Real-Fictional Entanglements: Using Science Fiction and Design Fiction to Interrogate Sensing Technologies

Richmond Y. Wong
BioSENSE Lab, UC Berkeley
School of Information
Berkeley, California, USA
richmond@ischool.berkeley.edu

Ellen Van Wyk
UC Berkeley
School of Information
Berkeley, California, USA
ejvw@berkeley.edu

James Pierce
UC Berkeley, Jacobs Institute
for Design Innovation
Berkeley, California, USA
pierjam@berkeley.edu

ABSTRACT
We present a set of design fiction proposals related to sensing and tracking technologies, inspired by the 2013 science fiction novel *The Circle*. By creating design proposals that explore connections between the novel's imagined world and our present and future realities, we show that we are able to explore, expand, and articulate a range of social, technical, and legal configurations of the future. This paper contributes a set of design fiction proposals and a case study of a design project that uses design fiction inspired by a science fiction text to engage issues of privacy and surveillance. The paper also provides a new approach to creating design fiction, by using science fiction texts as a starting point.

Author Keywords
Design fiction; science fiction; privacy; design workbooks;

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

INTRODUCTION
Emerging sensing and tracking technologies often seem like something straight out of science fiction, although their implications for the future can be very unclear. Our work aims to better understand the privacy implications of emerging and near-future sensing technologies. Many such technologies are developed and studied by HCI researchers, such as detecting heartbeats from a distance [1], image analysis [11,23], or wearable sensors [21,49]. Social issues (including privacy) related to these technologies are often explored through technical research or user studies. Here, however, we engage with these technologies and issues by adopting a design approach involving the creation of design fictions in order to explore near-future scenarios.

DIS 2017, June 10-14, 2017, Edinburgh, United Kingdom

ACM 978-1-4503-4922-2/17/06…$15.00
DOI: http://dx.doi.org/10.1145/3064663.3064682

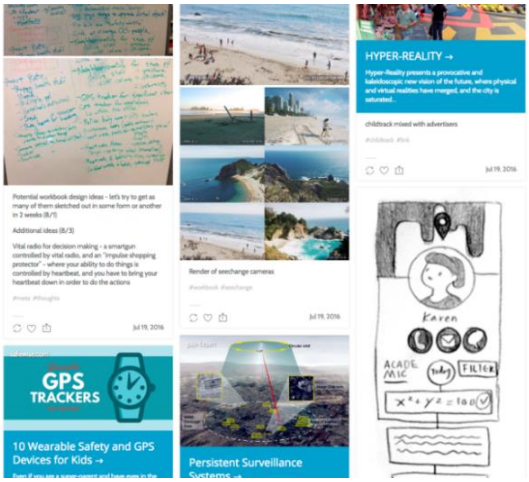

Figure 1. A screenshot of early design ideas and references, shared among the authors on a tumblr blog.

Inspired by fictional sensing technology products from the 2013 fiction novel *The Circle*, this paper uses a design workbook to develop variations of visual design fiction proposals, exploring privacy and surveillance implications of sensing technologies. This work develops and deploys design fictions in a novel way: by explicitly adapting written science fiction we tap into an author's existing richly imagined world, rather than creating our own imagined world from scratch or being implicitly inspired by ideas from science fiction. Adapting fictional worlds from literature allows researchers who are not professional fiction writers to engage in creating design fictions. This helps us engage ideas in the cultural imagination, forging a bridge between popular speculative fiction and research.

This paper provides three main contributions. First it contributes a workbook of visual design fiction proposals; second it presents a case study addressing how researchers can understand and make use of cultural representations of new and emerging technologies to interrogate their privacy implications; third it points towards a design approach for creating design fictions by using science fiction texts as a starting point. In the following sections, we review prior work and discuss why we find *The Circle* a useful starting point for our work. We next present our designs and analyze them through a privacy framework. We then step back and reflect more broadly on our design approach.

ENGAGING FICTION IN PRIOR WORK

Researchers, particularly in design and HCI, have engaged with fiction in a number of ways which contribute to our approach. Bleecker provided one of the first discussions of "design fiction," placing it as an authorial practice that exists in the space between science fiction and science fact, using yet-to-be-realized design concepts to understand, explore, and question possible alternative futures [4]. Bleecker and Kirby describe "diegetic prototypes," noting that design fiction objects exist within a narrative or story world [4,22]. Other authors expand on how these diegetic design fiction "props" help imply or create a fictional world in which they exist [9,25].This suggests that design fictions must be considered in relation to sociocultural contexts.

In the design research community, design fiction has been predominantly deployed in one of two ways. First, a line of work uses the process of making design fictions as a method of inquiry. Blythe has used fictional abstracts to interrogate the genre of research papers [5], expanded upon by Lindley and Coulton who use fictional research papers to examine and critique practices in the HCI community [27]. Design fictions have increasingly taken non-textual forms, including textual-visual artifacts studying the roles of "counterfunctionals" [36], videos exploring sustainability futures [19], and creating material artifacts as design fictions [7,48]. These bring attention to the exploratory and critical roles the process of *making* design fictions can play. A second line of work uses the lens of design fiction to analyze diegetic practices and narratives, including the practices of steampunk communities [46] or concept videos that portray corporate futures [52]. Tanenbaum et al.'s analysis of the film *Mad Max: Fury Road* [45] and Lindley et al.'s analysis of *Her* [28] suggest considering science fiction films as design fictions. These authors use design fiction as an *analytical lens* to interrogate fictional worlds created by others, particularly ones in popular culture.

We bring these lines of work together by creating new design fictions to both analyze an existing fictional world from a novel, and to ask and explore new questions about privacy. Instead of using science fiction media as objects of analysis, we use a science fiction text as a starting point to create our own design fiction artifacts.

Our work builds on past connections drawn among design, research, fiction, and public imagination [29]. For researchers and designers, science fiction has helped shape the field of ubiquitous computing [13] and inspired interface and interaction design [37]. Pastiche scenarios use characters from fiction in design scenarios to flesh out personas [6]. Sturdee et al. explicitly find inspiration in the sci-fi film *Blade Runner* to create design fiction [42], while Dunne and Raby's "United Micro Kingdoms" Train design fiction [14] appears implicitly inspired by the film *Snowpiercer*. Literary scholars note how science fiction has garnered more literary respect in recent years and how literature engages technology in complex (and not purely adversarial) ways [16]. Fictional representations of technology also take hold in the public imagination, such as the vernacular use of "big brother" from George Orwell's dystopian novel *1984* or the popularity of the speculative fiction anthology show *Black Mirror*. Public processes of imagination are facilitated in part through cultural and media production, including advertisements [18,52] and films [45]. Design fictions and speculative designs appear to hold similar potential, such as Superflux's *Drone Aviary* [43] and Matsuda's *HYPER-REALITY* [30] videos which have been viewed by hundreds of thousands of people. Our work contributes to understanding the 'infrastructuring' of new technologies [40] by using design fiction as a bridge between technical and design research, and popular culture representations of future technologies.

CREATING DESIGN WORKBOOKS FROM FICTION

Our design work draws from the fictional world of *The Circle*, a 2013 novel by Dave Eggers. Set at an unspecified time in the near-future, the novel focuses on Mae, a new employee at The Circle, the most powerful internet company in the world. The Circle (the company) provides services like social media, email, and personal finance, and creates hardware devices like cameras and health-monitoring bracelets. In the story, consumers are encouraged to share more and more details of their lives online in the name of transparency and knowledge building. The Circle uses its power to limit users' desire and ability to opt out of its systems. Though critical of technology, the novel is not dystopian. Rather it employs a dark humor, as throughout the story new technologies and services are introduced in the name of providing greater user value, though to the reader they may seem increasingly invasive.

