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# Making the In le Visible

## - Presenting Information in Context


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**Synopsis:**

This thesis focus on understanding the possibilities of making invisible information visible, and how the concept can be achieved through mobile technology. We recognize that information possibly encompasses different temporal aspects. *PhotoWorld* seek to visualize past information, through presentation of photos in an urban environment. Subsequently, *HouseView* was implemented to visualize information with a future temporal foundation, by presenting architecture in-situ.

From our evaluation of both systems we learned valuable lessons: visualization through Augmented Reality requires thought into 3D registration, temporal diversity is a key element when presenting information and digital visualization is a good way of presenting temporal aspects of a context.

## Preface

This Master Thesis has been carried out at the Department of Computer Science at Aalborg University. During our $9^{th}$ semester we were part of a six man project group. Resulting from our work we wrote one paper, which has been included in this thesis. The entire paper have been revised, the findings heavily revised and the introduction, discussion and conclusion rewritten.

We would like to express our appreciation by thanking Jesper Kjeldskov for his comments and input and our group members on the $9^{th}$ semester: Glen Nielsen, Michael Vestergaard and Søren Thorup for extraordinary teamwork and inspiration. Finally, we would especially like to thank our supervisor Mikael B. Skov for his constructive feedback, assistance and supervision through the last year of working on this thesis.

Literature references will use the Harvard model, for instance: [Carter, 2008]. A list of relevant literature can be found in the back of the report, see the Bibliography on page 29. The Appendix can be found last in the report and will contain material from the entire thesis, including the two research papers.

Aalborg, $11^{th}$ of June 2010

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### Reading Instructions

This thesis is composed of two research papers and a report that relate the two based on topics such as Augmented Reality, Context and Visualization. Each of the research papers can be read individually. The report unifies concepts covered in the papers and provide a red line throughout the entire work.

**Chapter 1 - Introduction** Introduces the concepts of Augmented Reality, temporal diversity and the use of context. It identifies the challenges of making the invisible visible, and how emerging technologies can be used to facilitate this goal.

**Chapter 2 - Research Contribution** Presents an overview of each research paper. Each summary presents the motivation, solution and evaluation of the paper.

**Chapter 3 - Lessons Learned** Covers three lessons from our work on visualizing invisible information.

**Chapter 4 - Conclusion** Conclude on the results from our research papers and covers any limitations that surfaced during the process.

**Appendices** A comprehensive list of screenshots, user study data, questionnaires and the like, created and used during the research is presented in the appendix to provide better insight in the work behind the research.

# CONTENTS

CHAPTER

# ONE

## INTRODUCTION

> *"Nobody has ever built a time machine that could take a person back to an earlier time. Nobody should be seriously trying to build one, either, because a good argument exists for why the machine can never be built. The argument goes like this: suppose you did have a time machine right now, and you could step into it and travel back to some earlier time. Your actions in that time might then prevent your grandparents from ever having met one another. This would make you not born, and thus not step into the time machine. So, the claim that there could be a time machine is self-contradictory"*
> - Philosopher Bradley Dowden

According to the logical reasoning by Bradley Dowden, time travel would never be possible since the core concept is a paradox in itself. But no matter how contradictive time-traveling sounds; it has always been a dream of the human race to travel in time. We see it depicted in movies and books. It seems like we are forced to accept that actual time travel is out of our reach, but how about getting as close as we can? Would it be possible to use today´s technology to achieve some sort of shifted temporal insight? To get the effect of time travel, we imagine that a visualization of the surroundings in which the time-traveler is situated would be needed. It sounds reasonable to assume that showing differentiated temporal information requires some sort of contextual knowledge to relate to. Furthermore, constructing a window to another time, which is fixed to a specific location, would greatly limit the possibilities of usage. Therefore to make our time-machine as generic as possible we want it to be mobile, and by doing that, even increasing the need of relating the traveler's location, and thereby context, to the visualization.

The importance of context when visualizing information on mobile systems has been evident for quite some time [Dey and Abowd, 2001]. Dix et al. defines context, in its broad sense as all things that are relevant for the interaction between the user and the system [Dix et al., 2000]. These elements would include the goal or intention of the user, plus the physical and social environment the individual is operating within [Sun and May, 2008]. Since we want to give the user a glimpse of another time, our focus is on visualization. Facilitating the users' objective is a major challenge because of the dynamic nature of the context. This is the reason why most context aware mobile systems have to resort to the use of context cues. Portable tourist guides is a good example of this tendency, since we here see the use of information like the visitor's interests and previous visits to a location [Jörstad et al., 2005]. They use the users' preferences to decide what data to visualize.

Within the field of HCI a lot of research into how best to visualize information to a user has been conducted. No matter if it was in the context of a hospital ward [Skov and Høegh, 2005] or to visualize construction imagery [Summerfield and Hayman, 2006]. This has become even more evident with the introduction of augmentation of the context into the academic society. By augmentation the context, focus was on providing extra information to a user's perception on top of the context, instead of just filtering information based on it. By augmenting, we seek to increase or extend. The possibilities of augmenting the surroundings for helping a user achieving his goal are now being investigated in a series of different fields. We see the concept being used in aiding assemblies [Billinghurst et al., 2008], visualizing wind flow [Eissele et al., 2008] and even in games [AR-Drone, 2010].

While context augmentation systems the last decade has been tied to big cumbersome systems like portable laptops and Head-Mounted Display (HMD), we now see technologies incorporated in today's smartphones - making it portable and the fruit of academic research public available [Newitz, 2009]. This also spawned the use of augmentation to flourish onto even more areas. The city was suddenly augmented with fiction [Kjeldskov and Paay, 2007], or something invisible were made visible [Kjeldskov and Paay, 2005]. Especially the concept of "Making the Invisible Visible" presented by Kjeldskov and Paay is intriguing, and goes hand-in-hand with the notion of time travel. Invisible objects in the urban environment can now be made visible as an "extension" to the real world [Schall et al., 2009]. Using the physical movement and views of the user, nearly creating x-ray vision.

In general, the use of these emerging technologies now makes it possible to do even more advanced, and easily obtainable, augmentation of the surroundings. We clearly stand on the brink of huge untapped potential. What we do with these possibilities, are entirely up to us.

## 1.1 Augmenting the Surroundings

When augmenting the surroundings, two different concepts need to be defined: Virtual Reality (VR) and Augmented Reality (AR). A virtual world in which a user is immersed is defined as VR. Advanced computing, display, interaction and graphic technologies allow us to create a realistic 3D scene in which the user can view, hear and maybe even smell and touch the created world. One very important thing to note is: Everything is still *not* real. The user cannot sense the real world around him, since everything is virtual. AR takes a different approach. AR supplements the real world with virtual objects that appear to coexist in the same space as the real world. It links real and virtual worlds. It offers an intuitive and natural means for people to navigate and work effectively in the real world, as previously mentioned [Billinghurst et al., 2008, Eissele et al., 2008].

Since AR overlays information on the real world, it makes sense to make AR systems mobile, so the user really can explore the environment. Consequently, AR system components have made transition from laboratory to commercial domain. We see it with the huge increase in smartphones containing components like GPS, compass, accelerometer and camera. All core components of AR. The consumers are therefore getting access to AR on a daily basis on the mobile phone. This introduces interesting opportunities to create generic AR systems aiding users in their everyday life.

Only the imagination of developers, is the limit of ideas, to what should be presented as augmented information to the user [Terdiman, 2009]. Overlaying bus stops, landmarks or user generated photos is just a few of the endless possibilities. In the following section we will delve deeper into the impact the actual virtual content of the system would have on the user.

## 1.2 Temporal Content

Since the introduction of the earliest system for augmenting the surroundings in context researchers and, in the recent years, commercial initiatives have pushed the bounds of what information the users have at their finger tips, when for instance exploring the city or socializing. Even though this development have brought us from showing building and street names, to who is visiting a specific restaurant and why, the same fundamental question still defines most of the AR systems: "What is available in the surroundings". By asking ourselves this question, when designing AR systems, we limit the system and content by letting the surroundings layout the possibilities and information available, but what if the most interesting factor have not yet been added to the surroundings and still heavily rely on and impact the surroundings. Would this change the possibilities of AR?

To answer this question it must be acknowledged that AR content fit into different temporal categories; past, present and future. Past and present represent common use of AR today because of the restrictions about presenting information about what is and have been available in the surroundings - for instance rebuilding a Greek Temple as a virtual representation [Gleue and Dähne, 2001] or showing the possible routes to the nearest subway [Presselite, 2010]. Both these examples present content that has been real or is real, thereby the past and present. Presenting the future demands the use of non-existing content and thereby something which is not directly available in the surroundings - for instance the classical example where workers at Boeing uses AR to help assemble cables into an aircraft. Here AR is used to visualize how the cables should be laid in the aircraft, therefore how they want the future to be. As an extension to this example, presenting the future has an equally important potential namely showing a possible future and thereby inspire the users and visualize possibilities in the surroundings.

## 1.3 Research Questions: Making the Invisible Visible

Triggered by the promising opportunities with today's smartphone's to visualize information to users in novel way, this thesis investigates, describes and analyze aspects of “Making the Invisible Visible”. With a focus on the user’s perception we pursue an understanding of situated visualization of information containing differentiated temporal aspects. Our findings supply reasoning for pitfalls and design consideration of future mobile visualization systems.

We acknowledge the difference in visualizing information from the past and from the future. Visualization of past is based upon well known or at least information that has seen the light of day. Envisioning the future is in large based on dead reckoning, since no information can be seen as close-knit, when everything can change over time. According to the above argumentation we have devised two questions, which cover the two aspects of our focus. These questions will be sought answered through the argumentation of this thesis.

### 1.3.1 Research Question I

The first question focuses on understanding the characteristic of past information and exploring the possibilities of using mobile technology to facilitate an in-situ clarification of these information. We will investigate how a “window to the past” can be introduced as a mobile system, which enables users to freely explore their surroundings. Additionally, the question seeks to investigate how mobility affects the users’ relation to the visualized temporal snapshot of the past.

**What characterizes *past* information and how can mobile technologies support a situated visualization of the *past*?**

### 1.3.2 Research Question II

The second question focuses on understanding the traits of future information and exploring the possibilities of using mobile technology to facilitate an in-situ clarification of these information. The question centers on deploying a mobile system, developed to explain future object in-situ, into an area of usage where the comprehension of situated future information already is an important part of the work process, but at the same time have a particular weak link to the location. We seek to investigate, how being situated, influences the understanding of the visualized future object. Furthermore, the question is concerned with investigating the contextual possibilities of adding a future object to the present context.

**What characterizes *future* information and how can mobile technologies support a situated visualization of the *future*?**

CHAPTER

# TWO

# RESEARCH CONTRIBUTIONS

The following chapter presents the two research papers. Each paper is written as a stand-alone contribution. It should be noted, that the second paper continues on the findings in the first paper, so a sequential reading would be preferable.

## Paper I: "Mobile Photo Consumption: In-Situ Merging of Context and Imagery"

Today's mobile phones make it possible for users to create imagery everywhere and anytime. This enables people to capture photos of important moments at the right time and place. Usually, these photos are then moved to a desktop computer or website for better viewing or sharing, leaving the phone as a tool for creation, but not for viewing of imagery

Consuming photos in context can be seen as merging the capture and usage context, hereby reconstructing the captured moment supported by the in-situ information. We recognize a merging of creation and usage implies a shift in temporal context. A photo is by default past information since the captured moment instantly will be in the past. So by presenting photos in context we are actually opening a door to the past. Photos all have a unique story, so by opening this temporal door, it could make the story behind the photos more tangible. Doing photo presentation at the exact same location as the photographer lets the users experience their surroundings as was they following the footsteps of the photographer. Inspired by previous research, we introduce the concept of *Mobile Photo Consumption* to frame an approach where mobile phones are used to present imagery in context, merging the capture context and usage context.

This paper introduces an application called *PhotoWorld*, aiming at supporting mobile photo consumption by creating a presentation form that, by using spatial information about each photo, reproduces the visual link between the photo and its context. We seek to investigate how mobile photo consumption influences the experience of watching photos. The system was build to run on smartphones, and make use of the technical possibilities of such phones. It was important to have a working system, to avoid any need of mockups during testing.

We report on a Field Study conducted with eleven people testing our system in downtown Aalborg. An explorative approach was taken with the field study, since users were simply asked to freely play around with the system. Following interviews and questionnaires made it possible for us to go into greater detail on key elements like: comprehensibility, usefulness and concept.

Data from the interviews and questionnaires was analyzed using Grounded Analyses techniques. Open Coding was used to discover 243 different properties, which identified 57 phenomenon's. Selective Coding was then used to construct two main themes. First, Troublesome Spatial Interaction. Second, Augmented Temporal Experience.

