

Internet of Things

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Social Internet of Things

 Springer

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Beautifying IoT: The Internet of Things as a Cultural Agenda



Jeffrey Bardzell, Shaowen Bardzell and Szu-Yu (Cyn) Liu

Abstract As an IT research agenda, the Internet of Things is often framed according to technical and economic issues, such as protocols, standards, job-creation potential, etc. We argue that IoT also constitutes a cultural and aesthetic vision, that is, a projected image of urban- or region-scale beauty, in which lives are pursued in more meaningful and fulfilling ways than before. In HCI and related disciplines, aesthetics—when not outright dismissed as too subjective and/or confusing to engage—is commonly investigated as individual judgments about individual interfaces. This is a problem, because we know that technologies can produce ugly and unlivable environments at scale—from nuclear disaster sites to urban desolation caused in large part by the automobile. Aesthetic IoT is not a matter of making device surfaces more pretty, but of thinking deeply about the ways it will shape how we live; after all, urban desolation didn't happen because roads weren't painted attractively, but because roads disrupted communities and their established ways of life. This chapter demonstrates that aesthetic theory provides concepts sufficient to engage matters of IoT aesthetics in precise and pragmatic ways. It does so by analyzing a policy intended to beautify a major city in Asia alongside aesthetic interpretations of two design initiatives contemporaneous with it: an agricultural IoT project that proposes a computationally enabled new intimacy between humans and their land, and a kitchen design company that innovates not only on manufacturing materials but also on the aesthetic conventions needed for consumers to recognize those material properties as beautiful.

1 Introduction

The Internet of Things (IoT) refers to a vast network of interconnected objects in our everyday environments [1]. It has received enormous interest and investments aiming to envision a new form of service ecology supported by streaming data through

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© Springer Nature Switzerland AG 2019
A. Soro et al. (eds.), *Social Internet of Things*, Internet of Things,
https://doi.org/10.1007/978-3-319-94659-7_1

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interconnected devices to provide meaningful actions in the context. Topics of IoT research and public policy discourses often focus on technical and economical aspects such as infrastructure, protocol, security, privacy, or its potential to create jobs and boost company profits [2]. HCI and CSCW researchers such as [3–5] have broadened this research agenda to encompass the socio-technical experiences that IoT devices bring about by studying the social arrangements of people and technology in everyday life. This literature shows how IoT innovation can go beyond tools to mediators of human social relationships.

Höök [6] takes this argument a step further, when she points to Sweden’s traditions of participatory design and technology democratization to argue that the nation is distinctively fit to position itself as an IoT nation and a global innovation hub. On such a view, IoT is not only a product of technology but also a *cultural* product, that is, both a reflection of and a perpetuation of given culture. This view calls attention to issues that technocentric approaches to IoT—as vital as they are—tend not to. How well IoT fits with a given culture likely will deeply shape experiences, with implications for adoption, acceptance, and productivity.

In this paper, we began to pursue this question when we saw that participants in our ongoing multi-sited ethnography in Taiwan were likewise inquiring about it in earnest. Although many of them are engineers, themselves fascinated with the technical possibilities of IoT, they also equally asked what IoT could or should mean in Taiwan—not unlike Höök’s ruminations on a Swedish IoT. These engineers wondered how IoT can contribute to and benefit from Taiwan’s ongoing efforts to cultivate creativity, including the related question of how to establish innovation hubs [7]. This is in turn led to questions of Taiwanese ways of life, that is, a Taiwanese lifestyle, which reflects cultural tastes and values. Along these lines, we have seen a collective agenda—reflected in policy, social media discussions, public design events, and so forth—to “beautify Taiwan.” This agenda includes but is not limited to IT development, extending to issues of environment sustainability, green energy, urban aesthetics, and the formation of a Taiwanese consciousness.

As we witnessed the overlapping discussions between beautifying Taiwan and the development of an IoT imaginary for Taiwan, we began to wonder: *what might it mean to beautify IoT?* To make this question more tractable, we scoped it to Taiwan: *what might it mean to beautify IoT in Taiwan?* We stress that this is a speculative question, not an empirical one. We are not asking, “what did beautifying IoT mean in Taiwan?”, because beautifying IoT in Taiwan remains more an aspiration than a reality that can be investigated empirically. Accordingly, our methodology is suited to a speculative investigation, rather than an empirical one. We appropriate a methodology from serious science fiction: we use *cognitive speculation* [8] to constructively and experimentally imagine futures that are *plausible* (because they are based on the best available empirical knowledge) and *preferable* (because they more completely embody our values than the mundane present).

Specifically, we use our empirical knowledge from Taiwan as a launching point for our own speculative investigations of what beautifying IoT could mean if developed as a research and design agenda. Here we rely on a distinction we made in [8] between a technology agenda and a vision agenda. A technology agenda is primarily about the

research and development needed to pursue a technology agenda (e.g., improving computational sensing to improve computers' contextual awareness, in pursuit of the ubicomp agenda). A vision agenda is an image of how that technology agenda will play out when situated within society; it is a vision of everyday life when such technological capabilities are widespread, available, and mundane. Beautifying IoT is a vision agenda, in that it seeks to envision a future where IoT is mundane, yet also beautiful or beautifying.

