

**Designing for In the Wild Gesture-based Interaction: Lessons Learnt
from Vuores**

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Abstract

With the emergence of affordable gesture recognition technology, such as the Microsoft Kinect, interactive displays are making their way to *in the wild* setting, or public spaces, largely as information systems. It then becomes essential to delve deeper into users' perception of these systems and study the aspects that contribute to a rich and pleasant user experience. In addition to the general principles of interaction design, development and installation of such systems requires an understanding of social affordances or social dynamics between an actor and an audience as well as the role of an individual within a group. Interaction affordances or, hints and clues about ways to interact with the system, and technology affordances or, capabilities of current technology, also help build a smooth interaction and rich user experience. The system needs to be exciting and enticing for users to initiate interaction yet simple enough to allow fluent interaction without any prior experience. This thesis explores the opportunities and challenges introduced by interactive public displays systems in the wild by presenting a case study of a gesture-based system, Energyland, which was installed at the month long annual Finnish Housing Fair in the summer of 2012, in Vuores, Finland. By analyzing the data collected from the user experience questionnaire, system logs, informal user interviews and observations made by researchers, I discuss my findings and compare them to previous work in this area. Overall, users responded very positively to the system experience as evident from the questionnaire consisting of seven factors: individuality, authenticity, story, contract, interaction, sound and pleasantness of the system. Users also stated their interests towards using similar systems in the future. Based on the system logs and researcher observations, social, interaction and technology affordances are the building blocks of user experience for in the wild systems, and there should be mechanisms to help users overcome an initial reluctance to interact by presenting interesting and intriguing interactive content. A key finding was the user's attitude towards interaction, namely as a risk into the known, which dictates that installation spaces must provide for a quick and easy escape route. The end result of this thesis is a set of guidelines covering the design, implementation and installation process for similar systems involving interactive public displays.

Keywords: Gesture Interaction Design, User Experience, Design Guidelines

Contents

1.	Introduction	1
2.	Related Work.....	3
2.1.	Nielsen’s Principles Applied to Embodied Interaction.....	3
2.2.	Initiating User Interaction in Public Spaces.....	7
2.3.	Interactions in Public Spaces	9
2.4.	User Experience Evaluation.....	12
3.	Vuores Case Study: System Description.....	15
3.1.	System Architecture.....	17
3.2.	Design and Layout	19
3.2.1.	Patio.....	20
3.2.2.	Kitchen	23
3.2.3.	Entertainment Room	26
4.	Vuores Case Study: Evaluation Procedure and Results	30
4.1.	Vuores Installation	30
4.2.	Procedure	31
4.3.	Data Collection	32
4.4.	Participants.....	33
4.5.	Questionnaire	34
4.6.	System Logs.....	36
4.7.	User Interviews	38
4.8.	Researcher Interviews	39
5.	Design Guidelines for In-the-Wild Interaction	42
5.1.	Interactions based on Real World Metaphors.....	42
5.2.	Support for Fight or Flight Reaction.....	43
5.3.	Encouraging Performative Interactions	43
5.4.	Enabling Honeypot Effect.....	44
5.5.	Supporting Interaction Affordance	44
5.6.	Working with Technology Affordance.....	46
5.7.	Researcher Observations with Pre-defining Evaluation Goals.....	47
6.	Conclusion.....	48
	References	50

Appendices

Table of Figures

Figure 1: Fukuda's Automatic Door (adapted from Dan Saffer [2008, p75])	4
Figure 2: Dyson's Airblade (adapted from Dan Saffer [2008, p81]).....	6
Figure 3: Bubble Screen (adapted from EIT Lab [2012]).....	8
Figure 4: The Audience Funnel (adapted from Müller et al. [2010])	10
Figure 5: Experience Pyramid (adapted from Tarssanen and Kylänen [2006])....	13
Figure 6: Patio	16
Figure 7: Trash Sorting Game and Lightning Catching Game	16
Figure 8: Entertainment room	16
Figure 9: Software Architecture.....	18
Figure 10: Skeleton Joints (adapted from Kinect HI Guidelines [2013])	18
Figure 11: Six Levels of the energy piggy	19
Figure 12: Patio Layout.....	21
Figure 13: Jacuzzi with Bubbles	22
Figure 14: Kitchen when it's sunny	23
Figure 15: Kitchen when there's thunder	24
Figure 16: Levels of Coloring Spot.....	25
Figure 17: Entertainment Room.....	27
Figure 18: Entertainment Room without video.....	27
Figure 19: Entertainment room feedback spot.....	28
Figure 20: Bird's eye view of the Tekes tent (adapted from Tekes [2012]).....	30
Figure 21: Vuores Screen Layout.....	30
Figure 22: Setting up the Installation at Vuores.....	31
Figure 23: Number of users by age group.....	34
Figure 24: Number of users by frequency of use	34
Figure 25: Mean ratings of the elements of experience	34
Figure 26: Mean rating by frequency of use	35
Figure 27: Interaction Spot entries as a percentage of total entries	37

1. Introduction

Gestures are an integral part of human communication. They are a natural and intuitive part of our body language and have the potential to convey information that might not be explicitly mentioned in speech [Goldin-Meadow, 1999]. Even though it sometimes conflicts with what is being said, they still “provide [users] with another representational format in addition to speech, one that can reduce cognitive effort and serve as a tool for thinking” [Goldin-Meadow, 1999]. It is no surprise then that gestures are becoming a part of this new wave of emerging pervasive technologies [Bhuiyan and Picking, 2009]. With the advent of motion tracking technology and the ease of the availability of devices such as the Microsoft Kinect, which allow developers to build their own applications, incorporating gestures into human-computer interaction is a logical step forward.

Gesture-based input also extends the concept of direct manipulation, or user’s control over virtual objects by actions based on real world metaphors. For instance, to move a file from one folder to another, one can drag it using a mouse on a computer or a finger on touch-based tablets. This action of dragging a file, or any object, to move it from one place to another is similar to actions performed on real world objects. From the traditional desktop systems with a mouse and keyboard, to natural user interfaces with multimodal interaction [Steinberg, 2012], directness of control is increasing. Using gestures allows for more natural and intuitive metaphorical manipulation. Dan Saffer defines “a gesture [as] any physical movement that a digital system can sense and respond to without the aid of a traditional pointing device such as a mouse or stylus. A wave, head nod, touch, toe tap and even a raised eyebrow can be a gesture.” [Saffer, 2008, p2] He broadly categorizes gestures as either touch screen or free form.

There are several factors to consider when developing a gesture-based interaction system: from designing gestures that can be tracked and identified, while still being natural, intuitive and effective for the user [Saffer, 2008, p22], to the actual system installation space and the impact of the social context on users [Michelis and Müller, 2011; Perry et al., 2010]. Nielsen’s ten design principles are time-tested human computer interaction guidelines, which can be applied to gesture-based interaction. In addition there are several user studies of gesture-based systems in open spaces in real world environments, commonly referred to as *in the wild*, that discuss important factors to take into account while designing the system and its space. The focus of these studies ranges from understanding user attitude and attention towards interactive public displays [Kukka et al., 2013; Müller et al., 2009], analyzing a user’s in the wild interaction experience [Peltonen et al., 2008; Kellar et al., 2005], to examining audience or passer-by behavior and the inherent social dynamics with respect to user interaction [Brignull and Rogers, 2003; Michelis and Müller, 2011; Perry et al., 2010]. Nevertheless, there is still a need to combine these individual facets of in the wild

interaction and provide an all-inclusive set of guidelines for implementing such a system.

This thesis focuses on this very topic of gesture interaction systems by exploring the opportunities and challenges of an in the wild gesture-based interaction systems in detail by thoroughly analyzing the Energyland case study, a system that was installed at the annual Finnish Housing Fair, July 2012 in Vuores, Finland. The system was part of the Tekes Smart House installation and presented the impact of energy technology and energy consumption in everyday life. The goal of this study is to provide a holistic set of guidelines to facilitate the process of designing, implementing and installing a gesture based system for in the wild user interaction. For this study, the emphasis is mainly on free form gestures.

Participants visiting the Tekes smart house installation were recruited opportunistically and their interaction was observed by a researcher. Participants were also requested to fill out an evaluation form. These evaluations and researcher observations provide an insight into user preferences, behavior and challenges from both the user's and an observer's perspective allowing for critical comparisons with previous research. Drawing from these comparisons, it can be noted that while interactions that depict real world objects offer a sense of confidence to the users and encourage them to interact, they can also be perceived as boring and too common. One needs to find the right balance between designing for exploration of ambiguous content and designing with generic objects that might be easier to relate to but seemingly less intriguing. Users need to feel comfortable and secure about their interaction and should have the option to simply walk away from a system in case their fear of failure or embarrassment overwhelms their desire to interact. This is because interaction in public spaces is inherently social, and is thus subject to social norms that evolve with the group's dynamics. In these cases, watching another user or a researcher helps install confidence in a potential user to interact while also enticing several other passersby. In some instances, limitations of the current gesture recognition technology and a user's perception of the intention and goals of interactions also affect the user experience. It is thus imperative to keep the above guidelines in mind, balancing those that seem contradictory, to provide users a rich experience with gesture-based interactive public display systems.

This thesis starts with a review of current literature on gesture interaction design and in the wild user studies focused on enriching user interactions and evaluating user experience (section 2), followed by a technical description of the system (section 3). Next, the installation and evaluation procedure is explained in section 4. The results of the user evaluations and researcher observations are also summed up in section 4 with an in depth discussion of the critical observations in section 5. Lastly, these findings are summarized in terms of simple guidelines in the conclusion (section 6).

2. Related Work

Based on current research, the process of analysing and discussing design aspects of a gesture-based interaction system in the wild, needs to be divided into two parts: gesture interaction design guidelines and guidelines for in the wild user interaction. This is because most gesture interaction guidelines focus on the user experience considering a single user interacting with a system and do not take into account the social dynamics that affect the user when the interaction is in a public space. In the wild experiments move the user from a traditional isolated laboratory setting to a more open environment, usually in full public view, which introduces feelings of social embarrassment. Users accept pre-defined social roles, which affects the overall interaction and experience with the system. Ways to encourage and initiate user interaction in the wild is of much debate: how can users interact explicitly with a public display without feeling like the center of unwanted attention.

To gain a perspective on gesture interaction guidelines, I first show how Nielsen's principles can be applied to embodied interactions. For in the wild user interaction, user studies on gesture based interaction with large displays and their evaluation methods are discussed in the subsequent sections.

2.1. Nielsen's Principles Applied to Embodied Interaction

Jakob Nielsen's ten principles [1994] are the probably the most popular and well-applied guidelines for human-computer interaction design. Although these principles were derived for traditional user interfaces such as the keyboard and desktop, they extend to more modern interfaces such as touch screens and gesture-based systems. By applying these ten principles to gesture-based systems for embodied interaction, an initial set of guideless for gesture-interaction design is explained as follows:

1. **“Visibility of system status”**: It should be clearly evident how and when a system responds to gestural input from a user. Users should get continuous and simultaneous feedback of their actions allowing them to know that the system has recognized and identified their actions. For instance, in Fukuda's Automatic door, the door bars open automatically identifying the user's presence near the door as shown in Figure 1 [Saffer, 2008, p75]. In the case of Energyland, an onscreen human shadow, shown in Figure 6, mimics user movement and gestures for continuous gesture recognition feedback as explained in sections 3.1 and 5.5.
2. **“Match between system and the real world”**: Gestures are natural part of communication and thus there are various intuitive and natural metaphors already embedded in a user's mind. Some basic gestures such as up, down, right and left movement of the arm to suggest corresponding movement or placement of an object, form natural mappings in the user's mental model. Using these can

greatly reduce the learning curve associated with new styles of interaction. As explained in section 5.1, in case of EnergyLand, the gestures based on real world metaphors were the most preferred by the users.



Figure 1: Fukuda's Automatic Door (adapted from Dan Saffer [2008, p75])

3. **“User control and freedom”**: The system should be able to handle false positives or unintentional gesturing and allow easy recovery from such mistakes. This is especially difficult with gestures being used so extensively and inattentively. For a user to be able to intuitively control a system, building trust in the system, it is fundamental for the user to feel that he/she has “control over the consequences of executing gestures, without experiencing unjustified physical strain” [Hespanhol et. al, 2012]. For Energyland, users could interact in several smaller interaction spots within a single room, where each spot had a different gesture as explained in section 3.2. Users could spend more time on the spots they were most comfortable with and quickly cross through or skip the ones that they found particularly difficult.
4. **“Consistency and standards”**: There is a dire lack of an elaborate universal gestural vocabulary but as explained before, there are a few gestures for certain tasks, which can be considered as an unspoken standard. It is important that within a system or a series of products, the interaction style is consistent allowing for a shorter learning curve. All the gestures in the Energyland required only one hand, either the right or left, even though they differed from task to task. Each of the Energyland interaction spots also had a consistent storyline based on the user’s position and gestural input: an introduction to the energy problem at hand, a hint or clue about the solution and then an end of story where the problem is solved, explained in section 3.2.

5. **“Error prevention”**: As Donald Norman says, some interaction styles seem “designed for errors” [Norman, 2002, p131]. A system should use gestures that are possible based on human physiology and motor movement, which do not require extremely precise movement that might be difficult and tiresome to follow. Another restriction on gesture design can be the capabilities of available technology to differentiate similar gestures as explained in section 5.6. Gesture recognition is inherently error prone and it is easy for the system to detect many false positives, i.e., detect a gesture not meant to trigger a reaction from the system, mainly because gestures are a natural part of human communication and interaction. For Energyland, user’s had to be in close proximity of specific virtual objects to initiate interaction as mentioned in section 3 Table 1.
6. **“Recognition rather than recall”**: Since gestures involve free limb movement, it is often hard to instruct users on how to perform them. This makes it difficult for a system to indicate that gestures are an input channel. There is an element of discoverability through affordances as mentioned in section 5.5, usually visual or auditory clues to help users figure out the appropriate gesture for a task [Hespanhol et. al, 2012] without having to memorize them. Having to refer to a manual more than once to interact with a system is a failure on the designer’s part [Norman, 2002, p190].
7. **“Flexibility and efficiency of use”**: Efficiency can be thought of as gestures that are easy to reproduce and are repeatedly identified correctly by the system [Hespanhol et. al, 2012]. Gestures should assist or speed up task completion but the system should also allow for other forms of input as gesture-based interfaces are not so common and the user can either tire very easily or simply be uncomfortable using them. The Energyland system has several shorter interactions within one room but without any time restrictions, as discussed in section 4.2. Users could spend as much time as they preferred and this allowed users the flexibility to stop interacting as when they liked even though there was not any other explicit form of interaction except for the gestures.
8. **“Aesthetic and minimalist design”**: The system needs to consider ergonomic, social and contextual aspects. The key to good design is to keep it simple. For instance, as shown in Figure 2, a user has to put his hands inside the Dyson Airblade system, to activate the air blowers, which does not inspire much confidence and at first feels very suspicious to use. In case of Energyland, gestures for object selection were consistent throughout the rooms and of minimalistic design as described section 3.2.
9. **“Help users recognize, diagnose, and recover from errors”**: There should be enough real-time feedback to help users identify if a mistake has been made and an easy way to quickly recover from it. The system should also allow users to

recognize the trigger for the error so that they can avoid similar errors in the future. As mentioned earlier, in case of Energyland, a user's onscreen shadow (refer to sections 3.1 and 5.5) helped form a correlation between user action and system behavior, assisting users in completing the gestures-based tasks correctly.