The Circle (the novel) presents an opportunity to look at a contemporary popular depiction of sensing technologies, and reflects timely concerns about privacy and increasing data collection. We have no interest here in assessing the literary or cultural quality of the novel. Rather we were drawn to the novel as it was a New York Times bestseller, and thus a noteworthy part of the public discourse about the social, political, and ethical implications of new sensing technologies. We were also drawn to news that a film adaptation of the novel was in production, suggesting that the story will play a larger role in the public imagination after its release.[1] *The Circle* can be viewed as science fiction, defined broadly, using a near-future narrative to explore social issues related to fictional technologies that have a discernible basis in what is being developed today.

While prior design fictions incidentally touch on privacy (such as gestures towards data collection concerns in "Game of Drones" [26] and the "Future IKEA Catalogue" [10]), we wanted to use design fiction to explore a space of

[1] Our designs were created before the film adaptation's release in 2017 and represent our visual interpretation of the novel's world.

possible futures involving sensing technologies' potential privacy implications. We turned to design workbooks as our method to open this space, and to a privacy framework to analyze and map the breadth of our explorations.

We follow the design workbook method to create a set of design fiction proposals. Design workbooks are collections of design proposals or conceptual designs, drawn together to investigate, explore, reflect on, and expand a design space; they purposely lack implementation details, allowing designers and workbook viewers to reflect, speculate, and generate multiple stories of possible use [17]. Grounded in our readings of *The Circle*, we chose a set of sensing technologies that might be interesting to explore variations upon. Our goal was to create a set of proposals to open a design space of possible futures that would both include and expand beyond the future described in the book. We also wanted to see what new themes might emerge over time. Designs were primarily brainstormed and created by the second and first authors, shared among all authors through a blog (Figure 1), and periodically all three authors would discuss the design ideas to reflect on what questions and themes arose from the designs. The first author worked on a separate but related project using surveys to explore respondents' reactions to technologies from *The Circle*. Qualitative responses from that project's pilot survey were shared with the authors to provide design inspiration.

Our designs make use of two design genres: "interfaces," and "products and services." Our interface designs imagine what these technologies' user interfaces might look like. Product and service designs play on the genres of Amazon product pages, or websites for startups, products, and services. These genres help us think about the designs as everyday objects and imagine how they might be situated in the world. To create the interfaces we used Photoshop, Illustrator, and Sketch. To create the product and service pages we adapted HTML and CSS from websites including Amazon.com and getbootstrap.com. We included a variety of public domain stock images, hand drawn illustrations, and photos that the second author staged and shot as assets.

Given our interest in privacy and surveillance concerns, we looked to privacy literature, finding that contemporary approaches view privacy as *contextual* [32]; that is, the same technologies can preserve or violate privacy in different social contexts. Furthermore, Mulligan et al.'s privacy analytic framework suggests that rather than attempting to discuss privacy under a single definition (which can be debated endlessly, e.g.[38,39,50]), it is more productive to map how various *dimensions* of privacy are represented in *particular situations* [31]. Their dimensions include: theory (why there should be privacy), protection (who and what is being protected by privacy), harm (actions and actors who violate privacy), provision (what mechanisms provide privacy protection), and scope (how broadly does privacy apply) [31]. This review of the literature led us to focus on creating variations on our designs by placing them into new contexts and new social situations to change the values of these dimensions.

We began our first set of designs by trying to visually imagine the technologies described in *The Circle*, staying as close to the textual descriptions as possible. We then discussed privacy themes emerging from the designs. We did two more rounds of design iterations to explore new combinations of privacy dimensions creating variations on our first set of designs. In these iterations, we used new social contexts, put the technologies in the hands of different users, or integrated Eggers' fictional technologies with real-world contexts and technologies. After each round of iteration, we evaluated how our collection of designs mapped onto Mulligan et al.'s dimensions. We ended our iterations after finding we explored a wide variety of combinations of privacy dimensions, suggesting that we had opened and broadened our design space.

USING TECHNOLOGIES FROM *THE CIRCLE*

Our design fiction proposals draw from three technologies presented in *The Circl*e. While reading the novel, we noted that the story reminded us of several non-fictional technologies. To diversify and blend our design work with non-fictional technologies, some proposals are based on a fourth real technology currently being developed but could fit into the novel's story world. We provide a brief summary of Eggers' three technologies from *The Circle* and a description of the fourth non-fictional technology.[2]

SeeChange

SeeChange is the most prominent technology introduced in the novel. It is described as a small camera, about the size of a lollipop, which wirelessly records and broadcasts live high-definition video. Its battery lasts for 2 years without recharging. It can be used indoors or outdoors and can be mounted discreetly. Live video streams from the cameras can be shared with anyone online. The story introduces the cameras as a way to monitor outdoor sports locations, share video streams for entertainment, or monitor spaces to prevent crimes. Later in the story, SeeChange becomes ubiquitous: they are placed in Mae's parents' house while they undergo medical treatment; worn continuously by elected officials to ensure democratic transparency; and eventually worn by Mae to promote The Circle to consumers through a constant live personal video stream. Below is a short excerpt from the novel which takes place during SeeChange's product launch, in which a lead executive from The Circle publicly demos the product.

SeeChange Excerpt from The Circle

"I set up that camera this morning. I taped it to a stake, stuck that stake in the sand, in the dunes, with no permit, nothing. In fact, no one knows it's there. So this morning I turned it on, then I drove back to the office, accessed Camera One, Stinson Beach, and I got this image. Actually, I was pretty busy this morning. I drove

[2] **Spoiler alert:** Several descriptions of these technologies include mentions of major plot points from the novel.

around and set up one at Rodeo Beach, too. And Montara. […]" With each beach Bailey mentioned, another live image appeared, each of them live, visible, with perfect clarity and brilliant color.

[…] "Now imagine the human rights implications. Protestors on the streets of Egypt no longer have to hold up a camera, hoping to catch a human rights violation or a murder and then somehow get the footage out of the streets and online. Now it's as easy as gluing a camera to a wall. Actually, we've done just that."

[…] "imagine any city with this kind of coverage. Who would commit a crime knowing they might be watched any time?"

[…] Live shots from all over the world filled the screen, and the crowd erupted again. Now Bailey cleared the screen again, and new words dropped onto the screen:

ALL THAT HAPPENS MUST BE KNOWN. [15]

ChildTrack

In the novel, ChildTrack is introduced as an ongoing project at The Circle. It is a small chip that can be implanted into the bone of a child's body, allowing parents to know their child's location at all times. In the story, ChildTrack starts as a pilot program involving the insertion of location chips into children's wrists to prevent kidnapping. This leads to the problem of criminals knowing where the chips are located, and removing them from children. The solution is to embed the chips into children's bones, making it harder for criminals to extract. Later in the story, The Circle uses the same chips to store data about a child's educational records which parents can access "in one place." It is speculated that there eventually would be a complete record of a student's every academic activity, including every word ever read and every math problem ever completed.

NeighborWatch

NeighborWatch is introduced as a product pitch to The Circle within the novel. It is a neighborhood watch service utilizing SeeChange cameras placed throughout a neighborhood, so that residents can identify suspicious persons. People in the neighborhood register their data and biometrics with NeighborWatch to identify them as residents. Via a screen-based interface users can see an outlined-version of the inside and outside of nearby homes. Residents of the neighborhood or known visitors are displayed as blue figures. Unknown people are displayed as red figures, triggering a notification to residents. It is speculated in the story that other sources of data, such as criminal records, can be further used to color-code people.