Our contribution to design research is to contribute towards the construction of IoT agendas that take seriously, even centrally, the significance of aesthetic beauty in everyday life. A secondary contribution is to make our speculative methodology explicit, in hopes of supporting other design researchers interested in contributing speculative images that intervene upon and enrich IT agendas.

2 Methodology: Speculatively Contributing to IT Research Agendas

Our methodology can be summarized as follows. From our multi-sited ethnography of creativity and innovation in Taiwan, we identified an agenda of interest to stakeholders in Taiwan, that of beautifying Taiwan, in which beautifying IoT is a subordinate goal. We summarize the relevant discourses to demonstrate both that this aspiration is in the discourse and also that it is under-specified. From this point, we take a speculative turn. Obviously, we cannot answer for Taiwan what beautifying IoT could or should be for the Taiwanese. Instead, we treat this question as a prompt for our own imaginations, for us to envision an answer to take back to the HCI and design research community. We move forward by doing design criticism of two design initiatives in Taiwan that are contemporaneous with the policy agenda, and we turn to philosophical aesthetics to work from rich and generative theories of what "beautifying" might mean.

We have been conducting ethnographic studies on IT innovation and creative industries in Taiwan since 2011, focusing in particular on cultural and creative industry policy implementation [9], urban experimentation [7, 10], making and bottom-up innovation, and everyday aesthetics and traditional craft among others [11]. The present work draws from and is informed by our fieldwork on cultural creativity and making in Taiwan, involving hundreds of ours of participant engagements across different physical sites. We also conducted digital ethnography [12–17] of our informants' use of Facebook groups. While this paper does not primarily report on findings from these ethnographic engagements, it is through them that we became aware of relevant policy discourses, innovation initiatives, and design examples, which we discuss in more detail below. The ethnographic research gives us confidence that the topics and resources that we are drawing on are important to innovation stakeholders in Taiwan—policymakers, entrepreneurs, inventors, makers, educators, manufacturers, etc.

2.1 Policy and Beauty in Taiwan

Taiwan is well-known for its information technology and precision manufacturing. It is home to a host of high-tech companies including Asus, Acer, Foxconn, and HTC. It also has a long history in offering original equipment manufacturing (OEM) services to global IT innovators, such as Apple. IT and precision engineering are often foregrounded in policies because they drive the economic growth in Taiwan. In September 2016, the National Development Council of the Executive Yuan inaugurated “Asian Silicon Valley Development Plan”, aiming to upgrade Taiwan’s IT industry and innovation ecosystem to support entrepreneurship and the development of IoT [18]. The development plan is part of the government’s five-plus-two pillar industries initiatives, along with intelligent machinery, green energy, biomedicine, national defense, high-value agriculture, and circular economy [19]. In spite of its name, the policy goal is not to clone Silicon Valley in Taiwan, but to use it as a hallmark for promoting this island as Asia’s technological innovation hub. The plan will run from 2016 to 2023 with an initial budget of US\$359 million for 2017. Official measurements of the plan focus on aspects of economic growth and industrial reform, such as “increase Taiwan’s IoT global market share from 3.8% in 2015 to 5% in 2025”, and “grow 100 successful companies” [18].

Part of this policy agenda and others like it in Taiwan is to build on Taiwan’s cultural strengths, not just its technical ones. This includes constructing images of Taiwan’s future out of its cultural past, arguing that its democratic values foster creativity better than alternatives, and that technology and culture are co-implicated [9, 10]. Thus, while the economic message is that Taiwan wants to transition from a service provider (i.e., manufacturing for others) to an innovation pioneer, this work will reflect and perpetuate the cultural identity of Taiwan. Although many have criticized the policy and its implementation, policy analysis is out of the scope of the present work. We are interested instead in the ways that the policy exemplifies the country’s aspiration to leverage distinctive cultural knowledge and local infrastructure to foster the development of technology and innovation.

Indeed, cultural concepts have been foregrounded in recent Taiwan policy. We did not ourselves come up with the notion of “beautifying Taiwan”; in fact, the language of beauty is often highlighted in Taiwanese public policy. One example is the “Taipei Beautiful” (台北好好看) urban renewal policy issued in 2009, aiming to make the city “charming” in preparation to the 2010 Taipei International Flora Exposition. This policy offered guidelines and subsidies for renovating obsolescent buildings, creating green parks, and reviving idle spaces in order to “revitalize the [city’s] shabby appearance” and transform Taipei into a “beautiful international city” [20, 21]. In this discourse, terms like “revive,” “renovate,” and “shabby” all suggest similar ideas—a city in a state of architectural decay needing to clean itself up and give it a new life. Green spaces will be used to punctuate blocks of these renovated buildings, the overall effect of which will be “charming.”

Related development policies include “Shaping a Charming Taipei” and “Representing Taipei Elegance”, in which vocabularies such as beautiful, attractive,

livable, visionary, creative, comfortable, humanized, and local characteristics were used in white papers to communicate a public imagination of urban style [22, 23]. As before, we recognize that the policy has been criticized [e.g., 21, 24, 25], but our purpose is to show that the policy wants to pursue a notion of “beautifying Taiwan.” One might refer to such aesthetics as aspirational because it builds on a particular culture’s traditions to propose a desirable future [10, 26–28].

