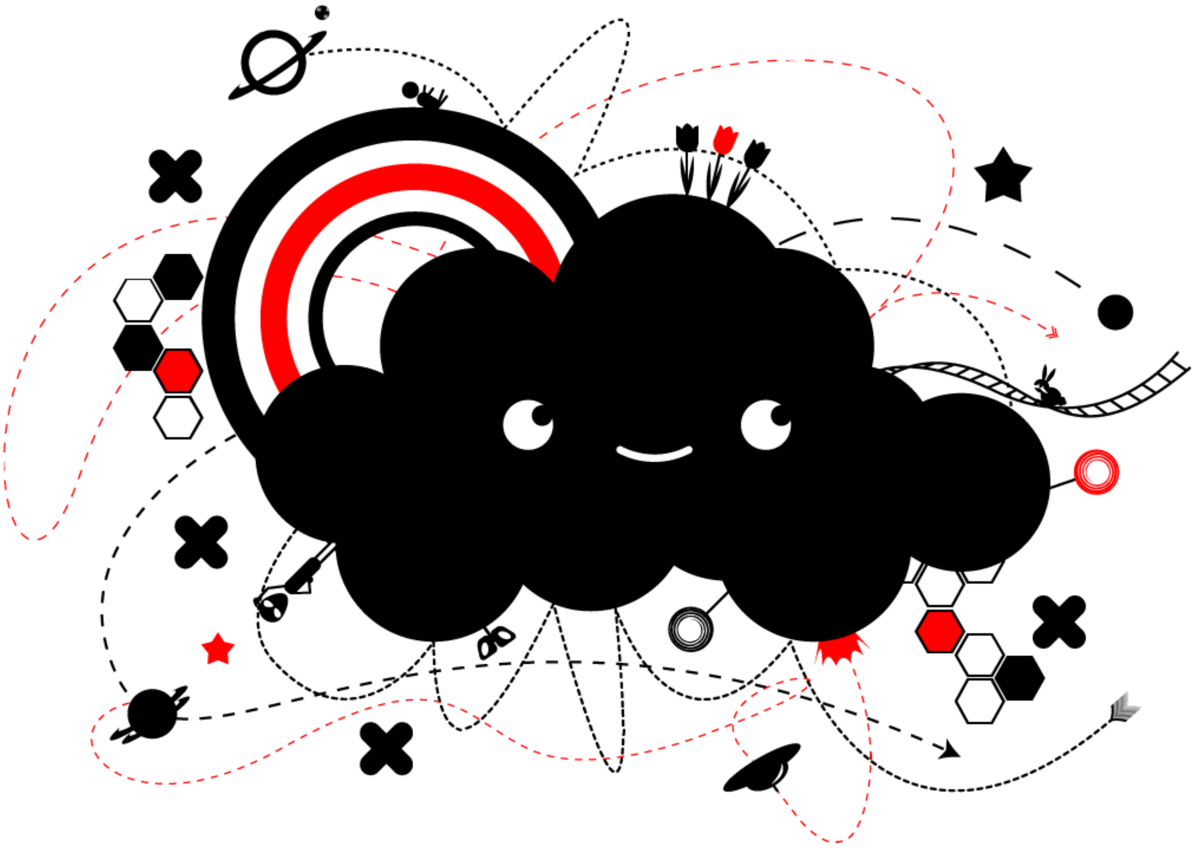
ThingyCloud



ThingyCloud

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Preface

In this report we address the methodology and products of “Thingy Cloud” the interactive ceiling prototype we have made. This prototype, of a interactive system application, was made for the course “HMI project” for the study, Human Media Interaction(HMI) at the University of Twente. The assignment for this course was to develop an interactive system with the user in mind. During this project we had to focus on the following points:

- Designing and implementing a prototype of an interactive system.
- Techniques and methods from the field of Interaction Design.
- Performing and applying research in the area of Interaction Design.
- Designing, performing and evaluate a small scale user experiment.
- Reporting and presenting the findings in a consistent manner.

The target group of this report is therefore people who want to know how this project is conducted and what the results are of creating our interactive system “Thingy Cloud”. We expect readers of this report to have some basic understanding of developing interactive systems and software development methods.

This project was part of our study guided by two instructors. We want to thank them, Mannes Poel and Gijs Huisman, for their support and guidance during this project. We also want to thank the other staff of the HMI group for their time in answering questions and sharing their knowledge and experiences.

This report gives an insight into the methodology, research and results of the assignment to develop an interactive system with the user in mind.

In chapter one we will introduce you to our conceptual idea, goals and methodology of our project. Here we will answer the questions: why did we choose this project, what is the idea behind the system, what are the goals and what we used during the execution this project.

Chapter two will focus on the research we did on forehand and what we learned from it.

The study we performed during the first iteration of this project will be described in chapter three. Here we will address what we researched during this time and what we learned from it and what its effects were for the second iteration.

In chapter four we will look at the prototype we made during the second iteration. We will look at the requirements, graphical and technical design, and how it was used in practice.

In the fifth chapter the final user study will be explained. Here we will describe how the experiment was designed, the results of the experiment and the conclusions we drew based on these results.

In the final chapter we will evaluate our project, based on the goals as described in the first chapter. We asked ourselves the question: was our project a success and did we meet the goals of the project plan? In this chapter we will will also look at what future work can focus on based on our project. In this section about future work we will answer the questions: what can be improved in our system? What does the ideal system looks like?

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Introduction

For our HMI project we wanted to create something that consisted of an unexpected and playful interaction situated in a public area. Instead of just passing through a space, we want to entertain people and to get people to see their surroundings in a new way. A space that is augmented with an interactive system, that could seduce people to start exploring the system.

Also we want to get people to connect with each other. By implementing features that require multiple people to work together, we want to encourage teamwork and give people an opportunity to catch up with colleagues or people they have never met.

To achieve these goals we want to create a system that can achieve all the goals we set, but it has to be a system that would is optional to interact with, and can be easily ignored when people are not interested in interacting with it. After considering numerous options we decided on a ceiling as our medium.

A ceiling has a couple of unique advantages that are beneficial for us to achieve our goals. It is easily ignored when you do not want to interact with the system. People can just stare straight ahead without noticing the system.

Another unique feature to ceilings is that people need to look up to see it. This is beneficial to our project because we want to make an interactive experience. When you have a projection on a floor or wall, people notice the installation more easily, but since they see it while walking they are not forced to stop and take a look. This limits the chance that people will start interacting. While looking up at the ceiling people tend to slow down or stop. This gives us more time to get the person interested in starting to explore the capabilities of the system.

Also seeing multiple people looking up, you get tempted to start looking up yourself. In this way we get more and more people to start interacting with the system. And multiple people are needed to explore all the interaction we have to offer.

Goals

The main goal is: “Creating a prototype of an interactive ceiling, which entertains people during their walk through public areas”. During the first iteration we figured out what entertains people, what interactions they like and what is possible with the current technology. Depending on what entertains people and what the results of the first iteration were, we made goals to verify if our resulting system works. These goals are in no particular order:

1. Create an interactive ceiling in a public space.
2. The system must be entertaining for people, whether they just walk underneath it or play actively with it.
3. Generating a graphical projection on a ceiling with which people can interact based on their position and movement.
4. Adding audio that supports the visual aspects on the ceiling.
5. The audio should adapt to the number of people that are using the system, it should then become more noticeable and louder.
6. Creating an interactive prototype that uses the ceiling as a graphical user interface: the actions the people perform manipulate the graphical elements on the ceiling.
7. Determine a set of interactions determined by an evaluation group.
8. At the end of this project the system has to make people smile.
9. Change the normal behaviour people when they are walking underneath the installation, i.e. have them stop and figure out what is happening.

Interactions

ThingyCloud has a number of interactions that users can explore. These interactions are developed during the conceptual phase and were later refined by the results we got from the user tests we did.

Following a user
ThingyCloud will detect when people are standing underneath it and then will track them while they are moving. These movements are then visualised on the screen with an avatar.

Merging & splitting of avatars
When multiple people are underneath ThingyCloud, they are able to form groups. These groups are then represented on the screen by a larger avatar. You see that all the individual avatars of the people that make up the group are merged into one new avatar. Now when the group disperse the large avatar will break up into an avatar for each individual that was in the group.

Eating thingies
As an avatar you're not alone in the world of ThingyCloud, there are Thingies floating around, just going about their business, which as an avatar you can eat. By moving to the position of a Thingy your avatar will eat the thingy. This can be done alone or as a group.

Changing shapes of avatars
The system changes the shape of an avatar based upon some variables: How many people are in a group (avatar gets bigger or smaller); Jumping will make the avatar become larger for a short moment; Ducking will make the avatar become smaller for a short moment.

Attracting and repelling of thingies
When you are a large avatar consisting of multiple people, the thingies will slowly move towards you. And when you are moving around the system alone, the thingies will be repelled by you and try to move away from you.

Project methodology

During this project we used the "Dynamic systems development method" (DSDM) [6] as a approach for our project. This choice was based on the nature of our project and the advantages the DSDM method will give us. DSDM is ideal for projects that:

- are interactive;
- have a predefined target group;
- are complex and have an isolated goal;
- have a strict deadline;
- have requirements that can be prioritized;
- have requirements that can change during the progress of the project;
- have a need for an iterative design process.

DSDM is an agile project delivery framework, primarily used as a software development method. DSDM is an iterative and incremental approach that embraces principles of Agile development, including continuous user involvement. DSDM fixes cost, quality and time at the outset and uses the MoSCoW [4] prioritisation of scope into Musts, Shoulds, Coulds and Won't haves to adjust the project deliverable to meet the stated time constraints.

Iterations

During this project we did two iterations of our prototype. In the first iteration we want to figure out what kind of interactions we can use in our installation. Do they understand the possible interactions we offer them? Do they like the interactions we offer? And what are the interactions they want us to implement? At the end of this iteration we want a list of interactions that are going to be implemented. Also we want to test, is to see whether or not users like the idea of an interactive ceiling.

The second iteration consisted of a digital system with which people can interact. This system contains one projector and two Microsoft Kinects, to display the graphical user interface and track the movement of the people. In this iteration we determined the audio effects, which are included in the system. The goal for this iteration was to find out if our system offers an user friendly and fun user experience?

A more detailed description of the project setup can be read in Appendix A

CHAPTER 1: CONCEPTUAL PHASE

To get an creative and original idea for our HMI project, we engaged in an brainstorm session where we explored our thoughts about cool ideas for the project.

One of our conditions we set ourselves while coming up with ideas, was that it had to be something interactive that could be used by multiple users at a time, and it must be fun to do. Also we wanted not to make a game for the HMI project.

After some time discussing various ideas, the concept of a interactive ceiling began to take shape. Were we all were very excited about was the idea that whatever we decided to make, it had to be in a public area where it was open to interact to anyone.

Furthermore we didn't want to make something that already had been done by dozens of people. So an interesting floor or wall was out, and we decided on a ceiling as the medium on which we were going to build our interaction.

The idea of a ThingyCloud materialised a bit later. We were thinking about letting external inputs, like the weather and such, control various aspects of the installation. These factors, which were not controllable by the user, could trigger unexpected events. This unexpectedness could have been a nice effect to the project but in the end didn't make the cut.

In the end, after considering everything we had come up with, we agreed upon the very basics of what ThingyCloud would be. These basic ideas of ThingyCloud were then put into our project proposal and later on our project plan.

YouTube proved to be a very inspiring source during our brainstorm session. Getting inspired by other projects really got us thinking about what we possibly could make and how it should work. And this set the bar of what we wanted to accomplish higher and higher, but in the end it resulted into the dedication we put into this project.

CHAPTER 2: RELATED WORK

What research did we do for this project and what did we learn/could we use during the project. To find these projects we did an extensive web search in order to find examples of interactive ceilings or related interactive installations, such as interactive floors or bars.

During this search, we found that the concept of an interactive ceiling is something that is not extensively been researched. And therefor it was not very easy to find a lot of interesting related projects.

Below you can find the projects we found most interesting and useful.

2.1 Interactive Ceiling, Ambient Information Display for Architectural Environments

[5] This thesis was quite an interesting read, as it described many facets of the ceiling as a medium for information displays. As this thesis aimed at ceilings as an ambient display, however it did not go into detail about how you could entertain people with an interactive ceiling.

What we learned from this thesis is that there are a couple of unique features that make ceilings an interesting surface for displaying information. To name a few:

- ceilings are clean surfaces, with little to no elements that would obstruct the view to the ceiling;
- the information that is non-obtrusive, always available, and can be accessed by simply looking upwards;
- information on a ceiling is easily ignored by users when they do not want to interact with the system;
- interactive ceilings should strive for simple aesthetic visualizations that create an engaging experience rather than for complex ceiling-based applications that translate the concept of desktop computing into the built environment.

2.2 Interactive ceiling at the Rockefeller tower in New York

This installation (see figure 2.1) is an interactive room which dynamically changes colors, and will track you when you walk underneath it projecting a cross above your head that follows you around.

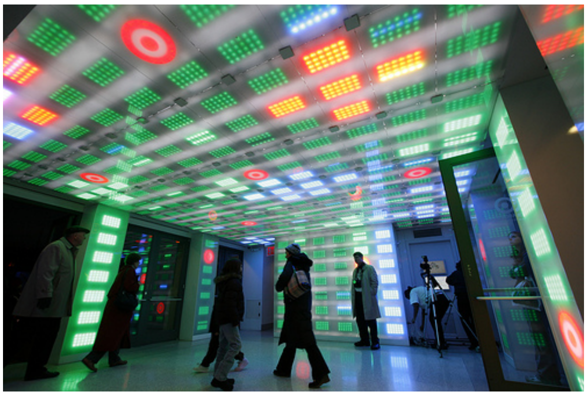

Figure 2.1: Interactive ceiling at the Rockefeller tower in New York

This famous interactive installation has served as an inspiration for our project. From the footage that we saw all across the web, you could see that people really liked it. They were very curious to explore the system. See how it works what all the possibilities are. At first sight it is an undefinable piece of technology that does not clearly communicate the functionality of the system. This forces people to explore and find out what it can do for themselves.

This installation taught us that exploration is an important factor while designing an interactive installation. If people can explore the system they get curious about its functions; trying new things to see if they have any effect. [1]

2.3 "Squash the Bug" Interactive floor

In the second quarter of the study year 2010-2011 two of our team members, Michiel and Mark, worked on "Squash the Bug" (see figure 2.2), an interactive floor installation. It was developed for the course Art, Media and Technology and involved a sort of game where all kinds of bugs would crawl over the floor and when a person stands on top of a bug it gets killed.

Figure 2.2: Squash The Bug

This project gave us some useful experience with building an interactive installation. But most importantly it showed us the importance of teamwork in a interactive installation. When the system is focused on one user at a time, things get boring fast. But when you're in a group, even if the system doesn't have many functionalities, you will spend more time interacting with the system.

This project showed us that working together makes the experience more fun. And people spend more time interacting with the installation when they are working together.

2.4 Project Anemone

Going out is supposed to be a social experience, but how often do you find yourself standing at the bar, waiting for drinks, surrounded by people that keep their hopeful gaze fixed solely on the bartender? Anemone brings the surface of the bar to life (see figure 2.3), providing entertainment to everyone around it and serving as an ice breaker. Anyone can join in on the interaction, leading to a shared experience.

Figure 2.3: Project Anamone

From this project we learned, that the augmentation of a ordinary everyday environment fosters curiosity within people. They are surprised to see that there is a new function given to something they may have known for years. And they are more easily inclined to start exploring the installation. This project showed us that choosing a public area is something very interesting, since it will change the way people perceive the public area. [3]

2.5 Osmos

Osmos is a crossplatform video game made by Hemisphere Games. Osmos is a perfect example of a videogame that inspires serenity. Its combination of movements, with the addition of serene music and settle graphics made it the example that our team inspired. In addition it is visually realistic enough to resemble a microbial world but also abstract enough to leave some room for the imagination of the player. For a demo movie see `http://vimeo.com/5892502`.

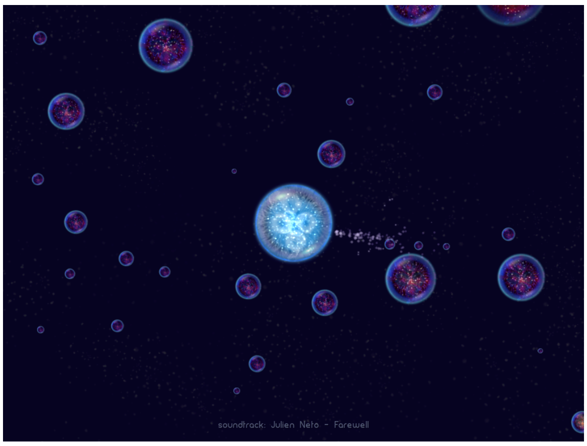

Figure 2.4: Osmos: The user (a light blue sphere) has to absorb the purple spheres.

The video game served us as an inspiration for the audiovisual aspects of our installation. It teaches us that there should be a deeper understanding to the images that were projected onto the screen. So that instead of looking at something generic pictures there is something that holds meaning and could appeal to the curiosity of the user. In this way we could seduce the user to start interacting with the system and keep them engaged for a longer period of time.

2.6 Conclusion related work

These works most of all inspired us and gave us good ideas for our own project. Also these projects helped us to identify the key aspects of what makes an interactive installation suitable for use in a public area. These were: exploration, teamwork and tapping into the curiosity of people.

CHAPTER 3: FIRST ITERATION

3.1 Goal

The main goal of the first iteration was to investigate what kind of interaction the users would like to have in our system. We thought of some interactions during our brainstorm session (like the avatar following the user), but our user could have other ideas.

In this iteration we designed the creatures of our world (avatars and thingies). We investigated if users could make the distinction between avatar and thingies.

Other goals of this iteration were to investigate how users thought we could attract attention to our ceiling, and if users would understand the link between themselves and a representation on the ceiling.

The end result of this iteration was a sorted list of interactions, based on user preferences. This list functioned as a guide in the second iteration as to implement which interactions. A detailed description can be read in Apendix E

3.2 User Study

In this section we will explain our user study.

3.2.1 Participants

This user study was done with five participants, of whom four are students and one is an employee of the University of Twente. All participants were male and between 18 and 25 years of age.

3.2.2 Materials

Our setup consisted of an overhead projector that was operated by one for our group members. We intended to follow the movements of the users as they walked in the determined area (see figure 3.1). Our avatars were represented by cutout drawings.

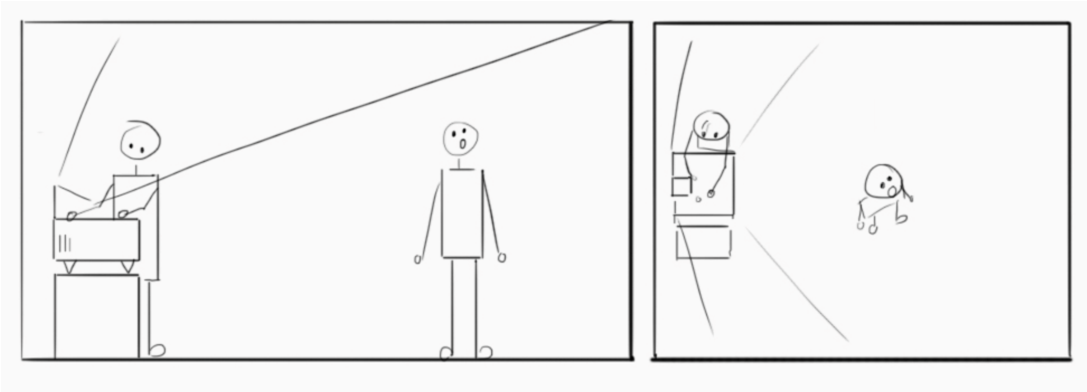

Figure 3.1: Technical Setup: left frontview, right topview

3.2.3 Procedure

The experiment consisted of three parts. The first part was to determine whether the user noticed the ceiling and when they did noticed the ceiling whether they saw that they were being followed by the shadow above their head.

The shadow was produced by using an overhead projector and a piece of paper the size of an avatar. One person made sure that the shadow did follow the participant. We asked the participant to walk in a circle, stand still for 10 seconds and then walk back. Afterward questions were asked in a structured manner. We asked them if they noticed something, what did they notice, did they notice the ceiling (if they did not say this before), whether they saw that they were being followed, and whether they wanted to try other actions to see if the system would respond to that.

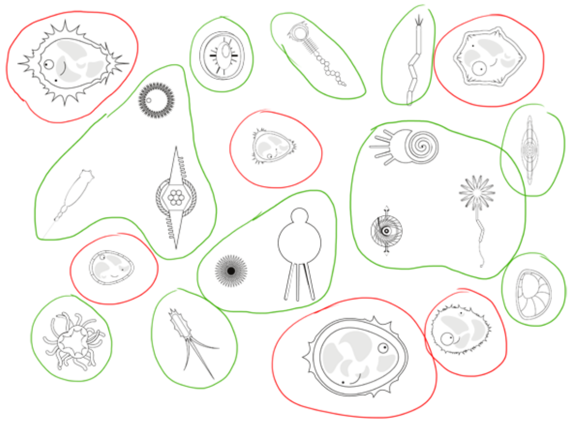

Figure 3.2: Difference between thingies and avatars; avatars are circled red, thingies are circled green

The second part consisted of some scenarios accompanied with images of avatars and thingies. We explained to the user that the purpose of our project was to create an interactive ceiling, and explained how this virtual world in the ceiling was composed of creatures called avatars and thingies. We asked the user to distinguish between avatars and thingies by circling them in different colours as can be seen in figure 3.2.

After this we explained how a person obtains an avatar above his head and how the avatar follows the person wherever he walks. We explained the interactions we thought of by propose scenarios to the user in which different interactions took place. During the explanation we showed the user images of different interactions without explaining what was happening at first.

