Hand Gestures for the 22nd Century

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ABSTRACT
This research paper explores a speculative future through the lenses of embodied interaction. The overarching aim for this research is to delve into how expressive mid-air hand gestures may feel, and be used in a ubiquitous environment. The paper considers the implications of an embodied interaction by means of hand gestures, to inform novel approaches to hidden ubiquitous computers in the 22nd century.

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Embodiment; tangibility; hand-gestures; gesture recognition; speculative design;

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H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; See http://acm.org/about/class/1998 for the full list of ACM classifiers.

INTRODUCTION
Imagining the future has long been used as a tool in design. Art, literature, and product design have long found inspiration by speculating in what the world may unfold in the distant future. Speculative- and design fiction are frameworks in interactive design based on imagining the future, leaving freedom for the designers to find inspiration (Dunne & Raby, 2013).

In 1991, Mark Weiser defined the term Ubiquitous Computing, UbiComp in his text *The Computer for the 21st Century.* Weiser visualised a future of computing that could be anywhere or anything. Users would freely interact with the technology, and it would no longer be an object of attention but one that has become one with the environment.

For this paper we have used the vision of Weiser as inspiration, envisioning a distant future, in full transparency between the human and computer. We conceptualise a future home whereas devices are a rendering of a strong minimalistic and simplified approach. These devices no longer inherit knobs, buttons etc. They afford no perceivable actions. *How does one interact with an artefact that affords no interaction?* In such lived space, we imagine interaction with invisible technology through hand gestures. Hand gestures are versatile and highly varied─but foremost they do not constrain human motion (Foley, van Dam, Feiner, & Hughes, 1996). In that sense, "*hands feel things and hands manipulate things*" (Sahin, 2013). They have the natural ability to represent ideas and actions easily. Most importantly, the potential to provide a more natural input to the future hidden computer.

Research question
The overarching aim for this research is to delve into how expressive mid-air hand gestures may feel, and be used in a ubiquitous environment. *Would one feel change in relationship towards an artefact? Would one feel a deeper connection if the action were to be mapped to the response with meaning?*

Our main research question is thus: *How can hand motions reveal the communication between technology and household devices?*

With this question, we aim to examine perception, embodied emotions, and tangibility in relation to hand gestures. In light of tangible materials, our case study concerns physical hands. Also, ask the questions; *what embodied gestures can users of technology use to operate a device?* In light of this, explore how users use their bodies and hands whilst performing gestures. *How does it feel? What feels natural and what space is needed for sufficient hand movement?*

Constraints
To get a deeper understanding of our topic a few constraints were set. Firstly, our research is limited to exploring household devices in a home environment only. Secondly, we focused mainly on one aspect of the functionality of the household devices. Lastly, due to the time frame, we aimed to confine ourselves with rapid prototyping material.

Outline of paper
The following paragraphs outline our research design. Firstly, introducing relevant prior work that includes embodied interaction, tangible computing and studies of hand gesture in HCI. Secondly, the methods of data-collection and analysis. This is followed by a detailed overview of our design process, broken into two iterations. That includes detailed technical information regarding the construction of our prototypes. Lastly, the report concludes with a discussion reflecting upon the theory and the research process.

BACKGROUND/RELATED WORK

As UbiComp emphasises computing being hidden, everywhere, with seamless integration, this paper delves into the research theme of invisible computers. Such a theme, derived from Norman's research (Norman, 1998), focuses on embedding computing into everyday objects that integrate with our lived space. The characteristics of UbiComp is to support humans in their everyday experience. Such smart objects exist in a dynamic environment that is characterised by many sensors that perceive the day-to-day existence. Furthermore, Dourish (2001) notion "*the way physical and social phenomena unfolds in real time and real space as a part of the world in which we are situated*". These two areas of research, Tangible and Social computing, are essentially the foundation of embodied interaction. Social computing is the attempt to incorporate sociological understandings into technologies we design, to fit more easily into the ways in which we interact. In contrast, Tangible computing dwells upon interaction with physical objects which inherit computational abilities. This allows designers to take advantage of human physical skills.

