Tangible Interfaces and Interactions in Sci-Fi Movies

A Glimpse at the Possible Future of TUIs through Fictional Tangible Systems

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ABSTRACT

Science-Fiction (Sci-Fi) movies have long been a frontier in showcasing futuristic computer interfaces and their associated interactions. Unconstrained by technological limitations, they are free to depict the most imaginative systems, including augmenting objects attributes that are not yet possible in reality. We present a case study on Sci-Fi movies where tangible objects are part of these systems, and examine how they illustrate Tangible User Interfaces (TUIs) concepts. We provide three examples of tangible systems and one that deviates considerably (holographic system), and analyze them using a well-established interaction model (MCRpd). We found that TUIs in movies exhibit various levels of the model's characteristics and demonstrate an inclusive and diverse context through combining interaction modalities and catering to audience needs. We argue that these aspects provide valuable lessons and implications in designing future TUIs and hope to broaden the design space by initiating discussions on the fascinating worlds in Sci-Fi movies.

CCS CONCEPTS

• Human-centered computing~Interaction paradigms • Human-centered computing~Interaction techniques

KEYWORDS

Tangible systems; Sci-Fi movies; speculative interfaces; futuristic interfaces; interface and interaction design; case study

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1 INTRODUCTION

One of the most prevalent examples of futuristic computer interfaces depicted in Science-Fiction (Sci-Fi) movies is the PreCrime system in Minority Report (2003) [29], where the protagonist waved his arms in mid-air to use what the HCI community terms as Gestural User Interface. What is less discussed about, however, is the part where the system alerted a soon-to-be-committed crime, using two colour-coded, uniquely-grained wooden balls as a tangible representation of an otherwise abstract description of an incident (Figure 3). The same idea of physicalizing an event as a spherical tangible object was the core of the Marble Answering Machine by Bishop in 1992, considered as one of the first examples of Tangible User Interfaces (TUIs) [3, 8], where physical artifacts act as both representations and controls for computational media [32]. Remarkably, none of these interfaces were described in the original short story [6], but rather designed by the production team and researchers to answer the question: *What will computers look like in 50 years?* [5].

Sci-Fi movies have put in considerable efforts in designing futuristic interfaces to convince the audience that the worlds they portray are plausible, and by extension the stories are believable [27]. There is, however, a tension between making the interfaces (and their associated interactions) "out-of-this-world" and understandable: they should look advanced, but still communicate what they are doing during the short screen time. One way to achieve this is to incorporate recognizable objects/systems and augment them with futuristic properties via "cinematic magic". For example, the Kimoyo beads (Figure 1, next page) in Black Panther (2018) [4] are simply bracelet beads, but could project holograms for communication and health monitoring, capitalizing the common practice of each bead symbolizes a meaningful event/aspect.

Figure 1. The Kimoyo beads from Black Panther (2018), used for holographic communication between characters.[†]

In spite of being fictional, some of these futuristic interfaces, like voice commands, gestural inputs, and holographic displays, have inspired many personal and research projects in real-life; some even made their ways to commercialization and gaining publicity. For example, voice interfaces are now ubiquitous as personal assistants (Alexa, Bixby, Siri, Ok-Google, etc.), and holographic displays are now available through Microsoft's Hololenses and others' volumetric displays. This partially confirms Kirby's notion of Sci-Fi movies "stimulating desire in audiences to see those possibilities become realities" [19].

In this paper, we focus on interfaces that show properties of TUIs and examine how concepts and methods in the academia are illustrated in them. We do so by providing three examples of tangible systems that demonstrate TUI characteristics at various levels of adherence, followed by one example[1] of a widely used but intangible system to illustrate designs that could inspire the future of TUIs. We are intrigued by the questions: *How do tangible systems depicted in Sci-Fi movies differ from those conceptualized in the TUI research community? What do these Sci-Fi TUIs tell us about the future of tangible computing?* By answering these questions, we make two reciprocal contributions: (1) we introduce Sci-Fi TUIs to researchers to open up discussions on assessing where the field is and is going relative to speculative visions of society; and (2) we invite speculative fiction creators to apply TUIs to their designs when resolving the tension between depicting futuristic systems and portraying plausible narratives.

