



Botanical Printer: An Exploration on Interaction Design with Plantness

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Abstract

Thing-centered design has suggested analyzing our product-scape through the metaphor of agency. However, interaction design with plant-related agency usually animates plants to simulate human behavior. We intend to make interactive things with the ontological nature of plants. Through workshops including guided annotation of six artifacts and situated probes, the senses of the “plantness” of an artifact emerge. Drawing on these understandings, we built and deployed Botanical Printer, which lives with us slowly responding to natural and electronic climates. We present rich results including conceptual, situated, and interactive plantness. Empirical data allow us to explore the future of object-oriented speculation in greater depth.

Authors Keywords

Speculative design; agency; object-oriented ontology; plantness.

ACM Classification Keywords

H.5.m. Information interfaces and presentation

Introduction

A growing number of HCI studies are now available to shed some light on thing-centered speculative design [9, 29]. Nonhuman agency is perceived [26] and believed to be equally important to human agency. In the coming age of many IoT products, understanding the distribution of agencies in our “product-scape” [3] would allow us to create meaningful interaction between the human and the nonhuman.

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Latour's Actor-Network Theory (ANT) regards human and nonhuman as equal actors in a network [18]. Moreover, object-oriented ontology (OOO) takes a non-anthropocentric perspective seeing objects as ontological entities in their own right [13]. Object-oriented ontology declares that all things equally exist, yet they do not exist equally [2]. According to OOO, the agencies of things differ in definable ways. In this pictorial, we frame the agencies as a spectrum ranging from objects, plants, and animals, to human, with an increasing order of their capacities to act independently.

Within this spectrum, many variations in design transform things or plants into the agencies of animals and humans. These can be understood via animism [28] and robotics [26] respectively. There is a tendency in IoT design toward maximal agency that tends to overload our attention. Regarding artifacts as beings around us, we notice that people often have many plants but usually have fewer pets since plants do not engage us too much. However, there has been relatively little HCI research that focuses on the agency of plants in our perception. The purpose of this study is to intentionally design medium level agency into things and to speculate on what a not-so-engaging interactive artifact could be.

We propose novel methods to produce intermediary knowledge by bridging botanical terms and six artifacts which we chose as being potentially plant-like. Further situated placement of life size artifact photos allowed us to probe the spatial meanings of such plant-like artifacts. Drawing on these *conceptual* and *situated* understandings of "plantness", we built the *Botanical Printer*, which prints in response to accumulations of CO₂ and Wi-Fi intensities, in order to identify an object's *interactive* plantness. The contents and forms of the printouts represent the natural and electronic climates respectively and are detailed in the following pages.

Empirical data from deployment of the Botanical Printer allow us to anchor our discussion and speculation in thing-centered perspectives. In addition to the meanings of lived experience with our artifact, we seek to identify possible issues of significance by examining and mapping these concepts in object-oriented ontology (OOO).

The Spectrum of Artifact Agency

Figure 1.

Most "intelligent things" are objects that simulate the agencies of animals or humans to form an alterity relation [25] that shows specific intentions of things. Animistic metaphors [28] and artificial intelligence are often implemented to raise the agencies of things to equal those of animals and humans respectively.



Figure 2.

Many plant-related interaction designs equip sensors and actuators in potted plants to allow these plants to express their desires, emotions, and needs as human beings. Through raising the agency of a plant, for example, the Selfie Plant [17] demonstrates its need for social interaction by uploading selfie photos as if it were human.

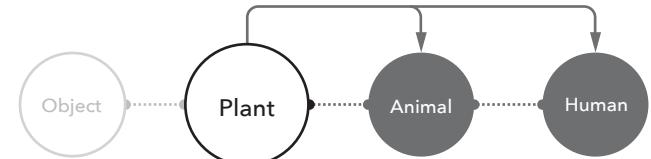
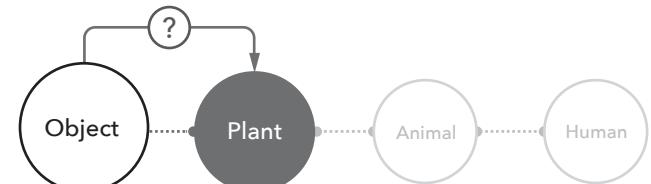


Figure 3.

Seeing plants' ontological natures as the target metaphor of agency, this research intends to explore the possibilities of transforming things into plant-like interactive objects with perceived qualities of plantness.



Intermediary Knowledge Workshop

We adopted an interpretative approach to understanding people's experiences of plant-like features embodied in interactive artifacts, i.e. possible experiential qualities of plantness which could be incorporated into interaction design. The workshop was composed of two activities. The first activity was the use of guided annotation with botanical cards in the laboratory. The second was the situated placement of artifact probes in participants' living spaces. The intention of the guided annotation activity was to bridge the gap between design practices and botanical theories. Through participants' annotations and interpretations about existing artifacts using botanical terms, we intended to extract the intermediate-level knowledge [6, 21] between conceptual knowledge and concrete examples. The purpose of the placement activity was to elicit participants' situated experiences with the images of chosen artifacts that encompass different levels of perceived plantness.