Results showed that the use of the participants own physical movement to present photos, was difficult to understand. The navigation through the photos required the users to understand the mapping between what they saw on the screen and the surroundings they were in. Each movement by the user, being either directional or orientational, spawn a reaction in the application that re-arranges the photos based on the new position of the user. Furthermore, the participants experienced an enhanced temporal understanding of the context. This was shown by the participants experience with exploring the city in a different temporality. For instance, seeing the city at different times of the day, or to see how a shop would look if it was open. Since the photos presented were taken over a period of just two days, the temporal diversity was limited. The photos that stood out in this way, by depicting clear differences between the time they were taken and the time the participants were looking at the photos, were also the photos that the participants found the most interesting. The system was faced with some technical difficulties. Using GPS positioning when moving around tall buildings was not optimal. Several times users were thrown off by an extremely inaccurate GPS reading, and consequently an unusable system.

## Paper II: "Situated Digital Elucidation: Explaining Future Architecture in Context"

Families often initiate construction of their future home without adequate contextual information. Current visualization of future architecture is often limited to pen and paper drawings inside an office. Hence, it is hard to get a spatial understanding of the building. We introduce the term Situated Digital Elucidation as a frame for investigating the users troubles with envisaging the future.

*HouseView* is a system designed to elucidate buildings in context via AR. The system aim to explore three main issues: First, elucidation of two-dimensional placement, which covers the issue of mapping a blueprint placement to a physical lot. Secondly, elucidation of spatial characteristics, which delves into the area of spatial perception of the construction. Last, the visual appearance, which aim to elucidate the look of the future house within the actual context. Making it possible to see the house with different materials next to the neighbors. The system was implemented on a smartphone, which included all necessary technologies for making AR. We created a series of house models which were rendered on the smartphone, in our custom made 3D engine based on GPS positions. The interchangeable positions of the user, house, and the user's movement of the smartphone, constantly changed the angles and distances, which were represented on-screen.

To evaluate the effect of situated elucidation a series of user studies were conducted. Participants were recruited into three separate groups based on their progress of a building lifecycle. We defined these three groups as: Lot Seeking, Signed Contract and House Extension. This was done to cover as much of the house construction process as possible and welcome any form of diversity. In total 40 people, 11 of them children, male and female, participated in the study. Succeeding notes, questionnaire and recordings were analyzed using Grounded Analysis. Through Open Coding 362 different properties was found, which identified 41 phenomenons. Axial and Selective Coding was then used to identify the final themes.

The results showed four main themes: First, an enhanced visual perception was gained by the user as they expressed an increased understanding. They were surprised of how their imagination did not match the visualization, even when they felt they had a good prior understanding of the building. Secondly, a primed contextual influence was noticed - they suddenly saw their house next to their neighbors. This made participants compare their materials and design decisions to adjacent houses. This often confirmed their choices, but a few participants expressed insecurity with their house design after seeing it next to its coming neighbors. Thirdly, participants experienced a refined mutual understanding, which spawned interesting discussions and comments. Parents argued about decisions, using *HouseView* as their frame of reference. Furthermore, they engaged their children in a social visualization, walking around showing the kids their rooms and what view they were going to have. Last, they achieved a genuine dimensional insight by physically walking around the virtual house. Even if the on-screen visualization lacked in depth perception, the spatial interaction, the participant physically moving around, gave the participants an increased understanding of the dimensions of their future house.

CHAPTER

# THREE

# LESSONS LEARNED

Exploring the subject “Making the Invisible Visible” made us aware of three particularly interesting lessons. The lessons span across both temporal aspects: *How can mobile technology visualize past information?* and *How can mobile technology visualize future information?*. The three lessons are: 1) When visualizing invisible information using Augmented Reality it is essential to contemplate the possibilities of 3D registration, 2) Temporal diversity is a refreshing element in situated presentations and 3) Mobile digital visualization excels in explaining a context. This chapter discusses these lessons in relation to our findings presented in the papers.

## 3.1 Lesson Learned I

> **When visualizing invisible information using Augmented Reality it is essential to contemplate the possibilities of 3D registration.**

When utilizing AR one of the most important aspects are registration as described by Azuma [Azuma, 1997]. Registration covers problems associated with the perception of depth and perspective, resulting in possible misalignment of the virtual and real world. Azuma argues that inaccuracies in implementations trying to achieve AR will result in bad registration and ultimately a subpar user experience. For instance, an inaccurate GPS position placing a user 25 meters from his actual position could have a major impact on the users experience, if the system relies on very accurate data. In both of our papers we encountered several accuracy issues that influenced registration. The issues relates to:

- GPS precision problems
- GPS and accelerometer smoothing
- Screen size
- Camera feed

- Field of View and perspective
- Believable 3D graphics

The precision of the GPS signal can at times be very inaccurate. With this inaccuracy the user would experience the house or photos jumping around or that his movements would not be registered by the system. These aspects can be very damaging for the user experience. We learned that many factors could influence the quality of the signal. For instance buildings, trees or even the clouds. In testing of *PhotoWorld* this was a big issue, since the user study was conducted in the center of the city. During almost all of the tests the user experienced problems with precision. In our user study of *HouseView*, this was not as big an issue. When testing house extensions in *HouseView* we had some smaller problems with precision. This was mostly due to trees blocking the signal or when the user got too close to the wall of an existing house. It is a known problem that the GPS at times can be very inaccurate [Benford et al., 2003].

To avoid jumping GPS positions smoothing of the GPS position was implemented. During the two projects we tried several approaches of smoothening the GPS signal. In [Benford et al., 2003] they implemented a filter that moves the user's position to the nearest street. This ensured that the user's position could for instance not be on top of a building. This technique could have been useful in the *PhotoWorld* application but not in *HouseView*. One of the big problems when working with GPS is that it updates with random time intervals. If the GPS is programmed to give a new position once a second, it might not give a new position for several seconds at a time. This is one element that makes it hard to make a GPS smoothing that works well. One of the algorithms for GPS smoothing that were tested was a Kalman filter [Fletcher, 2009]. A Kalman filter works by removing all the deviating readings. In theory this algorithm would be perfect, and for some time it was our main GPS smoothing approach. But during the final stages of the development process it was abandoned, because of one major drawback introduced by the Kalman Filter. The reaction time from when the user starts to move until the system react upon it was too long. This made the mapping between physical movement and visualization very hard to grasp - resulting in less convincing AR. During the development of *HouseView* it was observed that the user sometimes had to move more than five meters before anything happened in the system. Clearly that did not work. In the final implementation a very simple GPS smoothing was used. The location was calculated by taking the average of the last three GPS readings.

As with the GPS, the orientation sensor output needs to be smoothened. The update frequency of the accelerometer is very fast, so without any smoothing the house would constantly jump around. The objective with smoothing of the orientation sensor data, was to have the house on the screen being as static as possible, when the user was not moving. If the user then started moving around the updating of the screen should be fast and only have a very small delay. This is not a trivial thing to implement and the final implementation does only just comply with our demands.

During the user study of both applications, users complained that the screen was too small. This made it hard for the users to see all the small details in the models or in the photos. Another problem with the screen was that it was very sensitive to light. For instance if it was sunny day the user could not see anything on the screen. It is impossible to make convincing AR if the user cannot see what is on the screen. With the current technology we cannot do much about this problem without compromising the mobility of the system. We know that within a year, several companies will be introducing new devices that can solve this problem.

The camera feed can help prevent registrations problems by making it easy for the user to understand the mapping to the real world. Especially in *PhotoWorld*, several user had problems understanding the mapping and how their movement influenced the system. We believe it was caused by the lack of a camera feed behind the photos. In *HouseView* there was a camera feed behind the 3D models. It is rather interesting, that the people who tried *HouseView*, did not have any major problems understanding the mapping, unlike in *PhotoWorld*. Furthermore, they were fast at understanding how their movement influenced what they saw in the screen. In one of the tests of the *HouseView* application the camera feed, due to a glitch, went black. This gave us one very interesting finding: the current user found that he lost the link to the real world. He mentioned that the illusion did not work with a black background. In *PhotoWorld* adding a camera feed to the background might have helped some users understand the mapping.

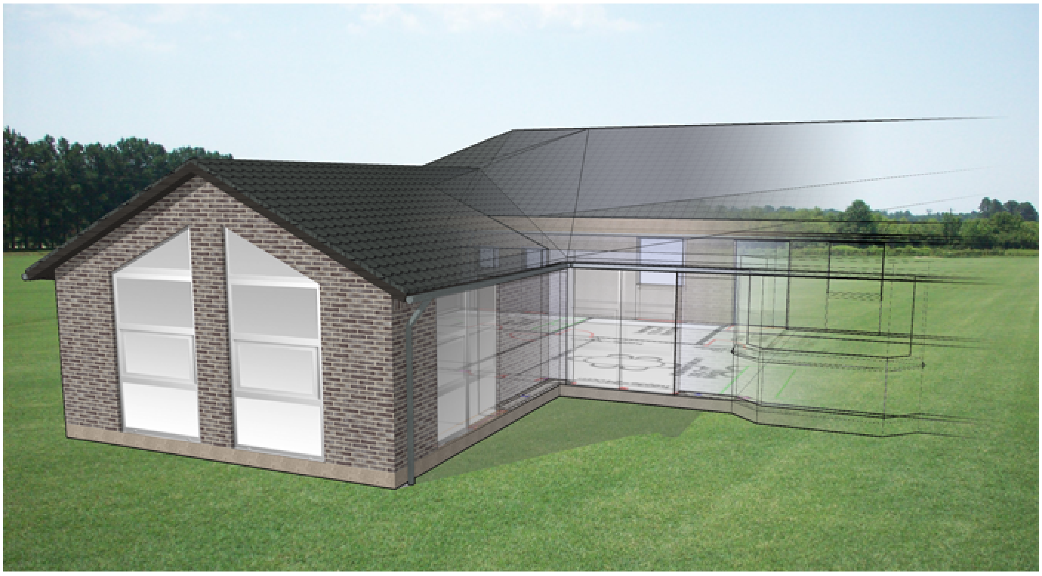

Figure 3.1: Conceptual drawing of *HouseView* in use. The visual elements consisting of vertices and textures are overlaid on top of the camera feed.

In order to create convincing AR the layer added on top of the real world has to fit the perspective of the real world. In *PhotoWorld* this is not a big issue since it is only showing flat photos. But in *HouseView* where more complex geometry has to be displayed this is an important aspect. A conceptual drawing can be seen on Figure 3.1. This shows how a virtual house is positioned on top of the camera feed showing a grass field. The house itself are made of geometry and textures to achieve as close relation to the real world as possible. The perspective consists of two factors the field of view and the disappearance point. These two factors have to relate to the real world in order to create believable AR. To complicate matters even further, it is the real world as seen through the camera in the phone, which then again distorts the view.

When creating believable 3D graphics one of the important things is the textures. For instance the bricks on the house, in *HouseView*, have to be of the proper size, and look like real bricks. When working with textures one of the problems is filtering. If a texture is viewed at a large distance, OpenGL have to select what pixels from the texture that is used on the surface. Using a texture with patterns, like a brick wall with joints, none of the build-in filtering techniques in OpenGL ES 1.0 gives a good result. Therefore mipmapping have to be used to ensure that textures look realistic at all distances. Mipmapping is a 3D graphic concept used, when a collection of images that accompany a main texture is created, to increase rendering speed and reduce aliasing artifacts. Unfortunately the OpenGL ES 1.0 implementation on the Android platform does not contain the function for making these mipmaps. We implemented a function that can generate these mipmaps, and thereby solve our problem. Generating mipmaps is a rather heavy process resource and timewise. In *HouseView*, this can be seen when loading a model for the first time or changing materials on-the-fly. On Figure 3.2.A image from *HouseView* with mipmapping can be seen. On Figure 3.2.B it can be seen how the filtering adds waves, or aliasing artifacts, to the image if mipmapping is not enabled.

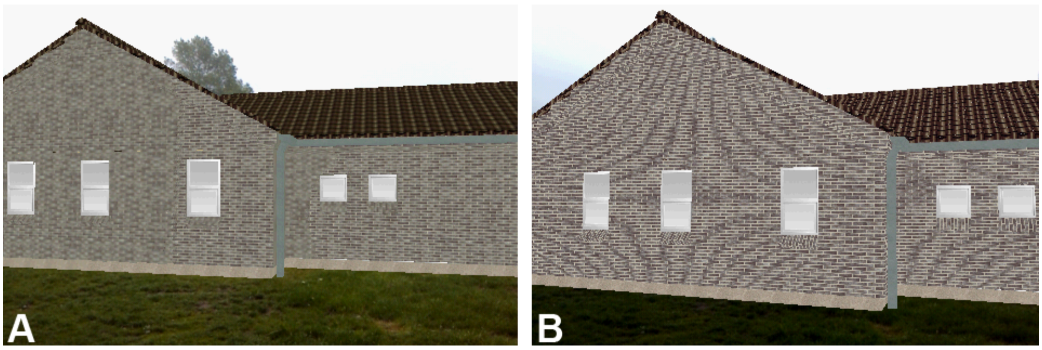


Figure 3.2: *HouseView* with and without mipmapping. Figure A shows the house with a mipmap system running. Figure B shows the same house with mipmapping disabled and the aliasing artifacts.

