Performative Ornament: Enhancing Humidity and Light Levels for Plants in Multispecies Design

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Abstract. The paper shifts the design conversation from a human-centered design methodology to a posthuman design, considering human and nonhuman actors. It asks how designers can incorporate a multispecies approach to creating greater intelligence and performance projects. To illustrate this, we describe a project of "ornaments" for plants, culminating from a course in an academic setting. The project methodology starts with "Thing Ethnography" analyzing the movement of a water bottle inside a house and its interaction with different objects. The relationship between water and plant was chosen to be further developed, considering water as a material to increase environmental humidity for the plant and brightness through light reflectance and refraction. 3D printed biomimetic structures as supports for water droplets were designed according to their performance and placed in different arrangements around the plant itself. Humidity levels and illuminance of the structures were measured. Ultimately, this created a new approach for working with plants and mass customization. The paper discusses the resultant evidence-based design and environmental values.

Keywords: Posthumanism · Nonhuman · 3D printing · Thing ethnography · Multispecies design

1 Introduction

The human-centered paradigm has dominated design for over three decades. Designers are currently being challenged to work on complex socio-technical systems due to the ramifications of technology and environmental transitions [1]. The paper shifts the design conversation from a human-centered design methodology [2] to a posthuman design [1], considering human and nonhuman actors. It asks how designers can incorporate multispecies [3, 4] and "design for all-life" [5] approaches to create projects with greater intelligence and performance. The study includes research on biomimicry strategies to investigate how ergonomics operate when designing for nonhuman bodies and better design performance.

The paper provides a posthuman reading of the notion of "user", moving beyond anthropocentrism [6] towards biocentrism [7]. It examines examples of emerging design

P. F. Yuan et al. (eds.), *Hybrid Intelligence*, Computational Design and Robotic Fabrication,
https://doi.org/10.1007/978-981-19-8637-6_41

techniques that stress the rising discourse of posthumanism [8] and suggests that non-human lifeforms should be included as partners in design research, either as informants and co-designers or as users. To illustrate this, it describes a project that designed a set of "ornaments" for plants, which culminated from a course in an academic setting. As a novel contribution to the field, the work extends traditional understandings of the "user" to nonhumans and questions the field of action for the contemporary design practitioner.

The project methodology starts with "Thing Ethnography" [9] analyzing the movement of a water bottle inside a house and its interaction with different objects. The relationship between the water and plant was chosen to be further developed, considering that the lack of humidity and light in internal environments affects plants and that water can be used as a material to create a wetter microclimate and enhance brightness through reflection and refraction of light. The plant could be relocated to another space under different conditions, but sometimes, a plant is wanted in a specific place, regarding the functionality of an internal environment. So, water was introduced into the project to amplify light using 3D printed biomimetic structures as supports for water droplets. These design decisions became beneficial and evolved according to their performance. The structures can be combined and arranged in different ways around the plant as architectural elements staged around the individual plant specimen, as long as they don't block the sunlight of the leaves. These arrangements were important because they allowed for an evidence-based design tuned for maximum performance and plant health. Humidity levels and illuminance of the structures were measured using an in-door hygrometer, Inkbird ITH-20, and a digital lux meter HoldPeak 881D.

Ultimately, this created a new and novel approach for working with plants as nonhuman actors and recognizing the potential of "other-than-human" perceptual capabilities and mass customization. The results pointed us to a deeper understanding relative to nonhuman design, ergonomics, and design performance to gain insight into desirable nonhuman situations.

2 Posthuman Design and Multispecies Theory

The traditional dualistic systems of natural and artificial, human and animal, human and machine, are blurring because of technological advancements. They emphasize the new sorts of agency that nonhumans, whether environmental or technological, have in the world. A rising body of social theory has arisen around concepts that aim to make sense of this blurring of boundaries and introduce hybrid, non-dual, relational modes of thinking [3]. This paper focuses on one of these hybrid modes of thinking, particularly the posthuman, for a design practice that considerably increases our understanding of the many agencies, dependencies, entanglements, and relationships following current problems and questions facing the design field [1].

The human-centered design methodology is a practice where designers focus on human needs [2]. However, humankind is just one of many variables that shape our environments, and its agency is constituted through relational processes rather than predetermined. As design moves into the social sector and deals with issues in complex socio-technical systems, it's critical to change this approach to a broader one, such as a posthuman design, considering human and nonhuman actors. The work being done in post-humanist and post-anthropocentric disciplines argue that we should start thinking of manufactured systems as networks that encompass a variety of living creatures and the agency structures that act in and around them to understand our planet's transitions better.

