Human Factors in Responsive Landscapes: Importance and Method

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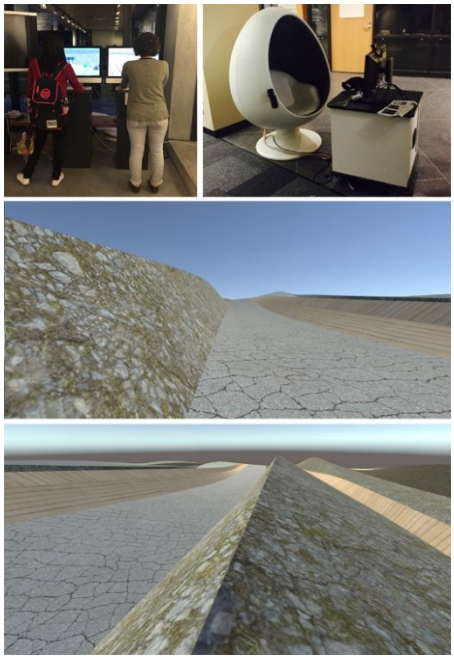
Abstract: Current ecological thinking posits humans as the major contributor to the changing environment. Drawing ecological theories from science and philosophy, this paper suggests that designers should prioritize the study of human interactions with the environment in landscape research, and thus, human factors need to be addressed in developing and conceptualizing responsive landscapes. This paper identifies human factors in the responsive landscape framework and introduces game engines as a type of responsive technology to facilitate the study of human factors in responsive landscapes. Through constructing interactive representations that simulate interactions between human and non-human factors, designers can establish relations with more robust ideas in responsive landscapes that could better respond to unpredictable cultural practices. The method proposed by this paper also allows for opportunities to develop responsive landscapes that are not only ecologically supported but also experientially enhanced.

Keywords: Responsive landscapes, human factors, simulation, video game

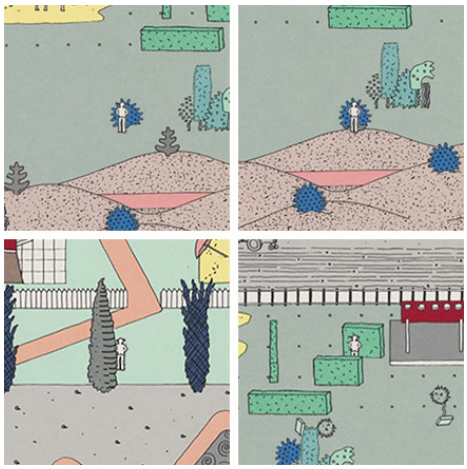
1 Introduction: A Juxtaposition of Two Games



This is a workflow that provides instant experiential feedback during the generative design process. The 3D model is developed in Grasshopper, an algorithmic modelling plugin for Rhinoceros 3D modelling software. The VR environment is developed with Unity game engine and represented with Oculus Rift. Generative design is usually used in form-finding, based on rules or algorithms that rely on scripting platforms such as Grasshopper, Processing, etc. The output of the algorithms will be judged by the designers who then would change the algorithms until they find the most satisfying forms. Since the output is usually represented as images on the computer screen, the experiential quality cannot be judged until the form is realized. This workflow provides an extended representational output in the virtual environment to stress the experiential aspect of the forms.

Fig. 1: Landform virtual reality (VR)

Journal of Digital Landscape Architecture, 2-2017, pp. 10-17. © Wichmann Verlag, VDE VERLAG GMBH · Berlin · Offenbach. ISBN 978-3-87907-629-1, ISSN 2367-4253, e-ISSN 2511-624X, doi:10.14627/537629002.



This game is in the form of a third-person role-playing game (RPG) on multiple platforms including WebGL, Windows, and MacOS. The background image is from OMA's competition drawing for Parc de la Villette.[1] Players can experience the pro-posed park by exploring the gaming environment and interacting with the game objects. Using this method, designers can simulate human interactions with pro-posed landscape and can study human behaviours in the proposed environment.

Fig. 2: OMA's Parc de la Villette RPG

Simulation[2], as "numerical experiment," a local model lying between theory and experiment (WINSBERG 2003), is useful landscape research strategy that uses abstraction to generate knowledge (SWAFFIELD & DEMING 2011). Building simulations are important to visualize and understand the complex systems in developing responsive landscapes (CANTRELL & HOLZMAN 2016). Video games are a type of interactive or human-in-the-loop simulation that emphasizes processes in which human action is an important consideration and studies human behaviours in the complex systems (ROTHROCK & NARAYANAN 2011). This raises a question: can landscape architects use interactive simulations, such as a game, to simulate human factors in landscapes? Another question lies before this one: why do human factors need to be addressed in responsive landscapes and how do they manifest?