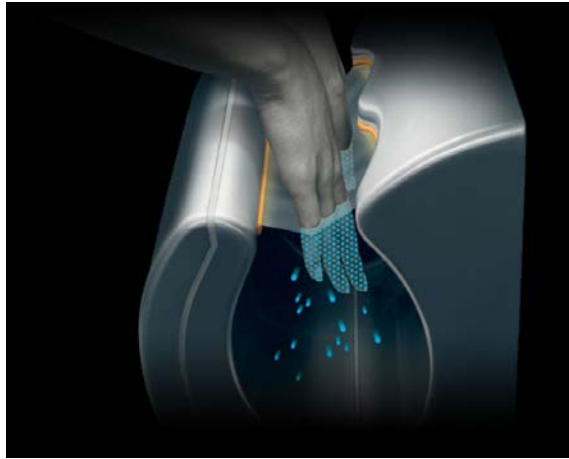


Figure 2: Dyson's Airblade (adapted from Dan Saffer [2008, p81])

10. **“Help and documentation”**: Since gestures are spatiotemporal, it is difficult to document, draw or demonstrate them on paper. Dan Saffer suggests various alternatives to overcome this limitation such as using animated scripts to depict movement [Saffer, 2008, p146]. This was quite difficult in case of Energyland and help was mainly provided by the researcher present at the installation as mentioned in section 4.8.

These guidelines apply to the designing of gestures for interactive systems to reduce the challenges faced by users during their interaction with new and unfamiliar systems. As these interactive systems move from traditional laboratory environments to open spaces in public settings, various social norms affect user interaction in ways unseen in the laboratory. From ways to initiate user interactions to keeping a user engaged, user interactions in the wild are more complex because environmental factors brought in by the surroundings. Factors such as the presence of an audience or casual passersby, large displays that instinctively feel like a T.V. rather than interactive displays or then a lack of interest and curiosity; are not expected in a laboratory where users have already decided to participate in an experiment with pre-defined goals. There are numerous studies examining and explaining such user behavior and attitude towards interactive systems set up in the wild. Understanding the challenges faced in these user studies with large interactive public displays and the proposed research solutions help provide a more holistic perspective for designing gesture-based interaction in the wild.

2.2. Initiating User Interaction in Public Spaces

In their study, Brignull and Rogers [2003] discuss a user's socially inhibitive response towards interacting with large displays in public spaces based on the system setup. They observed user behavior and people flow around an interactive system called the Opinionizer that consists of a wall mounted display and a keyboard to enter comments and opinions on a thought inspiring phrase or question. Opinionizer was setup at a book launch party and a welcome party. By comparing the difference in setups and its effects on users, they postulate that for a user to overcome his/her initial inertia as a passive observer to becoming an active participant depends on the following criteria:

- Duration of the interaction
- Purpose of the Interaction
- Steps involved in the Interaction
- Interaction experience for the user
- And whether there is a "quick let out, where [users] can walk away gracefully, without disturbing the on-going public activity" [Brignull and Rogers 2003].

While the duration, purpose, method and ease of interaction can be attuned towards the user by following the ten general principles for user interface design by Jakob Nielsen [1994], the support for a user's fight or flight reaction is concerned more with how the system's installation space is laid out. For instance, users should have the option to quickly move away from the system or merge back into the audience as an observer, from being a participant, if they so wish. Having this option is similar to having an escape route or a safe exit from the awkwardness and unpleasantness of the unknown. This is also a social phenomenon experienced by people in the physical world, because of its uncertainty. It induces a feeling of "vulnerability leading to a constant preparedness for danger and surprises" [Klemmer et al., 2006] that controls and guides our experiences and interactions. Klemmer et al. [2006] state that all intended human physical action has an associated risk and that this act of taking risks is an important social and psychological factor governing human experiences of embodied interaction. They draw comparisons between high risks situations where people are negatively forced to be more attentive and focused, and low risk scenarios, where people can be more creative, curious and relaxed although they are less attentive. They further suggest that embodied interaction needs to consider the effects of risk, attention and engagement, which are interconnected.

In addition to having this quick and reliable way out, users also need constant encouragement and demonstration to excite them to interact with systems in the wild. There are several phases that a person goes through when interacting with public displays. These phases are based on his/her attention towards the display and his/her motivation for initiating interaction. Dan Saffer [2008, p143] defines them as the three

zones of engagement: attraction, observation and interaction. Users need to overcome the thresholds that exist between these phases or zones. For instance, not all passers-by will be attracted towards the display as some might not even notice it. This can be attributed to people's instinctive nature to ignore large displays they feel contain uninteresting information that is not useful for them, coined as *display blindness* by Müller et al. [2009], even though the system might actually have information they say they would like to see. Thus, there is a mismatch between what information the users expect the display to provide and what it actually presents, which cannot be resolved without the trying out the system. This provides an insight into how users' attention can become highly selective and is understood more as a coping mechanism for the information overload felt by people in general. Another mechanism to handle information overload is *display avoidance*, which is when users consciously and purposely ignore a display or interactive system even though they are right next to it, as observed by Kukka et al. [2013].

From those that do pay attention to the system and display, they should feel a sense of attraction towards it and be pulled in towards it. This can be achieved by the system acknowledging a user's presence and creating a sense of awe for the user. The EIT ICT Lab's Kulpa UI bubble screen [EIT Lab, 2012] tries to solve the problem of gaining a user's attention and encouraging them to interact with their five meter long interactive MultiTouch wall as shown in Figure 3.



Figure 3: Bubble Screen (adapted from EIT Lab [2012])

By using Microsoft Kinect's infra-red motion sensors and in-built cameras to detect user proximity to the displays, the system creates a visual bubble that follows the user as she walks along the wall. This creates a sense of wonder and the user is intrigued to observe system behavior in response to her movements. A transition is then

needed from a casual observer to a curious on-looker by just seeing how the system reacts to the user's presence. This curiosity can generate enough motivation and intrigue to encourage the user to eventually interact with the system.

2.3. Interactions in Public Spaces

Considerable research has been devoted to understanding user behavior around large public displays, often resulting in defining taxonomies to describe the observed behavior. The Audience Funnel case study by Michelis and Müller [2011] is especially relevant as the focus is on understanding audience behavior around multiple large displays that used gesture-based interaction. Based on their in-depth observations, they classify six stages of interaction with more emphasis on the different level and attributes of interactions as compared to the three zones of engagement as mentioned in section 2.2. These six stages of interaction are:

1. Passing by: people in the immediate vicinity of the installation and who can see the display are defined to be the passers-by.
2. Viewing and Reacting: passers-by who look at and react to the installation by turning their body or head can be thought of as viewers.
3. Subtle interaction: subtle interaction can be initiated by a viewer with the intent to 'check-out' the system without being noticed and usually not as the main user.
4. Direct Interaction: when a user stands right in front of the display for explicit interaction.
5. Multiple Interaction: if a user interacts with multiple displays one after the other or with the same display after a short pause of no interaction, it is considered a period of multiple interactions.
6. Follow up Actions: this can be explained as either observing another user after interacting with the display or then taking a photo of oneself, the display or a friend interacting with the display to show and share with others.

Similar to the three zones of engagement, users need to cross a certain threshold to move to next phase where attention and motivation are the key driving factors, as shown in Figure 4.

Several studies have shown that interactions in public are inherently social to the effect that the user becomes a performer or an actor with an audience or observers making the user more self-conscious. Perry et al. [2010] called this *performative interaction*. This creates a feeling of embarrassment and social awkwardness among people as they are afraid and concerned about how others around them perceive their actions and performance. There is fear of public shame and "it requires a considerable amount of confidence to cope with [it]" [Brignull and Rogers, 2003]. People need to

mentally overcome such social inhibitions to be comfortable enough to use interactive system in public view. Connecting this to the three zones of engagement, a person can be thought of as a passer-by during attraction, an audience during observation and an actor for interaction introducing distinct social roles that come in to play.

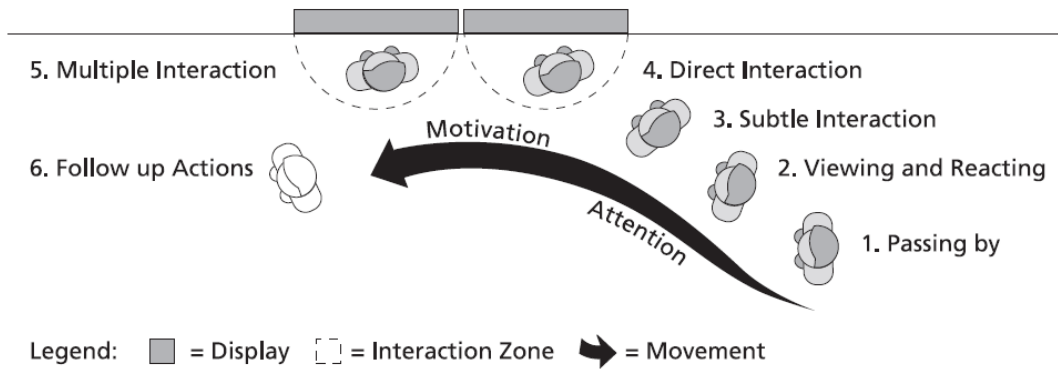


Figure 4: The Audience Funnel (adapted from Müller et al. [2010])

One way to reduce the performance anxiety, associated with being an actor, can be by using well known metaphorical gestures that lean towards predictable interaction [Müller et al., 2010], but this also affects the system's novelty factor and appeal. There is a trade-off between familiarity backing a user's confidence and the explorative nature akin to uncertainty [Saffer, 2008, p17]. A system should evoke feeling of curiosity yet as mentioned by Jakob Nielsen [1994], there still needs to be a match between the user's real world mental model and the system's content and interaction methods. Müller et al. [2010] reiterate that if "interactions bear resemblance to already known situations, [they] can be grasped more easily and utilized more efficiently." They advise a balance between fuelling a user's fantasy by means of imaginary settings and building on newer interaction forms by linking these fantasies to "already established behaviors."

On the other side of the coin, Perry et al. [2010] suggest that "building on user's competitiveness may offer greater interaction with the system and engagement with the content", although this is counter-intuitive when following conventional usability design guidelines. With the same zeal, they also suggest using elaborate gestures to purposely convert the interaction into a performance to arouse the curiosity and interest of the nearby onlookers, thus cashing in on the performance anxiety that is bound to affect users.

Another well-known flip side to having explicit gestures as interaction is what spectators or nearby onlooker gain by just watching the user: an opportunity to observe and learn the interaction, an increasing curiosity and interest to try it themselves [Reeves et al., 2005; Hardy, et al., 2011] and by virtue of the first two, attracting even more passer-by and on-looks towards the system like bees towards a honey pot. The Honeypot effect is a well-researched "social affordance" [Brignull and Rogers, 2003]

where by the number of potential users, or current bystanders, keep on steadily increasing as more people are drawn towards the source of excitement in the air, introducing possibilities for social interactions between users and the audience [Michelis and Müller, 2011]. Honeypot can be determined by the location and placement of the installation, and surprisingly also by the display form factor [Koppel et al., 2012].

A point to revisit is that the dynamics of these roles, from actor to observer or vice versa, become even more complex when users interact in groups. For single user systems, people tend to follow turn-taking rules although sometimes interlaced with competitive feelings and other times with collaborative efforts. The WaveWindow system [Perry et al., 2010] observed that people with children were more open to performance-like interaction. This was attributed to the presence of children that seem to give the adult in the group an acceptable social excuse to be animated and possibly silly. If the system allows for multiple users at the same time, territorial issues crop up between the users. As observed by the CityWall installation in Helsinki [Peltonen et al., 2008], using interfaces with undefined territorial borders and overlapping work-spaces can cause conflicts between the users. For instance, when two users simultaneously interacted with the CityWall, and one of them accidentally blew up a photo such that it affected the work-space of the other user, a conflict conjured between the users. There were several conflict resolutions that users resorted to ranging from withdrawing from the system, bringing in the audience for support or then exchanging casual or friendly remarks about the situation. Thus, it can be argued that the “visibility and audibility of these interactions makes them available to audience and collaborates alike with both inhibitory and facilitatory consequences” [Perry et al., 2010].

Ojala et al. [2012] add *interaction blindness* to list of deterrents effecting user interaction in public spaces. In their reflections over the three years of the UBI Hotspot around the city of Oulu, they mention that “people in all population demographic” simply did not realize that they could interact, via touch, with these Hotspots. This is even more troublesome for gesture-based systems that are just making their way into the public installation domain. Interaction blindness is different from display blindness, which refers to the un-noticeable displays or reluctance of users to interact with a display. Interaction blindness is defined as the missing knowledge of how to interact with a certain system mainly because of its lack of technology affordance with respect to the user’s mental model. There is a direct link to people’s perception of and their action towards such systems, or in this case, *interaction affordances* where “hidden and false affordances lead to mistakes” [Gaver 1991] Thus, it becomes essential to make these affordances perceptible to users with an element of exploration to arouse curiosity and interest.

It can be said that current limitations in technology add to the lack of technology affordances. For instance, Microsoft Kinect's skeleton data is affected by occlusions such as a user's hand in front of his/her body, or when a user is wearing loose clothing or a skirt. This also plays a negative role in how that user interacts and experiences the system. Peltonen et al. [2008] observed that user interaction with their CityWall was mainly one-handed as users were carrying bags, camera and mobile phones among other things during their interaction in the wild; even though they do not explicitly mention any technical issues they faced because of this.

As discussed above, there are several studies emphasizing ways to encourage and entice users to interact with new age interactive systems. These studies base their suggestions on observations and evaluations of user experience that is explained further in the following section.

2.4. User Experience Evaluation

As the saying *customer is king* goes, in HCI, the *user is king* and the new outlook of designers is to focus on what makes a user have a good experience. Thus, the new mantra in HCI is designing for user experience in addition to past emphasis on functionality. Donald Norman [Norman, 2002, preface *xiv*] talks about this in his book *The Design of Everyday Things* where he mentions that in first decade of the 21st century, good design meant functionality: the system provided robust and reliable functionality. The way technology has evolved, it seems now that functionality is expected and taken for granted. What really makes a system or product click with its users is how it makes the user feel. This can be better analyzed by evaluating how the user experiences a certain system. An in-depth survey of currently available evaluation methods for Public displays is discussed by Alt et al. [2012] “to understand how to best evaluate public displays with regard to effectiveness, audience behavior, user experience and acceptance, and social as well as privacy impacts.” For user experience or UX, they suggest laboratory studies, field studies and deployment-based research as the most common approaches to these types of research. The classic arguments towards and against laboratory and field studies apply here as well, laboratory studies enable more control over internal and external validity while field studies allow for more ecological validity. Deployment-based research aims to provide a mechanism to “introduce technology in a social setting” “integrated into the everyday lives of their users” [Alt et al., 2012]. There are several methods and tools available to researchers to collect data in these evaluation approaches such as interviews, questionnaires, focus groups, observations and logging.

The evaluation of public displays is affected by a number of things including the surrounding environment that dictates people flow and display visibility, and also by the presence of researchers observing users. As is with any type of research, there is a

possibility of users altering their behavior to better suit and please the researchers present. For in the wild setups, where there is less control over the environment, it still makes sense to have researchers physically present to observe user behavior. “Dynamic and unpredictable, urban environments seriously challenge experimental observation and control. Yet, as our experiences demonstrate, there are also tremendous insights to be gained” [Kellar et al., 2005].

There are no right answers for choosing one evaluation method over another and as suggested by Alt et al. [2012], one should bear in mind the validity of the internal, external and ecological validity, consider the impact of the content, understand the users and check for common problems such as display blindness, interaction blindness and display avoidance.

Going back to idea of treating the user as a king, Tarssanen and Kylänen [2005] talk about producing experiences and what makes them worthwhile for users. They discuss six distinct elements “for the creation of [a memorable and unique] experience” that can ultimately lead to a personal change. Although their study reflects on this process for tourism, their ideas of the experience creation and their six elements are valid also for interaction design. The Speech-based and Pervasive Interaction (SPI) group at TAUCHI, at the University of Tampere has developed an in-house questionnaire based on these six elements of experience creation that “form the criteria for building a setting for experiential moments, situations and undergoing” [Tarssanen and Kylänen, 2005] This questionnaire has been applied successfully to gain an insight into user experience in various user studies conducted by SPI group, and was also thus used for the Energyland user experience evaluation.

These elements are: *individuality*, *authenticity*, *story*, *multi-sensory perception*, *contrast* and *interaction* using which they conceived the Experience Pyramid as shown in Figure 5.