All these countermeasures was created to achieve a better accuracy and thereby a better registration. While we with *HouseView* emphasize the contextual importance of registration, our papers combined suggest that the importance of registration varies depending on the information that the systems seek to visualize. *HouseView* presented 3D architecture and came short when clear visual cues were present, like when trying to visualize a house extension. In *PhotoWorld* a similar approach was used and since it was used in an urban environment plenty of visual cues were present, but the nature of the content negated their importance. It was not detrimental for the *PhotoWorld* participants if the perspective was a bit of. The important thing was that they could see one thing on the screen and another thing in the real world, but still be able to recognize the spatial placement and appreciate the temporal difference. When designing AR systems one should therefore consider the content before spending time on achieving perfect 3D registration.

## 3.2 Lesson Learned II

**Temporal diversity is a refreshing element in situated presentations.**

Our thesis show an inclination towards temporal aspects of in-situ presentation and visualization as being the key element for users. Through our work with *PhotoWorld*, photos containing some sort of different temporal aspect from the current surroundings were the ones that got most positive feedback. We tried to achieve the feeling of traveling back in time and seeing exactly what the photographer saw at the time. This was achieved by positioning the photos through GPS, hence forcing the user to face at the same direction as the photographer had taken the image. While the interaction itself received mixed feedback the temporal link between the image and the context was highly praised by the participants. Suddenly, they were able to stand in front of a shop and view an image of how the shop looked like when it was open last night, with lights and all. This increased understanding as an extending layer of information on top of the real world was the key finding in *PhotoWorld*.


Figure 3.3: *HouseView* presenting a distant future where people live in small elliptic houses. The in-situ visualization would create a dimensional link to better understand the future.

Extending the concept of using a separate layer to augment the surroundings, *HouseView* was created using AR technology, to explore the impact of a direct mapping between real and virtual world on temporal information. While *PhotoWorld*, with its lack of camera feed in the application only presented the user with a positional and visual link to the context, *HouseView* with is camera backdrop made a direct visual mapping of the temporal information available. This went hand-in-hand with the temporal information being future information - buildings only on blueprints. The extra dimension in *HouseView* made sense when tied with future content and especially architecture. Imagine using *PhotoWorld* to achieve the same as *HouseView* did. You would be standing on a bare field looking at a virtual image of a house. The mapping created in the urban environment with these past images would simply not be present when visualizing future architecture, because the visualization is limited to presenting the architecture from pre-determined angles.

Based on these experiences we encourage other researchers to consider the importance of differentiated temporal aspects when working in the area of visualizing. The concept of temporal visualization can be used for a lot of things, like local authority wanting to show a new city plan or maybe creative architects showing of their ideas for the distant future, like shown on Figure 3.3. All these scenarios could possibly gain from a situated visualization as presented in our two systems.

## 3.3 Lesson Learned III

**Mobile digital visualization excels in explaining a context.**

Findings from *PhotoWorld* and *HouseView* point at contextual visualization as being a great tool for heightening the understanding of the specific context. The visualization made available by *PhotoWorld* showed how digital imagery can be effective in context. The effect can be seen on Figure 3.4, where the image presented by *PhotoWorld* matches the real world surroundings the user is facing.

Figure 3.4: Photograph of *PhotoWorld* in use. Dictating facing direction of images made it possible to emulate the photographers position.

The same experience could have been achieved with printed photos, but it would have been nowhere near as generic. The digital implementation made the mapping between images and real world environment a lot easier for the user. The possibility to dynamically guide the user to face in the correct direction before viewing the photos correctly made a strong link to the surroundings. We believe this would be very hard to achieve without the mobile digital aid. The user was given a broadened sense of presence when seeing other peoples images, thinking: “Ah, he though this place was cool? Why did he do that?”. Starting new thoughts of the surroundings that would not have appeared if the photos tied to the exact location would not have been presented.

*HouseView* showed another form of explanation in form of dimensional understanding. We found users having a greater understanding of size and relations after testing *HouseView*. The possibilities of digital visualization tied with physical movement triggered a direct mapping from the virtual to the real context. This mapping is shown on Figure 3.5 where the user is looking at his future house next to a tree. The screen information is exactly like what he would see when not looking at the phone, except for the virtually overlaid house. The difference from *PhotoWorld* was, that with *HouseView* the context was often a bare field. Presenting visitors with few contextual clues to how the future will be. That is also why we in *HouseView* emphasize the approach of presenting details by elucidating them in-situ. We create the details and the context creates the frame. With *PhotoWorld* one could argue that it was kind off the other way around. The photo creates the frame and the context presents the details by giving life to the photo.

Figure 3.5: Photograph of *HouseView* in use. Using AR the virtual element is mapped to the surroundings using hardware sensors.

Both papers investigate how users use these digital solutions to make invisible information graspable. Each system saw a broad spectrum of usage based on the users individual preferences. The system as a visualization facilitator was used very differently based on what interested the user, even within a very narrow test group. One person would maybe rather find missing images in *PhotoWorld*, where another looked at the images within the system. The same system was suddenly both a facilitator for presenting and creating information. The context inspired the user and he engaged the systems based on what he found most useful at the time. This could easily change over time as shown in our dual user tests of *HouseView*, where the second tests showed a different use from our participants. In the first test, users inspected the house as a whole in the second they inspected small details.

In general, we underpin the fact that a dynamic context should be visualized with a dynamic approach. Mobile applications can be made very generic and dynamic and is therefore an obvious choice, as was also shown by our findings.

CHAPTER

# FOUR

# CONCLUSION

Augmentation of the surroundings is becoming more prominent as technical advancement on mobile platforms is reaching the consumer market. In addition, the HCI field is investigating perspectives and possibilities of these emerging presentation forms. AR and similar techniques has been adopted commercially after having seen use in academic societies for some years, so moving these concepts to the general public, new domains has to be explored. As designers we have to understand these new technologies and how they influence a user's experience. This chapter will conclude on our work of understanding how these technologies can facilitate a visualization of invisible information.

The process, which we have undergone to answer our research questions has been divided into two. This was done based on our acknowledgment of information having differentiated temporal aspects. First, we investigated past information, by implementing *PhotoWorld*, to present photos in an urban environment. This made us understand characteristics of past information and how technology can assist in a visualization of such. Last, we implemented *HouseView*, to see what influence a future temporal aspect of information visualization had on users. This presented us with some core features of visualization of the future and made us capable of answering the research questions.

## 4.1 Research Question I

The first question addressed the implementation of "window to the past" into a mobile system, which enables users to freely explore their surroundings. We seek to investigate how mobility affects the users' relation to the visualized temporal snapshot of the past.

**What characterizes *past* information and how can mobile technologies support a situated visualization of the *past*?**

Through investigating the concept of Mobile Photo Consumption, we found that mobile technology can facilitate a merge of capture- and usage context. These contexts represented a temporal leap, since the main characteristics of photos is their default representation of past information. The captured moment will instantly be in the past. So by presenting photos in context we are actually opening a door to the past. *PhotoWorld* showed how users exploring the city engaged in viewing especially images with a differentiated temporal aspect. Furthermore the system showed how images in urban environments can be presented and a virtual- to real world link created without the use of real AR.

Spatial interaction in *PhotoWorld* was found to be troublesome for users to understand. Furthermore, the temporal aspect of photos was found to positively augment the surroundings and broadened the users' perception of the context

## 4.2 Research Question II

The second question address the deployment of a mobile system, developed to explain future object in-situ, into an area of usage where the comprehension of situated future information already is an important part of the work process, but at the same time have a particular weak link to the location. We seek to investigate, how being situated, influences the understanding of the visualized future object. Furthermore, we are concerned with investigating the contextual possibilities of adding a future object to the present context.

**What characterizes *future* information and how can mobile technologies support a situated visualization of the *future*?**

Mobile technology can support visualization of the future by integrating the concept of Situated Digital Elucidation. Hereby emphasizing the need of explaining information in detail when focusing on the future. The main characteristic of future information is the aspect of being, at best, a good guess. Since the future has not happened yet, the information to be shown cannot be seen as grounded information. By using AR to visualize future architecture, *HouseView* showed that mobile technology can facilitate a richer base for understanding the future, which in architecture, can be vital and save a lot of money.

We found *HouseView* to enhance the user's visual perception, prime the contextual influence, refine mutual understandings and give him a genuine dimensional insight.

## 4.3 Limitations

The design and implementation of both *PhotoWorld* and *HouseView* was done using an ad-hoc approach. By ad-hoc we mean our focus on finishing the prototypes using trial and error with ourselves as expert evaluators. Thereby, we conducted "Expert

Walkthroughs" throughout development. We realize that involving the end user in the development process could have given valuable feedback and smoothened out usability issues. Our development was done with an agile mindset, so implementation using an external focus group or by doing e.g. paper prototyping with users could have been done.

Our user study participants possessed the somewhat same demographical characteristics. All participants were recruited from the vicinity of Aalborg. This has limited the level of variance and consequently our data has the risk of being uniform. Our results might therefore be limited to people with the same demographical characteristics and other themes might have been identified with participants from other cities or even countries.

Finally, each test session consisted of a large element of "Wauw"-effect. All participants were presented with 3D graphics interacting based on their physical movement. It was clear, that this was something very new to all participants, so first hand impression itself had a positive nature. A longitudinal study might reveal different aspects of the visualization, since the initial surprise would have faded over time.

## 4.4 Future Work

Paper one and two are both directed toward supporting a single user in experiencing glimpse of another time. During the evaluation of *PhotoWorld*, in paper one, participants identified their experience with the role of being a tourist visiting Aalborg. Being a tourist is often a social activity, thereby contradicting the nature of testing with a single user at a time. Therefore, incorporating a stronger relation to the specific application domain of tourism and focusing on social aspect of the visualization, by letting participants take part in a group experience instead, would generate information about how a the temporal glimpses would influence a shared experience. In paper two we applied a more social approach for evaluation, by using whole families at each test session, but the application developed still had the same single user tendency. It would be interesting to study, how the introduction of cooperative features in *House-Viev*, would stimulate the process of elucidating and designing future object in-situ.

Beside the above aspect of future work, the presented limitations as well introduce areas where improvement and refinement of our work with making the invisible visible would be natural.

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# Appendices

APPENDIX

# A

## RESEARCH PAPER I - MOBILE PHOTO CONSUMPTION: IN-SITU MERGING OF CONTEXT AND IMAGERY

# Mobile Photo Consumption: In-Situ Merging of Context and Imagery

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## ABSTRACT

Using the context when using mobile phones for presenting imagery are neglected in todays application. We introduce *PhotoWorld*, a smartphone application running on the Android platform, to investigate how a merging of capture- and usage context can be facilitate a presentation of the temporal diversity of these contexts. We introduce the concept of Mobile Photo Consumption to frame our goal of understanding the influence of using the context for presenting images using the spatial information they hold. A user study was conducted with recruitment of participants not familiar with the Aalborg City - our designated test area. We find that that a presentation of temporal data in context can add a lot to the user experience, but that spatial information can be ambiguous and not necessarily easily understandable.

### Author Keywords

Mobile Photo Consumption, Mobile Context, Photo Presentation, Smartphone, GPS, Digital compass

## INTRODUCTION

Today's mobile phones make it possible for users to create imagery everywhere and anytime. This enable people to capture photos of important moments at the right time and place [22]. Usually, these photos are moved to a desktop computer or website for better viewing or sharing, leaving the phone as a tool for creation, but not for viewing of imagery, as presented by Ahn et al. [22].

To understand the use of mobile phones for "consuming" photos one could investigate where the possibilities of mobility lies. We identify one major difference, from a non-mobile approach: The in-situ placement - being in context. Karlsen and Nordbotten define two separate context classes: Capture Context and Usage Context [15]. Capture context describes the environment that a photo was taken in, while usage context describes the environment where a photo is used. Karlsen and Nordbotten separate the two by seeing capture context meta data as time, position and sensor data and usage context as the surrounding printed information: title, abstract and caption. In other words, usage context describes the printed photo. Inspired by their definition of context, we adopt a variant for consuming photos in-situ. We focus on the situated context influencing the description of the photo, which for instance are the people, the history, the spatial dimensions and the atmosphere at the current location. Furthermore, consuming photos in-situ can hereby be seen as merging the capture and usage context, hereby reconstructing the captured moment supported by the in-situ informations.

We recognize a merging of creation and usage automatically implies a shift in temporal context. A photo is by default past information since the captured moment instantly will be in the past. So by presenting photos in context we are actually opening a door to the past. By opening this temporal door in-situ, it could make the story behind the photos more tangible. Even though it might not be something normally considered, latent questions about why, how and when the photographer took the photo is always there. Doing photo presentation, at the exact same location as the photographer, could possibly strengthen viewers' relation to the photos and the surroundings, by letting users experience their surroundings as was they following the footsteps of the photographer.

Inspired by previous research, we introduce the concept of *Mobile Photo Consumption* to frame an approach where mobile phones are used to present imagery in context, merging the capture context and usage context. The temporal link made visible by merging the contexts is a concern when consuming photos in-situ.

