THE INTERACTIVE MIRROR

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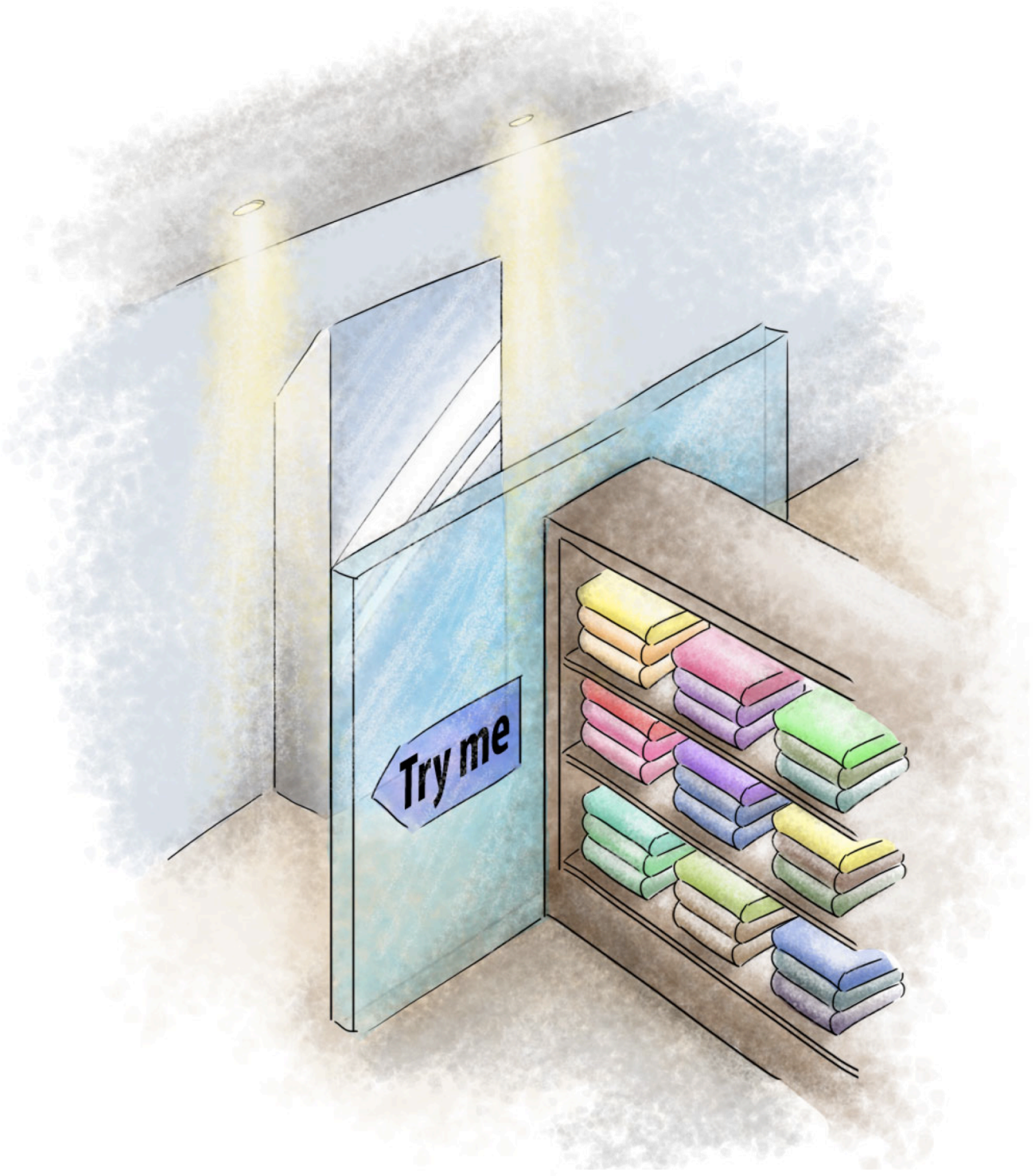

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1. Introduction

The following chapter introduces the HMI Project that is being described in this report and consists of two sections. The first one describes the aim of the project, motivates it and provides a first overview of the ideas that we collected during a brainstorming in the beginning of the project. The following section will then give an overview about the applied methodology.

1.1. Project

The following section introduces the aim and the scope of the project. First, we give a description of the main stakeholder of this project, NEDAP, and the underlying product, the Tweet Mirror. Following, the project's aim is described and motivated. The last section sketches the vision of the aim of the project as it was developed in the beginning of the project.

1.1.1. NEDAP and the Tweet Mirror

NEDAP is a company that develops a wide range of products that include, for instance, library systems, products for healthcare and agriculture. The retail department offers, amongst others, products for customer statistics, theft prevention and the Tweet Mirror, the product that was the starting point for our work.

The Tweet Mirror[1] is a product that should combine shopping with social networking. It is supposed to be placed in fashion stores and allows customers to make pictures of them. These snapshots can then be shared on Twitter or sent via email, for example to get feedback from friends on their outfits. The Tweet Mirror should benefit the customer by providing a fun and interactive shopping experience, and also the stores as it increases the visibility of their name and their brands on the Internet.

1.1.2. Aim and motivation

The main aim of the project was to work out and evaluate ideas that enhance the capabilities of the Tweet Mirror. We extended the concept of the Tweet Mirror by adding functionalities to select and buy pieces of clothing. Furthermore, we worked on the share functionality by, for

[1] See: http://www.nedap-retail.com/fashion/intelligent-mirror.

instance, including further social networks. The effects of these enhancements were also addressed by our research.

The effects of the new device on the behavior of the customers were also targeted, with a lower priority. The Tweet Mirror is supposed to provide a new shopping experience by allowing a customer to take and share photos of him or her. This new shopping experience can result in an increased engagement between the customer and a store and, thus, increase its profits. Furthermore, the interactive mirror, which features certain enhancements that transgress the capabilities of the Tweet Mirror, could increase the likelihood of the customers to visit a store, thus possibly increasing the profits. The possibly increased profits of a store, an effect that lies outside the scope of this report, will also be beneficial for NEDAP as they might lead to an increased number of sold devices.

As a new means of interaction, we also included gestural interaction, using the Microsoft Kinect, to supplement the touch-based interaction that is already used in the Tweet Mirror. Various projects using controllers of the Wii as a means for gestural interaction exist (e.g. (Schlömer, Poppinga, Henze, & Boll, 2008), (Lee, Kim, Gupta, & Mazalek, 2008) or (Chow, 2008)). Projects employing Microsoft's Kinect are relatively rare, possibly due to its rather recent introduction. The usability of gestures will be targeted, as well as, the effect of gestures on the shopping experience. Such an effect might exist since gestures are being called "exciting" by, for instance, (Saffer, 2009).

Deliverables of the project were this report and a working Flash prototype that practically demonstrated the enhancements that we developed.

1.1.3. Vision

The version of the Tweet Mirror, on which we based our work, left room to enhance its capabilities. Some ideas that we collected in the beginning of the project will now be outlined. At this stage of the project we have identified three directions in which the efforts could be aimed.

The first is providing assistance to the customer in choosing his or her outfit. Possible functionalities are, for instance, allowing to "wear" clothes in virtual. This make it possible for the customers to try different colors, get suggestions for outfits, for instance based on outfits of celebrities, or to allow to order a customized version of your clothes[2] (see figure 1.1 for a sketch of a setting in a store involving the mirror).

[2] See e.g. http://www.shoesofprey.com/.

The feature of sharing photos on social networks, which is already incorporated in the Tweet Mirror, forms the second aspect. Possible improvements are the introduction of more direct techniques of communication, as for instance videoconferences or the integration of instant messaging services.

As a third direction we identified features that enhance the mirror to provide shopping functionalities, for instance by allowing to pay with your credit card or to order items that are not in stock in the store. A usage of the interactive mirror as a part of the store's shopping window is also possible (see the illustration of such a setting in figure 1.2), but not considered in the following report.

Figure 1.1-1: The interactive mirror in an indoor setting

Figure 1.2: The interactive mirror in an outdoors setting

1.2. Approach

This section explains how we approached the project. Its first part gives an overview of the project followed by a section that explains the parts of our methodology.

1.2.1. Process

The project was carried out in an iterative way, as it is advised by for instance (Maguire, 2001) who mentions iterative design as a key principle that allows the incorporation of user feedback to produce the develop the design further. Benefits of iterative design of user interfaces, for instance usability benefits of 25% between iterations, are also discussed by (Nielsen, 1993a) based on four case studies. We executed the project in two iterations, which is the minimum number that is advised by (Nielsen, 2011), resulting in three designs: one draft version at the beginning and one version after each user test. A phase to plan and define the project preceded the first iteration and a phase to finish the report and prepare the presentation followed after the second iteration.

Our approach is a reduced version of the design cycle that is presented by (Maguire, 2001b) and consists of the following steps that will be carried out iteratively:

1. Specify the interaction and interface requirements

2. Produce designs and prototype
3. Carry out user-based assessment

As said, these steps will be preceded and followed by a phase to define the project and to wrap it up at the end.

1.2.2. Methodology

This section explains the parts of our methodology. First, we will describe the context of use analysis, which was done in the beginning of the first iteration. Following, we show how we approached the requirement analysis and, in the third section, how the user tests were carried out.

1.2.2.1. Context of use

A context of use analysis provided the information that was necessary to design a product that works in its later context. The influence of the context on the usability of product is discussed by various authors, for instance (Bevan & Macleod, 1994) who also frame usability as "quality of use in a context." Furthermore, we obtained data that was used to select realistic users and representative tasks in the user tests. The necessity of representative users that can be better selected using the data from a context of use analysis is mentioned by (Maguire, 2001a).

The context of use analysis consisted of two parts. The first part discusses the users, which are according to (Bevan & Macleod, 1994) part of the context of use of the product. We defined the target group and collected data on the target group by a web survey. Context factors that influence the usability of the product, for instance the auditory environment, were identified and discussed.

1.2.2.2. Requirements

The initial set of requirements was collected by brainstorming. We introduced a set of themes to structure the requirements that belong to the same functionality. Requirements and themes were collected in a simple and informal format to leave freedom for the design process. A user survey and input from NEDAP provided the sequence in which the ideas were addressed in the project.

1.2.2.3. User tests

Tests with real users are the most fundamental usability method. They provide direct information on how people use a product and what their exact problems are (Nielsen, 1993b). We carried out three user evaluations whose setup is sketched in the following.

First user test

The first user test was carried out using a low-fidelity prototype. Nevertheless, we strived to setup a test scenario, which was as close to the real context of use as possible.

The prototype was based on Flash, to allow a quick creation of a prototype without loosing the possibility to have real interactivity. One alternative to a Flash prototype was to use a paper-based prototype that would lack real interactivity, since the interactivity if a paper-based prototype has to be simulated. We created a Wizard-of-Oz or a "man behind the curtain" setting (as described by (Saffer, 2009), or used by e.g. (Hummels & Stappers, 1998)), to simulate not implemented capabilities as gesture recognition.

Factors that were identified in the context of use analysis were partly replicated in the user test. Therefore, we used a display of a size that was similar to the size of the display of the Tweet Mirror and placed it similar to its possible placement in a store. A reflecting foil in front of the display was used to simulate the effect of a mirror. Context factors that affect the usability of the product, like the visual and auditory conditions, were as far as feasible controlled in the test; for instance by providing fixed light conditions (Bevan & Macleod, 1994).

Small-scale evaluation

This small-scale evaluation, which took part in the second iteration, was meant as a preparation for the second user test and was conducted on a smaller-scale using a notebook instead of a larger LCD screen. Its main aim was to test whether the adaptations that were made to the prototype, based on the results of the first test, were able to solve the usability problems that they addressed.

Second user test

The third user test made use of a working prototype that incorporated additions that were based on the findings of the first user test. It was still based on Flash and used a Microsoft Kinect to provide gesture recognition capabilities. The interactive whiteboard on which the prototype was projected provided the capabilities for touch-based interaction. The data from the third user test was used to create the final prototype.

2. First Iteration

2.1. Tasks

One main task of the first iteration was to define the scope of the project, what was necessary because of the limitations in resources and time. After the scope of the project was defined, the functionality of the system that lied in the scope was prioritized to provide a sequence in which we addressed these parts later on. Based on this priorisation a prototype of the system, which was then evaluated in a user test, was developed. After having carried out the user test the results were evaluated and translated into adaptations of the prototype.

The focus of the work in the first iteration was to arrive at a first and evaluated version of the interface of the prototype without paying great attention to technical conditions like the interaction means. The technical component of the system will be addressed in the second iteration.

2.2. Context of use

Considering the context of use is crucial for the usability and the evaluation of the usability of a product. The quality of use of a system, including usability and user health and safety, depends on having a good understanding of the context of use of the system (Maguire, 2001b).

We wanted to achieve the following two aims by carrying out a context of use analysis.

- **Allow meaningful tests with representative users.** Knowledge about the context of use allowed it to create a test setup that was similar to the conditions of the later place of use and allowed the selection of relevant participants. If, for example, the target group of the product is bordered in the context of use, the test of users that are not a member of that group can be avoided, to avoid results with a lower relevance. This aim is addressed in section 2.2.1.
- **Understand the context in which the interactive mirror will be used.** Contextual factors that were considered by us were: the auditory environment the visual environment and the user

posture. Of course, also the users, whose characteristics will be researched during the analysis, are part of the context of use. Being aware of these factors allowed it to incorporate their effects during the design of the system. This aim is addressed in section 2.2.2.

In the following section our context of use analysis is described and these two aims will be addressed. The first part deals with the users of the system and their characteristics, which we researched with a web survey. The second part describes contextual factors of a store where the interactive mirror might be used.

2.2.1. Users of the system

The following section describes the user group of the system. First, the target group of the system will be given followed by a discussion of the users' characteristics, which were researched by a web survey. This section is concluded by a discussion of the influences of the users' characteristics on the design of the system.

2.2.1.1. Target group and place of usage

The target group, which we decided to address in the project, was male and female people between 16 and 32 years. We opted for this group because of two reasons: people of this age group are more likely to have experience with technologies that are used by the Tweet Mirror, for instance twittering, as the results of studies suggest[3]. Furthermore, participants for user test were easier to recruit in this age group, since we could make use of other students, a group of people that is easy to find at a university. The interactive mirror was supposed to be setup in clothing stores as it is also stated by the product's website.[4]

2.2.1.2. Characteristics of users

To obtain data that is necessary to define the characteristics of the interactive mirror's target group more clearly, we conducted a web survey using a questionnaire. The first part of the following section describes the researched attributes, which are split into *personal attributes* and *experience, knowledge and skills* as it is done by (Maguire, 2001a). The complete questionnaire can be found in appendix A.1. A discussion of the

[3] See e.g. http://www.webpronews.com/who-is-using-twitter-2011-06

[4] See http://www.nedap-retail.com/fashion/intelligent-mirror

results of the survey and their implications for the design of the system can be found at the end of the following section.

Personal attributes

Two of the personal attributes that are listed by (Maguire, 2001a) were included in the questionnaire. These were age and gender to ensure that the respondents were member of our target group. Further attributes were not considered as we expected a homogenous group of participants regarding their cognitive capabilities and physical limitations.

Experience, knowledge and skills

The questions of this type focused on the categories *related experience, task knowledge* and *input device skills* that are given by (Maguire, 2001a).

As *related experience* we wanted to address how often the participants visit clothing stores and whether they rather go shopping alone or in a group. This has vital implications for the design of the system. A group of shoppers that approaches the interactive mirror, for instance, creates another context of use then a single shopper. Thus, a first judgment based on these responses whether we have to expect groups of users was important. Further related experiences that were targeted contain the users' experiences with social networks that will be described in the following paragraph.

A core task of the Tweet Mirror and also of the interactive mirror that we developed is sharing. To target the *task knowledge* we researched the users' experience with social networks, and with sharing media on social networks. This was done to gain insight whether experience with a core functionality of the Tweet Mirror, sharing, could be expected or whether the users are likely to be in need of guidance during that process, or even in need of an introduction to that process. Of course, further tasks, like buying items, are also potentially relevant here, but were excluded from the questionnaire, as their inclusion in the interactive mirror was not decided at this point.

Further questions were targeted are the users' *input device skills*. We asked for the users' familiarity with touch-based interaction devices and gestural interaction devices. As the primary goal hereby, we wanted to find out whether people had experience with devices that use gestures. One implication of low experience could be that visible cues of the available gestures were to be added to the interface.

Results

Table 2.1: Results of the survey for the context of use

	Younger than 16	16-24	25-32	Older than 32
Age	0%	70%	10%	5%
		Male	Female	
Gender		55%	35%	
	At least daily	At least weekly	At least monthly	More seldom
Do you use social networks?	45%	35%	5%	20%
How often do you share media in social networks?	0%	20%	30%	45%
	Videos	Photos/Pictures	Stories	Other
What do you share in social networks?	18%	76%	41%	35%
	At least daily	At least weekly	At least monthly	More seldom
Do you use your computer for shopping?	0%	5%	40%	50%
		Yes	No	
Have you ever used a touchscreen?		95%	0%	
Have you ever used a device that uses gestures and moves to interact with it?		80%	15%	
Have you ever used such a device that is not a gaming console?		10%	85%	
	At least daily	At least weekly	At least monthly	More seldom
How often do you visit a clothing shop?	0%	10%	25%	60%
		Alone	Group	
Do you go shopping rather alone or in a group?		65%	30%	

Discussion

In the following we will outline the conclusions that we drew from the results that are shown in table 2.1. First of all, the study was not representative, as we, for instance, did not know whether the participants of our survey would ever visit the clothing stores that might invest in an interactive mirror. Furthermore, the number of respondents was with 20 rather small. Nevertheless, we hoped to gain insights into the experiences and characteristics of potential users of the interactive mirror, which could aid the further development process.

The majority of the participants (80%) were, regarding their age, member of our target group, so we assumed a certain relevance of the results, having the described limitations in mind.

A majority of the participants responded that they go shopping rather alone than in a group (65%). Thus, interactions that are optimized towards groups were not considered in the project, as this result implied a rather little need for them. We therefor decided to, given the limited timeframe for the project, focus on the larger fraction of the users that is more likely to go shopping alone.

Acquaintance with social networks could be deduced from the answers since 70% of the participants responded that they use social networks at least weekly. As well assumed was a certain familiarity with the practice of sharing media in social networks (50% answered “At least weekly” or “At least monthly”). A majority (76%) declared that they mostly share pictures on social networks. These two questions allowed the conclusions that a core functionality of the Tweet Mirror, sharing of pictures on social network, is common among a considerable part of the potential user base, so that little problems to grasp this concept were to be expected.

95% of the respondents reported to have had experiences with touchscreens. Thus, a low barrier for a touchscreen interface could be expected. Experiences with gestural interfaces[5] were stated by 80%. It was assumed that most of these experiences were made with gaming consoles as it was implied by the results that only 10% have used gestures in a system that was not a gaming console. Thus, we conclude that the participants of the tests are, at least to a certain degree, acquainted with gestural interaction, although we have not researched data on the frequency of the usage of such systems or the time of the last usage to thoroughly found such an assumption.

[5] A possible source for misunderstanding might have been that the term “gesture“ is also used in the domain of touch based interfaces.

2.2.2. Physical context

In the following section we describe the physical context in which the product might be used in the future. The physical context is relevant for our project because of two reasons. First, knowledge of the context is vital for the product's usability. Factors like the light or the level of noise have to be considered when designing the product. Furthermore, the context of use has to be considered when testing the product since the contextual factors should be incorporated there as far as necessary to provide realistic test environments.

Two contextual factors are discussed in the following section for a sample clothing store: the auditory environment and the visual environment(Thomas & Bevan, 1996).

2.2.2.1. Auditory environment

Here we summarize conditions, which may distract the user or affect the user's perception of sounds relevant to the task (Thomas & Bevan, 1996, p. 69).

The auditory environment inside a store can be noisy because of other customers and because of the background music that is being played. A certain level of background speech caused by other visitors is also present.

Effect on user tests

- To incorporate this contextual factor in the user tests, we could play recorded background noise from a clothing store while the user is interacting with the system.

Effect on functionalities

- It has to be ensured that auditory elements, if any are used, of the interface are also working in a noisy environment.
- Speech interaction, if used, has to function in a noisy environment.

2.2.2.2. Visual environment

Here we summarize conditions, which affect the performance of the user and the product, and might affect the user's ability to see items relevant to the task (Thomas & Bevan, 1996, p. 77).

The visual environment in a store features various lighting conditions, ranging from brighter, for instance near the doors, to darker environments,

for instance between shelves. Thus, the visual context of the interactive depends largely on its placement in the store.

Effect on user tests

- The lighting conditions under which the interactive mirror has to be operated inside a store might be replicated during the test.

Effect on functionalities

- The screen and the elements of the interactive mirrors' user interface have to be readable under various visual conditions.

2.3. Requirement analysis

This section describes the requirement analysis of the first iteration. We approached the analysis by first collecting an initial set of requirements through brainstorming with NEDAP and, as well, inside the team.

This set of requirements was then validated and prioritized by a survey, which consisted of two personal interviews and an online questionnaire. The aim of this analysis was to arrive at a starting point, in the sense of having a clear functional scope and as well a priorisation of the functions, for the further development. Input from the project's main stakeholder, NEDAP was gathered as well, contributed to the priorisation and ensured that the scope of our work was aligned with a main stakeholder of the project.

2.3.1. Requirements

The following section describes the initial requirements that we collected by brainstorming. A coarse structure was introduced by choosing, afterwards, three broader themes to which the requirements have been assigned. An open and informal format for the specification of the requirements and the themes was chosen, as we wanted to leave the detailed implementation of them open for the user feedback that we gathered and incorporated later on. The scope of this section is kept on a pure functional level, so requirements regarding especially the interactions will not be considered in the following, as they are addressed mainly in the second iteration when a more stable design of the interface of the system has been found.

At first, we will now describe the three themes followed by a description of the individual requirements.

2.3.1.1. Themes

The following section describes the three themes that we identified while collecting the initial requirements (see also the vision in section 1.1.3): “find outfit,” “shopping” and “share media.” A brief summary of the scope of the theme, which was deliberately left incomplete, as the precise extent of the functionality was not known at this point, and a list of requirements that implement the theme are given. The requirements will be described in detail in section 2.3.1.2.

Find outfit

Table 2.2: Theme 1 – Select outfit

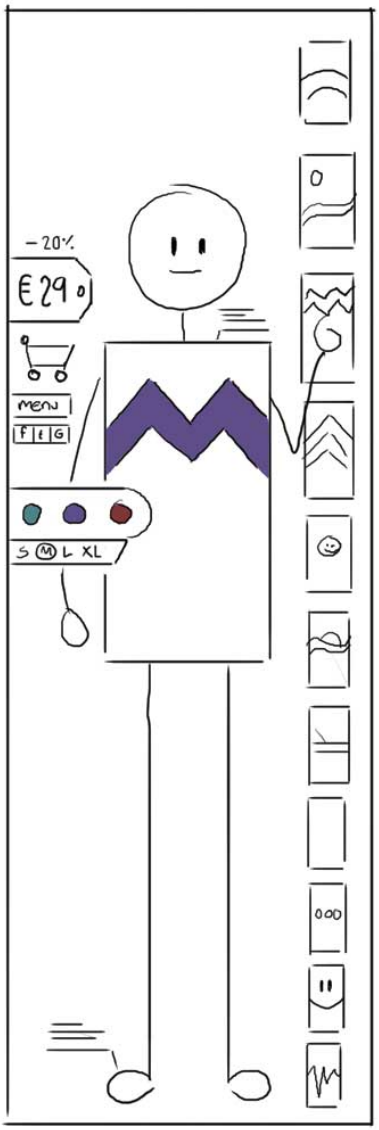


Figure 2.1: Theme 1 – Select outfit

Theme#	Theme1
Requirements	FR2, FR4, FR5, FR6, FR7, FR8, FR10, FR11
Description	The system provides the user functionality to chose an outfit that it displayed by the system. This incorporates, for instance, selecting different designs of clothes and change their color.

Shopping

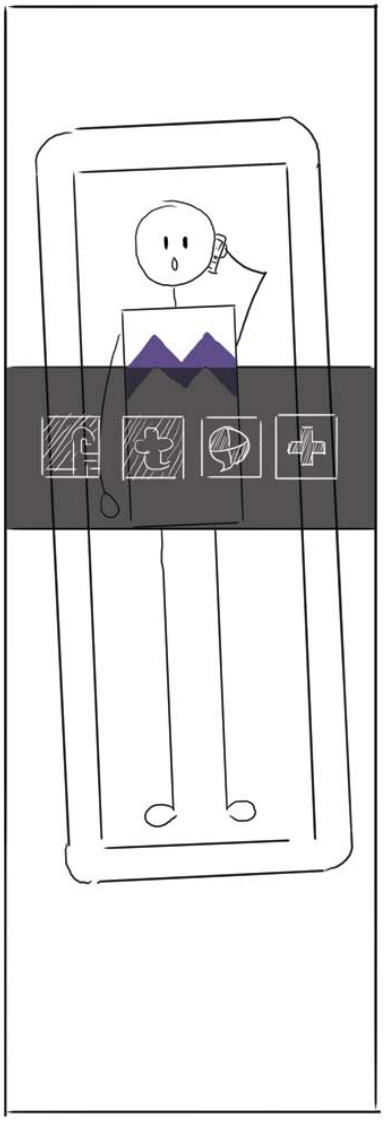
Table 2.3: Theme 2 - Shopping

Theme#	Theme2
Requirements	FR1, FR2, FR3, FR6, FR7, FR8, FR10
Description	The system provides the user functionality for buying items in the store. This includes, for example, paying at the interactive mirror and ordering clothes using the mirror.

Figure 2.2: Theme 2 – Shopping

Share media

Table 2.4: Theme 3 – Share on Social Networks



Theme#	**Theme3**
Requirements	FR9, FR10, FR12
Description	The system provides functionality to share media, for example photos or videos, on social networks or using email.

Figure 2.3: Theme 3 – Share on Social Networks

2.3.1.2. Requirements

The following section lists the requirements that were identified during a brainstorming. The employed format is open and supposed to leave room for a later refinement in the design phase based on user feedback that was gathered in a web survey and in a user test. Each requirement is listed with a short description of its functionality and a link to the theme it was assigned to. These requirements will be prioritized later on in this iteration (see section 2.3.2).