CANTRELL & HOLZMAN (2016), in the book *Responsive Landscapes,* have forecasted an emerging paradigm of "robotic ecology", in which landscapes will be hybridized with artificial intelligence and thus constructed ecosystems will have the heuristic capacity to evolve and better respond to disturbance and dynamic inputs across scales (CANTRELL & HOLZMAN 2016). On the other hand, ALBERTI (2016) calls for "cities in which humans are key players in nature's game … cities that rely on wise citizens and not just smart technologies" (ALBERTI 2016). By reviewing some current ecological theories, this paper asserts that human factors are equally if not more important than, non-human factors in ecosystems, therefore human factors should not be neglected within the responsive landscape framework. However, study about human factors in responsive landscapes remains an underexplored territory. This paper posits "interactive representation" to describe a design drawing/model that is represented in an interactive or human-in-the-loop simulation. On the one hand, the simulational quality could help designers to study a landscape system with human factors in it. On the other hand, the representational quality situates design ideas and concepts, rather than the performative aspects, in the simulation: interactive representation is essentially a simulation that simulates interactions between human factors and non-human factors. The workflow proposed by this paper could facilitate designers in developing robust ideas in responsive

[1] http://oma.eu/projects/parc-de-la-villette

[2] Simulations in this paper only refers to computer simulations.

landscapes that better respond not only to environmental inputs but also to unpredictable cultural practices.

2 Human Factors in Anthroecological Landscapes

It is not a novel idea to integrate humans into ecological studies. In fact, this idea has been discussed in multiple disciplines throughout time. Historically, Chinese philosophers suggest *li* (patterns) of nature, rather than Law of Nature; the latter is a human construct imposed onto nature, but the former is the pattern in nature so that humans and non-humans are all equal elements of the vast pattern (LACHAPELLE 1992). This idea echoes the "deep ecology" and "ecosophy" movements that acknowledge the intrinsic value of all beings and assert the human-nature reciprocity, for which the prosperity of the human societies depends on the flourishing of the "more-than-human whole" (NAESS 1973, 1989; XIANG 2016). These ideas would all favour the object-oriented ontology, which states that beings exist in a "withdrawn" way, refuse direct access, and influence each other aesthetically at a distance (MORTON 2016). At the same time, the Anthropocene posits humans as the major geological factor that changes the Earth systems (CRUTZEN 2002, STEFFEN et al. 2015, STEFFEN et al. 2007). ELLIS (2015) proposes anthroecology theory to argue that the old notion of "natural systems with humans disturbing them" should be replaced by the new paradigm that "societies are sustaining an anthropogenic biosphere" (ELLIS 2015). Despite different languages used when describing their ideas in these theories, there is a shared consensus that humans are an intrinsic part of ecological studies of any kind.

In the United States, landscape architects have taken on ecology as a model to approach design since the 1960s. SPIRN (1995, 2000) reviews two important figures in the U.S. landscape history – Fredrick Law Olmsted and Ian McHarg: the former practices landscape design through reconstructing nature and the latter takes on scientific rigour through designing with nature (SPIRN 1995, 2000). Their practices demonstrate the development of the perception of nature among the landscape profession from an early understanding that nature is a pristine entity and a resource for social utility to a more sophisticated recognition that the complexity of the natural processes needs a scientific approach – ecology – to study and analyse. The legacy of McHarg is not only the infusion of scientific techniques and approaches in design processes but also a conception of ecology as the model for interpreting landscapes. This idea, while radical at the time, has now become a common practice. Though there are critiques from those who hold the belief that landscape architecture is in the realm of art, the norm of beauty has already been altered by ecology. MEYER (2008) asserts that aesthetic experiences in ecological landscape "can result in the appreciation of new forms of beauty that are discovered … because they reveal previously unrealized relationships between human and non-human life processes" (MEYER 2008). In practice, Yu's "Big-feet" landscape movement seeks to cultivate an appreciation of productive and ecological landscapes in Chinese cities (YU 2009).