2.2 *Design Criticism*

As important as verbal discourses, such as policy documents and press releases, are, IT research agendas are also manifest through non-verbal discourses, such as design initiatives, technological infrastructures, and so forth. For this project, we collected a number of design projects that exemplified some aspect of beautifying IoT. In this chapter, we present two of them: an IoT project often characterized as contributing towards aesthetic experiences, and a collection of kitchen products that exemplify how designers transform material properties into aesthetic properties. The second example does not involve computation at all; we chose it not as an example of emerging IoT, but instead because it exemplifies how products beautify environments. Our contention is that eventually exemplars such as these can be and will be blended, so that IoT products feature sophisticated material aesthetics, and everyday products such as kitchen accessories participate in computational environments.

We interpreted these using design criticism, a practice we have been engaging in for years, reflecting our own backgrounds in the humanities as well as current research in philosophical aesthetics, literary theory, film studies, and more. We have synthesized these practices using labels such as interaction criticism and design criticism, and we have attempted to define them as entailing “rigorous interpretive interrogations of the complex relationships between (a) the interface, including its material and perceptual qualities as well as its broader situatedness in visual languages and culture and (b) the user experience, including the meanings, behaviors, perceptions, affects, insights, and social sensibilities that arise in the context of interaction and its outcomes.” Design criticism further seeks to explicate and evaluate “the relationships between present and near-future technological possibility and future ways of being, such that design solutions can be introduced” [29].

Our design criticism methodology included accounting for the qualities of the design as it is embodied in objects (e.g., collecting images of the designs, accounts of their materials and qualities, etc.); as they were intended by their creators (e.g., via media interviews, product descriptions, “About Us” content); and as they have been received by the public (e.g., media coverage, design awards, and so forth). This work provided us with many critical-interpretative statements about the designs, which became the “raw materials” of our analysis. But because our goal was to use these cases to construct an understanding of “beautifying” IoT, we also turned to philosophy of art. This body of work provides theoretical constructs, methodological moves, and a repertoire of examples to help researchers navigate complex concepts

such as “beauty” and “aesthetic.” In this paper, we emphasize two such theories, that of “aesthetic experience” and that of “aesthetic medium,” because they sensitized us to aspects of the designs under consideration relevant to our research question.

2.3 *Thinking with Theory: Philosophy of Art and Beauty*

In attempting to speculatively develop potential agendas for beautifying IoT, we are faced with the problem of beauty as a concept. Taiwan’s policy discourse uses the term, but obviously it is not intended to offer a robust theory of beauty. HCI research also has raised the topic of beauty, but frequently it is investigated in the context of individual user judgments of particular interfaces (e.g., [30]). Neither offers a concept of beauty rich enough to support the sort of speculation that we are proposing: to imagine pathways to beautify IoT. We do not subscribe to the belief that to use a concept one has to be able to define it first (a belief that is patently false, as Wittgenstein’s famous efforts to define “game” demonstrates), but we do believe that a rich account of a concept like beauty can be used in a generative way. That is, we turn to philosophy of beauty (commonly, though not universally, found in philosophical aesthetics) to guide how we interpret both concrete design objects and more abstract IT research agendas. Specifically, philosophical conceptions of beauty help identify what sorts of qualities and features we should attend to, how we should attend to them, and what sorts of consequences we can expect from such attention.

To develop conceptions of what “beautifying” might mean, we wanted a theory of beauty rich enough to support generative thinking. Of course, the philosophical discourse is rich with such theories, and they disagree with and rival each other, and none achieves consensus as definitive, so there is no obvious one to work with. Neither do we want to offer our own original philosophically defensible theory of beauty. Instead, we surveyed a range of theories available in current philosophical aesthetics to surface common concepts and mechanics. A common theme in aesthetic philosophy is that sensual perception and intellection—and, in a parallel pairing, individual particulars and universal themes or ideas—are somehow unified through engagement in aesthetic encounters. Phenomenological philosopher Hans Georg Gadamer expresses the idea in his book, *The Relevance of the Beautiful* (1986):

The ontological function of the beautiful is to bridge the chasm between the ideal and the real [...] in the apparent particularity of sensuous experience, which we always attempt to relate to the universal, there is something in our experience of the beautiful that arrests us and compels us to dwell upon the individual appearance itself. [31]

On such a view, beauty is obviously not about superficial sensual pleasure, but about a form of transcendence that is rooted in and returns to its sensual qualities—that which can be seen, heard, and so forth. Yet as Eldridge [32] writes, this engagement is cognitive:

It is important to remember that the absorptive pleasure that is afforded by successful arrangement is not a mere sensory buzz or tingle. Instead it involves the active use of the cognitive powers of imagination and conceptualization in order to explore the representational and expressive significance of formal elements and their interrelation. Moreover, this absorptive pleasure is itself significant within human life, not gratuitous. [...] A successful work of art can seem to embody and exemplify full action and full meaningfulness as such—a meaning wholly fused to material elements in arrangement—and so to anticipate and promise a human world suffused with meaningful action, rather than emptiness and coercion. In both cases the object of absorptive pleasure is something considerably more significant than an occasion for idle sensory delectation. We are pleased in and through actively exploring the beautiful natural scene or object and the formal arrangement of the successful work. This active exploration discloses in continuous attention dimensions of meaning and presence. [32, 66]

What Gadamer calls “the ideal” in one philosophical tradition, Eldridge in another characterizes as “full action” and “full meaningfulness,” as opposed to “emptiness and coercion.” The beautiful for both gestures through our senses to a world that more meaningful, free, and whole than our mundane present.