Participants

We recruited four small groups of participants for this study. Two groups were composed of two participants and the other two groups contained three participants. The ages of the total 10 participants (5 females and 5 males) ranged from 23 to 29. All participants were graduate students majoring in human-computer interaction or interaction design through convenience sampling.



Light Collector [10] Slow Games [1] PhotoBox [24] Reflexive Printer [27] Scentonight [20] Intouch [19]



Activity I: Guided annotation with botanical cards

We made 36 Botanical Cards (extracted from [4, 15], see next page) for the first annotation activity in the laboratory. Each card contained one term as well as its description borrowed from botanical or gardening theories. These cards were used to annotate a collection of six interaction design artifacts labeled as slow technology [11], calm technology [30], or poetic interaction [20], which were assumed to relate to plant-like interactivity based on our limited experience. This collection included Light Collector [10], Slow Games [1], PhotoBox [24], Reflexive Printer [27], Scentonight [20], and Intouch [19].

Activity II: Situated placement of artifact probes

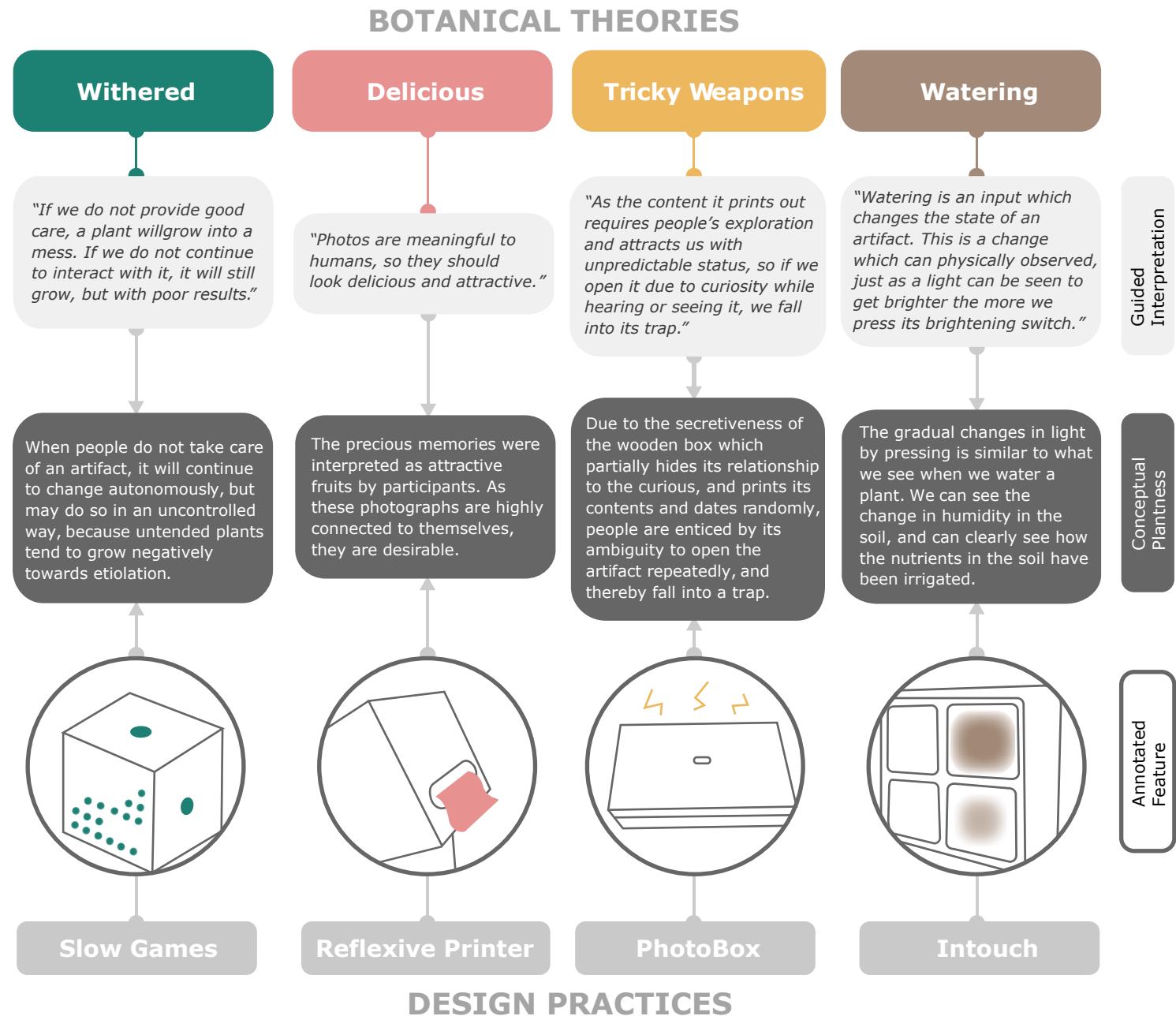
The six artifacts were color printed in the life size of their physical counterparts. The participants were asked to take these "artifact probes" back and deploy them in their living environments according to each artifact's characteristics. The participants were told to take pictures of the locations of these artifacts and to note down the details of their environments. These data were brought back into follow-up individual interviews with the participants to collect their situated experiences about how these artifacts, each with a different level of perceived plantness, might exist in their everyday lives.