Today, we see people presenting images on TV screens or over the Internet, but all share the common trait of using a separate using context. Releasing the user from these stationary presentations also imply that the presentation in context should seek to support the user in experiencing his surroundings and thereby utilizing the temporal shift.

This paper introduces an application called *PhotoWorld*, aiming at supporting mobile photo consumption by creating a presentation form that, by using spatial information about each photo, reproduces the visual link between the photo and its context. By creating the visual link, merging the context of the photographer with the context of the user. We seek to investigate how in-situ mobile photo consumption influences the experience of viewing photos.

The remainder of this paper is organized as follows. First we give an account of related work, with description of relevant research literature. Then the design of *PhotoWorld* is presented before the user study is described. Consequently the findings are described, followed by a discussion. Finally, the conclusions and future work are presented.

## RELATED WORK

When creating a mobile application for presenting photos in context, there are important aspects to examine. These are: showing and browsing data on a small screen, the limited screen size which enforces some sort of sorting and interaction with a mobile device.

Showing and browsing photos on a mobile device has been subject to several studies. On laptops and home PC's browsing photos is usually done in a grid of thumbnails or a similar way of showing many photos. By selecting a thumbnail the user can see it in a high resolution [3]. This way of browsing photos has been adapted to mobile devices and is one of the biggest hurdles when displaying many photos on a small display. Xie et al. observe that browsing photos on a mobile device requires more zooming and scrolling actions than desktop browsing [21]. There are other hurdles, like the photo quality and hardware performance, but as technology improves these will become lesser of an issue. The display size will likely remain approximately the same, as the nature of a mobile device requires it to be of a physical size that is easily portable, and hereby the challenge with the small display will persist. Because of the small display size, the amount of photos that can be shown on the screen is limited and when working with many photos it is necessary to do some kind of sorting of the photos. There are many different ways of sorting photos. It can for instance be done by letting users input search criteria like an area, the weather or time of the day. Harada et al. implements a system named: Timeline Browser that automatically sorts photos based on time, while Gurrin et al. presents a prototype system letting the user browse photos sorted by both time and location. Both systems are implemented on handheld devices [11, 12].

When it comes to presenting the photos on a small screen, sorting of the photos is crucial, to prevent flooding of the screen. This sorting can be achieved by using the information available to the mobile device about the users context. Several ideas evolve around knowing the current location, by using the GPS signal [16, 14]. For instance Effrat et al. develop GeoFoto, which is a mobile system showing others photos captured at the users current location [9]. This way the nearest photos are shown, but the problem with showing all the nearest photos on the small display remains, because location tagged photos are often clumped in areas, like popular places for tourists. GeoFoto lets the user choose a direction, either north, south, east or west, displaying only the photos in the chosen direction according to the user's current location [9]. This concept has been developed further in a recent poster session [16], where the user also chooses between the same four directions, but instead of clicking the display, the system uses a digital compass to determine which direction the user is facing, freeing the user from GUI interaction.

Interacting with a mobile device in context can be approached in a number of different ways. In recent years interaction methods using sensors has been developed [1, 5], examples are the touch screen and the accelerometer, known from the iPhone. These can be used to improve the users experience of the interface, but some interactions may be too complex or ambiguous to solve using these sensors as can be seen on the prototype developed by Hinckley et al. [13]. It is important to consider which types of interactions that are viable for using sensors. In mobile gaming the interaction has been improved by using the accelerometer on mobile devices. For instance, in the 3D multiplayer space game developed by Chehimi et al. [5], where it was accomplished by mapping the physical actions of the user to the spaceship in the game. When you play the game and tilt the device to the right the spaceship turns right. Their evaluation showed a contribution to the user experience in a very positive way [5]. Creating a mapping between the physical actions of the user and the application, can hereby have a positive effect on the relation between the user and the presented content.

## PHOTOWORLD: IN-SITU PHOTO SYSTEM

Inspired by [7, 16, 5] and preliminary brainstorming we identified two representations for presenting photos in the surroundings - with focus centered on creating a clear mapping between the surroundings and the photos presented, by using geographical location and orientation of the photos. The two representations are: "Panorama View" and "Compass View". They have different ways of presenting photos to the user and are designed to solve two different aspects. The two views are shown on Figure 1. When the user holds the device in front of him, like a camera, the Panorama View is activated, which makes the user able to look into a 3D world where the photos are placed around him like posters, thereby creating a direct mapping between photo and user location. When the user holds the device flat down in his hands the Compass View is shown and presents the user a top-down view of the photos, scattered like a deck of cards on a table, thereby introducing an overview of the surroundings. The Panorama View and Compass View will be presented in greater detail in the following sections.

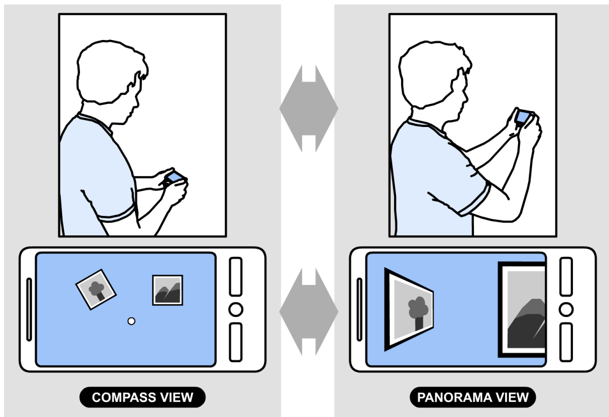


**Figure 1. The user can switch between Panorama View and Compass View by moving the device from horizontal position to vertical position.**

The application was implemented on a HTC Hero smartphone using the Android 1.5 platform. The device has a screen with a resolution of 320x480 and hardware accelerated 3D graphics using OpenGL ES 1.0. Interaction with the device mainly takes place via a capacitive touch screen and a series of hardware buttons. Furthermore it features a GPS, accelerometer, 5MP camera and digital compass. Programming for the device was done in Java by using Eclipse IDE paired with the official Android API and plugins.

### Panorama View

The first representation lets the user interact with the application as if he is holding a camera in front of him - looking through the camera lens into a past world, the world of photos. This lets the user watch photos up close. A concept drawing of this view can be seen on Figure 2, which illustrates how the photos are displayed, corresponding to a users facing direction. This is inspired by elements from 3D gaming, which implies an implementation of standard 3D camera rules with perspective projection. Perspective projection makes distant objects smaller than objects only a few meters away, and it makes a perception of depth on the screen by skewing the elements.

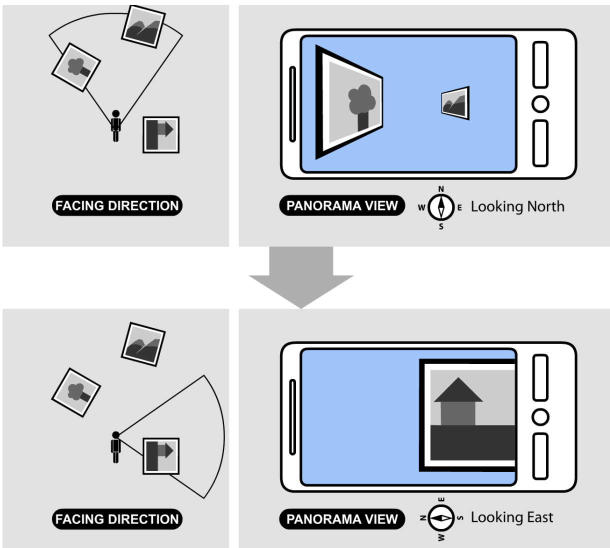


**Figure 2. Concept drawing of the Panorama View which illustrates a change in screen content based on the direction the user is looking.**

As seen on Figure 2 the photo of a tree is skewed inwards. This simulates the fact that the photo is taken from a different angle than the user is facing. The user has to walk more to the right to look straight at the photo. Another photo is represented smaller in the Panorama View, since its real world location is further away. In the bottom of Figure 2 the user has made a 90 degree turn to the right. He is now watching the house photo without it being skewed in any way, since he is standing right in front of its original creation direction. The other photos have disappeared. This is caused by another element from 3D gaming - the Frustum [19]. Frustum is often used in 3D graphic engines to determine what needs to be drawn and what can be culled. This implies that the user has to physically turn around himself, when using the Panorama View, to see all photos around him. Thereby, creating the illusion of photos placed around him as posters.

To show the photos in the same direction as they were taken, and not just make all photos face the user, regardless of

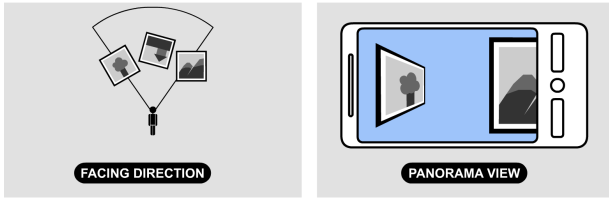


**Figure 3. Concept drawing of a photo not being displayed in the Panorama View. This is because the photo was taken with an angel towards the user position.**

which direction they were taken. Rotation in 3D was chosen to simulate an angle from the user's position to the angle the photo was taken in. But what should be done with photos that were taken from the opposite direction than the user is facing? A figure sketching this concern can be seen in Figure 3. In the figure we can see how the middle photo of a house is not shown in Panorama View. The photo of the house is taken from the opposite direction of the user. When viewing the photo of the house in 3D, the user will see the backside of the photo. Removing photos taken from the opposite direction and not just show a white photo to indicate backside viewing, clears the screen of dummy content and lets the user see photos placed behind dummy photos. Therefore, if an angle between the user and the photo become too great it will simply be removed instead of showing the backside. Users are therefore only able to see photos taken in approximately the same direction they are facing.

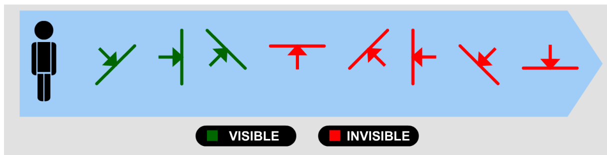


**Figure 4. Illustrating how the angle of the photos relative to the direction the user is looking determines whether they will be visible in the panorama view or not.**

The Panorama View is implemented by placing the photos in a 3D space with positions and relative directions, resembling how photos were taken, as seen on Figure 5. The maximum view depth is set to what corresponds to 200 meters, so photos taken more than 200 meters away from the user will not be visible. Furthermore, only photos taken within a 40 degree angle from the direction the user is looking will be fully visible, as illustrated on Figure 4. When the angle is between 40 degrees and 60 degrees, the photos are gradually fading more and more out, until they finally become completely invisible. This sorting is needed to ensure proper performance on the limited hardware of the smartphone.

### Compass View

The second representation creates an overview of the surroundings and is hopefully familiar to the user, since its representation is similar to Google Maps and other top-down 2D maps. The insensitive for making this view was based upon the need of an overview of the photos, in contrast to the Panorama View. Thereby, letting the user discover inter-

**Figure 5. Screenshot of the Panorama View showing three photos from central Aalborg. The size of the photos relates to the distance to the photo.**

esting locations with photos and furthermore use the view as a guide to these locations. This lead to the Compass analogy based on the purpose of pointing the user in the direction of the location of interest.

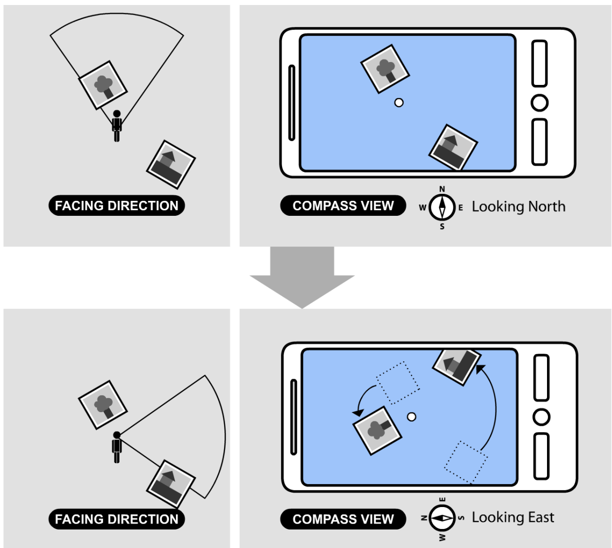


**Figure 6. Concept drawing of the Compass View showing the user making a 90 degree turn. As it can be seen the same photos can still be viewed on the screen, but they have been rotated around the user with 90 degrees.**

This analogy is illustrated on Figure 6, where a rotation from North to East is shown. The drawing shows how we represent the user's position in the center of the screen, illustrated by a small circle. The photos are then placed around this center, based on their individual geographical position in proportion to the user. The center circle is always fixed on the screen, but the photos will move around this fix point and get closer as the user moves towards their position. Following the arrow on Figure 6 to the second photo, illustrates a person looking due North who is then turning 90 degrees to his right, just as we showed in the prior section about the Panorama View. As can be seen on the figure, the photos would turn around him to represent their position in the plane according to his new orientation. The photo of a tree that was in front of him when looking north is now on his left.