2 RELATED WORK

This work is inspired by our passion about Sci-Fi movies, and numerous anecdotes on how Human-Computer Interaction (HCI) projects "work just like in the movies". We see Sci-Fi movies as a way to engage the general public and potential pointers to the design of TUI systems, and use this view to structure this section.

[1] We label it as an "anti-example" instead of "counter-example" to reflect our effort to show an interface that deviates from TUIs considerably without undermining them, similar to an "anti-hero" in Sci-Fi movies. Refer to Section 4.4 for details.

2.2 Sci-Fi Movies and Societal Impact

Like many other media, Sci-Fi movies (and TV shows) have the ability to reach the general public and impact how it perceives technologies. Kirby [19] used Threshold [23], a Sci-Fi movie in 1981 depicting the implantation of a permanent artificial heart, to illustrate how the public's concerns (necessity, normalcy, and viability) about a new technology (artificial heart) can be addressed in the narrative of the movie. Dourish & Bell [7] compared Sci-Fi TV shows with research in ubiquitous computing and argued that science, technology, and society are all connected, and thus affect each other's development. Shedroff & Noessel [27] collected interaction design lessons from Sci-Fi movies and TV shows, covering a wide range of futuristic systems including gestural interfaces, virtual reality, and brain-computer interfaces, to help practitioners designing real-world interfaces that meet the expectations of the general public.

All of the prior work suggests that Sci-Fi movies do affect the opinions and expectations formed within the general public, and thus the acceptance of a new technology (at the very least make it known). Compared to conventional interfaces like command-line and graphical interfaces, TUI is still a relatively new concept that is not commonly used and has much room to grow. Perhaps those that exist in the Sci-Fi worlds could shed some light on how tangible systems could move forward in the real world.

2.2 Sci-Fi Movies and HCI

The HCI community has also observed the similarities and differences between Sci-Fi movies and its own work, where researchers typically survey Sci-Fi movies and draw parallels between the Sci-Fi systems and existing systems or interactions. Schmitz et al. [24] surveyed 26 Sci-Fi movies (1902—2003) and categorized them into levels of actualization in real-life. The authors also established a mutual relationship between movies and technologies inspiring each other. Figueiredo et al. [11] surveyed 24 Sci-Fi movies (years not specified) and focused on hand gestures, which the authors compiled and found complex patterns not identified by Shedroff & Noessel [27]. Troiano et al. [30] surveyed 340 Sci-Fi movies (1920—2015) and focused on 101 instances featuring Shape-Changing Interfaces (SCIs). The authors identified four main behavioural patterns (reconfiguration, transformation, Adaptation, and physicalization), which they used to analyze existing and guide future designs of SCIs.

In a different direction, Jordan & Auernheimer [18] identified 232 publications (1975—2017) from the ACM Digital Library referencing Star Trek, a Sci-Fi TV series debuted in 1966, and evaluated its use in the context of computer science and HCI. In particular, the authors highlighted examples where the series inspired research (e.g., VR from Holodeck) and illustrated potential future technologies (e.g., androids from Mr. Data).

To our knowledge there has not been prior work looking specifically into tangible interfaces and interactions in Sci-Fi movies. To better highlight TUI's concepts, we opt to focus on examples (and an anti-example) of representative tangible systems. This approach allows us to examine them in a detailed manner as a case study, similar to the format used by Ullmer & Ishii [32] in describing emerging frameworks for TUIs.

2.3 Tangible User Interfaces & Interactions

The marking difference between TUIs and the now ubiquitous WIMP Graphical User Interfaces (also other interfaces such as command-line and gestural) is the inclusion of physical, tangible, and representational objects. This concept of using physical objects as part of the interface and interaction was first formally introduced as Graspable Interfaces by Fitzmaurice [13]. A more comprehensive version is later proposed by Ishii & Ullmer [16] as Tangible Bits, highlighting three key concepts that form the basis of TUIs (interactive surfaces, coupling of bits and atoms, and ambient media). About a decade later Hornecker & Buur [15] proposed Tangible Interactions as a framework emphasizing the user experience instead of the physical system being developed.

Besides those mentioned above, over the years models, taxonomies, and frameworks of TUIs have been proposed, some cover a broader context by focusing on a particular aspect, for example, coupling physical with digital [12, 14, 20] and tokens and constraints [25]; some being domain-specific, for example, learning [1] and music performance [17] (refer to Shaer & Hornecker's [26] monograph for more examples and details).