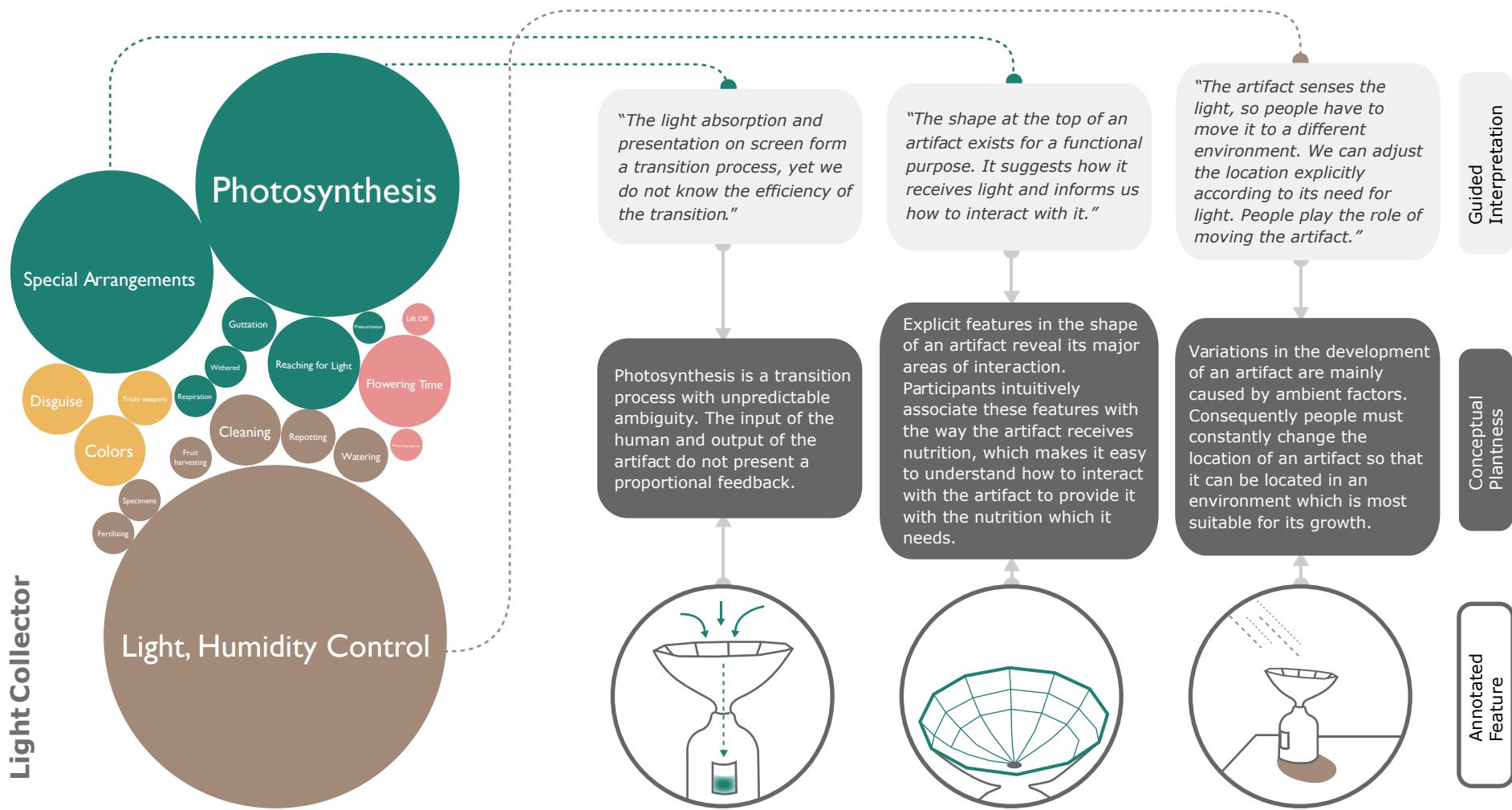
Nutrient	Breeding	Atmosphere	Plant-Care
Photosynthesis When plants obtain sufficient water and CO ₂ , they convert sunlight into bio-energy [15].	Attachment The seeds of plants grab onto the fur or body of different animals [15].	Colors The colors are specifically directed at pollinators, trying to allure them [15].	Light, Humidity Control Different plants have different humidity and sunlight needs, so we have to locate a suitable environment for them [4].
Reaching for Light Certain plants alter their leaf shapes and sizes to maximize the sunlight [15].	Delicious Some plants provide delicious food for animals to help them spread seeds [15].	Tricky Weapons Many plants use several techniques to arm themselves against herbivores [15].	Cleaning We should make sure plants' leaves are free from dust to enable them to breath easily [4].
Dormancy As winter approaches, the stems and leaves located above ground wilt [15].	Traveling	Fragrant	Fertilizing Plants in pots will eventually exhaust the nutrients in their potting mix and will need supplementary food [4].
Withered	Lift Off	Obstruction	Cutting
Respiration	Flowering Time	Shelter	Deinsectization
Special Arrangements	Asexual Reproduction	Mercenaries	Fruit harvesting
Taking Root	Botanical Cards There are four types of Botanical Cards. The first three types are titled Nutrient, Breeding, and Atmosphere. Nutrient Cards center on the plant itself, such as nutrient production, absorption, and transportation processes that don't involve any impact on the environment or on surrounding organisms. Breeding Cards focus on procreation, such as pollination and seed dispersal, that requires the assistance of other organisms through contact or ingestion. Atmosphere Cards describe changes of the environment and atmospheres such as color, scent, and appearance that indirectly draw surrounding organisms closer. Plant-Care is the fourth type of card emphasizing actions that can be taken by humans toward plants, such as fruit harvesting, fertilizing, and other common plant care techniques.	Disguise	Seeding
Pressurization		Setting the Trap	Watering
Guttation			Repotting
Water Conservation			Specimen
Changing Shapes			
Turgor Pressure			