Like the Panorama View, the photo direction is also represented, so it is possible for the user to understand the direction in which the photo is taken when searching for a photo. This feature can also be seen on Figure 6, where the bottom of the tree photo is still pointing towards the user even after the user turned East. Creating an overview will in its nature show the big lines and hide the more detailed information - in *PhotoWorld* this manifest itself as making the size of the photos smaller to show more at the same time, to counteract this, a zoom feature is added, which zooms in directly at the center point and thereby the user's location.

To create the map representation, photos are made orthogonal and placed in a plane, and rotated to match the direction in which the photos were taken, as seen on Figure 7. This makes the compass view look two-dimensional like a map, even though 3D was used.

**Figure 7. Screenshot of the Compass View showing a series of photos from central Aalborg. The red dot in the center of the photo is the user's position.**

### Interaction

To support the mobile approach, a direct mapping between user movements and actions was implemented as main interaction form.

The use of the free roaming meant moving away from standard button pushing through menus, as more smooth seamless interaction would fit the concept better. Using the user's actions and movement as the interaction form and thereby relieving the user from a heavy GUI application, was the choice of smooth seamless interaction. Another interaction form for the user will be the transition between the two views. Inspired by Cho et al. where they use a tilting phone to browse photos [7], it was decided to make the movement from Compass to Panorama view, require the user to raise his arm and move the phone up in front of him. A drawing of this interaction can be seen on Figure 1. The Compass View is shown as long as the phone is held horizontally, as it can be seen on the drawing. When the user moves the phone to the vertical position the view will automatically change without any further input from the user, which is done by registering input from the device's accelerometer. The goal is that this form of interaction will be intuitive and not obstruct the user in his natural use of the two views.

Another interaction available to the user is a feature to capture photos within the system. It would give the user the opportunity to take photos of places they felt were important and wanted others to see. Furthermore, it would create a synergy to the capture context defined by [15]. Furthermore the zoom feature for the compass view was designed and implemented, as prior mentioned. Zooming is done by sliding the finger up and down on the touch sensitive screen of the device, just like zooming normally works on newer touchscreen phones.

### Technical Details and Challenges

To technically solve the issue of linking a photo to a specific geographical position and direction, data about where each photo was taken and in which direction, was saved by our application in an XML file. By using the device's GPS and compass data, the photos' direction and distance from the user at any given time could then be calculated, and translated to relative positions on the screen of the device.

The compass is rather sensitive to magnetic materials, like a pair of keys or metal buttons in a coat, which could cause inaccuracy. To compensate for this, smoothing the input by using interpolation and by calculating an average value out of the 10 latest measurements was implemented. It makes reaction time to directional changes a little slower, but more smooth with less flickering caused by inaccurate measures.

To display the photos on the screen, OpenGL ES graphics API was used for both the Compass and Panorama View, by mapping the photos as textures on 3D planes. The application is designed to work when the device is held sideways in order to make as many photos as possible viewable in the Panorama View.

The result of the implementation described in this section, was an application, which made it possible to test and evaluate our ideas in the same way they are described here. The user can utilize and interact with the system in the way it was designed, without having to imagine the feel and functionality of the application, like if it was faked by using for example mockups.

## USER STUDY

The purpose of this study was to investigate how in-situ mobile photo consumption influences the experience of watching photos, using *PhotoWorld*. In order to test the application user studies was conducted. As suggested by Göger and Myrhaug [10], it is essential to ensure a context match between the study and the application use. This includes things like documenting results in the situation and the context at the specific moment. Göger and Myrhaug also suggest that relevant tasks are given to the user, but since the application is focused on presentation of data in a free roaming environment, it was not found relevant for the test of *PhotoWorld* to do such tasks. Furthermore the test would focus on the users experience, so making tasks to control a participant's use would contradict the purpose. The inspiration came from the approach presented by Chin and Salomaa [6], where an open ended user study allowing the users to walk around freely and experience the device, is used.

Göger and Myrhaug [10] stress how important choosing the right participants is. Based on the stage of the development different participants could be relevant. During early development "Expert Walkthroughs" would be a valid approach since this early prototype would be very unstable. These Walkthroughs were conducted by ourselves, since we constantly made iterative builds of the application and tested it.

Before starting the actual user study two pilot studies was conducted to evaluate the testing frame, improve any obvious errors and get some experience as testers. A single critical error in the application was identified and corrected. Furthermore the wordings of the questionnaire questions were improved to remove some ambiguity that was found.

### Setting

A good deal of photos for our user study was needed. Testing the system would be rather pointless without anything to show the participants. Considering our in-depth knowledge of the system we decided to recruit external people to take photographs. To ensure that photos would not be biased, four people were recruited to take a series of photos within a designated area of the city. The area selected can be seen on Figure 8, and covers most of mid-town Aalborg. These four photographers were given their own starting point and were asked to take 40 to 50 photos of the area. They received no further instruction besides a guide on how to take a photo. 150 photos from central Aalborg were taken by our four photographers. After the photos were taken, all duplicates or out-of-focus photos were removed, as handling such photos is beyond the scope of this test. In total 135 photos were used in the User Study. After each test the photos taken by the participant was saved and then removed from the phone to ensure that all participants experienced *PhotoWorld* in the same way.

### Participants

Eleven people with limited prior knowledge of Aalborg city participated in our study - four females and seven males. Three of them were exchange students who just moved to Aalborg from Iran two months earlier, two of them were visitors from southern Denmark, and the rest were students who just started at the University. About half of these students were still living outside Aalborg. The participants were between 19 and 50 years of age, with the major part in the early twenties. Their experience with using a phone with touch screen and using the built-in camera were very mixed. The younger male participants in general had a greater experience with the smartphone elements than the females had.

### Procedure

All tests took place in down town Aalborg. The user study itself consisted of several elements. First the user was given a textual introduction, which described the setting and what was expected of him. Following this general introduction the user was introduced to the application, by the test leader. The participant was shown the different views, how to switch between them, how to zoom and a short explanation on how the photos would appear as he walked around. The participant was then encouraged to just freely walk around and explore

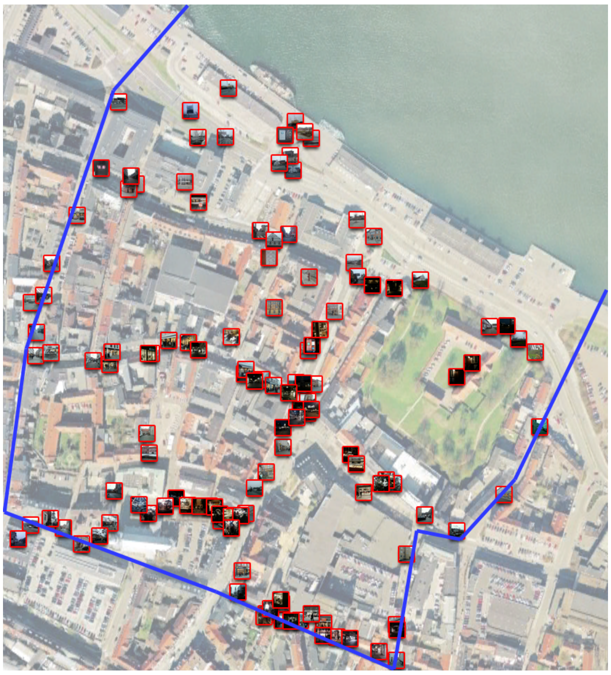

**Figure 8. Map of our test area marked by the blue line. The location of the different photos taken by our four recruited photographers can be seen with a red border.**

the possibilities of the program. During the test the participant was followed by a test leader and an observer. The observer was in charge of taking notes of relevant events while the test leader was in charge of trying to make the participant think aloud and help if there was a problem. The participant constantly interacted with the test leader, who asked questions and probed the user to "think aloud". After the test, which took approximately 30 minutes, the user was asked to fill out a questionnaire. Lastly, the test leader conducted a semi-structured interview, and the observer asked questions to clarify any interesting behavior he had noticed during the test itself.

### Data Collection

During the test the application logged GPS positions and interactions with the device. This information were written to a pre-formatted log file, which then could be analyzed by a parser we created for this specific purpose. The parser made it possible to transform the logs to drawings on a map and groupings in a graph. Furthermore notes were taken on site by an observer walking around with the participant and the test leader. The participant was asked to fill out a Likert Scale questionnaire [20] consisting of 17 questions grouped in two: Your Experience and Views. The Semi-Structured Interview answers were written down by both observer and test leader as the interview progressed.

### Data Analysis

Our data consisted of notes, questionnaires, logs and interview recordings. To structure our qualitative data Grounded Analysis was used to identify and classify identities and relations [18, 8]. Grounded Theory provides a framework to organize and structure collected data. Themes were generated by systematic use of techniques and procedures to split qualitative data into controllable elements before using this foundation to create higher level concepts. Three group members analyzed data from the interviews and the notes taken. First open coding was used to discover 243 different properties, which identified 57 phenomenons. Following the open coding, axial coding was used to create structure in the data and make categories based on the phenomenons. Eight categories were created from the phenomenons. Selective coding was used to relate the categories to each other, with the purpose of gaining an understanding of how the categories are interrelated and hereby finding the main themes. This resulted in two themes listed below.

- Troublesome Spatial Interaction
- Augmented Temporal Experience

These themes were then compared to answers from the Likert scale questionnaire. Furthermore relevant categories were examined against automatic logged data. For example a category about misplaced photos would be checked with the questionnaire to see if the user actually noticed this problem. It was then taken a step further, by examining GPS data through the test, to see where and when the GPS signal were inaccurate and what impact it had on the applications perception of placement.

## FINDINGS

The following findings are based on 11 sessions lasting from 25 to 45 minutes, most of them about 30 minutes. The exchange students in general spend more time on the mobile photo consumption experience than the Danish participants.

### Troublesome Spatial Interaction

The use of the participants own physical movement to present photos, showed to be difficult to understand. The navigation through the photos requires the participants to understand the mapping between what they saw on the screen and the surroundings they were in. Each movement by the participant, being either directional or orientational, would spawn a reaction in the application that would re-arrange the photos based on the new user positioning.

It became clear that not all participants understood this relation. Some of the participants would for instance not realize, that if they walked "through" a photo in panorama view and wanted to see it again, it would require them to walk backwards while still facing the same direction, and not simply look behind them. Doing so would only show the backside of the photo, and thereby nothing. Related to this was the connection between GPS coverage and understanding the mapping, which was discovered by relating this finding to the questionnaire replies and automated log data. This showed a connection between good GPS coverage and understanding of the mapping. Participants who did not believe the photos were positioned in correlation to where their real world positions were, was also the participants who experienced the worst GPS coverage.

**Figure 9. Picture of Panorama View in use. The image shows a good mapping between the image presented on the phone and the context behind it. Notice how the setting has changed: The picture do not have snow, as the real world.**

When there was good coverage, the participants were astonished by how well the photos were positioned in correlation to their context. Figure 9 is an example of good GPS coverage matching the photo position. One participant said:

> *"Wow it is pretty amazing how the photos match their real position!"[9]*

This shows that when the precision of the system was optimal the connection between imagery and context had a great effect on the user. Contrary to this, some of the participants experienced the GPS lost its link, and thereby stopped updating the content on the screen. A visual example of this can be seen on Figure 10 where the actual path and GPS positions from a single user study have been drawn on a map. This made it impossible to perceive that ones movement affects the representation. When situations like these occurred it spawned different responses from the participants. Some was able to determine that the GPS or compass did not update properly, while others, mainly the ones with lesser understanding of the concept, would get confused and stop moving trying to see if it was possible to relate the real world to the photo world.

The reconstruction of the connection between the users' perspective and the perspective of the photographer of each photo in Panorama View, involved positioning and rotation of the photos. The rotation of these photos was the feature that got the most mixed feedback. Some participants quickly understood and liked the fact that they could see in which direction the photographer had captured the photo, and used this to see if they could get the same perspective. Others understood the rotated photo in Panorama View as an arrow pointing in the direction they had to walk to see the photo. This relates to the problem where the participants have not realized that the display works like a window to another temporality. One participant thought that the rotation of the photos was quite amusing, but not especially useful.

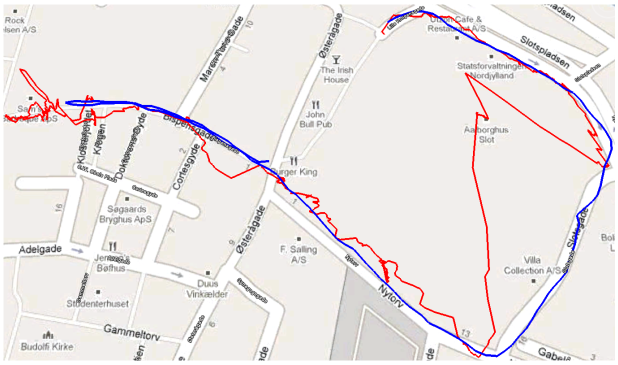

**Figure 10. Drawing showing a single participants actual path (blue path), and the route registered by the GPS (red path). As it can be seen there is some large fluctuations in the quality of the GPS signal.**

Some participants got confused when they used the Compass View to find the photo. It made them believe that, if they from their current location could see the photo in the Compass View, they would also be able to see a photo in the Panorama View. E.g. the user sees three photos in Compass View, but only two in Panorama View and does not discover that one of the photos is taken in the opposite direction. That certain photos disappeared, when switching views, was the aspect that confused the participants the most. As one expressed:

> *"Hmmm there is something about the photos, which you can see in Compass View and not in Panorama View - it's a bit confusing. " [9]*

Half of the participants found it difficult getting an overview of photos found in the area. They sometimes had trouble interpreting the photos on the screen and tell where they were placed. To gain a better overview of the photos, the participants often zoomed out in the Compass View, which in turn made the photos smaller. This action therefore spawned lots of user reactions related to the size of the photos in the compass view. In general all participants wanted to see the photos in a bigger format, and thought it was possible to click on a photo to see it in full screen. As they discovered that this was not possible, some participants instead held the device rather close to their face to have a closer look at the small photos. Figure 11 shows how a user is using Compass View to get a perception of the surroundings.