The scenarios to go with the images were as follows. Keep in mind that the description of the interaction was our interpretation; this can be different for the user:

- merging of the avatar
- splitting of the avatar
- when the avatar is small the thingies come towards the user (see figure 3.3)
- when the avatar is large the thingies go away from the user
- the avatar changes shape according to the shape of the user

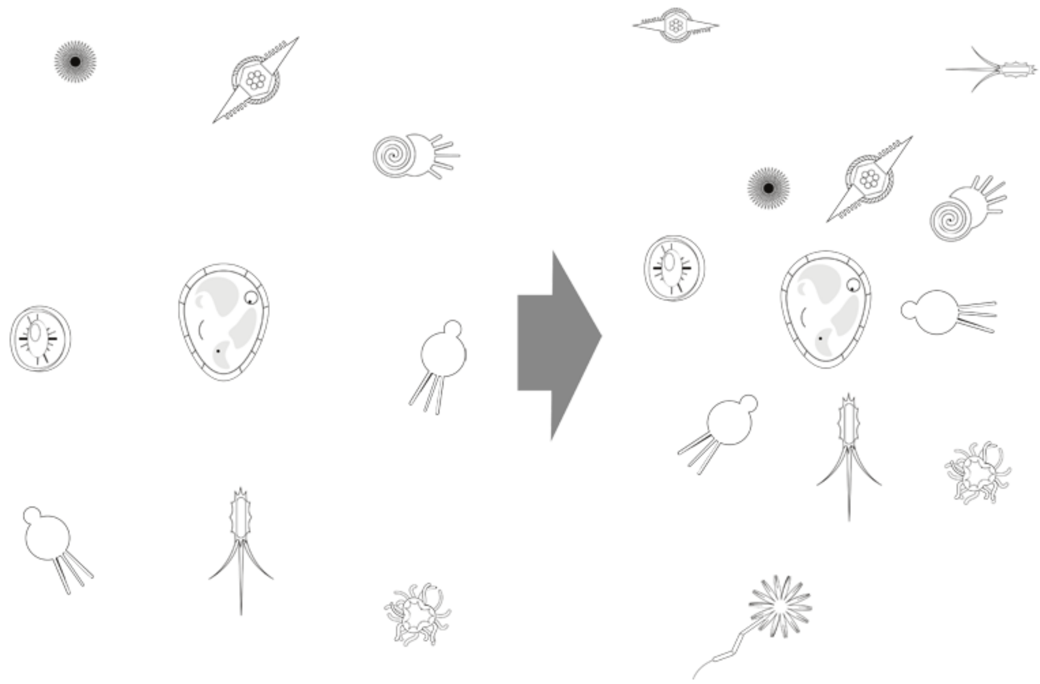

Figure 3.3: Example of images that go with a scenario:thingies come towards the user

After each scenario we asked the user about their thoughts on what was happening during the interaction and their opinion on it. Once they gave an answer we asked follow-up questions to get more information on the reasons behind their opinion.

The last questions of this part of the evaluation were to let the user give their own suggestions for other possible interactions or other ideas that he/she might want us to implement in our prototype.

During the third part we presented the first user nine cards with all the possible interactions composed of the ones we imagined plus the ones that were imagined by the earlier participants, or by themselves. Therefore the last participant had to sort 13 cards. We gave these cards to the participant and asked them to sort them according to their preference. This gave us a good insight into which interactions the end users may prefer to appear in the system. During the processing of the results we did take into account that some cards were sorted more often than others. For more information see the results. We chose this approach so that we would also have a rating for the interactions the participants thought of. Rather than having a sorted list of interactions we thought of and a bunch of new interactions we would have no clue about how well they were liked.

3.2.4 Results

In the following part we will summarize the results of the user study, for a complete overview of the results we refer to appendix F.

During the first part of the experiment three participants noticed something was happening, only one of them noticed he was being followed. None of the participants, except for one (not the same), saw the avatar going to sleep. Only one participant tried to jump to see if this would produce any interaction.

In the second part of the experiment all participants were able to identify all avatars except for one participant who missed one of them (a small one). All participants, but one, were also able to identify all thingies. The other participant thought some thingies were not actual thingies.

All scenario's we presented during the second part of the experiment were received positively. The merging and splitting of the avatars was explained by a participant as a kind of mating, the evolutionary table was perceived as interesting and "cool", and that this kind of evolution would encourage interaction with other people. Only one participant expressed concern of merging his avatar to the avatar of unknown people. The interactions with the thingies is perceived as intimidating by two in five participants, while others found it logical. Three out of five participants liked the stretching of the avatar according to their own shape and position.

Most participants said they would like to be able to eat the thingies. Possible actions to cause the avatar to eat the thingies were by either hugging, grabbing, jumping or moving to the position where the Thingy is. At least one participant reported interest in seeing a reaction (either by growing or a particular change in the avatar) once the Avatar eats a Thingy.

Participants said they would like to have "Easter eggs" or unexpected fun interactions in our installation so they could look for them. However -the laying down on the floor gesture- would be considered "weird" by two of the four participants, unless this would cause an Easter egg reaction (this interactions was given as an example of how an Easter egg could be triggered).

Most participants said they considered that we could attract enough attention to the ceiling by just implementing our world in it. They thought that the movements and colours on the ceiling would be enough to attract the attention of people walking in the area. In addition two out of four participants thought that sounds could also aid our objective to attract the attention of the people passing by. One participant even considered that the ceiling should have interaction even before the user's arrival to the active zone.

The sorting of the interactions were processed by giving points according to the ranking. The most interesting one got thirteen points; the least interesting one got one point. To analyse the ranking of the interactions we calculated the median of each interaction and the higher this value was the higher it is in our priority list. We chose to calculate the median so that we would take into account that not all interactions were rated the same number of times. The priority list can be found in table 3.1.

Interactions	Median
Eating the thingies	11
Merging of the avatars	11
Changing shape of the avatar	10
Separating of the avatars	10
Jumping interaction	8
Thingies come towards user	8
Following the user	8
Duck/getting smaller	8
Stealing an avatar	8
Jump on top of thingies	7
Thingies go away from the user	5
Avatar going to sleep	4
Avatars die and become food	2

Table 3.1: Priority list Interactions

3.3 Conclusions

The main goal of the first iteration was to investigate what kind of interaction the users would like to have in our system. The following list of interaction is based on the rating given by the user to both the interactions we thought of as well as the ones they came up with. We tried to combine the answers given during the explanation of the scenario's and the priority list in a way that we include as many features as possible. A good example of this is the first interaction; eating thingies by jumping. In this interaction we combined the eating of thingies with the jumping and the colour change which was suggested during the scenarios.

Eating thingies by jumping:
Jumping on top of the thingies is the interaction that will be used to eat thingies. The effect that will occur is that your avatar changes colour.

Merging and separating of the avatars:
Merging and separating is another interaction we will implement. When users come close together, close enough for their avatars to touch each other, their avatars merge together and a new avatar is created. The new avatar is assigned according to the evolutionary table. When users move far from each other, far enough that the individual avatars do not touch each other, the avatars separate and a new avatar is assigned to each. The assigning here is also done according to the evolutionary table.

Changing shapes of the avatar:
Changing shapes will happen constantly in our system. When the shape of the user changes,

seen from a top-down view, the shape of the avatar changes along with it. This means that if the user spread their arms the avatar will get a long stretched shape.

Thingies towards user if his/her avatar is large:
Thingies come towards users when their avatar is large. This means that if multiple users let their avatars merge together thingies will come towards them for cover.

Thingies turn away from user if her/his avatar is small:
Thingies flee from you when your avatar is small. In this case your avatar is still larger than the thingies and they feel threatened, afraid that you will eat them.

Avatar following user:
While the user walks or moves under the interactive ceiling, the avatar must follow the user.

While ducking getting smaller:
While the user is ducking for a small period of time the avatar (which is related to its user) should get smaller. The deeper the user ducks the smaller the avatar should become.

Stealing someone else's avatar:
This interaction is not going to be implemented because the interaction will contradict with the merging and separating interaction.

Avatar goes to sleep:
The Avatar goes to sleep if the user stands still for longer than x minutes. This interaction is not likely to occur, but users stated that they liked to have Easter eggs in the system. An Easter egg in our system would be an interaction that is hard to find, which is why we select this interaction as an Easter egg.

We do not include the interaction: "Avatars die and become food.", we decided this for the reason that the last participant came with this idea, but did not like it himself and did not have a clear idea when this should happen.

We also investigated if users could make the distinction between avatar and thingies. Based on the results we can say that Avatars and thingies are different enough for the user to identify one from the other.

Other goals of this iteration were to investigate how users thought we could attract attention to our ceiling, and if users would understand the link between themselves and a representation on the ceiling. Based on the results we can say that only the ceiling itself with just the world on it that moves, will probably be enough to attract attention. It is important to make use of bright colours, because the users think this will attract more attention. Adding sound to it will make it more likely that people will notice it, because it makes the user aware that something is happening. The test-setup we used for this iteration in combination with the assignment we gave was not enough to attract the attention of the user.

CHAPTER 4: FINAL PROTOTYPE

Two wooden frames were attached to a larger metal frame that went from the floor to the ceiling. The two wooden frames were covered in multiple sheets of paper to create a surface for projection. The interaction was meant to take place under the frames. A Microsoft Kinect was attached in the center of each of the frames and a couple of holes were created to allow the device visibility, since the Kinects were behind the sheets of paper. A short range projector was placed on a stand on the floor (See figure 4.1).

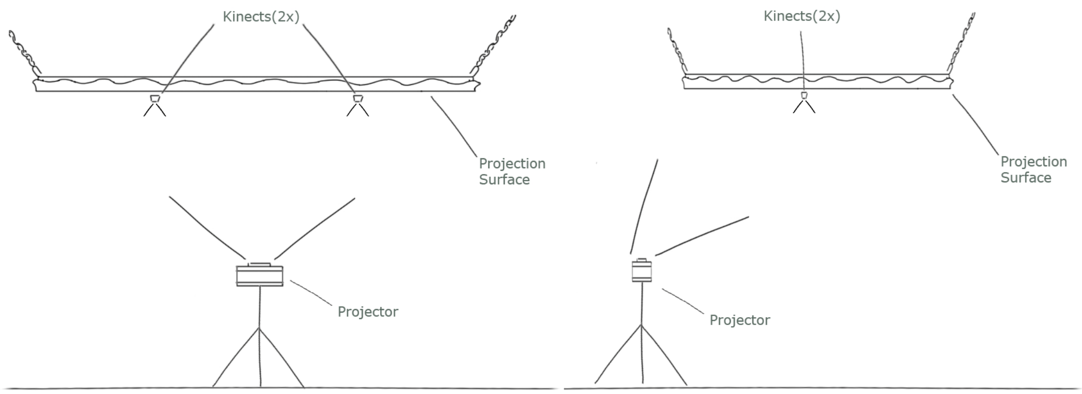

Figure 4.1: Technical Setup: left frontview, right sideview

4.1 Requirements

This section will contain the list of requirements that we decided were the most relevant to address according to our findings in the first iteration. For a detailed information of each requirement please read Appendix B

- **[SRq1] System display:** The system had to be able to create a visual projection in a large surface for the user to be able to move and interact.
- **[SRq2] Position detection:** The system had to be able to detect the position of the user within a limited and determined area.
- **[SRq3] User's position representation:** The system had to be able to represent the position of the user. This requirement constitutes the product of both SRq1 and SRq2.

- **[SRq4] Optional engagement:** The system had to be unobtrusive and optional to engage. The user should not need to engage the system to cause an effect in the virtual world.
- **[SRq5] Multiple users engagement:** Multiple users had to be able to engage with the system at the same time. Therefore multiple positions had to be tracked SRq2 and multiple representations had to be displayed as in SRq3.
- **[SRq6] Multiple parties engagement:** This requirement was the plural version of SRq5. We understand that users come accompanied by people sometimes friends, acquaintances or relatives, and some other times it may seem that even with unknown people. We wanted our system to be able to group them together and place a representation of their group in the virtual world.
- **[SRq7] Easter Egg element:** The easter egg element is concerned with the non-expected reaction by the system. Anything that is planned yet unmentioned as a feature of the system can constitute an easter egg.
- **[SRq8] Installation Temporariness:** This requirement was concerned about the temporary aspect of the physical installation. The system was intended to be placed in a public space for the short term rather than the long term. It was necessary to create a physical installation that can be placed for an amount of time and that is removable without leaving any trace or physical evidence of its existence or former presence in the space.
- **[SRq9] Cause and Effect scheme:** The Cause and Effect scheme requirement was concerned with the effect that happens after the user generates a cause for it to happen. In order to make this installation interactive and not simply a static art installation.

4.2 Graphical Design

4.2.1 Avatar & Thingy concept development

We decided that our installation should display a virtual world in which the player would become immersed. Our interactive installation was inspired by a popular computer game called Osmos (see Section 2.5). Osmos was designed for a different purpose than our interactive installation. The ThingyCloud was intended to be used by multiple people simultaneously. We concluded that the while Osmos was a good example for our visual design, we required to build our own system and generate our own graphics along the lines of Osmos.

In this world there would be avatars that are controlled by the users, and there would be "thingies" that are just part of the world and interact with the "avatars".

After some brainstorming sessions, we decided that the world should be, to some extent, a representation of our microbial world. We wanted an abstract looking world that could in a way resemble a familiar concept in the user's mind. We thought that by displaying concept familiar to the users (such as a microscopic world) we could attract the participant to use our system and therefore giving us the chance to immerse him/her in our audiovisual installation.

4.2.2 Avatars and Thingies

There are two lifeforms in the ThingyCloud world: avatars and thingies. Avatars are the life forms that follow the user around when you are walking underneath the ceiling as depicted in figure 4.2. In general avatars can be divided in two families: the rounded avatars and the spiky avatars.

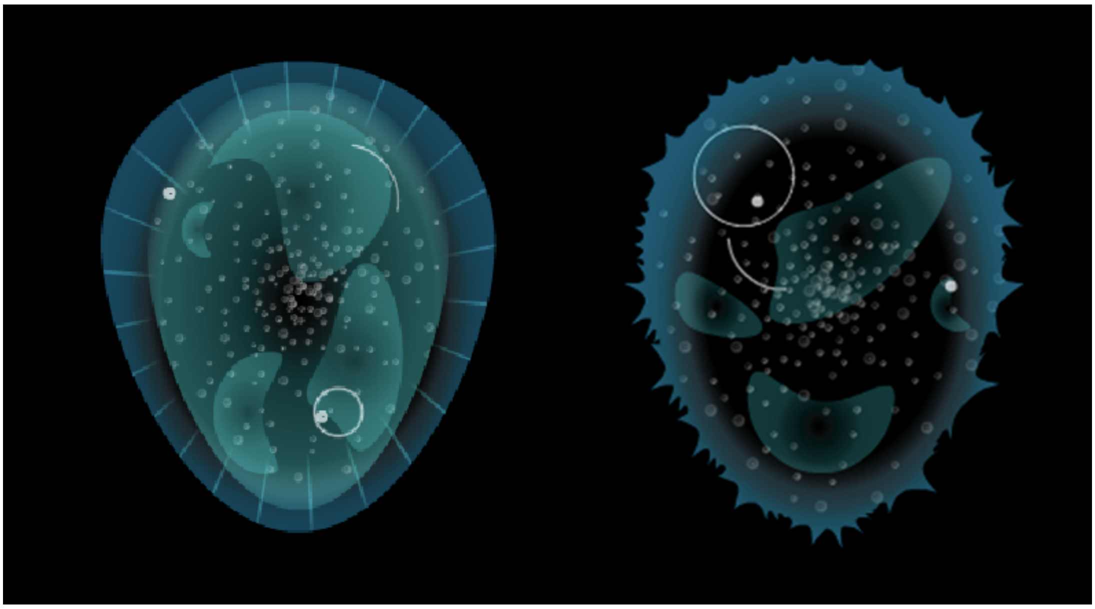

Figure 4.2: Rounded Avatar (left) and Spiky Avatar (right).

Thingies are the creatures that can be eaten by an avatar, but do not have any direct interaction with the users, as it depicted in figure 4.3. In order to translate highly complex images of the moodboard with vivid colors and highly detailed pictures into vector graphics simplification was required. Due to technical limitations; both the avatars and thingies are colored by layers with different degrees of transparencies. In our quest to familiarize our look with the microbial world several layers of gradients were placed one over another to bring the most accurate possible representation of how would look.

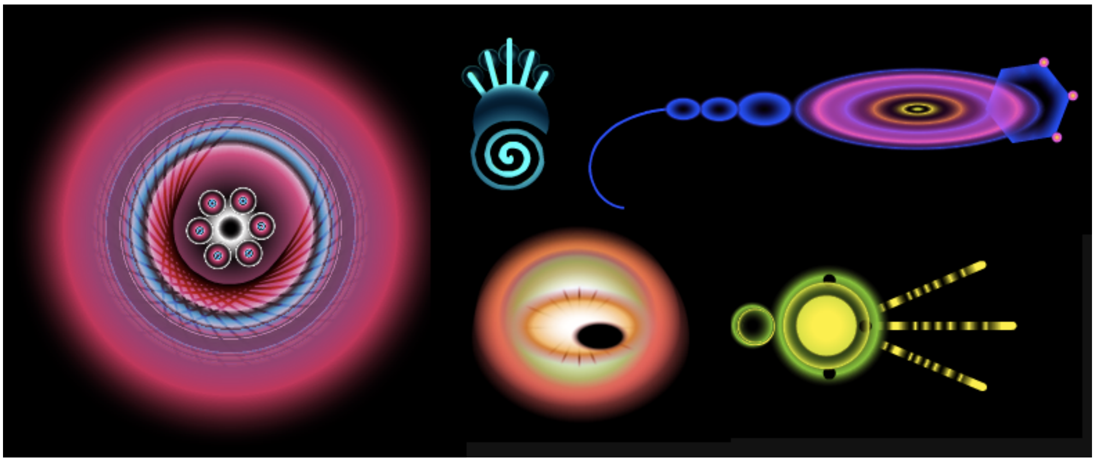

Figure 4.3: Thingies

In order to translate the highly complex images of the moodboard into actual characters and objects in the virtual world we had to start by simplifying shapes in three dimensions into flat shapes in two dimensions. We limited ourselves to designing thingies with simple outlines. After this details were added such as the internal divisions inside the body of a thingy and an avatar. The third step consisted of recreating the potential avatars and thingies in bitmaps; since bitmaps allowed us a little more freedom to represent how we want our avatars and thingies to look we used it as a guide to then translate them into vectorized graphics again but this time with textures and colours.

After applying the potential colours to both the thingies and avatars and designating the different elements within the bodies of both they were split apart to be animated. Both thingies and avatars contain little elements within their bodies that had to be animated separately to bring an illusion of being alive. For further information about the Graphical Design please read Appendix C.

4.3 TechnicalDesign

Although the technical aspect is not the most important one of this project, we will still elaborate on it somewhat. The software consists of three separable components: computer vision, logic and visualization. The computer vision part was solved using an application called ParleVision, which is being developed by HMI students as well. ParleVision is able to send its final information through a TCP socket. The application responsible for the logic receives this information and creates avatars, thingies and is responsible for the interactions. The scene as it is created by the logic is transfered over another TCP socket, which is picked up by the visualization component. This way all components can run on different systems. Especially the computer vision component, since that requires quite some processing power.

The visualization however was the most tricky component. At first we decided to implement this in Adobe Flash, as all the animations for the thingies and avatars had already been made in Flash. During the development process we had several issues with the Flash application. With only a few days to go before the final user experiments, we had to make a decision. We decided to build a less impressive visualization using the Windows Presentation Foundation. The visualization was less impressive, but at least we had a stable solution that allowed us to conduct the final user experiments. This choice was made because the focus of the project were the user experiments, not the technical implementation. A consequence of this is desision and the limited time we had is that not all the interactions were implemented as we hoped. It had only a big effect on the interaction “eating thingies”. The change of colour wile eating a thingy was not implemented and therefore there was no feedback.

We will elaborate on this further in the Technical Design document, where you will also find several diagrams of the software and hardware setups. A more detailled description can be read in Apendix D.

CHAPTER 5: USER STUDY

5.1 Goal

After designing and building our prototype, based on what we learned from our first experiment evaluation, we could now test our prototype. This experiment was focused on the usability of our system. It is worth mentioning at this point that we define usability as being easy to learn and being easy to use. We will also address the problems with the "discoverability" of our system. Last factor we wanted to look at is the user experience; is our system fun use and how do users feel about our system. The goals of this experiment were:

- Usability
  - Does the user notice the ceiling?
  - Does the user understand that the avatar follows the user?
  - Does the user find all interactions?
  - Is the system easy to use?
- User experience
  - Does the user like the system?
  - Does the user like the interactions?
  - Is the system fun to use by the user?
  - Does our system produces smiles?

While our prototype may not yet be ready to be placed in a large public environment, it is suitable to be used in a controlled environment since it performs all the required technical system functionalities. Note that, because our system is intended to be placed in a large public environment, not only individual users will use our system, but also groups will use our system. Therefore our system was tested with groups and individuals, with a maximum of three users per group due to a limited space. The following sections will describe the participants, materials, procedure, results & analysis and conclusions of the second user study.

5.2 Participants

The total number of participants for this experiment was 21 (17 male, 4 female, see figure 5.1). They differed in age from 18 to 25 (15 between 18 to 21, and 6 between the ages 22 to 25). Health wise there were two participants who had suffered severe back and/or pain damage, and three people who tended to lose their balance if they stoped looking at the floor. Out of 21 participants 11 had previous experience testing a prototype. 19 had education in a technology-related field.

Our 21 participants were divided in 8 groups. The composition of the groups was diverse. Most of them were composed of 3 members in which 2 of the members did not know each other while both knew the other person as can be seen in figure 5.2. Only one person took the experiment alone, and only one group was composed of two people.

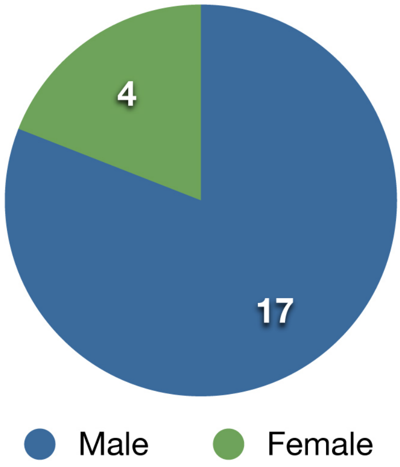

Figure 5.1: Male & Female distribution

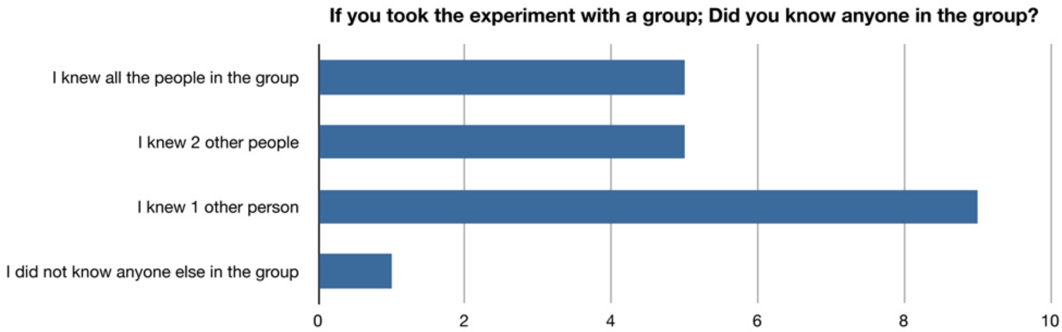

Figure 5.2: Familiarity with the other participants

Most participants felt comfortable while participating in the experiment. In a 7 point scale where 7 is the maximum and 1 the minimum, 19 participants reported the maximum or near maximum comfort level at 7 or 6 (mean 6.2, std 1.5). Only 2 participants reported almost the minimum comfort level at 2.