Activity I: Bridging Theories and Practices

There were six rounds of Activity I. In each round, each participant was given a full set of the Botanical Cards and asked to do free association among one of the six artifacts and the cards. After identifying associated botanical terms, the participants discussed the reasons behind their choices with their group members and the researchers in an interpretation session of the round. The purpose of the interpretation session was to clarify the plant-like interactivity of each artifact. The annotation sequence of the six artifacts was randomized for each small group. Each round took about 20 to 25 minutes. The whole activity took about 2 to 2.5 hours.

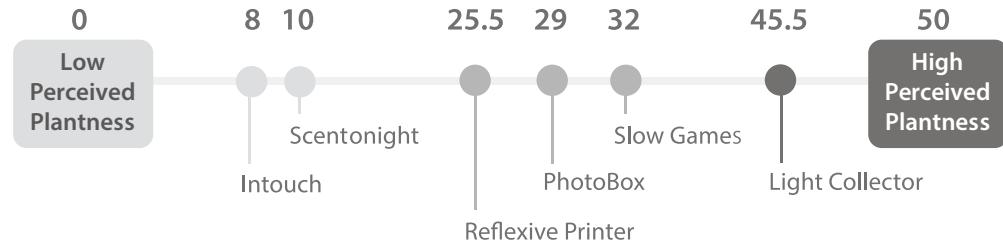
The diagram on the right shows some examples of the generation of our intermediary knowledge of conceptual plantness.