"*Human beings are physical creatures; we like to interact directly with objects. We're simply wired this way. Interactive gestures allow users to interact naturally with digital objects in a physical way, like we do with physical objects.*" (Saffer, 2008). A book by Dan Saffer that in an entertaining way sets up guidelines for gestural mechanics as well as considerations for present-day designing.

Sahin (2013) believes that gesture-based technologies will have a strong emphasis in our future through gesture related interfaces and devices. A notion that Saffer (2008) agrees on and emphasises strongly. "*Keyboards, mice, trackballs, styli, and other input devices, although excellent for many situations, are simply not as able to convey as much subtlety as the human body. A raised eyebrow, a wagging finger, or crossed arms can deliver a wealth of meaning in addition to controlling a tool. Gestural systems have not begun to completely tap the wide emotional palette of humans that they can, and likely will, eventually exploit.*". Gestures are the motion of the body or physical action formed by the user in order to convey meaning. A study of human preferences in the usage of gesture types for HCI by Aigner et al. (2012), speak of advances in computer vision, particularly in real-time hand and body tracking. These advances are empowering intelligent environments to recognise human gestures from a distance. In particular, these novel technologies reduce barriers to interaction and increase the input bandwidth between the user and the computer, without requiring the user to wear a tracked object.

"*Indeed, the important thing about gestures is that they are not fixed. They are free and reveal the idiosyncratic imagery of thought*" (Wobbrock, Morris, & Wilson, 2009).

The study of gestures for surface computing by Wobbrock et al. (2009) is resourceful in the matter that it provides a fundamental basis towards a study of gestures, and a wide spectrum of prior research and terminologies. Most importantly, emphasising the involving of users early on. Furthermore, Wobbrock et al. (2009), speaks of the following; *"User-centered design is a cornerstone of human-computer interaction. But users are not designers; therefore, care must be taken to elicit user behaviour profitable for design."*.

METHODOLOGY

In this research, we worked within the frame of Speculative design. Speculative design and design fiction are both derivatives of the critical theory. They exist to open up design space, to allow the creativity to flow unhindered by the restraints of reality (Gaver & Martin, 2000). Gaver and Martin (2000) emphasises, ideas and prototypes generated through speculative design approaches may seem vague but their value is for the purpose of serving as '*milestones*' for future design possibilities. Speculative design allows designers to approach design that is too hypothetical for the perspective of a modernist. The type of prototypes within that genre has nothing to prove (Bleecker, 2010). They are not tested in the technical sense, or represent technical possibilities. These prototypes convey possibility through the stories they awaken and the discussions they initiate. The intent of speculative design is to ask, *What if?* Spark conversations that compel us to imagine things beyond our present.

"*What we are interested in though, is the idea of possible futures and using them as tools to better understand the present and to discuss the kind of future people want, and, of course, one's people do not want.*" (Dunne & Raby, 2013).

As we familiarised ourselves with speculative design, we were inspired by the work of John Underkoffler. In particular, his work as a science advisor for the film *2002: Minority Report*. From essentially creating the legendary scene where Tom Cruise uses '*data-gloves*' and gestures to control a hollow/transparent interface, John Underkoffler now delves into gestural implications and significance for future design. "*We have forgotten to invent new interfaces.*" (Underkoffler, 2010). By that, a notion of the idle development of screen-based interfaces, even though the technology has progressed greatly.

Delving into all stages of iterations in light of a speculative future, we engaged Buchenau & Suri's (2000) *Experience Prototyping*. This, to set up a setting to understand, explore and communicate what it might be like. For a subjective experience, our main focus was to engage with Buchenau & Suri's methods to support active participation. Hence, scenarios were utilised throughout the whole design process as it required the participants to exist within our future framing. Furthermore, the technique of bodystorming was initiated early on to gain deeper insights.