A strategy attempted by the participants when wanting to see distant photos in a larger format, was trying to zoom by clicking on them in the compass view. This was not possible because of the zoom implementation, which only made it possible to zoom at the current location. Some of the users expressed a wish to move the photos around, so they were able to zoom in on other photos than the photos close to them. One of the participants asked directly if it was possible to see distant photos.

Furthermore, participants requested a map underneath the photos, to help determine which route would lead them to a photo, and to help create the relation between the real world

**Figure 11. On this picture a user can be seen using the Compass View to get an overview of the surrounding photos.**

and the photo world. In contrast to this, some participants discovered that the position of photos actually created a map showing possible paths they could use when walking around the city. One of the participants remarked, that because she she did not know Aalborg that well, she had a hard time finding her way from her current position to the position of the desired photo.

In general, participants used the Compass View while moving. When they arrived at a place of interest they stopped walking, and started using the Panorama View to explore the surroundings. For instance the following situation where a participant identified a photo of interest in Compass View and started walking to its location.

> *"Interesting - I haven't seen that before[He discovers a ferris wheel], lets walk there and have a look " [2]*

This reveals a general tendency when using the Panorama View, the participants often only moved short distances. This became very clear when analyzing the log files from the phones. The participants on average walked 67% of their total distance while using the Compass View, as it can be seen on Figure 12. Two participants stood out in their use of the system. Analyzing their use patterns showed that they did the opposite of the rest of the participants, and walked around using primarily the Panorama View.

From the questionnaire it can also be seen that when the participants were asked if they found it natural to interact with the phone in the way *PhotoWorld* demands it, there was no

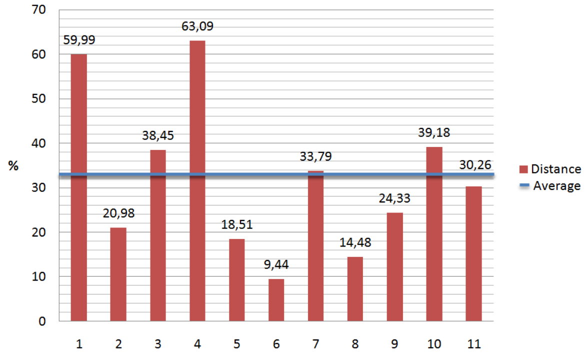


**Figure 12. Graph showing how many percent of the distance was walked while the participants were using the Panorama View. As it can be seen in the graph most of the participants were using the Compass View when walking.**

clear answer. Most of the participants did not find it natural, but the people who had experience with smartphones found it very natural to use and rated the interaction 5, where 5 is strongly agree. On the other hand, all of the participants expressed that it made sense for them to change between the two different views. When asked the question: *It made sense to switch between compass and panorama-view by tilting the phone up and down?*, they all agreed with an average score of 4.55.

Some of these findings does however reveal some kind of contradiction, as almost every participant agreed that *PhotoWorld* created a good overview of the photos in their surroundings, even though some of the observations imply something else.

### Augmented Temporal Experience

Our findings show the participants experience an enhanced temporal understanding of the context. This was shown by the participants experience with exploring the city in a different time. For instance, seeing the city at different times of the day, or to see how a shop would look if it was open. Since the photos were taken over a period of just two days, the temporal diversity was limited. The photos that stood out in this way, by depicting clear differences between the time they were taken and the time the participants were looking at the photos, were also the photos that the participants found the most interesting. For instance at the time the photos was taken, there was a Christmas market in the city. One of the photos in the system was of a seller in his booth, which during some of the tests was closed. The participants who noticed that they could see how the booth looked like when it was open were very pleased.

Some of the participants expressed a need for more photos. For instance two of the participants who walked to a well-known church, expected to see some photos of it, but there were no photos of it even though it is one of the tourist attractions in the city. However, many of the participants added photos of places they felt were missing from the system, which was also the case for the church. The photos in the current system tend to be clustered around a few places, and generated a clear pattern of where the photographers mainly took photos. Some of the users followed the path of photos and stayed in close proximity, others left the path to explore "lonely" photos.

The participants could roughly be divided into two groups. The first group never walked away from areas with photos, unless they had a specific location they wanted to go to. Most of the time they found a photo in the compass view and walked towards it. When they got close to where they thought it was captured, they tried to locate the photo in the Panorama View. The other group tried to fill out some of the more empty areas where there were no photos, by taking a photo at the location. During the interview one of the participants stated that he tried to find "black spots" in the system and fill them out. Thereby dividing the participants into groups of creators and consumers. Furthermore, participants identified the photo consumption experience as a social activity with similarities to tourism and by expressing their wish to share photos with friends or other people visiting the same spot at a later time or to view pictures captured by their friends, creating a social link between capture and usage context.

In general there was a wish for different types of filtering and sorting of the photos. For instance only to show photos taken by friends. Furthermore many of the participants asked if it would be possible to get information about the photos. One participant mentioned that he would like to have historic information linked to some of the old buildings in the city center. Free roaming/mobile photo consumption

## DISCUSSION

In this section we discuss central aspects of *PhotoWorld* and its relation to related research. PhotoWorld was designed to merge capture and usage context of photos, as they were presented by Karlsen and Nordbotten [15], thereby creating a situated window to the past. By moving the use context in-situ *PhotoWorld* explored a new representation form, by using spatial placement of images and the user's physical movement as interaction. GeoFoto by Effrat et al. implements image selection based on screen interaction from the user [9], something we tried to achieve through the users physical movement. This implementation received mixed feedback, which we relate to two things. First, it did not seem natural for most users to interact based on movement. They often fell back to familiar touch screen interactions and sought a way of viewing images without moving. Secondly, the inaccuracies by using GPS in an urban environment weakened the link between images and surroundings - something especially essential for mobile photo consumption.

To maintain a link between the digital photos and the real world, *PhotoWorld* depends on precise information from GPS and compass. In "Can You See Me Now", they depend on fast GPS updates to ensure consistency between runners' position in the real world and the systems knowledge about their position [4]. *PhotoWorld* also depends on frequent GPS updates, but is more reliant on GPS accuracy. In [4] they reported to have measured the accuracy to be between 1 and 384 meters and with an average of 4.4 meters. In our tests we saw similar wide spread measurements. Our test showed how absent GPS updates and low accuracy made users try to understand or handle the situation. The same reaction was found in "Picking Pockets on the Lawn" [2], where it was reported that players started to redo their actions by walking backwards or by doing a 180 degree turn. In [4] the GPS accuracy is optimized by implementing a filter, which ensures that the users current location cannot be e.g. on top of a building, in the middle of a lake or any other unreachable place. Our findings underpin the need of smoothing or filter to remove inaccuracies with sensor data, when working in an urban environment.

This placement in an urban environment with low accuracy is therefore a contradiction to the aspect of "following in the photographer's footsteps". The urban environment has a large population; hence potentially more diversity of content, but its environment damages the sensor data and introduces a tradeoff. Nevertheless we feel our presentation form achieved its goal of merging contexts. The photos presented temporal information and added to the user experience, which for instance was seen when the user was doing a test in broad daylight and saw pictures from the evening. It made it possible for the user to visualize the same building or street in past tense. Furthermore, mobile photo consumption showed to create a wish for experiencing the situation captured on the photos.

The division of the participants, into the creator and consumer group and the wish to share photos with friends or view photos captured by friends show similarities to the work presented by Patel et. al. concerning collocated-synchronous mobile photo sharing, where it was discovered that group diversity was an important aspect of enriching the experience, because of mixed interests and thereby photos shared [17]. Furthermore, it was observed that participants competed in capturing the best photos of new location. Participants in our user study, who knew the area well, showed the same interest when arriving at places that were not yet in the system. This is likely due to that people who know the area well, has a better understanding of what is happening in the area and which things might be interesting for others to see. Compared to people that is new to the area, and with limited knowledge, who more or less seeks an introduction to interesting places - thereby following the path of photos.

## CONCLUSION AND FUTURE WORK

This paper introduces the concept of Mobile Photo Consumption and investigates challenges of merging a capture context and usage context by presenting photos in-situ. A smartphone application, *PhotoWorld*, was implemented to investigate how in-situ free roaming photo consumption influences the experience of watching photos. Based on a user study with 11 participants, we found that the spatial interaction introduced by *PhotoWorld* was troublesome for users to understand. Furthermore, the temporal aspect of photos was found to positively augment the surroundings and broadened the users' perception of the context. We recognize how our findings are based on subjective statements and are very closely linked to the *PhotoWorld* system. Other aspects and relations could have been analyzed resulting in different results.

It would be interesting to expand the concept of mobile photo consumption to more than photos. For instance showing more complex objects on top of the real world. From our finding we know that the content the users find the most interesting is the content with a different temporal aspect. An idea, could be to present city development, for instance if the city has plans to renew a street we could present the old street with elements from the new street. A long-term study could be applied, to test how the concept would be received as more content is added. While the amount of photos in the system increases as time goes by, a more diverse temporal foundation would possibility present new intriguing aspects. The *PhotoWorld* system itself could very well be the foundation for further studies into contextual photos, social interaction and spatial interaction.

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APPENDIX

# B

# RESEARCH PAPER II - SITUATED DIGITAL ELUCIDATION: EXPLAINING FUTURE ARCHITECTURE IN CONTEXT

# Situated Digital Elucidation: Explaining Future Architecture in Context


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## ABSTRACT

Families often initiate construction of their future home without adequate contextual information. We introduce *HouseView*, a mobile augmented reality system to support in-situ visualization of relevant virtual data, which we denote *situated digital elucidation*. We address three issues of house construction by elucidating two-dimensional placement, spatial characteristics and visual appearance. A user study was conducted, with recruitment of participants covering a broad spectrum of a buildings lifecycle. Participants were grouped in three: lot seeking, signed contract and house extension. We find that *HouseView* facilitate an enhanced visual perception, a common social understanding, primed contextual influence, refined mutual understanding and a genuine dimensional insight.



### Author Keywords

Situated Digital Elucidation, Augmented Reality, Architecture, Spatial Comprehension, Smartphone, GPS


## INTRODUCTION

Mobile technologies provide interesting and promising opportunities for in-situ information [16]. Presenting information about a situated future object, while being in its surroundings, brings life to the explanation of the future object. Adding life to explanations creates new opportunities for understanding the object and how the surroundings influence the object. The idea of using the context to describe and understand the impact of a object is not new. For instance, Pedell and Vetere uses picture scenarios to visualize the influence of context on future mobile systems [13].

Such contextual information could also assist in decision making. For instance, one of the most significant private financial decisions in our life is to buy or build a house. Having second thoughts about a building after it has been constructed can be very costly, so starting construction based on the best possible information is essential. Summerfield and Hayman underpin the inclusion of contextual information in architecture as absolutely necessary [18]. So by explaining future architecture in its surroundings through technology, we emphasize the process of visualizing situated information not directly visible. One could argue that it would be the same when buying a car, but there is a clear distinction. When buying the car you can try it out and decide afterwards. When building a house you make a decision on something you cannot see, touch or feel.

To facilitate an increase of information an elucidation system could be devised. It would have to encompass a huge degree of detail to be effective for contextual decision making. It should strive to elucidate the object in its context - presenting a detailed explanation [18]. It should visualize contextual correct information, just like when you test drive a car against a scooter and realize that the car is more comfortable when it is raining.

Inspired by previous research, we coin the term *Situated Digital Elucidation* to define a situation where people are digitally explained details about an object in-situ. Architecture is the prime example of decisions made concerning a situated object - thereby involving a lot of detailed situated information. Architecture would simply not make sense without a lot to place it on, and the surroundings it is situated within and is therefore a field of great potential for investigating situated digital elucidation. A part of this information is the visual explanation - an acceptance of the appearance based on personal preferences.