Also, design can function as a process-oriented critical instrument rather than being interpreted as an affirmative discipline. One area open to exploration concerns the design of re-interpreting man's relationships with other species and the environment, proposing future multispecies cohabitation scenarios. Exploring multispecies worlds to learn about environmental challenges requires designers to become familiar with alternative methodologies, intended to be more than just collections of procedures but also distinct ways of behaving, thinking, and experiencing [10].

The word "multispecies" first appeared in the fields of biology and ecological sciences more than a decade ago to describe patterns of co-construction of environmental niches and wildlife management [3]. Its recent arrival into the discipline of anthropology has aided in the development of new interpretations of the notion. The concept of multispecies provides a starting point for reconsidering the role of nonhuman participants in the design and related processes. Also, it extends the concept of sustainability because examining environmental challenges from nonhuman perspectives could lead to different outcomes rather than those envisioned through technocentric methods [10].

This paper describes a project that proposes a speculative design that engages human and vegetal perspectives to create a multispecies reading of the concept of light quality, reflectance, refraction, and humidity in interior spaces.

3 Theoretical Underpinnings for Methodology

3.1 "Thing Ethnography"—Water

Ethnographic research is a design approach that uses observation and interview techniques to learn about the people who will use the designed objects. The fundamental concept is that a detailed understanding of people's lives, habits, motivations, and challenges can lead to better products or, at the very least, more relevant design proposals. Ethnographers and anthropologists spend extended amounts of time engaged in the people they study, enjoying daily life with them. They observe, photograph, record, take notes, interview, etc. and generate hypotheses, texts, and publications based on these activities to establish their academic credibility [11]. Designers are exploring this knowledge and ethnographic tools to come up with new ideas, develop concepts, and put them into action [12].

However, beyond standard ethnographic research, this project was based on "Thing Ethnography" based on Elisa Giaccardi and other authors' study with nonhumans [9]. They state that we shape objects as humans, and objects also shape us. Recognizing this continual interplay between people and objects necessitates anthropological and design methods that allow both parties an equal voice. They also affirm that things that inhabit our houses demonstrate different degrees of dynamism and emplacement. In our project, "Thing Ethnography" was developed by analyzing the movement of a water bottle inside a house and its interaction with different objects (Fig. 1). Water was chosen because it is necessary for humans' and nonhumans' survival. Also, a water bottle is one of the most dynamic objects in our homes as it moves through space, occupying multiple ecosystems.

According to "Thing Ethnography", paying attention to movement reveals how objects interact: they live in communities of things and behaviors that are sometimes distinct and sometimes overlapping. This knowledge raises concerns about the habitats in which they operate. Our research wasn't equipped with software or sensors differently from Giaccardi's one; ours was a simple analysis of the movement of a water bottle throughout the day. However, it was interesting to understand which objects a water bottle interacts with day-to-day and could potentially develop a better relationship. In this case, the one between a water bottle and the plant. So, the project's starting point was the following question: how could the relationship between water and plant be enhanced?

This research also tackles the concept of co-performance. According to Giaccardi and Kuijer [13], co-performance views artifacts as capable of learning and performing alongside humans. Co-performance recognizes the dynamic contrasts in capacities between humans and objects from this perspective and emphasizes the inherently cyclical relationship between professional design and use. In our proposed scenario, we decided to focus on the capacity of artifacts to perform alongside humans. Both plants and humans establish a mutualistic relationship within a win–win scenario. Nonhumans and humans need water and light to survive, so when designing to enhance one's performance, the other will automatically increase. The idea is that when there is co-performance, both species can thrive and generate greater cooperation between humans, nonhumans, and the earth. Lovelock extends this concept by posing the earth as a self-regulating entity [14].

Fig. 1. "Thing Ethnography": the study of the movement of a water bottle inside a house and its interaction with different objects.

3.2 Biomimicry Strategies

With the analysis of the plant and water relationship, the "Thing Ethnography" led to the initial idea of designing 3D printed structures embedded with water that would create a wetter microclimate for the plant and enhance the light in internal environments through reflection and refraction. This design necessity was observed because of discoloration on certain leaves due to a lack of humidity and light in specific situations. Two biomimicry strategies were used to support the design of the structures in this project.

The first one was related to how nature optimizes sunlight. There is a silvery-whitish-gray shrub native to deserts of the southwestern United States called The Desert Holly, scientific name *Atriplex hymenelytra;* its strategy to deal with sunlight in the desert is very effective. It needs sunlight to do photosynthesis, and mainly it gathers different sunlight rays, such as the morning and the evening sun, due to its fragmented and tilted in high angles leaves. So, the plant takes advantage of the sunlight that is not so strong during these periods, but at the same time, it has a silver-colored feature to help reflect sunlight when it is too strong [15].