Vital-Radio

Vital-Radio is a real life prototype developed at MIT which uses radio waves to wirelessly detect a user's breathing and heart rate. It can monitor users up to 8 meters away and in separate rooms [1]. Adib et al. note that Vital-Radio is limited to monitoring users who stay in-place and can only monitor three people simultaneously. We imagined a future version of Vital-Radio that could monitor more than three people simultaneously while moving. We also imagined that users could see and interact with their heart rate data as well as their stress levels, emotional states, and other extrapolated information. In order to imagine how Vital-Radio might exist in the world of *The Circle*, we composed a short fiction passage in the style of Eggers depicting a launch and demo event for Vital-Radio by Victor, our own made up executive at The Circle.

Our Vital-Radio Fan Fiction

Mae watched as Victor held a sleek black box, about the size of a small DVD player. He turned to the audience and smiled.

"My grandma's eighty-seven. Last year she broke her hip and I've been concerned about her. Last week, while she was napping-"

A wave of laughter rippled through the audience.

"Forgive me! Forgive me!" he said, "I had no choice. She wouldn't have let me do it otherwise. So I snuck in, and I installed Vital-Radio in her bedroom and the living room. It can see through walls up to twenty five feet, so with just two of these boxes I can cover her whole house. She won't notice it."

"And of course," Victor continued "all that data is stored in the cloud, and in your tablet, anywhere you want it. It's always accessible, and is constantly updated. So if you fall, hit your head, you're in the ambulance, the EMTs can access everything about your vitals history in seconds. And it's not just healthcare. Imagine your home adapting music and lighting based on your vital signs and your mood. Or getting customized assistance based on your stress level at a Vital-Radio kiosk in an unfamiliar airport. Imagine the possibilities!"

DESIGNS

We present a sample of our design workbook proposals that show the progression of our design explorations, the breadth of design ideas inspired by the four technologies, the varying genres we used, and different ways we were inspired by the novel. (See supplementary materials for additional detail on these proposals.)

Design Round 1: Adapting *The Circle*

Our first designs adapt the technologies from the novel's textual descriptions. As there are no illustrations in the novel, these designs realize our interpretation of the novel's world, in which these technologies were sold as consumer products by a large technology company.

SeeChange Beach (Figure 2) interprets SeeChange's interface based on its introduction in *The Circle*, when Bailey, one of the company's executives, reveals live SeeChange footage. This design highlights the features of the fictional camera by juxtaposing two languages—glossy stock photos, and a security camera overlay that usually accompanies grainy, low resolution footage. This design felt surprisingly believable after we made it, and slightly creepy as it put us in the position of feeling like we were surveilling people when looking at the design.

ChildTrack UI (Figure 3) interprets the book's description as an interface. Since ChildTrack is a complicated system that tracks children's location and academic records, its look is borrowed from Facebook's design patterns to make the concept easier to consume. A contrast is presented between presumably benign, user-friendly design, and the reality that The Circle has an extensive knowledge of their users that goes beyond individual posts and photos.

ChildTrack builds more 'meaningful' profiles by aggregating feed data over time, which is represented in the "overview" tab. This design puts the viewer in the position of a parent, able to see all of their child's information.

Grandma's Data (Figure 4) is an interface for Vital-Radio which realizes the description from our own *Circle*-like fiction passage. This design focuses on the presentation of the device's data and the visual design is kept to a wireframe stage. The data present a narrative of grandma's day and raise questions about how the data are related and how "emotion" and "stress" are classified and quantified.