Part of the work of criticism (which operates at the level of individual works) and aesthetic philosophy (which operates as a theory of criticism) is to cultivate appreciation of how *aesthetic properties* contribute to *aesthetic experiences*. Aesthetic properties have been characterized as follows:

It is widely agreed [among contemporary philosophers] that aesthetic properties are perceptual or observable properties, directly experienced properties, and properties relevant to the aesthetic value of the objects that possess them [...] Some of the hallmarks of aesthetic property status that have been proposed are: having gestalt character; requiring taste for discernment; having an evaluative aspect; affording pleasure or displeasure in mere contemplation; [...] requiring imagination for attribution; requiring metaphorical thought for attribution; being notably a focus of aesthetic experience; being notably present in works of art. [Examples of aesthetic properties include] beauty, ugliness, sublimity, grace, elegance, delicacy, harmony, balance, unity, power, drive, elan, ebullience, wittiness, vehemence, garishness, gaudiness, acerbity, anguish, sadness, tranquility, cheerfulness, crudity, serenity, wiriness, comicality, flamboyance, languor, melancholy, sentimentality (Levinson in OHA, 6)

And a classic formulation of aesthetic experience is as follows:

experience has a marked aesthetic character when it has some of the following features [...]: attention firmly fixed on a perceptual or intentional object; a feeling of freedom from concerns about matters outside of that object; notable affect that is detached from practical ends; the sense of exercising powers of discovery; and integration of the self and its experiences. [33, lxiii]

Summarizing, aesthetic beauty provides concrete and sensual access to a fuller, more meaningful and free world in the imagination of the beholder. Aesthetic beauty is able to do this because it features aesthetic properties, which in turn are accessible to and constitutive of aesthetic experience. We note as well the similarity of the conception of aesthetics presented here with a definition of aesthetics from design theory:

in general, I regard aesthetics as an overall matrix for conceptualizing and understanding design as the creation and communication of meaning. [Aesthetics is] an avenue for under-

standing and investigating design as a medium of meaning construction at the intersection of a concrete-sensual as well as a conceptual relationship with the world. [34, 6]

The concept of “beautifying IoT,” therefore, would seem to entail (a) objects or systems that are perceptually accessible, and whose aesthetic properties become a focal point for their experience; and (b) experiences that are rooted in direct perception and yet that invoke imaginaries of a fuller, freer, and more meaningful way of being. That “way of being” is highly contingent: what it means in Taiwan is likely different from what it might mean in Sweden or Namibia. And it is likely to be embodied more fully and more powerfully in design products, works of art, and IT systems than in verbal discourses, which is why we turn to design criticism.

3 Design Criticism: Two Cases

We turn to our critiques of two cases of innovation in Taiwan to exploratively imagine how IoT might be framed as an aesthetic agenda in this island. We will revisit the notion of beautifying Taiwan—in terms of aesthetic experience and properties. Taken together, the two cases yield insights on how the conception of beauty is pursued by local innovators, and how this innovation agenda beautifies Taiwan as opposed to other places of the world. By foregrounding cultural practices and considering subjective experiences, we hope show the benefit of widening HCI research on IoT to incorporate aesthetic concerns, and, in doing so, to appropriate research methods from the arts and humanities developed for such inquiry.

3.1 *LASS: From Environmental Sensing to Lasting Aesthetic Experiences*

The first design case we discuss is an open source citizen science platform focused, at least initially, on air pollution. Particulate matter in the air is known to trigger respiratory and cardiovascular diseases, and it has been a serious environmental issue across Asia for the past decade [35–37]. According to Taiwan’s Ministry of Health and Welfare, 7 out of 10 leading cancers of death are associated with air pollution problems [38]. Although researchers and the media alike tend to frame environmental pollution as a health or climate problem, we add that it is also an aesthetic one. Pollution contributes to cancer, but it also is ugly—not just to our senses (sight, smell) but in the ways that it cuts off beautiful ways of being and doing. Asthma exacerbated by pollution can force someone to stay within artificially lit indoor settings, rather than experiencing the childlike joy of riding of bike or simply being out in the park with friends on a sunny day.

To pursue a cleaner future, several sectors in Taiwan have been working collectively since October 2015 to develop the Location Aware Sensor System (LASS,

<http://lass-net.org/>), an open source environmental sensing system that monitors PM2.5 concentrations across the island [39]. LASS is a grassroots system using inexpensive and small tracking devices, which enables its rapid dissemination and deployment of air quality more agile than systems deployed by the government. According to LASS open data (<https://pm25.lass-net.org/>), there are more than 4,000 tracking points across Taiwan, enabling citizens to access environmental measurements such as temperature, humidity, CO₂ and PM2.5 concentrations through real-time maps [40].