What we expected to gain from Buchenau & Suri's (2000) attitude was to facilitate a more informed development of the user experience and the tangible components which creates it. By asking, *What are the contextual, physical, temporal, sensory, social and cognitive factors we must consider as we embark on design? What is the essence of the existing user experience? What are essential factors that our design should preserve?* We sought to direct any new ideas into the design artefact and its experience.

Johansson & Linde's (2005) practice towards Participatory design involves *designing* going into a dialogue with the design situation. That is, driving the exploration as well as the design process. It sets the theme. As the creation of the theme was essential to the project, it was fair to say that we aspired to involve users early on. In light of the workshop, rules and scenarios was a way of getting a structure in the collaborative user testing. Later in the process, the digital prototype had the function of mediating the theme during the user testing as well as a collaborative story creation around the theme.

Archer (1997) argues that video-recording and video analysis is *the* method to be used for the study of gestures. In this respect, the method may be utilised for recording movement, capturing gestural speed in real time, and present the gesture along with other fluid non-verbal behaviours as they occur. Hence, facial grimaces, postural changes, etc.

DESIGN PROCESS

Workshop

The purpose of the workshop was to create a monologue in which, the participant's behaviour was always acceptable. We sought to remove any factors that could influence the participants. By so, enable us to observe any unrevised behaviours. The workshop consisted of close observations, video-recording, and bodystorming, which all were made together with the participants. In light of the theme of speculative design, we intended to observe gestural actions to the future smart home devices. Here, to foremost understand the correlation between the physical moves and expressiveness in gesticulation and the functions that were to be achieved through these movements.

The expected outcome was to inquire the reasons why certain gestures are invoked and how that can serve as inspiration for novel interactions with a household object. In view of this, to avoid bias, no elements specific to commercial brands were present in the process. Similarly, no specific application domain was assumed. Instead, participants were to act freely through natural hand- and body movements.

Set-up

Five participants volunteered for the workshop. Two were female. The average age was 28.5 years. All participants had a technical background. No consideration for the dominance of hand was taken. All were recruited from the Malmö University. Participants cultural backgrounds included Sweden, Germany, Poland, and New Zealand.

Care for the atmosphere was enforced by ensuring a closed-door environment, for the participant and facilitator to feel utmost comfortable. Here, ensure that the participants were not observed by unapproved volunteers of the workshop (Archer, 1997, p.87). Also, the facilitator took notes as an addition to the data-collection methods.

By using a think-aloud protocol and video-recording measures (Wobbrock et al., 2009), we sought to capture interpretations of common household objects by having them perform such. We were interested in non-verbal monologues. Meaning, removing the goal of action from the dialogue, and delve into facial grimaces, postural changes, hesitance, use of bodies and hands (Archer, 1997, p.84).

Figure 1. The nine cards used in *charades*.

For the concerning material, our inspiration derived from the playful collaborative practice as described by Johansson & Linde (2005). In this paper, such an approach is argued to induce new design ideas. Also, as a way of involving users early on in a Experience Prototyping (Buchenau & Suri, 2000). In light of this, we chose the game of *charades*. The rules are clear, like the following; a single person is to act out each syllable of a word or phrase in order. And, followed by the whole phrase together, while the rest of the group guesses. Now, nine cards were made out of cardboard with pictures framed onto them (*Figure 1*). The imagery consisted of household objects as such; *washing machine, vacuum cleaner, coffee machine, speakers, television, game console, door,* and a *ceiling lamp*. The last imagery, however, exhibited the phrase *on/off,* which was added to observe the types of gestures that were mapped to meaning. Each card included the corresponding object name in a legible font. The use of both imagery and phrasing was a deliberate choice to make the participant immediately aware of what the card represented. We sought to observe the immediate thought and reaction that influenced the participant's minds when performing. The procedure was executed as following; all cards were stacked, laying on top of each other with the representative side covered. None of the participants had or was allowed to view any of the cards prior to the exercise. Here, to catch any inclinations that comes in mind whilst performing the interpreted gesture. As Sahin (2013) in a related study approached gestures as signs, he believed they had other potential meanings embedded in them. In light of this, not only the correlations between physical moves and the cards but also any indications of meanings embedded into them.

