis. On the one hand, rather than turning community members into sensors, the CCUS constructs the human-tool assemblage by allowing community members to exercise their agency in technological development. In a sense, community members are active human components, without which the CCUS would lose the capacity to address environmental issues based on the different communities' concerns accordingly.

On the other hand, the concept of *human-tool assemblage* challenges us to reimage what it means to be a designer in the big data world. Self-reflexivity leads us to realize that designers

[7] Arduino Software (IDE) is based on Processing; the coding language is series of C/C++ functions.

are in fact part of the human-tool assemblage: designers can exercise their agency by developing strategies, but these strategies are inevitably modified by other human or non-human components through interactions in the assemblage. For example, community input modified the original intention and strategy and the Arduino based collection tool enabled the flexibility of the project. Working with technological systems in a big data world, it is not designers who construct the environment, but it is *human-tool assemblages*, in which designers are active parts, that exercise the capacity to shape the world around us. And this capacity is irreducible to any human and non-human components in an assemblage. An important lesson learned through analysing the CCUS is the self-reflexivity when working with digital tools in the big data world: first, designers should recognize how they may exercise their agency by developing strategies with the facilitation of digital technologies. Second, designers should realize how a specific technology in turn structures and limits landscape strategies, thus exercising its framework of compliance and resistance to rearrange social and ecological relations in the constructed environment.

5 Conclusion

By introducing the concept of data literacy in the design context, we first argue that being able to create data is important for designers to frame problems and ask the right questions in the design process. Traditionally, in the landscape profession, designers acquire data from secondary sources, so the design questions are inevitably bounded by the quality and the resolution of data, and burdened with the categorical biases of the creators of the datasets. Using the DIY sensing strategy, designers can ask critical questions outside the existing discourses and create their own datasets to address emergent issues. This shifts the role of designers from data consumers who follow the trends, to data creators who define the discourse. Since the DIY approach introduced in the CCUS is flexible, low-cost, and relatively easy to replicate, we can expect a growing number of interests in this area. This suggests that landscape design programs should invest resources in the research and education in physical computing and coding for the next generation of landscape architects who can actively participate in the big data world.

The CCUS also raises questions concerning the role and agency of the human components including community members and designers in the sensing systems. Using the lens of assemblage theory, we rely on the concept of *human-tool assemblage* to understand the CCUS and conceptualize the role and agency of community members and designers in the technological systems. On the one hand, community members are active human components in the urban sensing framework. On the other hand, designers' strategies can be modified through the interaction with digital tools and other human components, i. e. community members.

The self-reflexivity − the ability to keep questioning the role as data creator in the human-tool assemblage, and whose agency that has been permeated in the data creation − keeps raising new challenges that need further investigation. One of them is realizing the fact that, in the CCUS, even though designers can create data through DIY approach, the sensors and boards are in fact designed and manufactured by firms according to specifications that are standardized by organizations and corporations, and the CCUS project is funded with an academic research grant with clearly defined research agenda. How much will the agency of manufactures and institutions be carried out in the final dataset? Where is the boundary of this human-tool assemblage? To answer these questions, we suggest future research on urban technologies should draw ideas from the extremely diverse field of Science Technology and Society (STS). In the end, it is designers who bring all the socio-technical resources together to create environments as stages where other relations unfold. So, it is important for designers to know their roles in the ever-expanding socio-technical system and to practice in a self-reflexive manner.

Acknowledgements

The authors thank the student research assistants and community members who participated in the data collection and creation process.

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