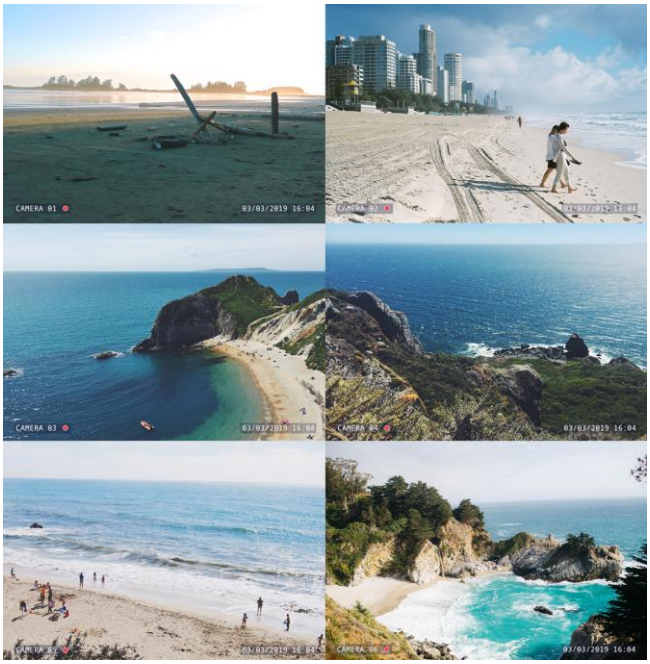

Figure 2. SeeChange Beach cameras

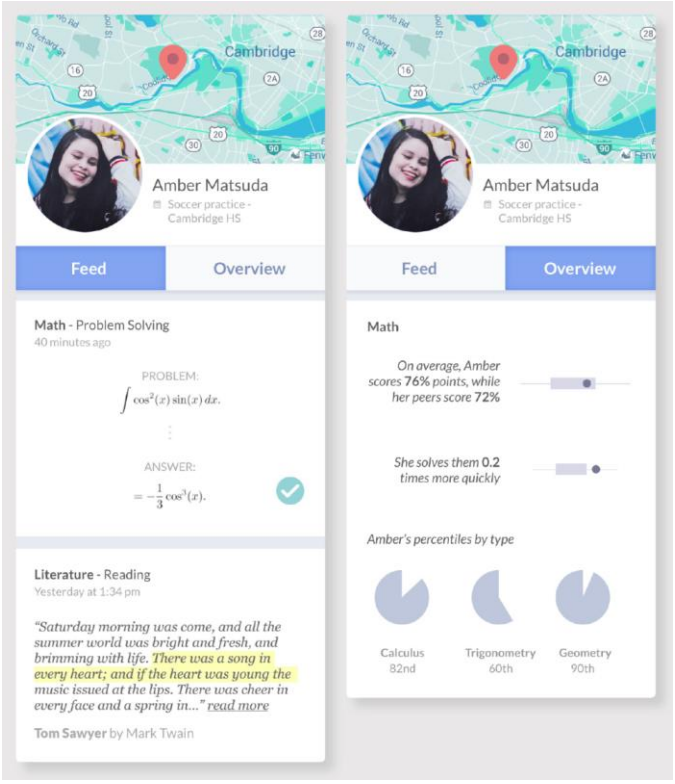

Figure 3. ChildTrack UI

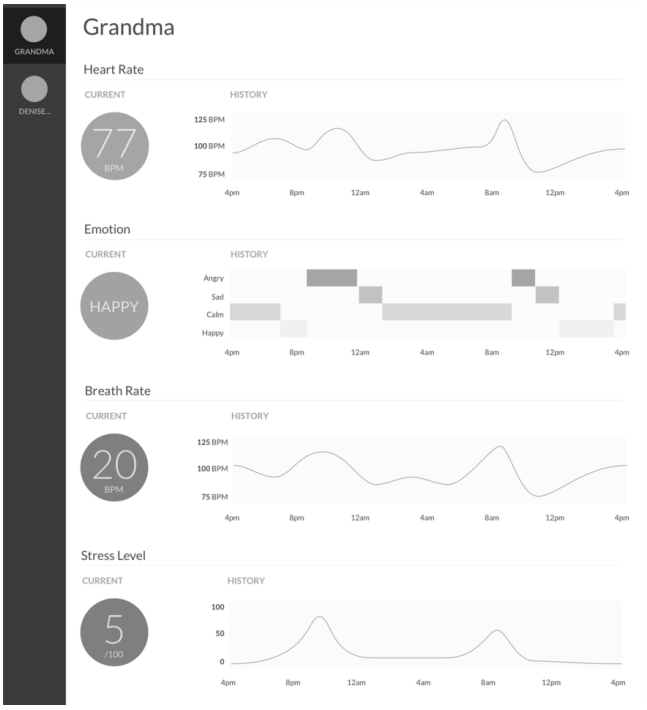

Figure 4. Grandma's Data in Vital-Radio

Design Round 2: *The Circle* in New Contexts

After our initial set of designs adapting technologies from their descriptions in *The Circle* (and our Vital-Radio fiction passage), we discussed how our first set of designs reflected potential privacy concerns. We began thinking about how the same set of technologies might be used in other situations within the world of the novel, but not depicted in Eggers' story, and how that might lead to new types of privacy concerns [31,32]. This second set of designs goes beyond the textual descriptions in the novel by taking the same technologies and re-imagining them for new sets of users or for use in new social contexts, but could still exist and be sold in the fictional world presented in *The Circle*.

The **SeeChange Amazon pages** present the SeeChange camera being sold as three different products to user groups not discussed in *The Circle*. First is SeeChange as a **police body camera** (Figure 5a). Second is SeeChange framed as a small, hidden, wearable **camera for activists groups** like PETA (Figure 5b). Third is SeeChange marketed "**For Independence, Freedom, and Survival**," to be used by people suspicious of the government who may want to monitor government movements (Figure 5c). The latter was inspired by a pilot survey respondent's worry that SeeChange could be used by "right-wing activists harassing liberal groups" in the U.S. Our design frames SeeChange as a product that might seem valuable and useful to a person

who might want to hide the camera with the desire to watch government employees for perceived abuses of power. This set of designs interrogates which surveillance concerns

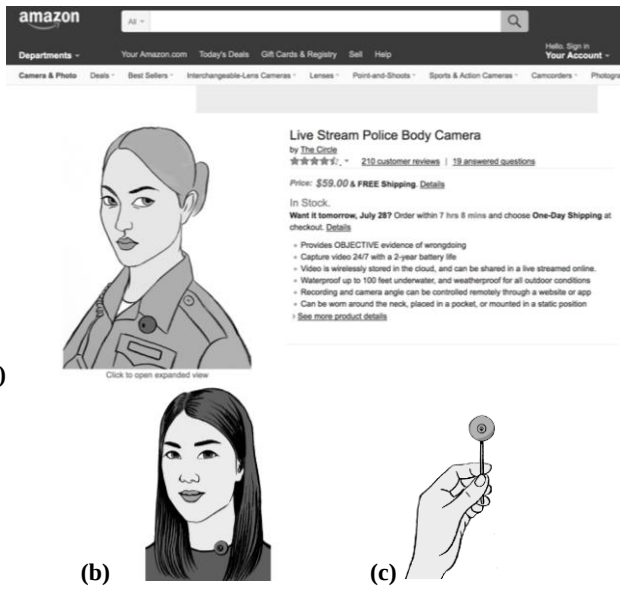

Figure 5. Amazon wireframe pages. Swapping out the product name and image, we show SeeChange as (a) a "live stream policy body camera", (b) a small wearable version for activists, and (c) SeeChange "For Independence, Freedom, and Survival", small enough to hide and monitor the government.

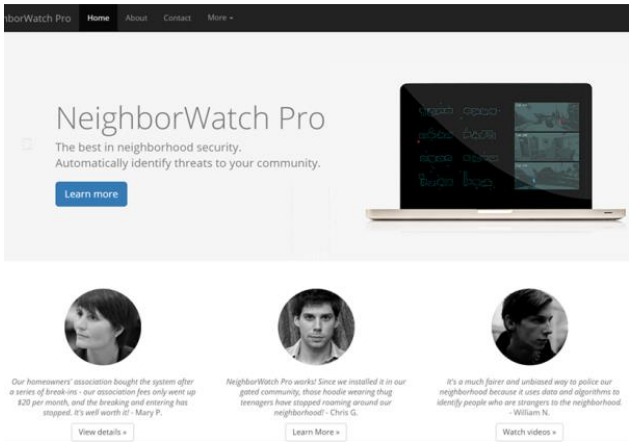

Figure 6. NeighborWatch Pro website

Figure 7. SeeChange Angles

stem from SeeChange's technical capabilities and which come from concerns about who SeeChange's users or subjects are. We play on this question by writing in the body camera's product description "Provides OBJECTIVE evidence of wrongdoing," leaving ambiguity about whether it is recording the police officer's or citizen's wrongdoing.

NeighborWatch Pro (Figure 6) uses a product website to market a version of NeighborWatch. While presented in the book as a service that any community could use, a pilot survey participant expressed concerns that only "wealthy closed communities" would use it. Our design imagines an "enhanced" automated version of NeighborWatch which intentionally caters to those communities, raising questions about racial and socioeconomic biases reflected by users, datasets, and algorithms utilized by the system.

SeeChange Angles (Figure 7) was inspired by our thinking about the implications of ubiquitous SeeChange cameras always recording and broadcasting. On one hand, it might be nice to be able to automatically (re)watch sports and special events from multiple angles. Conversely, it might be creepy to use many multiple angles to watch a person doing daily activities. To explore this use case, the second author took photos of a subject from multiple angles inside and outside a room, and added a security camera overlay. The high quality and large quantity of photos suggest what may be possible with many high-definition SeeChange cameras.

Design Round 3: New Fictions and New Realities

After our second round of designs and thinking through the privacy analytic, we began thinking about privacy concerns that were *not* particularly present in *The Circle* or our existing designs, such as government surveillance (instead of surveillance by web companies), or how advertisers or other third parties might benefit from this expanded collection of data. We also began to realize that many of the design ideas we were thinking about reflected non-fictional products being researched or developed. We wanted to more tightly integrate fictional and real emerging technologies through our proposals. The following designs, while inspired by *The Circle*, are imagined to exist in worlds beyond the novel's.

Airport Security (Figure 8) depicts an imagined use of NeighborWatch and SeeChange, where an airport surveillance system automatically assigns threat statuses to people by color-coding them. Rather than focusing on consumer technologies like in the novel, we re-imagine these as government technologies. The user interface is omitted in this design in order to invite questions about how the system classifies people, and what each of the colors mean. One interpretation is that it uses computer vision or machine learning techniques to classify people (instead of the manual database entry technique in the novel).