Furthermore, all imageries were deliberately chosen in light of speculative design, to exhibit a *futuristic* look (*Figure 1*). For example, a self-controlled vacuum cleaner rather than a traditionally wired vacuum cleaner. By not influencing the participants to imageries associated with present household objects, our intent was to invoke new mindsets. The workshop was strategically divided into two rounds. The first round involved the participants to act out the card, as in the traditional game of charades were the person observing would comprehend the act in front of him/her. In the second round, all participants were to demonstrate what type of gestures they found symbolic for the card. The following cards in the first round were re-used for the second round.

Analysis

We began the analysis process by reviewing our recorded footage one by one. After reviewing all actings, we discussed patterns and similarities, but also considered what was surprising us or contradictory data. Our concluding analysis from the first round goes as following; each participant would gesture the *dynamic* action of the object. E.g. one of the participants used their hands to express a circular mid-air spin, which imitated the card with the washing machine. A card that illustrated a *static* object had the opposite effect on the participants. That is, each and every participant showed hesitance creating correlative gestures. For e.g. the television or the game console that does not present motion in its physicality or action, all participants expressed struggle when thinking of gestures. As an effect of that, they rather portrayed the object that in present time controls the illustrative on the card. E.g. remote control for the television, or the game controller for the game console. These insights, to this extent, were not anticipated. The reliance on the actions of the object rather than the physicality of the object presented a new turn in our iterative process.

Designing user-defined gestures

In this section, we discuss the implications of our insights for gesture design in our prototype. From the analysed qualitative data, a new research sub-question rose, "*How may we map gestures to meaning, in terms of versatility, through the use of hands*?". Our next strategic approach was to settle on two of the household objects and convert all qualitative gestural data of those two household objects into programmable gestures. The concerning gestures were; turn on the objects, as well as turning them off. In addition, be able to switch between the two objects through gestures. Consequently, each of the two objects would have a unique *targeting* gesture, and a generic on/off gesture to be used on both.

The chosen household objects were the lamp and the television. The lamp has the ability to express nuanced feedback. Conversely, the television does the opposite. Thus, in terms of turning on and off. Emphasising *static*, they do not present motion in physicality and action. But, as they both qualify as *static* devices, a further sub-research question was added to the lamp. With the use of an additionally designed gesture, may there be a difference in *nuance feeling* despite being static, and in addition to on/off? *What could the affordance of dimming communicate?*

Approaching the prototype with the insights in hand, our user scenario went as follows; (i) a unique gesture was to target each household object, (ii) a generic gesture in terms of push/pull would control the function on/off. Additionally, a gestural motion in the same manners would increase/decrease the dimming function. When emphasising household object at this point, we imply a replica (*Figure 6*) that mimics the household object in minimal functionality. In the context of push/pull, the inspiration derived from the workshop. Reviewing the subject of on/off, one participant stated: "*Really, it should just be the same on all devices... For me, it feels very natural if it was the same gestures for turning on or turning off. Like day and night.*". The pulling motion symbolise closeness towards the subject. Thus, closer to the subject may symbolise *on*. The pushing motion has the opposite effect and has a better fitting to the *off* function.

Prototypes

The structure of the digital prototype was based on the JavaScript programming language. In addition, the prototype utilised a colour-tracking library throughout all iterations. The library itself tracked colours through a camera. The initial idea was to use gloves marked with colour indicators. As the colour-tracking library could detect a wide range of colours within a projected canvas element, we had the possibility to work with the data captured─and redirect actions (*Figure 2*). Here, the glove material and its colour, colour indicators, and placement of such indicators on the gloves. That knowledge was dependent on the analysis from the workshop. The video footage revealed how mid-air hand gestures are to be presented in front of a camera. Furthermore, how hands move in terms of in a three-dimensional space, and how the hand movement reveals the colour indicators. Also, placement of the camera's field of view, distance to the gloves, and foremost the lighting conditions.