5.3 Materials

Our setup consisted of our final prototype as can be read in chapter 4. Two wooden frames covered with paper functioned as our ceiling. Two Microsoft Kinects attached to the frames were used to track the user. A short range projector was placed on a stand on the floor to project our world to the ceiling. For technical details we refer to section 4.3.

5.4 Procedure

The experiment consisted of two parts. The first part consisted of a practical task we asked our participants to fulfill. This task was an easy one; enter our test-room and explore the system we have made. All this without explaining anything. They could explore for 3-4 minutes. This part will give us insight in the usability of our system.

The second part consisted of a questionnaire that gave us some additional information about the participant's demographic background, how he perceived our prototype and system and some information about his/her experience while using our prototype. The questionnaire was divided into three sections and in the following order:

- Questions regarding the participant's demographic background
- Questions regarding the discoveries by participant of our system during the experiment
- Questions regarding the participant's perception of the system (this part was based on Attrak-Diff [2])

The questionnaire gives us more insight in the user experience while using our system. For detailed information please read the Appendix G.

We explained to all participants that we would take video-footage to analyse afterwards, and use them for presentation purposes or in our final report. The analysis of the video-footage will give additional information on both the usability and the user experience.

5.5 Results & Analysis

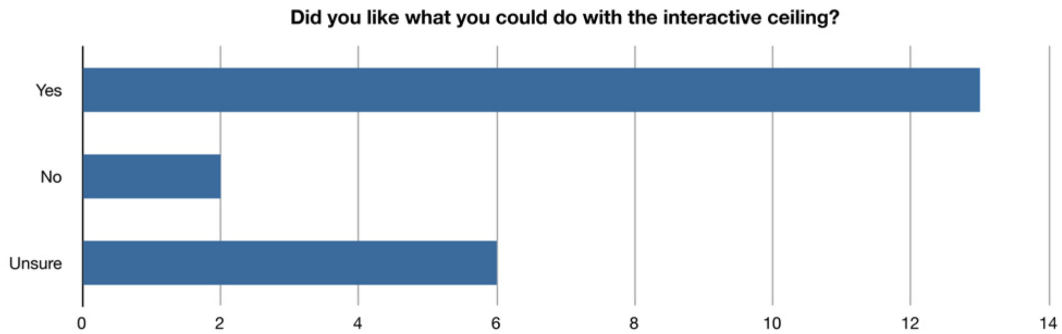

Figure 5.3: Participants' opinion on our system

All participants without exception indicated that they liked the interactive ceiling. Thirteen participants (out of 21) reported liking what they could do with the system. Six reported being unsure while two reported a negative reaction (figure 5.3). Three groups would have liked to try interacting with the system for a longer period of time because they were still enjoying it after

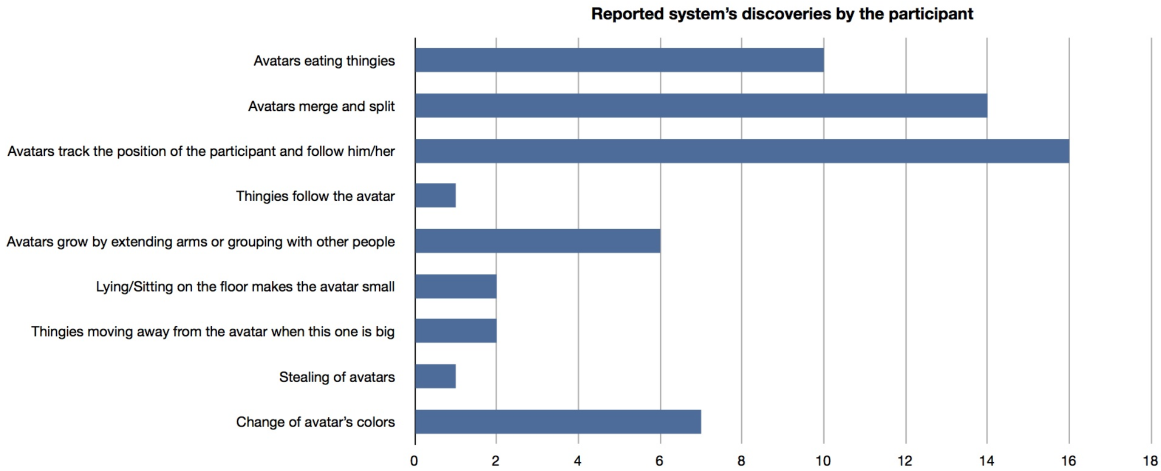

Figure 5.4: Discoveries by the participants

the exploration time was over. The features the participants indicated they discovered can be found in figure 5.4.

As can be seen, none of the interactions was reported to be found by all users. The interactions which was reported to be found the most was the following of the user by the avatar.

Two participants thought that our system should be a bit faster in it reactions, because there now was a bit of a delay which sometimes makes the interaction less obvious. Two participants commented afterwards that they liked that they could interact with other people they did not know before. They thought it was a nice way to be more interactive with other people in the same space.

Figure 5.5 shows the thoughts of the participants on our system based on word-pairs. In this graph the orange line is the mean value that was given, while the greyish area indicates the standard deviation.

As last result we looked at the video footage we got, to see/hear participants reactions while exploring. Figure 5.4 shows the features that users reported to have found. According to these numbers, most features were not found by all users. However, since this was an open question, they might not have been complete in answering it. We annotated the recordings to see what the behaviour of the users was, which features they found and which not. Figure 5.6 shows our most important findings.

As can be seen the interactions our users reported finding are not complete when looking at the annotated recordings.

Besides these implemented interactions, the following remarks were made:

- Three groups expected an animation (or some other visible sign) after eating a thingy.
- Three groups mentioned that they got a sore neck.
- Three groups noted the unintentional colour change of the avatar at certain times.

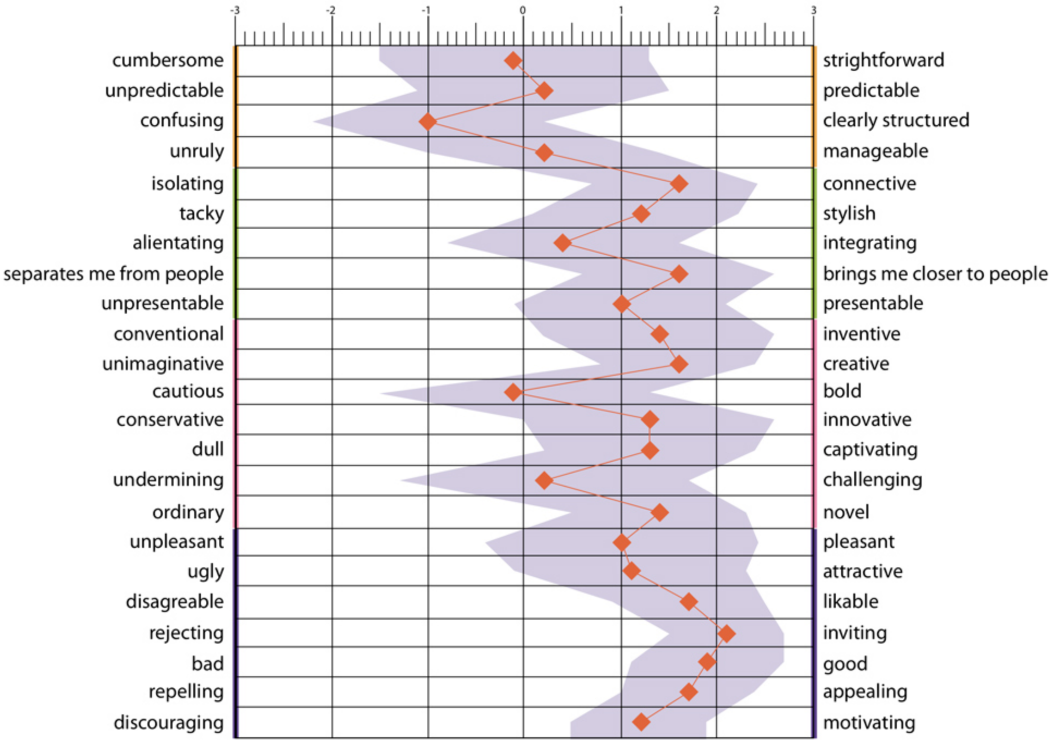

Figure 5.5: results of the word-pair questionnaire

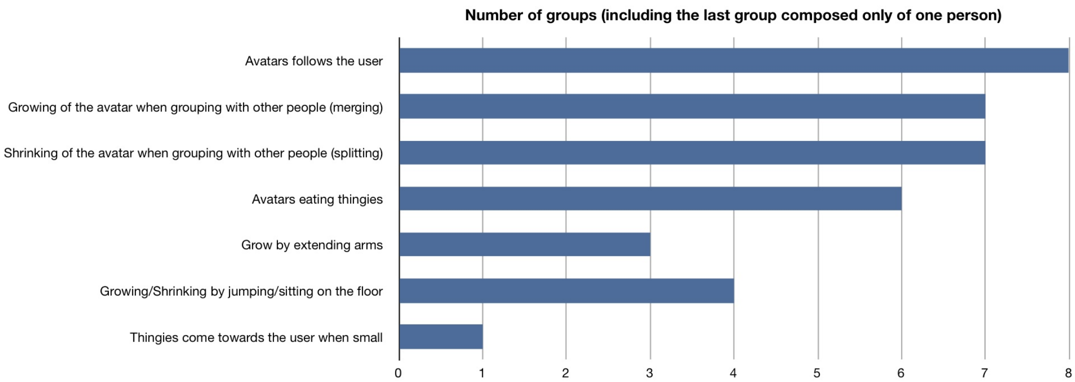

Figure 5.6: most important findings of the video analysis

Finally, all groups (with more than one person) worked together in some fashion, and in all groups laughter was heard a lot. One group thought the system was a cuddling-machine, designed to make people cuddle (which they also did). These observations show that most intentional interactions were indeed recognized by the users. However, they also noticed some missing functionalities, and sometimes suggested interactions they would have liked.

Because of the number of participants it is hard to make quantitative statements. 21 participants is just too low to be conclusive. To analyse the results we first made an inventory of answers given and comments made. Answers that were given more often were weighted more. This gives us good overview of what the participants did, or did not like. We also converted the results of the word-pair questionnaire into a more readable standard (see figure 5.5 and figure 5.7).

5.5.1 Word-pair questionnaire

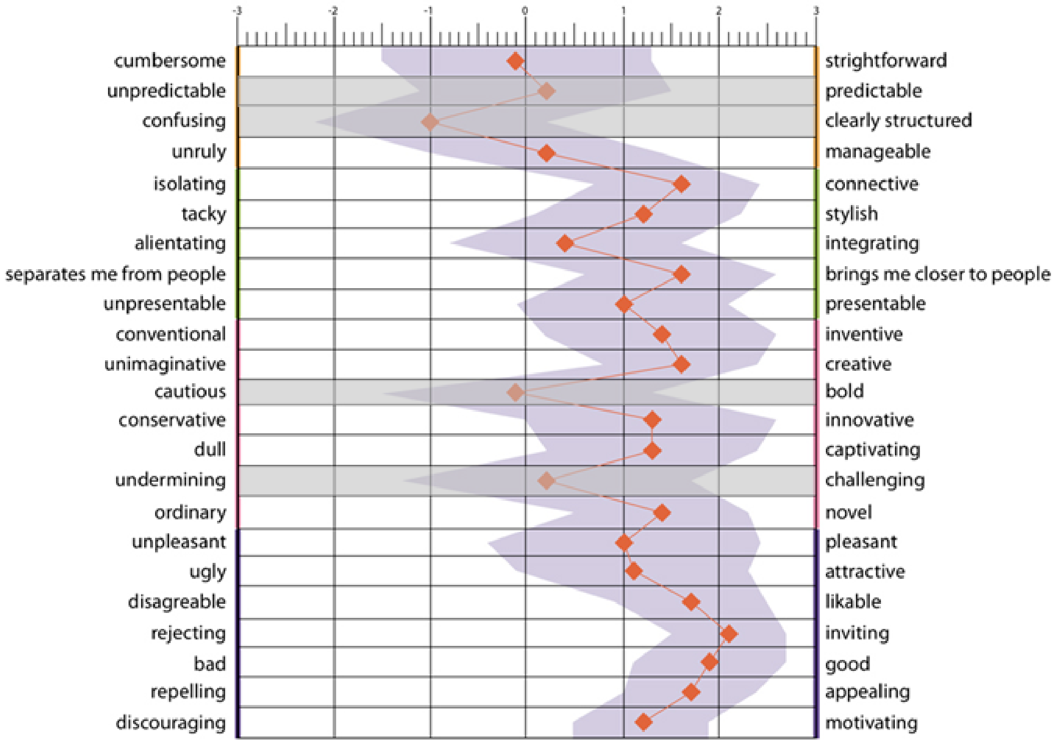

Figure 5.7: results we use of the word-pair questionnaire

Figure 5.7 shows the results of the word-pair questionnaire. Note that some word-pairs have been made grey, these are word-pairs we do not want to include anymore. The reason for this is, that when looking back these were not correct word-pairs to ask. For example: unpredictable - predictable is not a good word-pair to ask, because we want our system to be predictable, but only to a certain point. Too predictable is not good, because it then might easily become boring. Therefore we also do not know, which part our participants would rate, the part we want to be predictable, or the other. The same goes for the other gray word-pairs. This also explains why there is such a high standard deviation with those word pairs.

The colours at the side indicate four aspects you can measure with those word-pairs. [2] The word-pairs at the Yellow beam are used to measure Pragmatic Qualtiy (this describes the usability of a product and indicates how successfully users are in achieving their goals using the product), the word-pairs at the Green beam are used to measure Hedonic qualtiy - stimulation (this indicates to what extent the product can support the need to develop and move forward), the word-pairs at the Pink beam are used to measure Hedonic quality - identity (this indicates to what extent the product allows the user to identify with it), and the word-pairs at the Blue beam are used to measure Attractiveness (this describes the global value of the product based on the quality perception).

The graph shows that especially the Attractiveness quality scores very positive for our system(keep in mind this is just our system, and no comparison with other systems). All word-pairs in that category have an average value that is greater than 0, even when taking the standard deviation into account. The average value for Attractiveness is 1.5, with a standard deviation of 0.9. Even though our number of participants is too small to draw definitive conclusions, we can say that it looks as if people find our system attractive.

The Hedonic qualities also score positive, although less strongly. The Hedonic quality - stimulation has an average score of 1.4 (SD is 1.1), and the Hedonic quality - identity has an average score of 1.2 (SD is 1.1). The Pragmatic quality was rated as neutral in our system. However, these word-pairs are hard to apply to the system.

5.5.2 Answers, comments and video's

Looking at the answers, comments and video annotations we can conclude that all user groups found all our intended interactions (see figure 5.6). They even found some unintended ones, which they also liked. The fact that all intended interactions were found contradicts what users reported. However, this was an open question, which makes it likely that not all participants included everything they discovered.

Most users liked what they could do with our system, although some noted unfinished parts, or would have liked to have even more interactions to be possible. There were some remarks made about things that could be improved. For example: an animation or reaction after eating thingies, getting a sore neck, and unintended colour change. All user groups that could work together to uncover interactions did so, some even thought of our system as being a cuddling-machine. During all experiments we heard lots of laughter.

5.6 Conclusions

The main goals of this study were to get answer on usability and user experience. We will first discus the usability, after this we will discus the user experience, and give some other interessting results.

When we look at the usability we can say that all users noticed the ceiling, and discovered that they were followed by the avatars. All our intended interactions were discovered by the groups that could discover them, they even found unintended interactions, which they also liked. We could say that our system is easy to use, since all groups discovered all interactions, within a 3-4 minute time frame. Therefore we can say that we made all our usability goals.

When we look at the user experience we can say, based on the results, that users like our interactive ceiling. Most users also like what they can do with it, although some noted unfinished parts, or would have liked to have even more interactions to be possible. When looking at the results from the word-pairs we can say that our users tended to find our system attractive.

There were some remarks made about things that could be improved. For example; an animation or reaction after eating thingies, getting a sore neck, and unintended colour change.

There was lots of laughter to be heard during the experiment which answers the last goal, to produce smiles. Therefore we can say that we made all our user experience goals. Our system is ment to be explorative and fun to use. Which interpretation the user give to the interaction is not the most important, as long as they enjoy it.

Chapter 6: Conclusion

Was our project a success? Did we meet the goals of the project? The goal of the project was “Creating a prototype for an interactive ceiling, which entertains people during their walk through public areas”, with the ultimate sub goals:

1. Create an interactive ceiling in a public space.
2. The system must be entertaining for people, whether they just walk underneath it or play actively with it.
3. Generating a graphical projection on a ceiling with which people can interact based on their position and movement.
4. Adding audio that supports the visual aspects on the ceiling.
5. The audio should adapt to the number of people that are using the system, it should then become more noticeable and louder.
6. Creating an interactive prototype that uses the ceiling as a graphical user interface: the actions the people perform manipulate the graphical elements on the ceiling.
7. Determine a set of interactions determined by an evaluation group.
8. At the end of this project the system has to make people smile.
9. Change the normal behaviour people when they are walking through the installation, i.e. have them stop and figure out what is happening.

When we look at these goals we can say that most of them were accomplished by the prototype. The only goal that was not addressed in our prototype is number five “The audio should adapt to the number of people that are using the system, it should then become more noticeable and louder”. Although we included audio, the volume didn’t adjusted itself based on the number of users. This was caused by a lack of time and problems we encountered on the technical front.

The sub goals one, two and four, we accomplished as a prototype. These goals need some improvement in future work. For sub goal one, we tested the ceiling in an experimental environment (as can be seen in figure 6.1) and not on a public space, this is something that needs testing.

For sub goal two, we implemented not all the interactions as the users would have liked. And the most important interaction that makes it really something you can actively play with (eating thingies) did not contain clear feedback (as described in section 4.3). Therefore this needs improvement in the future.

Figure 6.1: Participants using the system

Audio, as described in sub goal four, was only added as background music. There is no audio feedback with different interactions as planned for the ultimate system.

Although our system was not perfect, we can conclude from the user studies (see chapter 5) that people liked the concept. We got positive reactions from participants in the last user experiment and heard lots of laughter. We can therefore say that we succeeded in meeting our main goal: "Creating a prototype for an interactive ceiling, which entertains people during their walk through public areas". Although there is still enough work in the future for this project.

6.1 Future Work

We believe that ThingyCloud has tremendous potential in entertaining people and beautifying public areas. Therefore, we view the work described in this report as only the beginning of a large project.

In our view the ultimate system should be placed in a large public area where a lot of people transit. An example of a great place for the system is the O&O square at the University of Twente (figure 6.2). The ultimate system has all the interactions which were a result of our user experiment in the first iteration as listed in chapter 3. The graphics should all be animated like the animations we made for this project but could not include due technical complexity.

Figure 6.2: Tarps at the O&O square

Future work therefore could:

- Include all the interactions as proposed.
- Improve graphics engine so that the animations are included and can change shape and

size easily.

- Prepare the system to track people in a large open area?
- Prepare the system to project (or another display method) the user interface on large and uneven surfaces?
- Add audio effects to enhance the feedback of the interactions?
- Create a spacial sound engine to play the audio effects, so you can create a localized audio experience.

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Appendix A: Project Plan

Assignment

Client

Dr. Mannes Poel is the supervisor of this project. The project will be developed in and for the University of Twente: Human Media Interaction department.

Contractor

Project group Appleflap:

- Saskia Akkersdijk;
- Steven Gerritsen;
- Michiel Neelen;
- Mark Oude Veldhuis;
- Gilberto Sepúlveda Bradford.

Target group

Our primary target group consists of students and staff of the University of Twente who transit the area in between the Waaier, the Educafe in Zilverling and Hall B. In addition, our secondary target group consists of people in public areas, so the whole community.

Assignment formulation

"Creating a prototype for an interactive ceiling, which entertains people during their walk on public areas."

Goals

The main goal is: "Creating a prototype for an interactive ceiling, which entertains people during their walk on public areas". During the first iteration we will figure out what entertains people, what interactions they like and what is possible with the current technology. Depending on what entertains people and the results of the first iteration we can make measurable goals to verify if our resulting system works. As a result of this the goals are not as specific as we would like, but we made goals for this global idea to already set some success criteria:

1. Create an interactive ceiling in a public space.
2. The system must be entertaining for people, whether they just walk underneath it or play actively with it.

3. Generating a graphical projection on a ceiling with which people can interact based on their position and movement.
4. Adding audio that supports the visual aspects on the ceiling.
5. The audio should adapt to the number of people that are using the system, it should then become more noticeable and louder.
6. Creating an interactive prototype that uses the ceiling as a graphical user interface: the actions the people perform manipulate the graphical elements on the ceiling.
7. Determine a set of interactions determined by an evaluation group.
8. In the end of this project the system has to create smiles (make people smile).
9. Change the normal behaviour people when they are walking through the installation, i.e. have them stop and figure out what is happening.

Our ultimate goal is to place the setup outside, on the O&O square of the University of Twente. We don't know if this is possible, because of the technical and organisational barriers. Therefore, the realistic goal is to place the setup of the system inside in a more controlled environment.

Interactions

The interactions that will be implemented are not yet defined. During the first iteration we will do a user experiment to define which interactions will be implemented. We already thought of interactions that may be possible to implement, but it is up to the user (and the possibility to make it with the current technique) if we are implementing it. To give a first impression we listed our first ideas below:

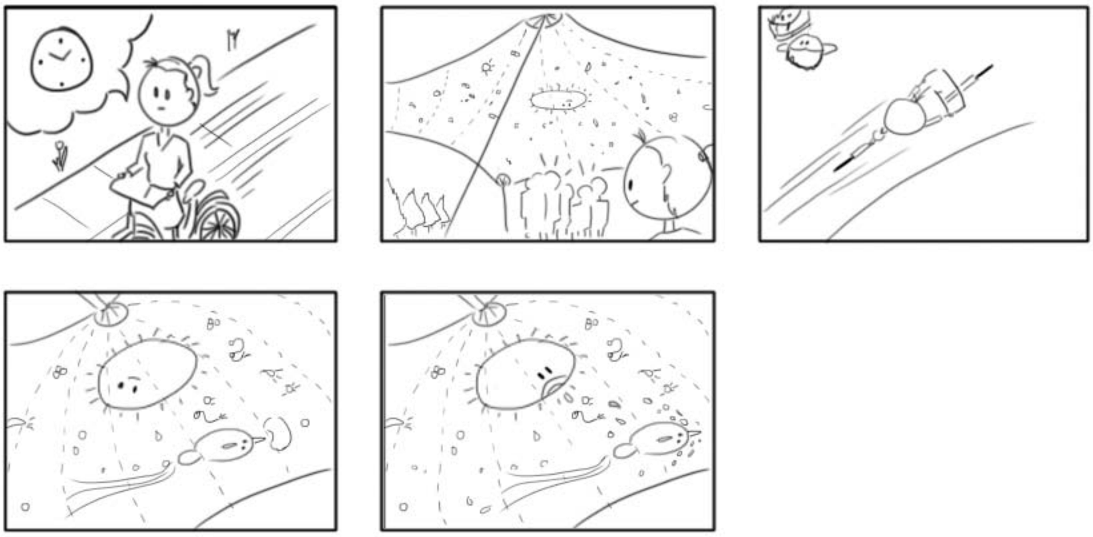
- movement of the user will result in a similar movement of the avatar.
- grouping of the users will result in merging of the avatars into one big avatar.
- splitting a group of users will result in splitting of the big avatar in multiple avatars (depending on the number of groups).
- avatars will leave a trail if they move. It will disappear after a while (time should be decided on).
- ambient sounds can be heard depending on the number of people using the system.
- thingies will be attracted to the avatar if the avatar is small.
- thingies will be repelled by the avatar is the avatar is big.
- avatars will eat the thingies if the thingy is surrounded by avatars
- if the user moves in a certain pattern his avatar changes colour
- if the user stands still for a certain time, his avatar will go to sleep (produces "zzzzzzzzz")

Scenarios

The discovery and grouping

Sjoerd and Frieder are two students walking by to the Waaier to get some lunch after their class in the Ravelijn. While they transit the area with the white tent roofs, Frieder notices a sign saying “do not look up”; Frieder ignores the order doing exactly the opposite and looks up just to discover that the ceiling contains a universe of “little things” otherwise known as thingies; some of them even making sounds. Sjoerd and Frieder appreciate the ceiling for a little while and then decide to walk on. They then discover that the ceiling is actually interacting with them and their position within the visible range. Both decide to engage the system and they walk a little bit more allowing their avatar to chase the thingies, surrounding them, away. While Frieder stays interacting with it and making the system produce all sorts of sounds Sjoerd then tries to move on and discovers that the avatar is able to split in two pieces making two separate avatars producing “pop” sound.