The **License Plate Tracker** (Figure 9) also puts SeeChange in the hands of the police or government intelligence agencies. It is presented in a low fidelity mockup where the

Figure 8. Airport Security, inspired by NeighborWatch. Images adapted from [35,51] under CC BY-SA 2.0

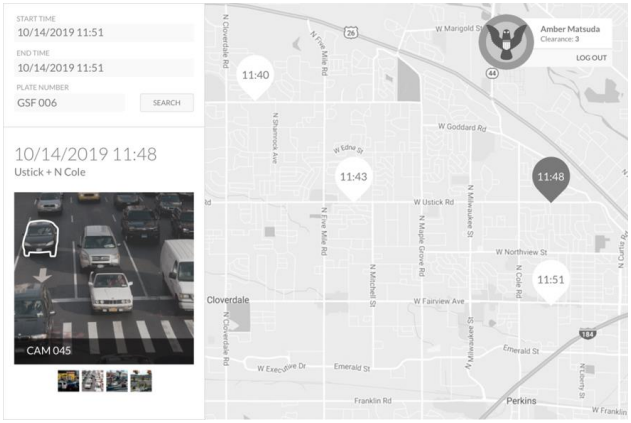

Figure 9. License Plate Tracker, inspired by SeeChange

UI elements help describe system's context and capabilities. For instance, the imagined user is a government official who can easily see anybody's location history and traffic camera images using the search feature, without restriction.

TruWork (Figure 10) re-imagines ChildTrack as an implantable tracking device for employees that employers use to keep track of their whereabouts and work activities, as employer surveillance is not critically addressed in the novel. Our design presents a product website targeting employers, using language like "Know the truth" about your employees. While presented positively, the lack of employee viewpoints raises questions about power, and how employees may try to resist or game these systems.

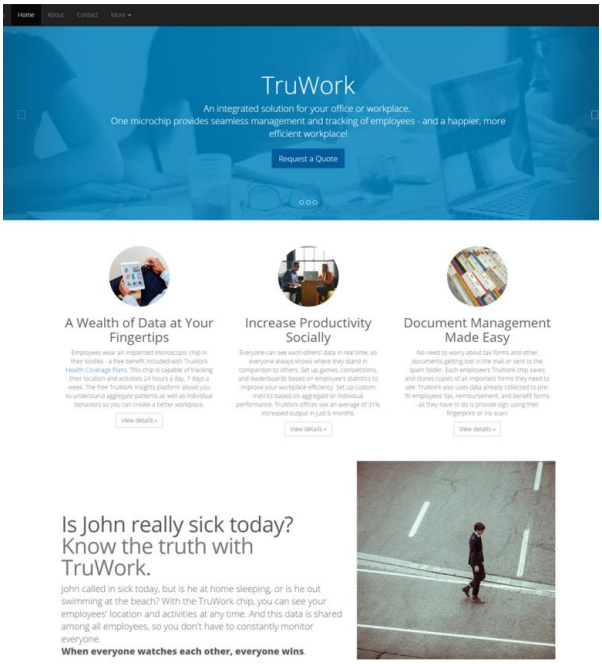

Figure 10. TruWork website, inspired by ChildTrack

The next set of designs employs the visual language of startup companies and their products and services. For example, onboarding tutorials or advertising often include cute, simple cartoons explaining the use of a product. **Vital Radio Match** (Figure 11a) extends the real-world Vital Radio to be used as an online dating service by matching people's "compatible" heart rates. The visual language draws comparisons to other dating applications, and provokes questions about the persuasive power of algorithmically generated results. **CoupleTrack** (Figure 11b), based on ChildTrack, allows adult couples to use implanted chips to continuously track each other's location and activities. **ChildTrack for Advertisers** (Figure 11c) allows advertisers, who are never discussed in *The Circle*, to leverage a child's location data to individually target them with advertisements, or for things that children with a "similar profile" like. Together these designs interrogate the relationship between privacy and personal data from the viewpoints of different stakeholders.

Amazon Echo with Vital-Radio combines the real Amazon Echo—a hands-free speaker, smarthome controller, and virtual assistant—with Vital Radio, presented as a product for sale by Amazon (Figure 12). Our design proposal uses a person's heartbeat patterns to adjust a home's lighting and temperature settings, and automatically buys items from Amazon.com that it thinks will suit the user's current mood, raising questions about what types of third parties have access to a user's data.

ANALYZING PRIVACY DIMENSIONS IN OUR DESIGNS

Using Mulligan et al.'s privacy analytic [31] to interpret our design fictions after each round of designs, we ended our iterations after finding we explored a wide variety of combinations of privacy dimensions, allowing us to explore

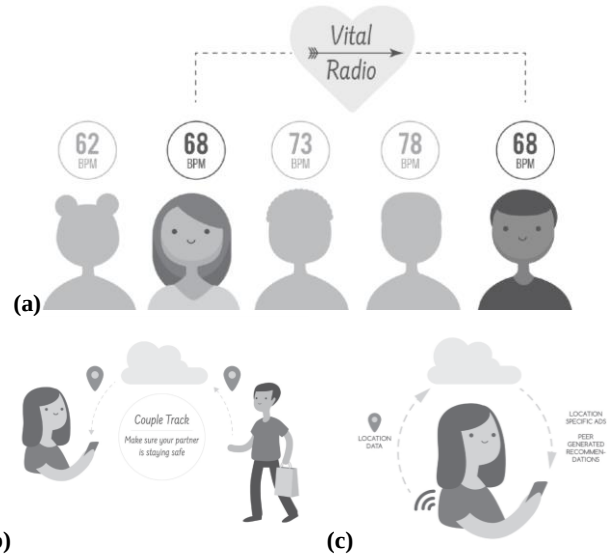

Figure 11. Product diagrams depicting (a) Vital Radio Match, (b) CoupleTrack, (c) ChildTrack for Advertisers

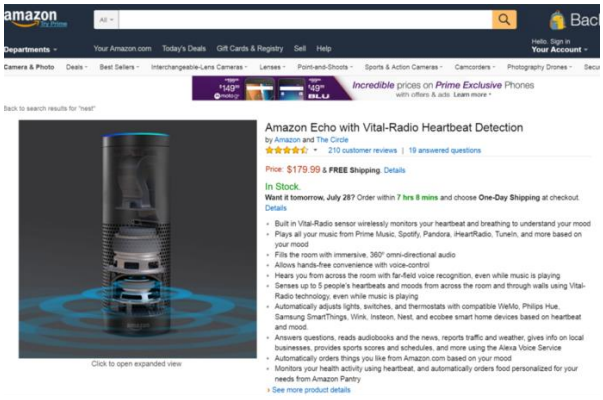

Figure 12. Amazon Echo with Vital-Radio

a broad space of privacy issues in and beyond *The Circle*. We present a brief analysis and interpretation of our design fictions using the privacy analytic dimensions (theory, protection, harm, provision, and scope) before discussing some broader reflections on our design process.

First looking at the issues arising from our initial round of designs (SeeChange Beach, ChildTrack UI, Grandma's Data), the main theory of privacy employed is that privacy protects individuals' personal information. What is being protected is individuals' data and their image or likeness (in SeeChange). Privacy harms stem from other individual consumers who buy and use these technologies. The novel does away with mechanisms that might provide privacy protection: laws and social norms that require consent before collecting information or embedding devices in someone's body do not exist in this fictional world; and new technical abilities that make it easier to hide or disguise sensing technologies. The scope of these privacy issues is broad, encompassing both public and private spaces. Our design fiction proposals in subsequent rounds of design vary or provide more specifics to these dimensions of privacy, to think about issues not present in the Eggers novel. Each of these dimensions is outlined below:

Theory. Our designs go beyond conceptualizing privacy as merely keeping data secret. NeighborWatch Pro and Airport Surveillance both conceive privacy as protecting adults' personal autonomy from surveillance. SeeChange Angles shows another conception of privacy focused on maintaining the sanctity of private space.