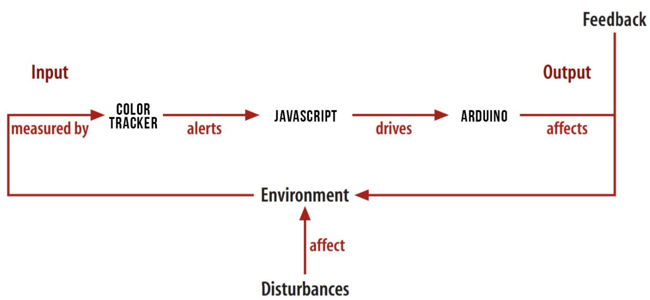

Figure 2. The process of input and output.

Continuing, the use of employing Arduino (Banzi, Cuartielles, Igoe, & Mellis, n.d.) allowed us to replicate a lamp, from the gathered insights of the workshop. Both the Johnny-five (Waldron, n.d.) and Socket.IO (Rauch, n.d.), NodeJS (Dahl, n.d.) packages, bridged the communication between the colour-tracker and the Arduino board.

However, having a functional prototype at this point allowed us to investigate the calibration level required. Our discovery concluded that the values, projected by the library, would vary heavily depending on the lighting conditions as well as the size of the colour indicators on the gloves. In addition, an iterative process at this stage enabled us to explore embodied design alternatives for the gloves. Hence, a prior cardboard glove mockup was produced to test the functionalities of the prototype throughout the early iterations. The discovery of assessing the paper prototype (*Figure 3*) made us realise the *distant* embodied feeling it inherited. The feeling of it was quite more the opposite of natural, it shared similar properties as of a remote control. The following discussions led to the re-designed glove mockup (*Figure 4*). On immediate use, the glove felt greatly more natural and embodied than the previous mockup. As there was full control in movement, there were no restrictions from the material. It felt more incorporated in the hand movements.

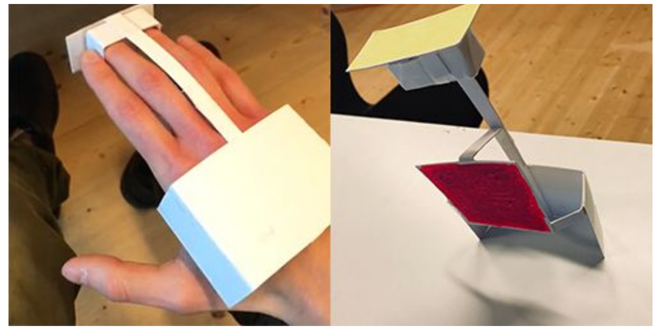

Figure 3. An early- disembodied prototype, for testing the boundaries of the colour-tracking library.

Figure 4. A late- embodied prototype, for use in all user testing sessions.

User testing

The arrangement of the user testing resembled the set-up of the workshop. Five participants volunteered for the user testing. Three were female. The average age was 26.2 years. Similar to the workshop all participants had a technical background. No consideration for both right- or left-handed users. All were recruited from the Malmö University. Participants cultural backgrounds included Sweden and Poland. Moreover, one of the participants had partaken in the workshop. All other participants were new to the project.

All tests were executed individually, with only two facilitators present to ensure the participant the freedom to interact with the prototype without feeling observed. Every user testing session was video-recorded, replicating the same procedure carried out in the workshop. This again, to catch facial expressions, elements of surprise, frustration or confusion.

The procedure of each and every user test was as of the following; participants were instructed to, wearing the glove mockup, to turn on/off a TV with gestures. A computer screen was used to mimic a TV, only displaying a black-screen until the correct gesture was produced. Once the correct gesture was detected, the screen would reveal a video clip to symbolise the '*turn on*'. The participants had the possibility to reverse the interaction, and '*turn off*' the TV. Additionally, the second part of the user test included

Arduino built LED lamps mimicking a table lamp. Via gestures, the participants could target the lamp and dim the light.