When the conception of ecology and human-nature relations evolve in science and philosophy, designers and urbanists start to introduce these ideas into works and reconceptualise *ecologies* in landscape design (REED & LISTER 2014). ALBERTI (2016) argues that cities are hybrid ecosystems and "we are nature" (ALBERTI 2016). Similarly, BALMORI (2014) suggests that "nature is heterogeneous and constantly changing, and that we are an intrinsic part of it"

(BALMORI 2014). The aforementioned theories in science and philosophy indicate that in the Anthropocene, ecology is not only ecological but also anthropological: it is time to reinsert humanity into ecological practices. Since humans are the ones who serve as stewards of the ecosystems that we make, human factors need to be studied in the anthroecological landscape. Human factors or ergonomics refer to studies of interactions between humans and their surrounding environment including machines, the ambient environment, etc. with a goal to optimize the safety, comfort, and efficiency of the system (DEMPSEY et al. 2006). For example, to study the human comfort in architectural design is to prioritize human factors in the architectural systems. However, most conventional studies in human factors are anthropocentric – the goal is to optimize the system to benefit humans and their societies. However, the anthroecological landscape requires designers to study human factors with the goal to achieve the mutual flourishing of both human and non-human natures.

3 Human Factors in Responsive Landscapes: People as Data, Experiences as Outputs

Paradoxically, although we have realized the significant role of human activities in environments, human factors are not made specific in the current responsive landscape framework. In other words, anti-anthropocentric concepts should not result in practices that hold misanthropy, rather the human agency should be embraced and utilized, and thus human factors should be emphasized and studied. To make clear how human factors manifest in responsive landscapes, we need to look closely at how the responsive landscape plays out in the anthroecological framework: *it is a twofold system with two layers*. At the top layer is the anthroecosystem; it is the physical manifestation of the complex interactions among human and non-human beings. At the bottom layer is a responsive system that records the phenomenon in the top layer as data, processes the data and responds with an output. The output causes an updated phenomenon in the top layer and changes how the anthroecosystem functions. The new phenomenon at the same time feeds back into the responsive system as a new input. The "causal chain of response is the feedback loop and is central to self-regulating or evolving systems" (CANTRELL & HOLZMAN 2016).

Human factors manifest in both layers of the responsive landscape. In the top layer, the anthroecosystem, cultural practices as collective human decisions based on values will change how this system functions: "good practices" help the co-flourishing of human and non-human natures, while "bad practices" cause negative impacts to either or both natures. In the underlying responsive systems, human factors manifest in both ends of the responsive system: inputs and outputs. At the inputs end, cultural practices should be captured as data, and we are already doing so in some fashions such as crowdsourcing. The question is: what does it mean to emphasize human factors in the output? Answering this question requires us to review the goal of responsive landscapes – to co-evolve with changing environments. So, emphasizing human factors means that cultures and societies also need to evolve. This requires cultivating values that motivate "good practices" which help the mutual flourishing of human and non-human natures. However, how do we cultivate values in the ecological context? XIANG (2016) posits *ecophronesis* to introduce Aristotelian *phronesis* – practical wisdom – in the context of ecological practices, which refers to "the master skill par excellence of moral improvisation to make, and act well upon, right choices in any given circum-

stance of ecological practice"; it is "motivated by human beings' enlightened self-interest, which asserts that it is in human being's self-interest – ethical, moral as well as material – to respect and appreciate the intrinsic value of all living and non-living beings on the earth" (XIANG 2016). In this regard, the goal of responsive landscapes in the anthroecological framework should not only concern the ecological functions but also enhance the human beings' enlightened self-interest to motivate "good practices." This requires responsive systems, at the output end, to enhance the performance of beauty and experience which will serve as "vehicles for connecting with, and caring for, the world around us" (MEYER 2008). In this way, responsive landscapes are not only ecologically supported but also culturally enhanced.

4 Study Human Factors with Game Engines

Since building models and simulations can help designers to better understand the complex systems (CANTRELL & HOLZMAN 2016, SWAFFIELD & DEMING 2011), it is important to develop methods to simulate human factors and their relations with other non-human factors. Most of the current landscape simulations only cover non-human aspects, e. g. simulation of the yearly solar radiation of the site, simulation of the hydrology, fluid dynamics and sedimentation of a river over time. Developing simulations that involve human factors in landscape design is still an underexplored territory.