In this paper we employ Ullmer & Ishii's [32] MCRpd[2] interaction model to examine the tangible systems we found in Sci-Fi movies, as it extends the authors' previous widely adopted work [16] with explicit discussion on the characteristics of TUIs such as coupling and application domains, as detailed next.

[2] Also known as MCRit (tangible and intangible) for improved clarity in [31].

3 TUIS AND THE MCRPD INTERACTION MODEL

The core feature of Tangible User Interfaces (TUIs), as coined by Ishii & Ullmer [16], is that they "will augment the real physical world by coupling digital information to everyday physical objects and environments" (p.235).

A real-life example of a TUI is the Urban Planning Workbench (URP) system [33] that uses physical architectural models placed on an ordinary table to support urban simulation. In URP, the physical forms of the optically tracked models are associated with their 3D graphical geometries, such that when they are physically moved, the table shows, through projection, appropriate shadows/wind patterns as simulated by the system based on the position and orientation of the models.

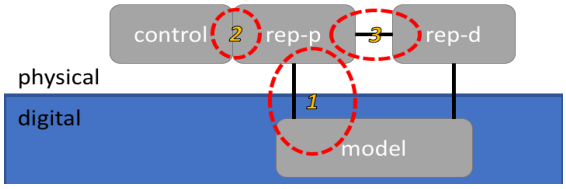

Figure 2. The MCRpd interaction model (redrawn based on [32]), depicting key characteristics of tangible interfaces. †

The extension of the TUI concept is the Model-Control-Representation (physical and digital) (MCRpd, see Figure 2) interaction model proposed by the same authors [32]. This model draws inspiration from the classic Model-View-Controller (MVC) interaction model for GUIs [21] and divides the "view" element into two subcomponents: physical representation ("rep-p"), information that is physically embodied in concrete, tangible form; and digital representation ("rep-d"), computationally mediated displays that are perceptually observed in the world, but are not physically embodied, and thus intangible in form (p.3). It is this separation that highlights TUIs' integration of physical representation and control. The four characteristics of TUIs highlighted by the MCRpd model are as follows:

MCRpd-1 (Computational Coupling)
Physical representations (rep-p) are computationally coupled to underlying digital information (model).

MCRpd-2 (Control Embodiment)
Physical representations embody mechanisms for interactive control (control).

MCRpd-3 (Perceptual Coupling)
Physical representations are perceptually coupled to actively mediated digital representations (rep-d).

MCRpd-4 (Representational Significance)
The physical state of interface artifacts partially embodies the digital state of the system.

We use these characteristics as a checklist when examining tangible systems used in Sci-Fi movies, and use *Absent*, *Low*, *Medium*, and *High* to indicate how closely each characteristic is met. Researchers and creators can also apply this scaling approach to design and evaluate their own work in relation to TUIs.

4 THREE EXAMPLES & ONE ANTI-EXAMPLE

We present three examples and one anti-example of tangible systems from Sci-Fi movies. Our selection criteria for the example systems are: (1) at least one tangible object is directly used in the system, (2) the system exists in the future or a settlement unlike our current state of reality (e.g., a hidden organization with advanced technology), and (3) the system is used computationally for purposes advancing the narrative of the movie. We chose these movie examples because they are relatively well-known, thus likely familiar to our audience, and there is similar prior art in the TUI literature. Also, our selection cover a variety of forms, contexts, and technologies, comparable with current research.

For each example system, we first describe how it fits our selection criteria and the context where it operates. We then analyze the system with the four MCRpd characteristics, detail those that are low or absent, and compare it with a similar system from the TUI literature.

4.1 Example 1: Minority Report (2003) [29]

The example system in this movie is one that gives alerts about crimes that is about to happen, each incident represented by two colour-coded, uniquely-grained wooden balls—one engraved with the perpetrator(s)' name, the other engraved with the victim(s)'. The setting of the movie is year 2054 and the system is used to investigate soon-to-be-committed crimes and prevent them from happening by catching the perpetrator(s) before they begin.