Pay at the interactive mirror

Req#: **FR1**	Theme#: **Theme2**
Description:	The interactive mirror provides a means to pay for items that have been bought in the store or ordered using the mirror.

Check availability of articles

Req#: **FR2**	Theme#: **Theme1, Theme2**
Description:	The interactive mirror provides information on whether an article is in stock at a certain store.

Order items

Req#: **FR3**	Theme#: **Theme2**
Description:	The interactive mirror allows ordering items.

Display different colors and designs

Req#: **FR4**	Theme#: **Theme1**
Description:	The interactive mirror enables to see different colors and designs of a piece of clothing.

Get suggestions for outfits

Req#: **FR5**	Theme#: **Theme1**
Description:	The interactive mirror displays suggestions of outfits or pieces of clothing that may fit the user's preference or to the outfit that he is wearing.

Customize piece of clothing

Req#: **FR6**	Theme#: **Theme1, Theme2**
Description:	The interactive mirror enables the user to customize his outfit, for instance by adapting its design. Customized versions can then be ordered.

Display related items

Req#: **FR7**	Theme#: **Theme1, Theme2**
Description:	The interactive mirror allows seeing items that are related to some other item (e.g. to the one that is displayed on the screen).

Display advertisements and/or discounts

Req#: **FR8**	Theme#: **Theme1, Theme2**
Description:	The interactive mirror enables the store to display advertisements to the users.

Share media

Req#: **FR9**	Theme#: **Theme3**
Description:	The interactive mirror enables to share media on the Internet (e.g. social networks or email).

Provide background music and/or ambient light

Req#: **FR10**	Theme#: **Theme1, Theme2, Theme3**
Description:	The interactive mirror provides music and ambient light during its use.

Suggest the size of clothes

Req#: **FR11**	Theme#: **Theme1**
Description:	The interactive mirror is able to propose a cloth's size so that it fits the user.

Have real-time conversations

Req#: **FR12**	Theme#: **Theme3**
Description:	The interactive mirror enables to have real-time conversations and videoconferences (e.g. using Skype or MSN).

Provide navigational support

Req#: **FR13**	Theme#: **Theme1, Theme2**
Description:	The interactive mirror provides navigational aids to the location of a certain piece of clothing in the store.

2.3.2. Priorisation and user survey

The validation and priorisation of the requirements that were collected in the last section will now be described. We used a web survey and input of NEDAP to arrive at a priorisation. Based on the priorisation, we chose a subset of the requirements that was considered in the remainder of the project.

2.3.2.1. User survey

Aim

The main aim of the user survey is to provide a priorisation of the requirements that were given in section 2.3.1.2. These requirements include a fairly broad range of topics. It was impossible to address all mentioned requirements in detail because of the limitations of the project in terms of resources and time. Thus, a priorisation of these requirements had to be created to make it possible to narrow our focus.

Methodology

For this user study, there were no sketches or design of the look of the interface available. To nevertheless give the participants of the test a possibility to understand and judge our envisioned interactions we opted for an approach that was based on scenarios. These scenarios demonstrated exemplary interactions that can be carried out with our system.

This approach was selected to have an easy and illustrative means to present the functionalities to the participants of the survey. An alternative

approach to provide a priorisation was to confront the user directly with the requirements. This was rejected since it might be hard to actually envisage how this device would work in a store, solely based on textual of the separate functionalities. More open approaches, for instance interviews, were also not taken, as we wanted to clearly prioritize an existing set of requirements and obtaining of qualitative in depth information was not a primary goal of the approach.

We worked out three user scenarios that illustrated the requirements of the three themes that were described in section 2.3.1. We then asked a series of question on these scenarios that aimed at getting an idea of whether the respondents would actually use these functionalities and how they perceive them. Based on these results, and as well the input from NEDAP, the set of requirements was prioritized. Apart from a web survey we also conducted personal interviews to be able to understand the results better and get ideas on the possible implementation of the presented requirements.

Questionnaire

A questionnaire, which consisted of two parts, was used to obtain these results. Its first part was used to collect the information for the context of use analysis, which was discussed earlier in section 2.2.1.2. The second part addressed the topics that were relevant for this user survey, namely the scenarios and the respondents' attitudes about them.

We used a web survey and additional personal interviews to obtain the data. The web survey should provide data from a larger number of people and should complement the more detailed information that we wanted to gather by the personal interviews.

The scenarios were presented as text that was supplemented by an illustrating graphical storyboard. A sample scenario, the remaining scenarios can be found in the appendix in section A.1, with its associated storyboard is given in the following. The questionnaire that was used in the online survey featured two scenarios; this reduction was done to keep the questionnaire short to possibly increase the number of complete responses. The questionnaire that was given to the participants of the personal interviews featured all three scenarios.

Scenarios

In the following section the three scenarios that were used in the questionnaire and interviews will be described and motivated. The first scenario will be presented completely together with the text and the illustrating storyboard. For the remaining two scenarios only the requirements that were addressed by them will be given. Not only the priorisation requirements will be tackled, as we were furthermore

interested in researching whether the participants would, for instance, be willing to login to their account on a social network using the interactive mirror.

First scenario

The first scenario and the corresponding questionnaire addressed the following aspects:

- Requirement FR1 “Pay at the interactive mirror”
- Requirement FR3 “Order items”
- Requirement FR4 “Display different colors and designs”
- Requirement FR6 “Customize piece of clothing”
- We wanted to research whether the participants would be willing to pay using a purely electronic device like the interactive mirror.

Text

Elizabeth a 28-year-old costumer, well adapted to new technological gadgets, enters a clothing store to buy a dress for her friend's wedding.

While walking on the corridor she finds a particular blue dress that may fit her but she is not sure whether to buy it. She takes it to get a first glance of how she looks with it. Elizabeth gets in front of a mirror, and holds the dress in front of her to see how she would look in it.

She likes the dress, but she would prefer a different color that is not available in the store. While thinking about the color, she notices that this mirror is not a regular mirror since it starts to offer a variety of options to chose from including the shape, texture and color of her particular dress. The mirror is actually offering Elisabeth the option to change the color of her dress. Elizabeth starts interacting with the mirror, customizing her outfit using the options that the mirror offers. First, she points at the turquoise color icon but realizes that the color does not fit her at all. So she opts for the purple color icon. After seeing the dress from different angles, she chooses the purple one. She uses her account on the interactive mirror system to be able to use her already known personal data. Elizabeth pays with her credit card directly at the mirror. Elizabeth receives the package with her order two days later.

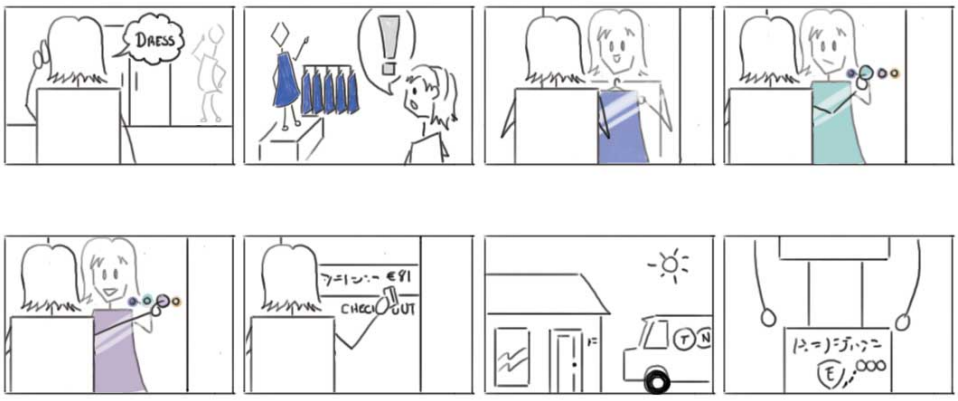


Figure 2.4: Storyboard for scenario Elizabeth

A set of questions was then asked to gain insights into how these interactions were perceived by the users of the product. In the following, we show two sample questions for the interaction above (for the remaining questions see section A.2). The questions had to be answered on a four-point Likert scale. This scale was chosen to avoid neutral responses.[6] In the following we give two sample questions of the questionnaire.

- I understand the presented interaction.
- I would enjoy having a possibility to try different colors of a piece, using the Tweet mirror.
- I would order clothes in the store and have them sent to my home.
- I would use a pure electronic system to pay at.
- I would order customized versions of clothes. (for instance in a different color)
- What did you find especially positive in that interaction?
- Is there anything that you would like to add?

At the end of the questionnaire some general questions, which were targeted on the users' view of the whole concept of the interactive mirror, were asked.

Second scenario

- Requirement FR9 "Share media"
- Requirement FR12 "Have real-time conversations"
- One question that was not related to a requirement was whether the participants would create an personalized account on the mirror and store their personal information

[6] Using a scale with an even number of answering options was abandoned later on to allow neutral responses.

The text and the illustrating storyboard for the second scenario are given in section A.2.1.

Third scenario

- Requirement FR1 “Pay at the interactive mirror”
- It was researched how the participants think over the possibility to replace the contact with employed of the store, for instance when paying, with using the interactive mirror.
- It was researched whether the participants could imagine entering personal information, for example their credit card number, to the interactive mirror.

The text and the illustrating storyboard for the second scenario are given in section A.2.

Results

A personal interview was carried out with two participants. 20 participants filled out the questionnaire on the Internet. The following section discusses the results of the survey grouped by the three themes that we identified in section 2.3.1.1.[7] The results and the priorisation from NEDAP (see section 2.3.2.2) were used as input for a discussion that arrives at a final priorisation of the three themes that provided the directions for the further work. In that discussion we used the results from the user test as a foundation that was aligned with the priorisation from NEDAP. In case of conflicts we preferred the results from the users. The results are given in table 2.5 with the mean score and standard deviation being calculated using a numerical value of 1 for “strongly disagree” and using a numerical value of 4 for “strongly agree.”

[7] Participants that did not answer a question cause the difference to 100%.

Table 2.5: Results from the web survey

	Strongly disagree			Strongly agree	Mean	S.D.
Storyboard Kim						
I understand the presented interaction.	0%	5%	25%	60%	3.61	0.61
I would use the interactive mirror to share media on the Internet.	40%	20%	25%	5%	1.94	1
I would use the interactive mirror to have a videoconference with a friend using MSN or Skype.	30%	30%	15%	15%	2.17	1.1
I would use the interactive mirror to login to my account on a social network.	50%	10%	25%	5%	1.83	1.04
I would create an account on the interactive mirror.	50%	15%	25%	0%	1.72	0.89
Storyboard Elizabeth						
I understand the presented interaction.	0%	0%	20%	75%	3.79	0.42
I would enjoy having a possibility to try different colors of a piece, using the interactive mirror.	5%	10%	60%	15%	2.94	0.73
I would order clothes in the store and have them sent to my home.	10%	30%	40%	15%	2.63	0.9
I would use the mirror to pay at.	15%	30%	30%	20%	2.58	1.02
I would prefer paying at the interactive mirror to paying at a counter.	30%	35%	30%	0%	2	0.82
I would enter my personal data to the interactive mirror.	40%	35%	20%	0%	1.79	0.79
I would order customized versions of clothes.	5%	25%	45%	10%	2.71	0.77

Storyboard Jon[8]						
I understand the presented interaction.	0%	0%	100%	0%	3	0
I would prefer paying at the Tweet mirror to paying at a counter.	0%	50%	50%	0%	2.5	0.71
I would use the mirror to pay at.	0%	0%	100%	0%	3	0
I would enter my personal data to the Tweet mirror.	0%	0%	100%	0%	3	0
Closing questions						
I think that I would use the interactive mirror	10%	20%	50%	10%	2.66	0.84
I think that the interactive mirror would improve my shopping experience	10%	25%	40%	15%	2.66	0.91
I think that the functionality of the interactive mirror would help me when looking for clothes	0%	20%	60%	10%	2.89	0.58
I would revisit a store that has an interactive mirror	0%	20%	50%	20%	3	0.69

The following section discusses the results of the survey and the interviews for each of the three themes "find outfit," "shopping" and "share media."

Find outfit

The basic idea of using the mirror to assist one while finding an outfit was perceived positive since the question whether they would like such functionality received a mean score of 2.94. The related concept of having the possibility of trying and creating customized versions of clothes was seen rather positive (mean score: 2.71). Participants of the survey considered these functionalities "extremely useful" and appreciate the possibility "to try different colors which aren't in the shop." The idea of creating an account at the interactive mirror, for example to be able to store self-created outfits, was seen negative (mean score: 1.72).

Important issues, which were mentioned in the interviews, were privacy concerns when trying, for instance, underwear or similar clothes in front of a device that is placed in a store. To address this issue, the participants

[8] Only the two participants of the personal interviews answered these questions.

suggested placing the mirror in a more private environment, or creating a more private environment around it.

A functional requirement that was mentioned by the participants regarding this theme was that the picture of the user in the mirror must accurately follow the user's posture – just as a "real" mirror would. Further ideas that were mentioned were a precise, automated prediction of dress sizes or an extension of the concept from only being able to select pieces of clothing to accessories, such as hats or collars.

Shopping

The idea of using the interactive mirror as a device to pay at, was regarded quite critical by the participants of the survey. The question whether one would pay at the interactive mirror was answered undecided (mean score: 2.58). Paying at the interactive mirror instead of paying at a counter was judged negative (mean score: 2). Entering personal information to the mirror was also perceived fairly negative (mean score: 1.79). The missing presence of humans in such a setting was also criticized in the personal interviews. Participants mentioned the possible necessity of human assistance when being exposed to such a system.

Ideas of this theme that were not centered on the payment process were perceived more positive. For instance the function of ordering clothes (mean score: 2.63) or the function of ordering customized versions of clothes (mean score: 2.71) was rated as being beneficial.

Share media

The idea of logging in to ones own account on a social network with the interactive mirror was rejected (mean score: 1.94). This result is also supported by the rejection of the idea of entering personal data because of concerns "of possible visibility" or that users wanted to be sure "that your social network will log out as you walk away from the mirror" that were voiced in the interviews. Additional ideas on sharing were as well seen fairly negative (sharing media on the internet: mean score: 1.94; videoconferencing: mean score: 2.17). Important issues that were expressed in the interviews regarding the sharing capabilities were privacy concerns.

A possible extension for this theme, which was mentioned by a participant of the interviews, was the possibility to also send MMSs (Multimedia Messaging Service) to mobile devices.

2.3.2.2. Priorisation from NEDAP

The following section shows the priorisation of the requirements that was given to us by NEDAP. As our user tests implied, the focus should, also

according to NEDAP, be put on the theme “find outfit.” Only secondary attention should be given to the remaining themes, which were “shopping”, and “share media.” The individual requirements were prioritized by NEDAP as shown in the following lists.

Priority 1

- **FR4** (Display different colors and designs)
- **FR5** (Get suggestions for outfits)
- **FR6** (Customize pieces of clothing)
- **FR7** (Display related items)
- **FR11** (Suggest the size of clothes)

Priority 2

- **FR1** (Pay at the interactive mirror)
- **FR3** (Order items)
- **FR12** (Have real-time conversations)

Priority 3

- **FR2** (Check availability of articles)
- **FR8** (Display advertisements and/or discounts)
- **FR9** (Share media)
- **FR10** (Provide background music and/or ambient light)
- **FR13** (Provide navigational support)

2.3.2.3. Results

The responses to the questions on the system as a whole were positive, as it will be described in the following. The majority of the participants answered that they would indeed use such a system in a store (mean score: 2.66). The question whether the participants would revisit a store that offers such a device was also answered positive (mean score: 3). A slight majority answered that such a device would improve their shopping experience (mean score: 2.66).

The results of the survey motivated a focus on the theme “find outfit”, which is having the possibility to try different colors and designs of clothes. This is justified since the features of this theme were, as discussed above, regarded most positive as a basic functionality of this theme received a mean score of 2.94. Requirements and further ideas from the users for these functionalities were also collected, as mentioned in the preceding section.

The share functionality scored rather worse in the user survey. But, nevertheless, we decided to give it the second priority in the further work.

One reason was that sharing is a core functionality of the underlying product the Tweet Mirror, which is already successfully in use in stores, and thus excluding the share functionality would mean a break with the foundation of our work. A second reason was that we researched that the concept of sharing is a common concept among our target group and we expected lower problems when presenting such functionality to the user. One explanation for the rather negative could be privacy concerns, which will also be mentioned below when discussing the "buying" theme. These concerns might arise, as it is rather uncommon to use devices in a common space to share media.

A theme that will, based on the user survey, be neglected in the further work is the one that concerns the paying functionalities. The survey provided a rather clear picture of possible problems. Privacy concerns of the participants were present in the negative, meaning a mean score from less than 2.5, answers to questions like whether one would enter personal information to the mirror or whether one would create an account at the interactive mirror. Furthermore, the participants of the personal interviews also voiced such concerns. Possible negative effects on the atmosphere on the stores could be deduced from the negative answer to the question whether one would prefer paying at the mirror to paying at a counter. Furthermore, allowing it to pay at the mirror might also force a consideration of legal issues of that process, which lies outside the scope of our report focusing on the interface of the system and the interaction.

The priorisation that resulted from the user survey was to a certain extent similar to the priorisation that was given by NEDAP. Both sources named the "find outfit" as a clear first priority for our further work. NEDAP's second priority was, in contrast to the results of the user test, rather the "shopping" theme. Prioritizing the results of the user test higher, we decided to place a secondary focus on the "share media" theme and put the "buying" theme as third priority.

2.4. Prototype

The following section describes the functionalities of the prototype that we used in the user test of the first iteration. Two themes were, based on the priorisation that was discussed in section 2.3.2.3, implemented in the prototype. First "choose outfit" which received the highest priority and second "share media" which received the second highest priority in the user survey. A brief overview of how these themes were implemented in the prototype shall be given now.

An important consideration in the design of the prototype was to give it a sketchy and incomplete look. By doing this, we hoped to lower the obstacles of the participants of the user test to give feedback and provide ideas about the prototype.

2.4.1. Functions

As said, the prototype featured functionalities from two themes that will be discussed in this section. Furthermore, we will also mention how the prototype was controlled, of course not really since the prototype did not have capabilities for touch-based interaction and gesture recognition and was, thus, tested in a Wizard-of-Oz setting.

2.4.1.1. Choose outfit

Three requirements of this theme were implemented. They were chosen because we considered them to be the basic requirements of the themes. Getting feedback on the implementation of them allowed it to proceed on a foundation that was justified by user tests when implementing the further requirements. For instance the implementation of the requirement “display different colors and designs,” could serve as a basis for the requirement “customize piece of clothing,” which demands similar functionalities like displaying and switching pieces of clothing on the screen.

Display different colors and designs

Req#: FR4

This functionality is displayed in figure 2.5. The shirts and pants of the prototype can be changed by clicking on the small shirts and pants, which are to the left and right of the representation of the user. When clicking on it, it shows that design on the representation of the user. Clicking on the colored dots on the left of the user changes the color of the design of the shirts and pants that is currently selected.

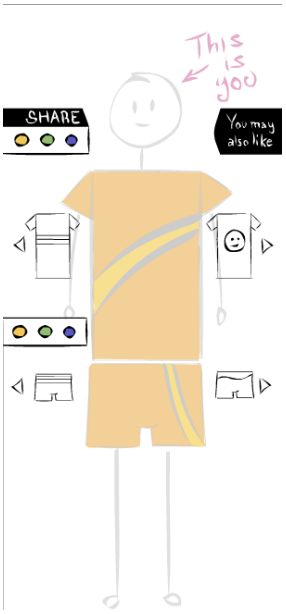


Figure 2.5: Screenshot of the prototype – Display different colors and designs

Suggest outfit

Req#: FR5

Suggestions for an outfit can be accessed when the user clicks on the “you may also like” button. An overlay shows then some pieces of clothing that can be selected by clicking on them (See figure 2.6).

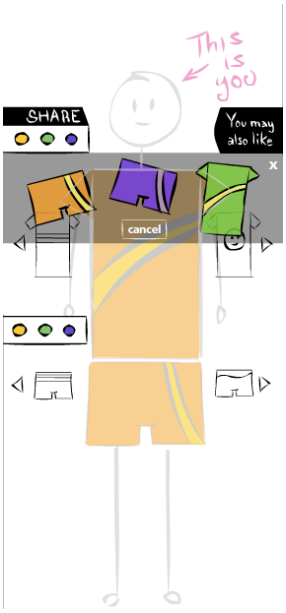


Figure 2.6: Screenshot of the prototype – Suggest outfit

2.4.1.2. Share media

Req#: FR9

Create picture/movie to be shared

After clicking on share, the user can select between two options (see figure 2.7). The first option shares a photo of how the user looks in his outfit. Clicking on the second option shares only the clothes, without taking a picture of the user.

Figure 2.7: Screenshot of the prototype – Share functionality

Choose platform for sharing

After selecting what to share, the user can choose the platform on which the created picture or the selected outfit should be shared by clicking on the corresponding logo (see figure 2.8). After having selected the platform, the message is entered – in the prototype the message cannot be altered – and can then be virtually sent.

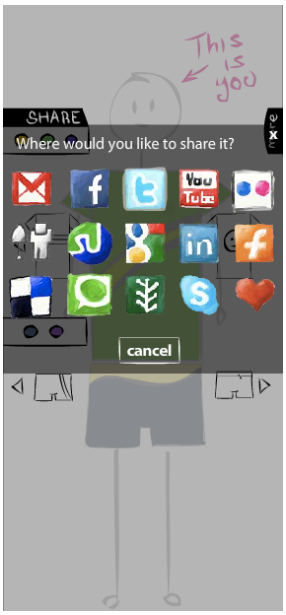


Figure 2.8: Screenshot of the prototype – Choose platform for sharing

2.4.2. Interaction

The following sections shortly explain the interaction techniques that we used in the prototype. Two techniques of interaction were implemented: touch-based interaction and gestural interaction. Touch-based interaction is a logical choice, since lots of systems that are used in a similar context, for instance information kiosks or ticket selling machine, rely on touch-based interaction. Gestural interaction was chosen because of its novelty and also because it allows, compared to touch-based interaction, interaction from a distance. This is something that we expected to be desirable as the user of such a system is likely to move and stand on some distance to the interactive mirror while interacting the system, for instance to be able to watch himself from different perspectives.

Both interaction techniques were deliberately kept simple to avoid an orientation towards the interactional component of the system. Such an orientation would not be desirable since we first wanted to establish a stable user interface through user tests.

2.4.2.1. Touch-based interaction

Tapping on the elements of the interface with a finger controlled the prototype. This technique is described by (Saffer, 2009) as “tap to select.” He calls it one of the most basic gestures. Thus, we expected it to be intuitive for the users of our prototype as it is used in numerous interfaces.

2.4.2.2. Gestural interaction

We relied on a pointing gesture for the selection of the interface elements, for instance the color selectors or the share button. This gesture is named by (Saffer, 2009) to be the most natural gesture for selection in gestural interfaces. We did therefore as well assume that it would be intuitive for the users. The changing of the design of the clothes was done by a waving gesture. This is also mentioned by (Saffer, 2009) as a common gesture for scrolling

2.5. User test

After having described the prototype of the first iteration, we now continue by explaining how it was tested. The first two parts of the following section address the setup and planning of the user test. The last part of this section discusses the results and evaluates the procedure of the test.

In the following section we are going to describe the design of the user test that was carried out in the first iteration. The first section describes the results that we wanted to obtain from the test by stating its aim. How we planned to obtain this data is then stated in the following section about the methodology. Following, we discuss the setup of the test. To do this, we describe the technical setup of the test, the tasks that the participants had to carry out and the means that we used to obtain the necessary data to evaluate the prototype.

2.5.1. Aim

First of all, we needed to decide which interaction technique – gestures or touch – to include in the system. Of course, both interaction techniques are not mutually exclusive since they can supplement each other. The decision which interaction technique to include, and to what extent, in the final system should be supported by comparative data on their usability characteristics that was collected in the user test. In the following we understand usability as being easy to learn, being useful, being easy to use and being pleasant to use, as it was summarized by (Dicks, 2002).

We also aimed for a judgment of the usability, as it was summarized above, of the prototype. To achieve this, we compiled a usability questionnaire from the literature that addressed these aspects of usability and conducted some interviews afterwards.

Furthermore, finding usability problems at this early stage was important. Later implementation of a working prototype embodied bigger

technological difficulties, mainly the component for gesture-recognition, compared to the simple Flash-based approach that we employed in this user test, thus making adaptations more difficult.

2.5.2. Methodology

We addressed the aims that were described in the last section by a within-subject, Wizard-of-Oz laboratory study. The within-subject approach was chosen, as it is particularly suitable for comparisons of alternatives. One aim of our test was comparing the participants' views about using gestural and touch based interaction to control the system. To gather the data for this comparison, each participant filled out two subjective satisfaction questionnaires that covered their opinions on both interaction techniques that they tried in the test. The Wizard-of-Oz approach and also the carrying out of the tests in a laboratory was chosen since the prototype itself was, due to lacking technological capabilities, not yet ready to be tested in a real environment.

The aim of getting a usability judgment and exposing potential problems was addressed with two techniques. First, we asked the participants to think aloud while they were interacting with the prototype. This technique helps to expose and understand usability problems of the system (Holzinger, 2005). This method was supplemented with videotaping to allow a more thorough study of the participants' comments afterwards. The participants also filled out a usability questionnaire that was compiled from the literature after the completion of the tasks, which enabled us to also rely on quantitative data for our judgments to supplement the qualitative data gained from the thinking aloud and the interviews. Furthermore, we conducted a short interview with the participants after the filling out of the questionnaire to address incidents and problems that occurred during the test.

2.5.3. Test plan

After having described the technical setup we now explain how the test was carried out in detail. A precise definition of the procedure of the test was important to ensure that every participant had the same prior information about the system when carrying out the tasks and that the test could be reproduced later on.

2.5.3.1. Setup

The following section describes the setup of the user test in detail. We discuss the number of participants, the technical setup, the tasks that the participants had to carry out, and how we obtained the information that was used to evaluate and adapt the prototype.

Participants

The user test was carried out with six participants. According to (Virzi, 1992), this number should be enough to find the majority of the major usability problems of the tested system. Nevertheless, a larger number of participants would have provided a higher certainty that the major usability problems have been found as discussed by (Faulkner, 2003).