Each and every user testing session was initialised with the facilitator briefing the participants with a short description of the project theme; "*Now, imagine your home in the far future, twenty years from now, where your household devices no longer afford embodied forms of interaction, i.e. they have no buttons or remote controls. You have to interact with your products via gestures.*". Such briefing ensured to set the required mood, and for the participants to visualise the context. A short tutorial followed, where the participants would familiarise themselves with the gestures. When they felt ready and comfortable, the experience would start. Once the gloves were on, they tested the gestures towards the devices in this order (*Figure 5*); (i) turn on the TV, (ii) turn off the TV, (iii) target the lamp, and (iv) dim the light. Afterwards, all participants were offered the chance to explore the prototype in their own terms. As there were no tasks for them to finish, they had the freedom to explore each and every devices and gesture for as long as they wanted. This improvised idea was done with the purpose of not to stress the participants to feel like they needed to complete certain tasks. But rather, have the freedom to interact with interests in mind.

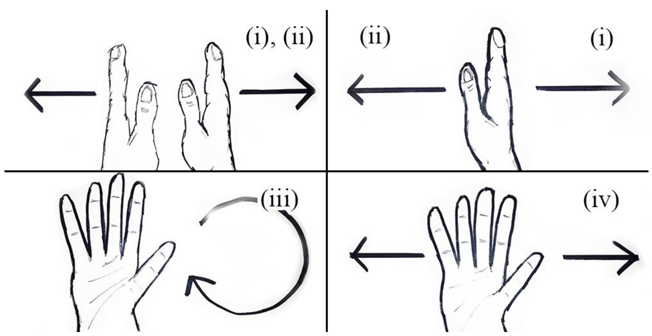

Figure 5.

Once the interactions were completed, approximately fifteen prepared questions were asked, and the answers noted. The purpose of the questions was meant to ignite discussions regarding the participant's interaction with the gestures. A few of those questions were; *How did you experience the prototype? Do you feel comfortable/confused? List three things you like/dislike about the interaction? Do you feel that the gesture symbolises the household object? How would you describe the interaction using your own words?* All questions included supplementary questions. Each user testing session elapsed for about twenty-five minutes following with discussions.

Analysis

We began the analysis process by reviewing our recorded footage one by one. Also, examine all notes from the discussions. In terms of *feeling*, all participants expressed a good understanding of the project and its interaction. Two participants understood the gestures immediately from the provided tutorial, whereas one of those had partaken in the workshop. For those two candidates, the interaction went flawlessly, and the comprehension of the prototype was continuous. For the other three, more time was required to memorise the gestures and presented trials and errors in the earlier stages of the testing. When a gesture was not performed correctly, the TV would turn on by mistake, raising a '*buggy*' feel to the users. One participant recognised the need to try the gestures themselves in front of the camera to understand the '*space*' available to perform their gestures. However, it took all users no more than five attempts before they could gesticulate successfully. All participants expressed a feeling of control when using their bodies to interact; "*With remote control, the conversation is between the object (remote control) and the device. But with my body, it is between me and the device. There is a much more emotional exchange between then*", "*More fun to control with your body than a physical button. It gave much more meaning to the interaction. I can control it more*", "*It felt like I communicated with the device, that does not really have its own language*". One participant expressed the feeling of reward after completing a gesture correctly. With this insight, we believe that the interaction can lead to a deeper connection to a device.