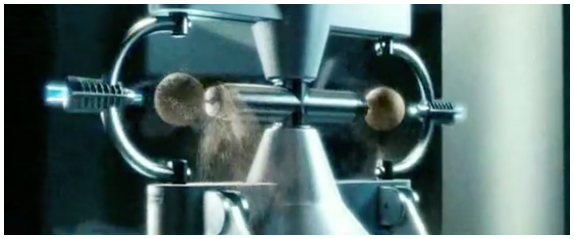

Figure 3. The PreCrime system in Minority Report (2003), where wooden balls uniquely representing perpetrators and victims of a soon-to-be-committed crime are being carved out. †

Analysis

MCRpd-1 (Computational Coupling) – ***Medium***
While the colour, grain, and the name engraved on each ball are linked uniquely to a person and thus representational, a spherical object is hardly the best representation of a human being.

MCRpd-2 (Control Embodiment) – ***Low***
The physical movement and rotation of the balls do not serve any control purposes in the system, only their placement (when placed at the tray area) dictates whose information is brought up.

MCRpd-3 (Perceptual Coupling) – ***High***
The ball (physical representation of the person) is linked to their personnel information (digital representation) used by the system.

MCRpd-4 (Representational Significance) – ***High***
The presence of the balls is needed to define an incident. As indicated in the scene where the protagonist witnesses himself committing a murder, he hides the ball so the others cannot figure it out until they recognize him in the predictive footage.

It appears that the choice of spherical form is mostly based on aesthetics and the physical property of being able to quickly roll around and stop at a cradle, as a figurine shaped like a human would be a more accurate representation of the involved parties. Moreover, none of the other physical property of the ball (e.g., spin, move) is used afterwards as controls to the system, which are dominated by hand and arm gestures.

As aforementioned, a similar system in the TUI literature is Bishop's Marble Answering Machine [3, 8], where incoming calls and messages are represented as coloured marbles that roll into a dented area in the machine. The interaction is similar between the systems: the user picks up the spherical object, places it to a specific area to bring up the content that it represents. The difference is that the balls in the Sci-Fi system have engravings identifying what they represent, while the marbles in Bishop's system have to be placed in a player for identification.

4.2 Example 2: The Island (2005) [2]

The example system in this movie is a tabletop display that allows handling of several digital media (e.g., profiles, drawings), which are controlled (moved aside, handed over) by a transparent pyramid. The pyramid behaves like a magnet that gathers and slingshots virtual windows. The setting of the movie is year 2019 (future at the time of its release), and the system is used in a hi-tech company (separated from the outside world) in meetings.

Figure 4. The tabletop system in The Island (2005), where a transparent pyramid acting as a handle of virtual windows is being tossed around to control their locations. †

Analysis
MCRpd-1 (Computational Coupling) – ***Low*** The physical form of the pyramid has little computational coherence to its underlying digital information, which is an invisible handle with attracting force to control virtual windows. *MCRpd-2 (Control Embodiment)* – ***High*** The physical movement and rotation of the pyramid affect the virtual handle and thus the location and orientation of the controlled virtual windows in real-time. *MCRpd-3 (Perceptual Coupling)* – ***High*** The pyramid (physical representation of a virtual handle) is constantly tracked by the system as a tool (digital representation) for responsiveness. *MCRpd-4 (Representational Significance)* – ***Low*** The pyramid is merely the physical representation of a virtual tool. Thus, while its presence affects the system's digital state, its physical state only has a meaning digitally when the system is up and running, but not the other way around.

Throughout the entire scene, the tabletop display is never used as a touchscreen (characters' arms and hands are often in contact with it but do not cause anything). This has led us to believe that the only way to control the virtual windows is via the pyramid. Therefore, manipulations with such a tangible object can be viewed as innovative way to interact with a futuristic system. Nevertheless, it has not been mature enough to illustrate many of the characteristics of TUIs as highlighted by the MCRpd model.

A similar system in the TUI literature is the reacTable [17], a table-based tangible system where tangible objects, each represent a modular synthesizer component, are placed on a tabletop display to generate live music performance. Similar to the Sci-Fi system, these objects act as handles of the virtual content. The difference is that reacTable uses multiple handles, thus enables interactions within objects and encourages multi-user collaboration.