Goals achieved in this scenario: 1; 2; 3; 4; 6; 7; 8; 9.



Passive Interaction

Marije was about to get late to her class and she had to be in hall B as soon as possible because she only had 3 minutes to arrive to class. Before she could get there, she noticed some people under the white tent roofs looking at them and doing strange movements. She decides to ignore it since she was too busy to pay any attention to it and since she was late, she started running to get to her destination. Since she was running to get there the system detected her speed and position so her avatar started bumping with other thingies shooting them all across the board. Marije did not notice what happened because she was too busy to pay any attention to that, but she had some indirect interaction that affected the whole board and the other avatars.

Goals achieved in this scenario: 1; 2; 3; 6.

Trails and Patterns

Thea and Kees were crossing the square where the interactive ceiling is placed; Kees heard previously from other people about this new attraction in the university and decides to engage the system. Kees gets assigned a purple avatar and starts using it to chase the thingies across the board. Thea follows some seconds later getting together with Kees resulting in both avatars merging into one. Kees decided to undo the change by getting a little bit distant from Thea and decides to do a spiral with the trail that avatar was leaving behind. Soon he noticed that the system could recognize the pattern and all the thingies started moving clockwise.

Goals achieved in this scenario: 1; 2; 3; 6; 7; 8; 9.

Agents

Based on the scenario's, we can define the following agents: users (people interacting with the system), avatars (virtual representations of the users), and thingies (computer-controlled virtual entities). In this section we will describe these agents in more detail.

Users

The users of the system are people that move under the screen. However, to keep things simple we will probably not differentiate between people and other moving things (such as cars). This means that probably everything that is large enough and moves will be a user, and therefore represented by an avatar. People who are close enough (with a distance that will be determined later in the project) will be considered to be a group and will be treated as one big user. If the group splits, then the remaining groups will be treated as separate users too.

Because we wanted a representation of the user in our world on the ceiling we decided that we wanted some kind of avatar to represent them. Next we will discuss those avatars.

Avatars

Avatars are the characters that represent the user in the system, which have animated expressions. Avatars are inspired on organic, smooth forms. Some ideas of what avatars can do are:

- **Leaving a trail**: Avatars leave a trail behind them in which the user is able to create patterns
- **Patterns**: Some patterns can be recognized by the system and have a local or global effect in the virtual universe.
- **Merging/Separation**: Avatars are able to merge when two or more users get together under the traceable zone of the system. If the group of users split apart the large avatar should split in different pieces.
- **Eating**: Avatars may interact with Thingies by eating them up. Eating produces an animation in the Avatar. Some thingies can have a special effect in the Avatars once they get eaten; read the Thingies section for more information.
- **Sounds**: The interaction with other thingies can produce some special sounds that add a new layer of experience to the user.
- **Other Interactions**: Other additional interactions that may not be mentioned in this document may or may not appear in the system. This will be determined during the first iteration as described in the chapter approach.

Thingies

Thingies are all the non-avatars character-like items in the virtual universe. They are generally smaller than the Avatars and they interact with the Avatars in many different ways. The form of the thingies will be inspired by viruses. Some ideas of these interactions are:

- **Avatar alterations**: The avatar may change colour or shape upon interaction with thingies, while it's not clear yet if the Avatar will actually eat the thingies or simply cause attraction or repulsion, Avatars are supposed to have a degree of interaction with them.
- **Gravitation**: The virtual universe may contain gravitational laws where the generally smaller objects (Thingies) may gravitate towards or against the Avatars position and direction. The Gravitation may be altered depending on the patterns created by the user.
- **Other Interactions**: Other additional interactions that may not be mentioned in this document may or may not appear in the system. This will be determined during the first iteration as described in the chapter approach.

Results

The results of this project consist of the following products:

- Prototype of the system as will be described in the user and system requirements, which are based on the goals of the project;
- Final Report, in which the following documents are integrated:
  - Project plan;
  - System requirements;
  - User requirements;
  - User test design;
  - Graphical design;
  - Technical design;
  - User evaluations.
- Presentation of the prototype.

Boundaries

There are some boundaries in this project, which we will describe here:

- We will not adapt our system to meet the specific needs of people with disabilities.
- We will use existing sound in our prototype and will not create / record new music.
- We assume there is an API for controlling the hardware and will not create software for controlling this hardware.
- Our prototype will be developed with the focus on particular areas and cannot be placed in other environments without adjustments, which are not part of this project.

Preconditions

There are a couple of preconditions in order to successfully finish this project:

- Support from the university:
  - Supervision on the handling of the project and reviewing the documents;
  - Information and advice on a solution for tracking people;
  - Information and advice on the solution to control multiple beamers;
  - Advise on how to make the setup of all the hardware;
- Availability of the appropriate resources to build the physical installation:
  - Computers to run the system on;
  - Devices for tracking the position and movement of the people;
  for example Kinects;
  - Devices for projecting (beamers, overhead projectors);
- A space to develop the system and perform experiments:
  - A space for the testing of the interactions (first iteration);
  - A controlled space for the second iteration, in which we can place and build on the system.
  Ideally this means that we can leave it where it is, without having to dismantle it.

Challenges

Of course, the project involves several challenges. Most of them are technical challenges, but also challenges in the process of designing exist. This section describes challenges we identified.

Tracking people

One of the major challenges is the tracking system that we need. Clearly, this is a large technical issue. There are several solutions available but we have to figure out which one of those is best suited in our situation. To make this ourselves would not be a good idea, as that would be a rather large project itself. The system that we choose should be able to track a lot of people in a large open area, as it also has to be able to deal with our ultimate situation in which we have set up the system outside.

Displaying the projection

Of course, there is the issue of the actual projection. Because ultimately we have the setup outdoors there is a large are that has to be covered. This will involve using multiple beamers and aligning them properly will be tricky. Furthermore, we have to use a rather powerful beamer in the outside situation that is able to deliver a good projection considering the bright ambient light.

An interactive ceiling opposed to an interactive floor

Although the approaches may look similar, there are some technical differences that can make either one more difficult. For example, in the case of an interactive floor one could mount the beamer and camera next to each other on the ceiling. In the case of an interactive ceiling, the camera cannot be placed where the projection also is, as too much light will probably enter the lens. This means that the camera for tracking has to be placed under an angle, which is another challenge. Also, mounting the beamer is a physical challenge since it can also not be placed on the floor where people walk. It also has to be placed under an angle, which requires proper calibration of the beamer.

Risks

There are a couple of risks involved in successful completing the project. The risks are mainly present in the areas of time and technical complexity.

The time based risks start to exist by the hard deadline and the amount of work in the time we have for it. In order to take this risk into account we choose the system development method DSDM as described in the Approach chapter. This method is ideal for projects with a high time pressure, because of the Iterative approach and the MoSCoW classification of the requirements. (The MoSCoW method is explained in the Approach chapter)

The technical complexity is a big risk during this project. In order to take this into account on forehand, we found experts on the field of motion tracking and the technical setup of the hardware. In the first iteration we will do research on what is possible and what not with the current techniques, so we can anticipate on this during the determination of the interactions.

A risk concerning the system itself is, that the users will not notice the system. If this happens, our goal of creating smiles will probably not be achieved. In order to make sure this will not occur, we planned to get the attention up by letting sound come from above and place signs in order to shift the attention upwards towards the system.

There is also a risk that the users don't understand the interactions with the system. In order to solve this we planned to let the users decide what interactions are logical and fun, by doing a user test. If these users decide which interactions we are going to use, than they already know the interactions when we deploy the system. When they are interacting with the system the rest of the crowd will imitate them.

Related work

Similar interactive projects are done by others, but these rarely include projections on a ceiling. It could also be an interactive floor or wall for example. This section describes projects or sources that are relevant to what we are working on, and that we could use for ideas for example or general knowledge about the subject.

Project Anemone

This project is probably known by all our team members and supervisors, and it is surely related to the project we are setting up. Project Anemone is an interactive bar installation and showcased in (among others) MAC Berlijn in Enschede. When people are at the bar ordering a drink, they usually try to get the attention of the barkeeper but seldom interact with each other. The project tries to change that, by projecting a sort of underwater life on the bar, where reefs are built around the glasses that are placed on the bar that people can either take care of or terrorize. The goal then was that people would interact with each other's reefs and thus with each other.

What we learned from this is that interactive applications work. They trigger people to investigate what the interaction is. The installation is used in different ways by people on the other sides of the bar. The barkeeper could for example see how long a glass was already standing there unattended. What we could more learn from this is how it was technically realized. Although we do not know the exact details about the implementation, we can easily obtain them as this project as an HMI project.

Anemone, a social interactive bar installation (teaser), by Michel Jansen
http://www.vimeo.com/5522487

Interactive ceiling at the Rockefeller tower in New York City

At the top of the Rockefeller tower in New York City there is an interactive LED light installation. Using four cameras, each in one of the corners of the space of the installation people are tracked and the LEDs above them light up. Although there is no sound or other form of visualization than just LED lights above people, it does invite people to stay around for a while and figure out what is happening.

Something we can learn from this is, just as with the previous related work, people stop and find out what is happening. Once they realized that they were being followed by lights on the ceiling they started playing around and tried to find out what happened when you get close enough to each other, and thus were interacting.

Target Interactive Breezeway at Rockefeller Center
http://www.colorkinetics.com/showcase/installs/target/
http://electroland.net/projects/targetbreezeway/

Interactive floor

Two of our team members, Michiel and Mark, worked on an interactive floor installation in the second quarter of the study year 2010-2011. It was developed for the course Art, Media and Technology and involved a sort of game where all kinds of bug would crawl over the floor and when a person stands on top of a bug, it gets killed.

The setup was realized in the centre truss in the SmartXP lab in the Zilverling, because that one could be equipped with black curtains to keep the light out. Furthermore, both a beamer and infrared camera were mounted in the middle of the truss so they both had a view from above. Software wise it was realized using Adobe Flash for visualizations and the open source package Community Core Vision for recognizing the position of people.

During an open day the installation was also present and people really got into the game. They started running around and jumping on the bugs. This shows that the interaction triggered and people were really enthusiastic about it. Although our current project is not meant to trigger people in a way that like with the bug game, it again shows that people are trigger by an installation that responds to them.

Interactive Ceiling, Ambient Information Display for Architectural Environments

This paper by Martin Tomitsch investigates the use of architectural ceilings as a means of providing information in an ambient manner, so that it is always available to the user. The paper suggests guidelines for the development of interactive ceilings. A conclusion is that interactive ceiling are best used to display spatial information as it can be easily visualized for the user.

The main thing we can use from this paper are the guidelines. For example,

Interactive Ceiling. Ambient Information Display for Architectural Environments, by Martin Tomitsch. Doctoral Thesis. 2008.

Interactions

All participants liked the idea of having an interactive ceiling and all said they would try to interact with it. From this we can conclude that users like the idea of the system itself.

The interactions we proposed together with the interactions thought up by the user were sorted during the first user experiment. The end result of this iteration is a prioritized list of possible interaction (see table 1).

We already discarded one of the interactions which was more a functionality ("Avatars die and become food"). We decided this because the last participant came with this idea, but did not like it himself and did not have a clear idea when this should happen.

Based on the remaining list we looked at each interaction to see if the interaction was feasible in the time, if we could combine some interactions, and if the interactions would be technical feasible with the information we have now. Interactions with a rating lower than 8 were seen as less important to include.

Interactions	Median
Eating the thingies	11
Merging of the avatars	11
Changing shape of the avatar	10
Separating of the avatars	10
Jumping interaction	8
Thingies come towards user	8
Following the user	8
Duck/getting smaller	8
Stealing an avatar	8
Jump on top of thingies	7
Thingies go away from the user	5
Avatar going to sleep	4
Avatars die and become food	2

Table 1 Prioritized interactions

Eating the thingies together with the merging of the avatars is rated highest. For the eating of the thingies several ideas were given as to when one should be able to eat them. The ideas include: jumping, hugging, grabbing and moving to the position where the Thingy is. There were several other ideas that included jumping. Therefore, we decided to combine those into one interaction: When jumping on top of the thingy you will eat it. As a result your avatar will change colour.

Merging and separating of the avatar was seen as a key element, because it enhances interaction with other users. When users come close together, close enough for their avatars to touch each other, their avatars merge together and a new avatar is created. The new avatar the persons get, is assigned according to the evolutionary table. When users move far from each other, enough that the individual avatars would not touch each other, the avatar separates and a new avatar is assigned to each user. The assigning here is also done according to the evolutionary table. We want to include this interaction, and think it is feasible.

Changing shape of the avatar was seen as a fun interaction. However we think that due to time constrains combined with technical difficulties this might prove hard to implement. We therefore will not focus on this interaction.

Thingies that come towards the user

The following of the user by the avatar is a key interaction, because we want to represent the user by the avatar. We therefore think it is necessary to implement this interaction.

While ducking getting smaller: While the user is ducking for a short period of time, the avatar (which happens to be related to its user) should get smaller. The deeper the user ducks the smaller the avatar should become. We think while this interaction is fun, it would not be wise to include this interaction, because of time constrains.

Stealing someone else avatar sounds as an interaction that would enhance interaction between users. However this interaction is not going to be implemented because the interaction will contradict with the merging and separating interaction.

When standing still for a long while the Avatar goes to sleep. This interaction did not receive a high ranking. We do think that this interaction would great to be implemented as an easter egg.

Approach

Project members

The project group Appleflap consists of five members who all are capable to carry out the different tasks required for the project. The only official responsibility we assigned is the function of project leader, which we assigned to Steven Gerritsen.

Twice a week the whole project group comes together to work on the project. These meetings we start with an update session where everyone tells: What he has done, What he is going to do until the next session and what problems may occur. Once a week the whole team has a meeting with the supervisor in order to keep him informed of the most recent developments.

Method

As said in the section of the Risks, we are going to use the DSDM software development method. This choice is based on the nature of the project and the pros of the DSDM method. DSDM is ideal for projects that:

- are interactive;
- have a predefined target group;
- are complex and have an isolated goal;
- have a strict deadline;
- have requirements that can be prioritized;
- have requirements that can change during the progress of the project.

“Dynamic systems development method (DSDM) is an agile project delivery framework, primarily used as a software development method.”

“DSDM is an iterative and incremental approach that embraces principles of Agile development, including continuous user/customer involvement.”

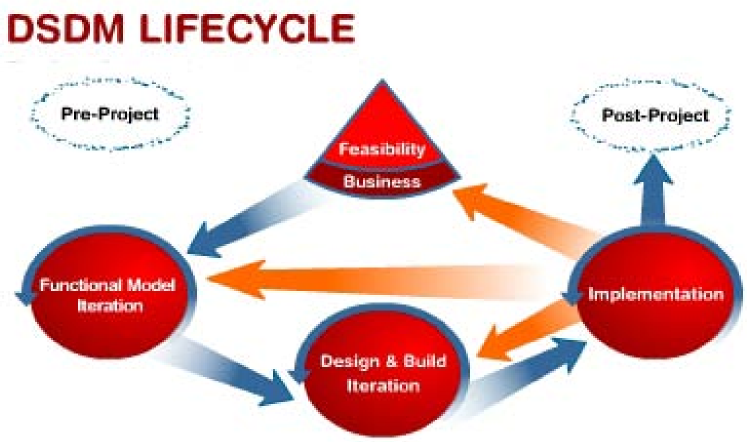
“DSDM fixes cost, quality and time at the outset and uses the MoSCoW prioritisation of scope into Musts, Shoulds, Coulds and Won't haves to adjust the project deliverable to meet the stated time constraint.”[1]

The process of the development will be done in four phases. The last three phases will be repeated during each iteration.

The first phase is the Feasibility and Business Study. During this phase we will define the project definition and the planning. The final product of the phase is the project plan.

[1] http://en.wikipedia.org/wiki/Dynamic_Systems_Development_Method

The second phase is the Functional Modal Iteration. During this phase we will focus on the functional aspects of the project. This includes the requirements and the design of the user tests. The products which belong to this phase are: the system and user requirements and the design of the user test. This is also the phase in which each iteration starts.



The third phase is the Design and Build Iteration. Here we are designing and building the system based on the functional requirements we set in the Functional Modal Iteration. At the end of this phase we have the user design, system design and the actual application.

The fourth and last phase of the iteration is the Implementation phase. During this phase the system will be tested by some participants from the target group and complete the documentation of the system, including the evaluation of user tests and combining the older documents into a final document.

Planning

We divided this project in three iterations. In each iteration we focus on another part of the functionalities. Below you can see the planning when each iteration has to be finished and the detailed description of the different Iterations.

Phase	Date
Project plan	23-09-2011
Iteration 1	28-10-2011
Iteration 2	23-12-2011
Iteration 3	20-01-2012
Final report	30-01-2012

Iteration 1

During this iteration we will focus on the interactions, research and graphical aspects of the system.

The list with interactions which we will use in our system will be the main product of this iteration. We want to define these interactions based on an user-experiment we will do at the end of this iteration. The experiment will also focus on the concept of this project and we will ask feedback from the users. The user-experiment during this iteration will be a Wizard of Oz experiment. The system that is used for the experiment will not be a digital (programmed) system. It will consist of an overhead projector and cut out figures or a beamer with a PowerPoint presentation, which we can control our self, to create the user-interface on the ceiling.

The research will focus on: “How to track people walking underneath the ceiling and monitor their movement” and “How to project the graphical user interface with multiple beamers”. For this we will start with research what technique we can use for these problems and after this we will program the subsystems for tracking, monitoring and projecting, which we need in the second iteration. We don’t know how far we come with the programming of these subsystems, this iteration, because we didn’t finish the research yet. Before we start programming we will start with the technical design in which we describe the design of the two subsystems.

The Graphical aspects that will be created during this iteration will be the drafts of the thingies, avatars and the background. These drafts will be used during the user-experiments to interact with the participants. While the drafts are necessary for this iterations experiment we will create the detailed versions of the different object to use in the next iteration.

The planning for the different products of this iteration will be as follows:

Product	Date
System requirements	07-10-2011
User requirements	07-10-2011
User test design	14-10-2011
Graphical design	14-10-2011
Technical design	14-10-2011
Prototype for this Iteration (includes building evaluation setup)	21-10-2011
User evaluation	28-10-2011

The detailed planning of who does what, is shown here, so you can get a better idea of what we are going to do this iteration.

	Steven	Gilberto	Mark	Michiel	Saskia
Week 36	Brainstorm				
Week 37	Project Plan	Project Plan	Research tracking	Graphical specs thingies	Graphical specs thingies
		Graphical specs thingies			
Week	Project Plan				

38			Research tracking	Graphical specs Avatars	Graphical specs Avatars
Week 39	Research beamers	Drafts graphical design thingies & avatars	Research tracking	User test design	User test design
Week 40	Research beamers	User & System requirements Detailed design Thingies	Research tracking	User & System requirements Detailed design Thingies	User & System requirements Detailed design Thingies
Week 41	Technical design	Graphical & Technical design Detailed design Avatars	Technical design	Graphical & Technical design Detailed design Avatars	Graphical & Technical design Detailed design Avatars
Week 42	Programming Beamers	Prototype system Detailed design Background	Programming tracking	Prototype system Detailed design Background	Prototype system Detailed design Background
Week 43	Execute user-experiment				
	Programming Beamers	Write user evaluation	Programming tracking	Write user evaluation	Write user evaluation
Week 44	Project Plan update	Extra time iteration 1	Programming tracking	Extra time iteration 1	Extra time iteration 1
		Start iteration 2		Start iteration 2	Start iteration 2
Week 45	Programming/Beamers	Iteration 2:has to be defined	Programming tracking	Iteration 2:has to be defined	Iteration 2: has to be defined

The products of the first iteration are:

- List with interactions based on the outcomes of the user-experiment.
- Graphical design of the thingies, avatars and background.
- Feedback on the concept from the user.
- Choice of which technique we are going to use to track people and a part of the programmed subsystem for tracking.
- Choice of which technique to use for projecting the graphics with multiple beamers and a part of the programmed subsystem for projecting.
- Technical design for the subsystems projecting and tracking.

Iteration 2

The second iteration will consist of a digital system with which people can interact. This system will contain only one beamer and one camera, to display the graphical user interface and track the movement of the people. During this iteration we will look at the software we are going to use for our system. In this iteration we will determine the audio effects, which will be included in the system. This system will be suited for six people. The system setup will be inside. A detailed planning like the one at the section of iteration 1 will follow at the end of the first iteration.

Week	Steven	Gil	Mark	Michiel	Saskia
2nd Iteration					
45	Background Design	Background and Graphic Design	Scenario Design	Background and Graphic Design	Background Design
	Technical Design		Technical Design		Technical Design
46	C# Flash Interface design	System Requirements	Scenario Programming	C# Flash Interface design	Scenario Programming
47	Interface design	User Requirements		Flash Design	
48		User Experiments Design		Flash Music	
49	Documents and Scenario Programming	Flash Music			

50	Final test application				
1	User Experiments				
2	Project Plan Update	Experiment Evaluation	Multiple Kinect Integration	Location Setup	Experiment Evaluation

The products of the second iteration are:

- User Requirements: The user requirements are used to determine what the user is expecting from the system. Our user requirements are based on the results of the first iteration.
- System Requirements: The system requirements are used a guide to determine what the system needs to contain in order to effectively address the user requirements.
- User test Design: A designed test plan will be implemented to measure the effectiveness of our system.
- Technical Design: The technical design will be first introduced in the second iteration. This portion of the design addresses the logical and technical issues found while building the first prototype which is to be tested in the second use test design.
- Graphical Design: The objects, their look and animations are included in this portion of the design. The Graphical design section addresses the issues found in the first iteration and prepares the system for the second user test.
- Prototype:
  - Flash portion: Our system is based partially in Flash technology which controls the output of the system.
    - Audio: Audio will be added to attain the desired interaction with the user or users.
  - C# portion: The C# portion contains the intelligence of our system. Which has to connect to Flash and Parlevision.
- User Evaluation: At the end of the iteration we will do a user experiment which evaluate if the system fulfil the goals of this project.