Video games as a type of human-in-the-loop simulation have the potential to simulate systems with both human and non-human factors in them. In fact, using games to emphasize design and environmental issues has been explored in different fashions by architects and researchers. Jose Sanchez and his Plethora Project, for example, have designed "block'hood", a sandbox game in which players can build their neighbourhood with blocks including apartments, houses, wind turbines, parks, and other urban typologies. Each block has environmental inputs and outputs, and the goal is to create a sustainable neighbourhood that fights for decay. This game has been used for exploring players' creation and interactions, serving as an educational tool for players to realize the complex problems that a city faces (SANCHEZ 2015). Another example is UVa Bay Game, which uses the multi-player game platform as a simulation to study complex real-world problems (LEARMONTH et al. 2011). Different players can choose to become farmers, fishers, legislators, or other roles and they can make decisions based on their goal. The decisions will then pass through a complex algorithm that is developed by experts from different disciplines. The outputs are various scenarios such as environmental degradation, economic growth, etc. The game can serve as a platform for multidisciplinary collaborations and for experts to test their theories in the simulated experiment.

Rather than arguing for a complex, holistic and multidisciplinary platform that emphasize real-world landscape problems, this paper suggests that when open-source game engines – a software designed for video game development – become more available, designers who are interested in digital technologies could construct *interactive representations* with game engines to simulate a system that involves human factors. This method first asks designers to import their design drawings/models into an open-source game engine, such as Unity. Then through simple operations setting up physics, adding players' controller and object interactions – designers can quickly turn their static design drawings/models into quasi-games. Finally,

designers can export the games into stand-alone software. By enabling VR setting in the export process, the product can be experienced in a VR environment (Fig. 1). Alternatively, by exporting as WebGL, the games could be easily uploaded online (Fig. 2).

A quasi-game produced using this method is an *interactive representation* that simulates interactions between human decisions and design ideas. In other words, the systems being simulated are different relationships between human factors and non-human factors in the proposed landscapes. SCHEER (2014) asserts that the inevitable gap between signs and reality causes ambiguity in representation, and the ambiguity creates opportunities for creative expression in the design process. Simulation replaces the reality with signs so that design will eventually focus on the performance rather than ideas (SCHEER 2014). However, since the gaming scenes are constructed based on design drawings, the representational quality can be preserved in the gaming environment, so that the design ideas can also be simulated. For example, in the preliminary test, the author uses think-aloud METHOD (BOREN & RAMEY 2000, CHARTERS 2003), by asking participants to play the "Parc de la Villette RPG" and at the same time verbally report their thinking process. By observing their behaviour in the gaming environment and analysing their verbal reports, interesting patterns show up. Participants tend to move the avatar towards the pond and verbally describe the water feature. This evidence opens up discussions such as whether the water features in the drawing would become the most attractive element in the landscape. More importantly, designers could base on such results to adjust design proposals accordingly.

5 Discussion and Outlook

Drawing theory from the current discourse in ecologies in science and philosophy, which posit humans as the major contributor to the changing environment, this paper suggests that including the study of human interactions with the environment in landscape research should be prioritized, and thus, human factors need to be addressed in developing and conceptualizing responsive landscapes. This paper identifies human factors in the responsive landscape framework. As input, people are data, and cultural practices need to be recorded. As output, the performance of beauty and aesthetics should be emphasized with responsive technologies in order to construct experiences that cultivate human beings' enlightened self-interest to respect and appreciate the intrinsic value of all beings. The appreciation, in turn, motivates people to perform "good practices" that benefit both human and non-human natures.

This paper also introduces game engines as a type of responsive technology for studying human factors in the landscape research. Designers can experiment with and study human behaviours by simulating interactions between people and the proposed landscape in the "interactive representations." On the one hand, representational quality allows for different interpretation during the simulation process so that through observing participants' interactions with design ideas and analysing their verbal reports, possible scenarios can be tested. Designers can adjust design according to different scenarios in the simulation before the project is realized. On the other hand, simulational quality allows designers to study human factors in the simulated experiment, in turn developing responsive landscapes that are not only ecologically supported but also experientially enhanced.

This paper presents some unresolved issues which merit further study and exploration. Future research on human factors in responsive landscapes requires interdisciplinary collaborations, particularly with the well-established discipline of human factors and ergonomics. Moreover, to effectively carry out the method requires a clear workflow and more systematic evaluations. Research methods employed in user interface evaluation such as think-aloud protocols show potential to support this proposed workflow. Collaboration between researchers and practitioners is crucial for this method, and research through practice is the only way to refine the workflow in real-world scenarios. Since the technology introduced in this paper requires knowledge in programming and software development, the method requires pedagogical support in schools. The multi-disciplinary nature of the method also suggests different modes of practice for landscape architects with specialties in digital technologies.

Acknowledgement

The author thanks Guoping Huang and Michael Lee for their deep thoughts and contributions to the paper. The author also thanks Chad Miller and Shurui Zhang for their support.

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