4.3 Example 3: Black Panther (2018) [4]

The example in this movie is another tabletop display, which is made of fine particles that can assemble into any shapes (e.g., contour of the area, vehicles), allowing characters to pick up, examine, and get a sense of the surroundings. The setting of the movie is in 2016 (current timeframe with advanced technology hidden from the outside world), and the system is a simulation of the geographic area for strategizing a rescue mission.

Figure 5. The tabletop system in Black Panther (2018), where the simulated geographic area is materialized with objects available for physical manipulation. †

Analysis
MCRpd-1 (Computational Coupling) – ***High*** The physical form of the objects are the miniaturized but otherwise exact copies of their underlying digital information (models of terrain and vehicles) representing the surveyed area. *MCRpd-2 (Control Embodiment)* – ***Low*** The physical movement and rotation of the objects initiated by the user have no effect on the simulation beyond that they can be manipulated as regular items and reveal details. *MCRpd-3 (Perceptual Coupling)* – ***High*** The physical representations are constantly updated to reflect the simulation of the surveyed area in real-time. *MCRpd-4 (Representational Significance)* – ***High*** The main purpose of the system is to visualize (and materialize) the simulated area and provide its user up-to-date information. Thus, as long as the physical objects are present, they are the direct representation of the digital state of the system (simulation).

The low adherence of this system to the Control Embodiment characteristic suggests an output-oriented design. However, it also provides the freedom to manipulate the physical objects without affecting the simulation, thus allows additional controls, such as swipe gestures (revealing the inside of the truck, in Figure 5).

A similar system in the TUI literature is the shape displays [22], where hundreds of motorized pins extend vertically from a tabletop to form 2.5D shapes, such as UI elements and landscapes. While there are similarities in interaction,

including direct touch and mid-air gestures, the differences are more apparent: the Sci-Fi system has a much higher resolution, and supports overhangs (the character could hold an object in mid-air). This indicates a considerable technological gap between Sci-Fi and real-life tangible displays, as acknowledged by the authors as some of the challenges shape displays need to address (p.10).

4.4 An Anti-Example: Iron Man (2008) [10]

Lastly, we provide an anti-example of a tangible system. We include this example not to advocate against TUIs, but to show an interface that is popularized by many recent Sci-Fi movies yet deviates from TUIs in one key aspect: lack of physical objects in the interaction. We believe this example could demonstrate the myriad possibility of futuristic systems and inspire the future of TUIs.

The anti-example in this movie[3] is an interactive system that simulates a workbench and displays everything as holograms. The setting of the movie is in 2008 (current timeframe with advanced technology proprietary to the main character), and the system is used by the character to design his combat suit.

Strictly speaking, the MCRpd model is not applicable to this example as apart from the workbench itself, there is no physical representation in the system. Yet, a relaxation (indicated with an asterisk) in this aspect would prove that many of the TUIs concepts are still relevant, thus broadening the design space through considering other non-tangible systems, and their adherence to the other characteristics of the MCRpd model.

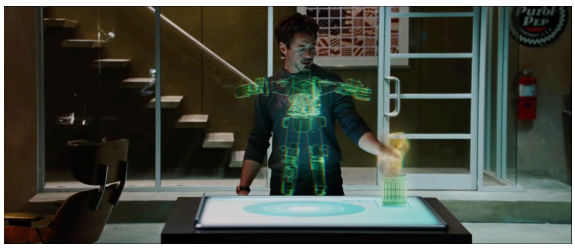

Figure 6. The interactive display in Iron Man (2008), where all the information (e.g., combat suit, trash bin) is displayed as holograms, and can be manipulated using hand gestures. †

Analysis
MCRpd-1 (Computational Coupling) – ***Absent*** There is no physical representation in the entire system.
MCRpd-2 (Control Embodiment) – ***High**** The movement and rotation of the holographic objects initiated by the user affects the same properties of the simulated objects in real-time, demonstrating direct manipulation principles [28].
MCRpd-3 (Perceptual Coupling) – ***High**** The holographic objects are constantly updated to reflect the simulation of the workbench in real-time.
MCRpd-4 (Representational Significance) – ***High**** The main purpose of the system is to visualize the simulated design and provide interactivity. Thus, as long as the holographic objects are present, they are the direct representation of the digital state of the system (simulation).