Technical setup

The following section discusses the technical setup of the user test. It summarizes and motivates the characteristics of the prototype, which has already been described in detail, and explains the technical equipment that was used to carry out the test.

The test was carried out using a low-fidelity prototype that was based on Flash. This technology allowed a relatively fast production and modification of the prototype and, compared to paper prototypes, real interactivity. Moreover, studies reported that computer-based low-fidelity prototypes have a positive influence on the results of user tests. The employment of such prototypes makes the participants feel more comfortable (Sefelin, Tscheligi, & Giller, 2003). Furthermore, (Walker, Takayama, & Landay, 2002) found that using a computer-based prototype leads to a higher amount of comments from the participants of a user test.

The user test has been conducted in the Smart XP lab of the University. We used a standard LCD screen to display the prototype to the participants. The prototype was controlled from an external computer that was operated by one experimenter to simulate the responses of the system to the participants' input. A Wizard-of-Oz setting was chosen to make the system appear interactive to the user, as the prototype was technically not able to recognize gestures or touch (Saffer, 2009, p. 122). The wizard was placed in a way that he was able to see precisely where a participant touched the screen or on what that target he pointed. We opted against a setup using a camera that transmitted the participants' interactions to a wizard that was seated behind a barrier because we expected that the participants' to move or standing at different distances from the system while interacting and, thus, possibly blocking a fixed camera.

To simulate the mirror effect we placed a reflective foil, which was mounted on a wooden frame, in front of the screen. Figure 2.9 shows the setup of the user test.

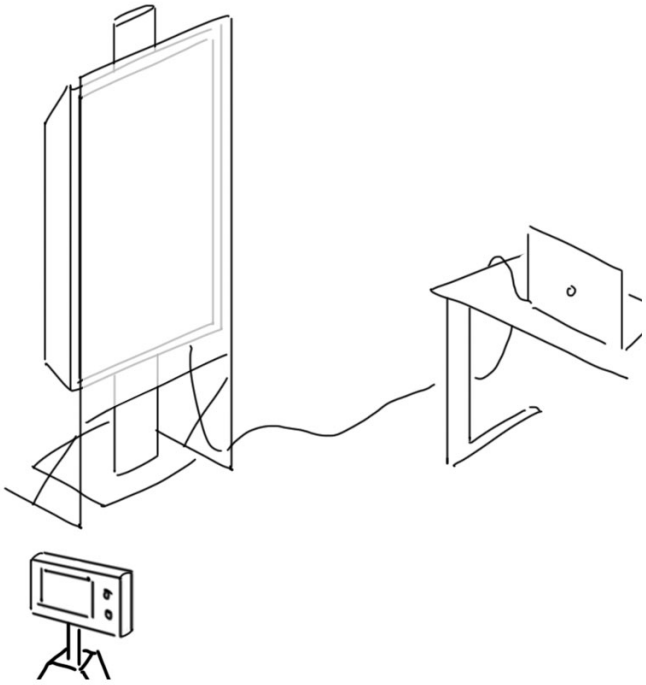


Figure 2.9: Setup of the first user test

Observation

First of all, the user test was recorded on video to allow a thorough analysis of the test at a later time. We chose an unobtrusive position for the camera to lower the participants' distraction. To increase the participants' feeling of privacy we recorded their interactions from behind to solely capture their actions and the screen but not their face.

One experimenter conducted the test. He instructed the participants and answered their questions during the test. A second experimenter took notes of unexpected or interesting events, for example unusual ways to control the interface or occasions when the participant got stuck, to discuss them later on if necessary. The third experimenter acted as the wizard that controlled the prototype from an additional computer.

2.5.3.2. Briefing

The briefing was used to instruct the participants about the purpose of the test, what kind of data was collected during the test and what was done with the results that were obtained. We also explained to the participants that we wanted them to think aloud during the test. A set of topics that can be

mentioned in such a briefing and served as a basis for us is given by (Nielsen, 1993b, p. 188). The complete text that was used is given in section A.3.1.

2.5.3.3. Demographic questionnaire

After we completed the briefing the participants were asked to fill in a questionnaire that asked for characteristics of the participants, like their age or their shopping behavior (see section A.3.3 for the complete questionnaire).

2.5.3.4. Tasks

Participants were asked to complete a set of tasks with the prototype. These tasks were the same for all participants, to get comparable results. The list of tasks spanned basic functionality that got prioritized high in the user survey.

The following sections describe these tasks. They explain how the tasks were introduced to the participants and when a task was judged as completed. (Saffer, 2009) calls this creating a "moderator script."

The tasks had to be completed twice by the participants: once using touch-based interaction and once using gesture-based interaction. This should give the participant the possibility to compare the usability characteristics both interaction techniques. To avoid ordering effects the order in which both interaction techniques were used was changed between the participants.

2.5.3.5. Explanation of the interface

In the first step we wanted to give the participants an impression about how the system could be controlled by using gestures or touch. To do this, we showed them once how to change the design of a piece of clothing and how to change its color.

Introduction

"In the beginning, we want to give you an idea of how this system can be controlled using free form gestures/touch based interaction. We are now showing you a part of the system's functionalities. After you have completed a set of tasks using gestures-based/touch-based interaction we would like you to do the same set of tasks again with the other interaction technique."

Explanation of touch based interaction

“First, we show you how you can use touch to control the system. You can click on this part of the screen to switch your shirt. You can also change its color by clicking on one of these icons.” *(The experimenter did the described actions.)*

Explanation of gestural interaction

“Now we want to show to you how you can use gestures to interact with the system. When you do this gesture you can switch the shirt. You change its color by pointing on one of these icons.”

“Do you have any questions about the things that we explained to you?“

2.5.3.6. Select outfit

This is the first task of three in which we addressed functionalities of the theme “find outfit.” It was the participants’ task to alter their outfit in a certain way. This task was introduced with the following text:

“Your first task is to use the interactive mirror to change the outfit that is being displayed on the screen.”

The separate steps of this task were introduced with the following texts:

1. “First, change the shirt design to the one with a diagonal stripe.”
2. “Change the color of the shirt to purple.”
3. “Now select the pants with the two stripes.”
4. “Change the color of the pants to red.”

After the participants have completed the last step of the list we continued and introduced the second task that will be described now.

2.5.3.7. Share media

The second task addressed the functionalities that are related to sharing pictures on the Internet, in this task using Twitter. This task was introduced with the following text:

“Now after selecting an outfit you are going to share this picture using Twitter.”

The separate steps of this task were introduced with the following texts:

1. “First, you should select the menu option to share your outfit.”
2. “Select Twitter and send the message.”

After the participants have completed the last step of the list we continued and introduced the third task that will be described now.

2.5.3.8. Recommend outfit

This task tested the functionality to have the mirror propose an outfit to the user.

“After choosing an outfit by yourself, you should now use the function to recommend an outfit to you.”

1. “Select the option to have the interactive mirror do a recommendation for matching clothes.”
2. “Select a random outfit.”

After the last step was completed, the participants were notified of the end of the first part of the test. If the tasks were finished using the first interaction technique, the second interaction technique was introduced and the tasks had to be carried out again using the other technique. If this was the second time that the tasks were finished the debriefing, which is being described in the following, was done.

2.5.3.9. Debriefing

The first step after completing the tasks was letting the participants fill in a questionnaire. The content of the questionnaire is discussed later on. A further part of the debriefing was a short, semi-structured interview with the participants on any questions that stayed open during the test or on remarkable observations.

2.5.4. Evaluation

The following section describes how we evaluated the data that we obtained from of the user test.

2.5.4.1. During the test

During the test, the participants were asked to think aloud. Thinking aloud helps understanding why users do something (Nielsen, 1993b). Thus, it was an addition to better addition the characteristics of the system.

2.5.4.2. Questionnaire

Two sets of questions addressed the usability characteristics of the interaction techniques that the participants used in the test. They were asked for both techniques and were answered on a five-point Likert scale.

The questions that addressed gesture-based interaction can be found in the following. Analogue questions were asked for touch-based interaction.

1. I found the interaction with gestures intuitive.
2. I found that the gestures were easy to learn.
3. I found that using gestures was tiring.
4. I think that gestures are a good technique to control this interface.
5. I think that using gestures was an exciting way to control the interface.

After completing the tasks, the participants were asked to fill in a questionnaire. To avoid biased responses, the filling out of the questionnaire took place before any further discussion (Brooke, 1996).

To create the questionnaire, we relied on input from the usability questionnaires that were proposed by (Chin, Diehl, & Norman, 1988) and (Brooke, 1996). The questionnaire was supposed to provide a more precise picture on how the system was perceived by the participants in terms of its usability. [9] The aspects of usability that we targeted were: easiness to learn, usefulness, easiness to use and pleasantness to use. (Dicks, 2002)

The following questions from (Brooke, 1996) were asked to the participants and had to be answered on a five-point Likert scale.

1. I think that I would like to use the interactive mirror frequently
2. I found the interactive mirror unnecessarily complex
3. I thought the interactive mirror was easy to use
4. I think that I would need the support of a technical person to be able to use the interactive mirror
5. I found the various functions in the interactive mirror were well integrated
6. I thought there was too much inconsistency in the interactive mirror
7. I would imagine that most people would learn to use the interactive mirror very quickly
8. I found the interactive mirror very cumbersome to use
9. I felt very confident using the interactive mirror
10. I needed to learn a lot of things before I could get going with the interactive mirror

Additionally a set of further more specific questions was asked. These included the following questions that were proposed by (Chin, et al., 1988) and had to be answered on a five-point scale:

[9] To facilitate the evaluation, the questionnaire was filled in on a computer.

1. Organization of information on the interactive mirror (Confusing — Very clear)
2. Elements on the interface of the interactive mirror (Hard to read — Easy to read)
3. Sequence of the steps of the interactions (Confusing — Very clear)
4. Position of information on the interactive mirror (Inconsistent — Consistent)
5. Tasks can be performed in a straight-forward manner (Never — Always)

As closing questions we asked a set of general question on the interactive mirror. Answers had to be given on a five-point Likert scale.

1. I think that I would use the interactive mirror
2. I think that the interactive mirror would improve my shopping experience.
3. I think that the functionality of the interactive mirror would help me when looking for clothes.
4. I would revisit a store that has an interactive mirror.

2.5.5. Results

The following section shows the results of the user test. The conclusions that we drew based on them are described in a subsequent section.

2.5.5.1. Task success

There were seven tasks the user had to complete using touch-based interaction and gestural interaction. These seven tasks, which were already discussed in detail in section 2.5.3.4, were the following:

- **Task 1:** Change the shirt to a certain model
- **Task 2:** Change the shirt's color to a certain color
- **Task 3:** Change the pants to a certain model
- **Task 4:** Change the pant's color to a certain color
- **Task 5:** Share a picture with the outfit
- **Task 6:** Select Twitter and send a message
- **Task 7:** Select a recommended outfit

The detailed results of the tasks can be found in appendix A.3.4. In the table below, the results are represented in a condensed form. For every task the

percentage of successful executions are mentioned; not executed[10] tasks are not taken into account in the calculation of the success rates.

Table 2.6: Task success in the user test of the first iteration

	Touch-based	Gestural	Total
Task 1	100%	100%	100%
Task 2	83%	80%	82%
Task 3	100%	100%	100%
Task 4	83%	100%	91%
Task 5	100%	60%	82%
Task 6	100%	60%	82%
Task 7	100%	80%	91%

Observations:

- One participant commented that it could be difficult to find one specific model of a piece of clothing just by scrolling.
- One participant got confused on how to change the color of an item with the use of gestures. This participant used the gesture of waving his hand from top to bottom to change color instead of pointing on the colored buttons, as it was presented in the beginning of the test. This participant considered that while swiping the hand from top to bottom is the most logical step to change the color of the garment, it required arrows up and down to indicate that such gesture is available.
- One participant considered that pointing at the piece of clothing itself is the best option to change its color.
- One participant indicated his preference to scroll the recommended outfits instead of having multiple options at the same time.
- One participant had trouble finding the share button. He overall felt more comfortable and familiarized with the use of a touchscreen. However he expressed some amusement and approval of the use of gestures.
- One participant swiped the shirt model instead of clicking on the arrows as it was presented in the beginning in order to get to the

[10] They were not executed because of technical problems with the prototype.

next model. This was, as he explained in the interview, due to his familiarity to Android devices.

2.5.5.2. Questionnaire

After completing the tasks, the six participants were asked to fill in a questionnaire. The questions and reasoning of this questionnaire can be found in section 2.5.4.2. Complete results of the questionnaire can be found in appendix A.3.5. The responses for the questions can be found in table 2.7. The mean and the standard deviation (S.D.) were calculated using a scale reaching from 1 for "strongly disagree" to 5 for "strongly agree."

Table 2.7: Results of the questionnaire of the first user test

	Strongly disagree				Strongly agree	Mean	S.D.
Gestures interaction							
Intuitive	0%	50%	17%	33%	0%	2.83	0.98
Easy to learn	0%	67%	0%	33%	0%	2.67	1.03
Tiring	0%	60%	20%	20%	0%	2.60	0.89
Good technique to control the interface	0%	50%	17%	17%	17%	3.00	1.27
Exciting way to control the interface	0%	0%	0%	100 %	0%	4.00	0.00
Touch input interaction							
Intuitive	0%	0%	0%	50%	50%	4.50	0.55
Easy to learn	0%	0%	17%	33%	50%	4.33	0.82
Tiring	33%	50%	0%	17%	0%	2.00	1.10
Good technique to control the interface	0%	0%	0%	83%	17%	4.17	0.41
Exciting way to control the interface	0%	17%	17%	67%	0%	3.50	0.85
Interactive mirror in general							
Would use it frequently	0%	33%	17%	50%	0%	3.17	0.98
Unnecessarily complex	17%	50%	17%	17%	0%	2.33	1.03
Easy to use	0%	17%	17%	50%	17%	3.67	1.03
I would need the support of a technical person to be able to	17%	83%	0%	0%	0%	1.83	0.41

use it							
Various functions well integrated	0%	0%	17%	83%	0%	3.83	0.41
Too much inconsistency	17%	50%	0%	17%	17%	2.67	1.51
Most people would learn to use it very quickly	0%	0%	33%	50%	17%	3.83	0.75
Very difficult to use	33%	33%	17%	17%	0%	2.17	1.17
I felt very confident using it	0%	0%	33%	50%	17%	3.83	0.75
I needed to learn a lot of things before I could get going	50%	50%	0%	0%	0%	1.50	0.55
Closing questions							
I would use it	0%	17%	0%	83%	0%	3.67	0.82
It would improve my shopping experience	0%	0%	50%	50%	0%	3.50	0.55
Functionality would help me when looking for clothes	0%	0%	50%	50%	0%	3.50	0.55
I would revisit a store that has an interactive mirror	0%	0%	50%	33%	17%	3.67	0.82

2.5.5.3. Discussion of the results

The section summarizes the results of the user tests and discusses their implications for the further work.

Participants group

All six participants were in the age group of 16 to 32, which was also our defined target group. However, this narrow age spectrum could lead to a bad generalizability of the results for users that do not fit in this tested age group. Four of the participants were male and two were female. The frequency of visiting a shop, where the answer options ranged from one for "daily" to four "more seldom than monthly", is rather spread (standard deviation: 0.89) among the participants with a mean at "at least monthly." All participants use social networks daily but the experience with sharing of media on social networks, where the answer options were the same as above, is rather spread (standard deviation: 1.22) with the mean value between "at least weekly" and "at least monthly."

Interaction techniques

Touch-based interaction scored, as it will be clarified later on, better in the questionnaire than gestural interaction. This did also hold in the user tests.

The results for touch-based interaction were also less spread as shown by their standard deviations. The intuitiveness of touch-based interaction was answered, on a scale between one for “strongly disagree” and five for “strongly agree,” positive with a mean of 4.5 and a, compared with similar questions, small standard deviation of 0.54. Another measure where touch-based interaction outperformed gestural interaction was easiness to learn where touch-based interaction received with a mean score of 4.33 a higher result than the 2.67 for gestural interaction. The question whether touch-based interaction was a good way to control the system received a mean score of 4.17 with a standard deviation of only 0.41. The only question in which gestural interaction received a higher score was whether it is an exciting way to control the interface (mean score for gestural interaction: 4.0 with a standard deviation of 0, mean score for touch-based interaction: 3.5 with a standard deviation of 0.84).

Interface

In general, the interface received, as far as it was measured by our questionnaire, rather positive feedback from the users. This was evident in the responses to the questionnaire (easiness of use received a mean score of 3.67 with a standard deviation of 1.0, learnability received a mean score of 3.83 with a standard deviation of 0.75). Other facts were as well judged positive. The way in which the tasks could be carried out was perceived positive (i.e. 74% regard the position of the information as “rather consistent” or “consistent”, 83% answered that the tasks could be performed in a straight-forward manner). We considered these results as evidence that the concept of the interface that we presented aimed in the right direction.

An aspect of the interface that was an issue for many participants was the placement of the “Share” button on the screen. Participants had difficulties to find it and considered its placement illogical. Its placement close to the buttons for color selection suggested a relation between these functionalities that did not exist.

The labels of the options that appeared after clicking on share were considered ambiguous. Participants were not sure which option to select as the difference between “Share outfit” and “My look” was hard to grasp (see figure 2.10).

Figure 2.10: Share functionality

The menu layers were not visualized clear enough. It was not clear for the participants that the elements of a lower level were not to be used when a menu layer was placed on top of them, as not enough visual evidence for this was given. A good example of this was the function for selecting related outfits, where participants tried to click on the shirt selectors of the lower menu layer (see figure 2.11).

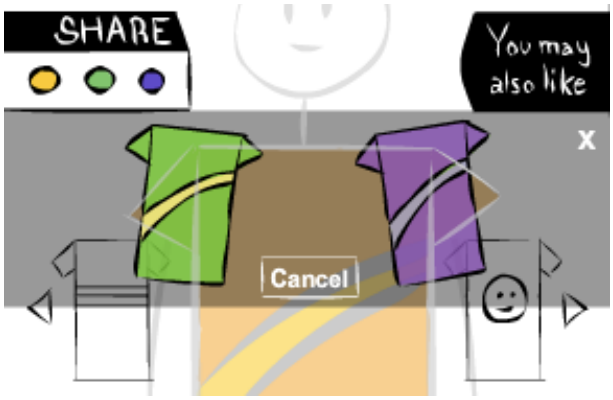


Figure 2.11: Menu layers

The last two issues exposed a confusing organization of some elements on the screen. This did also hold in the questionnaire (50% of the participants found the organization “slightly confusing” or answered neutral).

Some of the elements on the interface were considered too small. The selectors for color, for instance, were easy to miss when using them with touch-based interaction or gestural interaction. For example, even the wizard had problems to distinguish what element the participant selected.

Another example for this is the layout of the screen where the platform for sharing was to be selected. The small size of these elements did also increase the possibility to overlook them, as it happened with the “Share” button and the color selector.

The function for the selection of related outfits was difficult to use as it just presented a set of clothes without an indication of how they could be used or why exactly these were being displayed.

2.5.6. Conclusions

Based on the results that were discussed in the last section we are now going to describe which directions we derived from them for the work in the second iteration.

2.5.6.1. Interaction

Generally, the interaction techniques that were used for touch-based and gestural interaction turned out to be usable. The recommendations of (Saffer, 2009) regarding intuitive interaction techniques for basic operations using touch-based and gestural interaction on which the interaction techniques were based (see section 2.4.2) turned out to be correct as far as we were able to asses this with our test procedure.

Gestural interaction alone was not able to provide a reliable way of interaction for the user. Functions such as changing the piece of clothing or changing its colors worked well in the user test, but selecting elements on the screen was rather problematic.

We decided to rely mainly on touch-based interaction for the following prototypes. The reasons for this choice should be explained in the following section. Touch-based interactions worked for all participants without causing major problems. Gestural interactions worked worse and caused serious problems for some participants. A second reason for this choice is that reliable technologies for gesture recognition were not available. Based on the results of the tests, we decided that the following prototypes will rely primarily on touch-based interaction. Gestural interaction will be used as an addition

2.5.6.2. Interface

The user test resulted in the exposition of numerous usability issues of the prototype that were addressed in the second iteration. These issues are listed in the following.

- The placement of the “Share” button had to be changed, since the placement in the first prototype was considered confusing and was easy to overlook.
- The wording of the options after clicking on “Share” had to be revised, as it turned out to be ambiguous.
- The placement and size of the color selectors had to be improved, as it turned out to be too small for touch-based and gestural interaction and as it was also in a place where it was likely to be overlooked.
- The hierarchy of the menu layers should be made clearer, as it was unclear that the menu elements of a menu layer could not be operated when another layer was placed on top of them.
- The functionality for outfit recommendation and selection had to be improved. Participants missed, for instance, a possibility to get an overview of all existing shirts.

2.5.7. Evaluation of the procedure

This section discusses the methodology that we employed in the user test and points out its limitations and weaknesses to provide possibilities for improvement for the following user tests.

In general, the user tests proceeded satisfactorily since the tasks were formulated understandable and could be carried out by the participants with the prototype. The specified wording of the task descriptions did facilitate the user tests inasmuch as they forced us to adhere to the same sequence and structure for all participants.

Using a usability questionnaire that was based on the literature paid off. It allowed a broad and complete judgment of the usability of the prototype and allowed the validation of the qualitative data that was obtained in the user tests. However, our questionnaire missed questions regarding the familiarity with the two addressed interaction techniques and also regarding the participants’ technical background in general. These questions could have provided the possibility to understand and classify the responses to the questionnaire and the comments from the user test better. For instance whether a participant that encountered problems with a certain part of the prototype, for example the gestural interaction, had or had not previous experience with something related, for example a Nintendo Wii. Furthermore such information would have allowed assessing whether a link between the technical background of the participants and their performance in the test existed. We also considered, purely subjective, the questionnaires that the users had to fill in at the end as being slightly too long.

Parts of the wording of the task description were ambiguous and words that were used in the questionnaire were not familiar to all participants. One example of an ambiguous task description is “Choose a random outfit.” It was unclear for some participants that they should just pick one of the alternatives that was offered by “you may also like” at random. The word “cumbersome” that was originally used in the questionnaire was unknown to the first participant. To resolve this problem and since we expected that the word would also be unknown to further participants, it was replaced from then on by a synonym which was “difficult.” We were aware of the possible effects of such a change but assumed them to be, especially compared to the problems that this change solved, rather small.

Some technical problems did also hamper the flow of the user tests. The computer that was used for controlling the prototype froze once. Furthermore, some bugs of the prototype were exposed during the test. We cannot make a sound judgment about their impact on the test results, but the distraction that was caused to the user seemed rather small and only temporary.

Another shortcoming of our test setup was the lack of a written consent form that had to be signed by the user. Such a form would have allowed it for the user to review the conditions that he is agreeing on more clearly and would have also provided us legal security for the use of the material in the report that was obtained during the test.

A further shortcoming of the technical setup was that the wizard, the person that simulated the responses of the system to the acts of the participants, was placed in a position that the participants could easily see. Thus, it was likely that they recognized him as the person who actually controlled the system. It is possible that this observation by the participants influenced the results of the user test. This could have been avoided by a more complex setup using a camera that recorded the screen at an angle that was suitable for this. Section 2.5.3.1 describes why we opted against this option.

The prototype itself was biased towards the use of touch-based input. This became evident, for instance, with the small size of some interface elements that were not suitable for gestural interaction. For example the color selector was not usable with gestures because of the small size of its elements that were also grouped too close together. This was rather an issue of our design process, which did not take the necessities of gestural interaction into account, but should, nevertheless, be mentioned here.

The answers to the questionnaire were probably biased. The scores for the intuitiveness and learnability of the system were judged after the

participants tried the system twice, one time with gestures and one time with touch-based interaction. Having had the possibility to try the system two times might have had an influence on the participants' judgments on these questions.

We failed to provide a specification of the test procedure that was clear enough to, for instance, allow another person to precisely reproduce the procedure to be able to verify the results. One example is the missing specification of when a task was judged as completed successfully by the user. Furthermore, the explanation of the interaction techniques was not specified precisely enough. Once, the introduction of the touch-based interaction led to the result that the shirt that the user had to select in the task was already selected.

3. Second iteration

3.1. Tasks

The adaptions to the prototype that were derived based on the results from the user test of the first iteration were implemented to create an improved prototype. The technical capabilities to support gestural and touch-based interaction were implemented in the new prototype.

A procedure to test this new prototype was developed and carried out. This user test was evaluated and adaptions for the final prototype of the system were proposed.

3.2. Adaptions to the prototype

The following section describes adaptations that had to be made to the interface of the prototype of the system in the second iteration and also specifications of the interaction techniques that the system would use. The described tasks are based on the results that were obtained by the user test of the first iteration.

3.2.1. Touch-based interaction

Unlike in the prototype that was used in the user test of the first iteration, where the touchscreen interaction had to be simulated, we now developed a prototype that features a working touchscreen interface.

A working touchscreen allowed, compared to the Wizard-of-Oz setting that we used in the first iteration, a more realistic test setup. For instance, technical influences like delays or inaccuracies that are caused by the touchscreen are also present to the participants of the user test. This also solves the problems of the Wizard-of-Oz technique that we encountered, for example the wizard not being able to see precisely what the participants did. Furthermore, the system that we were developing will, at the end, use a touchscreen as the primary means of interaction, so an evaluation of our interface using a working touchscreen was of importance.

3.2.2. Gestural interaction

The results of the user test suggested that the participants preferred touch-based interaction to gestural interaction when regarding its usability characteristics. The reason why we, nevertheless, decided to keep gestural interaction was that the participants expressed excitement about the gestural interaction that was implemented in the prototype of the system that was evaluated in the first iteration. We considered excitement to be a valid reason to use our system in a store.

We developed and implemented gestures for a limited number of basic tasks. This restriction to basic tasks was introduced since there are tasks in our system, like the typing of a message, where gestural means were available but not yet widespread. Furthermore, we wanted to avoid technical difficulties when implementing complex gestures involving, for instance, recognition of the movements of the fingers. Other tasks, like selecting items on the screen, turned out to be difficult to carry out intuitively for the participants of the first user test. We chose the most basic tasks, the ones that were related with switching the different parts of the displayed outfit and their colors.