The second one was related to how nature collects and retains water. The Namib desert is home to Darkling beetles, and to survive, some species of these beetles include unique points and bumps in their wing scales that aid in water collection. Water droplets occur as air condenses on the tips, which run off the bumps and into the beetle's mouth [16]. Warka Tower, a biomimetic project inspired by the beetle, similarly gathers atmospheric water vapor from rain, fog, or dew which condenses on the polyester mesh's cool surface, generating droplets of liquid water that flow down into a reservoir at the structure's bottom [17].

These two survival strategies of the Desert Holly and Darkling beetles were applied to the shape and geometry of the structures for better performance (Fig. 2).

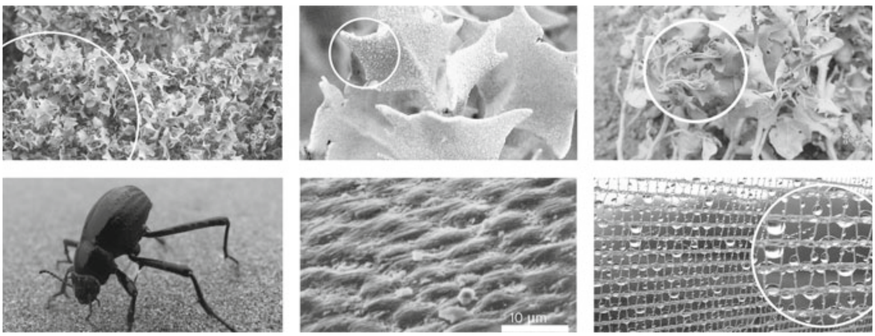

Fig. 2. Desert Holly, angulation of leaves; Darkling Beetle; scanning electron micrograph of the textured surface of the depressed areas on Stenocara surface; atmospheric water vapor condensed on the Warka Tower mesh's surface.

4 Methodology

The design of the structures started based on the different angles of the fragmented leaves of the Desert Holly as a strategy to capture more sunlight. One structure was composed of a hexagon with six triangles bent in opposite directions due to a "v" shape join design on the geometry. The connections between them were thought to be on the extensions of the edges of two triangles, implying different design typologies. The structures were 3D printed using Polylactic Acid (PLA). An object that would interact with the plant should be composed of natural and compostable materials just like the plant, in this case, PLA and water. Also, they should be lightweight to better adjust to the plant's ergonomics. They were printed as flat structures and then folded for efficient storage and transport, like origami (Fig. 3).

Fig. 3. First 3D printed structures: flat, bent, and a different typology showing the connection.

In parallel, textures were studied based on the Darkling beetle and Warka Tower to understand how water droplets could be stored within a mesh. However, the 3D printed structure would not harvest water from the air, but just store sprayed water differently from the examples above. The structures were used as supports to accommodate the water droplets to create a wetter microclimate for the plant and increase the light reflection and refraction. Since water is denser than air, light is refracted as it enters the drop, which can illuminate a larger space [18].

A parametric definition was generated using Rhinoceros and Grasshopper. Different meshes with 1, 2, and 3 layers of 3D printed PLA were tested, and the one that performed better was the two-layered one. The one-layered mesh was not enough to store a good amount of water droplets, and the three-layered one, although it could hold more water droplets, was not malleable and quite heavy (Fig. 4).

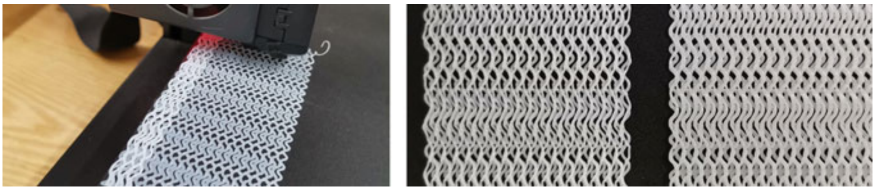

Fig. 4. Meshes with one, two, and three layers of 3D printed PLA.

Observing that the mesh had undulations on the outer part and that this could be used to join the structures together, it was decided that there weren't going to be different typologies but rather one structure that would allow multiple connections. An open-ended possibility of combinations was created using an interlocking system of a standard module.

After the tests above, the structure's design was simplified: the hexagon in the middle was substituted by triangles to increase the number of distinct angles and better capture different stages of sunlight. Other joints were created on the structure as part of the weaving strategy for the triangles to bend in different directions. Also, the undulations on its outer part were exaggerated to make the interlocking system more stable and expand the plant's grip-ability (Fig. 5).