LASS was first proposed by Wuulong Hsu, a professional maker who retired from an integrated circuit engineering job, and who is now associated with MakerPro, one of Taiwan’s largest online maker/IoT communities. As Hsu writes on the LASS development platform GitHub [41], the bottom-up, open source aspect of LASS was key,

My dream is to display all kinds of environmental data on the map so everyone can access the data with one click [...] Is this a dream? It was five years ago, but not anymore in the era of makers. This is what LASS wants to achieve.

Similarly, co-founder of LASS, Ling-Jyh Chen characterized LASS as a project of “participatory environmental sensing” and “saving your own environment” [42]. Pursuing environmental monitoring in an open-source, democratic way is, first of all, characteristic of many IT movements in Taiwan [26]; and second, it opens up the possibility of emergent uses that go beyond the initial intentions of the project. And our focus here is an emergent use of LASS. To date, LASS has expanded to include different fields of application, such as forest protecting, flood sensing, and sea monitoring [43].

It is lifestyle farming that we focus on here. By lifestyle farming, we refer to former city dwellers and professionals (many of them former engineers) who gave up their urban lifestyles, moved out to the countryside, and are living off the land. Many of them can be found in a small farming village in Yuanshan Township in Yilan, located in northeast Taiwan. This village is populated with small-scale, eco-friendly farmers who pursue an alternative lifestyle, one that fosters intimacy between themselves and their land, their families, labor, and sustenance. We view this lifestyle as above all a kind of aesthetic choice.

Yuanshan was one of the sites of our ethnography, which we visited in the summer of 2017. In Yuanshan, we encountered the Open Hack Farm (Fig. 1). The Open Hack Farm is a side project of LASS, featuring on-going experiments in agricultural sensing. In it, LASS is being repurposed and augmented for assisting the practice eco-friendly farming and the concept of open source ecology. Aiming to establish a sustainable land management system, devices created and implemented in the actual farming fields collectively create a self-circulatory ecology. Our first impression of Open Hack Farm was that it was small and sloppy, with a worn hand-written sign said, “Open Hack Farm, RC2.” A large machine of unclear purpose was taking most of the empty space, and three quarters of the area was covered in plants that looked to us like weeds.



Fig. 1 Open Hack Farm. The blue barrels in the back collect rainwater for irrigation and organic composites for fertilizer, the counter on the right-hand side is a nursery, and the multi-functional FarmBot in the front contributes to seeding, plant monitoring, and growth recording. Photo taken by the authors

As we came to know the space better, we discovered that its haphazard appearance belies its sophisticated design. For example, sunlight is harvested through solar panels to charge agricultural machinery, including an auto-seeding system, an electronic weeding machine, and crop monitoring sensors for mobile tracking. Other low(er)-tech implementations include collecting rainwater for the irrigation system, composing food residue and chicken manure as organic fertilizer, and preserving seeds in preparation to future cultivation. There is a circulatory ecology happening onsite, where machines and natural cycles and processes are integrated. But this project is not in service of industrial agriculture. In this small village, we see farmers/developers utilizing IoT technology as a medium of self-expression, that is to embody the claim that eco-friendly farming is a beautiful lifestyle. Yen, who created and runs Open Hack Farm told us in an interview, “by introducing technology to the farm, I do not mean to replace human labor with machines; instead, what I aim to achieve is to propose an alternative to industrial conventional farming, to disseminate the idea of small-scale ecological farming, and to invite more people to join this practice.” For him, agricultural labor is not an economic or productivity problem to be solved by technology. Instead, agricultural labor is practice that can be made more meaningful, intensifying the relationship between humans and the land. In short, Yen wants to make agricultural labor more beautiful.

“Aesthetic” is a loaded term, as we indicated above. Here, we focus on those aspects of aesthetics that have to do with human experiences. Dewey has a notion of aesthetic experience [44] that has been highly influential in HCI research [45], which analyzes the qualities of “an experience.” Dewey claims that a good experience has a beginning, middle, and end; it is interactive and rhythmic; it is consummated or

completed; and it has an overriding felt emotional quality. While many even most theories of aesthetic experience are tied to contemplation of specific artworks, one of the strengths of Dewey’s account is that it can be extended beyond art—to the mathematician’s experience of solving a math problem or a child learning in school.

In developing his own account of aesthetic experience, philosopher of art Noël Carroll [46] observes that often when people are having aesthetic experiences, they attend to the structure of a work, noting how it hangs together (or fails to). Carroll calls this “design appreciation,” not referring to design as a field but rather to the human tendency to discern how individual choices contribute to the overall effect or purpose of the work, and to derive aesthetic pleasure from that act of discernment. For example, in a poem we might notice how devices such as rhyme, alliteration, and meter (all aesthetic properties) give acoustic emphasis to words that happen to be especially important to the poem’s meaning. Or, upon re-watching a favorite film, we might appreciate how the director uses props, camera angles, symbols, and cuts to foreshadow something important that will happen later in the film.