The following tasks were supported by gestural interaction:

- Change shirt to the next or the previous model in the list of shirts.
- Change the shirt's color to the next or the previous one in the list of colors.
- Change the pants to the next or the previous model in the list of pants.
- Change the pant's color to the next or the previous one in the list of colors.

Despite the development of the gestures themselves, also the technical framework to recognize these gestures had to be developed and integrated with the prototype.

3.2.3. Redesign the share functionality

Our user test showed that the placement of the share button was in a non-optimal way, as it implied a non-existing relation with the color selection element through its placement next to it. Only two of the six participants of the user test of the first iteration were able to find the share button right away. Thus, a placement for this and a design of that element that is easier to find had to be developed and verified by an user test.

Additionally, the wording of the menu options that appeared after clicking on the share button had to be revised. The user test showed difficulties of the users to distinguish between the option to share a picture of the user (the upper option in figure 3.1), and the option to share the outfit itself without taking a picture (the lower option in figure 3.1). Five out of the six participants made remarks about the ambiguity of that wording.

Figure 3.1: Screenshot of the share functionality

The way in which the platforms on which the outfit can be shared were presented was also problematic. The available platforms were displayed as a grid of their logos (see figure 3.2) which one user mentioned as a source of problems since some logos might be unknown and, as well, the clickable areas were rather small. A way to overcome this had to be found.

Figure 3.2: Screenshot of the selection of the network

3.2.4. Revamp the color selection element

83% of the participants of the user test were successful in changing the color of the clothes using touch-based interaction. The reason why the rest was not successful was because of the size and the placement of the color changer. Moreover, the small clickable areas of this element were suitable for neither touch-based interaction nor gestural interaction. Evidence for this was that it was difficult for the wizard in the first user test to clearly distinguish which element has been selected by the participants. Representing the available colors as discrete clickable items on the interface makes it practically impossible to include a large number of colors, since the consumption of screen space would become too big. Thus, the placement and also the functionality of the color selection element had to be reworked, to make it easier to use and that it adapts to both gestural and touch-based interaction.

3.2.5. Extend the functionalities to select outfits

The first user test exposed missing functionalities in the color selection element. Participants claimed, for instance, that a functionality that provides an overview over all available colors and designs of the clothes was missing. The function that proposed complete outfits to the user was, as well, not usable. Thus, the functionality had to be extended to support these features.

3.3. Prototype

In the following section it will be explained how the discussed issues were addressed in the adapted prototype of the system. The adapted prototype that will be discussed in this section is displayed in figure 3.3.

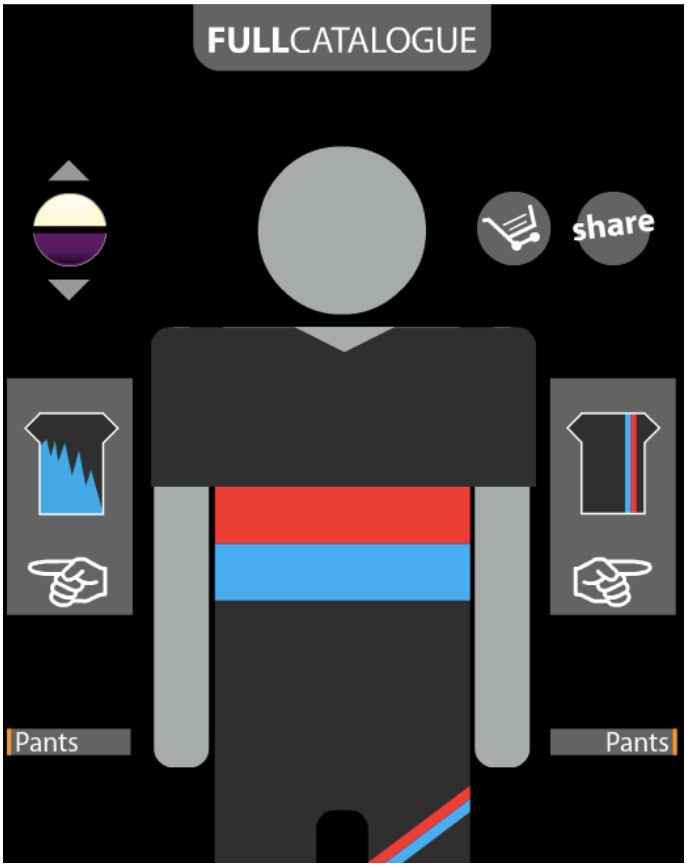


Figure 3.3: Updated prototype

3.3.1. Interaction requirements

To make the prototype more suitable for gestural and touch-based interaction we enlarged, following (Saffer, 2009), the clickable areas, for instance of the color selection tool, and also increased the visibility of their borders. Bigger items are, according to the findings of (Huang & Lai, 2007) preferred over smaller items by users of touchscreens.

The gesture to change the design of a piece of clothing was, as in the last prototype, a sideways swiping gesture. This gesture turned out to be intuitive in the first user test. To change the color of the shirt we had a gesture to swipe vertically. One participant of the first user test that used this gesture when interacting with the system inspired this gesture. The

vertical arrows of the color selection element also possibly supported this gesture.

3.3.2. Interface requirements

The pants and the shirts could no longer be changed at the same time, as it was the case in the prototype of the first iteration. In the prototype of the second iteration, the clothing that should be changed had to be selected by clicking on the horizontal bars with the text shirt or pants. After selecting the part of the clothing that is to be changed, the selectors to the left and to the right of the users' representation are updated in accordance. First of all, this adaption simplifies the interface, as there were now only two, and no longer four, elements to change the design of the clothes. In the final product more modes can be introduced, e.g. for hats, glasses and shoes. Simplification is a common usability heuristic that is, for instance, advised by (Nielsen, 1993b). Furthermore, this adaption allows it to change all types of clothing without having to take an uncomfortable position for a longer time. When, for instance, changing the pants in our first prototype, the elements to switch between the designs of the pants were located on the actual height of the pants. This position is likely to be, in case of a mirror in the size of the user's full body, too low to be operated comfortably for a longer time. In the new prototype the selector of the pants will, because of the discussed adaptation, appear on nearly the same height as the selectors for the shirts.

The size of the color selection tool was increased to provide a better target for gestural and touch-based interaction. Bigger interface elements have, as discussed by (Saffer, 2009), certain advantages as better usability and, as well, an increased accessibility for people with physical impairments. The element was also moved to a prominent place on the interface to make it easier to find. Compared to the old prototype that used discrete buttons for each color, the new structure of using arrows to scroll through the colors allows incorporating a bigger number of colors without consuming too much screen space. One color selector is now being used to change the color of both, the shirt and the pants, depending on what part is selected. This leads to another simplification of the interface. Its alignment with the cloth selection buttons should imply a functional relation between them.

The share button was separated from other unrelated functionalities. Its placement near the color selection tool in the first prototype led to confusion since their closure implied relatedness between them that did not exist. The new placement on the right side of the screen near another function (shopping) that is as well not related to the selection of clothes, should reduce the possibility of overlooking the item.

The ambiguity of the wording of the two share functions that became apparent in the first user test – share a picture of the user and share the outfit without taking a picture – was resolved by dropping the latter one. This was also justified by users in the user test expressing little need for a function to only share the outfit without a picture.

A functionality that was introduced in the prototype was the catalogue, which is accessible by clicking on the button on top of the screen. The catalogue contains two functionalities. First, the functionality of the selection of related outfits has been moved in there. The size of the catalogue, it is displayed as an overlay over the whole screen, allowed it to display a big selection of clothes and outfits on one screen. Furthermore, in the catalogue a list of all pieces of clothing is available to address the issue of the first user test where participants claimed that an overview of all available shirts or pants was missing. Figure 3.4 displays the catalogue.

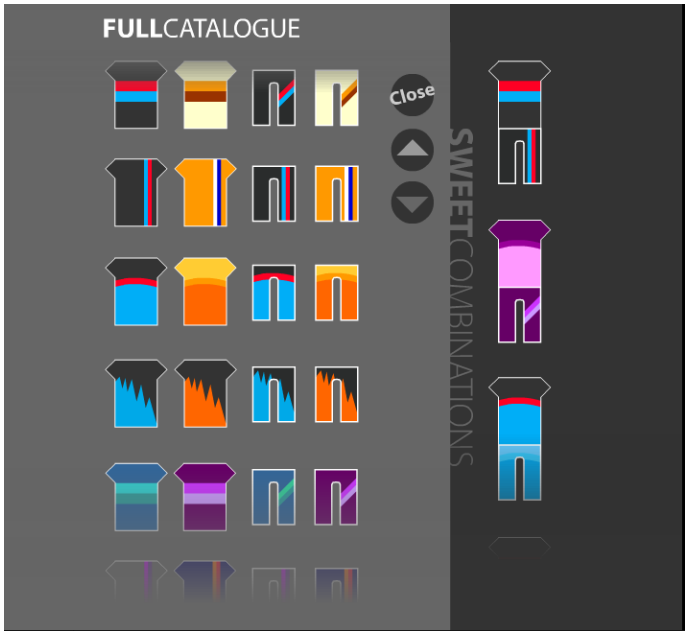


Figure 3.4: Catalogue

3.3.3. Technical boundary conditions

A change that was motivated by technical considerations was that the lower part of the user's body, which was present in the first prototype, was excluded. This was due to the fact that a touchscreen of a sufficient size – big enough for a true full-body mirror – was not available to us. To nevertheless be able to display the user's body as close as possible to its real size, and have touch capabilities on the whole interface, we made this decision to reduce the size of the mirrored image on the screen.

3.3.4. Evaluation

A small-scale evaluation of the prototype was carried out to obtain quick feedback and, thus, be able to improve the prototype before the second more elaborate and formal user test took place. The setup and the development of this test and the results and conclusions are explained in the following section.

3.3.4.1. Aim

It should be assessed whether the adaptations to the prototype, which were discussed before, did indeed yield the desired effect of solving the usability problems that were present in the first user test.

Furthermore, exposing usability issues of the adapted prototype was an aim of the evaluation, since we did not assume that the motivations and ideas behind our adaptions led to the desired results. Especially the interface element of the catalogue should be evaluated as it was not present in the prototype of the first iteration, and thus did no undergo user tests so far.

3.3.4.2. Methodology

The aim of assessing the adaptations that were made was addressed by having the participants carry out the same tasks as the ones that led to the exposure of these usability problems in the user test of the first iteration. Evaluating the task success rate and evaluating whether the issues that were obstructing the participants of the first user test, for instance the placement of the share button, were still present was done arrive at this judgment. Of course, basing this judgment on the rather small number of about five participants is problematic as discussed by (Faulkner, 2003). Nevertheless, the aim of this evaluation was not arriving at a final judgment of the prototype. It was rather getting a first picture of the effect of the adaptations to motivate their employment in the second user test, which was carried out on a larger scale later on in the second iteration.

Usability issues should be exposed by the tasks that we asked the participants to carry out during the test. A task that especially targeted the catalogue was included to evaluate this functionality.

3.3.4.3. Setting

The user test was carried out with five participants, as it is advised by (Virzi, 1992) to discover the major usability flaws of the tested system. More

participants were not recruited since this evaluation was rather meant as a preparation and motivation for the larger scale user study later on in this iteration.

The evaluation solely addressed the interface of the system. This rather focused approach made the study quick and easy to carry out, as no additional technology, for instance for gesture recognition was needed. Thus, the tests were conducted on a computer using a mouse as the input device. This setting was chosen, as we only addressed the interface and deliberately neglected aspects that are related with the characteristics of the different interaction techniques like touch or gestures.

3.3.4.4. Test plan

The following section summarizes the plan that was developed for this evaluation. It consisted of a briefing in the beginning to instruct the user about the purpose and the content of the experience, followed by a set of tasks that the users had to carry out using the prototype and concluded by an interview and debriefing.

Briefing

The purpose and the modalities of the user tests were introduced in a short briefing at the beginning. The precise text that was used can be found in appendix A.5.1. The written consent form, that the users signed after the briefing and before the test is given in appendix A.5.2.

Tasks

In the following we describe the tasks that the participants had to carry out and motivate them by explaining the adaptation of the interface that we wanted to test by their inclusion. We also provide the precise wording in which they were introduced to the participants. We only measured task completion to keep the evaluation fast to carry out and to evaluate. When we judged a task to be completed is also explained for each of the separate parts of the tasks.

Change the design of the shirts and pants

This task was supposed to test whether the adapted selection tools – shirts and pants could no longer be changed at the same time –worked well, meaning whether they were able to intuitively grasp the working principles and whether they discovered the element quickly, for the users.

This task should also test whether the adapted color selection tool performed better than the element that was providing this functionality in the first prototype and addressed the usability problems successfully, for

instance its insufficient size, that were discovered in the user test of the first iteration.

Introduction

1. “Your first task is to change the design and the color of the shirts and the pants. First select, the shirt design with the vertical stripe.”
2. “Now change its color to blue.”
3. “Now you have to change the design of the pants to the one with the vertical stripe.”
4. “Change the color of the pants to gray.”

Success criteria

1. The shirt design with the vertical stripe was selected in less than 15 seconds by the user and is displayed on the user’s avatar in the center of the prototype. The user did not click on buttons that are related to another function.
2. The user changed the shirt’s color to blue in less than 15 seconds. The user did not click on other buttons that are related to another function.
3. The user changed the design of the shirt to the one with the vertical stripe on it in less than 25 seconds. The user did not click on other buttons that are related to another function.
4. The user changed the color of the pants to gray in less than 15 seconds. The user did not click on other buttons that are related to another function.

Select an outfit from the catalogue

This task should evaluate whether the new functionality to select complete outfits, the catalogue, was usable.

Introduction

1. “Now we want to test the catalogue. Please open the catalogue and select the purple shirt that has two pink horizontal stripes.”
2. “You can also select a complete outfit. Please select the orange outfit using the catalogue.”

Success criteria

1. The user selected the purple shirt with the two horizontal stripes using the catalogue in less than 25 seconds. Finding the catalogue button took no longer than 5 seconds. The catalogue button was the first button on which the user clicked after being instructed.
2. The user selected the complete orange outfit in less than 25 seconds. Finding the catalogue button took no longer than 5 seconds. The

catalogue button was the first button that the participant clicked after being instructed.

Share functionality

This task should address whether the adaptations to the share functionality, for example the new placement of the button, were able to address the issues that were exposed in the user test of the first iteration.

Introduction

1. "Your next task is to share a picture of yourself with the outfit that you are virtually wearing at the moment. Select the share button and share a picture using Twitter."[11]

Success criterion

1. The user was able to carry out the steps of the sharing function without assistance and wrong clicks in less than 35 seconds. It was acceptable if the user selected another one of the offered social networks. If the user decided to retake the photo the timespan was enlarged by ten seconds.

Interview

At the end of the test we conducted a short interview with the participants to get an idea on their views on the prototype's capabilities. The questions were similar to the ones that were asked in the first evaluation. This is because we wanted to compare their results and, thus, understand how the adaptions affected factors like the users' shopping experience or the degree to which the mirror was considered helpful when looking for clothes. We asked the following questions:

1. Please name, if you want to, the function of the system that you like best and give a short reason for your choice. Of course, you can also name more than one function.
2. Please name, if you want to, a function of the system that you did not like and give a short for your choice. Of course, you can also name more than one function.
3. Do you think that such a system would help you when looking for clothes in a store? Please give also a reason your answer.
4. How do you think would the presence of such a system affect your shopping experience? Would it, for instance, affect your likelihood of revisiting a store that has such a mirror?

[11] If the participant tried to change the message, what was impossible, the experimenter gave him an appropriate hint.

5. Would you like to use such a system? Why would you (or would not) use such a system in a store?

Moreover, we did also address problems that the participants encountered when using the prototype, for instance when they were not able to complete a task successfully due to the interface.

3.3.4.5. Results

Five people participated in the user test.

User test

There were seven tasks, their details have been discussed in section 3.3.4.4, that the participants had to complete and which are summarized in the following

- Task 1: Change the shirt's design
- Task 2: Change the shirt's color
- Task 3: Change the pant's design
- Task 4: Change the pant's color
- Task 5: Select a shirt using the catalogue
- Task 6: Select a complete outfit using the catalogue
- Task 7: Share a picture using Twitter

Table 3.1: Task success of the user test

	User 1	User 2	User 3	User 4	User 5
Task 1	No	Yes	Yes	Yes	Yes
Task 2	No	Yes	Yes	Yes	Yes
Task 3	No	Yes	Yes	Yes	Yes
Task 4	Yes	Yes	Yes	Yes	Yes
Task 5	Yes	Yes	Yes	Yes	Yes
Task 6	No	No	No	Yes	Yes
Task 7	Yes	Yes	No	Yes	Yes

Observations:

- The difference between the shirt and pants mode was confusing for one participant. Thus, the user interchanged the shirt and pants mode when carrying out the task. The tasks that were meant for the shirt were executed for the pants and vice versa.
- One participant did not see the camera in the second screen (task 7) that triggered the taking of a photo. Therefore, this

participant first canceled the share operation. After trying the share functionality again the participant discovered the camera button and clicked on it to take the photo.

- To carry out task 6 one had to scroll down in the catalogue window. One participant tried scrolling down by clicking on the lowest outfit, from which the top image was just barely visible. After unsuccessfully trying that two times, the participant noticed that there were scrolling buttons.
- All participants found it difficult to decide what to do at the beginning of the test. The first task in the user test was to select a shirt, but no shirt was visible on the screen. The participant either had to click on the button to start the calibration or skip the calibration. This was unclear for all participants, possibly because the task was unclear (there was no shirt visible) or because the two given option (calibrate or skip) are unexpected.
- Finding the orange outfit (task 6) was difficult. That was because the outfit was initially hidden; the participants had to scroll down to make more outfits and clothing visible. Some participants did not use the scrolling buttons and selected the desired shirt and the desired pants separately. This latter problem can have its root in the ambiguity of the question.

Interview

Two participants named the catalogue, especially the possibility to see all clothes on one screen, as the most useful function of the system. Changing the color, selecting clothes and the share functionality were also mentioned. Finally, the design was praised as clear, very visual and stylish but also as simply nice.

The participants mentioned various points of improvement in the interview. It was not clear what to do in the beginning, so one participant suggested to remove the introduction screen entirely. This was not possible since the introduction screen was necessary for the calibration process for the gesture recognition. Also the shirt and pants mode were suggested to be combined. The color selector is difficult to skip through because not all available colors are immediately visible. The same color button for shirt and pants was not entirely intuitive. One participant proposed to use separate color buttons for the shirt and the pants. A possible future problem that one participant mentioned was that in a shop more outfits are possible than can now be put in the catalogue. Functionalities as searching for a brand could address this problem.

When asked about the helpfulness of such a system when looking for clothes, three out of five participants responded positive. Especially the

catalogue was considered helpful. One participant remarked that physically trying on clothes would always be necessary to see whether they fit and how they actually feel. Another participant would want to try the system out in the context of a store before giving a judgment of its quality.

When asked about the mirror's effect on their shopping experience, two participants answered that it might improve their shopping experience. Two participants answered that it might improve their experience a bit and that it has no negative effects.

All participants would try the system out when seeing it in a store.

3.3.4.6. Conclusions

Some of the issues that were exposed in the first user test (see the list in section 2.5.6.2) were no longer present in this test that used the adapted version. Of course, the rather small user test was not suitable to provide more then a first idea about whether the issues were addressed. The following issues were no longer present in the prototype:

- The new placement of the share button was no longer problematic for the users as it was visible without problems.
- The share functionality was no longer ambiguous as the ambiguous function, sharing the outfit without a picture, has been removed from the system.
- The problems regarding the size and the placement of the color selector buttons were no longer present. This statement is problematic as both tests were done under rather different circumstances; in the first test the user was standing and interacting with a real size prototype. Nevertheless, no possible problems with the adapted color selector that was tested came up. The user test that was carried out later on in the second iteration should provide clarification regarding this.
- The problems with the menu layers were no longer present since the overlays, for instance the catalogue, were no longer transparent but completely opaque.

The user test provided the clear result that the catalogue is a good functionality as some users explicitly mentioned its usefulness. Nevertheless, certain usability issues concerning this functionality, which will be described in the following paragraphs together with our ideas to solve them, have been found and have to be addressed in the next version of the prototype.

An option to search for clothes, for instance specific brands or specifying a price range, might be a valuable addition to the catalogue, as a participant mentioned. Providing such functionalities would make the catalogue also suitable for larger number of outfits that cannot be handled well using the current interface, which is restricted to scrolling.

Another issue was the calibration process that was troubling for the users. There is a risk that the necessity of a calibration scares away users in the final product, because it seems difficult to do. One option to address this would be to allow starting the calibration after the user has started to use the product. That way the user is already using the system and the risk of scaring away the user is lower. The downside of this solution is that the gestural interaction is not available to the user in the beginning. Another solution that might be less distracting would be to start the calibration automatically when the user approached the system.

The adapted version of the color selection tool turned out to be problematic for some users and should be refined in further versions of the prototype. Improvements that we will incorporate are giving the user the possibility to see all possible colors at once.

The results as a whole allowed the conclusion that the adapted version of the prototype is, despite some rather small usability issues, usable and motivates the efforts to integrate the technical capabilities for gesture recognition.

3.4. Technical realization

Using the Microsoft Kinect opened possibilities for using gestural interaction. The Kinect consists of a camera (640 x 480 pixels), a microphone and 3D sensor. The 3D sensor uses lasers to send out infrared light that is then registered with a sensor. Unfortunately, Microsoft did not yet release an application programming interface, so, officially, the Kinect can exclusively be used with Microsoft's Xbox 360. However, there are ways to use connect the Kinect with a computer to do, for instance, gesture recognition. This is done by reverse engineering the functionality of the Kinect and "hacking" it. The complete description of how we connected the Kinect to the Flash prototype is described in detail in appendix A.4.

After having connected the Kinect with the Flash prototype, we implemented the gesture functionality into Flash. Gestures are registered using a simple algorithm. Flash receives the coordinates of the skeleton joints of the user. The skeleton coordinates of the hand are used for the gesture. When a new coordinate of the hand is received, the changes compared to the previous coordinate are saved. The last five changes of

coordinates (delta) are compared to a fixed minimum change. When all five deltas are above the minimum change, the user has moved his hand enough to let it be registered as a swipe. To prevent multiple swipes at once, there is a minimum interval in which a swipe can occur. In other words: when a swipe has been executed, the next swipe can only happen after waiting the interval time.

In order to make the prototype more personal, the video stream of the Kinect was also used. For this video stream is a facial recognition program created in Flash that can register the user's face and display it on the face of the prototype. Unfortunately, this takes a lot of processing power, especially in combination with the Kinect gestures and following the user's movement. Another disadvantage was that the resolution of the Kinect is too low for the facial recognition program to detect a face in a fast way. Therefore the facial recognition program had to be set to a more detailed recognition level, which took even more processing power. After starting the prototype it happened that the entire program crashed because the computer could not keep up with the processing of coordinates of the Kinect. Therefore the facial recognition part was not in the prototype that was showed to the users.

The touch-based interaction was realized by using a touch screen. The larger the touch screen would be, the more could be displayed on it and easier it was for the user to select functionality. At the university we found an interactive whiteboard (of about 2 meter wide by 1 meter high) that could register input from a pen when touching the board with the pen. Where the pen touched the whiteboard, the mouse is clicked on the computer. A beamer showed the display of the computer on the board. This interactive whiteboard enabled us to display and used touch-based interaction from the prototype.

3.5. User test

As there were not many changes to the functionality of the prototype the procedure that was used in the user test that is described in the following was to a large extent similar to the user test of the first iteration (see section 2.5). A difference to the first user test was that we did no longer employ a Wizard-of-Oz setting to simulate the interactive capabilities as we now had a system with technological capabilities for touch-based and gestural interaction. Further differences were that the prototype contained more functionalities and looked less sketchy and more complete.

3.5.1. Approach

The following section explains the approach that we took in this user test. First, we state the aim of the user test and described its aim and the methodology that we used to address these aims.

3.5.1.1. Aim

Since the second prototype used technology for touch-based and gestural interaction, we wanted to test whether this technology was capable of providing a reliable means of interaction for the mirror. Reliability is an attribute that would qualify the system, of course only together with further attributes like usability, for a later setup in a real environment in a shop where it is used by a variety of different users. We did not expect problems with touch-based interaction as reliable technology was available to us, the context of use analysis gave the result that all users have experience with devised that use touch-based interaction, and as we did not make use of sophisticated techniques like multi-touch. However, to support gestural interaction we had to create a system using components that lacked an in vivo test with users that were not involved in the development of the system. So the more important part was to test whether our system was able to reliably recognize gestures in a real setting.

We also researched whether the addition of gestural interaction to the interface provided added value, as the results of the first user test did not provide a clear picture on it. Two aspects of the gestures' usability, in the sense of (Dicks, 2002), were targeted. These aspects were: gestural interaction making the system more pleasant to use, in other words whether it improves the experience of using the system, and if gestural interaction facilitates the usage of the system, in the sense of being learnable and more easy-to-use than the alternative touch-based interaction.

We also wanted to assess the usability characteristics of the prototype. This new evaluation became necessary, as the prototype was adapted in certain ways compared to the prototype of the first evaluation. This aim did also contain to expose usability problems in the prototype, which could then be addressed in the final (third) version of the prototype that was created later on.

Furthermore, we wanted to test whether this prototype performs better than the first prototype, in certain respects that will be explained in the following section on the methodology. It should also be assessed whether the usability problems, for instance the illogically placed share button that

were identified in the user test of the first iteration, were addressed successfully and ceased causing problems to the users. In the last user tests we assumed a connection between having a technical background and the task success rate with the system. This user test should provide a clearer and more formal view whether this connection actually exists. The procedures of the first user tests failed to obtain quantitative data on the technical background of the participants. This shortcoming was improved in this test by collecting data on the technical background of the user.

3.5.1.2. Methodology

The approach that we used in this user test was similar to the one of the first user test. One reason for this was that the prototypes were largely similar regarding the implemented functionality. Furthermore, this similarity allowed a comparison of the participants' answers to the same questions in the usability questionnaires that were to be filled out after the tests. This could be used as a measurement for the differences in usability between the prototypes. Moreover, we did also compare how smooth, using the amount of interruptions that were caused by the interface of the system as a measurement, the participants were able to carry out the tasks of the test. What we counted as such an interruption was when the participant was confused and not knowing where to go next. This was surely a subjective measurement, but could nevertheless produce insights in the quality of the interface. If such interruptions of the participant's flow occurred more than once per task we considered the functionality to be subject for improvement, even if the participant was successful in completing the task.