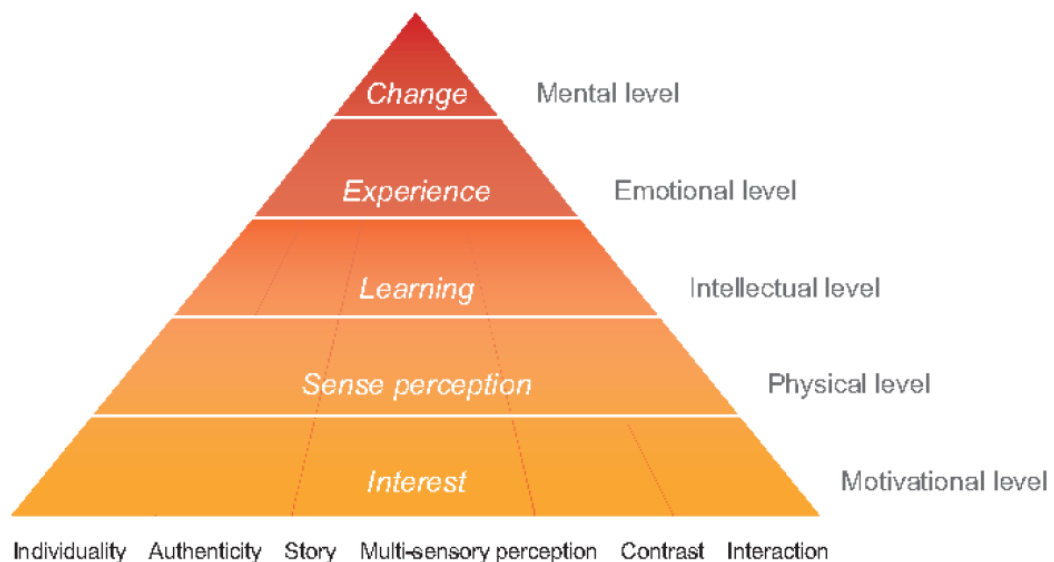


Figure 5: Experience Pyramid (adapted from Tarssanen and Kylänen [2006])

The Experience Pyramid also takes into account the levels of experience starting from the bottom layer, which pertains to user interest considered as the motivational level of experience. The interest will result, from an interaction point of view, into the user interacting with the system and experience an emotional response such as excitement or pleasure, which is the physical level of experience. The interaction also introduces a sense of achievement and learning that builds towards the intellectual level and the actual experience at the emotional level. This emotional experience can result in a personal change at a mental level; “a positive and powerful emotional response to a meaningful experience” [Tarssanen and Kylänen 2005].

3. Vuores Case Study: System Description

In light of the previous research on designing for in the wild embodied interactions discussed in the previous sections, this chapter describes the system design and gesture-based interactions of the Vuores case study: Energyland. It begins with a brief system overview leading to the software architecture followed by an in depth explanation of the interaction design, based on the human computer interaction guidelines mentioned in section 2.1.

The Energyland project was a collaboration between the Speech-based and Pervasive Interaction Group (SPI), in the Tampere Unit for Human Computer Interaction (TAUCHI) research center at the School Information Sciences, University of Tampere, and MUOVA Western Finland design center, which is a joint unit of Aalto University and the University of Vaasa in Finland, with Tekes – the Finnish funding agency for technology and innovation, as the funding partner. The SPI group worked on developing the systems and its interaction, implementation, setting up the installation and carrying out user studies, while MUOVA worked on the story, content and concepts of the installation. My contribution to the project included programming parts of the application namely the trash-sorting game and the lightning catching game.

The Energyland system was developed for providing ideas about future energy solutions in an entertaining way with the use of embodied interaction. One way to reduce energy consumption is by increasing awareness about possible conservation techniques. The Energyland system illustrates potential future domestic energy conservation possibilities. The system consisted of three rooms where each room has three tasks or interaction spots that users interact with using free-form body gestures. A user can identify how the system detected her gestures by means of an on-screen virtual shadow. The interaction spots are activated when a user's on-screen shadow steps in front of specific virtual objects upon which the system provides both verbal and textual instructions to guide the user to complete the task. Based on the user's input or gestures performed, the system responds with visual and audio feedback. If the task is completed successfully, the user collects energy points, which can be used for corresponding tasks.

The three rooms include a patio, a kitchen and an entertainment room. The patio shown in Figure 6 consists of a solar-powered grill, a Jacuzzi run by a water wheel and a wood chopping activity that controls the garden sprinkler to demonstrate alternate energy generating solutions.

The pink energy-piggy keeps an updated account of the total energy available for a specific room. Users are encouraged to generate more energy than they consume and to donate some of it, a subtle introduction to the concept of carbon-credits for individual households.

The kitchen reinforces the need to sort waste and recycle as a green practice, one that can earn users energy credits to cook a meal for themselves. Another interesting,

but slightly eccentric, option of catching a heavily charged lightning bolt through the kitchen window during a thunderstorm, also gives users energy credits to grow their own herbs. This is shown in Figure 7.

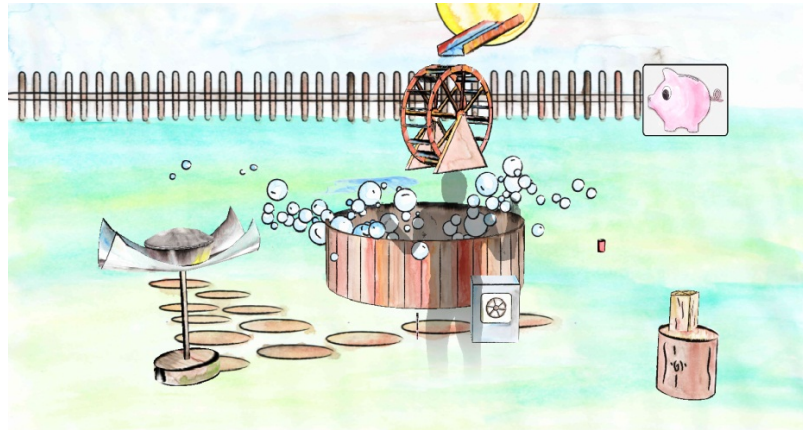


Figure 6: Patio

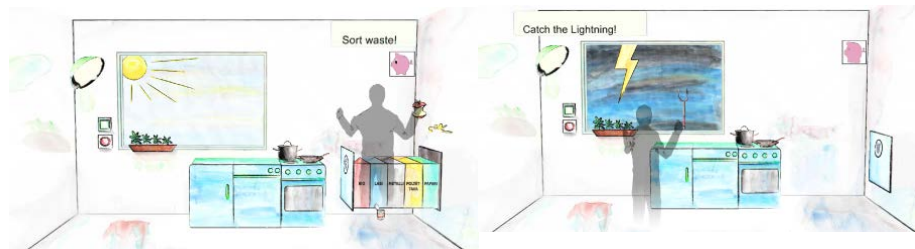


Figure 7: Trash Sorting Game and Lightning Catching Game

The third room, the entertainment room which uses a window as a multimedia screen display. To watch a video on the window-cum-entertainment screen, users can clap their hands to activate a windmill to produce energy. The figure below shows the entertainment room with a user's shadow at the windmill spot.

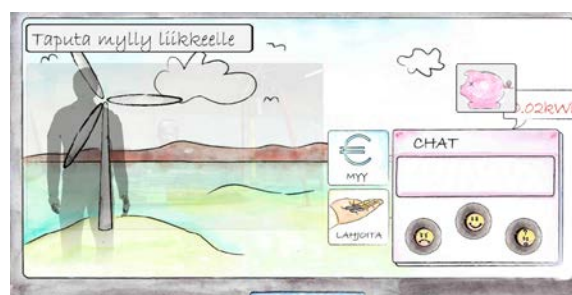


Figure 8: Entertainment room

This chapter describes the system architecture, each individual interaction and the audio-visual feedback of the Energyland system. Common terminology used in the explanations of interactions is listed in Table 1.

Table 1: Common Terminology

Term	Definition
Active Spot	An interaction spot that starts reacting to a user's gestures when the user is in close proximity of the spot's virtual object
Entry	Walking into an interaction spot in such way that the spot becomes active is referred to as entering a spot
Interaction spot	An interaction spot includes an energy-consuming object and a gesture-based solution to generate energy. Each room has 3 interaction spots (right, center and left) where the interaction is also affected by the current weather for some spots.
Skeleton Data	Spatial Data of the user's joints including right and left, hand and elbow joints
User Shadow	An on-screen 3D model of human shadow visible as part of the system (and not the user's actual shadow formed by standing in the way of the projector!) User activates or selects an object by placing her/ his onscreen-shadow on top of the object
User position	The user's center of mass (between the hips) position as recognized by the Kinect
Weather	The system operates under two weather conditions: sunny and thunder. It is controlled by an application called the WeatherMaster that starts along with the kitchen. The weather visuals include: <ul style="list-style-type: none"> a. sunshine (two different Sun positions in Patio) b. rain (Patio and Entertainment room) + thunder (audio) + lightning bolts (kitchen only)

3.1. System Architecture

The system consists of four processes: a Kinect service, a graphics engine, an audio engine and the actual core logic. Each of the three rooms have their own machines running a Kinect service, graphics engine and core logic whereas the audio engine is controlled by a master machine, which is decidedly the kitchen. The kitchen also controls the weather and each of the three rooms can request a weather change and lock or unlock the current weather to block a change, if a user is interacting with a weather-supported interaction spot. Changes in the weather are broadcasted to each of the rooms so that the weather is the same for all the rooms. The core logic is a Python based application that consists of an IOManager and spot objects. The core logic communicates with the Kinect service, graphics engine and the audio engine. The Kinect data is taken as the main input based on which messages are sent to the graphics engine and the audio engine via the IOManager. Thus, the active interaction spots communicate with their IOManager that sends out messages to the graphics and audio engines. This is shown in Figure 9.

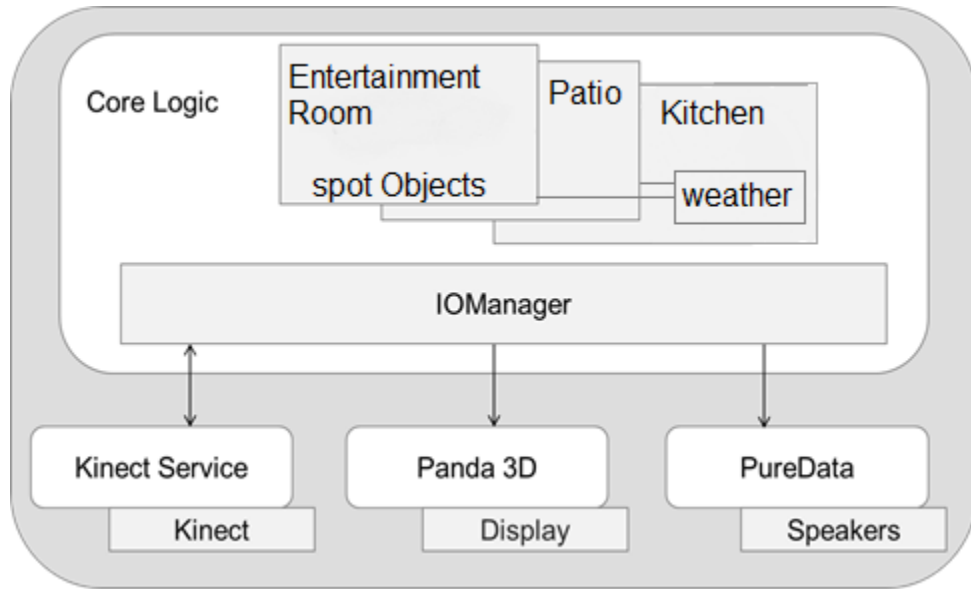


Figure 9: Software Architecture

The Kinect service is a thin client over the Microsoft Kinect SDK that is connected to via sockets and provides user information as 3D coordinates; x is the horizontal distance, y is the depth from the Kinect and z is the height. In principle, the Kinect tracks two user skeletons and one user location (no skeleton). A user skeleton comprises of twenty skeleton joints as shown in Figure 10. Each room has a Kinect device, and thus three users can simultaneously interact with two of them using free-form body gestures and one with center of mass or location information.



Figure 10: Skeleton Joints (adapted from Kinect HI Guidelines [2013])

The Panda 3D [2012] graphics engine is used to render both 2D images and 3D objects on the projected display. Messages are sent over sockets to control and animate these images. The audio engine is based on Pure Data [Pd, 2012] connected to a multi-channel audio card that drives six highly directional pan-phonics speakers and five regular speakers. Open Sound Control [OSC, 2012] messages are sent via the

IOManager, when a corresponding event is triggered in the core logic, and the audio engine decides the sound to generate and which speaker to play it on.

An interaction spot maps directly to a physical spot in 3D space where a user can interact with the system. An interaction spot is usually activated when a user enters the 3D space specified for the spot and deactivated when the user leaves. A user's on screen shadow is a special kind of spot that is active for any user in the vicinity of an interaction spot, remaining active for other interaction spots in the same room. Thus, for the user shadow, the entire room can be thought of as the interaction spot. The Kinect updates the user data information at 30 frames per second and this information is processed by the active interaction spots.

If there are three users interacting simultaneously in one room, the Kinect provides skeleton data for two users and only the position for the third user. Thus, for each interaction spot, there are two pre-defined interaction gestures for task completion. One gesture requires the user's skeleton data while the other gesture accommodates the scenario where only the user position is available.

3.2. Design and Layout

The Energyland system has three rooms representing rooms that are normally a part of a home: a Patio, a Kitchen and a Living-cum- Entertainment Room. For each room, the total energy available at any given time is represented by a pink energy piggy on the top right corner of the screen. This energy piggy has six levels as shown in Figure 11.

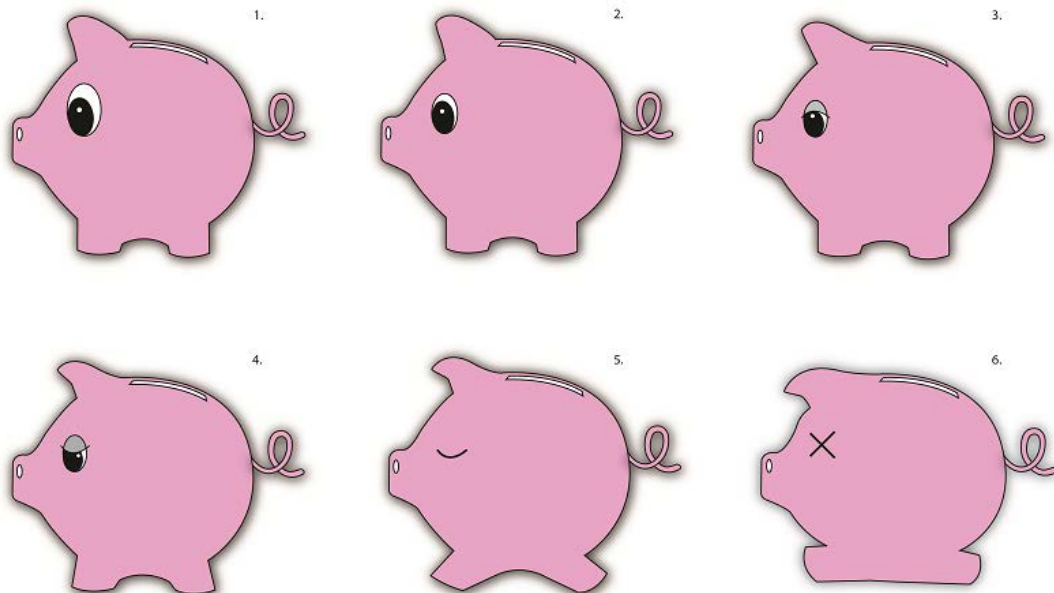


Figure 11: Six Levels of the energy piggy

The system sound scape consists of five different elements:

- speech synthesized instructions from directional Pan-phonics speakers,

- ambient sound including the wind and the weather from the 5.1 speaker system
- realistic sounds such as opening of the trash door as explained in subsequent subsections
- interaction sounds such as the energy piggy getting energy and plants growing
- generative background music.