Conceptual and Perceived Plantness

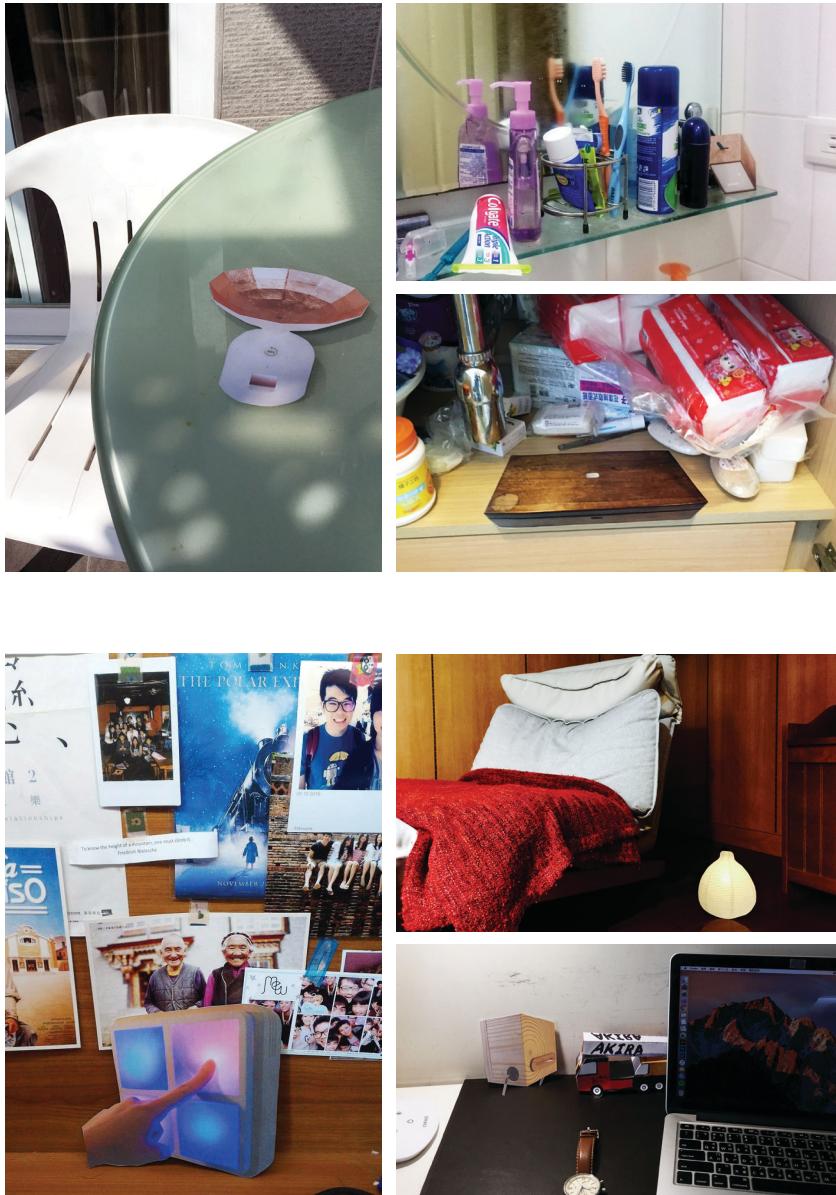
Through the participants' annotation work, each artifact's conceptual plantness can be visualized to observe the distribution as shown above. After annotating the whole collection, each participant was asked to rank the six artifacts according to their likeness to a plant. The highest ranked artifact got five points; the lowest got zero points, as shown on the right. Then the participants were interviewed to explain their decisions. This page only details the highest ranked artifact, Light Collector [10].



Activity II: Situated Plantness

In order to explore the plantness of the artifacts in situ, we invited participants to place artifacts' probes in their home. These probes were printed in the original size as the artifacts. Participants documented them in photos after their placement.

Analyzing the scenes where artifacts' probes were placed, we found the contents could be classified into two groups. The first group were more neutral and open spaces. The second group were more intimate and private places. In addition, most of the artifacts with higher levels of plantness in the early exploration stayed in the first group. Through the interview, we were gradually able to define the landscapes that are suitable for different degrees of plantness.



High plantness fits open space

Participants tended to set the artifact probes of Light Collector and Slow Games in a balcony, by a window, on a sundry shelf, in a bathroom, on a counter, or in a corridor. These spaces share the same characteristics of openness and non-individuality where people usually spend less time staying or working. Participants explained that the artifacts with higher ranks of plantness seemed suitable for being located in places where they usually walk by without paying much attention. Objects with higher levels of plantness seemed to fit in the backgrounds of people's lives. This type of space is in line with the notion of non-place [5], since sense-making of the place is unnecessary.

Low plantness fits personal space

Regarding those artifacts with lower levels of plantness such as Reflexive Printer, Intouch, and Scentonight, participants put them on a computer desk, by a bed, and on a photo wall. These are places that have high intimacy, are personally symbolic, and have individualized meaning. Although it only prints one photo per day, most participants put Reflexive Printer in a place where they could constantly check and be aware of it such as their desks for working and reading. The participants indicated that this type of object had become a center of a new activity. Such artifacts frequently draw our attention and are best located in our personal space.

Intermediary Knowledge of Plantness

Through the exploration of conceptual plantness (Activity I) and situated plantness (Activity II), we summarize four concepts (1-3 from Activity I and 4 from Activity II) towards interactive plantness:

1. The internal logic of things

When an artifact manifested plantness, participants described it mainly as having a status that is uncontrolled and unpredictable. Meanwhile it sneakily works behind people's perception. Users can not precisely expect how much transition will happen between inputs and outputs. It requires a period of time to get familiar with such an object to merely understand its range of expression. Artifacts gradually tend to have a relation with users, while retaining the feature of unpredictability. Therefore, designing an interactive artifact that shows plantness indicates embedding internal "hidden" logic into the artifact, such as an unpredictable time of activation and an ambiguous representation.