We used the same usability questionnaires that we also used in the first user test to be able to compare the results of test and to judge based on this data whether the prototype was in fact improved as far as it was tested by the questionnaire. The questionnaire itself was adapted as it was discussed in the section that evaluated the procedure of the user test. A further addition to the questionnaire was a set of questions that targeted the technical background of the participant. These were included in order to be able to test whether a link between the task success of the participants and their technical background exists.

To be able to evaluate the usability characters of gestures we had the participant, like in the first user test, carry out the tasks twice, once with each technique. Since only one function was supported by gestural interaction the gestural part of the user test was shorter. Obtaining the data to allow this comparison and evaluation of the interaction techniques was done with the same usability questionnaire that we also employed in the

first user test. Since the gesture recognition was not reliable its test was separated from the test of the touch-based interaction and carried out at the end.

At the end of the user test we asked the user some questions about the interface. This was included as a possibility to get more detailed information about the participants' view on the biggest adaptations that were made to the prototype, for instance the new color selection tool. To keep the testing procedure succinct, the usability questionnaire was shortened.

One main difference between both tests was in the technical capabilities of the prototype. Since we used working technology, there was no need for the Wizard-of-Oz technique as the necessary technological capabilities were implemented in the prototype.

The notion of *reliability* that was used in the description of the aim of the user test (section 3.5.1.1) is somewhat diffuse, since it lacks a precise threshold that could be measured quantitatively in a user test. We decided to measure the reliability by counting incidents where the flow of the task completion was hampered by not, or incorrect, recognized gestures. If such incidents occurred on average more than once per task, we considered the gesture recognition to be not reliable. Problems with gesture recognition could be further investigated after the test using the video recordings of the user tests.

3.5.2. Test plan

The following section explains the plan of the user test. We begin with a description of the technical setup and the task division between the experimenters. Then we give a chronological description of the test plan. First, we explain the briefing, followed by the tasks and the interview that we conducted with the participants. The evaluation of the gestural interaction of the systems has been separated from the evaluation of the touch-based interaction. This was done as the reliability of the gesture recognition of our system was not high enough – in informal tests we achieved an accuracy of about 50% – to present it as an equal alternative to touch-based interaction. By testing it separately we wanted to give it a more experimental look and gain input for further improvements of the gesture recognition and the gestural interaction as a whole.

3.5.2.1. Setup

The prototype was displayed on an interactive whiteboard in a lecture room of the university. Despite being rather large, the interactive whiteboard also provided touch capabilities. For the touch capabilities a special pen, with which one had to touch the interactive whiteboard, had to be used. The Microsoft Kinect was connected to the computer on which the prototype was running and provided the processing capabilities for the gesture recognition.

One experimenter was responsible for instructing the participants about their tasks and for answering their questions during the test. The second experimenter was responsible for taking notes of important observations, for instance problems that made it difficult to carry out a task and should be addressed later on in the interview, during the user tests. A third experimenter observed and controlled the gesture recognition and touchscreen functionalities of the system.

3.5.2.2. Briefing

As in the user test of the first iteration we started with a briefing of the participant, to explain the contents and the purpose of the user test. For this briefing, a consent form was used to explain the test to the user, and all participants did also have to sign this written consent form that was given them after the briefing (see appendix A.6.1 for the form).

3.5.2.3. Explanation of the interaction techniques

Before the participants started to carry out the tasks, the experimenter that was responsible for instructing the participants briefly demonstrated touch-based interaction. This was done in the following way:

1. **Explain the calibration process.** "At the beginning the system has to be calibrated so that it is able to recognize your posture and the gestures that you are doing. You have to position yourself as it is shown on the screen and wait until the system notifies you that the calibration was successful. *(Experimenter waits until the calibration that was simulated in this task was complete)* Now I will show you the two techniques that can be used to interact with the system."

2. **Demonstrate touch-based interaction.** "The system can be controlled using touch-based interaction. To select a certain item on the interface you have to press it using this pen." *(Experimenter presses once the element to select the previous shirt in the list to select the one with the ragged line)*
3. **Transition to the user's tasks.** "This concludes the introduction. Now I will ask you to carry out some important tasks with the system." *(Prototype is being restarted)*

3.5.2.4. Tasks

In the following section the tasks that had to be carried out are described in detail. We will give their order, the wording of the introduction and their success criteria that were used to judge whether the participants completed a task.

Change the color of the clothes and their design

Introduction

1. "Your first task is to change the design and the color of the shirts and the pants using the touch-based interaction. First select the shirt design with the vertical stripe."
2. "Now change its color to blue."
3. "Now change the design of the pants to the one with the vertical stripe."
4. "Change the color of the pants to gray."

Success criteria

1. The participant selected the shirt design with the vertical stripe in less than 15 seconds.
2. The participant changed the color of the shirt to blue in less than 10 seconds.
3. The participant selected the pants with the vertical stripe in less than 20 seconds.
4. The participant changed the color of the shirt to gray in less than 10 seconds.

Share

Introduction

1. "Your next task is to share a picture of yourself with the outfit that you are virtually wearing at the moment. Select the share button and share a picture using Twitter."

Success criteria

1. The participant was able to carry out the steps of the sharing function without assistance and wrong clicks in less than 35 seconds. It was acceptable if the participant selected another of the offered platforms for sharing. If the participant decided to retake the photo the timespan was enlarged by 10 seconds. If the participant tried to change the message, what was not supported by the prototype, the experimenter gave a hint that this was not possible.

Catalogue

Introduction

1. "Now we want to test the catalogue. Please open the catalogue and select the purple shirt that has two pink horizontal stripes."
2. "You can also select a complete outfit. Please select the orange outfit using the catalogue."

Success criteria

1. The participant selected the purple shirt with the two horizontal stripes using the catalogue in less than 25 seconds. Finding the catalogue button took no longer than 5 seconds. The catalogue button was the first button that the participant pressed after being instructed.
2. The participant selected the complete orange outfit in less than 25 seconds. Finding the catalogue button took no longer than 5 seconds. The catalogue button was the first button that the participant pressed after being instructed.

3.5.2.5. Gestural interaction

After the test that addressed touch-based interaction was completed, we tested the gestural interaction. As already explained, this separation was done as we expected the gesture recognition to not be reliable enough to be tested together with touch-based interaction without affecting the performance of the participants when doing touch-based interaction.

Calibration

The calibration had to be repeated, since the calibration before the touch-based interaction was only simulated. This was done since we were aware that the calibration process took long and was not reliable.

Demonstrate gestural interaction

"It is possible to use gestures to control some functionalities of the system. The gesture recognition is still under development, thus be aware of potential mistakes of the system that might happen in the following. I will now demonstrate how gestures can be used. If you swipe your hand to the side you can change the design of the shirt. *(Experimenter swipes once sideways to change the design of the shirt)* If you swipe your hand upwards, for instance, you can change the color of the selected clothing." *(Experimenter swipes once upwards to change the color to green)*

Gestural interaction

1. "Your first task is to change the design and the color of the shirts and the pants using gestural interaction. First select the shirt design with the vertical stripe."
2. "Now change the color of the shirt to blue."
3. "Now change the design of the pants to the one with the vertical stripe."
4. "Now change the color of the pants to gray."

Handling of technical problems

The following section describes how we planned to deal with technical problems that might occur during the test. Problems that we expected were, for instance, wrongly recognized gestures.

Touch-based interaction

We judged the touch-based interaction as not working when the participant pressed the correct item twice without the system recognizing this correctly. In such cases we used the computer that controlled the prototype and triggered the desired action manually. If technical problems occurred during the execution of two different parts of the task we skipped the task and continued.

Gestural interaction

We judged the gesture recognition as not working when the participant executed the correct gesture three times without the system recognizing it correctly. In such cases we used the computer that controlled the prototype and triggered the desired action manually. If technical problems occured during the execution of two different gestures we skipped the task and continued.

3.5.2.6. Questionnaires

The test plan included several questionnaires that the participants were asked to fill out. At the beginning, before the users started to carry out the tasks, we asked the participants to fill in a questionnaire that asked for demographic data, for instance their technical experience and their social networking experience. After completing the touch-based interaction tasks, the participants were asked to fill in a questionnaire that addressed the touch-based interaction technique of the system. The participants continued with the gestural interaction tasks, and when finished were asked to answer questions about the gestural interaction part. Some more general questions that targeted the participant's view of the system in general and questions about the usability were also asked at the end. Through splitting the questionnaires, we hoped to reduce the time of filling them in to an acceptable amount, compared to the user test of the first iteration where the questionnaires were filled in at once.

Demographic data

A set of questions had to be answered by the participants at the beginning of the test and asked, amongst others, about their technical background. The questions that targeted the participants' technical background were introduced since we identified their absence as a shortcoming of the preceding user tests. The questions can be found in appendix A.6.2

Usability questionnaires

The questionnaire was the same as the one of the user test of the first iteration and was to be answered on a five-point Likert scale after having carried out all the tasks. Some questions have been removed, since they were not of a high priority, for instance the readability of the screen elements, and we also wanted to shorten the questionnaire. Furthermore, a series of questions to target the emotional response of the participants to the systems have been added.

Usability of the interaction techniques
The following questions were asked:

1. I found the interaction with gestures intuitive.
2. I found that the gestures were easy to learn.
3. I found that using gestures was tiring.
4. I think that gestures are a good technique to control this interface.
5. I think that using gestures was an exciting way to control the interface.

Usability of the system

Emotional perception of the interface

The participants of the informal user test of the second evaluation mentioned different attributes like “stylish” or “clear” to describe how they perceived the system. A more formal judgment of the adjectives that users used to describe the system sounded promising, since such an approach might be suitable to research the emotional responses of the participants to the system.

The concept of user experience is broad and practical recommendations about ways to test the user experience for systems like the one we developed are not available. Nevertheless, we used a simple means, letting the participants judge a sort of adjectives using the semantic differential to gain insight into adjectives that they would use to describe the mirror. The pairs of adjectives were taken from the attrakdiff test.[12] The adjectives had to be graded on a five-point scale and can be found in appendix A.6.4.

Perception of the interface

As with the first iteration user evaluation, we asked the participants about their perception of the interface. The questions were nearly the same as in the first user test and can be found in appendix A.6.3.

3.5.2.7. Interview

After all tasks were finished we asked the participants a set of questions to have the possibility to investigate some aspects of the system in greater detail and obtain qualitative data on some aspects of the interface.

1. Please name the function of the system that you liked best and give a short reason for your choice. Of course, you can also name more than one function.
2. Please name a function of the system that you did not like and give a short reason for your choice. Of course, you can also name more than one function.
3. The following questions were asked if the user did not mention the functions in the preceding questions:
    a. How do you think about the function to select the colors?
    b. How do you think about the function to select the clothes?
    c. How do you think about the catalogue?

[12] See www.attrakdiff.de

4. Do you think that such a system would help you when looking for clothes in a store? Please do also give a reason for your answer.
5. How do you think would the presence of such a system affect your shopping behavior? Would it, for instance, affect your likelihood of revisiting a store that has such a mirror?
6. Would you like to use such a system? Why would you (or would not) use such a system in a store?

3.5.3. Results

The following section will discuss the results of the user test. This will be done in four steps. First, the characteristics of the participants will be described. Then the task success rates will be shown followed by a discussion of the comments and observations that were obtained from the user test. The closing section is then giving the results of the questionnaires. Section 3.7 is going to discuss the conclusions that were drawn based on the results. The conclusions are placed in a separate section as we also used input from NEDAP to reach them.

3.5.3.1. Participants

Five participants took part in the user test. We had three male and two female participants. Four of them were aged between 16 and 24 one participant was between 25 and 32. Thus, we had a rather equaled distribution between male and females and could also conclude that the participants were, regarding their age, to a large part in our defined target group.

All participants responded to have rather high computer experience. Four participants responded that they use their computer at least four hours a day and, as well four participants judged their computer skills as being professional. The further responses were similar to the ones of the preceding tests, for instance all users had experiences with touchscreen devices and also a majority with devices that use gestural interaction.

It was our intention to have more than five participants for the last user test. Unfortunately, due to time constraints it was not possible to plan more tests to have more participants.

3.5.3.2. Task success

One serious technical problem, which made it impossible for the first participant to be tested according to our specified procedure, was that the

interactive whiteboard that provided the touch capabilities for our system was broken.[13] Thus, there were no task success rates obtained for this participant, as we tested him using a notebook. Nevertheless, the notes that were made during this test are also included and used in the following.

There were in total eleven tasks, their details have been discussed before, that the users had to complete and which are summarized in the following. The first seven tasks were completed using touch-based interaction, the last four tasks had to be completed using gestural interaction.

- Task 1: Change the shirt's design using touch-based interaction
- Task 2: Change the shirt's color using touch-based interaction
- Task 3: Change the pant's design using touch-based interaction
- Task 4: Change the pant's color using touch-based interaction
- Task 5: Select a shirt using the catalogue
- Task 6: Select a complete outfit using the catalogue
- Task 7: Share a picture with a message on Twitter
- Task 8: Change the shirt's design using gestural interaction
- Task 9: Change the shirt's color using gestural interaction
- Task 10: Change the pant's design using gestural interaction
- Task 11: Change the pant's color using gestural interaction

Table 3.2: Task success of the user test

	1	2	3	4	5	6	7	8	9	10	11
1	Pass	Pass	Pass	Pass	Fail	Fail	Pass	Fail	Fail	Fail	Fail
2	Fail	Fail	Pass	Pass	Fail	Pass	Pass	Fail	Pass	Pass	Fail
3	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Fail	Pass	Fail
4	Pass	Pass	Pass	Fail	Pass	Fail	Pass	Pass	Fail	Pass	Pass

3.5.3.3. Notes from the tests and the interviews

User interface in general

No big issues that would concern the concept of the whole user interface were exposed by the user test. Numerous participants even praised the clear structure of the interface. Nevertheless, some aspects that worked well or

[13] Moving to a room with a working interactive whiteboard solved the problem for the remaining participants.

provided difficulties could be identified and will be discussed in the next paragraphs.

A technique, which was newly introduced, that did not cause difficulties was the switching between the shirt mode and the pants mode. Most participants found the appropriate items within the specified time limit for the tasks. Small problems – they did not hinder the users significantly – were caused by the color changer as its function was not immediately clear to the participants. One participant, for example, tried to change the color of the clothes by choosing different designs.

Feedback to the catalogue

The catalogue received positive feedback from the participants. It was considered as a compact way to show many options at once and creates a good overview of all available models.

An aspect that turned out to be problematic about the catalogue was the placement of the button to open it in the upper part of the interface. Locating that button caused difficulties to two participants. Reasons the participants gave for this were that the button did rather look like a label than then a clickable button and that it was at the top of the interface out of the immediate field of vision of the participants. One participant recommended placing the button next to the share and the buy button on the right side of the screen.

The selection of a complete outfit from the catalogue was problematic for two users. This was evident in them selecting the different parts of the complete outfit separately instead of making use of the corresponding function in the catalogue. One reason given for this was that the complete outfits were placed outside of the user's locus of attention and were therefor easily overlooked.

Share functionality

The share functionality was seen as a valuable addition to the mirror since it allows getting feedback and advice from other interested persons. A participant mentioned that sharing using the interactive mirror might be cumbersome, as it might be done more conveniently using a mobile phone.

One explicitly mentioned shortcoming of the implementation of the sharing process was that there was too much clicking (five steps and another step to get back to the start screen) necessary until the message was actually sent. This could also be an explanation for the rather low task success rate of 50% of the task that targeted sharing. Indeed, the participants that failed to complete this task were on the right track but only slightly above the specified time limit of 35 seconds.

Shopping experience, Impact on behavior

One group of participants mentioned that this system might make the shopping process faster, for instance that there would be no need to queue for a changing cabin any more. Whether this change would be good or bad was answered diverse. One group regarded these changes as an addition that would make their shopping process more convenient and more efficient. For instance, the availability of clothes in a particular size or color in the store could be checked faster with the mirror than by physically searching in the store.

The participants that regarded this skeptically answered that such a mirror would make shopping more passive and less physical. There was also agreement that the participants would not buy clothes just from seeing them in the interactive mirror. The physical contact with the clothes to evaluate their feeling was still considered vital.

The participants answered that the presence of such a system might increase their likelihood of revisiting a store. This answer was consistent over the participants that saw this system more as a toy and the participants that saw this system as a real addition to their shopping experience. The necessity of the presence of human persons in the store, for the atmosphere and the likelihood of revisiting, was also mentioned.

Additional functions

The participants mentioned two additional functionalities that could be added to the system. One mentioned that the system could be used at home to obtain overview over the set of clothes that a particular store has in stock and whether they suit ones taste. Another suggestion was to have the system recognize the articles that were placed in front of it. This was mentioned as a means to bridge the gap between the physical world of the clothes and the digital world of the interactive mirror. This functionality would allow to quickly try out different designs of a piece of clothing that one has found in the store.

Gap between digital and physical world

An interesting question, which was already mentioned above, is how the gap between the physical world and the digital world can be bridged. The need to address this question was also evident by nearly all participants stating that they would, in every case, wanted to try out the clothing physically before buying them.

Gestural interaction

A large part of the issues were expected, especially the ones that were related to the rather bad performance of the recognition, that was exposed

when testing the gestural interaction. The most frequent comment of the participants was, that the quality of the recognition of gestures was not sufficient. So did e.g. accidental movements of the user trigger some undesired action in the interface at some occasions. A related issue was the calibration process that was necessary to be able to use gestures. This process took far too long and was, as well, unreliable, especially when other people were present in the area that was recorded by the Kinect.

Despite the technical problems the participants made many positive comments regarding gestural interaction in general. They were considered as being exciting and novel, as well as being simply a good way to interact with the interactive mirror.

The tests exposed that a gesture to switch between the mode in which the shirts could be changed and the mode in which the pants could be changed was missing. Changing between touch-based input and gestural interaction was problematic since the participants had to move towards the screen for touching it and then move back to continue interaction with gestures.

Some participants overlooked the button that started to calibration process on the first screen of the interface. A reason that was given for this was that it did not look clickable and was also placed next to a large amount of text. One participant also mentioned that the calibration should start automatically.

3.5.3.4. Results of the questionnaire

The results of the questionnaire are given in appendix A.6.5. A comparison of the results of the questionnaire of the first and the second user test is going to be made in the section that draws the conclusions (section 3.7.1).

3.6. Feedback from NEDAP

We also had a discussion with NEDAP about the prototype that was tested in the user test of the second iteration. The adaptations that came up are listed in the following. Note that some of these adaptations were already implemented in the prototype as this discussion took place before the user tests.

It was proposed to reintroduce the discrete button for the available colors of the pieces of clothing that can be selected. The reason for this was that in a clothing store there are, according to personal experience, rarely more than five different colors for each piece of clothing available. Furthermore, the working principle of discrete color buttons was clearer than the one of our color selection element.

Another idea, which was already introduced to the prototype that was used in the second user test, was to replace the hands that were used at the cloth selection elements with arrows, since there was no natural mapping between the gestures of the hand icons and the gestures one is supposed to do.

It was also suggested to replace the black background of the prototype with the picture of a store to simulate the mirror effect that was, because of the absence of the reflective foil in front of the prototype, no longer present. This was, as well, already added to the prototype that was used in the user evaluation.

NEDAP did also mention the necessity for the interface to adapt its dimensions to the size of the user, as it was possible that certain interface element where outside of the users' field of vision. This conclusion was, as well, obvious in the results of the user tests. Thus such an addition to the prototype was necessary.

The interface moved with the user when using the capabilities for gesture recognition. Thus, it was always in front of the user. This functionality was seen positive. Nevertheless, the movements of the interface were not smooth enough in our implementation, therefore making it difficult to precisely aim at a certain point when using touch-based interaction.

It was proposed to make it visible that more shirts than just the two that were displayed were available to the user, for instance by adding some more small shirts to the left and to the right of the selector for the next model.

Comparison results questionnaire first and second iteration

Interactive mirror in general						
	1st iteration		2nd iteration		Difference	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
I think that I would like to use the interactive mirror frequently	3.17	0.98	3.40	1.67	0.23	0.69
I found the interactive mirror unnecessarily complex	2.33	1.03	2.60	1.52	0.27	0.49
I thought the interactive mirror was easy to use	3.67	1.03	3.40	0.89	-0.27	-0.14
I think that I would need the support of a technical person to	1.83	0.41	1.60	0.89	-0.23	0.48

be able to use the interactive mirror						
I thought there was too much inconsistency in the interactive mirror	2.67	1.51	2.40	1.67	-0.27	0.16
I would imagine that most people would learn to use the interactive mirror very quickly	3.83	0.75	4.20	0.45	0.37	-0.30
I felt very confident using the interactive mirror	3.83	0.75	3.80	1.30	-0.03	0.55
I needed to learn a lot of things before I could get going with the interactive mirror	1.50	0.55	1.80	0.84	0.30	0.29
I found the organization of information on the interactive mirror (Confusing - Clear)	3.33	1.21	3.4	0.89	0.07	-0.32
I found the sequence of the steps of the interactions (Confusing – Clear)	4.22	0.45	4.2	0.84	-0.02	0.39
I found that tasks can be performed in a straight-forward manner (Never – Always)	3.67	0.82	4.2	0.45	0.52	-0.37
Closing questions						
I think that the interactive mirror would improve my shopping experience	3.50	0.55	3.40	1.67	-0.10	1.12
I think that the functionality of the interactive mirror would help me when looking for clothes	3.50	0.55	3.60	1.67	0.10	1.12
I would revisit a store that has an interactive mirror	3.67	0.82	4.40	0.55	0.73	-0.27

The replacement of the word “Share” on the button by an icon was also mentioned. We decided to reject this change since no universal icon for sharing that would be quickly recognized as such existed.

3.7. Conclusions

The following section summarizes adaptions that were made to the prototype of the system based on the results from the user test as well as based on a discussion with NEDAP that was summarized above.

First, one limitation of our results should be mentioned. One research question that we wanted to answer in the user test was whether there was a link between the technical background of the users and their performance with the interactive mirror. This question cannot be answered based on our data, since the participants were regarding their computer experience rather uniform.

3.7.1. Comparison of the results of the questionnaires

In the table below, the results of the questionnaire of the user tests of the first and the second iteration are compared. Only questions that were in both of the questionnaires are considered. The mean is based on the value of answers reaching from strongly disagree (1) to strongly agree (5).

Basing conclusions on the answers of such a small number of participants, as it was the case in our tests, is likely to be of little value. Nevertheless, doing this shall rather serve as source of advice and guidance for the further work then as a sole foundation for clear decisions.

3.7.1.1. Interface

The following table contrasts the results of the user tests of the first and the second iteration. Providing this comparison of the characteristics of both prototypes was one major aim of our user test.

One remarkable observation that can be made based when comparing the results, is that the new prototype received in terms of being easy to use a similar and in some further questions a slightly worse rating. For instance, the organization of the elements was considered to be slightly more confusing (+0.7) and also the participants found the interface unnecessarily complex (+0.27). The rating for being easy to use dropped as well (-0.27). One explanation was that one respondent gave rather extreme responses that were at opposition with the further responses. But beyond doubt, the interface became more complex since new functionalities such as the catalogue or the separate modes for changing shirts and pants, that require effort to understand them have been introduced. The conclusion that we drew from this result was that simplifications of the system deserve our highest attention in the future.

The marks of measure that might yield benefits for a storeowner improved. For example, the likelihood of revisiting a store increased (+0.73). This possibly happened because of the introduction of functionality that

appealed to technical oriented people, for instance gesture recognition. Whether this high rating also holds for people without a strong technical background should be the subject of further investigations. Other relevant measures remained on a high level: the system would help me when looking for clothes (+0.1), the system would improve my shopping experience (–0.1). Again, one participant answering both questions in a way that was directly opposed to the answers of the others did also cause the stagnation of these measures (note the increased standard deviations).

3.7.1.2. Interaction techniques

In the following section the results regarding the two interaction techniques will be compared.

Table 3.4: Touch-based and gestural interaction comparison

Touch-based interaction						
	1st iteration		2nd iteration		Difference	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
I found the interaction with touch-based interaction intuitive	4.5	0.55	4.4	0.55	-0.1	0
I found that the touch-based interaction was easy to learn	4.33	0.82	4.8	0.45	0.47	-0.37
I found that using touch-based interaction was tiring	2.00	1.1	1.8	0.84	-0.20	-0.26
I think that touch-based interaction is a good technique to control this interface	4.17	0.41	4.2	0.84	0.03	0.43
I think that using touch-based interaction is an exciting way to control this interface	3.50	0.84	3.60	1.14	0.1	0.30
Gestural interaction						
	1st iteration		2nd iteration		Difference	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
I found the interaction with gestures intuitive	2.83	0.98	3.80	1.30	0.97	0.32
I found that the gestural interaction was easy to learn	2.67	1.03	3.40	1.14	0.73	0.11

I found that using gestural interaction was tiring	2.60	0.89	3.20	0.84	0.60	-0.05
I think that gestural interaction is a good technique to control this interface	3.00	1.27	3.80	1.10	0.80	-0.17
I think that using gestural interaction is an exciting way to control this interface	4.00	0.00	4.40	0.55	0.40	0.55

What can be concluded from the presented results of the questionnaire is that the usability of gestural interaction was, compared to the first user test, judged more positive after trying it out on a working system using a defined vocabulary of gestures. This increase in perception included all aspects: intuitiveness (+0.97), learnability (+0.73), being exciting (+0.4) and being a good means of interaction (+0.8). This clear increase motivates putting more effort in improved gesture recognition capabilities of future systems. Once again, a test of these findings with a more diverse group of participants regarding their technical background is necessary to thoroughly justify these conclusions.

The ratings of touch-based interaction did only change marginally. Only one value changed considerably which was easiness to learn (+0.47) and considering touch input less tiring (-0.2).

3.7.1.3. Perception of the system

The semantic differential that we used to gain insight in how the user perceived the system will be discussed in this section (see section A.6.5 for the results). The results that were obtained from these questionnaires were promising regarding the perception of the system, as it will be discussed in the following. Of course, no relevance of these results can be assumed since it is only based on the responses of six persons.