Next, 25 structures were arranged around a plant in an indoor environment that didn't receive constant and direct sunlight to prevent the evaporation of the water embedded in the structures. They were combined and arranged in different ways around the plant itself, as an architectural element to be staged around the individual plant specimen and according to how much weight the plant could support in each part and culminating in different performative qualities. These arrangements were important because they allowed for an evidence-based design tuned for maximum performance and plant health.

It was measured the humidity level with an in-door hygrometer, Inkbird ITH-20, and the illuminance using a digital lux meter HoldPeak 881D.

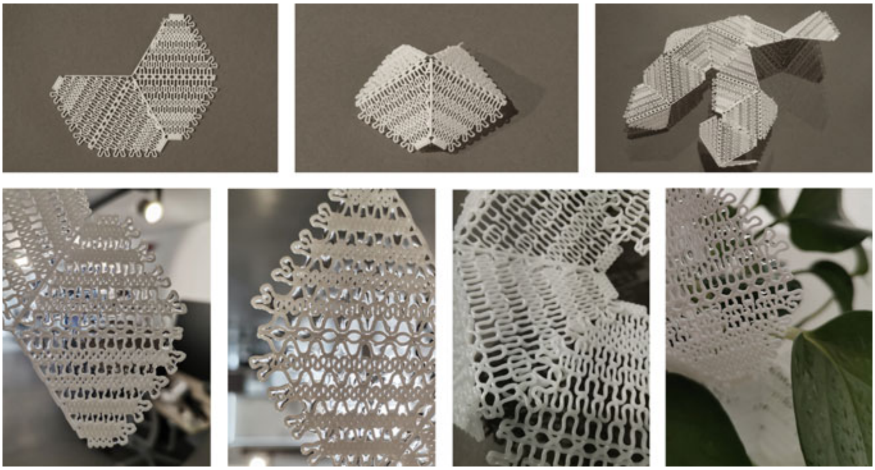

Fig. 5. Final structures: flat, bent, connected with others; structure with water; a close-up of the structures' interlocking system; and the structures arranged on a plant.

5 Results and Conclusions

The structures were tested by measuring the humidity level with a standard in-door hygrometer, Inkbird ITH-20. The initial humidity level was 39%, and after water was sprayed on them, the humidity level increased to 53%. When this last step was repeated with the structures arranged around a plant, the humidity level changed to 62% (Fig. 6). As indoor plants need humidity levels between 40 and 60% [19], the structures provided quite an effective change in humidity.

The illuminance of the structures was also measured using a digital lux meter Hold-Peak 881D with a rotating head sensor head. The illuminance measured on the plant was 44.5 lx, and subsequently, on the structures without water arranged around the plant, it increased to 78.5 lx. So, it is possible to notice an increase of 34 lx just with the addition of the structures. However, this tool was not accurate enough to measure the difference with the water in the structures because water reflection (from 5 to 80%) depends on the angle of incident radiation. The reflection coefficient of water is higher when the radiation angle is low: during the sun rising or setting. At 90°, the water body absorbs a great deal of sunlight, and only a small portion of the sunlight is reflected [20]. Also, the refractive index of water is 1.3, while air is 1.0, and it is important to take into consideration [21]. Therefore, it was noticed that the light quality increased, but further investigations must be conducted to gather quantitative data to measure the enhancement of light reflection and refraction of water in the structures.

Fig. 6. Photos of the structures without water (39% of humidity) and with spayed water (53% of humidity); structures arranged around a plant without water (39% of humidity) and with sprayed water (62% of humidity); photos of the structures arranged around a plant; the amount of lux was measured just on a plant (44.5 lux) and subsequently on the structures arranged around the plant without water (78.5 lux).

This paper moves the design conversation away from human-centered design and toward posthumanism, which considers both people and nonhuman actors, usually overlooked in design processes. It begins with an interdisciplinary conversation that connects new research in nonhuman design, ergonomics, and design performance to acquire insight into desirable nonhuman settings.

This study details the development of a project of "ornaments" for plants as part of an academic course. It begins with a "Thing Ethnography" and further research on the lack of humidity and light in internal settings and water employment to increase humidity levels and enhance brightness through reflection and refraction of light. 3D printed biomimetic structures were designed and tested to support water droplets and then placed in various patterns around a plant. The findings reveal that the structures increase humidity and light levels, but more research is needed to evaluate the augmentation of light reflection and refraction of water. They also imply that considering nonhuman actors can lead to different design proposals and a mutualistic relationship scenario based on the concept of co-performance.

This paper expands our sense of inter-dependence with other species. It creates a new approach for working with plants as nonhuman actors and recognizing the potential of "other-than-human" perceptual capabilities and mass customization. The study explores the evidence-based design that resulted and the environmental ideals we want our society to embrace, with important implications for future design rules and practice.

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