2. Simple function

Light Collector, the highest level of plantness here, has a simpler, limited annotation distribution than the other artifacts. The annotations adopted by the participants generally converge through consensus. However, due to its functional complexity, Reflexive Printer shows a divergent annotation distribution, because it is so strong in providing many functions. The lesson we learn is that multi-functionality harms an artifact's perceived plantness. Designing an artifact with a very limited number of functions results in a better sense of plantness.

3. Changes through accumulation

Plant-like artifacts usually show slow feedback. Since the transition between input and output may not occur

on sight, experience mostly comes from reflection after events. This shares a similar time structure to slow technology [11]. Besides, a higher sense of plantness refers to artifacts that have growth, and decline and accumulate changes. Along this time shift, such an artifact does not remain in the same status like normal tools. Instead, it keeps going through transitions and responds to its accumulative status.

4. Fitting non-place

Participants noted that the artifacts with a higher level of plantness fit better in places where great attention is not always necessary, and in which an engagement in long term activities does not take place. On an urban scale, these would be similar to spots with less likelihood of forming a culture, such as train stations. The French anthropologist Marc Augé called these spots "non-places", usually created to meet people's temporary needs [5]. Rather than forming a "sense of place", these spots are featured more in de-cultural, non-historical settings where there is a lower sense of belonging. Therefore, the form of a plant-like object could be intentionally designed to fit a non-place area in a home.

Speculative Design on Plantness

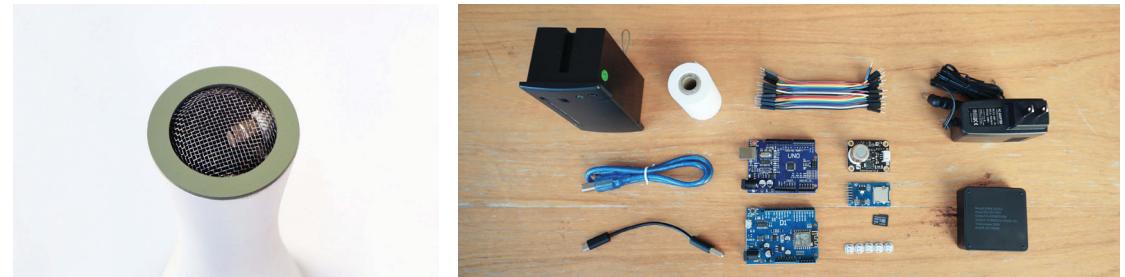
Inspired by the whole intermediary knowledge workshop, we have speculated about an interaction design of plantness. Implementing such features as internal logic, simple function, accumulation and non-place, we designed Botanical Printer which can reflect both a natural climate and an electronic climate [8]. Additionally, we chose two families in which to deploy our artifact in order to further explore the lived experience with interactive plantness.

Interactive Plantness through Botanical Printer

We chose to measure invisible CO₂ intensity in the natural climate and Wi-Fi signal strength in the electronic climate [8] as two factors to represent plantness. We did this by equipping Botanical Printer with electronic materials and tools (shown on the bottom right of the page). The main nutrients of the artifact come from CO₂ and Wi-Fi in the environment. Changes in light and printing behavior were based on the accumulated changes of these two factors. The appearance of the artifact is similar to a vase with an air intake aperture on the top to detect CO₂ intensity. Embedded in the middle of the artifact, there are 5 LEDs that can display the accumulation status of the two factors. Below the LEDs, there is a paper exit aperture that prints the contents corresponding to the two factors through an embedded thermal printer. The artifact updates a light change every six hours and prints one to two sheets randomly in a day.

When CO₂ intensity in the environment is getting higher, the number of lighting LEDs increases and the printed content shows photos or posts from the users' social media; conversely, the number of lighting LEDs decreases and the printed content tends to be fictional if CO₂ intensity in the environment is getting lower. The color of the LEDs turns from green to yellow and the amount of printed ink will increase when Wi-Fi signal strength is strong; conversely, the LEDs' color turns from green to white and the amount of printed ink will decrease when Wi-Fi signal strength is weak. The participants live with the artifact by adjusting its location within the coexisting space as well as gradually developing a sense of the way the two invisible climates affect the artifact.

The next page showcases the artifact's responses to different contexts.

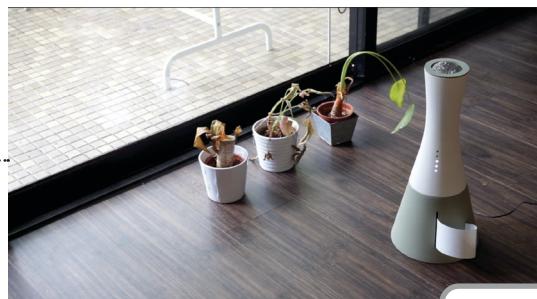


By the window

The Wi-Fi signal is weak by the window and CO₂ intensity is medium. When the artifact has been placed by the window for a while, it will gradually accumulate a lower amount of Wi-Fi signals. Consequently the LEDs will gradually turn to white, and the number of lighting LEDs will remain at three. Correspondingly, the printed ink will gradually decrease and become hard to read; printed content consist of a news update at that time.