In the following the adjectives that were voted by a majority (we decided to use as a threshold a mean score on a five-point Likert scale of more than 3.5 or less than 2.5):

- Pleasant
- Professional
- Attractive
- Inviting
- Good
- Clearly structured
- Motivating

- Warm
- Modern

Even the results that did not exceed the threshold value that we set had never a tendency towards the negative adjective of the pair. Based on this data we concluded that the appearance and the function of the interface aimed, also regarding the more emotional perceptions that were targeted with this questionnaire, in a good and promising direction.

3.7.2. Conclusions based on the tasks

In the following section the conclusions that were drawn from the results of the user test will be discussed.

3.7.2.1. Interaction techniques

Surely, one conclusion that has to be drawn from the user test was that the gesture recognition of our system was not reliable enough to be used in a real setting. Thus, further technical improvements of the system are necessary before being able to deploy it to real stores. Technical advancements in the near future, for instance the announced availability of an official Kinect API, are likely to aid in achieving this goal.

The starting screen of the system turned out to be hard to use, since the button that the users had to click to start the calibration was difficult to distinguish from its surroundings. This issue needs to be tackled by making this button more visible or starting the calibration process automatically.

Furthermore, having to switch between the use of gesture and the use of touch was awkward and should, thus, be omitted in the following prototype. On two occasions switching between interaction techniques was necessary: when having to start the calibration and when switching between shirt and pants mode. One possibility to tackle the first issue would be to start the calibration process automatically when a potential user is approaching.[14] Related to this would be the question of how the system should look like, and how it tries to attract the attention of customers of the store, when no user is interacting with it.

One function that should be kept was that the interface was moving with the user so that it was always placed in front of him. Such functionality might be necessary as it is thinkable that the user is moving in front of the

[14] To be able to do this, the calibration needs to be technically improved since it took far too long in our system.

mirror when holding clothes in his hand or switching between them. It received positive remarks from the participants of the user test and from NEDAP. This function was only available when using gestural interaction since it required the recognition of the user's position. An extension of this also to touch-based interaction is possible as soon as the calibration process is fast and reliable enough.

But despite these problems, the test implied that gestural interaction is a valuable addition to the user interface. It was considered a good mean to control the interface, as well as being exciting to use. Thus, the inclusion of gestural interaction in the interactive mirror is promising and justifiable.

3.7.2.2. Interface

The introduction of separate modes for the selection of shirts and pants did not cause problems for the participants. But a judgment whether this did improve the usability of the prototype was not possible based on the data that we had. However, the reason why we decided to stick with the separate mode was to keep the system expendable, as the introduction of separate selectors for all part of the outfit would quickly reach its limitation when making more parts of the outfit, for instance hats or sunglasses, selectable.

The adapted color selection tool posed minor problems to a set of participants, as it was not immediately visible and its working principle was not easy to understand. A reintroduction of the separate color buttons, which were present in the prototype of the first iteration, was considered. Having these separate buttons did not pose problems in the first user test regarding the understandability of its working principle. However, having a set of buttons for each type of clothing that could be selected, would reduce the expendability of the concept since this would not be appropriate when also allowing selecting hats, shoes or further accessories. Having only one set of discrete buttons can target this problem. A possible downside of the approach would be that the gestures that we used for changing the color, swiping upwards and downwards, would not be visible anymore. One argument for the discrete buttons was that there are only a limited number of different colors of a piece of clothing available. Whereby this might be the case for clothing stores, a short check at online stores resulted in some shirts being available in about fifteen different designs. Thus, we have to be aware of the fact that this adaption might limit later on the applicability of the interface to settings outside of a store.

Certain problems, for instance the overlooking of the catalogue button on top of the screen, could be explained by the fact that the dimensions of the interface did not match the size of the user. Thus, some elements were out

of sight for rather small users. A functionality of the interface to adapt its size based on the size of its user has to be included with high priority.

Catalogue

The placement of the catalogue button on the top of the screen provided difficulties to some participants of the test. One reason for this is that the placement on the upper part was outside their locus of attention and, thus, so easy to overlook that some participants had to be actively notified by the experimenter of that button. Another reason might be that the catalogue button looked rather like a label than a button. In the revised prototype the button will be moved to the other buttons at the right side of the interface. This is motivated by one participant searching in the beginning at this place for buttons since in this area were, as well, other buttons present. The catalogue is therefor no longer entering the screen from the top but from the right hand side. The affordance to click the button should be enhanced by adding arrows that point in the direction of the center of the screen.

Share

The user test exposed that the share interface required too many button presses. This was mentioned by one participant explicitly and was also evident in the rather low task success rate. The participants missed the time limit in most cases only slightly, which was partly due to too many screens. Thus, we decided to reduce the number of screens by reorganizing them.

The first screen will be, as before, the screen on which the taking of the photo can be triggered as displayed in figure 3.5.

Figure 3.5: Trigger the creation of a photo

The second screen combines the possibility to retake the photo with the choice of the network on which the photo should be shared (figure 3.6).

Figure 3.6: Reworked share functionality

We did also discuss different simplifications. One of them was to combine the screen in which the message was typed in with the reviewing of the photo. But such changes that adjust the layout of the screen on which the message that should be shared is entered are impossible since the network has complete control over these screens. Because of this, we decided to omit such changes to support the later applicability of the system in a real world setting.

In the prototype of the second iteration the selection of the platforms on which the picture could be shared started with an animation. When being implemented in Flash, this animation consumed too many resources to be played smoothly on the notebook that we used for the evaluations. Because of this and the expectation that the hardware on which the system will run later on will not be faster than the notebook that we used in our evaluations we decided to remove this animation.

Adapt the start screen

The start screen of our prototype failed to provide some visual evidence what could be done with the prototype (see figure 3.7). That the user actually had to press the button that stated “Start Calibrating” was difficult to see since it rather looked liked a text message.

Figure 3.7: Start screen

Since the calibration process will still be necessary for the following prototype, the visibility of the button that started the calibration has to be improved.

Automatically changing dimension of the system

An important shortcoming of our system was that the dimensions of the interface did not adapt to the size of the user. Adding this for further prototypes of the system is of high importance. A possible technical realization for such a function would be present with skeleton recognition capabilities of the Kinect.

Adaptations to the prototype

The following section summarizes the adaptations that were made to create the third and final prototype of the interactive mirror. Further functionality that was also implemented in the prototype, but was not derived from input of the second iteration, is being discussed in the next chapter.

- The separate buttons for each available color will be reintroduced. They will replace the color selection element that was present in the prototype of the second iteration. There is going to be one set of buttons that changes according to the available colors for the selected piece of clothing.
- The sequence of steps of the share functionality is going to be adapted like the following:
  1. The user triggers the taking of the picture
  2. The user has the possibility to review the picture and retake it if desired and he can also choose the platform on which the picture should be shared.

3. The user can also enter the message that he wants to share together with the picture. This screen is a combination of two screens of the second prototype.
4. After pressing share the user is taken back to the home screen where a popup gives feedback about the success of the sharing.

- The catalogue button will be moved to the right side of the screen next to the buttons for sharing and buying. The look of the button will be altered to make it appear more clickable by, for instance, adding an arrow.
- The button on the start screen will be modified to stronger afford clicking by changing its look and, as well, adapting its wording.

3.7.3. Evaluation of the procedure

The following section will, just as it was the case in the preceding user test, summarize a set of lessons that have been learned from planning and carrying out the user test.

The specific formulation of the success criteria for the tasks of the user test made it possible to reach more objective results than by just using common sense to judge when a task was completed. The specification of time limits made it possible to expose and to justify the issue of the too complicated share functionality in an objective way.

One shortcoming that limited the applicability of our results to our whole target group was that the group of our participants was rather homogenous regarding their technical background. Such a problem could be avoided by selecting the participants of the tests beforehand based on certain characteristics.

The course of the user test showed that the separation between the test of the gestural interaction part and the touch-based interaction part was, indeed, a good choice. This separation allowed it to test the gestural interaction in a more experimental setting, with the participant expecting mistakes of the system, which were, for example in the too long calibration process, obvious to him. The glitches of the gesture recognition did not hamper the flow of the tests of the touch-based interaction, as it might have been the case when both were tested closer together.

A shortcoming of the test specification, as well as one from the prototype, was that some colors that the participants were asked to select, for instance gray and black, were hard to distinguish on the screen. This made the tasks unnecessarily difficult to carry out without assistance from the instructor regarding the colors. A possible explanation is that the beamer distorted the colors that were used in the prototype.

4. Final prototype

The following chapter describes the third prototype that we produced. This prototype incorporates the changes that were motivated by the second user test and also some further functionality that should point out possibilities for further extensions of the system.

4.1. Functionalities

The prototype was adapted because of two reasons. First, a set of adaptations was motivated by the results of the user test that was carried out in the second iteration. A set of further enhancements of the prototype should point out possibilities that we envisioned for later enhancements.

4.1.1. Adaptations motivated by user test

The adaptations that were to the prototype based on the results of the user test were already discussed in detail (see section 3.7.2.2) and should here only be briefly repeated:

- Adapt the screens of the share functionality
- Move the catalogue button to the right side of the interface
- Adapt the layout of the starting screen
- Reintroduce the discrete buttons to change the color of the pieces of clothing

4.1.2. Further functionalities

Some functionality that could be implemented in further version of the mirror should be demonstrated in this prototype. They were only included as non-functional mockups but not implemented. The first is an enhancement of the prototype that allows searching the available clothes based on brands. Secondly, a function that allows locating clothes in the store.

4.1.2.1. Search for clothes

A participant of the user test of the second iteration mentioned the functionality of having the possibility to search for clothes that are available in the store. This would also address the potential issue of the catalogue, with scrollbars as the only means of navigation, becoming difficult to use if

the store features a large number of items that should be displayed in the catalogue.

4.1.2.2. Buy functionality

Another feature that was not included in the prototypes is having the possibility to locate the item that one is wearing in a store. This functionality originates from the initial brainstorming.

The interface element to select this functionality was placed next to the button to add an item to the cart. We did so because both functionalities are related since to be able to buy a certain item one has to know where it is physically located in the store. Pressing this item displays an overlay that shows the location of the selected piece and of the interactive mirror that is displaying the map.

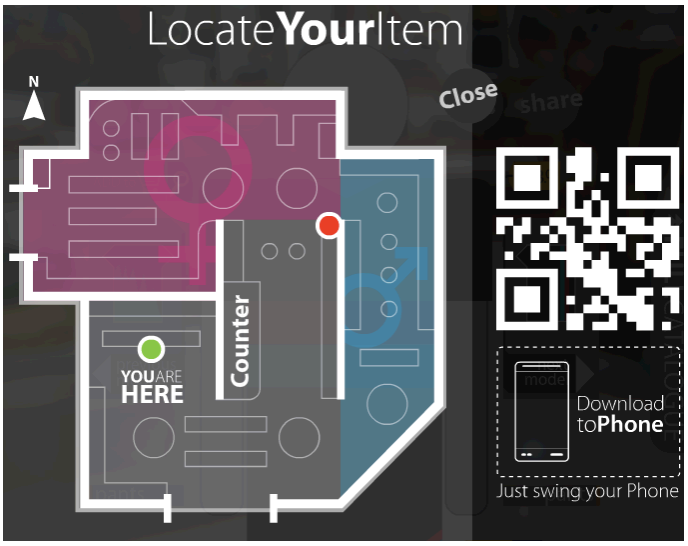


Figure 4.1: Locate a piece in the store

Clothes that are selected on the interactive mirror can be put in a shopping cart using an appropriate interface element (figure 4.2).

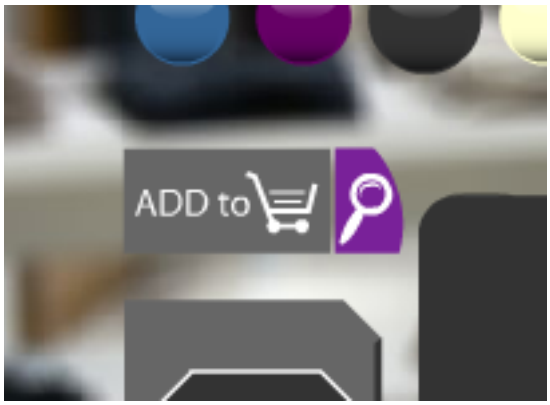


Figure 4.2: Add to shopping cart

After finishing the shopping process an overview of the contents of the shopping cart can be seen by clicking on the shopping cart item. Furthermore, this screen also displays the possible payment functionalities.

Figure 4.3: Shopping cart

4.1.2.3. Logging Out

It has to be considered that the user has the possibility to enter valuable personal information, such as passwords and usernames of social networks, into the system. To address potential issues of the users' privacy, the user should be able to delete his personal data.

With the logging out functionality, the user is able to manually delete his information. One issue that has to be addressed is when the user happens to forget about logging out. The system is then supposed to do it automatically to ensure that the personal information of the user of the mirror is not going to be misused.

4.2. Visual design

The visual design from the second prototype to the final version of the prototype did not change dramatically as opposed to the crucial contrast, for instance in the color of the elements and their placement, between the first and the second prototype (see figure 4.4).

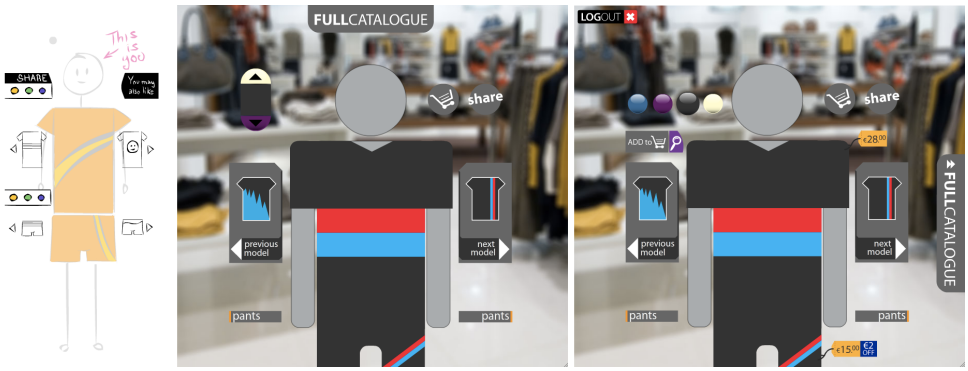


Figure 4.4: First prototype (left), second prototype (center) and third prototype (right)

The modifications that were done between the second and third prototype were mostly about rearranging the elements. This was done to provide visual real estate for new elements such as the price tags or the find button and to implement the adaptations that were motivated by the user test of the second iteration.

4.2.1. Redesign of the color selector

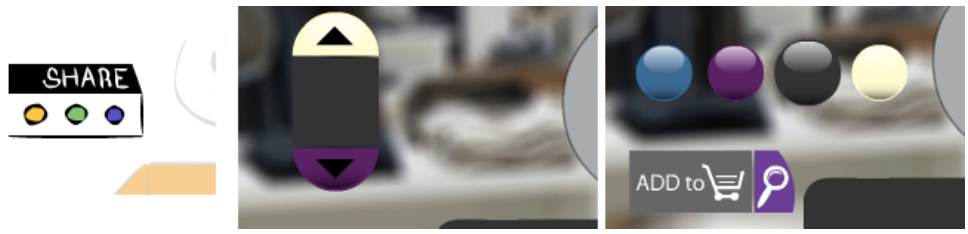


Figure 4.5: Three methods of displaying colors. First prototype (left), second prototype (center) and third prototype (right)

We returned to the concept of discrete buttons for the color selectors as it was implemented in the prototype of the first iteration. This was done since the color selector of the prototype of the second iteration (the middle part of figure 4.5) turned out to be more problematic than the one that was implemented in the prototype of the first iteration (the middle part of figure 4.5). Additionally, the user is able to access more functions of the system with fewer clicks using the color selector that features discrete buttons (see the right picture in figure 4.5).

The difference between the color selector of the first prototype and the one of the third prototype is that the first prototype relies on one color selector per type of clothing (see the left part of figure 4.6) whereas the third prototype relies on one color selector for all types of clothing (see the right part of figure 4.6). This was done to increase user familiarity over time since it creates expectations that the color changer is always located to the left side of the head of the avatar on the screen no matter what type of clothing is being selected.

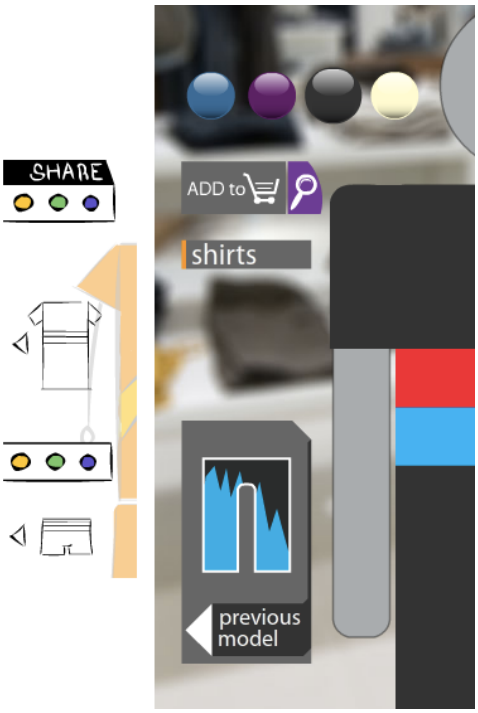


Figure 4.6: The color selectors of both prototypes. Left: first prototype with more than one color changer in different positions. Right: second prototype with one color changer fixed in the same position regardless of the item.

4.2.2. Reposition of the catalogue button

To make it more visible and to also make clear that the catalogue button is a clickable button we moved it to the right side of the screen and added an arrow to indicate its function as a button (see the lower part of figure 4.7).

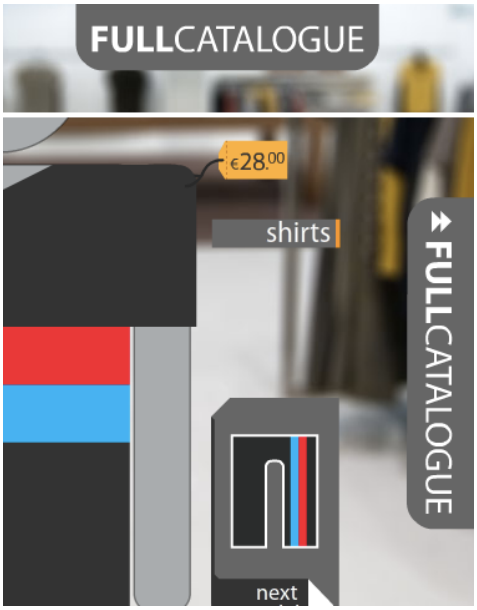


Figure 4.7: Top: catalogue position on the second prototype. Bottom: vertical position of the catalogue button in the third prototype.

With this solution we expect the user to have the catalogue within his field of vision while making it also clearer that this element is a button that opens another screen.

Since the catalogue button used to be positioned at the top, the intuitive transition to display the catalogue was from the top to the bottom of the screen (see left part of figure 4.8). Now that the catalogue button is on the right hand of the user, the animation takes effect from the sides of the screen. We took a different approach from the second prototype because instead of initiating the transition from where the catalogue button is positioned at (the right), the animation initiates from the left side of the screen. The reason for doing such thing is to make the mirror appear as if there was a band rotating to display the catalogue. In other words: one end leads to a reaction in the other end giving an effect as if the visual interface in the mirror is really a cylinder with a flat face facing the user. This choice was a design decision to possibly create more excitement without any motivations behind (see right part of figure 4.8).

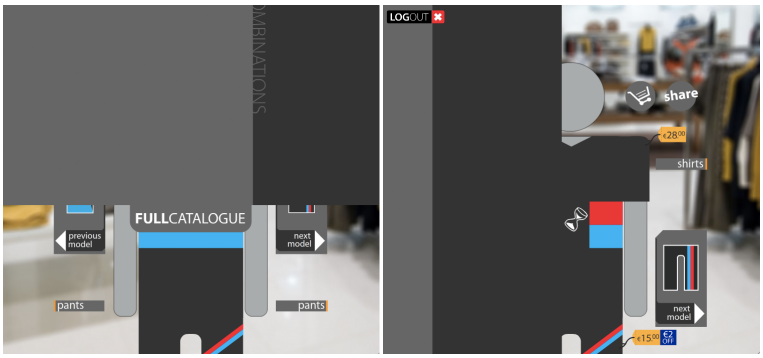


Figure 4.8: Left: second prototype downward transition motion. Right: third prototype horizontal (left-right) motion.

Some peripheral elements were added for visual enhancement such as the rotating sand clock that can be seen on the right side of figure 4.8. Apart from this, the phrase "Sweet Combinations" was replaced by the phrase "You're Looking Great!"

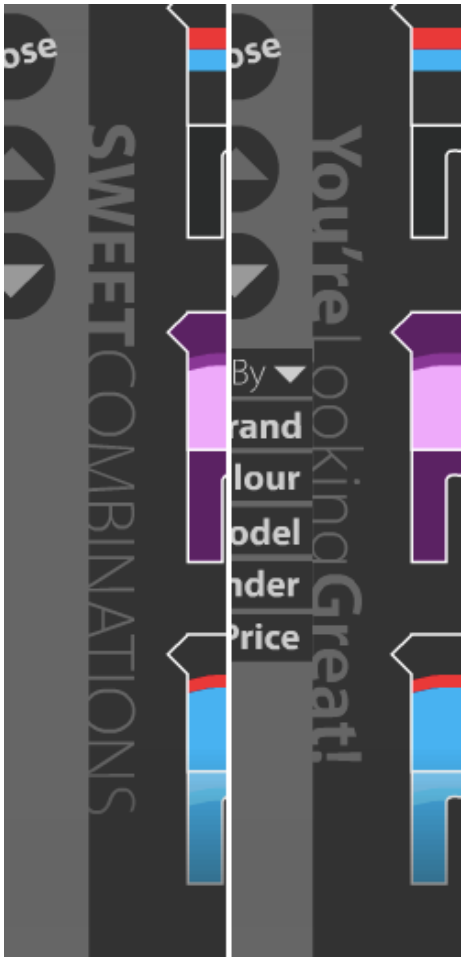


Figure 4.9: Second prototype (left) and third prototype (right)

4.2.2.1. Sorting within the catalogue

The functionality of sorting the catalogue was added and demonstrates some attributes that could be used for sorting (see figure 4.10). Further research is required to discover the best method for the user to sort the various items in the catalogue and also the best method to order and display the pieces that are in the catalogue.

Figure 4.10: The sorting options of the catalogue

4.2.3. Logout button

The logout button is always available and visible for the user. The function of the logout button is to delete all personal data that are stored about the user on the interactive mirror, for instance pictures that the user took using the mirror or payment details that has been stored to pay for clothes.

This button has a vital role in the system because as it enables the user to have some degree of privacy. Because of its vital role we decided to place the button in a fixed position that is always visible. The reason why the logout button was not included in the calibration screen is that the user has not yet disclosed any personal data to the system at that point.

Figure 4.11: The logout button is always located at the top-right corner of the screen regardless of what is shown in the screen

The position of the logout button is fixed to the top-left corner of the screen. Of course, further research is needed to find out if this location complies with the users' intuition. This question requires special scrutiny since some major websites position their logout or sign off functionality in the top-right corner of the screen instead of the top-left.

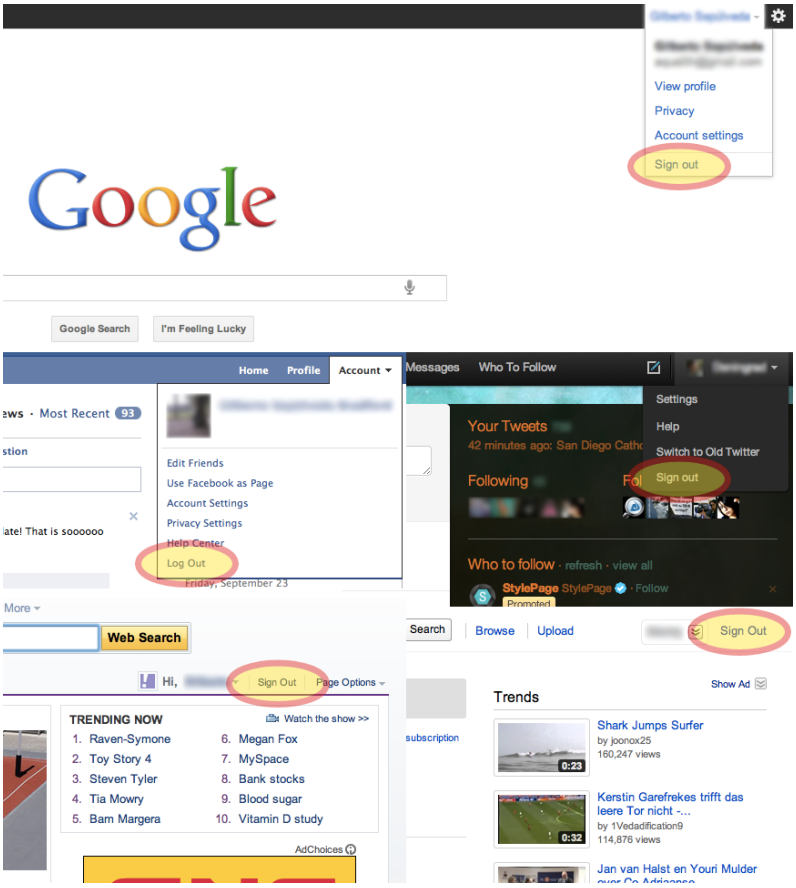


Figure 4.12: Logout functionality on different websites. Google's interface on the top, Facebook and Twitter's interface on the second row and Yahoo and YouTube's interface on the third row

As shown in figure 4.12, major websites locate the logout functionality in the top-right corner of their websites. However, even this variation from a

widespread convention would justify a replacement of this button in further work.

We added a red square with a white “X” to the logout button. Red was selected as a color of warning and the “X” was selected as a symbol of closing the system, as the user should already be familiar with this symbol due to the major operation systems in computers such as Windows, Mac OS X and Linux using such a symbol.