Today common visualization techniques like drawings, pictures and 3D models etc. are used to elucidate future buildings. Something that is hard to take into account by using these tools is the context, especially when most of the visualization and explanation happens in an office. Strangely, it is remarkable how architects emphasize the importance of the context. One example is a quote by the famous $20^{th}$ century Finnish architect Eliel Saarinen:

> *"Always design a thing by considering it in its next larger context - a chair in a room, a room in a house, a house in an environment, an environment in a city plan"*

We accept the importance of context when doing construction, but it is vivid in nature. Always changing. This makes it extremely hard, if not impossible, for a person to envisage the future building. By using mobile technology to achieve contextual correct situation, and presenting detailed information based on this context, we seek to investigate how a building process can be elucidated.

In what follows we begin by giving an account of related research literature. Next, the implementation is presented, before the user study is described. Consequently, the results are described, followed by a discussion. Finally, the conclusions and future work are presented.

## RELATED WORK

Situated presentation of information has been explored intensively by the HCI community. SiteLens, an situated visualization system, developed by Feiner and White, explore how invisible aspects of an urban environment can be made visible [19]. Inspired by their use of physical location to dictate what information to present, we transfer their approach onto our case of architecture. When elucidating architecture the most crucial aspect is spatial understanding of the building and its details [18]. A technique for visualizing spatial information, just like in SiteLens, is Augmented Reality (AR). Azuma presents three important aspects that define AR: It blends the real and virtual within a real environment, is real-time interactive and registered in 3D [1]. We will use this definition of AR in any further mentioning.

Within the field of AR we operate with three major display techniques. We classify them in three groups. First, Head Mounted Displays (HMD) like the one used in the Touring Machine created by Feiner et al., where they use a HMD system to display information of an university campus [4]. Second, Handheld Displays (HD) as used in Arnaudov et al.'s implementation of the mobile museum guide "The Louvre - DNP Museum Lab" [9]. Last, Spatial Displays (SD), removes any need of the user wearing or carrying a display. This make it useful for collaborative work, like the "The Future Office" presented by Cutts et al. [15].

The possibilities of AR have broadened the interest in AR to several different problem domains and academic fields. There have been numerous examples of tour guides using AR to enhance the experience for the user. In the ARCO system, Walczak et al. shows how museums can build interactive learning scenarios, which can transform visitors from passive viewers and readers into active actors and players [21]. AR has mostly been used for visualizing hidden information, for example as shown by Feiner et al. and Reitmayr and Schmalstieg [4, 16]. This is even more apparent in the commercial system, created by Mizell for doing wire bundles inside Boeing aircrafts. It showed an 30-50% increase in effectiveness by using this form of visualization [10].

A few studies have taken interest in the aspect of visualization of architecture. Guo et al. describes the presentation of buildings as one of the main features of AR [6]. They use the example of ARCHEOGUIDE where Greek researches and the government use AR to visualize the Grecian Olympia [5]. Junghanns et al. present an AR system used to visualize underground infrastructure. The system aids field workers of utility companies in outdoor tasks such as maintenance, planning or surveying of underground infrastructure. During their outdoor testing, shortcomings of the GPS tracking were found. Furthermore, depth perception remained an issue throughout their research [17].

Prior research on architectural visualization conclude that AR has great potential, but that current technological inaccuracies diminish the usefulness of the system [5]. Nevertheless, smartphones capable of doing AR have broadened this kind of visualization to the general public. We see the use of AR in applications like Layer and Wikitude [8, 20]. Some people even speculate that AR is about to change the way people view the world [11]. They speculate we will be living in AR, and getting location stickies from people tied to specific locations. Fantasy would become an overlay on reality when we participate in huge scale games through AR spanning from local streets to entire continents.

The use of AR introduces one fundamental challenge with depth perception as described by Junghanns et al. [17]. According to Azuma, this concern is related to registration, which is a cornerstone in AR for achieving successful utilization [1]. Registration covers the mapping of the virtual content to the real world and is therefore associated with the perception of depth and perspective. The problem is that objects in the real and virtual worlds must be properly aligned with respect to each other, or the illusion that the two worlds coexist will be compromised [1]. Azuma have divided registration into four main sources of static errors: Optical distortion, Errors in the tracking system, Mechanical misalignments and Incorrect viewing parameters (field of view, tracker-to-eye position and orientation). According to Azuma several approaches can be taken to minimize any of these errors. A very skilled user with good understanding of 3D can be used to calibrate the system until it "feels right". Another approach is to measure parameters using different tools. On a HMD the interpupillary distance is crucial to create a correct registration and could therefore be measured amongst other things. For video-based systems pictures taken by the camera can be used to matchup the 3D objects to the surroundings and thereby create mathematical constrains. With enough pictures with different perspectives a mathematical framework for the camera can be created [1].

Most of these studies share a common trait. The temporal aspect of their information is often either set in the past or present tense. From showing archaeological monuments in ARCHEOGUIDE to presenting current $CO_2$ levels in SiteLens, we have a great span of temporal information, but nothing beyond the present [5, 19]. By using situated elucidation we investigate visualization of future content, which seems to have been a rather unexplored area.

## HOUSEVIEW: IN-SITU ELUCIDATION SYSTEM

Inspired by [18, 14] and interview conducted with the construction firm Vendia Huset we define three aspects for situated elucidation of house construction. The three aspects are: Elucidating Two-Dimensional Placement, Elucidating Spatial Characteristics and Elucidating Visual Appearance.

1. *Elucidating Two-Dimensional Placement*. Elucidating a house in-situ depends upon explaining the house in its surroundings. This requires choosing a position of the house in the context. In construction this involves the process of choosing a position.
2. *Elucidating Spatial Characteristics*. Situated elucidation of house construction requires physical presence - being present introduce the possibility to obtain a spatial understanding of the surroundings in relation to and of the house by moving around.

3. *Elucidating Visual Appearance*. Elucidating the interplay between materials and especially the surroundings require detailed information about the context. Moving the process of choosing materials out of the office and to be situated at the lot oblige this need.

Based on these aspects and the challenges mentioned in Related Work, we designed *HouseView* to support elucidation of buildings in context via AR visualization. Overall, *HouseView* presents a virtual 3D house in context on a smartphone and makes it possible for the user to examine the house from different angles using his real-time physical movement to change the view, and inspect the interplay between materials. Figure 1 visualize how the description fit the concept of AR defined by Azuma [1]. *HouseView* combines the chosen materials and 3D model to a virtual house, and blend it with the real world by overlaying the house on top of a camera feed, creating an Augmented Reality.

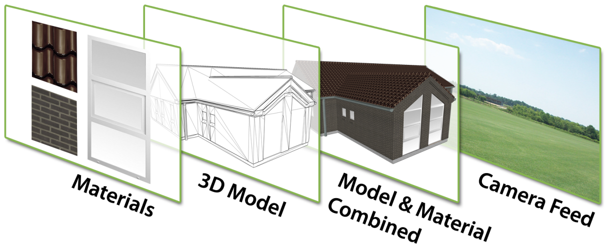


**Figure 1. The concept behind Augmented Reality. Virtual data (house with textures) is overlaid upon the real world (camera feed).**

To illustrate typical usage of the *HouseView* system, a scenario is devised below:

> John and his wife Kate want to build a house where their family of four can live. They visit a potential lot. Arriving at the lot, they start *HouseView* and choose a house. An opportunity to place the house on the lot is now presented to them. They place the house at a location on the lot which they believe is optimal. *HouseView* now shows the house based on their preferences.
>
> Walking around the lot, John gets different perspectives on how their choice fit into the surroundings. He notices all neighbors have red bricks, and that their house is in yellow. This makes him a bit insecure. To see how their house would fit into the surroundings with red bricks, he changes materials through *HouseView*. He is surprised about how the house has changed with the new bricks. It nearly vanishes into the surroundings. John confers with Kate about the chosen colors. In cooperation they decide that their initial idea about the yellow bricks is the best solution.
>
> John notices that a neighbor house is quite close to their living room panorama window. He uses the blueprint drawing in *HouseView* to position himself at the panorama inside the virtual living room. He starts to check how the neighbor house impacts their view from the living room, and to his disappointment he realizes that the neighbor house totally blocks the view. They are therefore forced to rethink the position and orientation.

### Elucidating Two-Dimensional Placement

The first aspect of situated elucidation depends upon explaining an object or phenomena in its surroundings. For *HouseView*, it is thereby important to facilitate the process of positioning the house at its designated position. Therefore, to support this process *HouseView* implements a separate View, named "Placement View". This is the first element the user sees after choosing a house model, as in the scenario. Satellite images from Google are set as backdrop to create a visual link between the application and the surroundings. An outline proportionally correct to the underlying satellite images is shown for the chosen house. The outline is presented as a red figure, shown on Figure 2.C, masking the outer bounds of the house from a top-down view. Two main interactions are available to the user. Clicking the map centers the outline and scrolls the satellite backdrop to focus on at the specific screen point clicked. This interaction makes it possible for the user to change position of the house. At the top of the view, a horizontal scrollbar makes it possible to rotate the outline, and thereby the house, around its own center point. The centre-screen GPS position and the rotation value is saved when the user accepts the position and rotation by clicking the button "Placer Hus".

### Elucidating Spatial Characteristics

The second aspect of explaining house construction in-situ is the problem of combining situated elucidation and AR as a visualization tool. It do not only make the application highly situated, it also foster the need to track the spatial movement of the user and respond visually to these movements. *HouseView* uses GPS positioning and orientation sensors to achieve the goal, of making the illusion of moving around the virtual 3D house and to make the user able to view the house from different angles.

The virtual house receives a GPS position from the Placement View, as mentioned, and the user's position is found by utilizing the built-in GPS receiver. These two points is then used to calculate the relative position of the house from the user's position. The calculation involves the distance to and the bearing between the two points, but this does not provide information of the user's orientation. To acquire this, the built-in orientation sensor is used, which provides information about how the phone is rotated according to azimuth, pitch and roll. Azimuth is the direction the user is facing represented as a compass degree deviation from true north. Pitch represents the user's vertical facing direction - is he looking up and down. *HouseView* do not utilize roll information, which could be used to simulate the effect of tilting the head sideways.

Being situated and facing a specific position lets people view real world object in relation to each other - for instance, two equally sized objects positioned at different distance, would make the closest object visually largest. This mapping is an important real world aspect of depth perception, which is necessary to adapt to the virtual world for weakening boundaries between what is virtual and what is real, thereby enhancing the believability.

To ensure 1:1 relation between the virtual and real world, one last parameter needs to be defined. The Field of View (FoV) defines how we visually understand the world. On Figure 2.D, notice how all lines point towards the same dis-


**Figure 2. User interface of *HouseView* - A: Screen capture of a virtual house positioned on a lawn. B: Screen capture of the Blueprint View, showing a general overview of the floor plan. The red square represents the user's position on the blueprint. C: Screen capture of the Placement View for house placement and rotation. The red shape represents the house, and the top bar makes it possible to rotate the house. D: Screen capture from inside the house. Notice the added dashed dividing lines between the roof and walls moving inwards and thereby creating perspective. E: Screen capture of the possible view from the living room. Notice how the real world is visible through the windows in the virtual walls.**

appearance point. This makes up the perspective, and is something we all latently use in our everyday life to get an understanding of distance. This is also why the size of the FoV in *HouseView* is crucial, since even small changes will change the entire perspective and ultimately the users understanding of what he sees.

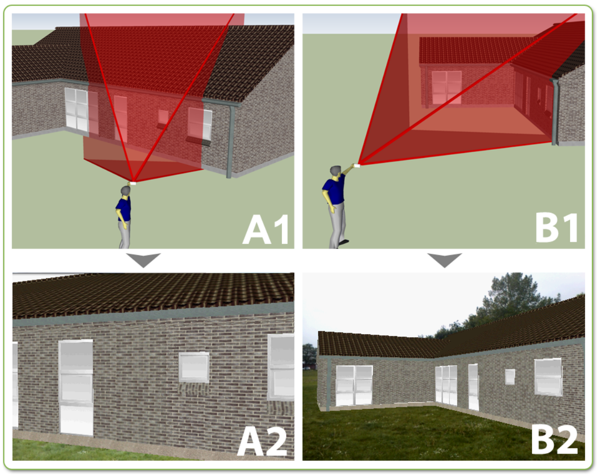


**Figure 3. Concept drawing of the user's movement in relation to the graphical output. The red cone emerging from the white device held by the user represents the Field of View and will be the outer bounds of what is presented on the screen. In A1 the user is close to the virtual house resulting in a smaller part of the house to be visible on the screen - shown on A2. In B1 the user has moved away from the house which lets him view larger areas of the house, corresponding to B2.**

The normal human FoV is roughly 120 degrees. Using a FoV at 120 degrees would not make sense on a small flat screen, because it would distort the visualization to something that resembles a wide-angle picture. The concept of FoV can be seen on Figure 3, where FoV is represented as a red cone. If the device is to work as a window to another world the FoV have to look realistic. It has to have a realistic perspective and depth perception when viewed together with the underlaying camera feed. A larger FoV would broaden the red cone on Figure 3, resulting in a changed perspective, which could introduce conflicts with the surroundings. Imagine you wanted to take a look at your view from inside the house like shown in Figure 2.E. The perspective of the house would make for one understanding of the house, but the real world outside the windows would still have the human FoV of 120 degrees. To ensure the best visual mapping *HouseView* uses a FoV of 45 degrees.