Each instruction text pop-up is accompanied by verbal instructions that are directed towards the interaction spot by using the Pan-phonics speakers. The instructions were generated using Acapela text to speech [Acapela TTS, 2012] convertor in a female voice speaking Finnish. The kitchen controlled that main sounds such as the generative back ground music and the ambient sounds for the weather, which were common to all the rooms. The speech synthesized instructions were triggered by each interaction spot independently, as were the realistic sounds and interaction sounds.

Each room has three interaction spots that each have an energy consuming object and an energy generating task, which adds to or subtracts from the current energy piggy level. These energy points fly from the virtual object towards the energy piggy that jumps when points are added. The energy piggy pulsates by shrinking quickly and then growing back to the normal size when energy points are consumed. A ka-ching sound, such as a rattling piggy bank, accompanies the jumping and generation of energy while the piggy squeaks when points are deducted. For each of the interaction spot, their key ideas, interaction goals and audio-visual feedback is discussed in the subsequent subsections.

3.2.1. Patio

The Patio consists of a grill, jacuzzi and wood chopping interaction spots as shown in Figure 12. Each of the three interaction spots has its own story that presents the user with a problem and its solution when he/she enters the spot. The solution is a gesture based game that has a success scenario, i.e., it is executed correctly or then a failure scenario where the user is unable to perform the gesture or complete the game tasks. If the user walks out of the interaction spot, the spot is reset to its initial state, as it was before the user entered.

The grill has solar panels on its side that allow for solar-grilling, which requires the sun. If there is bad weather and it is raining, the grill cannot be used at all. The solar panels on the grill need to be aligned at a certain angle towards the sun to activate them and once aligned; there is enough energy to cook. The sun alternates between two pre-defined positions in the sky. The user entry, system sounds and interactive game tasks for the Grill are defined in Table 2. The game gestures are defined for both scenarios,

with user skeleton information and with only user location or position information from the Kinect.

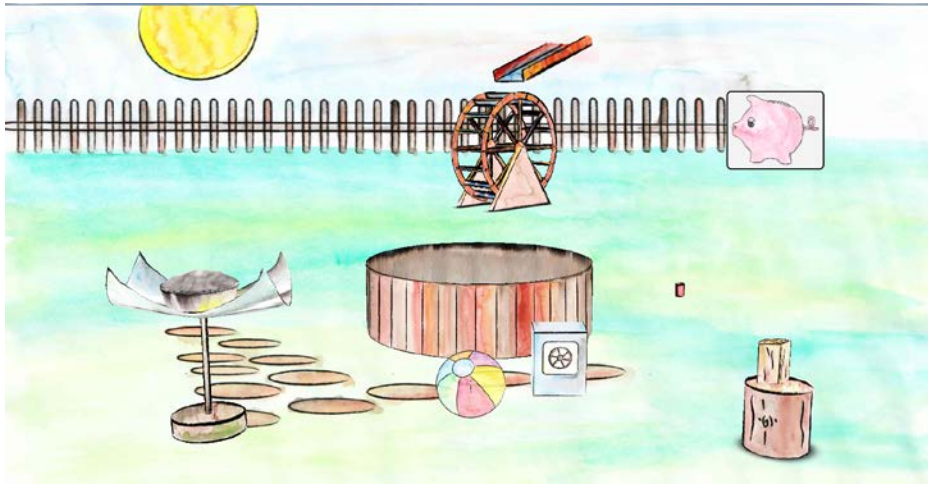


Figure 12: Patio Layout

Table 2: Grill Interaction spot

Weather	Sunny
Entry	A text pop-up and synthesized speech instructions inform the user that he/she needs energy to use the grill
Sounds	Aligning the solar grill produces a fire crackling sound and as the sausage is cooked, the sound gets more intense
Game Task	Grill's solar panels need to align towards the sun in the sky
Gesture with Skeleton	Alignment is achieved by moving the right arm horizontally from side to side (parallel to the ground)
Gesture with Position	Alignment is achieved by moving horizontally in the x-direction
Success	Once the grill is aligned to the sun, energy credits are sent to the piggy and a fork with a sausage appears in the user's right hand. It can be grilled by placing it directly above the open grill. The sausage cooks till smoke starts coming out of it
Failure	The user is unable to align the grill to the sun and thus no sausage appears
Weather	Rainy
Entry	a text pop-up explains how the grill cannot be used in the rain
Sounds	sounds of the rain
Game	no game can be played

The second interaction spot in the patio is the jacuzzi. The jacuzzi requires energy that can be generated by turning the waterwheel placed far behind it. The waterwheel is switched on by using the grey switch placed next to the Jacuzzi as shown in Figure 13.

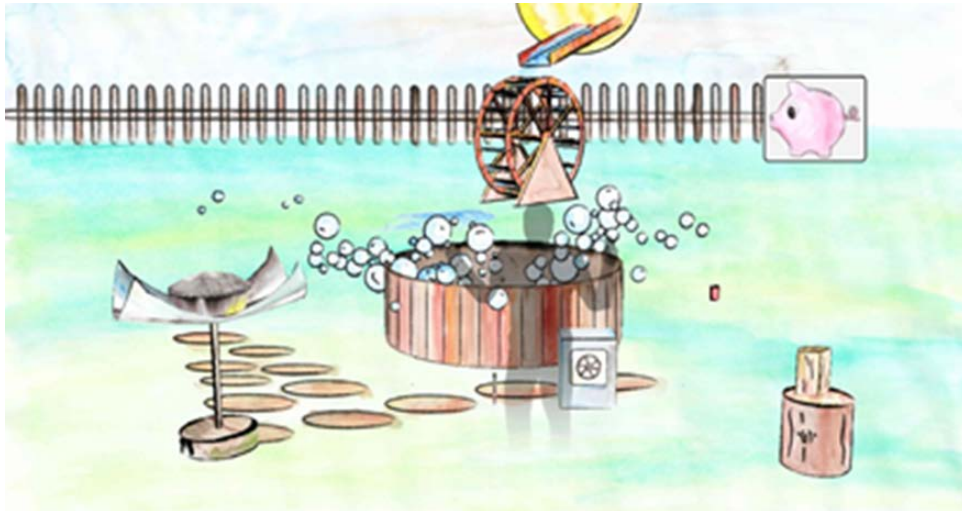


Figure 13: Jacuzzi with Bubbles

The interactions of the spot are defined in detail in Table 3. A selection is made by placing the left or right hand in front of the virtual object. If there is no user skeleton information from the Kinect, then the user needs to stand right in front of the virtual object to select it.

Table 3: Jacuzzi Interaction spot

Weather	Sunny and Rainy
Entry	A text pop-up and synthesized speech instructions inform the user that he/she needs energy from the waterwheel
Sounds	Selecting the Jacuzzi switch makes a click-type sound, the Jacuzzi bubbles affect the background music and make it more intense, the water wheel, when running, produces a water-splashing sound
Game Task	Switch on the waterwheel
Gesture with Skeleton	The waterwheel is switched on by selecting the switch besides it or by selecting the waterwheel itself using either the left or right hand
Gesture with Position	The user needs to stand in front of the switch to turn it on
Success	Once on, the waterwheel starts rolling and water fills the Jacuzzi, creating bubbles and energy credits are sent to the piggy. These bubbles can be moved around by waving ones hands, similar to playing with real bubbles
Failure	There are no bubbles and waterwheel is stationary

The third interaction spot is the wood chopping similar to the traditional chopping of a wooden log with an axe. By moving one's left or right arm in a swift chopping motion, towards the ground, a user is able to chop the wood that drives the water sprinkler placed nearby. Interaction details for the wood chopping spot are explained in Table 4.

Although not strictly an interaction spot, the patio also consists of a beach ball, which can be pushed or thrown-up by any user, accompanied by a ball-bouncing sound.

It moves around the patio and was mainly introduced for children though everyone was encouraged to play!

Table 4: Wood Chopping Interaction Spot

Weather	Sunny and Rainy
Entry	A text pop-up and synthesized speech instructions inform the user that he/she needs to chop the wood to get energy. An axe is attached to the user's hand
Sounds	Hitting the axe on the wood creates a wood-chopping sound and when the sprinklers are running they also make a gushing-water sound
Game Task	chop a log using the axe
Gesture with Skeleton	Once the axe is attached to the user's hand, the user needs to move his arm swiftly in a chopping motion
Gesture with Position	Once the axe is attached to the user's hand shadow, the user needs to jump up and down
Success	When the log breaks, the water sprinkler is activated and energy credits are sent to the piggy
Failure	The log does not break

3.2.2. Kitchen

The kitchen consists of three interaction zones; the kitchen window, all the appliances such as the fridge, dishwasher and stove and then the trash sorting bins. The kitchen with sunny weather is shown in Figure 14.

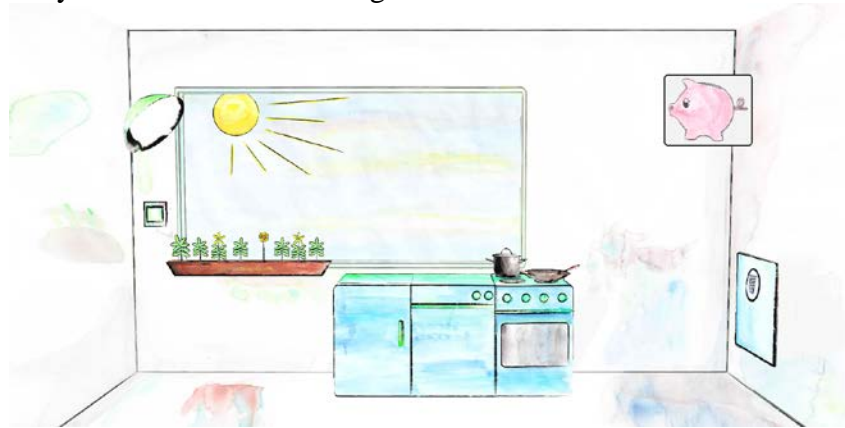


Figure 14: Kitchen when it's sunny

The kitchen window is equipped with solar panels that cover the window as window-blinds when activated. The energy from the solar panels lights up the lamp inside the kitchen, on the top left corner near the window. The window also houses a small array of potted herbs, which grow under the lamp light. When the weather is bad and there is thunder, the user can tap into the energy provided by lightning bolts for the indoor lamp. The user has a lightning-catching device to catch the lightning bolts that appear randomly for one to three seconds at a random location every one to five seconds in time, outside the window. A lightning bolt with the catching device is shown in Figure 15 and the interactions of the kitchen window are described in Table 5.

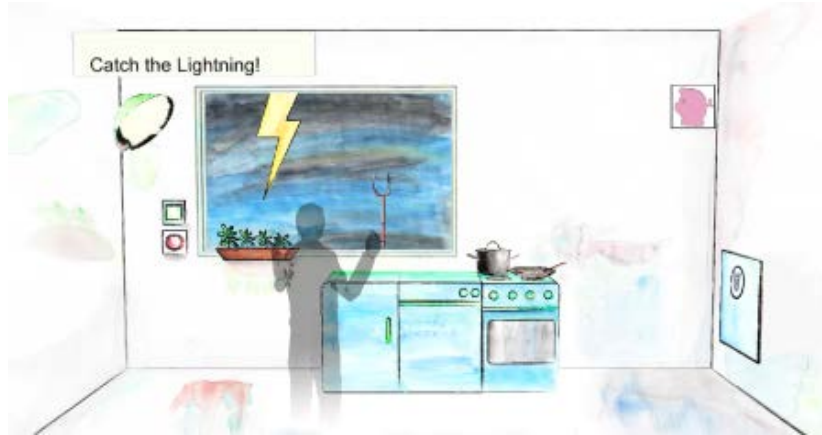
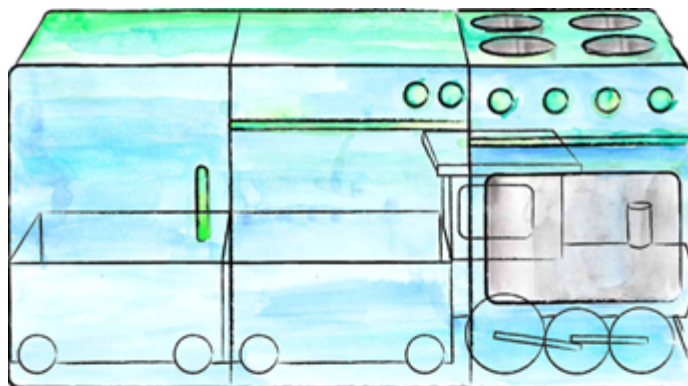


Figure 15: Kitchen when there's thunder

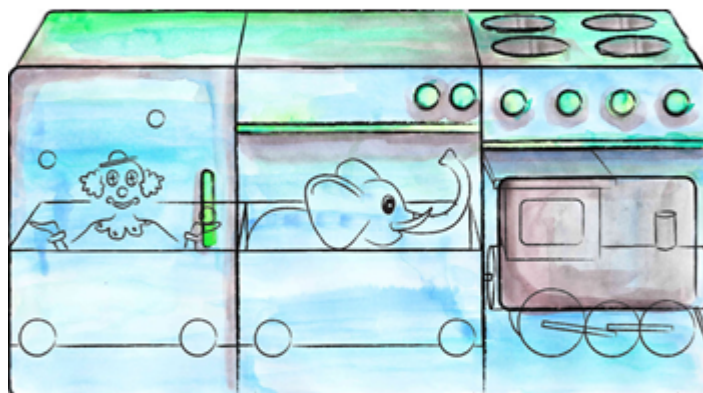
Table 5: Kitchen Interaction spot

Weather	Sunny
Entry	A text pop-up and synthesized speech instructions inform the user that he/she needs select the solar switch to power the lamp
Sounds	A humming sound of the lamp when it is on, music is played when the plants and herbs grow (background music becomes more intense), switching on solar panel switch makes a click sound
Game Task	Select the solar panel switch that flies to the middle of the window
Gesture with Skeleton	User's hand selects the solar panel switch and it goes back to its original location
Gesture with Position	User can select the solar panel switch by standing in front of it and it goes back to its original location
Success	The window is covered with blue solar panels, the lamp glows, the flowers grow and energy credits are sent to the epiggy.
Failure	Nothing happens, the switch goes back to its original location when the user exits the spot
Weather	Rainy
Entry	A text pop-up and synthesized speech instructions inform the user that he/she needs to catch a lightning a bolt
Sounds	Catching the lightning accompanies a buzz / zapping sound and thunder sound
Game	The user's lightning-catching device needs to select a flashing lightning-bolt
Gesture with Skeleton	The user needs to catch a lightning bolt using lightning-catching device attached to his right hand
Gesture with Position	The user needs to stand in front of the lightning bolt
Success	If it is the first bolt caught by the user after entering the spot, then the lamp glows, flowers grow, and energy credits are sent to the epiggy. For each successive catch, there is no change to the lamp or flowers
Failure	User is unable to catch the lightning, so the flowers do not grow

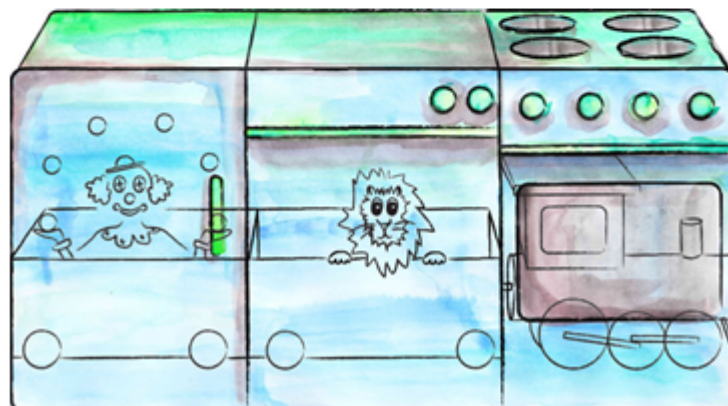
The interaction spot consisting of the fridge, dishwasher and stove are collectively called the coloring spot. They reveal hidden images on their surface when user's wave hands, similar to children using crayons in coloring books. The coloring spot is primarily meant for children and this was achieved by checking the height of the user and then only allowed children to color the spot. Based on the distance traversed by a user's right hand by waving, different images appear. There are three coloring levels on the fridge and dishwasher doors, while only two on the stove, as shown in Figure 16.