Protection. ChildTrack UI, CoupleTrack, and TruWork are imagined to use the same technology, but identify new specific groups being protected by privacy. ChildTrack UI violates a child's privacy; CoupleTrack explores privacy in the context of an adult relationship; TruWork explores employers violating employees' privacy.

Harm. Our designs identified privacy harms caused by actors beyond consumers and users. TruWork identifies employers as causing privacy harms, while License Plate Tracker and Airport Surveillance imagine government institutions using sensors to violate privacy. Amazon Echo with Vital-Radio and ChildTrack for Advertisers raise questions about privacy harms caused by data-sharing with third parties. NeighborWatch Pro and Airport Surveillance suggest that computer vision coupled with algorithmic decision making could also cause privacy harms.

Provision. Understanding why a design fiction violates privacy helps us understand what mechanisms currently protect privacy. For instance, ChildTrack would likely be illegal in the U.S. due to child privacy laws, highlighting legal privacy protections. It is also currently not technically possible to make a consumer camera as small as SeeChange with such high resolution and streaming capabilities or make a GPS transmitter as small as ChildTrack, highlighting technical limitations that help provide privacy protection [44]. And as of today, many people do not feel comfortable embedding digital technologies in their bodies, excepting small groups of body hackers and artists (e.g. [3,47]), surfacing social norms that help protect privacy.

Scope. Many designs help us understand potential privacy violations that could occur in public space (e.g. Airport Surveillance, License Plate Tracker), or private space (e.g. Grandma's Data). However, scope is not limited to physical spaces. SeeChange Angles helps us understand a scope of scale – the privacy violation of nine cameras in one room is different than a violation caused by one camera in the room.

This analysis suggests that design fictions can be designed for and analyzed using frameworks created for specific empirical topics, such as privacy. Design fictions can be used as examples for analysis, and perhaps help refine the frameworks themselves (e.g., creating borderline cases).

REFLECTIONS

Real-Fictional Entanglements

After creating our proposals, we found that several designs similar to our design fictions have been made or are in the

process of being implemented by companies. Some of these we were aware of beforehand, such as wireless security cameras. Yet we were surprised to find that some products we had imagined as fiction were close to being realized as 'real,' such as a smart employee badge similar to TruWork [20]. One interpretation of this might be that our proposals are design fictions while similar commercial designs are not; that is design fiction is based on intent—indeed some have distinguished between "intentional" and "incidental" design fictions [24]. However we find it useful to blur those boundaries, instead using our design fictions to interrogate the inherent entanglement between fictional representations of technologies and their material realities.

Here we are inspired by Barad's feminist philosophy, who conceptualizes phenomena in the world as emergent through the "mutual construction of entangled agencies" rather than as external, pre-existing things to be defined and observed [2:33]. Rather than viewing the real and fictional as separate pre-defined realms, we view them as inherently entangled and mutually co-constructive, questioning the clear distinction between them. This comes through in a tension that arises in our designs, as we try to make them seem like realistic everyday products in order to suspend disbelief, yet also present them as a way to explore fictional futures or realities. The blurring of boundaries allowed our designs to exist in a liminal space, situated among *The Circle*, our imaginations, other fiction and non-fiction technologies, and real-world debates about privacy. For example, our SeeChange-inspired designs reflect uses similar to those of life logging cameras and traditional closed-circuit surveillance cameras. These designs relate to established products and services such as smartphone cameras, GoPro cameras, or Facebook Live streaming. They also relate to experimental and emerging ideas such as Google Glass or smart-eye implants. SeeChange links to cameras in other media, including Telescreens which receive and transmit what people are doing in Orwell's *1984*, the *Big Brother* reality television show where viewers watch live streams of people living in a house, or predictive policing from *Minority Report*. The SeeChange-inspired Police Body Camera design places a fictional technology in the midst of current sociopolitical debates in the U.S and other countries about surveillance and police conduct.

We often felt a strong affective response while making and reflecting on our designs, particularly when it was not clear whether designs were fictional or real. By putting designs into the form of a product page with images and copy, they felt like they could be real products from the near future. This made several designs feel especially creepy, providing us with a useful starting point to explore norms, values, and expectations that have a bearing on privacy.

Our exploration of the space between real and fictional helped us chart relationships between technologies that are existing and nascent, emerging and experimental, and fictional and speculative. Rather than viewing science fiction as an external force that influences technological research and development, through design we highlight how the real and fictional are integrally connected and entangled. In that sense, our design proposals act as boundary objects [41]. They highlight the interconnections and blurred boundaries between real and fictional, between the imaginary, research, and commercial development.

Strategies for Using Science Fiction in Design Fiction

Choosing a Science Fiction Text for Complex Engagement

Given design fiction's focus on creating artifacts that exist within a fictional world, a benefit of starting with a science fiction text is that we do not have to create that world from scratch. Rather, we can build on a professional author's already richly imagined world. This allows designers and researchers without story-writing experience new opportunities to engage in making design fiction.

Choosing a piece of *popular* fiction allowed us to play with and develop concepts and ideas that are already part of the public cultural imagination. Popular fiction does not emerge from a vacuum, but rather reflects real desires, urges, or needs. *The Circle*, as a New York Times bestseller and being adapted into a movie, signals that it has a broad resonance. Furthermore, the novel's subject matter matched our interest in asking research questions about privacy.

We purposely avoided using an overtly dark dystopian novel. We find that one of Egger's key insights upon which he builds his novel is that the user-friendliness and convenient functionality of pervasive technology products belie their darker implications. We translate this insight into our design fictions, which also shed light onto the nature of currently available technologies. We describe TruWork as "an integrated solution" where "one microchip provides seamless management…and a happier, more efficient workplace!" CoupleTrack, ChildTrack for Advertisers, and Vital Radio Match use cartoon figures similar to the design genre of infographics. We took inspiration from Eggers' approach, which critiques technologies by framing them in an extremely positive and technologically deterministic way, parodying current technologies. This provides an alternative approach to engaging darkly serious and autocratic dystopian science fiction, such as *1984* or *A Clockwork Orange*, such as in Blythe and Wright's pastiche scenarios [6]. We find that using non-dystopian narratives can also be productive, in our case to explore the role of positive advertising in framing invasive products.

Using Design Workbooks for Design Fiction

We used the design workbook method to create a set of design fiction proposals. Creating visual design fictions in the form of a workbook allows for a moment of pause that one might not get in other media, such as film, or a user test of a digital or physical artifact. The static nature of the designs allows us to take our time to interrogate or reflect upon a design. Our use of a design workbook is similar to the speed dating design method [12,34] in that it provides a

low-cost and rapid way to broaden the design space and explore multiple potential future designs. However, while our design engagement is not able to explore questions related to the material construction of or lived experiences with these design products, we find that the workbook does important work without building a physical artifact. Using a fictional world can also explore designs that are difficult to produce technically, socially, or legally in our world (such as CoupleTrack's or TruWork's implanted GPS trackers).

Visually our proposals lie between rough hand-drawn sketches and glossy mockups to allow us to present our designs as real enough to attract attention, but leave enough openness and ambiguity to encourage interrogation and questioning. Keeping designs open-ended as to how they would function led us to ask interesting questions about their technical underpinnings. For instance, we wondered how the Airport Security system would categorize people into different threat colors. Might it use probability-based algorithms, computer vision, metadata, or existing no-fly lists? What types of biases might emerge? For License Plate Tracker, we asked what would happen if SeeChange collects metadata from people as well as images? What types of processing could be done on the images if combined with collected metadata? Metadata surveillance issues go beyond Eggers' largely vision-based surveillance scenarios. Our design fictions thus explore issues that Eggers does not sufficiently engage. Beyond research, it is possible that design fiction in the form of workbooks can be used as a rhetorical tool that is more widely accessible than academic papers and can engage broader audiences such as speculative fiction enthusiasts, or designers and cultural producers looking to create alternative designs.