Figure 4.13: The logout button is accompanied by a red square with a white “X” symbolizing the closure of the system and the deletion of information

4.2.4. Share functionality

The share functionality dialog has been revamped and its behavior has been modified. While in the second prototype a pop-up describing the functionality only when the user pressed the share button it now appears when the user logs into the system. We found that since this pop-up dialog appears automatically the user should also have the possibility of closing the popup by clicking on the “X” (see the right part of figure 4.14).

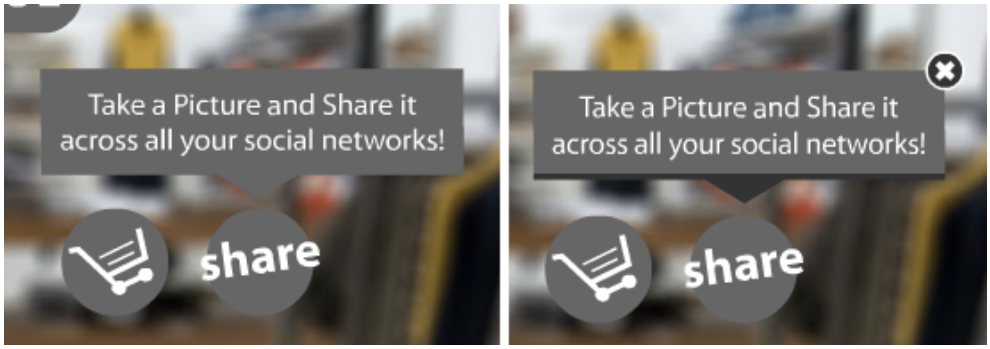


Figure 4.14: The dialog contains the possibility of getting closed. Left: version of the dialog in the second prototype. Right: version of the dialog in the third prototype.

The popup closes automatically after ten seconds so that the user can ignore the dialog if he considers it irrelevant or simply decides not to bother on closing it.

4.2.5. Add to cart button

While the former prototypes had the possibility to view one's cart they lacked a method of adding items to it. We added this button on the left side

of the users' control underneath the color selector. This was motivated by the fact that most of the functionalities of our interface were located on the right hand side of the interface. We wanted to visually balance this by placing this button on the left side of the interface.

The cart button features an animation that gives feedback to the user that the item has successfully been added to the cart. The cart icon is reused here since the cart icon is already used in the buying functionality and we assumed that it was natural to reuse the same element in another button that contains a related meaning with the buying functionality.

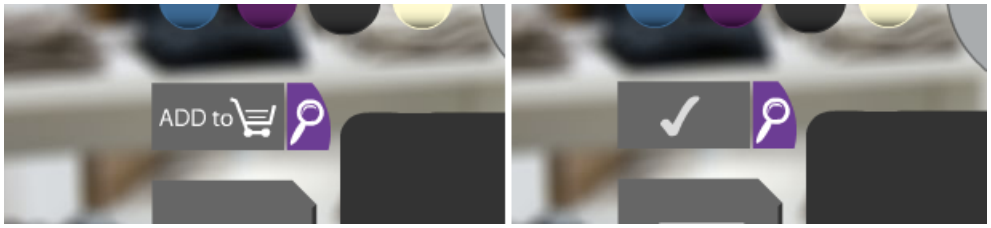


Figure 4.15: Left: The natural state of the Add to Cart button. Right: The Add to Cart button providing feedback to the user about his recent addition.

4.2.6. Locate item

4.2.6.1. Button

The locate item button initially looked differently. Instead of showing a magnifier, which is supposed to symbolize the act of locating something, the locate item button was initially thought to carry the word "Find." However, due to its size and at this point lack of visual real-estate in the interface, the "Find" word was replaced by an item of a magnifier. The background color purple has been chosen because of its contrast to the rest of the interface.

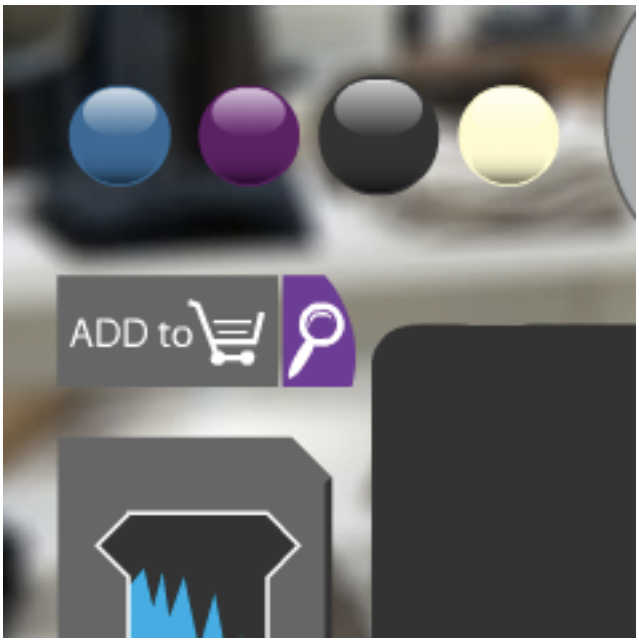


Figure 4.16: The locate item functionality can be accessed by pressing the white magnifier

4.2.6.2. Locate functionality transition

The animated transition of the locate functionality applied a different methodology than the buying functionality, sharing functionality and the full catalogue functionality. While all of these functionality, including the locate functionality, contain similar animations when the user is transported into another screen. The locate functionality is not intended to have any interaction other than retrieving data with the phone, therefore a different animated introduction was introduced. Instead of having the two gray panels gradually closing over the background a circular wave partially covers the whole screen.

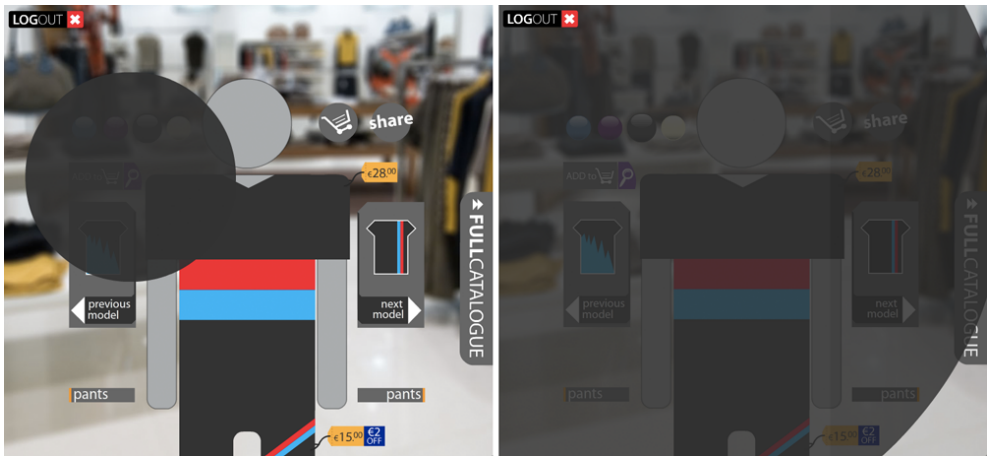


Figure 4.17: Transition animation of the locate functionality. Left: the early stage of the transition. Right: the late stage of the transition.

4.2.6.3. Locate item screen

The locate item screen can be distinguished from the screens of the other functionalities by the fact that it has a semi-transparent background and, unlike the screens of any other functionality, it does not contain interactive elements that would allow the user to go to another screen. This screen is merely informative and all its elements but the close button are either to inform or to give the user the option to retrieve the data that is being displayed on the screen on his phone.

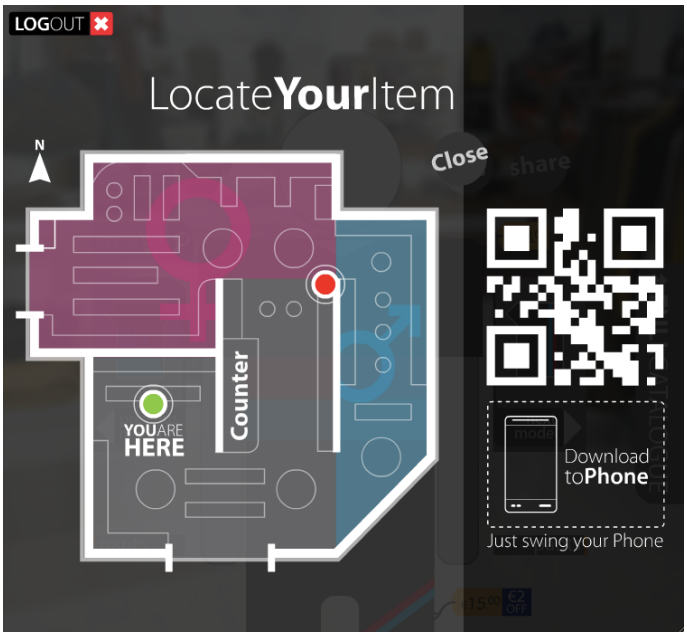


Figure 4.18: The locate item screen after pressing the white magnifier button.

Some modifications were made before arriving at this final version of this screen. The phrase “Just swing your phone” was added to indicate that the zone is reactive with the users’ mobile device and that he does not necessarily needs to read the QR-Code to retrieve the map if he does not want.

Figure 4.19: "Just swing your phone" phrase was added to increase the understanding of the intention of this element in the interface.

The icons that indicate the user’s and the target’s position on the map are animated to attract user’s attention to allow him to quickly identify where he and the selected item are located on the map.

4.2.6.4. Price tags

The price tags are one of the new elements that were added to the interface in the third prototype. Their function is merely informative; they do not contain any functionality that enables the user to further interact with it. Apart from informing the user of the price of the item, the price tags also have the capability of informing the user if there is, for instance, any promotion. They can be color coded as they often are in real life, however the color code of the promotion that is present in the prototype is only a proposal and can be adapted to the needs of an actual store.

All price tags face to the right of the item. This was done with the intention of maintaining a visual balance. The background color of the price tags was selected to provide a strong contrast against the background and the other gray buttons. The black text was selected to provide the appropriate contrast to make the text visually readable to the user.

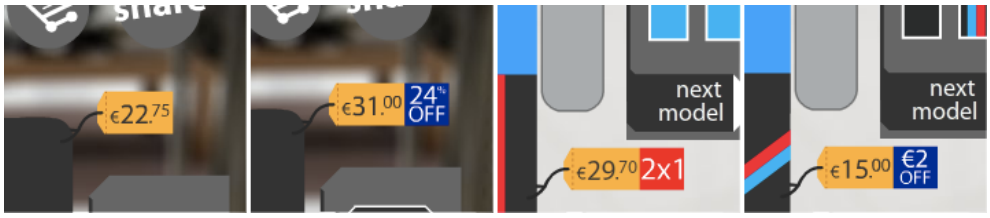


Figure 4.20 In the two examples on the left the price tag is positioned to the right of the shirt. On the two examples of the right the price tags are located to the right of the pants.

4.2.6.5. Buying Screen

The buying screen is a screen that was introduced in the third prototype. Itt followed the same visual style of the other screens with two bars in a different shade of gray transitioned by a unique animation. The purpose of the screen is to list the items that the user has in his cart while also giving the possible methods of payment.

Figure 4.21: Buying screen after the transition

Three methods are suggested as possibilities to pay for the item. The first one uses the phone of the user to pay. The second one incorporates other

methods that require retrieving information of the user, for instance payment via credit card. The third one allows ordering the item later so that the user can think about it and is, for instance able to buy the item when logging from his personal computer at home.

Both buttons below the swinging-phone option are layouted according to the theme of the prototype (see right part of figure 4.22). Both of them point to the right to represent moving forward or going to the next step, as it was done in the buttons of the share functionality (see left part of figure 4.22).

Figure 4.22: Left: Buttons of the share functionality in the second prototype. Right: Buttons of the Buying functionality of the third prototype.

5. Conclusions

The following chapter concludes and wraps up the report. At first, we will give a short summary. Following, we state the limitations of our work followed by a discussion about possible directions for further improvements of the system.

5.1. Summary

In this report, we described how we developed a prototype that features some adaptations that built on and extend the capabilities of the Tweet Mirror. These adaptations have been evaluated in two user tests and a smaller user evaluation targeting the possible users of the system. Based on these results, we believe that the presented system is usable for users the target group and provides functionality that can help them while shopping clothes.

5.2. Limitations

The presented product has several limitations in its applicability that are caused by the restrictions of the conditions under which it was tested and concerning the target group for which it was developed. These restrictions had to be made because of the limitations in our resources and, as well, the available timespan to carry out the project.

The needs of an important group of stakeholders, the owners of the stores, have not been considered at all. Interviewing such persons about their requirements regarding systems like the interactive mirror could have provided important information to ensure that the system does, as well, meet their needs. Addressing the needs of storeowners is likely to help to make the interactive mirror commercially successful.

The problem of persons of different gender using the mirror has, as well, not been considered at all. Users of different genders present different necessities and different perspectives, for example caused by differences in their size. By addressing this we could have made a system closer to the real needs of the customers of clothing stores.

5.3. Further work

The gestural interaction part of the mirror could be extended. First of all, the component that recognized the gestures was not reliable or versatile enough to be used in a real setting. Technical advancements in the future, for instance the availability of an official API from Microsoft for their Kinect, should help to tackle these issues soon. A functionality that could benefit from improved gesture recognition is that the system adapts the dimensions of the interface to the size of the user as this functionality needs a way to access the size of the user, for instance by using skeleton data. The second user test exposed a clear necessity of such a function.

Furthermore, a bigger vocabulary of gestures for the interaction with the interactive mirror has to be developed and evaluated, to be able to support more functions than just the two – changing designs and colors – that we supported. One important example for an important gesture that should be added is a gesture to switch between the shirt and pants mode of the system, since the addition of such a gesture would make it possible to select a complete outfit solely using gestural interaction.To increase the ability to serve as a "real" mirror we did some experiments to display parts of the users' body, for instance a picture of his face, on the screen to personalize the avatar on the screen. Such a function would also let the system appear more personal and it would also improve the capabilities to select clothes since the users would then be able to see whether the clothes fit their, for instance, eye color. The technical feasibility of this can as far as we tested it be answered positive. Nevertheless some problems, for instance in the performance when using Flash, have to be overcome since they made it impossible to include this in our final prototype. Further user research is necessary to see how such capabilities could be integrated in the interactive mirror in a user-friendly fashion.

Another expansion of the system would be to extend the concept to the selection of hats, shoes and other accessories might be desirable as different participants of our user tests mentioned it. Several decisions that we made during the development, for instance to have a separate mode for shirts and pants, were aiming at keeping the system expendable.

A possible extension to this might be that holding an object from the store in front of the mirror leads to it being displayed by the system. Technologically, this can be done using RFID tags that can be attached to the clothing from the store; they might already be in use in some stores.

Empirical data on the effects of the installment of such a system, for instance on the buying behavior of the customers, in a store would be

crucial for the selling of such a device since it could be able to justify the investment of a storeowner. The data that was collected in our user tests provides, indeed, a positive perspective for such a system. The applicability of our data is limited since it was collected with a too low number of participants and also in a laboratory setting. This is in need of a sound empirical foundation with a larger number of participants and in a real setting in a store.

As a further, probably more long-term, perspective this system could be made suitable to be used on other devices, like mobiles, tablets or also as a web-based application on the website of a store. Abandoning Flash and turning towards open standards as HTML and JavaScript could be an important step towards such platform independence.

Developing a mobile version would allow stores to provide some additional services, without the necessity to invest in a hardware mirror. Furthermore, online shops could also be users of an adapted version. To what extend the functionalities of the presented prototype of the mirror could indeed be ported to a web based system has to be subject of further investigations. For instance the gesture recognition might be problematic to realize. Some participants of the user tests kept suggesting, for instance, using this device at home. Use cases for such functionality could be imagined, for instance checking whether a store has clothes that suit one's taste or checking whether a certain piece of clothing is in stock at a store. Pictures that were created on such platforms could then be shared on social network, which might be fun for the user and also provide advertisement for the store.

The current product was, in the beginning, entirely based on the idea of a "mirror," in the sense of using a reflection of the user and projecting the user interface and a set of clothes on top of it. After the first iteration this idea was abandoned since we replaced the physical mirror, which was present in the user test by the reflective foil, with a video signal of the user. Our final prototype did even more diverge from a mirror since we decided to abandon the video signal in favor of the gesture recognition. Thus, we think that this abandoning of the mirror opens up the described possibilities like running this system on mobile devices and web browsers.

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7. Appendix

A.1 Questionnaire context of use analysis

1. How old are you?
    a. Younger than 16
    b. 16 – 24
    c. 25 – 32
    d. Older than 32
2. What's your gender?
    a. Male
    b. Female
3. Do you use social networks?
    a. At least daily
    b. At least weekly
    c. At least monthly
    d. More seldom
4. How often do you share media (Pictures, Videos, …) in Social Networks?
    a. At least daily
    b. At least weekly
    c. At least monthly
    d. More seldom
5. What do you share in Social Networks?
    a. Videos
    b. Photos/Pictures
    c. Stories
    d. Other things?
6. Do you use your computer for shopping?
    a. At least daily
    b. At least weekly
    c. At least monthly
    d. More seldom
7. Have you ever used a touchscreen?
    a. Yes
    b. No
8. Have you ever used a device that uses gestures and moves to interact with it? (For instance Nintendo Wii or Xbox Kinect)
    a. Yes

    b. No
9. Have you ever used such a device that is not a gaming console?
    a. Yes
    b. No
10. How often do you visit a clothing shop?
    a. At least daily
    b. At least weekly
    c. At least monthly
    d. More seldom
11. Do you go shopping rather alone or in a group?
    a. Alone
    b. Group

A.2 Storyboards and interactions

A.2.1 Kim

A.2.1.1 Storyboard

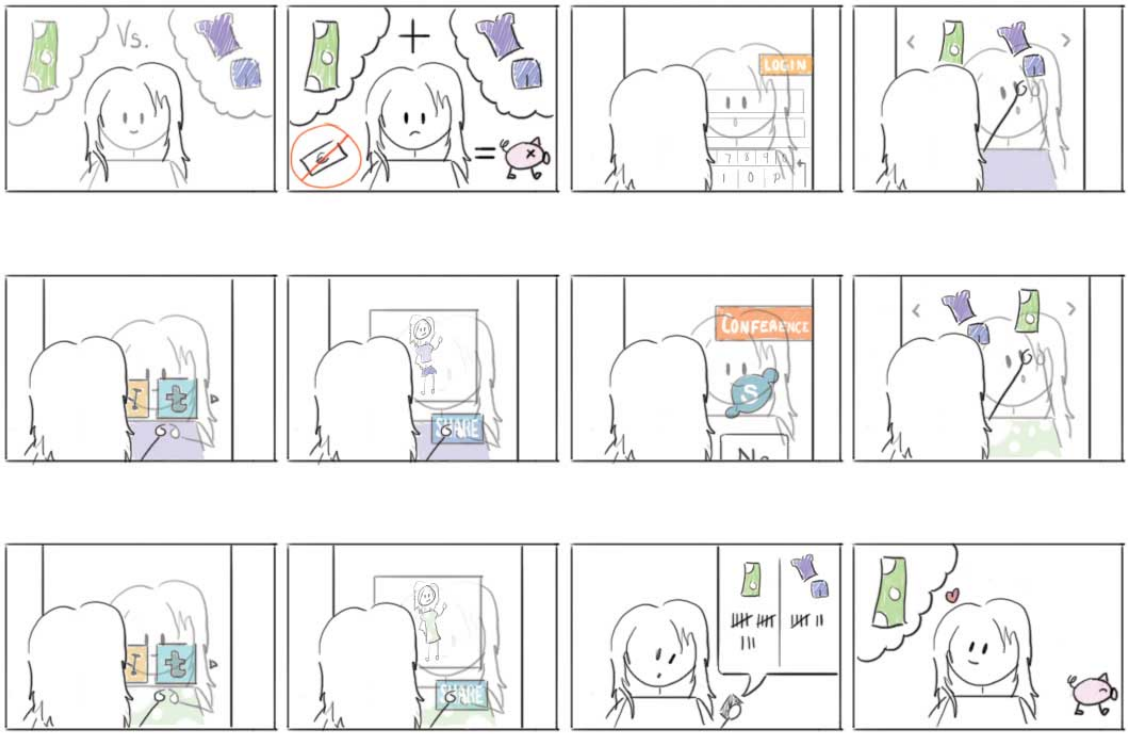

Figure A.1: Storyboard for scenario Kim

A.2.1.2 Story

Kim is a 16-year-old teenager who is about to turn 17 and is planning to buy a new outfit for her birthday party. She is not sure if she should go for a buttoned green dress or a purple blouse with blue shorts. She wants to buy both, but both outfits exceed her budget.

Therefore she decides to share photos of her two preferred outfits on her favorite social network. But instead of using her phone to take a photo she

goes to the Tweet mirror. The Tweet mirror, as usual, dresses Kim with the item in her hand. She can see that the green dress is also available in other colors but she decides to stick with green, her favorite color.

An icon to share is available on the screen. After selecting it, the mirror asks what she wants to share. Options are: a photo of her with the dress or the product itself. She decides to share the photo; so the mirror starts to count form 3 to 1 and takes a picture. Then the mirror asks where she want to share the photo. She chooses her preferred social network. She subsequently shares a photo of her other outfit. Minutes later she sees on her phone that her best friend Alex commented on her photos. He said that she looks better in the green dress. Kim does not take too long to realize that the majority of her friends support the green dress so she confidently decides to buy it.

A.2.1.3 Questions

The following questions were asked about the storyboard. The questions had to be answered on a four-point Likert scale.

- I understand the presented interaction.
- I would use the Tweet mirror to share media on the Internet.
- I would use the Tweet mirror to have a videoconference with a friend using MSN or Skype.
- I would use the Tweet mirror to login to my account on a social network.
- I would create an account on the Tweet mirror.
- What did you find especially positive in that interaction?
- Is there anything that you would like to add?

A.2.2 Jon

A.2.2.1 Storyboard

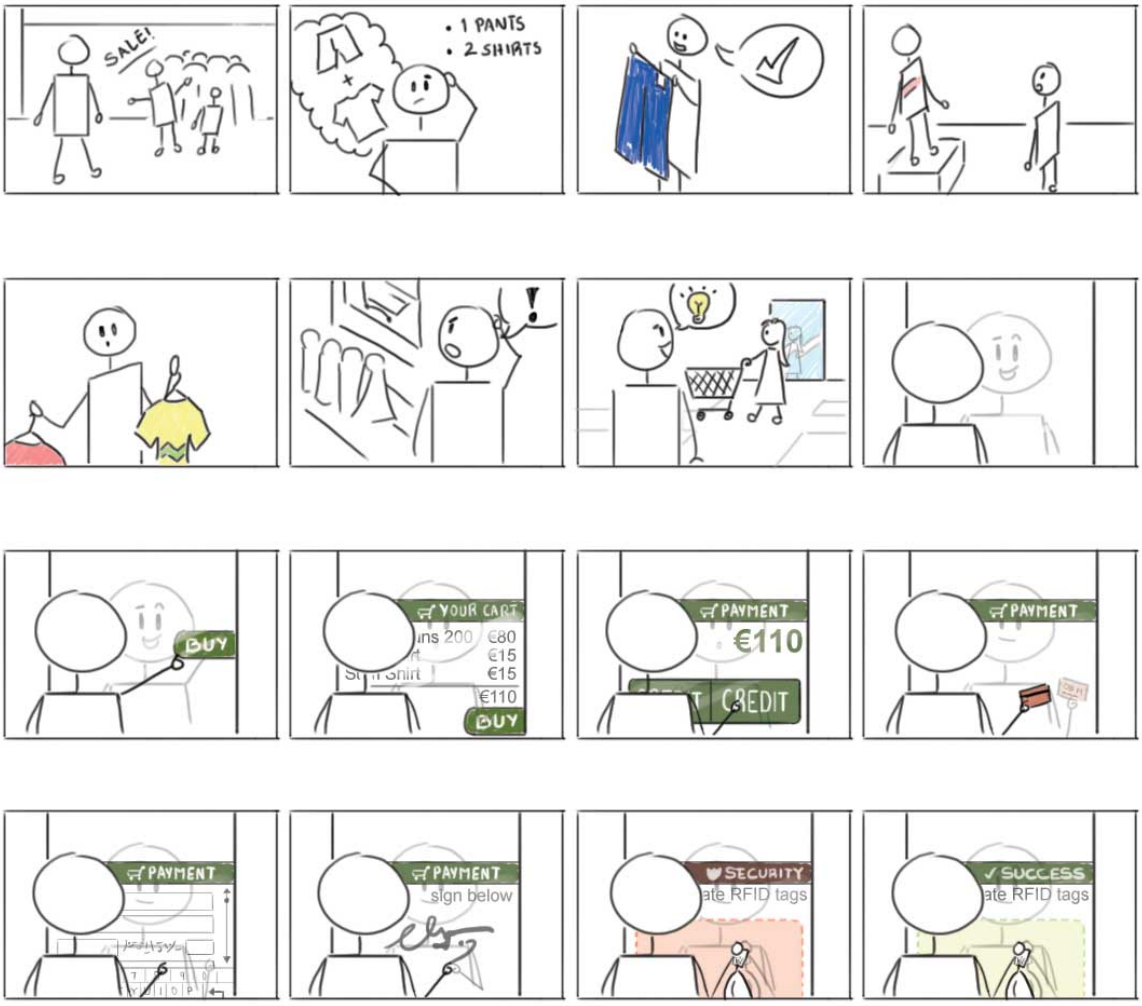

Figure A.2: Storyboard for scenario Jon

A.2.2.2 Story

Jon is a 21-year-old professional who is looking to buy a pair of jeans and a pair of shirts for his trip to Spain next month. The store is very crowded and he already found the pair of jeans and the two shirts that he wants to get.

He decides instead of waiting to try his garments and then waiting again to pay for them, to buy them right away from the mirror.

Jon gets next to the mirror, knowing that it's no traditional mirror. The Tweet mirror starts up detecting that Jon has some of the products of the store in his hand. The Tweet mirror dresses up the reflection of Jon, but he is not interested in seeing how he would look with the pants. Instead, he wants to buy the pants right away.

The Tweet mirror lists the items that he is holding with their respective prices in Jon's shopping cart. Then, the Tweet mirror asks Jon to place his debit or credit card in a particular place so the device can read it. After that he provides other details like his email address to send an e-ticket to his email address. To confirm the interaction he has to sign on the screen. After completing the transaction the mirror asks Jon to place his clothes in a special zone to deactivate the RFID tags so he won't set off the anti-theft alarm when leaving the store.