Resources

For this project we need a couple of resources. In this Section we will only describe the hardware requirements and not the normally money costs. This because it is a school project and there is no salary for students. The time we will spend on this project is around one and a half day a week so that will be around 13 hours a week.

There is no definite list of hardware we need for our project, yet. Research, which we already performing, should show the best hardware we can use for the tracking of people. Besides this we will need the following attributes:

- A room with preferable a high white ceiling, which can easily made completely dark.
- Till the end of November we will need one beamer and after this period we will need two.
- We prefer to have a private computer on which the program can run.

It is not excluded that this are the only things we need for the project, but this are the most important.

APPENDIX B: REQUIREMENTS

System requirements

The following section will discuss the system requirements for the second iteration. The following list will present the objectives to measure the degree of success for the second iteration, the requirements have been segmented according to: Their description which provides an overview of what the requirements constitutes, their rationale which provides the reason of why the requirement is considered an actual requirement, and a Fit criterion which describes how we will know whether or not the requirement is fulfilled:

Req: SRq1	**System display**
Description:	The system must be able to create a visual projection onto a large surface for the user to be able to move and interact with.
Rationale:	Our installation is intended as an interactive installation for a public space with one or multiple users at the time.
Fit criterion:	The user is able to see the projection an retrieve the information of his position within the virtual world.

Req: SRq2	**Position detection**
Description:	The system must be able to detect the position of the user within a limited and determined area.
Rationale:	Our team intends to create an interactive installation with a system that can somehow interact with the user. For this, reason the system must be able to detect the position of the user in a defined area.
Fit criterion:	The system is able to detect the position of the user in a determined area or space and provide coordinates to be used in other functions of the system.

Req: SRq3	**User's position representation**
Description:	The system must be able to represent the position of the user. This requirement constitutes the product of both *SRq1* and *SRq2*.
Rationale:	Since our objective is to create an interactive installation; We decided that using the user's position and representing it in a display is an appropriate way in which our system can interact with the user and yet not require the user's engagement with the system. *SRq4* will further describe an additional requirement that we intend to fulfill regarding the optionality of user's engagement.
Fit criterion:	The user can realize by his own that he is being represented by a figure in the system in this case we decided to call this an "Avatar".

Req: SRq4	**Optional engagement**
Description:	The system must not be intrusive but optional. The user shouldn't need to engage the system to cause an effect in the virtual world.
Rationale:	Our installation is intended to be placed in a public space. While we intend to create an interactive system, we realize that people are busy, and not everyone will have the time, desire or ability to engage the system. Therefore we have decided to create a system that does not block the user from passing through the space where the system will ultimately be placed. We want a system where only the users who are willing to engage it, actually do it.
Fit criterion:	A number of users are able to engage the system while others are able to simply ignore it or pass by without noticing. Yet even this second type of users will have an effect in the virtual world.

Req: SRq5	**Multiple users engagement**
Description:	Multiple users should be able to engage with the system at the same time. Therefore multiple positions will need to be tracked *SRq2* and multiple representations will need to be displayed like in *SRq3.*
Rationale:	We want our system to interact with multiple people at the same time. We believe that if multiple users are able to engage the system, no user will be able to feel as a stand out within the crowd ergo encouraging him/her to try gestures, movements or actions that he/she would otherwise not do if he/she is alone.
Fit criterion:	Multiple users are able to engage with the system simultaneously.

Req: SRq6	**Multiple parties engagement**
Description:	This requirement is the constitutes the plural version of *SRq5*. We understand that users come accompanied by people sometimes friends, acquaintances or relatives, and some other times it may seem that even with unknown people. We would like our system to be able to group them together and place a representation of their group in the virtual world.
Rationale:	While we realize that there may be technical constraints fulfilling this requirement we would like that groups of people are able to engage the system simultaneously as a party.
Fit criterion:	Groups of people are able to actually group together in the system and interact as a unit within the system by having a determined effect.

Req: SRq7	**Easter Egg element**
Description:	The easter egg element is concerned with the non-expected reaction by the system. Anything that is planned yet unmentioned as a feature of the system can

	constitute an easter egg.
Rationale:	Our user tests showed a strong support for adding at least one easter egg element within the system, to allow them to discover it.
Fit criterion:	An unmentioned feature in the system is added without letting the user know about.

Req: SRq8	**Installation Temporariness**
Description:	This requirement is concerned about the temporary aspect of the physical installation. The system is intended to be placed in a public space for the short term rather than the long term. It is necessary to create a physical installation that can be placed for an amount of time and that it is removable without leaving any trace or physical evidence of its existence or former presence in the space.
Rationale:	Because our installation is aimed to be placed in a public space owned by an external stakeholder who requires not adding anything permanent within its installations it is required to make an interactive installation that can be removed and not leave any permanent trace in the space.
Fit criterion:	The system can be placed and removed in a determined public space without leaving any physical and permanent trace.

Req: SRq9	**Cause and Effect scheme**
Description:	The Cause and Effect scheme requirement is concerned with the effect that happens after the user generates a cause for it to happen.
Rationale:	Making this installation interactive and not simply a static art installation.
Fit criterion:	The user is able to interact with the system.

Req: SRq10	Blob Measurement
Description:	The blob measurement system requirement is concerned with the size of the blob. The avatar size is in accordance to the size of the blob. A Blob is composed by a group of people. Kinnect sees people as items that occupy a space, those items can combine together to make a blob.
Rationale:	We have the intention to have different sizes of Avatars in our virtual world, since we intend to retrieve the position and size of the user with Microsoft Kinnect we realized that measuring the size of the blob composed by multiple users is the best piece of information our system can get to determine the size of the avatars.
Fit criterion:	The system identifies blobs of different sizes and links the size of the Avatars according to the size of its respective blob.

Hierarchy of Requirements

The list was divided in degrees of priorities in order to present an order of how the team will work in fulfilling the requirements. This is done with the MoSCoW methode.

- **Must have:** This first degree priorities determine the set of elemental requirements by which the system needs to fulfill without possibility of a compromise. Without this requirements the system would not be able to perform its most basic functions. Our team regards this requirements as the foundation for our prototype.
    a. **SRq1:** System display
    b. **SRq2:** Position detection
    c. **SRq3:** User's position representation
    d. **SRq9:** Cause and Effect scheme
- **Should have:** The second degree priorities is a set composed of requirements that must be fulfilled. However not achieving this set of requirements does not necessarily renders the system as completely useless. But it could possibly restrain the project from getting finalized. The second degree priorities address many of the risks that the project as a whole may face from achieving.
    a. **SRq4:** Optional engagement
    b. **SRq8:** Installation Temporariness
- **Could have:** The third degree priorities is a set composed of requirements that make the system more friendly for the user to use, or more attractive to different stakeholders. However, not fulfilling them would only render the project as incomplete and not completely useless unlike the first degree priorities.
    a. **SRq5:** Multiple users engagement
    b. **SRq6:** Multiple parties engagement
    c. **SRq7:** Easter egg element.

System functionalities

In the this chapter we will explain the proposed interactions, their relationship with the system requirements and their place in a theme. Our choice of system functionalities was defined according to the results found in the first experiment evaluation.

SF1	**Avatar follows the user**
Description:	The system is able to recognize the user position in the virtual world and represents it by placing an avatar. The user then is enabled to understand that his representation in the virtual world is in fact the avatar.
Requirements Involved:	SRq1, SRq2, SRq3
Source:	The source of inspiration of this functionality comes from the initial Brainstorm session and it was later confirmed by the first experiment evaluation.
Trigger:	The user is able to trigger this system functionality by moving from one point to another within the system's visible area.

SF2	**Merging and Splitting**
Description:	The system should be able to merge and separate avatars composed of both individuals (users) and groups of individuals (groups of users).
Requirements Involved:	SRq1, SRq2, SRq5, SRq6
Source:	The source of inspiration of this functionality comes from the initial Brainstorm session and it was later confirmed by the first experiment evaluation.
Trigger:	The user is able to trigger this by getting close enough with another user or group of users.

SF3	Shape Morph
Description:	The system should be able to morph the shape of the avatar according to the user shape as seen from the system's perspective.
Requirements Involved:	SRq1, SRq2, SRq3, SRq9
Source:	The source of inspiration of this functionality comes from the initial Brainstorm session and it was later confirmed by the first experiment evaluation.
Trigger:	The user is able to trigger this by altering his physical ratio as seen from above the user's head. Extending his arms is an example of shape morph.

SF4	Threat level
Description:	The thingies, which are the entities not controlled by the user should find a large avatar as a threat and therefore distance themselves from it. Meanwhile if the avatar is small and has a size similar to a thingy, the thingies should not find it as a threat, allowing the small avatars to prey on surrounding thingies and making it more challenging for larger avatars to grow even more.
Requirements Involved:	SRq1, SRq2, SRq3, SRq9
Source:	The source of inspiration of this functionality comes from the initial Brainstorm session and it was later confirmed by the first experiment evaluation.
Trigger:	The user can trigger this system functionality by making his/her avatar bigger by grouping with other people ergo other avatars.

SF5	**Avatar sleeping**
Description:	The Avatar should go to sleep if the user shows no movement or the movement is so little that the system is unable to recognize it.
Requirements Involved:	SRq1, SRq2, SRq3, SRq4, SRq7
Source:	The source of inspiration of this functionality comes from the initial Brainstorm session and it was later confirmed by the first experiment evaluation.
Trigger:	The user may trigger this reaction by not moving from it's position for a determined amount of time.

SF6	**Ducking makes one's Avatar smaller**
Description:	The user should be able to shrink the avatar's size when ducking. The smaller the Avatar is the more thingies will get near it, since they won't see it as a threat.
Requirements Involved:	SRq1, SRq2, SRq3, SRq9
Source:	The source of inspiration of this functionality comes from the initial Brainstorm session and it was later confirmed by the first experiment evaluation.
Trigger:	The user may trigger this functionality by ducking.

SF7	Avatar Theft
Description:	The user should be able to steal an avatar from another user.
Requirements Involved:	SRq1, SRq2, SRq3, SRq5, SRq6, SRq9
Source:	The source of inspiration of this functionality comes from a suggestion of a participant in the first experiment evaluation.

User requirements

The following section will discuss the user requirements for the second iteration. The following list will present the objectives to measure the degree of success for the second iteration, the requirements have been segmented according to: Their description which provides an overview of what the requirements constitutes, their rationale which provides the reason of why the requirement is considered an actual requirement, and a Fit criterion which describes how we will know whether or not the requirement is fulfilled:

Req: URq1	Space distinction
Description:	This requirement is concerned about how distinctive is the space where the system will be placed as opposed to the surrounding spaces. We want to create some distinctive space that is just different enough so the intended or unintended user is able to enter to and notice. For this we intend to use different audiovisual resources.
Rationale:	We require to somewhat distinguish the space so the users that transit notice that it is no ordinary space and has an actual function. Yet it should also be inviting so users don't attempt to avoid it.
Fit criterion:	Users find a difference between a regular space and our selected space yet are confident enough to cross it as they usually would or decide to interact with the system in the space.

Req: URq2	Noticeablity
Description:	This requirement is concerned about how to create a physical feature or en element in the installation so the user is able to notice the system but that it is discrete enough to be ignored if the user prefers to continue with his path.
Rationale:	Because the system is intended to be designed for a public space where people transit to get from one point to another. It is important to create an element in the installation that can attract the attention of some of the users (intended or unintended) yet that it does not block the unintended users to go across the space.
Fit criterion:	If the element attracts the attention of the possible users and brings some of them to interact with the system.

Req: URq3	Speed and Fluidity
Description:	This requirement is concerned about the speed in which the system process the user's actions and displays the information for the user to retrieve.
Rationale:	For the user to have a fluid interaction it is required to have a system that is quick enough to allow the user to interact on real time with the system.
Fit criterion:	The user does not need to wait and can fluidly interact with the system.

APPENDIX C: GRAPHICAL DESIGN

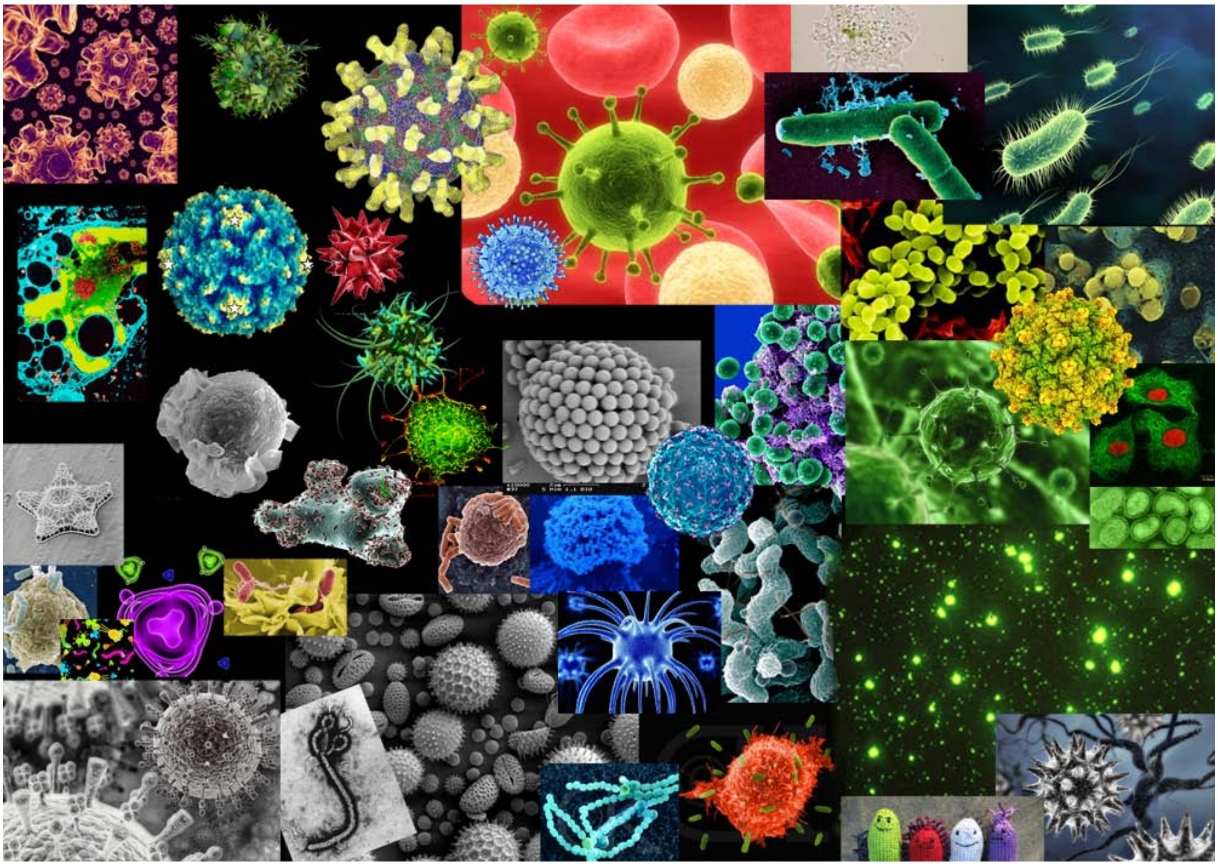
Avatar & Thingy concept development

We decided that our installation should have a kind of world in which the player would emerge. In this world there would be avatars that are controlled by the users, and there would be “thingies” that are just part of the world and interact with the avatars.

After some brainstorming we decided that the game world should to some extend represent our world. Predator and prey these simple concepts should be represented in our world.

But we did not want to recreate the world one sees every day, so we searched for a way to still have all the concepts we want, but show it to the users in a more abstract way.After some brainstorming we decided on the microbiology world. Viruses, bacteria, cells and other organisms we cannot see through the naked eye.

For inspiration we used all kinds of media. We looked at TV shows, videogames and pictures. Things like Osmos, Project Anemone, Squash the Bug, Power Puff Girls. From all the material we collected we composed a mood-board for the thingy design.



After we came up with the thingy moodboard we needed a style guide for our avatars. Because our thingies would be with a lot of spikes we liked our avatars to be a bit more smooth, but still be able to live and survive in this world. We also wanted the avatars to be slightly bigger that the majority of the thingies, with less ornaments and a more clean and simpler design.

Avatar & Thingy graphical design

After the moodboards were done, we needed to translate the style we decided upon to actual avatars and thingies. For our design we needed to keep a couple of factors into account that would dictate a couple of limitations for designing. The first limitation was processing power. Since we are going to make a large projection surface, our world also is very large. With a lot of characters on screen at the same time. We needed some animations that require small amounts of processing power. In other words; animations that do not take too long. We built our graphics in Adobe Illustrator and then transferred them to Adobe Flash, since that would drive our visualisation in the end and flash is also based on vector animations. Also the vector based graphics would help our goal which is to keep processing power as low as possible. Vector animations are not as CPU intensive as bitmap animations.

So having these limitations taken into account we started making the designs for the thingies and avatars.

From the moodboard to the screen

As mentioned earlier, both avatars and thingies looks are based in the looks of viruses, cells and bacteria; in order to translate highly complex images with vivid colours and highly detailed pictures into vector graphics simplification was required. Due to technical limitations; both the avatars and thingies were coloured in layers with different degrees of transparencies. In our quest to familiarize our look with the microbial world several layers of gradients were placed one over another to bring the most accurate possible representation of how would a virus could look like.

In order to translate the highly complex images of the moodboard into actual characters and objects in the virtual world we had to start by simplifying the shapes in three dimensions into flat shapes in two dimensions. We limited ourselves to design thingies with simple outlines. After this, details were added such as the internal divisions inside the body of a thingy and avatar. The third step consisted of recreating the potential avatars and thingies in bitmaps; since bitmaps allowed us a little more freedom to represent how we wanted our avatars and thingies to look like we used it as a guide to translate them into vectorized graphics again but this time with textures and colours.

After applying the potential colours to both the thingies and avatars, and designing the different elements within the bodies of both, they were split apart to be animated. Both thingies and avatars contain little elements within their bodies that had to be animated separately to bring an illusion of being alive.

Transition from Concept to Product

As explained earlier our inspirations was based on microbial organisms. So the look of both our characters that will represent the user in the virtual universe (Avatars) and the objects that will be fully controlled by the system (Thingies) should have a microbial look as well. Thingies/Avatars have different metabolisms therefore the rate in which they produce a contraction or relaxation is different. While some Avatars/Thingies may seem to act fast some others will make the impression of being slower. However this is not going to alter in any way the actual speed of the Avatar in the system.

Setting

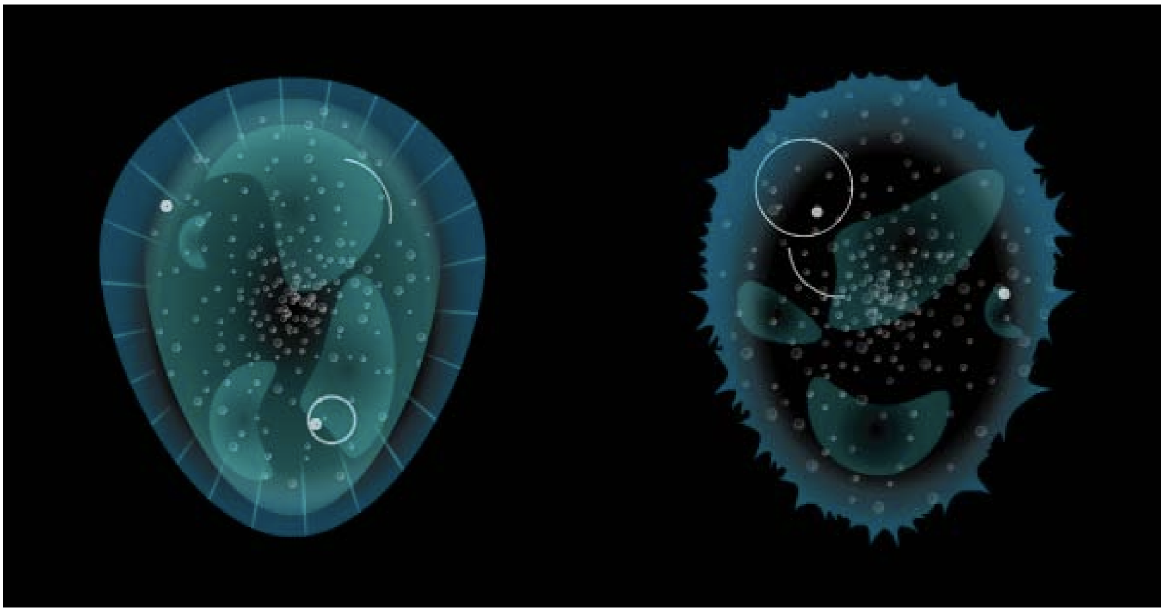
We defined that the setting could be a water drop or any liquid where the objects can be suspended in the space and where they could alter the position or place by doing microbe and fish-life movements.

Avatars

As opposed to thingies, Avatars have a more elliptical shape and a higher amount of detail. We have decided to spend more time on each Avatar because Avatars are the elements that will always be present when a user or group of users get into the visible range. Thingies on the other hand may come and go, and they are more varied so spending more time and effort on each one not only would require more time than what we planned but also they may not show as much or their size may not be big enough to distinguish the details. On the other hand Avatars have a minimum size, (the size of an individual) and even in this size details are supposed to be seen.