Open Hack Farm seems to bring these two notions of aesthetic experience together. The farming labor that it supports has the high potential to meet the qualities of a good experience as Dewey describes them: the activities of farming are holistic, interactive, rhythmic, meaningful, and directly linked to outcomes. But Open Hack Farm also provides an experience where what Carroll describes as design appreciation seems to do a lot of work. These farmers’ public accounts, reinforced in our data, suggest that this type of farming is aesthetic by achieving a kind of harmony among a small plot of land, a family, a close-knit neighborhood, and a tight coupling between one’s own labor (e.g., farming activities) and its product (e.g., one’s own food). Here, the “design” is not that of a work of art or a single artifact, but that of an ecosystem, where the human lifestyle or way of being is well integrated into natural rhythms (e.g., the diurnal cycle, the seasons, etc.).

But this is no mere romantic harkening back to a nostalgic past. This is an IoT farm, a farm so technologized that “Hack” is part of its name, and hacking is as integrated into the ecology as physical labor and the rotation of the Earth around the sun. Obviously, IoT is used as a resource to support farming. But we must not overlook that the relationship also works in the opposite direction: the farm—as a lifestyle, not just a physical place—presents a new opportunity for these former IT professionals to hack, to develop and extend the concept and practice itself of hacking. That this whole ecosystem is experienced aesthetically is key to its interest to research in IoT.

All of this suggests that “beautifying IoT” can refer to IoT’s potentials to contribute to aesthetic experiences understood in a relatively precise way. Specifically, it poses the question, how do the individual elements of our environments “hang together” to achieve an overall effect of aesthetic composition? What is the whole, the parts, and the principles of composition of the parts? For example, a “Smart City” is an environment (i.e., a city) that is intellectually grasped and pursued as a kind of Gestalt (i.e., it is “smart”). But “smart” is intangible—we cannot point to it the way we can point to a device or even a city. “Smart” is a principle of organization, and it is aesthetic not to the degree it can process information, but rather to the extent that this

information processing enriches and validates how all of the elements—including but not limited to human experiences—fit into its whole, the way a rhyme scheme and an apt metaphor convey a sentiment—say, of love lost—poetically. And Dewey helps decompose the dense notion of human experience similarly into a structured composition of parts, including material engagement, sensemaking, enlightenment, and emotional fulfillment. The Smart City will be aesthetic when the diverse elements of the smart city (the environment, human activities, technologies, the scales at which these are experienced, their mutual integration, etc.) are so well composed that they stimulate and reward the human desire to attend to their structure.

3.2 No.30: From Industrial to Aesthetic Material

Our second case, as indicated above, is not technical. Instead, it features an example of “creative living” in Taiwan, which refers to the aestheticization of everyday life. no.30 (<http://no30-inc.com/>) is Taiwanese home decor brand specializing in zinc alloy accessories and giftware. It has received international recognition for crafting products of high aesthetic quality. No.30 was founded by Shu-Jen Chang, daughter of the owner of Chi Hsing Metal, a family-run zinc alloy manufacturer based in Changhua, with almost 40 years of experiences in producing die-casting products for automobile, machines, and household appliances. Changhua is a county in central Taiwan that is home to the largest cluster of kitchen and bathroom hardware manufacturers in Taiwan. Zinc alloy is an industrial material with great strength and flexibility, high resistance to corrosion, and the ability to be polished to resemble the precious metal platinum. Although zinc has wide industrial applications, the material itself is rarely used as the primary material in high-end products.

The story of no.30 started with Chang’s appreciation for zinc, motivated in part by pride in the quality of zinc manufacturing achieved by her family’s business. The name, no.30, references the position on zinc on the Periodic Table of the Elements in chemistry [47, 48]. According to an interview conducted by Global Views, a popular magazine publisher in Taiwan, Chang recalled that she thought her family was a jeweler when she was young, because there was “glittering stuff all over the place” [48]. She wanted to make this hidden gem the center of appreciation. Together, she and her father founded no.30 in 2014.

Chang turned to Office of Product Design and Five Metal Shop, two design and creative studios with a presence in Taiwan, to reimagine the possibilities of zinc alloy products and to revitalize the family business. As the Office for Product Design characterizes the collaboration on their website, “We believe each material has its own unique qualities and, when thoughtfully used, the result can display integrity, honesty and beauty.” They add, “The no.30 objects are varied in terms of typology and surface finish, but unified in material, thought and purposefulness.[...] The objects are designed to add a special touch and ambience to any environment without dominating it or demanding too much attention” [49].



Fig. 2 Two views of Ganbei, a circular bottle opener. *Image Source* no.30-inc.com

Looking at no.30 products as a collection, we see how the designers make use of zinc alloy’s visual reflectivity to achieve a product identity, which we would characterize as understated and elegant. Let us consider Ganbei as an example. Ganbei (Fig. 2) is an award winning circular bottle opener, whose name is the Mandarin term for “cheers” during a toast. This product is finished with frosted zinc alloy on one side to assist a firm grasp and resembles the natural appearance of a pebble when not in use. Flipping it to its opposite side, polished stainless steel suggests its purpose as a bottle opener while expressing a modern, industrial aesthetic.