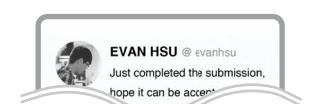


(Low Wi-Fi, Medium CO₂) •



Living room

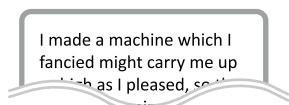
When the artifact is placed close to an activity area, the Wi-Fi signal from the surroundings is medium and CO₂ intensity is high. In such a context the LEDs' color will remain green, and the number of lighting LEDs will gradually increase to four or five. The printed texts are clear, and the content consists of historical messages on social media, or related messages of interaction with others.



• (Medium Wi-Fi, High CO₂)



(Medium Wi-Fi, Low CO₂) •



Balcony

On the small balcony close to the living room, the Wi-Fi signal is medium and CO₂ intensity is low. In this context the artifact will gradually accumulate lower CO₂, the LEDs' color will remain green and the number of lights will gradually be reduced to one or two. At this point, the printed texts are clear and the content will tend to be fictional such as a short paragraph from a piece of science fiction.



• (High Wi-Fi, Medium CO₂)

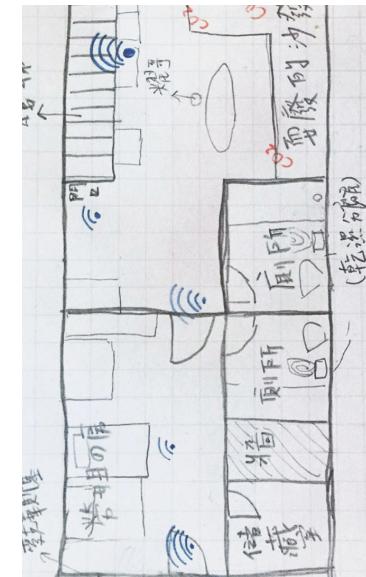
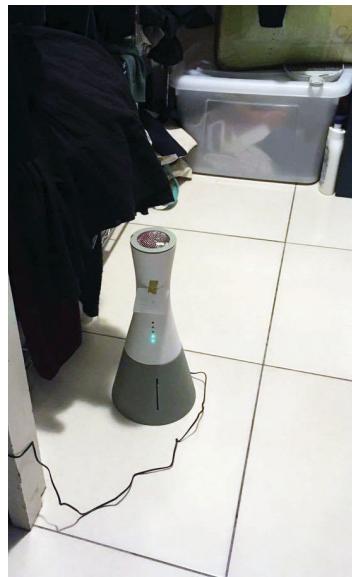
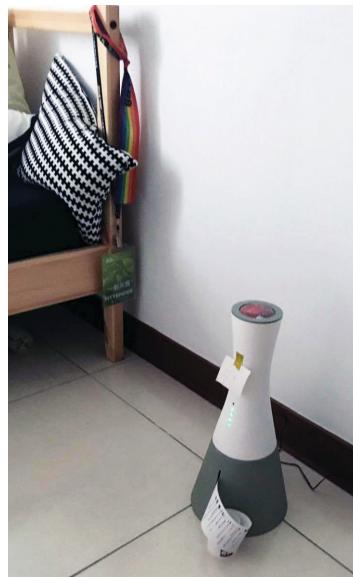


Around the router

When the artifact is placed close to the router, Wi-Fi signal strength is strong and CO₂ intensity remains medium. In such a context where the artifact receives less attention, the result may lead to an accumulation of excess Wi-Fi and the LEDs' color will gradually turn to yellow and the number of lit LEDs will remain at three. Printed texts will be smudged, blurred and difficult to read. The printed content is a news update at that time.

Findings of the Deployment

After designing Botanical Printer, we invited two families to deploy our artifact for one and two weeks respectively. We asked family members to document the scenery of deployment with photos in order to help them to remember the whole process and to gain more meaningful empirical data. In the preliminary exploration, we gathered accounts and found some interesting points from the families. Due to the limitation of space, we can only list partial results about their lived experiences with the artifact.



Objects' approaching

When social contents were printed out, the users felt a higher agency of the artifact, as if the printer were inquisitive about their lives and wanted to participate in their social events. Thus, the object appears to over-embody its presence, unlike normal plants in our daily life which always keep an inaccessible nature that human can never approach at all. The Botanical Printer deliberately joined the conversation with the family members, just like an animal who has a higher agency.