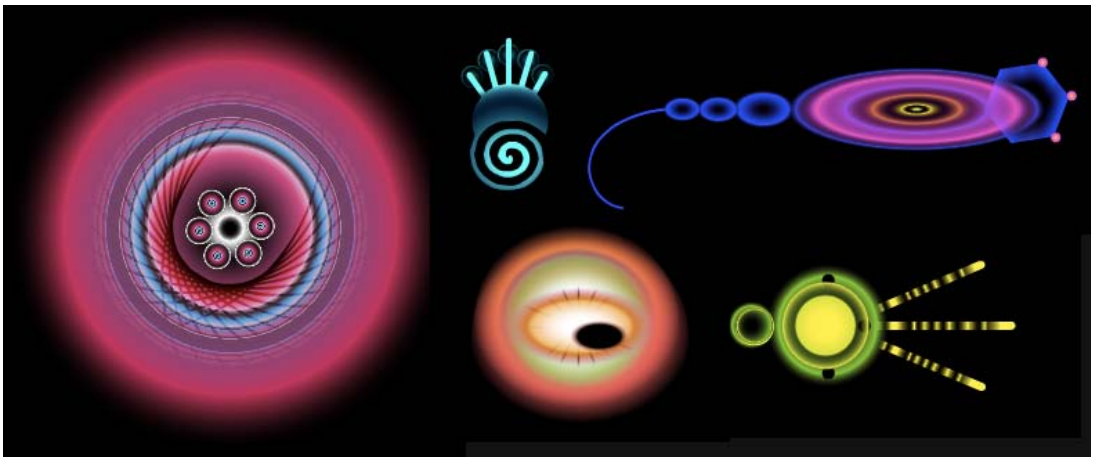
We want to fascinate the user by presenting him/her very diverse possibilities. 6 different types of avatars were created, two of those types contain 3 additional subtypes each, while the other 4 types contain 4 sub-types each; All this resulting in 22 different avatars. Each one has a different look.

In general Avatars can be divided in two families: The rounded Avatars and the spiky avatars.



Thingies

Thingies will tend to be smaller and as mentioned earlier, they do not really require a great amount of detail because of that. On the other hand the movements of the Thingies are more varied due to their body shape. Our objective is to impress the user with the variety of objects presented in the screen. Therefore we created 11 types of thingies. In addition each type has at least two subtypes of thingies totalling to 27 possibilities for a Thingy.



APPENDIX D: TECHNICAL DESIGN

Technical Research

This section contains research that is required in order to come up with a solution later. Here, topics involve hardware related issues such as how we should track people but also software issues, like visualisation or bumping effects.

Hardware

This chapter investigates issues and possible solutions related to hardware challenges.

Tracking

The main issue of our project is that we need to be able to track objects, which in our case are people, since our visualizations are based on the movements from people.

Heat camera, thermal imaging

This is a very interesting solution to tracking. The contrast in thermal images is really big, which makes it easy to detect many people using software packages like community core vision. However, the cheapest heat camera costs around $1,000 and has a resolution of 64x64 pixels, which is really small and too small for what we need and want to do. So this option is not feasible because of the price of the equipment.

Kinect

The Kinect is very interesting for motion tracking. At the University of Twente there are currently several projects being done using Kinects, plus that a master student is developing a software package that is able to combine the input of several Kinects, and to recognize people. Also our supervisors and other people from the University advise using Kinect.

An issue is that Kinect outputs a resolution of 640x480 pixels, which is not too big if we use it from a distance. Furthermore, the view angle is limited since it has been optimized to be used in combination with an Xbox. Luckily for us, the developed software is able to combine multiple Kinects and combine their video feeds to increase the field of view and thus also resolution.

Infrared Camera

An infrared camera allows us to more easy detect differences between image and thus allows better tracking of motion. Be it from people, animals, or any other object that moves within the range of the camera. By only choosing to use an infrared camera we still would not be done; we would have to choose a software package that is able to detect objects from the infrared video. To build such a package ourselves would not be a good idea.

Community Core Vision (CCV)

CCV is a very interesting application for motion tracking. It is an open source software package that is able to take an input feed (from an infrared camera, for example) and detect moving objects from that. It does this by using a reference image in which there weren’t any moving objects and a combination of several algorithms. The final output is a data stream that describes moving objects and their X and Y coordinates.

Conclusion

If we take into account the fact that the project should elaborate on user experience, we have limited time and there is a system available that is used amongst other projects, we think our best choice is to go with Kinect. This is also advised by HMI staff members who have experience in motion tracking.

Audio

Audio is relatively simple. One thing that is interesting to see if we can achieve, is to enable spatial audio for the ambient sound we want to use.

Spatial audio

One of the things we thought about, is spatial ambient sound. For this it would be interesting to have surround speakers that can be set up around the area.

Software

Logic

With logic we mean the software that is primarily able to detect movements from people and reason using that information to, for example, detect patterns in movement. We can separate this from the visualization application so that the visualization can be built in whatever environment we or someone else would want.

Java

Because of its popularity and its low learning threshold, Java is an interesting choice. Lots of libraries are available and , so this probably would be a fine choice.

It is known by three of our project team members, so it could be an interesting choice.

C++ / Visual C++

C++ and Visual C++ are only known by one of our project members, so this wouldn't be a very good choice as at least one other person should learn it as well. C++ however has quite a high learning curve. Based on that, we immediately scrap this choice from the list.

C#

C# looks a lot like Java, but has some nice extra features that make live nice and three of our project members know Java.

Visualizations

Flash

A lot of knowledge about Flash and the availability of visualization libraries is present within our project team. Also, we have experience in building Flash applications. Although we are not necessarily convinced by the script language ActionScript 3.0 that has to be used in Flash, it is very popular among people that create applications that require impressive graphics, meaning also that there are a lot of libraries available.

Visualization libraries

- André Michelle has lots of projects and references
  http://andre-michelle.com/

Physics engines

- Box2D
  http://box2d.org/
  http://box2dflash.sourceforge.net/

Conclusion

Because of the available knowledge about it and that it is relatively easy to build applications with impressive graphics that can be manipulated, we choose Flash as our environment for visualizations. However, we choose to separate the logic from the visualization and use a different programming language for that.

Technical Design

Of course there are also some technical challenges to the project. Although this is not the most important part of the report, we will still explain what we did and what choices were made.

Software

The ThingyCloud software setup consist of three components: computer vision, logic and visualization. The communication between these three components was designed to occur through TCP sockets and to be run on several computers. The original idea was to have one system take care of the computer vision and logic, and then send the information to another computer that is responsible of the graphical display and animations of the system.

Unfortunately, due to issues we encountered with the graphical component we altered our approach so that we could still conduct the final user experiments. Although the technical implementation is important, the project is more about conducting user experiments and making choices based on the results from those experiments. In short, the issue was that sometimes the graphical component crashed, and we were unable to detect where this came from. We will elaborate on this a bit more in this section.

Computer vision

Let us start with the very basics of the technical solution. We need to be able to recognize people walking in the area under the ceiling. To achieve this we use Microsoft Kinect and the software package *ParleVision*, developed by Human Media Interation students. ParleVision is a computer vision package that allows you to construct a directed graph of image processing elements. It is open source and easily extensible. The advantage of Kinect is that it provides depth information. This makes it very easy to filter objects that are further than a certain threshold value away from the camera.

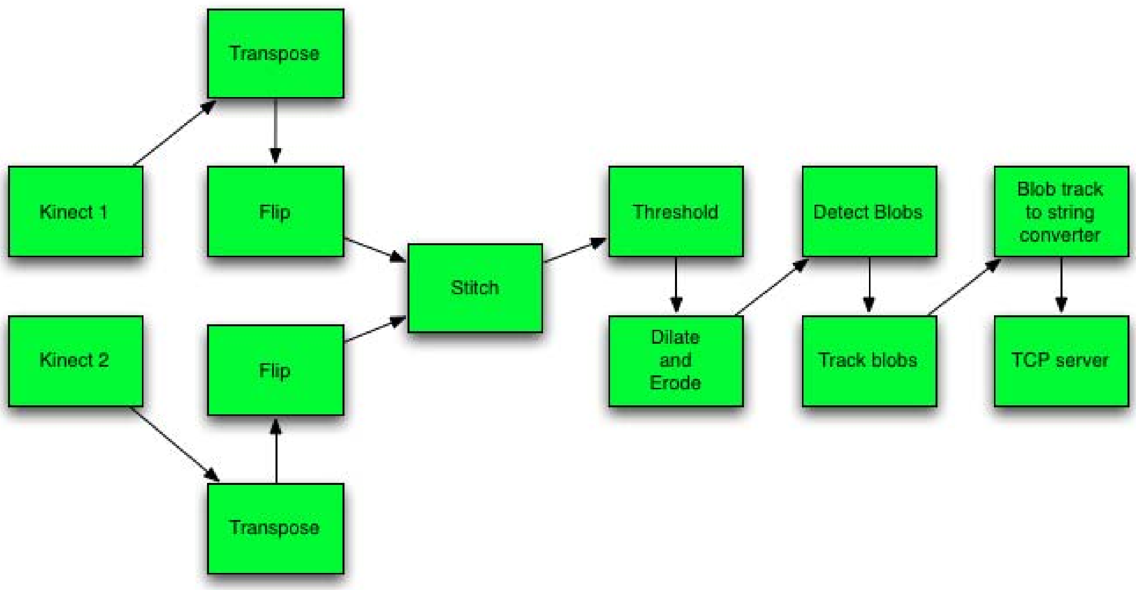
Because of the viewing angles of Kinect, to cover the entire area under the ceiling, we had to use two Kinects. The only problem here is aligning the Kinects so that the images from both Kinects can be stitched nicely by ParleVision.

The ParleVision graph

It is very easy to use ParleVision as our computer vision software. This saved us a lot of time, leaving enough time to work on the logic and visualization aspects. The steps that we need to perform to detect blobs are fairly simple:

- Get depth image from Kinects
- Perform rotation/mirroring to prepare stitching
- Stitch the images to create one big source image
- Filter everything that is further than a specified threshold value away from the camera's
- Detect and track blobs, providing them with a unique ID
- Publish the tracked blobs in string format over a TCP server

The figure below illustrates the implementation for our setup in ParleVision.



Rotation is a combination of transposing and flipping the image[1]. Two elements in this graph had to be developed by us. The *transpose* and *blob-track-to-string-converter* are two elements that were not available in ParleVision and have been developed during this project.

The information that is encapsulated in a string and sent over the TCP server is a list of all the blobs that are detected. Each blob is identified by an ID and has an (x,y) coordinate, width and height property.

[1] http://goo.gl/j1OR7

Logic

Now that we have a solution for the computer vision part and are able to detect people walking within range of the Kinect camera's, we can transfer that information to the system that is responsible for the logic. That is, the software that implements the interactions we designed. We decided to write this in C#, as it is a fast and simple programming language to learn.

The first component that was implemented was a thread that connects to the ParleVision TCP server and receives data constantly. This happens at the same rate of the camera's, approximately 30 times per second. As soon as a string is received it is analyzed and transformed into an event understandable by the application.

Building avatars from blobs

Interactions do not occur with blobs, but with avatars. Therefor we need to create avatars from blobs. By default, every blob that is detected gets an avatar with the same (x,y) origin, width and height. When two avatars get close enough to each other, they merge to one single avatar. That is, the blobs from both avatars are added to a new avatar and the old avatars are removed from the scene. The origin of the new avatar is ($x=min(x_1,...,x_n)$, $y=min(y_1,...,y_n)$), where x_i and y_i are the x and y coordinates of blob i, respectively, and *n* is the number of blobs contained by the avatar. The width of the avatar is defined as $max(x_1+w_1-x,...,x_n+w_n-x)$, and the height is $max(y_1+h_1-y,...,y_n+h_n-y)$, where x and y denote the origin of the avatar defined earlier. This creates a bounding box around all blobs within the avatar.

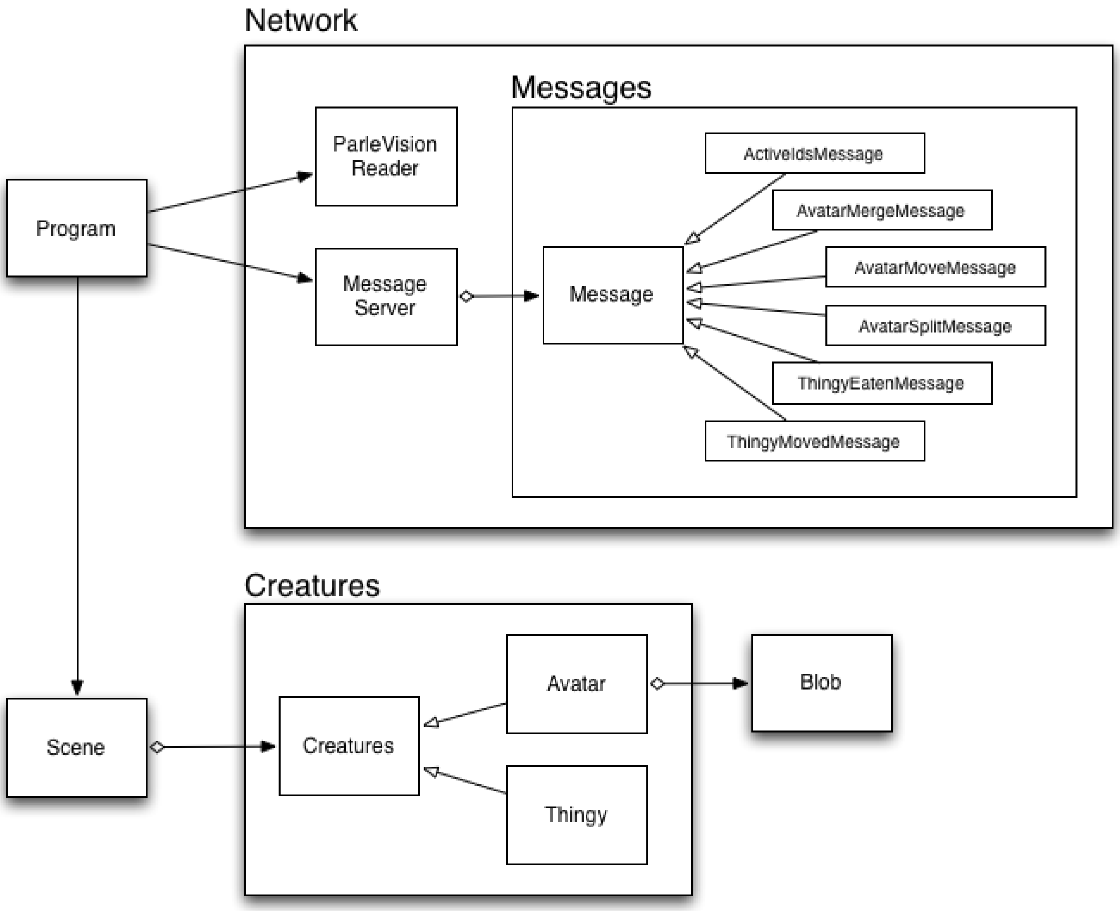
Interactions

In the first iteration we determined which interactions were most desired by the user experiment candidates. This section elaborates a bit on how each interaction is implemented, or why it has not been implemented.

- **Eathing thingies** is relatively simple. Both avatars and thingies have an (x,y) coordinate, width and height. Thus we can create bounding rectangles around them. If the rectangle of an avatar and thingy intersect, it means the avatar 'eats' the thingy and it is removed from the scene.
- **Merging and separating** is more tricky, but one that stood high on the list of desired interactions. Every time the logic component receives new blob information, it checks which avatars are close enough to merge. If it finds one, all blobs from both avatars are added to a new one and the merged two are removed from the scene. It also checks whether all blobs in all current avatars are still close enough to actually form the avatar they are in. If not, the blob that is too far away is assigned a new avatar.
- **Changing shapes** was unfortunately not possible. The only information we receive from the computer vision component is an (x,y) coordinate, width and height. We do not receive a polygon representing the blob, only a bounding rectangle.
- **Thingies towards user if his/her avatar is large** is again a more tricky interaction. Thingies run in their own thread and therefor actually 'live'. They check which avatars are within a certain range,. and what the weight of the avatar is (i.e. of how many blobs it consists). If the weight is larger than 1, the angle towards the closest avatar with weight >1 is determined using simple geometry, and the thingy its moving direction is updated.

- **Thingies turn away from user if her/his avatar is small** is of course the opposite of what is described in the bullet above.
- **Avatar following user** is something that is the case by default.
- **While ducking get smaller** is an interaction that is implemented automatically. The computer vision component provides us with a width and height of each blob. This is directly translated to the width and height of the avatar. If a person ducks he or she is further away from the depth camera and its size is reduced.
- **Stealing someone else's avatar** is actually more of a bug than feature in our system. The computer vision part is responsible of tracking blobs. When two blobs collide, the system is not always sure what blob moved where. In that case they are both assigned a new ID, resulting in a new avatar.
- **Avatar goes to sleep** is not implemented due to time constraints.

Class diagram



Visualization

The visualization was the most tricky part during the implementation. Originally we planned implement this in Adobe Flash. Since the animations were made in Flash already, using them in a Flash application would be relatively easy. Or so we thought.

For reasons we still do not exactly know, the Flash application we built was first of all not updating the scene fast enough, resulting in stuttering thingies and avatars. Even worse, the application randomly crashed. Crashing in this case means that either an exception was thrown and the application exited completely, or that the scene would not be updated anymore. In the latter case, avatars and thingies would still animate, but not move anymore.

When we had two more days to go before the user experiments, we had to make a decision. Either we keep trying to fix Flash, or we choose to drop the animations and implement a less impressive visualization using Windows Presentation Foundation, WPF. The latter option also meant that the visualization would run on the same machine as the computer vision and logic components, resulting in one computer system that performs all three components. The TCP socket between the logic and visualization was in this case no longer needed, as WPF can be used using C#. We built it in the same application as the logic, so that all software events generated by the logic could immediately be handled by the visualization.

It took about a day to build a new visualization application using WPF. Unfortunately this solution was not able to animate the thingies and avatar, but we were very happy to have a stable solution that allowed us to conduct the final user experiments. If we had more time available we could investigate how the original animations built in Flash can be used in WPF. Luckily, for the user experiments, the users did not see the animations at all so they were not aware of what they could have had.

Hardware

Next to the software that is used and had to be developed, also a physical setup, the hardware, had to be created. As our ceiling has to be white for proper projection, and the trusses in the SmartXP lab don’t have a ceiling we could use at all, we had to come up with something ourselves. We built two wooden frames, each with a dimension of 3.10x2.10 meters and chained them together, resulting in a frame of 3.10x4.20 meters. This means we have a little over 13 square meters for our projection. Good enough for our prototype setup. As projection area we placed pattern paper (often used for sowing) on the frame.

The Kinects that we use to track user positions should be connected to the frame, as we are interested in depth images from above. In the center of each frame a hole was pinched in the pattern paper and a Kinect was placed behind the projection surface. This way we have a perfect view from above and can easily filter anything further away than X meters, depending on what threshold value is provided.

Furthermore there is the challenge of projection. One option is to project from the rear. Unfortunately this was not an option as we would not have enough space. Also, the wooden frame would be between the projector and the pattern paper, meaning that from the other side you would see shadows. When projecting with a regular projector from below, there is the issue of skewing. Luckily for us, the HMI group had a short-throw projector available. This allowed us to place the projector on a tripod on the floor, and project on the ceiling.

The figures below show the setup as it was used during the final user experiments.

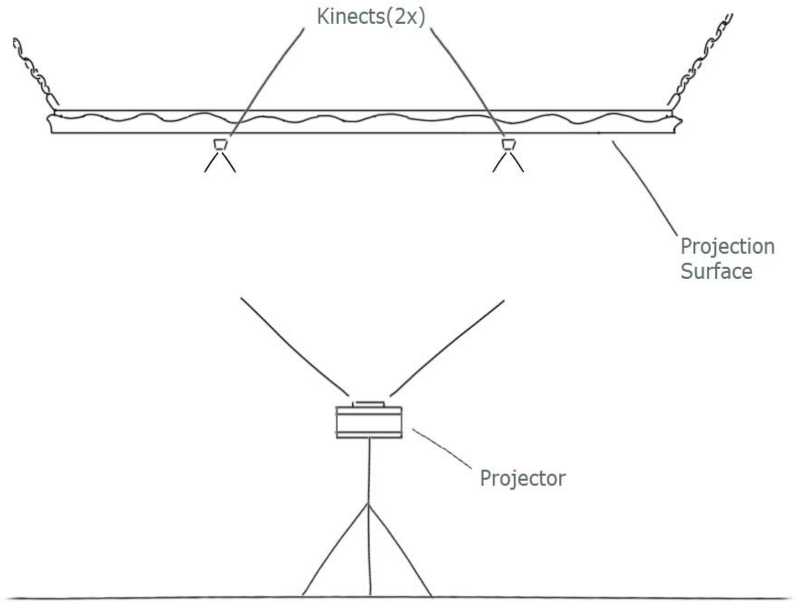


figure 1: Frontview

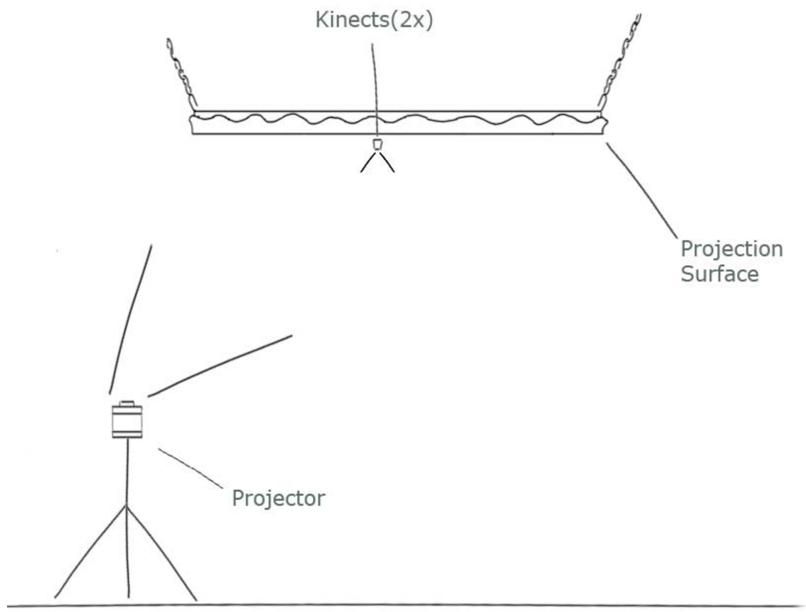


Figure 2: Side View

APPENDIX E: EXPERIMENT DESIGN ITERATION ONE

During the user test we want to figure out what kind of interactions we can use in our installation. Do they understand the possible interactions we offer them? Do they like the interactions we offer? And what are the interactions they want us to implement?

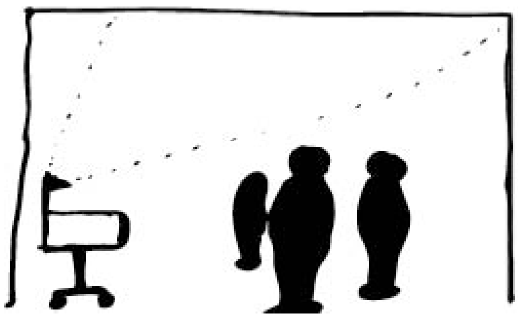
The goal of the user test design is to have a list of interactions at the end in order of most liked interaction. We will use this list in the next iteration so we can implement the most liked interaction first. The other purpose of the user test is to see if user like the idea of our interactive ceiling. The next iteration will be more usability oriented.

Experiment goals

For the test we have a couple of goals we want to achieve.