Using Design Fiction to Blur Real and Fictional

Our designs helped uncover entanglements between real and fictional technologies and social worlds. We used design language from commercial webpages and interfaces, and adopted copy language that focuses on positive user propositions. Using this language, we convey that our imagined products have the potential to be highly invasive, but exist in a world where consumers willingly purchase them. This helps us envision these (rather invasive) designs as everyday objects and makes them more affectively striking. In this sense, our approach is useful in bridging real technological trends with an often satirical critique of emerging technologies' privacy implications, or what Blythe and Encinas term design fiction's "Scientific Highlands" and "Great Plains of Irony" [8]. Despite the designs' similarity to some real products, we do not intend for these to be mass produced objects. However, it may be possible for some of these to be realized as research products in the future, as built objects that live in a person's everyday life to explore a set of questions and ideas [33].

Utilizing External Frameworks to Investigate Empirical Research Questions

Because our designs explored privacy issues, we reviewed the privacy literature and analyzed our designs using a privacy analytic framework. This framework helped us conceptualize and map the breadth of our exploration of the design space. Utilizing external frameworks can help design fiction bridge the languages, concepts, and ideas of design and other areas of empirical research. Design fictions can also be used to provide examples for frameworks, or explore a framework's limits. We believe our approach can also be utilized by non-expert designers, such as privacy researchers or non-designers in the HCI community who want to explore the social and ethical dimensions of systems, products, or artifacts they are creating.

CONCLUSIONS

This paper contributes a set of design fiction concepts in the form of a workbook, a case study of a project using design fiction to interrogate emerging sensing technologies to explore empirical privacy research questions, and presents an approach to creating design fiction artifacts by using science fiction texts as a starting point. We see potential further uses for our design fictions, as tools to broaden the design space for people who make decisions affecting the creation and use of sensing technologies. In further research, they could be used as interview probes with policymakers thinking about social and legal issues of emerging sensing technologies, or used in design or engineering ethics courses to quickly create and explore many different scenarios.

Pragmatically, explicitly tapping into an existing fictional universe provides a concrete starting point to begin design exploration; we did not have to start from scratch, making the process more accessible. This provides a new approach to creating design fiction that lies between creating a fictional world from scratch and implicitly being inspired by science fiction. Design fiction helps broaden the design space (or prevent a 'failure of imagination') to explore more possibilities. Exploring many possibilities will also help us find bad ones, problematic ones, and dark ones that we might otherwise ignore or not think about. Exploring positive and negative possibilities is important to better understanding the design space, and in informing choices about what to design. By engaging in real-fictional entanglements, design fiction can be used generate design ideas that explore and reflect on futures which might otherwise go unnoticed.

ACKNOWLEDGEMENTS

We thank Deirdre Mulligan, John Chuang, and the BioSENSE and Berkeley Social Science Matrix groups for their support and feedback, and we thank the reviewers for their valuable comments. This work was supported in part by the UC Berkeley Center for Long Term Cybersecurity, and the National Science Foundation Graduate Research Fellowship Program under Grant No. DGE 1106400. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF. Figures 5,7,11 © Ellen Van Wyk.

REFERENCES

1. Fadel Adib, Hongzi Mao, Zachary Kabelac, Dina Katabi, and Robert C Miller. 2015. Smart Homes that Monitor Breathing and Heart Rate. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*, 837–846. http://doi.org/10.1145/2702123.2702200

2. Karen Barad. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entangelement of Matter and Meaning*. Duke University Press, Durham.

3. Dann Berg. 2012. Body Hacking: My Magnetic Implant (12 March 2012). Retrieved September 20, 2016 from http://www.iamdann.com/2012/03/21/my-magnet-implant-body-modification

4. Julian Bleecker. 2009. *Design Fiction: A Short Essay on Design, Science, Fact and Fiction*.

5. Mark Blythe. 2014. Research through design fiction: Narrative in Real and Imaginary Abstracts. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14)*, 703–712. http://doi.org/10.1145/2556288.2557098

6. Mark A. Blythe and Peter C. Wright. 2006. Pastiche scenarios: Fiction as a resource for user centred design. *Interacting with Computers* 18, 5: 1139–1164. http://doi.org/10.1016/j.intcom.2006.02.001

7. Mark Blythe, Kristina Andersen, Rachel Clarke, and Peter Wright. 2016. Anti-Solutionist Strategies: Seriously Silly Design Fiction. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 4968–4978. http://doi.org/10.1145/2858036.2858482

8. Mark Blythe and Enrique Encinas. 2016. The Co-ordinates of Design Fiction: Extrapolation, Irony, Ambiguity and Magic. In *Proceedings of the 19th International Conference on Supporting Group Work (GROUP '16)*, 345–354. http://doi.org/10.1145/2957276.2957299

9. Torie Bosch. Sci-Fi Writer Bruce Sterling Explains the Intriguing New Concept of Design Fiction. *Slate.com*. Retrieved September 20, 2016 from http://www.slate.com/blogs/future_tense/2012/03/02/bruce_sterling_on_design_fictions_.html

10. Barry Brown, Julian Bleecker, Marco D'Adamo, et al. 2016. The IKEA Catalogue: Design Fiction in Academic and Industrial Collaborations. In *Proceedings of the 19th International Conference on Supporting Group Work (GROUP '16)*, 335–344. http://doi.org/10.1145/2957276.2957298

11. Rafael Calvo, Sidney D'Mello, Jonathan Gratch, Arvid Kappas, Nadia Bianchi-Berthouze, and Andrea Kleinsmith. 2015. Automatic Recognition of Affective Body Expressions. In *The Oxford Handbook of Affective Computing*. Oxford University Press. http://doi.org/10.1093/oxfordhb/9780199942237.013.025

12. Scott Davidoff, Min Kyung Lee, Anind K Dey, and John Zimmerman. 2007. Rapidly Exploring Application Design Through Speed Dating. In *International Conference on Ubiquitous Computing (UbiComp 2007)*, 429–446.

13. Paul Dourish and Genevieve Bell. 2013. "Resistance is futile": reading science fiction alongside ubiquitous computing. *Personal and Ubiquitous Computing* 18, 4: 769–778. http://doi.org/10.1007/s00779-013-0678-7

14. Anthony Dunne and Fiona Raby. 2012. Train - United Micro Kingdoms. Retrieved April 7, 2017 from http://www.unitedmicrokingdoms.org/train-comments/

15. David Eggers. 2013. *The Circle*. McSweeny's Books, San Francisco.

16. Peter Freese and Charles B. Harris. 2004. Introduction: The Holodeck in the Garden. In *The Holodeck in the Garden: Science and Technology in Contemporary American Fiction*, Peter Freese and Charles B. Harris (eds.). Dalkey Archive Press, Champaign, Illinois, ix–xxviii.