This system is similar to the tangible system in Black Panther (2018) in terms of scale (everything is within reach) and the embodiment of digital information (no additional tool is present). The differences lie in the absence of physical representation and hence its ability to control the digital representation. The interactions demonstrated with this system have a strong resemblance with gestural interfaces and affordances in graphical user interfaces (e.g., "throwing" a holographic item into a "trash bin" removes its digital representation from the workbench), which can be quickly understood by the system and the audience. In addition, the system also supports voice commands, which are used to further communicate the intent of the user (e.g., keep the project in a private server to hide it from others).

5 DISCUSSION

The MCRpd mapping analysis has provided us grounding to answer the first question we asked in the beginning of the paper: *How do tangible systems depicted in Sci-Fi movies differ from those conceptualized in the TUI research community?* Tangible systems in Sci-Fi movies differ by exhibiting various levels of the MCRpd model's characteristics, and we have yet found an example that adheres to them all. For characteristics that are not fully met, the systems typically supplement them with other forms of interaction, such as gestures and voice commands; or customize how output is shown.

Next, we describe four aspects we observed from our analysis of the example systems (including the anti-example) that we believe could help with the design of future TUIs and interactions, thus answering our second question: *What do these Sci-Fi TUIs tell us about the future of tangible computing?*

[3] Its next two sequels have expanded the holographic system to a more dazzling and immersive workspace, though the underlying system remains the same.

#1 Include passive observers (audience)

In all of the above examples, the users of the systems are experts in operating, likely to demonstrate their authority, as well as to save time in explanation. But the systems will only make sense when the audience, who is not actively involved in the interactions, also understands what the systems are doing. To achieve this, Sci-Fi movies use a mixture of visual and audio effects to communicate how the systems work, and if there is anything malfunctioning (e.g., red hue, siren-like sounds).

As tangible systems are designed and utilized in real-life, they should be implemented in ways that bystanders can also quickly understand and learn how to use them. While there could be differences between audience and end-user, they share the need for understandability and learnability. These qualities help break the barriers that stop potential users from adopting a new technology, and are not dissimilar to those that help the audience to comprehend the depicted technology. TUI systems could incorporate similar explicit visual and audio cues into the physical objects and ambient media to better engage their users.

#2 Combine with other interaction paradigms

All the systems in the above examples incorporate other interaction paradigms. Besides helping with the story-telling, they allow the characters to achieve more, for example, reveal the inside of a truck (Example 3).

TUI might limit interactivity due to physical constrains of the objects (e.g., they occupy space, and have weight). However, combining other forms of interactions, for example, gestural, voice, can complement and increase the vocabulary, making the system more versatile, easier to use, and more accessible.

#3 Use small number of visually capturing tangible objects

Each system in the above examples only involves a small number of highly refined tangible objects. This can be used to convey the sophistication of the system, while reduces the burden on the actor and audience to keep track of the objects by making them more eye-catching and identifiable.

Although TUIs do not pose a limit to the number of physical representations in a system, designers should consider keeping it in a manageable manner. Also, relevant tangible objects should be made such that they stand out from the rest of the system so users can quickly identify them. This issue is particularly noticeable in the anti-example where everything is holographic, so there is no distinction between what is interactive and what is not.

#4 Use context to help design the system

Ultimately, all the systems are props of the movies and hence part of the Sci-Fi worlds. Thus, their aesthetics follow the overall tone of the portrayed worlds, for example, a pristine prism, a sleek and steel table in a futuristic industrial facility (Example 2).

Like many other systems in real-life, TUIs do not exist in isolation. Rather, they are suitable to be used in many application domains. Besides being representational, physical elements in TUIs (tokens and reference frames [32]) should be consistent with the aesthetics of the context. For example, a tangible learning system for children should be colourful and toy-like, whereas one for modeling and simulation should be precise and utilitarian.

5.1 Towards More Inclusive & Diverse Contexts

We have used the MCRpd model to analyze TUIs in Sci-Fi movies in order to inform and inspire dialogue about the future of tangible computing. We suggest that this approach can be generalized. Researchers and practitioners can use our MCRpd analytical approach as a lens or tool to think about how people will interact through different modalities with their integrated physical-digital environments in the future, particularly with elements of TUIs.