- Figure out if the avatars are distinct enough from the thingies.
- Find out whether or not it is clear that the avatar follows the user.
- Find out whether or not the following of the user by the avatar is a liked interaction.
- Find out if the user likes the merging of the avatar.
- Find out if the evolutionary table add anything to the user experience
- Find out if the user likes the splitting of the avatar.
- Find out if the user would like the avatar to change shape according to his shape.
- Test if the users like the interaction that if they are standing still for a while that their avatar is going to sleep (produces "zzzzZZZZZZZ").
- Test if the user wants to be able to jump to see if that has an interaction.
- Ask what other interactions the user is going to try out.
- Test if the users like the interaction that when the avatar is small the thingies come towards the user.
- Test if the users like the interaction that when the avatar is large the thingies go away of the user.
- Test if the user likes the interaction that when condition 'x' is met they eat the thingies.

Experiment Setup



The test setup consist out of one overhead projector that is operated by two people. This is to make sure we can follow all the movements of the users. The people will imitate the responses of our system(the following of the user by the avatar). The avatars will be represented by cut out drawings.

We will use the test setup with up-to three people at the same time.

The other part of the user test design consists of some scenario's with appropriate images. We will describe the situation based on a short scenario and ask question to find out if they would like to have this interaction, if they understand the interaction and when necessary, some specific questions on some parameters.

To end the experiment we will ask them to order the list of interactions in order of what they would liked to see implemented.

Material List

- Duc-Tape
- 2 overhead projectors
- ROOM
- Cutouts of all the characters (around the size of a euro coin) (preferably on transparent paper)
- Metal Wire or transparent drinking straw
- Tripod
- Camera
- Set of images
- Scenario's
- List of possible interactions (in the form of cards)

Tasks, questions and scenario's

Projector section

We will give our test subjects one tasked to complete so we can get answer to our questions. The task will be the following:

- Walk through the room in a circle, then go to the middle of the room and stand still for 30 seconds, after that walk the same circle in reverse order.

Question to go with the task:

- What did you notice?
- If they do not say they noticed the avatar following, ask if they did not see it and why they did not see it.
- If they do not say they noticed the avatar going a sleep, ask if they did not see it and why they did not noticed it.
- Now that you have seen this, what other things would you like to try, to see if this has an interaction?

Avatar vs Thingy section

Figure out if the avatars are distinct enough from the thingies.

We will show the test subjects a sequence of images with different combinations of avatars and thingies.

We will ask them to identify which are avatars and which are thingies. (0)

Find out if the user likes the merging of the avatar.

We will explain situation to the test subject:

- You are interacting with the ceiling and come close to an other person
  (show image of the world with two avatars) *(1)*
- When you are in close proximity to the other person, you suddenly see that your two avatars merge together into one bigger different avatar
  (show image of merging avatars) *(2)*
  (show image of one bigger merged avatar) *(3)*
- Ask what they think of this interaction
  (show image of the evolutionary table) *(8)*
- Ask what they think of the concept of the evolutionary table, and ask why
- Ask with how many people do they think is ideal to group in one avatar

Find out if the user likes the splitting of the avatar.

We will explain the situation to the test subject:

- Together with your friend you are still represented by one avatar
  (show image of one bigger merged avatar) *(3)*
- You now move away from you friend and you are now separated by some distance
  (show image of splitting avatars) *(2)*
  (show image of two smaller avatars) *(1)*
- Explain them that if you are with multiple people and one goes away there will be two avatars, and when you are all going away that there will be as many avatars as there are people
- Ask what they think of this interaction, and why they think this

Find out if the users likes the interaction that when the avatar is small the thingies come towards the user.

We will explain the situation to the test subject:

- You are walking through the world on your own.
  (shown image of world with one small avatar) *(4)*
- You now attract thingies
  (shown image of world with the same avatar and thingies coming towards it) *(5)*
- Ask what they think has happened?
- Ask what they think of this interaction, do they like it, and why they think this?
- Ask if they find this interaction logical/natural, and why they think this

Test if the users like the interaction that when the avatar is large the thingies go away of the user.

We will explain the situation to the test subject:

- You are walking through the world as a group and are represented by one avatar *(shown image of world with one big avatar)* *(3)*
- You now repel thingies *(shown image of world with the same avatar and thingies going away from it)* *(6)*
- Ask what they think has happened?
- Ask what they think of this interaction, do they like it, and why they think this?
- Ask if they find this interaction logical/natural, and why they think this

Find out if the user likes the interaction that the avatar changes shape according to the shape of the user.

We will explain the situation to the test subject:

- You are walking through the world on your own and are represented by one small avatar *(shown image of world with one small avatar)* *(4)*
- The moment you stretch your arm out, you see the avatar changing shape *(shown image of world with one shape changed avatar)* *(7)*
- Ask what they think of this interaction, do they like it, and why they think this?
- Ask if they find this interaction logical/natural, and why they think this

Test if the user likes the interaction that when condition 'x' is met they eat the thingies.

We will explain to the test subject the situation:

- In the world you are represented by an avatar, but in the same world there are also thingies. These friendly creatures do no harm to your avatar. But it might be that you want to do something to them. Do you want to be able to eat the thingies? And if yes, you want to eat them, when should you be able to do that.

Test if the user wants to be able to jump to see if that has an interaction.

We will ask the test subjects to following:

- If you were walking through the world would you try to jump to see if that has an interaction?
- If yes, what do you think the result should be?
- If no, why not?

What other interactions does the user want or thinks he/she is going to try.

We will ask the test subjects to following:

- Are there any other interactions you think you are going to try if this would work?
- Or are there any other interactions you would like to do?

Would this have the attention of the user?

- Would this world attract your attention?
- How do you think would should attract the attention of the user?
- What would you like to see different?

Order the interactions

To get a good understanding of what interaction the user would like to see implemented, we will asked them to order the cards with the interactions. The top one should be the interaction they think should definitely be supported by our system, the bottom one should be the interaction they think they don't like or can live without.

Responsible UT staff member:

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Experimental Leaders:

Mark Oude Veldhuis
Michiel Neelen
Gilberto Sepúlveda
Saskia Akkersdijk
Steven Gerritsen

Information for participants

"Thingy Cloud – an interactive ceiling"

Welcome and thanks for participating in our user test. We are developing an interactive ceiling. This ceiling will have it's own world you can interact with. The purpose of this usability test is to find out which interactions are preferred by the end users, and we will implement.

This session will not 'test' you or your ability, rather this session will test the interactions to provide information on what you would like the interaction to be. There are no risks associated with your participation in this session.

During this session, you will be asked to complete one task using the system. Furthermore, we will present you some scenarios together with the accompanying figures. We will ask you some questions at the end of the task and after each scenario. As you complete the task, one experimenter will observe and take notes. The session will last no longer than forty-five minutes.

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

Approximately 10 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. 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.

All recorded data will be strictly confidential and anonymous. Your participation to this experiment is completely voluntary. You can quit the experiments whenever you want and you do not need to provide us with a reason.

If you have any questions or concerns about the experiment now, during the experiment or afterwards, do not hesitate to ask us. If you have any questions or concerns at a later moment after the experiment, you can send it to s.n.j.gerritsen@student.utwente.nl.

Informed consent

“Thingy Cloud – a interactive ceiling”

With this signature I confirm that I have been informed about the possible risks and the purpose of the study. I participate voluntarily and have been informed that I can quit the experiment at any time. I do not need to specify why I want to quit and no negative consequences will follow. My data will be treated with strict confidentiality.

Name of the participant

Date of birth

Date, place

Signature of the participant

Name of experimental leader

Signature of experimental leader

Dear participant,

Thank you for participating in our experiment! To ensure your privacy we hereby give you a participants number. Below you can see the code that is already written down by one of the experimental leaders.

Participants number:

Date: ______________________

Time: ______________________

Personal Information

Date of birth: Day_____ Month_______________ Year_________

Sex: male □ female □

Protocol

Code:

Notes :

- ☐ Consent form attached
- ☐ Demographic form attached
- ☐ Evaluation forms Filled in

APPENDIX F: EXPERIMENT EVALUATION ITERATION ONE

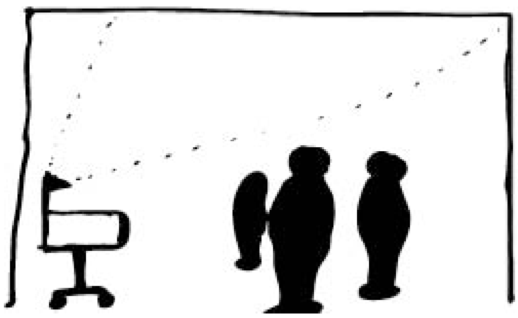
During the experiment we wanted to figure out what kind of interactions the users like to have in our system, do they see the projection on the ceiling, can they see the difference between Avatars and Thingies. The interactions we focused on are the interactions between the user and the system. In other words, which actions of the user produce a reaction of the system, and what is this reaction.

The goal of the experiment is to retrieve a list of interactions that we can use to build our system, prioritized by the user. In this way we can implement them the most liked interactions in our system. Besides this we wanted to get feedback on the idea of projecting something on the ceiling, and on the avatars and thingies. This experiment also made clear if the user notices the system on the ceiling so we can estimate how much work we have to do to get the attention of the user towards the ceiling. Also we asked them what they thought we should do to attract their attention.

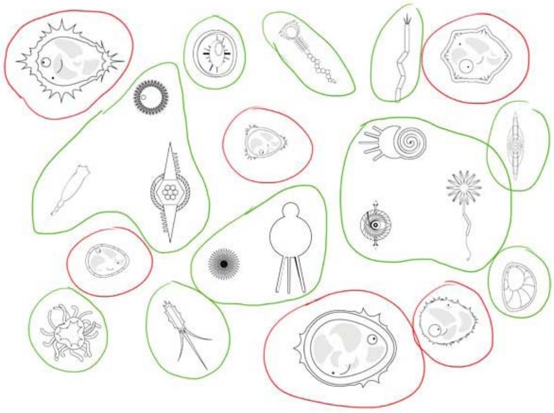
Based on the results, that will be presented in this document, we will adjust our plans and system in the next iteration.

The experiment

We did experiments with five persons, of whom four are students and one is an employee of the University of Twente.



The experiment consisted of three parts. The first part was to determine if the user noticed the ceiling and when they did noticed the ceiling if they saw that they were being followed by the shadow above their head. The shadow was produced by using a overhead projector and a piece of paper the size of an avatar. One person made sure that the shadow did follow the participant. We asked the participant to walk in a circle, stand still for 10 seconds and then walk back. Afterward questions were asked in a structured manner. We asked them if they noticed something, what did they notice, did they notice the ceiling (if they did not say this before), if they saw that they were being followed, and if they wanted to try other kind of things to see if the system would respond to that.



The second part consisted of some scenarios accompanied with images of avatars and thingies. We explained the user our project purpose of creating an interactive ceiling, and how this virtual world in the ceiling was composed of creatures called avatars and thingies. We asked the user to distinguish between avatars and thingies by circling them in different colours. After this we explained how a person obtains an avatar above his head and how the avatar follows it [the person] wherever he walks. We explained some scenarios to the user in which different interaction took place. During the explanation we showed the user images of different interactions without explaining what was happening at first, the images were:

- Two separate avatars navigating in a world with thingies
- Two separate avatars approximating to each other in a world of thingies
- 1 avatar alone and thingies navigating in the distance
- 1 avatar alone and thingies approximating to the avatar
- 1 avatar alone with thingies around while the avatar is stretching
- 1 big avatar in a world with thingies distant from it
- 1 big avatar in a world with thingies close to it

The scenarios to go with the images were as follows. Keep in mind that the description of the interaction was our interpretation, this can be different for the user:

- merging of the avatar
- splitting of the avatar
- when the avatar is small the thingies come towards the user
- when the avatar is large the thingies go away of the user
- the avatar changes shape according to the shape of the user

After each scenario we asked the user about their thoughts of what was happening during the interaction and their opinion on it. Once they gave an answer we asked follow-up questions to get more information on the reasons behind their opinion.

The last questions of this part of the evaluation were to let the user give their own suggestions on other possible interactions or other ideas that he/she might want us to implement in our prototype. The questions we asked were the following:

- when condition ‘x’ is met avatars can eat the thingies
- jump to see if that has an interaction
- other interactions does the user want or thinks he/she is going to try
- would the ceiling have the attention of the user?

During the third part we presented the user 9 cards with all the possible interactions composed by the ones we imagined plus the ones that were imagined by the earlier participants, or by themselves. Therefore the last participant had to sort 13 cards. We gave these cards to the participant and asked him to sort them according to his/her preference. This gave us a good sight of which interactions the end users may prefer to appear in the system. During the processing of the results we did take in to account that some cards were sorted more often than others. For more information see the results. We chose this approach so we also would have a rating for the interactions the participants thought of. Rather that having a sorted list of interaction we thought of and a bunch of new interactions we would have no clue about how well they are liked.

The results

The following chapter will discuss the different observations that we had during our test. Based on those observations we have listed a series of results that are used to form our conclusion of the experiment evaluation.

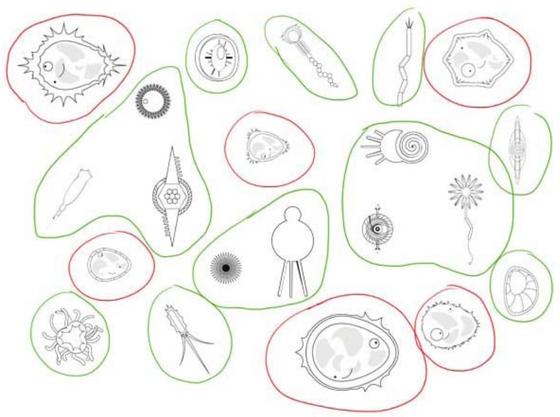
Part 1: Avatars following user

Two participants did not notice that they were followed by a shadow while walking. On the other hand one actually noticed he was being followed, while another two did notice that something was happening but decided to ignore it. Except for one, all the other participants did not see the avatar going asleep. Only one participant tried to jump to see if this would produce any interaction.

Part 2: The scenarios

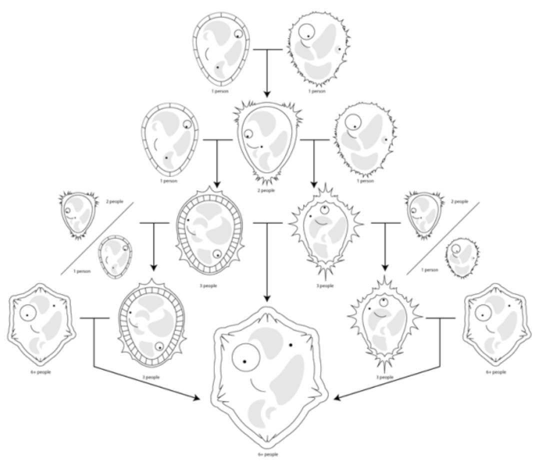
Distinction between Avatars and Thingies

Three participants were able to identify all avatars and thingies without error while only one did not identify all avatars correctly by only missing the figure of small avatar. In addition another different user from the one mentioned earlier one did not considered that all the thingies presented were actual thingies; however this same participant was able to identify all the avatars correctly. As shown in the figure below the objects within the green circles are thingies while the objects with the red circles are avatars. One of our participants did not identify all the objects in the green circles (thingies) as such and included some avatars as well.



Merging and Splitting interaction

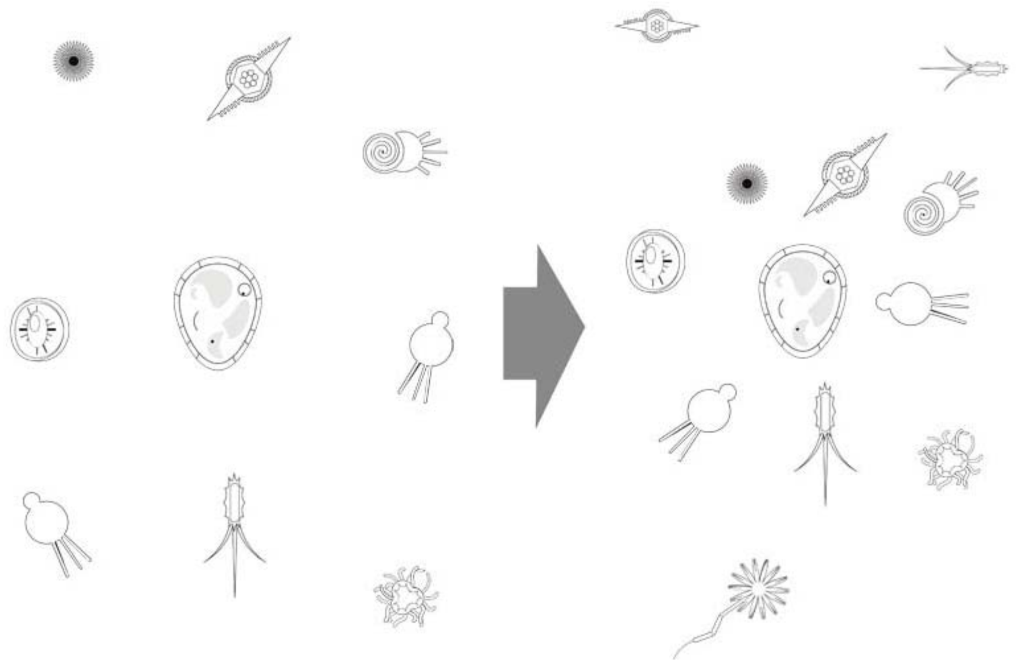
Merging and splitting are seen as a positive interactions. One participant drew parallels between mating and merging suggesting that the later one should be more mating-like; in that it could create new thingies instead of simply merging into a bigger avatar. The evolutionary as shown in the figure below table was perceived as interesting and “cool”, and that this kind of evolution would encourage interaction with other people. Only one participant expressed concern of merging his avatar to the avatar of unknown people.



Thingies grouping around and moving away from the Avatar position interaction

-The reaction where the thingies come towards the user when the avatar is small is perceived as intimidating by two in five participants. Other possible explanations given by the user for this reaction were that “grouping was a form of protection” or that “they [the thingies] were coming together [towards the avatar] for a chat”.

Some participants regard the interaction consisting of the thingies moving away from the user’s avatar position as a logical reaction while other users found it irrelevant.



Avatar Stretching interaction

Three out of five participants like the stretching of the avatar according to their own shape and position. One participant even suggested that the avatar was exercising; while another participant thought it was not really an interesting interaction.

Avatars eating thingies

Most participants would like for their avatars to be able to eat the thingies; one participant in particular liked the idea of eating thingies but was afraid of the thingies that had spikes. Possible actions to cause -the avatar to eat the thingies- were by either hugging, grabbing, jumping or moving to the position where the thingy is. The opinion regarding the action (or gesture) to have the effect of eating the thingies was split evenly among all participants. Each participant suggested a logical action while one did not suggest any action at all. One participant reported interest in seeing a reaction (either by growing or a particular change in the avatar) once the Avatar eats a Thingy.

Attracting attention to the ceiling

Most participants considered that we could attract enough attention to the ceiling by just implementing our world in it. They thought that the movements and colours on the ceiling would be enough aid to attract the attention of people walking in the area. In addition two out of four participants thought that sounds could also aid our objective to attract the attention of the people passing by. One participant even considered that the ceiling should have interaction even before the user's arrival to the active zone, in other words even if there are no users present in the world, the world should react to each other. For example thingies could have some kind of interaction with each other regardless of the presence of avatars.

Other remarks/interactions

Participants would like to have “Easter eggs” or unexpected fun interactions in our installation so they could look for them. What they meant by “Easter eggs” were reactions of the system that would normally not occur. These “Easter eggs” should be hard to find. They do not differ much form normal interactions, but the conditions for the reaction should be harder to be met.

Among other ideas mentioned were: getting faster after grouping of avatars, the avatar can die into small thingies, be able to exercise with thingies (throw them, bump into them or squeeze them were examples mentioned). However -the laying down on the floor gesture- (which we had as an example of other interaction they could think of) would be considered “weird” by two of the four participants, unless this would cause an Easter egg reaction.

Part 3: Interaction order

The sorting of the interactions were processed by giving points according to the ranking. The most interesting one got thirteen points; the least interesting one got one point. We took the median of each interaction and the higher this value was the higher it is in our priority list. You can see the priority list below:

Interaction	Median
Eating the thingies	11
Merging of the avatars	11
Changing Shape of the avatars	10
Separating of the avatars	10
Jumping interaction	8
Thingies come towards the avatar	8
Avatar follows the user	8
User ducks the avatar is getting smaller	8
Stealing an avatar from someone else	8
Jump on top of thingies	7
Thingies go away from the user	5
Avatar going to sleep	4
Avatars die and become food*	2

*It is worth noting that -Avatars die and become food- is not an interaction but a possible functionality in the interactive ceiling. However one of our participants suggested it and we decided to include it; given that the participant may not have a clear understanding of the difference between an interaction and a functionality.

Conclusion

All participants liked the idea of having an interactive ceiling and all said they would try to interact with it. From this we can conclude that users like the idea of the system itself.

The test-setup we used for this iteration in combination with the assignment we gave, was not enough to attract the attention of the user. Our results indicate that we need to make sure that users will notice the ceiling. Based on the results we can say that only the ceiling itself with just the world on it that moves, probably will be enough to attract attention. It is important to make use of bright colours, because the users indicated that this will attract more attention. Adding sound to it will make it more likely that they will notice it, because it makes the user aware that something is happening.

Our results indicate that avatars and thingies are different enough for the user to identify one from the other.

We didn't include the functionality: "Avatars die and become food." We decided this because the last participant came with this idea, but did not like it himself and did not have a clear idea when this should happen. Overall we succeeded in our objective of retrieving a list of possible interactions (and even one functionality) from our users. We also accomplished our objective of generating a list of priorities on what interactions are more desirable.

Eating thingies

There are a couple of ideas from the participants on how this can be achieved. The ideas include: jumping, hugging, grabbing and moving to the position where the Thingy is. Jumping on top of the thingies is the interaction that will be used to eat thingies. The effect that will occur is that your avatar changes colour.

Merging and separating

Merging and separating is another interaction we want to implement. When users come close together, close enough for their avatars to touch each other, their avatars merge together and a new avatar is created. The new avatar the persons get, is assigned according to the evolutionary table. When users move far from each other, enough that the individual avatars would not touch each other, the avatar separates and a new avatar is assigned to each user. The assigning here is also done according to the evolutionary table.

Changing shapes

Changing shapes happens constantly in our system. When the shape of the user changes, as seen from a top-down view, the shape of the avatar changes along with it. This means that if the user spread its arms the avatar will get a long stretched shape.

Thingies towards user if the avatar is large

Thingies come towards users' avatars when their avatar is large. This means that if multiple users let their avatars merge together thingies will come towards them.

Thingies turn away from user if his/her avatar is small

Thingies flee from you when your avatar is small. In this case your avatar is still larger than the thingies and they feel threatened, afraid of being eaten..