The withdrawal [12]

The withdrawal of an object indicates its own ontological richness and hidden depths [23]. Some participants wanted to optimize the “growing” environment for Botanical Printer, but found no suitable location. They felt frustrated since they could not control it well. Meanwhile, the resistance of the object emerged. Also, when they received contents which were fictional, Botanical Printer became “the other”, and thus the artifact strayed beyond their imagination. Only indirect or vicarious causation was available [14], to help them to access the reality of the object.

The allure of objects

The participants reported that when the condition of Botanical Printer became worse, for example, producing over-inked papers or when the strip became too long, the sense of experiencing plantness arose because they had to hurry to trim or move the artifact. Passive qualities may not demand that humans do any work for the artifact immediately, but it allured the participants to take care of it because its agency is so much lower than that of humans.

The detective of climate

By changing the deployment of the artifact, the participants could grasp the Wi-Fi and CO₂ conditions which affected it. One of the groups even drew a diagram to illustrate the real distribution of these two factors. This kind of artifact can be a detective helping us to measure changes in their living environment, because a plant owns the ability to reflect climates. Thus, Botanical Printer can be regarded as an alternative artificial plant recording different types of climates around them.

Discussion

In this pictorial, we investigate “the intermediary knowledge of plantness” in interaction design, through the participants’ interpretations of a number of artifacts and their felt experiences with them. Also, we create a plant-like artifact, to present a novel type of interactive experience. From these activities we draw the following 5 characteristics, from an exploration of conceptual plantness (1-3), situated plantness (4), and interactive plantness (5).

1. The withdrawal experience

When we receive fictional results from the printed sheets produced by the Botanical Printer artifact, the artifact becomes a stranger. This situation seems that it already withdraws from total access, living in another universe where it is encrypted. Whether the fiction is printed with wet ink or dry ink, the gap between the object and the humans always exists in the interaction process. However, the ambiguity and uncanny traits of the object create a tension which allures us into continuous negotiation with the Botanical Printer.

2. The limited interaction function

In the first probe steps, through botanical annotation cards and follow-up discussion, we came to understand that simple and limited interactive functions imply a higher level of plantness. Although the interaction experiences are limited, users’ imaginations upon plantness can be richer.

3. Slow-tech style

While deployed, Botanical Printer gave us non-immediate feedback over a period of time. Most plants have their own operational logic, but usually human can still become aware of the reasons why gradual changes occur after careful observation.

An artifact’s plantness gives us slow-tech benefits by presenting long-term experience over time. Although it becomes intrinsically unpredictable, we humans can continue to speculate about what is occurring in the natural and electrical climates in our everyday lives when we receive feedback such as seeing the lighting indicators change in it.

4. Non-place / Object-scape

The participants tended to set up design artifacts with a high level of plantness in fluid living space. Since people don’t need to care about them all the time, the “human-technology” relation goes to the background level as Ihde proposed [16]. Compared to highly interactive artifacts such as Intouch and Scentonight, the artifacts with a high level of plantness fit well into non-place landscapes. The artifacts with plantness could not only fit into one’s intimacy space, but they could be suitably placed in highly-opened object-scapes [22], employing a temporal pattern implying a natural wilderness.

5. Agency emerging from the milieu

Agency is not a fixed degree of capability. When people build a relationship with Botanical Printer, the perceived agency tends to rise in the form of a perceptual-crossing loop, similar to our domestication ritual with ordinary plants. Contrarily, Botanical Printer can return to its original uncanny and wild statuses, and become “the other” when it appears to refuse to build a relationship with humans. Therefore, the plantness agency can be understood as existing somewhere between a highly engaging perceptual-crossing level and total withdrawal. When Botanical Printer withdraws from social and Wi-Fi environments, it disengages from a highly engaged experience. The expression of Botanical Printer can be regarded as something emerging from the milieu [7] of agency. “It is in the milieu of these encounters – between

things and us, and between things and things – that agency is actualized [22].”

Conclusion

This pictorial proposes a novel type of thing-centered speculative design: interaction design involving the concept of “plantness”. We first framed the agencies of things as a spectrum, and then present the results of an intermediary knowledge workshop as a practical method to understand vague and intangible concepts such as plantness within IoT design research. We used two kinds of activities including “guided annotation with botanical cards” and “situated placement of artifact probes”, to describe and interpret six interaction examples, and used these to summarize the characteristics of plantness. We built an artifact called Botanical Printer to help in the development of speculations about our smart living future and “did” philosophy in terms of object-oriented ontology [2].

With our discursive reflection, we arrived at an important understanding that plantness is not limited to some prescriptive expression of agency. Rather, we intend to contribute a “milieu” concept to HCI, by which we propose that agency is always derived through encounters. With this conception, the agency of things can be seen as always emerging along a continuum between “perceptual-crossing” and “withdrawal”. Our Botanical Printer works as a an artifact which can be used to investigate degrees of plantness and the way its agency emerges in human-object encounters.

Acknowledgements

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