A.2.2.3 Questions

The following questions were asked about the storyboard. The questions had to be answered on a four-point Likert scale.

- I understand the presented interaction.
- I would prefer paying at the Tweet mirror to paying at a counter.
- I would use the mirror to pay at.
- I would enter my personal data to the Tweet mirror.
- What did you find especially positive in that interaction?
- Is there anything that you would like to add?

A.2.3 Summary

Some closing questions were asked which to be answered on a four-point Likert scale (except the last question).

- I would use such a system.
- The Tweet mirror would improve my shopping experience.
- The functionality of the Tweet mirror would help me when looking for clothes.
- I would revisit a store that has a Tweet mirror.
- Do you have any further suggestions or ideas?

A.3 First user test

A.3.1 Briefing

“Hello and thanks for you time to take part in our user test and to help us. Before we start with the test I am going to give you important background information on how we are going to proceed.

First of all, I want to clarify again that your participation in this test is absolutely voluntary. So you are allowed to leave at any time without giving reasons. If you need a break or feel uncomfortable, let us know.

The purpose of this test is to evaluate the quality of a prototype of a system. I want to make sure that you understand that it is the prototype what is being tested and not you.

We will ask you to carry out a series of tasks. I will give you all necessary instructions. Please ask questions immediately if you don’t understand what is being explained. One of us will be taking notes during the test. Besides that, we are going to videotape the test session to be able to gain the maximum use from your time. After completing the tasks, we are going to ask you to fill in a questionnaire. Furthermore, we might then ask questions on incidents during the test or your opinion of the system.

All information that we collect will be stored anonymous and will be treated confidential. The video recording that we make will only be used inside this team and will not be given or shown to other people. Nevertheless, we may use pictures of the videos in our report.

What we would like you to do during the test is to think aloud. This means that you should try to verbalize the thoughts that you have during the interaction with the system. No thought of you is unimportant, so don’t hesitate to express thoughts, even if you consider them irrelevant.

This concludes the briefing section. Do you have any further questions regarding the procedure? Then, let us start with the test. At first, we would like you to fill in a questionnaire.”

A.3.2 Debriefing

“Thanks for taking the time to participate in the test and to support our project. We would like you to fill in a short questionnaire that asks you about your opinions on the system that you have tried. If it is necessary we will ask some additional questions to you to clarify special situations in the

test. If you don't understand questions of the questionnaire please ask for clarification."

A.3.3 Introduction questionnaire

- How old are you?
  - Younger than 16
  - 16 – 24
  - 25 – 32
  - Older than 32
- What's your gender?
  - Male
  - Female
- How often do you visit clothing stores?
  - At least daily
  - At least weekly
  - At least monthly
  - More seldom
- Do you go shopping rather alone or in a group?
  - Alone
  - Group
- Do you use social networks?
  - At least daily
  - At least weekly
  - At least monthly
  - More seldom
- How often do you share media (Pictures, Videos, …) in Social Networks?
  - At least Daily
  - At least Weekly
  - At least monthly
  - More seldom

A.3.4 Task success

As explained in section 2.5.5.1, six users had to carry out seven tasks. The results of this user study can be found below.

- **Task 1:** Change shirt to another model
- **Task 2:** Change the shirt's color
- **Task 3:** Change pants to another model
- **Task 4:** Change the pant's color
- **Task 5:** Share outfit

- **Task 6:** Select Twitter and send message
- **Task 7:** Use outfit recommendation

Touch Mode	**Participant 1**	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**	**Participant 6**
Task 1	Yes [1]	Yes	N/A	Yes	Yes	Yes [13]
Task 2	Yes	Yes	No	Yes [10]	Yes	Yes
Task 3	Yes	Yes	Yes	Yes	Yes	Yes
Task 4	Yes [1]	Yes	No	Yes	Yes	Yes
Task 5	Yes [2]	Yes	Yes	Yes	Yes [12]	Yes
Task 6	Yes	Yes	Yes [6]	Yes	Yes	Yes
Task 7	Yes	Yes	Yes	Yes	Yes	Yes
Gesture Mode	**Participant 1**	**Participant 2**	**Participant 3**	**Participant 4**	**Participant 5**	**Participant 6**
Task 1	N/E	Yes	Yes	Yes	Yes	Yes
Task 2	N/E	Yes [3]	No	Yes [11]	Yes	Yes
Task 3	N/E	Yes [4]	Yes [7]	Yes	Yes	Yes [14]
Task 4	N/E	Yes [5]	Yes [7]	Yes	Yes	Yes
Task 5	N/E	No	No [8]	Yes	Yes	Yes
Task 6	N/E	No	No	Yes	Yes	Yes
Task 7	N/E	No	Yes [9]	Yes	Yes	Yes

Legend: Yes means that the task of the participant was accomplished successfully. No means that the task of the participant was not accomplished successfully. N/E means "Not Executed," so the user did not execute this task because of technical problems. A number next to the mark indicates details on the specific task.

1. This participant commented that it could be difficult to find one specific model of a piece of clothing just by scrolling.
2. This participant hesitated to click on the "Share" button since this button seemed to be quite small and in an illogical place. User 1 considered that gestures were overall illogical.
3. This participant got confused on how to change the color of an item with the use of gestures. This participant used the gesture of waving his hand from top to bottom to change color instead. This participant considered that while swiping the hand from top to bottom is the most logical step to change the color of the clothes, it

required arrows up and down to indicate that such gesture is available.

4. This participant swiped his hand from right to left to change pants.
5. This participant used the hand swiping gesture form bottom to top as opposed to task 2 were he changed the color of the shirt.
6. This participant considered that the arrangement of the Continue and Retry buttons were wrongly positioned and that they should be otherwise. This participant also considered that there were far too many elements to pay attention to the text on those buttons.
7. This participant considered that pointing at the garment itself is the best option to make a change in the color of it.
8. This participant indicated that the "Share" button is quite close the change of colors of the shirt.
9. This participant indicated his preference to scroll the recommended outfits instead of having multiple options at the same time.
10. This participant concluded that clicking on the object [shirt] makes more sense in order to change the color of the garment.
11. This participant considered that to change the color of an object it's better to open his fist.
12. This participant had trouble finding the share button. He overall felt more comfortable and familiarized with the use of a touchscreen. However he expressed some amusement and approval of the use of gestures.
13. This participant swiped the shirt model as opposed to click on the next arrow in order to get to the next model. This is due to his familiarity to Android devices.
14. This participant noted in the interview that he is an Android user due to the fact that he finds some familiarity in the touch and gesture interface.

General questions						
	<16	16-24	25-32	>32	Mean	S.D.
How old are you?	0%	67%	33%	0%		
	Male	Female				
What's your gender?	67%	33%				
	[1]	[2]	[3]	[4]		
How often do you visit a clothing shop?	0%	33%	33%	33%	3.00	0.89

	Alone	Group				
Do you go shopping rather alone or in a group?	17%	83%			1.83	0.41
	[1]	[2]	[3]	[4]		
Do you use social networks?	100%	0%	0%	0%	1.00	0.00
	[1]	[2]	[3]	[4]		
How often do you share media (pictures, videos, ...) in social networks?	17%	50%	0%	33%	2.50	1.23

A.3.5 Results of questionnaire in user study

Below are the results of the questionnaire presented, which was taken after the user study. In total 6 persons filled in the questionnaire. The percentages of each given answer is presented in the table below, as well as the mean and standard deviation (S.D.).

In the answering options, the numbers [1] until [4] stands for:

[1] = At least daily
[2] = At least weekly
[3] = At least monthly
[4] = More seldom

	Strongly disagree				**Strongly agree**	**Mean**	**S.D.**
Gestures interaction							
I found the interaction with gestures intuitive	0%	50%	17%	33%	0%	2.83	0.98
I found that the gestures were easy to learn	0%	67%	0%	33%	0%	2.67	1.03
I found that using gestures was tiring	0%	60%	20%	20%	0%	2.60	0.89

I think that gestures are a good technique to control this interface	0%	50%	17%	17%	17%	3.00	1.27
I think that using gestures was an exciting way to control the user interface	0%	0%	0%	100%	0%	4.00	0.00
Touch input interaction							
I found the interaction with touch input intuitive	0%	0%	0%	50%	50%	4.50	0.55
I found that the touch input were easy to learn	0%	0%	17%	33%	50%	4.33	0.82
I found that using touch input was tiring	33%	50%	0%	17%	0%	2.00	1.10
I think that touch input is a good technique to control this interface	0%	0%	0%	83%	17%	4.17	0.41
I think that using touch input is an exciting way to control the user interface	0%	17%	17%	67%	0%	3.50	0.84
Interactive mirror in general							
I think that I would like to use the interactive mirror frequently	0%	33%	17%	50%	0%	3.17	0.98
I found the interactive mirror unnecessarily complex	17%	50%	17%	17%	0%	2.33	1.03
I thought the interactive mirror was easy to use	0%	17%	17%	50%	17%	3.67	1.03
I think that I would need the support of a technical person to be able to use the interactive mirror	17%	83%	0%	0%	0%	1.83	0.41
I found the various functions in the interactive mirror were well integrated	0%	0%	17%	83%	0%	3.83	0.41

I thought there was too much inconsistency in the interactive mirror	17%	50%	0%	17%	17%	2.67	1.51
I would imagine that most people would learn to use the interactive mirror very quickly	0%	0%	33%	50%	17%	3.83	0.75
I found the interactive mirror very difficult to use	33%	33%	17%	17%	0%	2.17	1.17
I felt very confident using the interactive mirror	0%	0%	33%	50%	17%	3.83	0.75
I needed to learn a lot of things before I could get going with the interactive mirror	50%	50%	0%	0%	0%	1.50	0.55
User study							
	Confusing			**Very clear**		**Mean**	**S.D.**
I found the organization of information on the interactive mirror	0%	33%	17%	33%	17%	3.33	1.21
	Hard to read			Easy to read			
I found elements on the interface of the interactive mirror	0%	0%	17%	50%	33%	4.17	0.75
	Confusing			Very clear			
I found the sequence of the steps of the interactions	0%	0%	0%	83%	17%	4.20	0.45
	Inconsistent			Consistent			
I found the position of information on the interactive mirror	0%	0%	17%	67%	17%	4.00	0.63
	Never			Always			
I found that tasks can be performed in a straight-forward manner	0%	17%	0%	83%	0%	3.67	0.82
Closing questions							

	Strongly disagree				Strongly agree	Mean	S.D.
I think that I would use the interactive mirror	0%	17%	0%	83%	0%	3.67	0.82
I think that the interactive mirror would improve my shopping experience	0%	0%	50%	50%	0%	3.50	0.55
I think that the functionality of the interactive mirror would help me when looking for clothes	0%	0%	50%	50%	0%	3.50	0.55
I would revisit a store that has an interactive mirror	0%	0%	50%	33%	17%	3.67	0.82

A.4 Kinect connection

Connecting the Kinect to the PC is not yet supported by Microsoft. There are ways to get it working, but the software that does that is continually improving. Therefor, it is possible that our set-up is not working any more when trying to execute the steps below.

The Kinect was connected to a 32-bit edition of Windows XP. During the process was discovered that 64 bit gave problems with drivers of some software. The first four steps are also described on the website: http://www.kinect-hacks.com/kinect-guides/2011/02/02/beginners-guide-setting-your-microsoft-kinect-windows-pc-hacking

1. OpenNI (www.openni.org) is middleware software that connects the Kinect drivers to other software. Version 1.0.0.25 (unstable, binary version) was used. The software can be downloaded from www.openni.org.
2. Install SensorKinect, which as a connection between OpenNI and PrimeSence (installed later in step 3). This is also available via the OpenNI website (http://www.openni.org/downloadfiles/openni-compliant-hardware/31-latest-unstable). Version 5.0.0 was used.
3. PrimeSense (www.primesense.com) is also middleware; their program NITE is used to create a skeleton from the data of the Kinect. The latest version is available from the PrimeSense website or from the OpenNI website. For this project the version 1.3.0.18

was used. The license key: *0KOIk2JeIBYClPWVnMoRKn5cdY4=* must be used.

4. In order to get the PrimeSense examples running properly, two files have to be copied.
    a. Copy the XML files from "c:\Program Files\Prime Sense\Sensor\SampleXMLs\NITE\Data" into "c:\Program Files\Prime Sense\NITE\Data" (overwrite files)
    b. Copy the XML files from "c:\Program Files\Prime Sense\Sensor\SampleXMLs\OPENNI\Data" into "c:\Program Files\OpenNI\Data" (overwrite files)
5. Connect the Kinect to the PC. If the Kinect has no outlet adapter, a special adapter with a splitter for USB and power has to be bought. The USB port of the computer does not provide enough power for the Kinect. When connected to the computer, Windows will recognize the Kinect and assign the right drivers.
6. Download the FAAST package from http://projects.ict.usc.edu/mxr/faast/ . This software connects to NITE, can interpret the hand gestures and skeleton position to control the mouse or have keys pressed, and can send skeleton data via a VRPN connection. Opening the FAAST.exe and pressing the connect button should work now.
7. VRPN is the interface between the skeleton coordinates of FAAST and the Flash program of the project. VRPN can be downloaded from http://www.cs.unc.edu/Research/vrpn/ and especially the folder java_vrpn is used in this project. This folder contains Java files needed to connect to the VRPN output of FAAST.
8. The files TrackerServer.java and Server.java are written for this project to connect to the VRPN server, create an own socket and pass on the information to this socket. Flash will open this socket (and by doing so is the client) and can use the coordinates of the skeleton.
9. If necessary, install the Java SDK from oracle.com to be able to compile the java files. Execute “java test.TrackerServer” in a dos-window (start->run->cmd). Executing “java test.Client” in a separate window will show the output of the TrackerServer, which will also be used in Flash.
10. Having turned on a firewall can cause problems. If the VRPN software does not show any activity, try to turn off the firewall.
11. The Flash program connects to the java TrackerServer. Unfortunately, Flash has the policy not to be able to connect to a server, unless the server has a socket policy file. This file is requested on port 843 through a TCP connection. Explanation of

this phenomenon and a simple policy server can be downloaded from: http://www.adobe.com/devnet/flashplayer/articles/socket_policy_files.html . The policy file (flashpolicy.xml in the unzipped folder) has to be altered that connections from localhost:4445 are allowed. After installing Python (www.python.org) the program flashpolicyd.py in the folder Python_init can be started with Python with parameter --*file=..\flashpolicy.xml*

12. After the Kinect is connected to the computer and FAAST, the Flash policy server and TrackerServer are running, the Flash program can be started.

A.5 Small-scale evaluation of second iteration

A.5.1 Briefing

Welcome and thanks for participating in our user test. With this test, we want to evaluate a prototype of a system that we have created. The system that is going to be tested will be setup in clothing stores to assist customers when looking for clothes.

During the test, we are going to ask you to carry out some tasks with this prototype. What we are going to record is whether you were able to complete these tasks and what problems you encountered while doing this. No video or audio recordings of the test will be made. We will record the mouse movements on the screen. At the end of the test we will ask you a set of questions to get an idea about your views on the prototype and to discuss problems you maybe ran into. All data is stored without a reference to your name and none of the records will be given to persons outside the team. The results of this study will be presented to the university and the company NEDAP that is also taking part in this project.

A.5.2 Consent form

The following consent form[15] has been given to the participants of the informal user evaluation.

Participant Consent Form

Welcome and thanks for participating in our user test. The purpose of this usability test is to evaluate a prototype of an interactive mirror. This system will be setup in clothing stores to assist customers when looking for clothes.

We are interested in determining if people can accomplish common tasks using this prototype of the system. The session will not 'test' you or your ability, rather the session will test the application to provide information on areas that might be improved. Please be advised that there are no risks associated with participation in this session.

During this session, you will be asked to complete some tasks using the application. Furthermore, we will ask you a set of questions at the end. As you complete the tasks, I will observe and take notes. The session will last no longer than fifteen minutes.

No audio or video recordings of the session will be made. A recording of your mouse movements will be made.

If for any reason you are uncomfortable during the session and do not want to complete a task, you may say so and we will move on to the next task. In addition, if you do not want to continue, you may end the session and leave at any time.

Approximately 5 people will participate in this study. Results from all sessions will be included in a usability report to be presented to our supervisor at the university and to the company NEDAP. Your name will not be included in the report nor will your name be associated with any session data collected.

I, _____, have read and fully understand the extent of the study and any risks involved. All of my questions, if any, have been answered to my satisfaction. My signature below acknowledges my understanding of the information provided in this form and indicates my willingness to participate in this user testing session. I have been given a blank copy of this consent form for my records.

[15] The form is mostly based on http://www.indiana.edu/~usable/templates/Participant_consent_form.htm.

Signature:_____
Date:_____

A.6 Second user evaluation of second iteration

A.6.1 Consent form

Participant Consent Form

Welcome and thanks for participating in our user test. The purpose of this usability test is to evaluate a prototype of an interactive mirror. This system will be setup in clothing stores to assist customers when looking for clothes.

We are interested in determining if people can accomplish common tasks using this prototype of the system. The session will not 'test' you or your ability, rather the session will test the application to provide information on areas that might be improved. Please be advised that there are no risks associated with participation in this session.

During this session, you will be asked to complete some tasks using the application. Furthermore, we will ask you a set of questions at the end. As you complete the tasks, one experimenter will observe and take notes. Feel free to ask any questions that you might have. The session will last no longer than thirty minutes.

Audio and video recordings of the session will be made. Only the members of our group will see the recordings.

Approximately 5 people will participate in this study. Results from all sessions will be included in a usability report to be presented to our supervisor at the university and to the company NEDAP. Your name will not be included in the report nor will your name be associated with any session data collected.

If for any reason you are uncomfortable during the session and do not want to complete a task, you may say so and we will move on to the next task. In addition, if you do not want to continue, you may end the session and leave at any time.

I, _____, have read and fully understand the extent of the study and any risks involved. All of my questions, if any, have been answered to my satisfaction. My signature below acknowledges my understanding of the information provided in this form and indicates my

willingness to participate in this user testing session. I have been given a blank copy of this consent form for my records.

Signature:_____
Date:_____

A.6.2 Questionnaire

1. Age group
    a. Younger than 16
    b. 16 – 24
    c. 25 – 32
    d. Older than 32
2. Gender
    a. Male
    b. Female
3. Technical experience
    a. How long do you use a computer per day?
        i. Less than one hour
        ii. Between one and four hours
        iii. More than four hours
    b. How would you rate your computer experience?
        i. Beginner
        ii. Average
        iii. Professional
    c. Where do you employ a computer mostly?
        i. For my profession
        ii. For my hobbies
    d. Have you ever used a touchscreen device?
        i. Yes
        ii. No
    e. Have you ever used a device that uses gestures and moves to interact with it? (For instance Nintendo Wii or Xbox Kinect)
        i. Yes
        ii. No
    f. Have you ever used such a device that is not a gaming console?
        i. Yes
        ii. No
    g. Social networking experience

A.6.3 Perception of the interface

1. Organization of information on the interactive mirror (Confusing — Very clear)
2. Sequence of the steps of the interactions (Confusing — Very clear)
3. Tasks can be performed in a straight-forward manner (Never — Always)

The following questions had to be answered on a five-point Likert scale.

1. I think that I would like to use the interactive mirror frequently
2. I found the interactive mirror unnecessarily complex
3. I thought the interactive mirror was easy to use
4. I think that I would need the support of a technical person to be able to use the interactive mirror
5. I thought there was too much inconsistency in the interactive mirror
6. I would imagine that most people would learn to use the interactive mirror very quickly
7. I found the interactive mirror very difficult to use
8. I felt very confident using the interactive mirror
9. I needed to learn a lot of things before I could get going with the interactive mirror

As closing questions we asked a set of general question on the interactive mirror.

10. I think that I would use the interactive mirror
11. I think that the interactive mirror would improve my shopping experience.
12. I think that the functionality of the interactive mirror would help me when looking for clothes.
13. I would revisit a store that has an interactive mirror.

A.6.4 Semantic differential questions

The next questions about the feeling of the product had to be answered on a five-point scale.

- Human vs. Technical
- Pleasant vs. Unpleasant
- Simple vs. Complicated
- Professional vs. Unprofessional
- Ugly vs. Attractive
- Practical vs. Impractical
- Difficult vs. Straightforward

- Rejecting vs. Inviting
- Good vs. Bad
- Confusing vs. Clearly structured
- Motivating vs. Discouraging
- Warm vs. Cold
- Modern vs. Old-fashioned

A.6.5 Results of questionnaire second iteration user study

Below are the results of the questionnaire presented, which was taken after the user study in the second iteration. In total 5 persons filled in the questionnaire. The percentages of each given answer is presented in the table below, as well as the mean and standard deviation (S.D.).

General questions						
	<16	**16-24**	**25-32**	**>32**	**Mean**	**S.D.**
How old are you?	0%	80%	20%	0%		
	Male	Female				
What's your gender?	60%	40%				
	[1]	[2]	[3]			
How long do you use a computer per day?	0%	20%	80%			
	[4]	[5]	[6]			
How would you rate your computer experience?	0%	20%	80%			
	Profession		Hobbies			
Where do you employ a computer mostly?	80%		20%			
	Yes	No				
Have you ever used a touchscreen device?	100%	0%				
	Yes	No				
Ever used a device that uses gestures and moves to interact with it?	80%	20%				
	Yes	No				

Ever used such a device that is not a gaming console?	60%	20%

In the answering options, the numbers [1] until [6] stands for:

[1] = Less than one hour
[2] = Between one hour and four hours
[3] = More than four hours

[4] = Beginner
[5] = Average
[6] = Professional

Touch-based interaction							
	Strongly disagree				**Strongly agree**	**Mean**	**S.D.**
I found the interaction with touch-based interaction intuitive	0%	0%	0%	60%	40%	4.4	0.55
I found that the touch-based interaction was easy to learn	0%	0%	0%	20%	80%	4.8	0.45
I found that using touch-based interaction was tiring	40%	40%	20%	0%	0%	1.8	0.84
I think that touch-based interaction is a good technique to control this interface	0%	0%	20%	40%	40%	4.2	0.84
I think that using touch-based interaction is an exciting way to control this interface	0%	20%	20%	40%	20%	3.6	1.14
Gestural interaction							
	Strongly disagree				**Strongly agree**	**Mean**	**S.D.**
I found the interaction with gestures intuitive	0%	20%	20%	20%	40%	3.8	1.3
I found that the gestural interaction was easy to learn	0%	20%	40%	20%	20%	3.4	1.14
I found that using gestural interaction was tiring	0%	20%	40%	40%	0%	3.2	0.84
I think that gestural	0%	20%	0%	60%	20%	3.8	1.1

interaction is a good technique to control this interface							
I think that using gestural interaction is an exciting way to control this interface	0%	0%	0%	60%	40%	4.4	0.55

Interactive mirror in general							
	Strongly disagree				**Strongly agree**	**Mean**	**S.D.**
I think that I would like to use the interactive mirror frequently	20%	0%	40%	0%	40%	3.4	1.67
I found the interactive mirror unnecessarily complex	20%	40%	20%	0%	20%	2.6	1.52
I thought the interactive mirror was easy to use	0%	20%	20%	60%	0%	3.4	0.89
I think that I would need the support of a technical person to be able to use the interactive mirror	60%	20%	20%	0%	0%	1.60	0.89
I thought there was too much inconsistency in the interactive mirror	40%	20%	20%	0%	20%	2.40	1.67
I would imagine that most people would learn to use the interactive mirror very quickly	0%	0%	0%	80%	20%	4.20	0.45
I felt very confident using the interactive mirror	0%	20%	20%	20%	40%	3.80	1.30
I needed to learn a lot of things before I could get going with the interactive mirror	40%	40%	20%	0%	0%	1.80	0.84
	Confusing				**Very clear**	**Mean**	**S.D.**
I found the organization of information on the interactive mirror	0%	20%	20%	60%	0%	3.40	0.89
	Confusing				Very clear		
I found the sequence of the steps of the interactions	0%	0%	20%	40%	40%	4.20	0.84
	Never				Always		
I found that tasks can be	0%	0%	0%	80%	20%	4.20	0.45

performed in a straight-forward manner

Feeling of the product							
	Human				Technical		
Human vs. technical	0%	20%	40%	20%	20%	3.40	1.14
	Pleasant				Unpleasant		
Pleasant vs. unpleasant	40%	40%	20%	0%	0%	1.80	0.84
	Simple				Complicated		
Simple vs. complicated	20%	40%	20%	0%	20%	2.60	1.52
	Professional				Unprofessional		
Professional vs. unprofessional	20%	60%	0%	0%	20%	2.40	1.52
	Ugly				Attractive		
Ugly vs. attractive	20%	0%	0%	60%	20%	3.60	1.52
	Practical				Impractical		
Practical vs. impractical	40%	0%	40%	0%	20%	2.60	1.67
	Difficult				Straightforward		
Difficult vs. straightforward	0%	0%	40%	60%	0%	3.60	0.55
	Rejecting				Inviting		
Rejecting vs. inviting	0%	0%	0%	60%	40%	4.40	0.55
	Good				Bad		
Good vs. bad	20%	60%	20%	0%	0%	2.00	0.71
	Confusing				Clearly structured		
Confusing vs. clearly structured	0%	20%	0%	60%	20%	3.80	1.10
	Motivating				Discouraging		
Motivating vs. discouraging	20%	60%	20%	0%	0%	2.00	0.71
	Warm				Cold		
Warm vs. cold	0%	80%	20%	0%	0%	2.20	0.45
	Modern				Old-fashioned		
Modern vs. old-fashioned	60%	20%	0%	20%	0%	1.80	1.30
Closing questions							

	Strongly disagree				Strongly agree	Mean	S.D.
I think that I would use the interactive mirror	20%	0%	0%	60%	20%	3.60	1.52
I think that the interactive mirror would improve my shopping experience	20%	0%	40%	0%	40%	3.40	1.67
I think that the functionality of the interactive mirror would help me when looking for clothes	20%	0%	20%	20%	40%	3.60	1.67
I would revisit a store that has an interactive mirror	0%	0%	0%	60%	40%	4.40	0.55

THE INTERACTIVE MIRROR

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