Level One of the Coloring Spot shows an empty train



Level Two of the coloring spot shows an elephant and clown



Level three of the coloring spot shows a lion and clown

Figure 16: Levels of Coloring Spot

When a user enters any of the three coloring spots, instructions are placed on the top-bar of the screen. The spot is not affected by the weather and cannot be played without the Kinect's skeleton information. It is possible that the user does not reveal any of the hidden images if he/she passes by quickly from the window to the trash sorting bins, without waving at the coloring spot. Coloring the stove/fridge/dishwasher creates a sweeping sound, the dishwasher sounds similar to a whirlwind and the background music becomes intense as coloring continues and hidden objects are revealed. The sound of bubbling water is heard when the user stands near the stove.

The trash sorting bins open up when a user enters the spot and trash items are shown around the bins, ready to be sorted. Users need to select a trash-item corresponding to the current trash-bin displayed. The bins change every three seconds from bio (for biowaste) -> lasi (glass waste) -> metalli (metallic waste) -> paperi (paper waste). Each item goes into one correct bin. Item selection is based on user's position when there is no skeleton data or by grabbing the object with right or left hand when skeleton information is available. The interaction details for the trash sorting task are described in Table 6.

Table 6: Trash Sorting Interaction spot

Weather	Sunny and Rainy
Entry	A text pop-up and synthesized speech instructions inform the user that he/she needs to sort the trash. A bin opens up from the wall closet and changes every three seconds
Sounds	The trash door opening and closing makes a suction-like sound, each item has its own distinct sound like the paper and the metallic-can crumple as they go into the right trash bin, the glass bottle makes a clunk sound
Game Task	Sort the trash-items by putting them in the correct bin
Gesture with Skeleton	Three items appear on top of the trash bins and are slowly moving down. They can be selected (maximum of one by each hand). Once selected, the item grows twice in size and is attached to the user's hand, moving with the user's hand till it is placed inside the right bin
Gesture with Position	Five items appear on top of the trash bins and can be selected based on the user's horizontal position and stays selected (twice in size) till the user moves away. All items stay lined up above the trash bin and once the right bin appears, the selected item is zapped inside
Success	Once all the items are sorted, the game-time is displayed and energy credits are sent to the epiggy
Failure	Items are not sorted and trash door closes without any energy credit updates

3.2.3. Entertainment Room

The entertainment room consists of a windmill, a sell-or-donate spot and a feedback spot as shown in Figure 17.

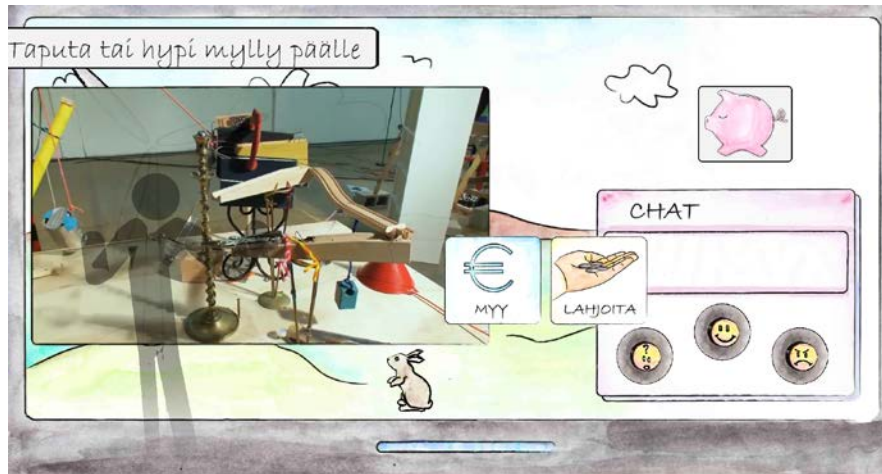


Figure 17: Entertainment Room

The windmill is activated only when the video on the window-com-screen fades out and there is not enough energy, as shown in Figure 18.

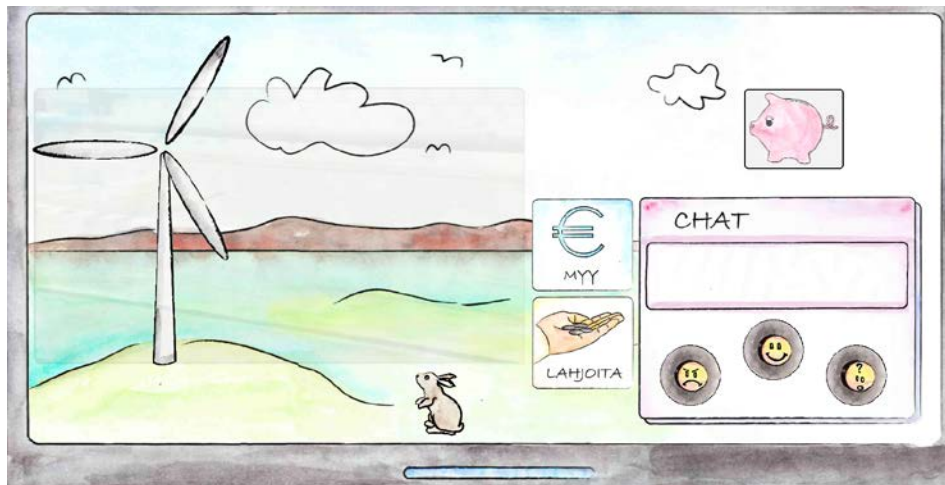


Figure 18: Entertainment Room without video

Energy is generated by either jumping up and down or by clapping. When there is energy, the windmill does not react to the user's gestures. Watching the video also consumes energy, thus the user needs to generate energy periodically to watch the full video. The windmill interactions are explained in Table 7.

The sell or donate interaction spot asks a user to either sell or donate the energy credits of the entertainment room. The sell and donate buttons are selected based on similar selection rules as in other spots, by placing the left or right hand in front of the button or then by standing right in front of the button if there is only user position information available. In addition, there is a minimum duration of one second for which the selection must be made and the button makes a clicking sound at the end of it. When a user enters the spot, a text pop-up informs the user he can sell or donate the energy (two points at a time) or if there is no energy in the piggy, a message stating that there is no energy to donate or sell is shown.

Table 7: Windmill Interaction spot

Weather	Sunny and Rainy
Entry	A text pop-up and synthesized speech instructions inform the user that he/she needs to jump or clap
Sounds	The windmill's fan makes a rotating sound as it runs, when the video played on the window-cum-screen it affects the background music
Game Task	To jump or clap to produce energy to watch the video on the window-cum-screen
Gesture with Skeleton	Clapping: the windmill works by measuring the distance traversed by both the hands when clapping
Gesture with Position	Jumping: distance traversed in the vertical position is measured, so jumping up and down rotates the windmill
Success	Either by jumping or clapping, the user is able to produce energy to watch the video and energy credits are sent to the piggy
Failure	The room runs out of energy and so the video fades out

The feedback spot is the final interaction spot of the installation and setup such that users are able to provide feedback on how they felt while interacting with the system, which is saved in the system logs. There are three feedback options, negative, positive or unsure and a button needs to be selected for two seconds as shown in Figure 19. When a button is selected a visible moving timer is shown around the smileys and a tick-tick sound is started, which stops either when a selection is made or if the user moves her/his hand away to deselect the current option. Based on the user's feedback, text appears on the chat window space. As mentioned previously, selection is also possible by user position when the Kinect skeleton data is not available, in which case the button needs to be held for five seconds to trigger a selection.

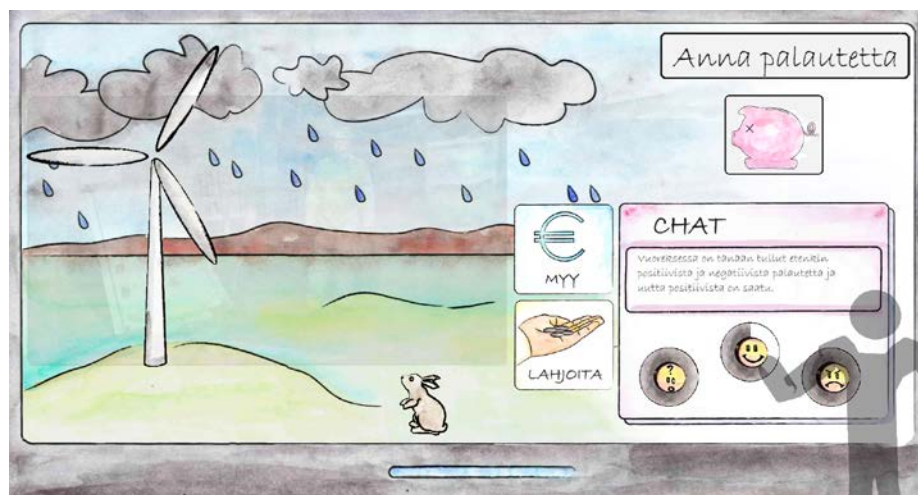


Figure 19: Entertainment room feedback spot

The gesture-based tasks for the interaction spots, as described for all three rooms above, adhere to the interaction design guidelines discussed in section 2.1. The gestures are consistent, minimalistic and ergonomically possible as described in section 2.1

(guidelines 4, 5, 8). Gestures for wood chopping and object selection are based on real world metaphors (guideline 2). The overall system allows users to control how they navigate the rooms, refer to guideline 7. As each room consists of smaller more flexible interaction spots, users can easily skip the tasks that are difficult for them (guideline 3).

The next section describes the installation space at the housing fair, the evaluation procedure and the results obtained from the evaluations.

4. Vuores Case Study: Evaluation Procedure and Results

The system was part of the Tekes Smart House installations at the annual Housing Fair, Asuntomessut 2012 at Vuores, Tampere. The entire tent was 20 meters by 20 meters and the Energyland system was installed in a 7m x 5m space inside the tent as shown in Figure 20. It was setup for eight hours a day for one month, from the 13th of July till the 12th of August.



Figure 20: Bird's eye view of the Tekes tent (adapted from Tekes [2012])

4.1. Vuores Installation

The installation at Vuores consisted of three large screens arranged along the length of the wall the Tekes tent. The middle screen, which was the Kitchen, was placed flat alongside the wall while the screens on the left and the right were slightly tilted towards the center of the space, in order to fit all the screens along the length of the wall as shown in Figure 21. This did result in a slight overlapping of the Kinect's field of vision between the wood chopping and kitchen window, and between the trash sorting and the windmill, although no significant problems were noted or mentioned for either.



Figure 21: Vuores Screen Layout

Three poles on the opposite wall held a projector each, one for each room. To have the Kinect run effectively, dark curtains were used to cover the ceiling of the tent

right above the setup. The floor was marked with printed light bulb stickers indicating the interaction points. The Pan-phonics speakers were placed above the patio and entertainment rooms, in sets of three. The 5.1 speaker system used for the ambient surrounding sound speakers was spread out and placed below the kitchen and under the projectors. The installation layout is shown in Figure 22.



Figure 22: Setting up the Installation at Vuores

4.2. Procedure

As the installation was part of a housing fair, visitors were expected to be open and excited about new ideas and demonstrations. Participants for EnergyLand were visitors that stopped by the installation as they went around the Tekes tent, who were encouraged to try it out. In most cases, casual observers were given a demonstration by the researcher present, especially if they showed some reluctance to interact but still seemed curious about the system.

The participants were allowed to interact with the system by themselves without any time restriction or any pre-defined tasks. A researcher was present at all time to assist the participants and answer any questions they might have. The entire testing scenario was more attuned to how people would expect to be introduced to a new ‘product’ at a fair. There were seven researchers in all, taking individual turns at the installation.

Researchers observed that visitors would walk in by themselves and start to interact if there was no one present near the installation. In such a scenario, the researcher would come in later when the participant required some guidance or was about to leave, and asked him/her to fill in the questionnaire.

The researcher present at the site also explained the system, interacted freely with the participants and wrote down any verbal feedback provided by the participants.

Participants who interacted with at least one interaction spot were asked to provide their experiences with a questionnaire and some short interviews. Participation, answering the questionnaires and subsequent interviews were all voluntary, and thus consequently only a fraction of visitors and participants filled in the questionnaires.

The system collected logs about spot interactions and successful task completion but there were no video or audio recordings of user interaction or interviews. The researchers were provided with an instruction manual (refer to Appendix 1: Energyland Instruction Manual) to help them start and shut down the system, and an Quick Interaction guide (Appendix 2) to learn how each of the interaction spot worked.

4.3. Data Collection

Data collection consisted of questionnaires, interviews and system logs. The researcher present at the venue also wrote down verbal feedback that he/she received from the users. These methods are discussed in detail below:

Questionnaires

Users were asked to fill in an anonymous questionnaire after they interacted with at least with one interaction spot. The original questionnaire based on the Experience Pyramid [Tarssanen and Kylänen, 2005] is in Finnish (refer to Appendix 3). The corresponding English statements are mentioned in Table 8.

Table 8: Questionnaire statements

Element of experience	Negative statement	Positive statement
Individuality	The application/system is not special – there are similar systems elsewhere also.	The program is unique – there are not similar systems elsewhere.
Authenticity	The application is artificial and incredible.	The application is genuine and credible.
Story	There is no story in the application – it lacks a “common thread”.	There is a story in the application, a “common thread”.
Contrast	The application does not provide me anything new or different from everyday life.	The application is something new and different from everyday life to me.
Interaction	I do not control the application.	I control the application.
Sound	I did not experience the soundscape of the application as aesthetic.	I experienced the soundscape of the application as aesthetic.
Pleasantness	Using the application was unpleasant.	Using the application was pleasant.
Future Use	I would not like to use the application in the future.	I would like to use the application in the future.

The statements were evaluated with bipolar differential on a seven point scale where the negative statement was on the left and the positive statement on the right hand side.

Users also filled in background information namely their age, gender and how often they used gesture-based applications (e.g. Nintendo Wii, Microsoft Kinect or Playstation Move? where 1 = daily (*päivittäin*), 2 = weekly (*viikoittain*), 3 = monthly (*kuukausittain*), 4 = less than monthly (*harvemmin kuin kuukausittain*) and 5 = I do not use at all (*en käytä lainkaan*).

System Logs

System logs consisted of logging user's entry and exit from an interaction spot, successful task completions, energy credits obtained or spent by a user and error logs. These logs provide a mechanism to calculate a crude success rate of the task by dividing the number of successful task completion by the total number of interaction spot entries.

Interviews

Users were informally interviewed by the researcher present at the installation. User comments and verbal feedback was noted down by the researcher present. After the housing fair was over, all of the seven researchers were also interviewed based on their own experience with the system, their interaction with the users and their observation of user behavior and interaction (refer to Appendix 4: Vuores Researcher Interview).

4.4. Participants

The installation was a part of the Tekes smart house initiative, so visitors to the Tekes tent would also generally cruise by the Energyland installation. Some of them would stop to look at the system while others moved on. If someone did not start using the system immediately, the researcher present started talking to him/her and demoing the system, encouraging him/her to also interact freely.

There were a total of 193 users that willingly answered the questionnaire, the actual number of users is assumed to be much higher but was not tallied. Of those 193, there were 90 Females and 101 Males (2 users did not answer) aged 4-74 years (Mean age of 35.38 years, SD= 14.61). Figure 23 shows the distribution of the age groups.

The biggest group of users were from the 26-35 years age group (28%) and of users were aged between 36-50 years (24%). There were also 36 users over 50 years of age comprising 19% of the total users.

Users also filled in how frequently they use gesture-based systems, such as the Nintendo Wii, Microsoft Kinect or Playstation Move (Mean 3.778). As can be seen from Figure 24, unsurprisingly a majority of users had little (used such a system less than once a month 36%) or no experience (31%) with gesture-based systems.