In fact, Ganbei is typical of no.30 designs, which share key features of its aesthetic. Most no.30 products are constructed in simple geometries with chamfered or rounded edges, combined with natural materials such as bamboo and glass to add contrast to the zinc alloys, and different production techniques, color coatings, and surface treatments are applied to create intriguing product personalities. No.30 designs feature aesthetic principles of rhythm, balance, and harmony.

No.30’s Ganbei is not literally an example of IoT, obviously. Rather, it is of interest for the way that it transformed an industrial material into an aesthetic material. This entails far more than seeing the aesthetic potential in a material. Philosophers of art such as Joseph Margolis [50] and David Davies [51, 52] distinguish between the physical medium and the artistic medium of a work. The physical medium is what gives it its physical form—marks of pigment on canvas for a painting or bodily movements in dance. The artistic medium is “a set of conventions whereby performing certain manipulations on a kind of physical stuff counts as articulating a particular artistic content” [53]. To continue from before, whereas marks of pigment on a canvas are part of the physical medium, delicate brushstrokes are part of the artistic medium; likewise, where bodily movements are the physical medium of a dance performance, a pose or articulated steps are part of the artistic medium. Key to this distinction is that the artistic medium is recognizable by others; in other words, what makes a mark of pigment a delicate brushstroke, or what makes a bodily movement



Fig. 3 Two views of Tetra, a fruit platter. *Image Source* no.30-inc.com

a dance pose, is a shift in viewing physical properties into viewing them as aesthetic properties.

In the context of no.30, this means that it was not enough for Chang to perceive aesthetic potential in zinc: in developing aesthetically pleasing zinc alloy products, she had to develop and successfully propose zinc alloy as part of an aesthetic medium—that is, as having a set of publicly recognized conventions whereby certain uses of zinc would count as aesthetic. Prior to her work, zinc was seldom used in upscale giftware; doing so meant developing conventions whereby zinc could be a primary material in such design. Now, such conventions need not be invented ex nihilo; it is clear Chang made use of existing aesthetic conventions in the giftware and the upscale kitchen product domains concerning the use of shapes, textures, contrasts, and functions. Nonetheless, in doing so she exploited material strengths of zinc, including its reflectiveness, strength, ability to bond with other materials, and capacity to be expressed with geometric shapeliness.

This work is visible in no.30’s characterization of a different design, Tetra, which is a fruit platter (Fig. 3). “The design of our fruit platter was inspired the way by piled up fruits at fruit-selling stands. [...] The dished areas in the top surface accommodate stacked fruits, various snacks and dry goods, displaying everything in an abundant fashion” [54]. Conventions of traditional Chinese produce markets help make Tetra’s design desirable to consumers, or (in the philosopher’s language), to “count as articulating a particular artistic content.” Making this aesthetic recognition possible means developing not just objects, but also aesthetic conventions: “We want to create a simple, universal language to communicate our own histories and memories to the world.” [55].

Not unlike the transformation of a zinc factory from an industrial chemical to an upscale designer product manufacturer, the Internet of Things promises to reimagine and reinvent industrial materials and devices. What will make them beautiful (or not) is not some mysterious or ineffably subjective quality intrinsic to the materials or objects, but rather how they are situated within publicly comprehended conventions,

expressive languages, and embodiments of cultural memories. Without these, objects are mere physical objects; they are only beautiful once cultural conventions of beauty are in currency. Put another way: the design of beautiful IoT is not limited to the design and distribution of aesthetic IoT devices, services, or experiences—it also includes the development and dissemination of aesthetic conventions and languages that allow them to count as beautiful in the first place.

4 Discussion

In positioning IoT as a matter of beautification and aesthetics at the outset, we were clearly claiming that the problem runs deeper than, say, hiring a graphic designer to pretty up IoT devices. Yet, as our sketch of aesthetic beauty above suggested, articulating what aesthetics might mean in the context of IoT is no trivial matter. In this Discussion, we explore that difficulty from two perspectives:

- Aesthetics can be justified as a primary, rather than secondary or even tertiary, concern for contemporary computing agendas.
- The scale of IoT poses a challenge to those hoping to appropriate traditional aesthetic valuation (read: criticism) methods.

The overriding characteristic of IoT that has motivated this study is its scale. IoT, including similar concepts of smart cities and ubiquitous computing, propose immersive environments not the size of the Holodeck, but the size of a metropolis, a nation, and potentially even the globe. In such a context, aesthetics cannot simply refer to attractive packaging. One need only consider the regional wastelands that humans have created, wastelands that no longer sustain the kinds of lives that humans want or need to live. This includes literal wastelands, such as the land around sites of nuclear disaster. But it also includes many cities, designed (we are now beginning to understand) for automobiles instead of pedestrians, at a scale that makes it nearly impossible to walk to work or the store, to know or engage one’s neighbors. It also includes cities designed to segregate citizens by race or social class, creating unlivable and inescapable concentrations of poverty and violence. These cities are in a literal way ugly: litter, pollution, and shabby buildings dominate lived environments. All over the world, urban planners are seeking to reverse these mistakes by creating pedestrian districts and public greenways, renovating buildings, and much more—Taipei Beautiful policy is a typical example.