When elaborating on the gestures themselves, the majority expressed the need for the gestures to symbolise the device. Essentially, demanding the gestures to be concise and concrete, to feel natural. All participants sanctioned the gesture for the TV. By so, comparing it to *curtains of a cinema screen* unveiling. The gestures for the dimming of the lamp was also well supported. The majority expressed the feeling of control as the intensity of the light would directly follow their gestures. In particular, one participant conveyed enjoyment over the fact that she could stop the dimming wherever she liked. She felt that she was in total control. However, none of the participants felt that the target-gesture for the lamp was less convenient. In light of this, even the participant who had partaken in the workshop and had expressed such gesture for the lamp card, now felt in this context that the gesture felt disconnected. Three out of five felt that the on/off gesture should be reversed. Primarily, as this confused them at times and made them perform the wrong gestures.

All participants expressed the need for feedback to be direct. When performing the TV on/off gestures, there would be a short noticeable delay before the action occurred. This produced uncertainty and the need to perform the gesture again. Direct feedback as an effect of an action is needed, much similar to the nuanced dimming.

The use of two hands for gestures was also questioned. Consequently, the need to be able to multitask was raised, a concern we had not considered prior to the user testing. Hence, to able to hold a cup of tea and turn on the TV at the same time, or hold a grocery bag whilst turning on the light was highly desired. Consequently, the use of two hands essentially hinders multi-tasking.

All participants expressed an interest in a future home being equipped with gestural interfaces. When asked, none of the participants expressed apprehension about learning gestures; "*I would imagine it would be just as when smartphones were introduced. Gestures, like swiping, may have felt unnatural to start, but it did not take long to learn. I think this could be something similar.*".

DISCUSSION

In this section, we will review our findings for using hand motions as a natural input for interaction, and how it feels to do so.

Presently, gestural interfaces have not begun to completely tap the wide emotional palette of humans. Most common inputs, keyboard and mouse, "*are not able to convey the same subtlety as the human body, and lack to deliver a wealth of meaning*" (Saffer, 2008). In our research, our insights conclude that all participants expressed a stronger emotion of control and a meaningful feeling of connection towards the device whilst interacting with hand gestures. Throughout our user testing, while comparing gestures against a disembodied input, participants expressed how the embodied interaction felt more significant and deeper. Using their bodies they felt an emotional exchange, a language to communicate with the artefact. It was both compared to, and expressed as, a explicit dialogue. Saffer (2008) talks about how using other objects to interact with devices are absent of delivering a more meaningful relationship. We propose, that using your body to interact, the relationship changes as you are controlling the device. Through the body, there is a value in communication which creates its *own language*. The body is the medium and in charge of its dialogue.

In addition, our findings reveals that for the interaction to be nondisruptive, certain aspects of the interaction must be attended to. Firstly, the feedback needs to be direct. Wobbrock et al. (2009) emphasise that in user-computer dialogue, feedback is crucial. The lack of feedback discourages a user's actions, causing the users to take a new action. Our user testing confirms this notion. A short delay in the feedback made the participant feel that they had done the gesture incorrectly or feel frustrated about what to do next. On the other hand, when the feedback was presented direct from the gestures, the participants felt full control. We believe that using other objects such as remote controls, a delay is expected or assumed, as the communication travels through other materials the delay is forgiven. However, when using our own bodies, the users speaks directly to the device and expects the feedback to be direct. Secondly, we found that the target-gestures had to symbolise the devices. This, even though one of the target-gestures derived from the workshop, it felt disconnected later on as it no longer symbolised the device in its new context. We believe, the gestures that did not "feel natural" during the user testing were still too static for the context. We claim, that more dynamic gestures are needed when communicating with a device. We define a dynamic gesture as being the objects main action in motion.

In our paper, we have asked our users to respond to our futuristic theme looking past issues of plausibility, and instead focusing on the possible benefits, drawbacks, and wider implications. Hence, opening up a wider conversation about what they want their future to be. The way our research is valuable is that it makes imagined futures tangible through the creation of the prototype. Through interacting with our prototype, the users could engage and react to what this future represents. A speculative approach allowed us to think beyond the current reality. We succeeded in igniting a discussion on how hand gestures could enrich the interaction for a user. Also, designing a prototype where a few aspects of our vision could be tested, emphasising the feeling of the interaction rather than the technical aspects.