Avatar following user

While the user walks or moves under the interactive ceiling, the avatar must follow the user. -The Avatar following the user interaction- is the main way the user can communicate with the system to alter the universe of Thingies and Avatars.

While ducking getting smaller

While the user is ducking for a short period of time, the avatar (which happens to be related to its user) should get smaller. The deeper the user ducks the smaller the avatar should become.

Stealing someone else avatar

This interaction is not going to be implemented because the interaction will contradict with the merging and separating interaction.

Avatar goes to sleep

The Avatar goes to sleep, if the user stand still for longer than two minutes. This interaction would be implemented as an easter egg.

APPENDIX G: EXPERIMENT DESIGN ITERATION TWO

After what we learned from our first experiment evaluation we are now on the track of test our second prototype. The following chapters will describe the setup, rationale and planning of the second experiment evaluation.

Aim & Goals

We now have a list of possible interaction, which is backed up by the user preferences. We defined user and system requirements, based on our vision of the project, the user's input and the technical limitations. This experiment is going to be focused on the usability of our system. It's worth mentioning at this point that we define usability as being easy to learn, being easy to use and whether or not the user experience is fun when using it. We will also address the problems with the "discoverability" of our system.

- The goals of this experiment are:
- Does the user notice the ceiling?
- Does the user understand that the avatar follows the user?
- Does the user find all interactions?
- Does the user like the interactions?
- Does the user like the system?
- Is the system easy to use?
- Is the system fun to use by the user?
- Does our system produce smiles?

Methodology

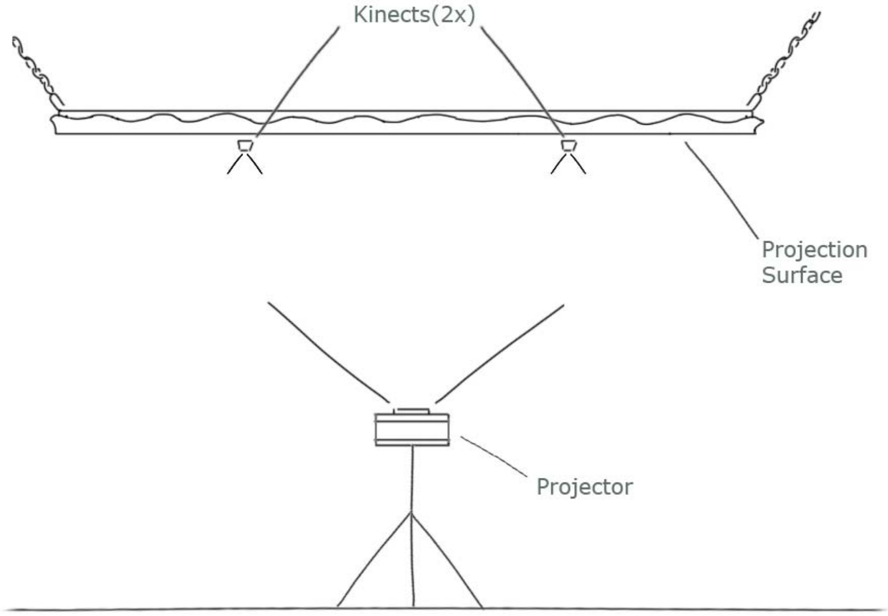
While our prototype may not yet be ready to be placed in a large public environment, it is suitable to be used in a controlled environment since it performs all the required technical system functionalities.

Test plan

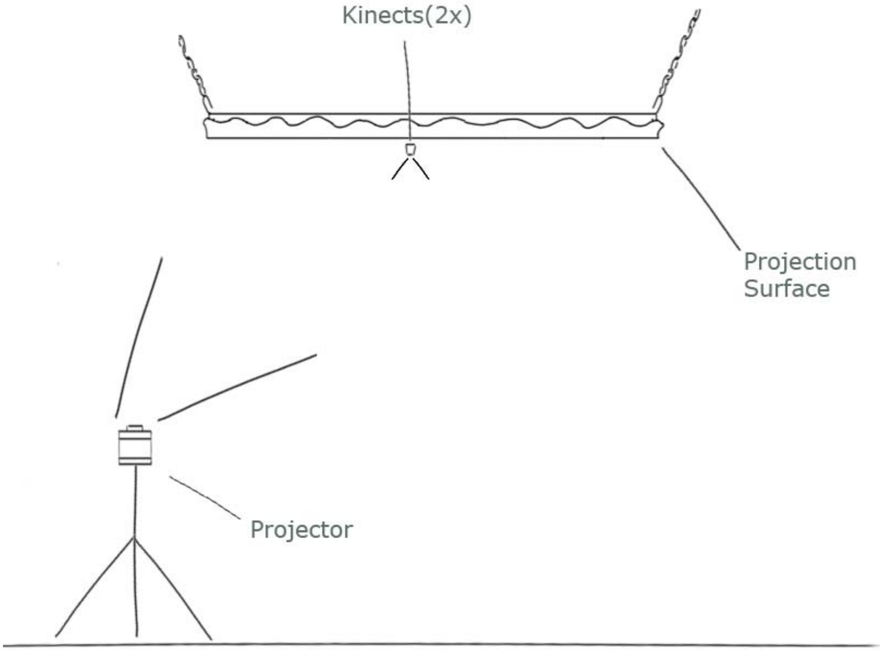
The following chapters will describe the details and the plan of the experiment.

Setting

Our prototype will consist of two wooden frames chained to a larger metal structure at the ceiling. The frames have a projection screen underneath it, where our projector can project the image. The interactions of the user will take place underneath the screens. Two Microsoft Kinects will be used to track the user's position and movement. The Kinects will be placed behind the projection surface. Small holes will be cut into the projection screen, so there will be no obstructions in the camera view. In our previous user test we found that observing the user alters his/her behaviour and attention. So we have decided that the area where the user will interact will be enclosed by a black curtain so the user can effectively feel alone in the room and he/she is able to behave as if no one was observing him/her. No observer will be inside the curtain covered area. The user or users will be observed through a camera and the instructions will be given from outside the covered area to the user.



Front view of the setting. In this figure The Kinects are shown under the projection screens for clarity purposes. In reality the Kinects were embedded within the projection screen.



Side view of the setting. In this figure The Kinects are shown under the projection screens for clarity purposes. In reality the Kinects were embedded within the projection screen.

Participants

We realize that our users may interact in groups or individually this is why we intend to test some of our participants as individuals and also test with groups of people. We define two possible types of participants:

Individuals:
The participants as individuals are participants that interact with the system on their own.

Groups:
The participants that come in groups will have access to additional interactions that would otherwise be impossible or unpractical if a user were to come alone. Since users are technically seen by the system as masses rather than individuals grouped together if a piece of the body of the mass separates from its parent the system would interpret it as if an avatar would be splitting in two.

Technical Setup

The setup is made up of a +/- 15m^2 projection screen, one projector, two Kinects and software. The application consist of three parts. One part is tracking users under our ceiling using Microsoft Kinects, translating the position of the people into a coordinates system. The second part is where all the logic of our application happens. It creates avatars based on the position of the user and creates thingies with their interactions. The third part will take care of the graphical user interface that is displayed on the ceiling. All applications communicate through TCP sockets, and the whole is processed by two computers. One computer takes care of the tracking and logic part of the application, and the second computer is rendering the graphics on screen.

Observation

We want to influence our test-subject the least possible. It is important to attempt to make the users feel as if no one is observing them. In our first user test we found that observing what the users do while they interact with this type of interactive installation distracts them from the purpose by making them shy for really engaging the system. We want to eliminate this side-effect, yet be able to observe them, therefore we will make video recordings.

Briefing

When participants arrived to the test site, we explained the test to the participants. What we expected of them, that we made video recordings of the experiment and that they could quit at any given moment during the experiment, without questions asked. We asked them to read our informed consent form, and asked them, if they would agree to the terms, to sign it. After that the experiment would begin.

Tasks

We want to keep the interaction with our system as natural as possible. For this it is important to influence our test-subjects the least possible. This also includes not giving them specific tasks to test all our interactions. We want to see which interactions they find on there own, and what their perception of the system is. Because of this we will only explain to our test-subjects that we have build a system and that we would like to know what they think of it. We will ask them to enter our testing-room and explore our system. All this without explaining anything.

Discovering the System: The user or group of users will be placed in a space where they will be asked to interact with the system. The group is supposed to find out by itself if they are in the system or not. We will let the user explore the system for up to 10 minutes.

Tasks after exploration

After the exploration period were the participants are exploring the system to find out what they can do with it, we will ask them to fill-out the questionnaire. We will do this before giving possible other tasks, because those will influence the perception of the system, and we will not get a clear understanding of what people would do or what their opinion of the system would be without explaining of pointing out something.

If the participants have not uncovered all the features the system has to offer we will give additional tasks after the questionnaire. We will then give the participants a brief description of the interaction. After this description they are set out to explore the ceiling again, and try to trigger the just described interaction. This is repeated until all the interactions of the system are aware to the user.

Groups of people are able to trigger more system functionalities than lone individuals because the system has certain functionality that requires multiple users at once (merging and splitting).

Possible tasks for interactions in the prototype system are:

Avatar Movement: Once the users know that they are indeed within the visible range of the system we will ask them to move around within the system's visible area (e.g. If they are located in the top left corner of the visible range, they will be asked to move to the bottom right corner of the visible range). For this we assume that the user will understand that the visible range only extends to the projection area.
Summary: *The user(s) will be asked to move around. Then one observer will ask them if they notice anything after performing the task.*

Eating Thingies: In this task the users will get an explanation of what an Avatar is and their role in the system. Then they will be asked to attempt to eat the thingies. However no explanation on how this task is performed will be given. The user should be able to assume a gesture to eat them. The gestures will be observed to reach to a concussion to what is the most obvious or intuitive gesture to perform this task. If the users aren't able to perform this task an explanation of how to perform this task will follow. If the users successfully complete this task no explanation will follow. The users then will be asked to describe what happened and how did they achieved the system functionality.

Summary: *The user(s) will be asked to eat the thingies without any explanation on how to do it. If after 1 minute they are unable to find a solution, we will explain them how to do it. Otherwise no explanation will follow. Then the users will be asked by the observer to describe what happened. Only if the users were able to achieve this interaction without explanation they will be asked how did they trigger it.*

Merging and splitting: If the users described accurately what happened in the previous step then they will be asked to merge their avatars together without an explanation of how to do it. If the users did not described accurately what happened in the previous step then they will get an explanation of how to merge Avatars and they will be asked to do it. We are assuming that the user will be able to deduct that if separate can be achieved through an specific method, then reversing the method will produce a merging. The observer then will ask the users to describe what just happened.
Summary: *The users will be asked to merge their Avatars together and an explanation of how to do it will follow only if the users were unable to describe accurately what happened int he last interaction. Otherwise they should be able to perform the task without further explanation. The user then will be asked to describe what happened and how he achieved this system functionality. Of course the same goes for splitting.*

Questionnaire

The questionnaire will constitute of the following parts:

- General Information about the user
- Questions about the discoveries that the user got during the experiment and if he/she liked interacting with the system
- Adjectives that the user would apply to our system and that allow us to understand the quality of the experience that the user just got while taking part in the experiment.

Questions as they appeared in the questionnaire:

***What is your gender?**
Possible Answers: Female, Male, Other, Prefer not to disclose
Rationale: This question will allow us to know the general composition of the genders of our participants and if the gender had any influence in the perception and opinion about our system.

***What is your current age?**
Possible Answers: 18-21, 22-25, 26-30, 31-40, 41-50, 51-60, 60 or more, Prefer not to disclose
Rationale: This question will allow us to know the general composition of the age of our participants and if the age had any influence in the perception and opinion about our system.

***Have you ever suffered server damage in your spine or your neck?**
Possible Answers: Yes, No, Prefer not to disclose
Rationale: This question will allow us to know the general composition of the health history of

our participants and if the health history had any influence in the perception and opinion about our system. The health history is limited to the Spine and Neck since the participants will need to look to the ceiling, using both their spine and neck to interact with the system.

***Is it common for you to lose balance if you stop looking at where you are walking?**
Possible Answers: Yes, No, Prefer not to disclose
Rationale: This question will allow us to know the general composition of the balance ability of our participants an if their balance ability had any influence in the perception and opinion of our system.

Do you commonly suffer from any of the following physical conditions?
Possible Answers: Headache, Dizzyness, Backpain, Neckpain
Rationale: This question will allow us to know the general composition of the common medial problems of our participants an if their medical problems had any influence in the perception and opinion of our system. It's worth to note that this is an option question.

***Have you ever taken part in an experiment where you test a technology related product?**
Possible Answers: Yes, No, Prefer not to disclose
Rationale: This question will allow us to know the general composition of the previous experience with experiments of our participants an if their previous experience had any influence in the perception and opinion of our system.

*Have you ever had studies in the technology field? (Example: Computer Science, Information Technology, Interaction Design, etc.)
Possible Answers: Yes, No, Prefer not to disclose
Rationale: This question will allow us to know the general composition of the technology-related education of our participants an if their technology related education had any influence in the perception and opinion of our system.

***With how many people did you take the experiment?**
Possible Answers: I did it alone, With 1 other person, With 2 other people, With 3 other people, With 4 other people, With 5 other people, With 6 or more other people
Rationale: This question will allow us to know the number of people that the participant took the test with. In addition to whether or not the experiment was done alone or in a group.

*Which hand do you usually do to perform manual activies? (Example: Writing, Drawing, Pointing, Cutting, etc.) Possible Answers: Right hand, Left hand, Both, Not Applicable / Prefer not to disclose Rationale: This question will allow us to know the general composition of the handedness of our participants and if the handedness had any influence in the perception and opinion about our system.

If you took the experiment with a group; Did you know anyone in the group?
Possible Answers: I did not know anyone else in the group, I knew 1 other person, I knew 2 other people, I knew 3 or more other people, I knew all the people in the group.

Rationale: This question will allow us to know if the participant knew anyone in the group, and if so how many people.

If you took the experiment with a group; Please tell us how comfortable you felt.
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Comfortable and the right end with the word Uncomfortable.
Rationale: Based on what we learned from the previous question we can now understand how the participant felt regarding his or her comfort level during the experiment. This question comes right after question 9a to trigger a relation between the number of people the participant knew, and his or her comfort in relation to the fact that the participant knew or did not know a number of people while doing the experiment.

***Did you like the interactive ceiling?**
Possible Answers: Yes, No, Unsure
Rationale: This question will allow us to know if the participant liked our system in general.

***Please list the things that you discovered that the interactive ceiling could do.**
Possible Answers: Open question, the participant can answer in any way, and describe his or her discoveries in any way he/she may find fit.
Rationale: This question will allow us to see what features of the system were noticed and discovered by the participant. This question is one of the few qualitative elements in the whole questionnaire and requires to be analyzed on case by case basis. The only reason why this is not a multiple choice question is so we can see what features of our system stayed in the participant's memory.

***Did you like what you could do with the interactive ceiling?**
Possible Answers: Yes, No, Unsure
Rationale: Unlike question number 10, this question will allow us to know if the participant liked the features of the system and not the system overall. It focus the attention of the participant on the things that the participant can do with the system.

If not, could you explain us what in particular you did not like and why?
Possible Answers: Open question, the participant can answer in any way, and describe his or her discoveries in any way he/she may find fit.
Rationale: This question will the participant to explain why he or she did not like what he or she could do with the system. It enables the participant to potentially separate the possitive things that can be done with the negative things that can be done.

***Isolating vs. Connective**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Isolating and the right end with the word Connective.
Rationale: This question will not only allow us to understand if the participant perceived the system either Isolating or Connective but, it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of

our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Pleasant vs. Unpleasant**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Pleasant and the right end with the word Unpleasant.
Rationale: This question will not only allow us to understand if the participant perceived the system either Pleasant or Unpleasant, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Inventive vs. Conventional**
Possible Answers: On a scale from 1 to 7 the semantic diferential rating system was applied with the left end with the word Inventive and the right end with the word Conventional.
Rationale: This quesiton will not only allow us to understand if the participant percieved the system either Inventive or Conventional, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Ugly vs. Attractive**
Possible Answers: On a scale from 1 to 7 the semantic diferential rating system was applied with the left end with the word Ugly and the right end with the word Attractive.
Rationale: This quesiton will not only allow us to understand if the participant percieved the system either Ugly or Attractive, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Likable vs. Disagreable**
Possible Answers: On a scale from 1 to 7 the semantic diferential rating system was applied with the left end with the word Likable and the right end with the word Disagreable.
Rationale: This quesiton will not only allow us to understand if the participant percieved the system either Likable or Disagreable, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Cumbersome vs. Straightforward**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Cumbersome and the right end with the word Straightforward.
Rationale: This question will not only allow us to understand if the participant perceived the system either Cumbersome or Straightforward, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user

experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Stylish vs. Tacky**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Stylish and the right end with the word Tacky.
Rationale: This question will not only allow us to understand if the participant perceived the system either Stylish or Tacky, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Predictable vs. Unpredictable**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Predictable and the right end with the word Unpredictable.
Rationale: This question will not only allow us to understand if the participant perceived the system either Predictable or Unpredictable, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Alienating vs. Integrating**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Alienating and the right end with the word Integrating.
Rationale: This question will not only allow us to understand if the participant perceived the system either Alienating or Integrating, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Brings me closer to people vs. Separates me from people**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the sentence “Brings me closer to people” and the right end with the sentence “Separates me from people”.
Rationale: This question will not only allow us to understand if the participant perceived the system as either bringing him/her closer to people or separating him/her from people, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. The sentences were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Unpresentable vs. Presentable**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Unpresentable and the right end with the word Presentable.
Rationale: This question will not only allow us to understand if the participant perceived the system either Unpresentable or Presentable, but it will enable the participant to indicate to what

degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Rejecting vs. Inviting**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Rejecting and the right end with the word Inviting.
Rationale: This question will not only allow us to understand if the participant perceived the system either Rejecting or Inviting, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Unimaginative vs. Creative**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Unimaginative and the right end with the word Creative.
Rationale: This question will not only allow us to understand if the participant perceived the system either Unimaginative or Creative, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Good vs. Bad**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Good and the right end with the word Bad.
Rationale: This question will not only allow us to understand if the participant perceived the system either Good or Bad, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Confusing vs. Clearly structured**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Creative and the right end with the words clearly structured.
Rationale: This question will not only allow us to understand if the participant perceived the system either Creative or Clearly structured, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Repelling vs. Appealing**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Repelling and the right end with the word Appealing.
Rationale: This question will not only allow us to understand if the participant perceived the system either Repelling or Appealing, but it will enable the participant to indicate to what degree

he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Bold vs. Cautious**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Bold and the right end with the word Cautious.
Rationale: This question will not only allow us to understand if the participant perceived the system either Bold or Cautious, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Innovative vs. Conservative**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Innovative and the right end with the word Conservative.
Rationale: This question will not only allow us to understand if the participant perceived the system either Innovative or Conservative, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Dull vs. Captivating**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Dull and the right end with the word Captivating.
Rationale: This question will not only allow us to understand if the participant perceived the system either Dull or Captivating, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Undemanding vs. Challenging**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Undemanding and the right end with the word Challenging.
Rationale: This question will not only allow us to understand if the participant perceived the system either Undemanding or Challenging, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Motivating vs. Discouraging**
Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Motivating and the right end with the word Discouraging.
Rationale: This question will not only allow us to understand if the participant perceived the system either Motivating or Discouraging, but it will enable the participant to indicate to what

degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Novel vs. Ordinary**

Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Novel and the right end with the word Ordinary.

Rationale: This question will not only allow us to understand if the participant perceived the system either Novel or Ordinary, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

***Unruly vs. Manageable**

Possible Answers: On a scale from 1 to 7 the semantic differential rating system was applied with the left end with the word Unruly and the right end with the word Manageable.

Rationale: This question will not only allow us to understand if the participant perceived the system either Unruly or Manageable, but it will enable the participant to indicate to what degree he or she felt one or the other, giving us valuable information of the user experience aspect of our system. Adjectives were based on the *AttrakDiff questionnaire by Hazzenzahl, Burmester and Koller (2003)*

Thingy Cloud: User Agreement

The following research project is being conducted by Appleflap Group of the MSc Human Media Interaction Degree at the University of Twente. Thank you for deciding to volunteer in taking part in this experiment. The purpose of this research is to understand the impact that our system has on its users, understand how our system is perceived by our users and how easy it is for them to use.

You will be asked to perform some tasks in a controlled setting. Some of the actions may involve additional people to perform them successfully. Therefore, you will be accompanied by other participants. In the end you will be asked to fill out a brief questionnaire. The experiment will take about 20 minutes.

The study will take place at the SmartXP lab of the University of Twente in the Zilverling building. No compensation will be given apart from the probable satisfaction feeling of contributing with your knowledge in the name of science.

In order to accurately record your answers we would like to create a video recording of your interactions with the system. We will keep your personal information confidential. Video recordings can be used in the following ways:

- watched/analysed by the research team members
- shown to supervisors or other staff-members of HMI
- quotes from users may be used in formal presentations
- appear in our report (screenshots)

Recordings will not be attributed to named individuals, since we will remove all personally identifiable information. Video and audio recordings will be kept to analyse the results but will not be published online. The video and audio recordings will be destroyed once the project's documentation and analysis is complete and approved by our supervisors.

By signing this consent form, you acknowledge that we can produce audio-visual recordings of you engaging the system and use quotes in our documentations in an anonymous way.

Due to the physical nature of the experiment there is a small risk of injury. We do everything to prevent any injuries. To prevent injuries we advise you to walk calmly and keep the palms of your hands and arms somewhat curved to prevent you from falling or bumping against any other user or object. Similar to how you would walk in a room with the lights off. Neither our team, nor the University of Twente will be held liable for any injuries that may occur during the experiment.

Your participation is this research is completely voluntary. The results may help us to learn more about the human aspects of our system. We hope that, in the future, other people might benefit from this study through improved understanding of our research aims. If you decide to participate in this research, you may stop participating at any time.

The research is being conducted by the team Appleflap constituted by Saskia Akkersdijk, Steven Gerritsen, Michiel Neelen, Mark Oude Veldhuis and Gilberto Sepullveda Bradford. At the time of the formulation of this document, all are students of the MSc Human Media Interaction degree at the University of Twente. If you have any questions about the research study itself, please contact **Steven Gerritsen at:**
s.n.j.gerritsen@student.utwente.nl

If you have any questions about your rights as a research subject or wish to report a research-injury, please contact **Dr. Mannes Poel** **m.poel@utwente.nl** Faculty of Electrical Enginering, Mathematics: Human Media Interaction Division of the Dept. of Computer Science of the University of Twente **P.O. Box 217, 7500AE Enschede, The Netherlands. Phone: +31 53 4893920, Fax: +31 53 4893503.**

Your signature indicates that: You are at least 18 years of age; the research has been explained to you; your questions have been fully answered; and you freely and voluntarily chose to participate in this research project.

Full Name:____ Date:_____________________________

Signature:____