What is the potential for IoT to create ugliness at scale? How do we know the IoT vision the HCI community is helping to create and sell will not in fact be the blueprint for future ugliness? Documents of Worlds Fairs from the 1930s and 40s provide visions of how, say, the automobile is going to improve urban life—failing to anticipate the ways that the automobile decimated inner cities, destroying neighborhoods, jamming thoroughways with traffic, filling cities with noise and air pollution, and enabling white flight. Are today’s IoT visions just the latest in the genre?

Obviously, we don't have the answer. But HCI researchers can at least attempt to bring a serious conception of beauty and aesthetics to bear on IoT. Aesthetics is often presented in research as if it is too complicated and subjective even to grapple with. But this claimed vagueness is precisely where art theory—from art history, literary theory, philosophy of art, etc.—can help, if they are used in certain ways. Such theories can make aesthetic issues more tractable, by identifying different dimensions, characteristics, or qualities of beauty or “the aesthetic” and making them easier to attend to. Our engagement with philosophy of art in this paper has not been to engage as philosophers ourselves—that is, we have not tried to propose a new and robustly justifiable theory that can defeat even the most dogged skeptic.

Instead, our use of aesthetic theory has been to help us attend to different aspects of systems, experiences, materials, and things that we intuitively feel are in some sense “aesthetic.” Specifically, our use of Dewey and Carroll in the LASS example helped us gain purchase on the ill-articulated but provocative idea that small scale farming is an aesthetically fulfilling way of life. It links the real (physical qualities of actual places and objects) with the ideal (a meaningful, fulfilling, and sustainable way of living). Our use of Margolis and Davis in the no.30 example helped us understand why the development of these upscale kitchen products was an aesthetic, and not merely industrial, use of the material zinc. There are hundreds of such theories, and we do not mean to claim that these are the best or most important for IoT. All we mean to demonstrate is that aesthetic theories can be used as resources to help us do what we want to do—which is to attend, as design researchers in HCI, to the aesthetic qualities of emerging technologies whose mature uses and look-feel have not yet come into view, and to creatively imagine some ways to carry those qualities forward.

But—and this is our second point—much of traditional aesthetic theory has been developed in the context of traditional artworks—paintings, poems, dance performances, and musical compositions being dominant examples. What these share is that they have human-scale interfaces: for the most part, they fit in a room. A poem can fit in a small book, held by one hand, while one is nestled in a chair. A dance performance takes up more space—but still it fits in an auditorium. Traditional WIMP interfaces, mobile apps, research through design artifacts, and so forth also, for the most part, fit in a room. Interaction criticism (as characterized in [56, 57] seems to assume and build off these similarities of scale).

But IoT and cities do not fit in a room, which is one reason why contemporary urban policies, like Taipei Beautiful, have implications for both. Aesthetics at a much larger scale seems most applicable here, and that is where more broadly scoped aesthetic perspectives are needed. Here, a sense of collective aesthetics, that is, the aspiration for future ways of life of a region, seems especially important. Here we are circling back to the idea of a Swedish IoT or a Taiwanese IoT. We do not mean this in a classificatory sense (e.g., treating Swedish vs. Taiwanese culture as buckets), but rather as an empirical aesthetic question: what ways of being do people in Taiwan collectively pursue, or hope for in the near future, and how can emerging technologies like IoT support them?

We mentioned in our methodology that our examples were chosen in part because technologists, entrepreneurs, and makers themselves identified them as interesting. no.30's Ganbei and Tetra might not have been interesting to a similarly qualified group in another region—they aren't even examples of IoT! But Ganbei and Tetra resonated with these technologists, in part because the designs speak to specific Taiwanese aesthetic concerns. This includes obvious aesthetic qualities, such as the meaning of “ganbei” in Chinese culture, or the way Chinese fruit markets present their wares, as alluded to by Tetra. It also speaks to one of the dominant questions in IT discourses in Taiwan: how can traditional manufacturers be more creative, so as to benefit from the innovation economy? Finally, the attraction to these designs also happened in a population where manufacturing expertise is far more dense than it is in many other places. In other words, technologists, makers, and entrepreneurs in Taiwan are more likely to appreciate a clever new use of an industrial material, because that is something many of them have been thinking about their whole professional lives.

5 Conclusion

In this research we have sought to push the limits of our own aesthetic thinking about IoT by identifying a set of aesthetic objects of interest to a group who focus quite seriously on IoT as an R&D agenda, and then seriously yet also playfully considering them in relation to computational aesthetics and aesthetic interaction in HCI, because they specifically address technology and interaction; urban/regional policies on aesthetics, because they address questions of scale and ecology; theories of aesthetic experience, because they account for the human scale; and theories of aesthetic medium, because they account for both the material and cultural dimensions.

We hope in doing so to have revealed some of the stakes of thinking about IoT in relation to beauty and aesthetics, and thereby to have motivated more research in this space. We also have sought to demonstrate a methodology that facilitates researcher appreciation of subtle aesthetic qualities, where they might not have been obvious on first glance. Finally, we have contributed to research recognizing the importance of, and meaningfully building on, IT R&D in Asia.

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