17. William Gaver. 2011. Making spaces: how design workbooks work. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11)*, 1551–1560. http://doi.org/10.1145/1978942.1979169

18. Ellie Harmon and Melissa Mazmanian. 2013. Stories of the Smartphone in everyday discourse: conflict, tension & instability. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13)*, 1051. http://doi.org/10.1145/2470654.2466134

19. Sabrina Hauser, Audrey Desjardins, and Ron Wakkary. 2014. Sfuture: envisioning a sustainable university campus in 2065. In *Proceedings of the 2014 companion publication on Designing interactive systems (DIS Companion '14)*, 29–32. http://doi.org/10.1145/2598784.2602774

20. Thomas Heath. 2016. This employee ID badge monitors and listens to you at work — except in the bathroom. (7 September 2016). *The Washington Post*. Retrieved September 20, 2016 from https://www.washingtonpost.com/news/business/wp/2016/09/07/this-employee-badge-knows-not-only-where-you-are-but-whether-you-are-talking-to-your-co-workers/

21. Javier Hernandez, Daniel McDuff, and Rosalind Picard. 2015. BioWatch: Estimation of Heart and Breathing Rates from Wrist Motions. In *Proceedings of the 9th International Conference on Pervasive*

Computing Technologies for Healthcare. http://doi.org/10.4108/icst.pervasivehealth.2015.259064

22. David Kirby. 2010. The Future is Now: Diegetic Prototypes and the Role of Popular Films in Generating Real-world Technological Development. *Social Studies of Science* 40, 1: 41–70. http://doi.org/10.1177/0306312709338325
23. Mohammed Korayem, Robert Templeman, Dennis Chen, David Crandall, and Apu Kapadia. 2016. Enhancing Lifelogging Privacy by Detecting Screens. In *In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 4309–4314. http://doi.org/10.1145/2858036.2858417
24. Joseph Lindley. 2016. A Pragmatics Framework for Design Fiction. In *11th EAD Conference Proceedings: The Value of Design Research*. http://doi.org/10.7190/ead/2015/69
25. Joseph Lindley and Paul Coulton. 2015. Back to the Future: 10 Years of Design Fiction. *Proceedings of the 2015 British HCI Conference (British HCI '15)*: 210–211. http://doi.org/10.1145/2783446.2783592
26. Joseph Lindley and Paul Coulton. 2015. Game of Drones. In *Symposium on Computer-Human Interaction in Play (CHI PLAY '15)*, 613–618. http://doi.org/10.1145/2793107.2810300
27. Joseph Lindley and Paul Coulton. 2016. Pushing the Limits of Design Fiction: The Case For Fictional Research Papers. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 4032–4043. http://doi.org/10.1145/2858036.2858446
28. Joseph Lindley, Dhruv Sharma, and Robert Potts. 2015. Operationalizing Design Fiction with Anticipatory Ethnography. In *Ethnographic Praxis in Industry Conference*, 58–71.
29. Conor Linehan, Ben J. Kirman, Stuart Reeves, et al. 2014. Alternate endings: using fiction to explore design futures. In *CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14)*, 45–48. http://doi.org/10.1145/2559206.2560472
30. Keiichi Matsuda. 2016. HYPER-REALITY. Video. (16 May 2016). Retrieved September 20, 2016 from https://vimeo.com/166807261
31. Deirdre K. Mulligan, Colin Koopman, and Nick Doty. 2016. Privacy is an essentially contested concept: a multi-dimensional analytic for mapping privacy. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 374, 2083. http://doi.org/10.1098/rsta.2016.0118
32. Helen Nissenbaum. 2009. *Privacy in Context: Technology, Policy, and the Integrity of Social Life*. Stanford University Press, Stanford, California.
33. William Odom, Ron Wakkary, Youn-kyung Lim, Audrey Desjardins, Bart Hengeveld, and Richard Banks. 2016. From Research Prototype to Research Product. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 2549–2561. http://doi.org/10.1145/2858036.2858447
34. William Odom, John Zimmerman, Scott Davidoff, Jodi Forlizzi, Anind K. Dey, and Min Kyung Lee. 2012. A fieldwork of the future with user enactments. In *Proceedings of the Designing Interactive Systems Conference (DIS '12)*, 338–347. http://doi.org/10.1145/2317956.2318008
35. Pelican. 2013. Sendai airport. Image. (17 May 2013). Retrieved September 4, 2016 from https://www.flickr.com/photos/pelican/8767376807/
36. James Pierce and Eric Paulos. 2014. Some variations on a counterfunctional digital camera. In *Proceedings of the 2014 conference on Designing interactive systems (DIS '14)*, 131–140. http://doi.org/10.1145/2598510.2602968
37. Nathan Shedroff and Christopher Noessel. 2012. *Make it So: Interaction Design Lessons from Science Fiction*. Rosenfield Media, Brooklyn, New York.
38. Daniel J. Solove. 2002. Conceptualizing privacy. *California Law Review* 90: 1087–1155. http://doi.org/10.1145/1929609.1929610
39. Daniel J. Solove. 2003. A Taxonomy of Privacy. *University of Pennsylvania Law Review*, 477: 477–560.
40. Susan Leigh Star and Geoffrey C. Bowker. 2002. How to Infrastructure. In *The Handbook of New Media*, Leah A. Lievrouw and Sonia Livingstone (eds.). Sage, London, 230–245.
41. Susan Leigh Star and James R. Griesemer. 1989. Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science* 19, 3: 387–420. http://doi.org/10.1177/030631289019003001
42. Miriam Sturdee, Paul Coulton, Joseph G. Lindley, Mike Stead, Haider Ali, and Andy Hudson-Smith. 2016. Design Fiction: How to Build a Voight-Kampff Machine. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems (CHI EA '16)*, 375–386. http://doi.org/10.1145/2851581.2892574
43. Superflux. 2015. Drone Aviary. Video. (7 April 2015). Retrieved September 20, 2011 from https://vimeo.com/124292043
44. Harry Surden. 2007. Structural Rights in Privacy. *SMU*

Law Review 60: 1605–1629.

45. Joshua Tanenbaum, Marcel Pufal, and Karen Tanenbaum. 2016. The Limits of Our Imagination: Design Fiction as a Strategy for Engaging with Dystopian Futures. In *Proceedings of the Second Workshop on Computing within Limits (LIMITS '16)*. http://doi.org/10.1145/2926676.2926687
46. Joshua Tanenbaum, Karen Tanenbaum, and Ron Wakkary. 2012. Steampunk as design fiction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*, 1583. http://doi.org/10.1145/2207676.2208279
47. Oliver Wainwright. 2015. Body-hackers: the people who turn themselves into cyborgs. (14 August 2015). *The Guardian*. Retrieved September 20, 2016 from https://www.theguardian.com/artanddesign/architecture-design-blog/2015/aug/14/body-hackers-the-people-who-turn-themselves-into-cyborgs
48. Ron Wakkary, William Odom, Sabrina Hauser, Garnet Hertz, and Henry Lin. 2015. Material Speculation: Actual Artifacts for Critical Inquiry. *Proceedings of The Fifth Decennial Aarhus Conference on Critical Alternatives (AA '15)* 1, 1: 97–108. http://doi.org/10.7146/aahcc.v1i1.21299
49. Chen Wang, Erik N. Geelhoed, Phil P. Stenton, and Pablo Cesar. 2014. Sensing a live audience. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems (CHI '14)*, 1909–1912. http://doi.org/10.1145/2556288.2557154
50. Alan Westin. 1967. *Privacy and Freedom*. Atheneum, New York.
51. Stan Wiechers. 2007. Taipei Airport. Image. (6 August 2007). Retrieved September 4, 2016 from https://www.flickr.com/photos/whoisstan/1035746340/
52. Richmond Y. Wong and Deirdre K. Mulligan. 2016. When a Product Is Still Fictional: Anticipating and Speculating Futures through Concept Videos. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS '16)*, 121–133. http://doi.org/10.1145/2901790.2901801