Reflecting over our part in the end, we acknowledge a few errors that could have improved our participants experience with the prototype immensely. A more comprehensive tutorial where the users could test the gestures in front of the camera could have led them to remember and understand the gestures considerably. The errors occurring in the early stages of the testing could have been prevented from such measures.

For future work, there is an need for considering the setting. We suggest a further exploration in terms of symbolisation. Hand gestures need to unfold in its used context.

CONCLUSION

This paper identifies both the significance of embodied interaction and the implications of a speculative approach on hand motions. Through the use of playful participatory design approaches, we could map certain *feelings* in a UbiComp home environment deprived of perceivable actions. In this respect, a close user-centred design process unveiled intriguing answers on how our speculative future may be. We found that hand gestures are embedded with meaning, drawing on Saffer (2008) and Sahin (2013). But from our research, we also discovered feelings inherited with a deeper connection in its dialogue.

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REFERENCES

1. Aigner, R., Wigdor, D., Benko, H., Haller, M., Lindlbauer, D., Ion, A., Zhao, S., & Koh, J. (2012). Understanding Mid-Air Hand Gestures: A Study of Human Preferences in Usage of Gesture Types for HCI. *Microsoft Research TechReport MSR-TR-2012-111*.
2. Archer, D. (1997). Unspoken diversity: Cultural differences in gestures. *Qualitative sociology*, 20, 1, 79-106.
3. Banzi, M., Cuartielles, D., Igoe, T., & Mellis, D. (n.d.). Arduino. Retrieved from https://www.arduino.cc/
4. Bleecker, J. (2010). Design fiction: From Props to Prototypes. *Negotiating Futures–Design Fiction*, 58-67.
5. Buchenau, M., & Suri, J. F. (2000). Experience prototyping. In *Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques* (pp. 424-433). New York: ACM Press.
6. Dahl, R. (n.d.). Node.js . Retrieved from https://nodejs.org/
7. Dourish, P. (2001). *Where the Action Is: The Foundations of Embodied Interaction*. Cambridge: MIT Press.
8. Dunne, A., & Raby, F. (2013). *Speculative everything: design, fiction, and social dreaming*. MIT Press.
9. Foley, J. D., van Dam, A., Feiner, S. K., & Hughes, J. F. (1996). The form and content of user-computer dialogues. In *Computer Graphics: Principles and Practice* (pp. 392-395). Reading, MA: Addison-Wesley.
10. Gaver, B., & Martin, H. (2000). Alternatives: Exploring information appliances through conceptual design proposals. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems* (pp. 209-216). ACM Press.
11. Johansson, M., & Linde, P. (2005). Playful collaborative exploration: New research practice in participatory design. *Journal of Research Practice*, *1*(1), M5.
12. Norman, D. A. (1998). *The invisible computer: Why good products can fail, the personal computer is so complex, and information appliances are the solution*. Cambridge: MIT Press.
13. Rauch, G. (n.d). Socket.IO. Retrieved from https://socket.io/
14. Saffer, D. (2008). *Designing Gestural Interfaces*. Sebastopol, CA: O'Reilly Media.
15. Sahin, A. (2013). Hacking the gestures of past for Future Interactions. In *Proceedings of International Conference on Advances in Mobile Computing & Multimedia* (p. 484). ACM Press.
16. Underkoffler, J. S. (2010) John Underkoffler: Pointing to the future of UI [Video File] Retrieved from https://www.ted.com/talks/john_underkoffler_drive_3d_data_with_a_gesture
17. Waldron, R. (n.d.). Johnny-Five. Retrieved from http://johnny-five.io/
18. Weiser, M. (1991). The computer for the 21st century. In *Scientific American, Vol.265 No.3* (pp. 19-25).
19. Wobbrock, J. O., Morris, M. R., & Wilson, A. D. (2009, April). User-defined gestures for surface computing. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1083-1092). ACM Press.