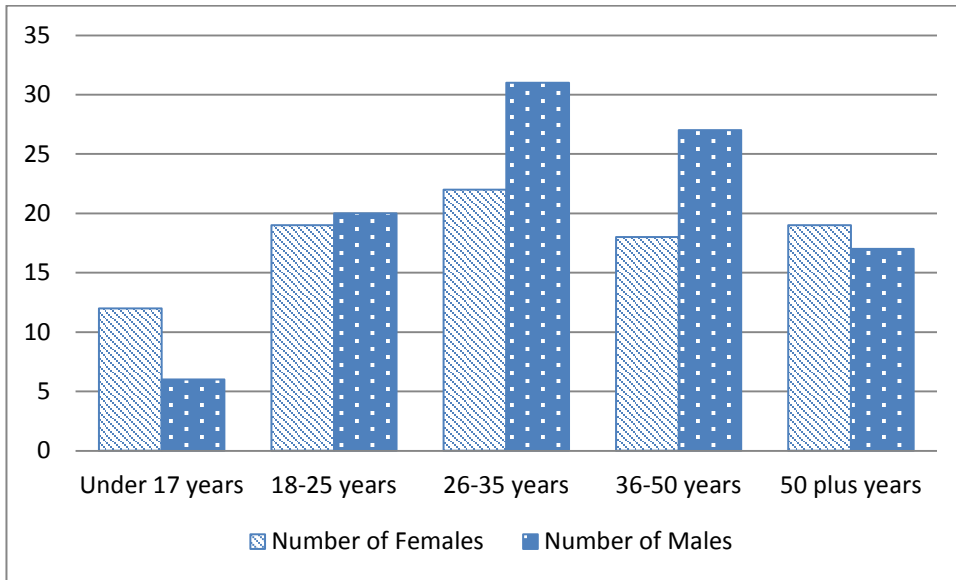


Figure 23: Number of users by age group

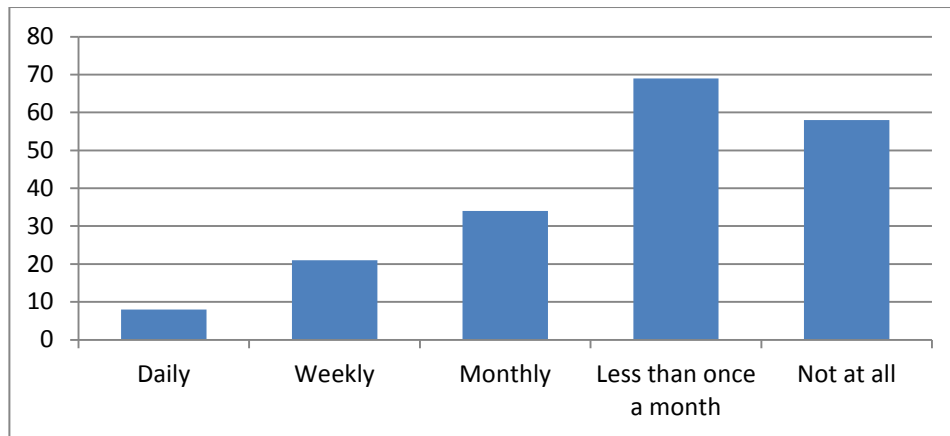


Figure 24: Number of users by frequency of use

4.5. Questionnaire

The system was very well received by the users as evident from the user ratings for the seven elements of experience in the questionnaire. The story, contrast and pleasantness were rated the highest (mean > 5.0) while all of them are above 4.45 (mean) on a seven point bipolar scale, as shown in Figure 25.

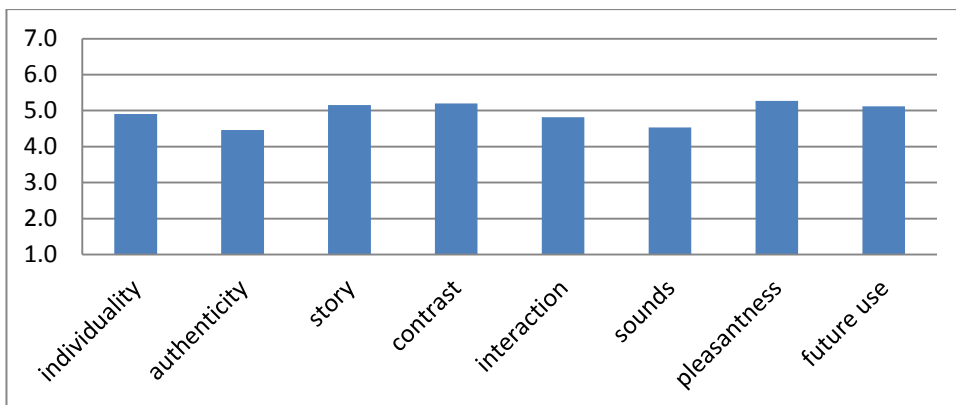


Figure 25: Mean ratings of the elements of experience

One of the reasons, as mentioned by a few users, is that users did not expect to see this type of a system at a housing fair making it novel and exciting. As also seen in Figure 25, most users had a very positive outlook towards using similar systems in the future.

Of the 191 users that gave us gender information, 47% were females and the rest male. There is no considerable difference in the way gender affected the system experience based on the ratings.

Based on the age wise comparison of user ratings, there is significance difference in the way that under 14 years old and above 50 year olds' expressed their attitude towards the system with respect to pleasantness and future use as opposed to the other age groups. The highly positive attitude of the under 14 years old does seem to depend on previous gesture-based experience as usage of gesture based system as their average was 3.08 or once a month while for 50 years and above it was 4.28 or less than once a month. Furthermore, a closer look at the mean ratings by frequency of system use reveals that increased exposure or usage of similar systems did not affect the ratings or show any sort of discernible trends as seen in Figure 26.

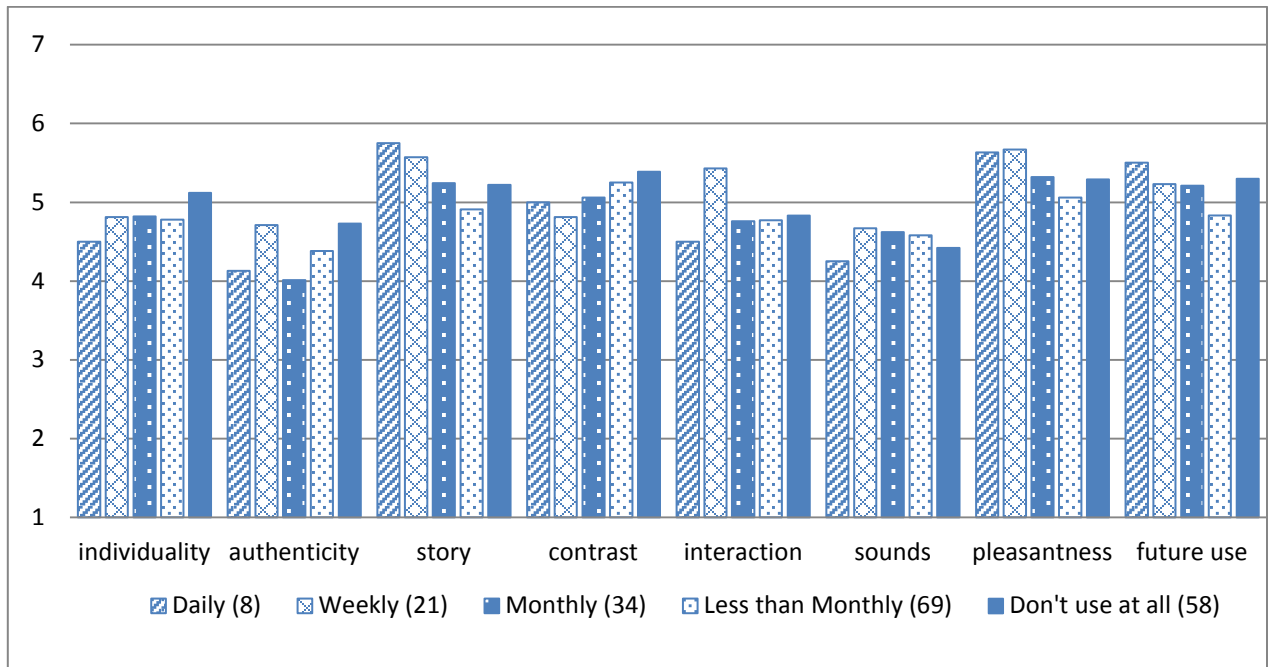


Figure 26: Mean rating by frequency of use

Additionally, by further exploring the relationship between different elements within the questionnaire using Spearman's rho, several statically significant correlations were found, namely at level $p = 0.01$ with $r > 0.3$. There was correlation between authenticity and the other six elements. There was also a high correlation between individuality and contrast ($r = 0.440$) and between story and pleasantness ($r = 0.380$). Future use and pleasantness ($r=0.618$, $p=0.001$) had the strongest statistically significant correlation. Future use also correlated with authenticity ($r=0.523$, $p=0.001$) and

individuality ($r=0.433$, $p=0.001$). There were slight statistically significant positive correlations with the background variable age where, the older users rated authenticity, contrast and interaction higher and unsurprisingly also had less experience of using gesture-based systems.

4.6. System Logs

The system logs collected information for each interaction spot, mainly the number of times it was activated, i.e. a user stepped into the interaction space, and also the number of times a user successfully completed a task and obtained energy credits. These are summed up in Table 9. These logs include details for the users and also the researchers who demoed the system or played with certain tasks as they spent their entire day at the installation. For the demos, researchers would start from an interaction spot in the patio or then the kitchen window making their way towards the entertainment room. Several researchers also sometimes repeatedly played their favorite games, namely the wood chopping, windmill, lightning catching game and trash sorting as they spent their day at the installation site. Based on the researcher interviews, there are no discernible trends for researchers' spot activations and thus the frequency of spot activation for that one researcher present every day can be assumed to be comparable to the user trails.

Table 9: System logs

Room	Spot ID	Activated	Task completed	Comments
Patio	Solar Grill	8279	1163	Low success rate of 15%
Patio	Jacuzzi	8748	7322	Success rate of 84%
Patio	Wood Chopping	7331	14269	High success rate of 190% implies that users would on average chop the wood twice.
Patio	Beach Ball	8710	NA	Beach ball had no task
Kitchen	Window	8043	1213 3193	Solar Cell switched on Lightning bolt caught
Kitchen	Trash Sorting	4969	710	Low success rate of 15%
Entertainment room	Windmill	6632	15398	High success rate of 232% implies that users would on average collect energy more than two times per trial.
Entertainment room	Sell Donate	6500	1575	For all other cases, there was not enough energy to sell or donate
Entertainment room	Feedback	3504	1811	Success rate of 51%

Several interaction spots, such as the wood chopping, catching the lightning and the windmill, allowed for multiple task attempts in one active session while other tasks were possible only once in an interactive session. Based on this, it can be seen that users tried the wood chopping and windmill multiple times in one active session, while this cannot be concluded for the lightning. It can be concurred that the wood chopping was one of the most favored interaction spot while the solar grill and trash sorting were the least favorite.

From the table, it can be seen that the Patio has the most number of interactions, which can be attributed to its position at the entry of the installation and also to the presence of the wood chopping that was highly popular among the users and the researchers as seen by its success rate. Interaction spot entries, i.e., number of times an interaction spot was activated by user entry, as a percentage of total attempts are shown in Figure 27.

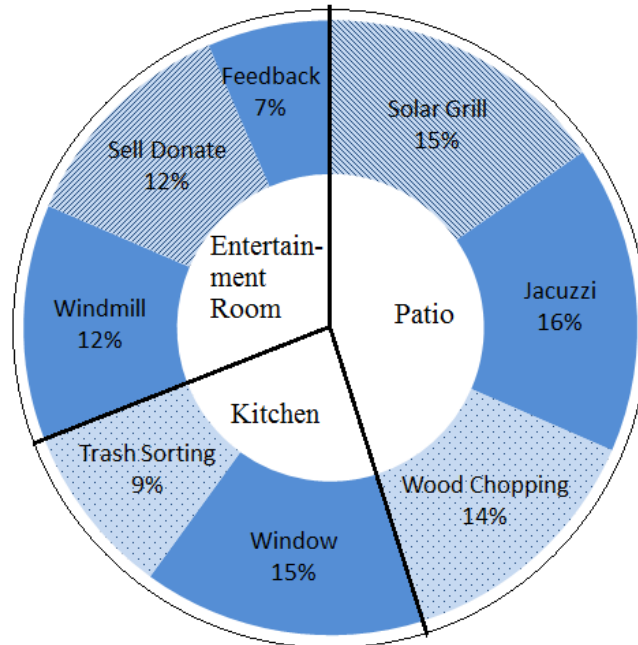


Figure 27: Interaction Spot entries as a percentage of total entries

As the beach ball and coloring interaction spot were meant primarily for children, they have not been included in the chart. As can be observed from the chart, the further away a room, the less likely it seems to be explored by a user. Although, there are additional factors such as the ease and popularity of a task in a room, its system performance and gesture design, the location of the room from the entry is also a plausible contributor. This can be deduced by comparing the windmill to the solar grill, both being the first interaction spot of their respective rooms. The solar grill task was considered quite difficult while the windmill was one of the most popular interaction spots, yet the solar grill has far more attempts than the windmill, this can attributed to

the location of the solar grill as being the first interaction spots to the installation while the windmill was located further inside the room-like space.

4.7. User Interviews

Users who volunteered to answer the questionnaire were also informally requested for an interview by the researcher present at the installation. User comments and ideas shared during system interaction or discussions with a researcher were noted down. User interviews, and also comments and ideas were all expressed and noted down in Finnish, and later translated, in essence and not verbatim, into English. Users were asked the following questions informally (as translated from Finnish):

- What are your thoughts on using the application? Was there something particularly nice, fun, hard or annoying?
- Which room (patio, kitchen or entertainment room) did you like the most and why?
- What do you think is the purpose of the application?
- Do you have comments, suggestions or feedback about the application or interaction?

Notes from the 16 user interviews and a few dozen individual user comments convey that most users, especially the children, enjoyed playing with the system, more specifically the wood chopping, the windmill and catching the lightning with the special fork-like instrument, as also evident from the system logs in the previous section. Users also expressed their delight over the visuals and ambient generative music. The colorfulness and had playfulness of the installation worked very well for the users who found the system enjoyable and pleasurable and expressed interaction with the system, as evident from a user who exclaimed, “the best part of the day because of the fun value, even though they have no practical experience with such systems, but at the fair it was delightful for the visitors”.

Some users felt the need for more specific instructions and help. As a user mentioned, “it would be nice if instructions should be repeated and are clearly displayed at all times. Instructions must also be clear. In fact, I did not figure out where the fridge is, let alone how to color it”. The fact that users did not expect such a system at a housing fair aggravated the interaction blindness although it also added an element of surprise, which was more positively received as exclaimed by a user, “what a great experience at the Housing Fair! Need more of such systems”.

Some visitors with children preferred to leave their children at the installation thinking of it to be more of a play area as one user mentions that “it is a good time-pass for children”, while another stated that “it is suitable for the little ones who might be more familiar with the Kinect anyway [and that the system] should be in a playground for children”.

Some users thought the system was touch based and they found it difficult to identify with their virtual shadow. The number of such users was limited and they were usually able to use the system after a brief demonstration by the researcher present. A few users mentioned that they experienced a lag between their gesture and the onscreen shadow's response, as stated by a user, "the idea is good, but the character has too big a delay". The lag was of the order of half a second and might have affected the user experience.

A user also noted that "the system was apparently confined in too little space or then gesture response was weak. The space does not inspire or invite people". This was echoed by several other users and also the researchers as mentioned in the next section.