For example, our approach could be used to provoke discussion and idea generation around the design of other ubiquitous and personal technologies targeted at a wide range of users (including both active users and bystanders) interacting through diverse modalities and interaction paradigms. Our anti-example demonstrates the utility of our approach beyond strictly tangible paradigms. The analysis of this example highlights the importance of understandability, the value of mixed interaction paradigms, and the need to highlight "usable" objects in particular when there are no physical cues (affordances). We suggest our approach has utility as a tool to speculate about and design future visions of a wide range of interactive technologies.

In this way, similar to what Schmitz et al. [24] described as "films inspire new technology", looking at Sci-Fi TUI systems gives us a glimpse at how computer systems would operate in a possible future free from current technological constraints. Using the MCRpd model provides a common language for researchers to compare systems in Sci-Fi movies with those explored in the TUI literature, and get inspired by the differences and similarities when designing their own interactive technologies.

5.2 Speculative & Fictional Design Practices

Beside taking a pragmatic stance and using our approach to discuss and ideate future visions of tangible computing, and more broadly of personal and ubiquitous computing, it may also have utility as a speculative design tool. Dunne & Raby's Speculative Design [9] proposes a way to challenge social norms, values and preconceptions users may have about the role technologies and products play in everyday life. In this approach, designers "use design as a means of speculating how things could be" (p.2), often as "what-if scenarios" to better understand the present and open up discussions about possible futures.

Referring back to Schmitz et al.'s [24] process model, Sci-Fi movies can also draw inspirations from the HCI community in designing systems that help exposing their "own unique vision of future" (p.1). Taking this idea further, speculative fiction creators can also use our approach in designing their speculative objects.

In particular, the tangible objects in TUIs can be chosen to be familiar from everyday life (or a variation based on such familiarity), making the system easily recognizable and understandable. By incorporating ideas from the TUI literature, which are often backed by rigorous studies, speculative fiction creators can design objects and systems that appear effective, socially-situated, and are familiar to the often-passive audience; thus create a speculative world to better instantiate critiques of social norms and values.

6 CONCLUSION

At the end of their description of the MCRpd interaction model [32], Ullmer & Ishii noted a fundamental challenge for the future of TUIs: *What makes for good tangible interface design?* (p.13) We believe one answer to that question lies in the worlds of Sci-Fi movies, where futuristic computer systems are being created without the limitations of current technologies and with the main purpose of intriguing a diverse audience.

We begin this paper with two research questions related to Ullmer & Ishii's question and answer them through a case study with three tangible examples and an anti-example, in which we extend the MCRpd framework to explore how Sci-Fi movies employ TUI designs. We make two reciprocal contributions. First, we show that Sci-Fi movies do provide valuable lessons for researchers to utilize when designing future TUI systems, and to go beyond the tangible interaction paradigm. Second, we position TUIs as a way for speculative fiction creators to design convincing futuristic yet plausible systems.

It is worth noting that this case study is not exhaustive: there likely are tangible systems in other Sci-Fi movies that we have missed, or in those being made at the time of this writing. There might also be Sci-Fi systems that adhere to the MCRpd model in other ways, or systems from the TUI literature that match closer to our examples. Regardless, our intention here is to initiate interests and discussions; to call for collaboration with researchers, Sci-Fi movies enthusiasts/creators, and perhaps speculative fiction creators; and to help speculate on a vision of how technologies could interact and interweave with our bodies (theme of the TEI'20 conference) through tangible interfaces and interactions.

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Figure 1: Screenshot of two characters communicating with a remote character using a device shaped like a bracelet, taken by the authors from the movie Black Panther (2018), Walt Disney Studios Motion Pictures.

Figure 3: Screenshot of a system carving out two wooden balls representing perpetrators and victims of a soon-to-happen crime, taken by the authors from the movie Minority Report (2003), 20th Century Fox.

Figure 4: Screenshot of two characters having a discussion over a tabletop system, taken by the authors from the movie The Island (2005), Warner Bros. Pictures.

Figure 5: Screenshot of a character picking up a tangible object shaped like a truck from a tabletop system, taken by the authors from the movie Black Panther (2018), Walt Disney Studios Motion Pictures.

Figure 6: Screenshot of a character interacting with a holographic system, taken by the authors from the movie Iron Man (2008), Paramount Pictures.

Figure 2: Redraw of the MCRpd interaction model (Figure 3 in [32]), courtesy of Ullmer & Ishii.

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