The most positive responses were gathered by professionals in the education or health care domain. Many of them mentioned the potential of using such a system for education, rehabilitation and the elderly. One of the teachers mentioned that she "works in elementary childhood education, in training and practical nursing of student. This application can be a great way for children to learn and experience something new". She also mentioned that "the windmill operated by clapping and the subsequent rotation of the blades can be used in the development of motor skills of children with special needs". Another user mentioned how "using gestures to operate house switches can be of great benefit for the elderly". Overall, the system was well received by the users though they faced certain challenges during their interaction.

4.8. Researcher Interviews

There were seven researchers in all; each one spent about four to five days individually at the installation. Thus, at any given day, only one researcher was present in the Tekes tent. Researcher profiles are presented in Table 10 below:

Table 10: Researcher profiles

Researcher	Age	Gender	Days spent
R1	25	Female	4
R2	25	Male	4
R3	28	Male	5
R4	32	Male	6
R5	26	Male	4
R6	24	Male	5
R7	28	Male	3

Researchers demoed the system, guided the users and had an open dialog with them. Researchers were later asked about their experience with the system, their experience with the users and their observations of the users in a semi-structured

interview in English (refer to Appendix 4: Vuores Researcher Interview) which were recorded. The recordings were later analysed for common themes and ideas that researchers mentioned. They were also encouraged to mention anything they found particularly interesting regarding their experience at the Housing Fair. From these interviews several common themes emerged regarding what worked and what did not. All the researchers unanimously agreed that the wood chopping was the most popular among users, also seen from the system logs in Table 9, especially children who would *play* it repeatedly, sometimes for as long as ten to fifteen minutes. The windmill was a close second, but many users did not enter so far into the installation to interact in the Entertainment room, as one researcher mentioned that “people tried the first few spots closest to the door and didn't quite use the windmill. They felt cornered if they went behind me and didn't want to go to a corner, [so they] stayed in the doorway” [R2]. Due to the nature of the installation space, most researchers remarked that the entry was similar to a doorway to a room instead of an open space, “people stayed for varying amounts of time, but most people saw the door and left” [R4].

Researchers also noticed that some people were hesitant to interact if there were others present at the installation; “people would interact when no one was there and leave the when researcher arrived” [R6] but “children liked the system most and were interested [in interacting] and also younger people [aged between] 20-22, even 30 years, had the courage to try to do something while the older people kept looking and didn't try it out. They didn't want to wave their hands in public” [R2]. These behaviors are akin to the social complexities introduced by interaction in public spaces where a user feel like a performer and takes on the added burden of an actor as well as being a user of an unfamiliar system. As observed by one of the researchers, “people didn't want to socialize and also because it was a housing fair” they were expecting to be demoed to rather than interacting themselves [R6]. However, these social norms were much more relaxed when interacting in a “group, as people [took] turns and enjoyed it the best when they got to do it together, like parents with their kids” [R5].

Several people did not realize that the system afforded interaction as “lots of the people walked through the points listening to the system but not knowing that they could interact with it. There were no instructions” [R5]. Some of the users believed that the stickers on the floor were interactive “because the system looks quite cool with stickers on the floor that felt interactive, but then [user were] little bit disappointed when [the stickers] didn't work” [R1]. As echoed by R3, “people lost interest when things didn't work, or they couldn't figure something out, they would complain or lose interest”. People also required constant encouragement to interact and most users preferred to see a demonstration of the system “people were able to chop the wood on their own and catch the lightning by mistake, but to have the users interact more, they

had to be constantly encouraged, but I think that they didn't listen to the verbal instructions at all" [R3].

"People saw potential in gesture based systems for their own work or experience, like for old people to wave their hands and control house hold appliances" [R2]. A teacher mentioned "using such systems for education and in schools", a doctor working with the elderly exclaimed its usefulness "in a house with the elderly if they fall down or can't get up and to get some quick help", and a young teenage a girl suggested "virtual shopping on stores" [R4]. R7 states that the "tech savvy users wanted to know technical details" about the system while "some people who had never seen the Kinect before, felt [very excited that] this can be done" [R1]. Thus, many users could relate to the system and its technology, and found interacting with the system as a positive experience, as is also seen with the high user ratings of the experience questionnaire in Figure 25 . The results of the researcher interviews can be summed as:

What worked

- Wood chopping, windmill, catching lightning (although accidently sometimes)
- Giving demos, explaining the system, encouraging the user
- Animation: visuals and sounds, generative Ambient Music
- Playful and fun for children: beach ball, coloring on the fridge
- Element of surprise: a novel concept, unexpected at a housing Fair

What was challenging

- Affordances: showing that the systems uses gestures, synthesized-speech instructions playing simultaneously confused the users
- False Affordances: stickers on the floor suggested a mode of interaction via pressure sensors that was not present
- Embodied feedback: there was lag between user's movement and the onscreen shadow
- Reducing performative interaction: users could not take a step back and simply merge into the crowd; they had to walk across the room to exit the installation.

5. Design Guidelines for In-the-Wild Interaction

Researcher interviews and system logs provided valuable insight into interactive public displays as experienced in the wild. Several common themes, in tune with previous studies of large interactive display, were mentioned by the researchers to describe user behavior and user experience. These themes and ideas can be summed up as a list of *Dos and Don'ts*, outlining what worked well and what requires further attention, as explained in subsequent subsections.

5.1. Interactions based on Real World Metaphors

As stated by Nielsen [1994], real world object understanding can be used to guide interaction with virtual objects in a way that is both comfortable and easy for the user to learn. Such natural and intuitive real to virtual object mappings also assist in reducing interaction inertia or, reluctance to interact with an unknown and unfamiliar system. However, a certain level of ambiguity is required to entice excitement and support exploration from an otherwise familiar and known system [Vogel and Balakrishnan, 2004]. Thus, it is essential to find the balance between the two to encourage users to interact by providing familiarity and keeping them interested by allowing for further exploration of the unknown space. This balance was seen in the Energyland installation. The wood chopping and beach ball interaction spots were observed to be a clear favorite of the users as they had a straight forward mapping with their real world objects. As stated by R1, “the wood chopping encouraged users the most”. As it was more natural and intuitive for users who were all new to this system, including those who had no previous experience with gesture based systems. The windmill interaction spot was also quite popular, although it had a slightly more abstract relationship, but clapping to charge the windmill worked just as well because clapping is a common gesture, in fact one of the first few things we learn as babies. For users who were able to spend more time at the installation, the kitchen window interaction spot that required one to catch a lightning bolt and the solar grill interaction spot that required users to wave their arms to align the grill towards the sun, were both examples of more novel interaction ideas that required a certain degree of exploration. As experienced by R5, “the grill was difficult: I never quite got how to spin it around and most people got it to the right position accidentally.” Since users were not explicitly interviewed about their favorite interaction spot and the data is based on the system logs and researcher interviews, it can be said that further research is required to understand the interplay between familiarity and novelty, and how to find the fine balance between them for providing a richer user experience and participation for in the wild public display systems aiming to entertain and educate without the need for regulated interaction.

5.2. Support for Fight or Flight Reaction

Brignull and Rogers [2003] state that the duration, purpose, actions and contemplated experience of an interaction help overcome a user's initial reluctance to interact with large displays in public spaces. Additionally, they mention that a safe exit option should be available to the users, to support a user's inherent feeling of vulnerability towards the unknown [Klemmer et al., 2006]. Attuned to this effect, researchers observed that many users would normally interact with the first screen, which was the patio and then leave. A few of them also mentioned that they felt this reluctance from the user to 'step-inside' the installation area to interact with the system. This can be attributed to the layout of the installation, which created a room-like interaction space where users had to enter into the space to interact in the kitchen and entertainment room. It seems plausible that a lot of the people adhered to their primitive instinct to avoid such uncommon situations and preferred to have a quick and safe exit option, as was available from the patio. As explained by a researcher, "people did not get to watch the system or feel comfortable, such as in a clothing store when one wants to just browse, and a store clerks approaches them: there is a 'commit or run away' reaction. [In Vuores] there was no empty space for the users to escape to. They were confined in the space and very visible" [R7]. As also seen by the system logs in section 4.6, there were far more interactions in the patio than the other two rooms, although these numbers also include the researchers attempts at the interactions while they spent their day at the installation, it can still be suggested that the patio was favored over the other rooms based on its proximity to the entrance/exit and the popularity of the wood chopping interaction spot. Future gesture based interaction systems need to provide for and support a safe escape route for users to reduce the anxiety of being trapped into the unknown. "The place should be set up in a way that users could go closer without having to interact, go closer and observe and then go only one meter to interact because [in the Energyland system,] they are so far away and they think that it would be nice but they have to walk three meters [to initiate interaction]" [R1].

5.3. Encouraging Performative Interactions

People take on social roles such as of an actor or performer when interacting with large public displays where there is an audience [Brignull and Rogers, 2003; Perry et al., 2010]. Thus, there is an inherent shyness or reluctance to interact, especially using explicit gestures, to avoid looking silly or stupid in public. As observed by the researchers present in Vuores, people passing by the installation in the Tekes tent were also shy and reluctant to interact with the system; "people would rather watch someone else demo than try it out" [R6]. The researchers would need to encourage and demonstrate the system for users to feel confident to follow. Exceptions to this behavior were children and younger tech-savvy people in groups, who were more comfortable

exploring and venturing out on their own because of unformed social inhibitions in case of children or then to stand out and perform in case of younger groups. Because of the fun and interactive nature of the installation, uncommon at a housing fair that is meant more for adults; a lot of the parents thought the installation was a play-area for children and would let their children interact, or “sent kids to go wild” [R7] with the system while they watched from the side. Children could run around freely and were excited about the wood chopping and the windmill interaction spots, probably due to the expressive nature of the gestures such as swinging an axe or jumping and clapping. Younger tech-savvy adults in groups also showed a willingness to explore [R7] and interact with the installation, probably due to the group’s social dynamics [Perry et al., 2010]. On the whole, gesture based interaction demands explicit user actions that can work well to support interaction depending on the audience. There is a certain safety and comfort in numbers as evident by *collaborative interaction* where “group members encourage each other to interact”, especially with children who display low social inhibitions and also provide a “proxy and warranted interaction” for their parents as observed by the WaveWindow [Perry et al., 2010].

5.4. Enabling Honeypot Effect

The social affordance of passerby’s being inspired and encouraged to engage in interaction by watching an interacting user, also known as the honeypot effect, has been studied in detail by Michelis and Müller [2011] and Brignull and Rogers [2003]. Passers-by are able to also learn by keenly watching and observing a user or a presenter demoing the system, which can encourage them to overcome social hesitance and embarrassment they might be experiencing. With the Energyland installation, the layout limited the potential advantages of the honeypot effect as passers-by could see the users that were interacting with the interaction spots in the patio. “When [researchers were not] around, people would go in and stay for less than a minute, but if there was a [user interacting with] the system, people would stand longer to watch, still not doing [anything] but watching” [R1]. Since visitors to the Tekes tent has a lot of stalls and installation to choose from, the number of people visiting the Energyland installation could have hypothetically been increased if all the rooms were equally visible to passers-by. Nonetheless, there were over 190 documented users and many more who interacted with the system but did not volunteer to fill in the questionnaire.

5.5. Supporting Interaction Affordance

As mentioned by Ojala et al. [2012], with the emergence of affordable digital displays public spaces such as malls, movie halls, restaurants and tourist information centres are filled with large displays and there is no certain way to identify the interactive ones from simple digital signage. Major outcomes of this include display blindness, display

avoidance and interaction blindness. People might not be aware of the presence of a display, which is interactive and contains potentially interesting content. Thus, there need to be sufficient clues or hints to indicate that a public display affords interaction. In case of the Energyland installations, for some users it was not very obvious that the system used gestures and was not a large touch enabled display or that the stickers placed on the floor did not contain pressure sensors to control the system. “Lots of people walked through the [interaction] points listening to the system but not knowing that they could interact with it. There were no instructions [saying this is a gesture-based system]. It would have helped a little [to have] static instructions such as posters and text explaining the system [as a whole]” [R5]. This is one of the most challenging design issues: to provide instructions and guidance without overloading a user's input channels. The Energyland system used a series of written instructions and synthesized speech output to help guide the user to task completion. It was observed that most users did not read the instructions because they were more focused on the completing the tasks with the virtual objects in front of them and the audio instructions became mumbled when more than two users interacted within a room simultaneously.

The system also had an on screen human shadow mimicking user movements and gestures to provided embodied feedback in real time. Although there was a noticeable lag between the user action and on the onscreen shadow as observed by several users, which could have affected the user experience, the onscreen shadow provided enough real time embodied feedback to assist user interaction. Users were able to observe their shadow and perform several tasks correctly. This feedback is crucial for such systems as it helps the users gain a perspective of them with respect to the virtual world. However, users still found a few task confusing to complete as the text and synthesized instructions were easy to miss or skip.

Such misunderstandings can be reduced by providing more clues and interaction instructions as a part of the system. One of the ways could be by providing posters or pictures that show a person interacting with the system [Saffer, 2008, p148] and [Nielsen, 1994]. One can also use real world symbols or metaphors to guide the interaction, as in the case of chopping the wood, which was fairly easy for the users to understand and control without any instructions. Most users were able to complete the task on their own and within a few tries, even though the task required users to face the screen rather than sideways as one would expect in a real wood chopping scenario. Another method can be giving demonstrations, showing how to interact with the system, especially when there are no universal real world metaphors as in the case of the solar grill whose alignment was the trickiest for the users.

It was also observed that users familiar with the Microsoft Kinect could immediately recognize it and deduce that they can interact via gestures. A few users commented that they did not expect such an interactive system at a housing fair and

were pleasantly surprised by its presence. Because of this reason, most users preferred seeing a demonstration rather than interacting themselves, as was the norm for a greater part of the housing fair. Researchers mentioned that users were less likely to interact with the system on their own without any encouragement from them, akin to display avoidance or in this case interaction avoidance for a number of reasons, including social norms as discussed above.

5.6. Working with Technology Affordance

In the wild studies introduce many parameters that are otherwise easier to control in a laboratory setting, such as lighting conditions, weather conditions and user attire. Peltonen et al. [2008] state that although their CityWall afforded two hand interactions, users frequently only used one hand as the other was usually occupied with bags or mobile phones. This did not affect overall user experience with the CityWall, but for the Energyland system, which required upper body gestures, loose clothing worn by users and the objects they carried hindered smooth interaction. Although Energyland worked with either hand, at the housing fair users were also carrying bags, scarfs and other objects in their hands that also distorted the Kinect data to some extent, further affecting the user experience; as emphasized by R5 “bags from the [people at] fair [affected] the recognition system, [and there were] no hangers to put the stuff out before [users] started trying.” Thus, to interact, some of these users had to place their objects on the floor near the installation, while other users decided not to interact with the system at all. For instance parents with a baby in a stroller found it difficult to interact with the system. Thus, in the wild interactions become limited due to what a user is carrying or wearing and affects the overall user’s experience.

Another technical problem with the Microsoft Kinect was that it failed to recognize user skeleton in bright sunlight. Since the system was installed in a tent during the Finnish summer, this was a persistent problem on days that had a lot of sun. With no technical workaround, thick black curtains were hung on the ceiling to keep the interaction area dark for the Kinect motion sensing to work properly. Nevertheless, Microsoft Kinect provides a viable solution for gesture recognition and worked fairly well once the lighting issue was resolved. As is with any developing technology, a good system design is able to reap the benefits the technology affords while minimizing the impact of its limitations.

One problem that even good design cannot salvage is nature’s wraths. There were consistent rains towards the end of the housing fair that soaked the carpets on the floor. All the machines were placed on the floor and although nothing was completely destroyed except one of the pan-phonics speakers, eventually during the last week, the main machine broke down and there was no sound. This most likely affected the overall experience of the users that interacted with the system those few days.

5.7. Researcher Observations with Pre-defining Evaluation Goals

As mentioned in section 2.4, in the wild user studies allow for more ecological validity while minimizing control over external and internal validity. User experience (UX) in the wild is influenced not only by the system and its interaction but also inevitably by people flow, environmental noise, display visibility and the presence of an audience including researchers. While the presence of a researcher is known to affect user behavior and consequentially user experience, researchers are still able to provide valuable insight [Kellar et al, 2005]. Johnson et al. [2012] mention that researcher insight is important as it “arise[s] from understanding [the] context, building rapport with participants and empathy based on shared experience.”

Kellar et al. [2012] also noted this in their City chase experiment, “researcher observations proved to be useful, especially in combination with participant’s evaluation and interviews”. For the Energyland case study, researchers provided valuable insights into user behavior and thus user experience. The user questionnaire captured high level user experience with the system, the tasks, the sounds, the story and the concepts. The system logs and user interviews also added to the UX evaluation data. It can be said that the researcher interviews carved the direction for data analysis, which can be quite cumbersome when there are multitudes of varied information to sift through. Of note is the mention of the 'room like installation space' (R1, R3, R5), which then also explained to some degree the data gathered by the system logs, why was the patio most visited interaction spot: because of its location, its tasks and system performance.

From Energyland evaluations, one point to note is having pre-defined UX evaluation goals to assist the data analysis. For instance, researchers at the Energyland installations could have been provided their interview questions before hand and be asked to take notes at the end of day, answering those questions on a daily basis, instead of free style journal or diary entries. This could have provided crucial information that might have been lost in retrospective interviewing weeks after the fair. Given the plethora of information that can be gathered, these pre-defined goals can also assist in data collection via system logs and user interviews, where data that answers the research goals is specifically gathered. This might limit the more serendipitous findings, but as mentioned by Kellar et al. [2005], “observation in context is a fundamental part of mobile and ubiquitous computing research practice.”

6. Conclusion

This thesis looked at several guidelines for gesture-based interaction design and in the wild interactions, and explored a few methods to evaluate in the wild user experience. This was further analyzed and discussed by presenting the Vuores case study of the Energyland installation at the Annual Finnish Housing fair, resulting in a holistic set of guidelines for in the wild gesture based interactions.

Designing gestures that can be tracked and identified, while still be natural, intuitive and effective for a user, is a key process in every gesture-based system development. On one hand gestures have the potential to allow for faster input channels making machine interface more receptive and intuitive to use. On the other hand, gestures are individualistic and culturally dependent making it fairly challenging to decode and interpret them. To sum up, this thesis suggests:

- Interactions should be based on real world metaphors: a fine balance between familiarity and novelty is required to provide enough encouragement to initiate user interaction and then enough novelty to maintain user interest and curiosity.
- Support for fight or flight reaction: interactions in the wild are akin to venturing out into the unknown, which has its own risks and rewards. Providing an easy escape route for users helps lower the anxiety of being trapped in a high risk situation.
- Encouraging performative interactions: gesturing in the wild is explicit and visible to the public making the interaction seem like a stage performance rather than just a personal experience. If such explicit gesturing is demonstrated by the researchers present at the installations or users are allowed to interact in groups, the feeling of social embarrassment can be reduced.
- Allowing for honeypot effect: the installation should be placed where it has maximum visibility allowing for passersby to casually observe. This helps the observers become curious and mentally prepared to interact. Although such highly visible setups might increase performance anxiety among users, they can also help provide a quick escape route.
- Supporting interaction affordances: Display blindness, display avoidance and interaction blindness affect a user's perception and willingness to interact with the system. The system and installation space should provide enough hints and clues, via posters or demonstrations, that it allows gesture-based inputs.
- Working with technology affordances: The ability of a system to recognize gestures affects how the system is perceived and experienced by users. Designers need to work around these technical limitations by understanding the use context and taking into account a user's attire and accessories.
- Researcher observations with pre-defined evaluations goals: in the wild user interaction is affected by various inevitable factors, such as people flow, social

norms and interaction affordances, making it difficult to evaluate user experience. The presence of a researcher as an observer, who has pre-defined research goals, helps build a rich use context for the evaluation data collected in the wild by means of a shared experience.

These guidelines provide a mechanism to aid and study gesture-based interaction in the wild. To further understand and analyze gesture-based interactions in the wild, an in-depth study of the effects of social spaces and installation setups on user experience is required. In addition, methods to document and gather the use context of in the wild interactions, as briefly mentioned by pre-defining research observations goals, need to be developed. Furthermore, ways to overcome the intrusive effects of researcher presence on user experience should be studied in more detail.

Gesture-based systems, although not devoid of their specific challenges, are still making headway into everyday lives of users by means of research prototypes and a few commercial products currently available, such as the Samsung smart TV, keeping the desire and need for such systems intact.

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Energyland Instruction Manual

1. First thing in the morning
 - a. Switch on the power cables: total of 3.
 - i. below the center screen, near the Red-laptop and behind the white board
 - ii. below the right screen, just behind the white board near the silver laptop
 - iii. in the far-right corner of the room, only one visible
 - b. Turn on the 3 projectors one by one. The remote control is in the shelves under the projectors. The easiest way would be to stand right below the projector (close to the white shelves) and point the remote directly towards it!

A backup remote is in the cardboard box is kept in the shelves under the projectors.

- c. Turn on the computers and check their IPs using Run->cmd->ipconfig
 - i. Red laptop (IP: 192.168.1.64)
 - ii. Silver Laptop (IP: 192.168.1.35)
 - iii. Desktop-computer (hidden behind the white board near the silver laptop and near the 1-a(ii) power cables, wireless keyboard is hidden behind the board as well, likely next to the side wall and a mouse connected to the computer should be somewhere nearby) (IP: 192.168.1.47)

If any IP is different, then restart the network box that is kept below the center screen, almost inside the hole in the wall. Easiest way would be to take out its power cord and put it back in.

2. How to Start the Energyland (EL) System

The EL system has 3 rooms: Patio, Kitchen and Entertainment Room and there is one machine for each room. Each room has its own bat file but each machine has all 3 bat files on its Desktop just in case there is a need to switch or duplicate rooms. The main bat file is placed at the center of the desktop and it is the preferred Room configuration. The other two bat files for the remaining rooms and are placed center-below on the desktop.

It takes more than 10 seconds to load a room. If you get a blank screen even after 1 minute, restart the EL system again as sometimes the panda does not start fast enough for the graphics to load. If you get blank screen on both left and right screens but not in the middle (even after restarts), try rebooting the network box below the center screen.

Note: all the machines need to have projector as the only display. For the laptops, the keyboard shortcuts can be used to go the Projector Only mode before starting the system. For computer, display driver menus can be used if necessary. By default, only the projector is connected to the computer.

After launching the system as described below, drag the mouse away from the visible screen so that the mouse is not visible on the projected screens. As there is a shadow associated with the mouse (activated by a mouse click and it will follow the mouse-click) just drag the mouse of out of the visible screen.

Closing the laptop lid will should not hibernate, sleep or shutdown the system, but it seems it still can cause some problematic behaviour so it is not recommended except perhaps for special occasions where tidiness of the room is paramount.

The default configuration (use it unless there is a specific reason) is:

- a. The Left screen is the Patio and is controlled by a Red laptop placed below the screen. To start the Patio, launch the EnergylandPatio.bat file placed at the center of the desktop (double click to launch)
- b. The Desktop-computer controls the center screen, the Kitchen, and requires the EnergylandKitchen.bat file

This machine also controls the audio and the main weather application. They all start in the same bat file, EnergyLandKitchen.bat

- c. The Right screen is controlled by the Silver-laptop. It is the Entertainment room and requires EnergyLandEroom.bat file

Although code changes are not required, each machine has the entire svn hierarchy of the Energyland repository.

- C:\svn\EnergyLand\code\vuores contains Audio and Visual Content, python code to run the EL system
- C:\svn\spi-sw\AVPlayer: AV player code that loads the content
- C:\svn\spi-sw\Kinect\SkeletonServer\bin\Debug contains the Kinect Server code

3. How to stop / restart the EL system

To stop, Press Alt + F4 to close the full screen projected window. Then close all other windows opened by the bat file (approx.: Patio and Entertainment room have 3, Kitchen has 6).

To restart, first stop the EL system and then start again. Each Room can be restarted independent of the others.

4. Possible Error and Handling them

- a. Socket Errors while starting the system:

- i. Check the system's IP as mentioned in step 1c. If the IP is different, restart the network box.
 - ii. Close all tabs, kill any python processes (like python *32) using the Task Manager and Restart the EL system
 - iii. If (i) fails, Restart the machine and then start the EL System
 - b. Weather Changes not synchronized (weather should be same in each room)
 - i. Walk past the Grill in the Patio, Window in the Kitchen or Video in the Entertainment room. By activating and deactivating these spots, the EL system tries to re-sync the weather.
 - ii. Check the router kept behind the center screen and almost inside the slot/hole in the wall, it should be working
 - iii. Check the IP of the desktop-computer. It should be 192.168.1.47. If not, then update the new IP to files in respective computers:
 - 1. C:\svn\EnergyLand\code\vuores\logic\patioDefinitions.py, line 14 (for sever_add)
 - 2. C:\svn\EnergyLand\code\vuores\logic\eromDefinitions.py, line 14 (for sever_add)
 - 3. Also check laptops' IPs and update to own_server_add for both the files mentioned above
 - c. No response from Kinect

If the user shadow is not visible on the screen when user is front of the Kinect, restart the EL system.
 - d. Unable to launch a room
 - i. The panda setting are such that the system should be run on the projected screen rather than the laptop's display. Check that the Projector Only mode is On
 - ii. Launch a different Room using the bat file on its desktop.
 - e. The kitchen stove disappears or some other object seems to be missing its texture (i.e., is plain white)
 - i. Restart the respective room
 - f. Audio content is not playing / cannot be heard
 - i. Restart the Kitchen
- 5. End of Day
 - a. Shut down all EL systems
 - b. Shut down all the computers
 - c. Shut down all the projectors, they take about 30s. to cool down
 - d. Switch off all three extensions cords mentioned in 1a (one at the back of the room, one below the center screen and one below the right-screen)

Quick Interaction guide

1. Patio

- a. Grill: works only when the sun is visible on screen, aim is to align the grill to the sun (two sun positions). Alignment is achieved by moving arms horizontally (parallel to the ground). Easiest way is to stretch out arms and move them side to side.
- b. Jacuzzi: has a waterwheel that fills up the Jacuzzi. It works when the switch (placed at the bottom-left of the Jacuzzi) or waterwheel is selected.

Note: Selection is made by placing user's left or right hand in front of the object. If there is no user skeleton/pose information, then user needs to stand right in front of the object. That is, user's virtual shadow (center of gravity) should be right in front of the virtual object.

- c. Chopping: user must move left or right arm fast enough in the vertical direction to chop the wood. Placement of the axe on the wood is not checked, only the velocity matters.

2. Kitchen

- a. Window:
 - i. Sunny: select the switch that pops out on the window to use solar panels. Selection made by placing user's right or left hand in front of the object or in case of no skeleton information, selection is made when the user stands in front of the switch. (horizontal coordinates are matched and height is ignored)
 - ii. Lightning: using the fork attached to a user's right hand, place fork near the lightning, similar to selection of objects but using only right hand. When there is no user pose information, then selection is made by matching horizontal coordinates.
- b. ColoringSpots (Fridge, Dishwasher and Stove): based on the distance traversed in space, the circus themed drawings appear. Easiest way is to wave right hand in the air in any direction, when the spot is active (coloring instructions are visible).
- c. Trash Sorting:
 - i. Gesture-based: when skeleton information is available, 3 items appear on top of the trash bins. They are selected (maximum of one by each hand) and then held above the bins, waiting for the right bin to appear. The bins change every 3 seconds from bio->lasi->->metalli->paperi. Each item goes into one correct bin. Once an item is selected, it grows twice in size and is attached to the user's hand and it moves with the hand till placed inside the right bin.
 - ii. Position based: similar to gesture-based, except that items (5 items) are selected differently. Since there is no user pose

information, an item is selected based on the user's horizontal position and stays selected (twice in size) till the user moves away. Thus it is not attached to the user and all items stay lined up above the trash bin. Bins keep changing every 3 seconds and based on the bin, user has to select (move horizontally) the trash item.

3. Entertainment room

- a. Windmill: the windmill works by measuring the distance traversed by the hands to meet when clapping. The easiest way would be to clap but starting with hands farther apart and not close together.

Note: the windmill can be activated once the video fades out and there is not enough energy. When there is energy, the windmill does not react to the user's gestures.

If there is no user pose, then distance traversed in the vertical position is measured, so jumping up and down will rotate the windmill, which produces energy.

- b. Sell/Donate: sell and donate buttons are selected based on similar selection rules as in other spots. In addition, there is a minimum duration for which the selection must be made. So sell and donate button need to be selected for a particular duration.
- c. Feedback: same as the sell and donate button, but the duration/timeout is visible around the buttons.

Kokemukset *Tulevaisuuden kodin energiaratkaisut* -sovelluksesta

Merkitse seuraavissa väittämissä rasti siihen kohtaan, joka vastaa parhaiten omaa kokemustasi.

- | | | |
|---|--|--|
| Sovellus ei ollut ihmeellinen – vastaavanlaisia järjestelmiä on muuallakin. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Sovellus oli ainutlaatuinen – vastaavanlaisia järjestelmiä ei ole muualla. |
| Sovellus oli keinotekoinen ja epäuskottava. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Sovellus oli aito ja uskottava. |
| Sovelluksessa ei ollut juonta – siitä puuttui ”punainen lanka”. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Sovelluksessa oli juoni, ”punainen lanka”. |
| Sovellus ei tarjonnut minulle mitään uutta tai arjesta poikkeavaa. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Sovellus oli minulle jotakin uutta tai arjesta poikkeavaa. |
| En kontrolloinut sovellusta. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Kontrolloin sovellusta. |
| En kokenut sovelluksen äänimaailmaa esteettisenä. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Koin sovelluksen äänimaailman esteettisenä. |
| Sovelluksen käyttö oli epämiellyttävää. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Sovelluksen käyttö oli miellyttävää. |
| En haluaisi käyttää sovellusta tulevaisuudessa. | <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> | Haluaisin käyttää sovellusta tulevaisuudessa. |

Vastaa vielä muutamaan taustatietokysymykseen.

Ikä: _____ vuotta
(esim.

Move)?

Sukupuoli: Nainen

Mies

Kuinka usein käytät eleisiin perustuvia sovelluksia

Nintendo Wii, Microsoft Kinect tai Playstation

Päivittäin

Viikoittain

Kuukausittain

Harvemmin kuin kuukausittain

En käytä lainkaan

Halutessasi voit antaa **vapaamuotoista palautetta** paperin **kääntöpuolelle**.

Kiitos vastauksistasi! Voit nyt palauttaa lomakkeen laatikkoon tai paikalla olevalle tutkijalle.

Vuores Researcher Interview

Experience:

1. How did you explain the systems to users? Were the instructions provided to you sufficient?
2. How did you find the demonstrations? Were some more difficult than others even after a few tries?
3. In general, did you feel comfortable interacting with the system? Any particular flaws or errors you encountered?
4. What would you like to change in the system?
5. What did you like most about the system?
6. What do you think we (designers) wanted the users to feel or understand?
7. How would you rate the system? (also fill in original questionnaire)

Observation:

1. Did some user stand out or was an exception? For instance, asked something or interacted differently.
2. Who filled out the evaluation forms? People who used the system, children, passer-by.
3. Were users able to find the 'goals' of interaction? Did they understand the 'story'?
4. Were users able to 'win' or complete a task on their own?
5. On average, how much time did each user spend at the installation?
6. On average, how many interaction spots or tasks did a user try out?
7. When did they quit or what discouraged them to interact further?
8. What encouraged them to interact?
9. Did users want to interact on their own or did you have to insist them to try it?
10. Which kind of user was more inclined to use the system, were most excited about the system? For instance, kids, parents with children, young adults, people who worked or had used gesture-based interaction before.
11. How do you think users felt using the system?

Interaction with User:

1. Did users mention any difficulties they had with the system?
2. Did users mention anything they found particularly fascinating, interesting or enjoyable?
3. Did you chat with the user while they interacted with the system?
 - a. If yes, then was it for instructions?
 - b. Or to correct them, help them?
4. Did user want to know more about the system say after they interacted with it?

Is there anything else that you would like to add?