With this set of information about position, facing direction and FoV, *HouseView* is able to visualize the virtual 3D house in relation to how the user looks at it and moves around. A conceptual drawing of how this is implemented can be seen on Figure 3. The red cone represents what parts of the house the user is be able to see on the screen. When the user changes orientation of the phone or walks to another position, it affects and changes the view captured by the cone, hence what the user can see. The effect can be seen on Figure 3 where the captured part of the house changes according to the user position and facing direction.

The actual visualization of the virtual house is split up into two different views which will change between each other by moving the phone from the vertical to horizontal position, exactly as implemented in the PhotoWorld application [7]. The view presented when held vertical will be denoted "3D View", shown on Figure 2.A and the view presented when held horizontally will be denoted "Blueprint View", shown on Figure 2.B. The red square in the center of the screenshot marks the users position within the house.

### Elucidating Visual Appearance

The third aspect concerns elucidation of how materials match each other and especially the surroundings. This introduces the need of having detailed information about the context. Moving the process of choosing materials out of the office and to be situated at the lot oblige this need. *HouseView* supports the possibility to change and thereby compare; brick type, roof type, color of the windows and doors and lastly the woodwork, when being situated.

The user is able to change building materials by activating


**Figure 4. Series of screenshots showing the sequential process of changing materials. First image show a gray house. Second image shows the *HouseView* menu, with the gray house presented behind. Third image presents the Material View, where it is possible to scroll a series of different materials. Last image shows the same house, now build with the red brick selected in the Material View.**

the *HouseView* main menu. The menu will appear when tabbing the screen and disappear again on the same action. A screenshot of the menu can be seen in the second image on Figure 4. At the top the user is presented with the possibility of changing the house model and re-positioning or rotating the current model. In the bottom is the buttons used for changing material of the different elements of the house.

Changing materials was implemented in a view called "Material View". The process of switching materials can be seen on Figure 4. Clicking a menu material button opens the Material View. In Figure 4, a change of the wall bricks, to a red color, is taking place. The user changes to different materials by swiping the screen left and right. To select the current visible material the user has to tab the screen. When the user clicks a material, it is passed along the rendering pipeline and the specific segment of the house model will change texture. The 3D View is shown again, with the new red bricks, as can be seen on the last image of Figure 4.

### Technical Details and Challenges

The prototype was implemented on a HTC Hero smartphone running Android 1.5 platform. The device has a screen with a resolution of 320x480 and hardware accelerated 3D graphics using OpenGL ES 1.0. Interaction with the device mainly takes place via a capacitive touch screen and a series of hardware buttons. Furthermore it features a GPS, accelerometer, 5MP camera and digital compass. Programming for the device was done in Java by using Eclipse IDE paired with the official Android API and plugins.

The 3D house models were created in Google SketchUp and exported to OBJ format. A file parser algorithm was constructed to import the OBJ information into OpenGL. This made the turn-around time of making models smaller, since no extra care would have to be taken once the algorithm was in place. This faster creation of models was needed for all the different personalized models used in the user study.

To smooth out any obscure readings from the GPS and orientation sensor different smoothing techniques was implemented. The short movement distances traveled when using *HouseView* showed to favor a simple average of the last three GPS readings. The orientation sensor is very precise and updates extremely frequently. This introduces an issue with drawing the overlaid 3D model, since it would jump around the screen. Another average smoothing algorithm is implemented on top of the sensor data to keep the house static.

## USER STUDY

The user study aim to explore the possibilities of elucidating troublesome aspects of house construction in-situ. We recognize that a buildings life cycle consists of several steps, each with their unique challenges. By challenges, we mean the different incentives a family would have for gathering information of their future building. First, a family thinking about building a brand new house would be interested in finding a lot and get an idea of the possibilities for placement. Secondly, a family a bit longer in the process, already having the lot and placement settled, would seek better understanding of the interplay between materials and between the environment they are situated in. Last, a family wanting to extend their house would be interested in how the extension fit the old house. These three groups will be named: Lot Seeking, Signed Contract and House Extension. Through the study we welcomed any kind of diversity, to cover as broad an aspect of the building process as possible.

### Participants

In total 40 people, 11 of them children, male and female, participated in the study. The adults ranged in age from 28 to 41, with the majority in their mid thirties. Participants were recruited from the following categories:

*Lot Seeking*
12 adults and two children split over six families participated in this group. During Open House or Open Lot events, in the vicinity of Aalborg, families were recruited on request. They were approach when leaving these events held by local construction firms. All in this segment had only a vague idea of their building criteria. They were seeking inspiration on house construction possibilities and most did not own a lot. These participants were presented with pre-designed houses made based on tract houses from Vendia Huset.

*Signed Contract*
12 adults and six children split over six families took part of our test in this group. Through our contact with Vendia Huset, families from Northern Jutland were recruited. All these participants either had signed a contract for a specific house or were in the process and only had some details in the blueprint awaiting approval. Every participants had seen ground plans of their house. Furthermore three couples had seen front elevation drawings. One couple had even made a 3D drawing of their future house. All participants were in their mid thirties, and had small children. With this segment of our participants we received their individual blueprint from Vendia Huset and made a 3D model.

*House Extension*
Five adults and three children, split over two families, were recruited based on their wish to make a house extension. One of the adults were the designated architect for both families. The families had ground plans, which we received and made into 3D models.

Above these three groups of participants a more general division can be made. The group with signed contracts and the group thinking about doing a house extension both had personal 3D models made by us, which required a significant work effort to prepare. Furthermore, there is a potential distinction between personal commitment in these two groups and the group just seeking a lot for sale.

**Figure 5. Family participating in a user study at their own lot. The two parents engaged their two children by showing them their future house through *HouseView*.**

## Procedure
All tests took place in-situ at the users own lot or at a lot for sale, if the participant was part of the Lot Seeking group. A picture of a family using *HouseView* is shown on Figure 5.

Participants were given a short presentation of the project. They were then asked to fill out a questionnaire and participate in a semi-structured interview. Following was an introduction to the system, where the participants were told how to handle the device and navigate the menus. We then encouraged them to explore the system by walking around the house placed on the lot. A test leader followed each participant to help with any problems and to probe for thoughts and comments from the participant. An observer was tasked to note comments and actions during this part of the study. Last, another questionnaire was handed out and a final interview were conducted to sum it all up.

A short phone interview were later conducted with participants from the Signed Contract group. Two couples from this group were asked to participate in a second test using the exact same procedure mentioned above, but based on a slightly altered 3D model made from input and requests from their first test.

## Data Collection
Before using *HouseView*, participants were asked to fill out a questionnaire consisting of a series of demographical and four general assertions which they were asked to answer based on a five point graded Likert scale ranging from “Highly disagree” to “Highly agree”. A semi-structured interview was then conducted to highlight current status, the process they had been through and uncover any difficulties they may have encountered. All interviews were recorded and notes were taking. During the users exploration of the system one person was taking notes of comments made or actions taken by the participant. A second questionnaire was handed out after the participants were finished exploring the system. The questionnaire consisted of the same four general assertions and a series of more specific statements regarding *HouseView*. Again they were graded on the same Likert scale. A second interview was conducted primarily based on a comparison of the two questionnaire. The participants were asked to describe changes in their answers.

## Data Analysis
Our data consisted of notes, questionnaires and interview recordings. Inspired by [3], we structured our qualitative data using Grounded Analysis to identify and classify identities and relations. Through Grounded Theory, themes were generated by systematic use of techniques and procedures to split qualitative data into controllable elements before using this foundation to create higher level concepts. Notes and recording transcripts were analyzed in unison. First, open coding was used to discover 362 different properties, which identified 41 phenomenons. Secondly, axial coding was used to create structure in the data and make categories based on the phenomenons. 14 categories was created from the phenomenons. Thirdly, selective coding was used to relate the categories to each other, with the purpose of gaining an understanding of how the categories are interrelated and hereby finding the main themes. This resulted in four themes:

- Enhanced Visual Perception
- Primed Contextual Influence
- Refined Mutual Understanding
- Genuine Dimensional Insight

The questionnaire were then compared with the emerged themes for any convergence between their answers and the topics distilled from the notes and interviews.

## FINDINGS
The following findings are based on 16 sessions lasting from 10 to 65 minutes, most of them about 45 minutes. Participants experiencing their own house or extension in general spend more time on the system than people from the Lot Seeking group.

### Enhanced Visual Perception

The elucidation of spatial information made visible by *HouseView* was found to enhance the participants visual perception of their house. This became evident, when several participants expressed difficulties in perceiving blueprints, and that it was hard for them to comprehend the interplay between chosen materials and the surroundings as well. When exploring the possibilities in *HouseView* they expressed that seeing their future house on the lot and being able to move around it, in context, made a big difference.

> *"I simply don't like blueprints, I don't understand them. But this . . . It is a lot easier to understand" [oh1-f]*

She made this comment after standing some time inside the house moving the phone between "Blueprint View" and "3D View". An outcome of using *HouseView* was a way of discovering areas where perception of the future house was incomplete. This can be seen by the following comment made by a participant, which prior to trying *HouseView* had expressed her very good visual understand of her future house:

> *"I actually thought I had a good idea of how my house was going to look, but there were things that surprised me and helped me understand a few things. All because I could see the house from different angles" [sols88-f]*

Many participants expressed their surprise of how their imagination of their house did not really match what they were shown when walking around. They simply could not comprehend the scale of the construction in its whole. This became even more evident, when the participants were asked to fill out the second questionnaire and grade their visual perception of their house. Several of them said they had made a clear mistake by grading their understanding above average in the first questionnaire. The tendency can also be seen in our questionnaire, where participants on the question: "It is easy for me to visualize the faces and appearance of the house on the lot" moved from an average of 3 before using *HouseView* to an average of 4.5. Clearly, participants felt they achieved a much better visual understanding.

Getting the visualization in context had a great effect on how the participants bonded to their future house and location. As a participant said standing in her future living room:

> *"It is so cool, that I can stand here in my living room and imagine what view I will have" [soe28-m]*

Based on the elucidated details presented to the participant it made her able to visually understand her house in exact this position with these surroundings. The importance of these surroundings was emphasized in one test, where the camera feed in *HouseView* suddenly turned black. The participant experiencing this immediately commented on how it spoiled the visualization and asked us to reboot the device and get the full effect back.

One of our couples, which participated in a second session, where their changes and suggestions to their house model were implemented, had a similar comment - just with another perspective. At the first test their carport was not included in the model, which was something we did the second time around. Standing at the road nearby the farther said:

> *"We have talked about how quick we would be able to drive into the carport from the road - we were afraid it would be too 'racing like'. But now that I can see it from here, I actually don't think it is going to be a problem" [kaer151-m]*

This extra edition clearly helped him address an insecurity issue with the placement of the house. Not all participants were totally impressed with the performance of AR in *HouseView*. Especially our participants looking at house extension commented on the lack of proper 3D registration. It was clear that the registration simply was not good enough when visual cues, the old house in this situation, was present behind the virtual element on-screen.

### Primed Contextual Influence

Explaining the house in-situ was a primer for the participants to consider the contextual influence on their building project. It was manifested in the participants' wish to investigate how their house influenced the environment and vice versa. Building and finally moving into a new house, involves not only getting to know a new location and house, but also getting acquainted with new neighbors. A common matter of dispute deals with how the view from the different windows will be -for instance as one participant recount in the final interview:

> *"When we chose the lot and position of the house, we thought a lot about how the house should be orientated - Will the view be directly into the neighboring bedroom?" [sols88-m]*

The user study revealed how the participant got the opportunity to check how their house would affect the neighbors and vice versa. In a situation, where one participant discovers how close their house will be to the neighbors. He becomes worried, because their bathroom window is directly in front of a big window section in the neighbors living room. Furthermore, it is possible that their house will overshadow the neighbor's living room because of the small distance between the houses. To understand the magnitude of these two issues he first uses *HouseView* to check the view of the living room from their bathroom window. Secondly he walks to the neighbor living room window and looks at the virtual house from this position to see how his house will impact their living room view. Such detailed investigation in context enables owners to consider how specific positions and orientation of a house impact not only the surroundings but also how the surroundings impact the house, thereby aiding owners to make a more responsible decision.

Changing the setting for decision making and visualization, from being in an office to standing on the lot, influences the factors involved in the process. Participants received new ideas to possible solutions to already settled decisions, which forced consideration of the decisions made. This was manifested as the wish to choose a material composition which would fit the context - as one participant mentioned:

> *"I actually think I was confirmed in my choices, when I tried changing the bricks to some of the colors, we had talked about. I compared them to the surroundings and they simply did not work, so clearly our yellow bricks fit better than black" [sols88-m]*

The participant uses the context as a tool to verify decisions. It shows how the couple did not want to be out of line with their neighbors. As newcomers they wanted to fit in.

Others started asking questions about some of their decisions when they noticed different solutions. In most cases this happened when one of the adults was looking at a detail of the house, and mostly about how the roof or some section of windows should be designed. It often happened that, one participant called for the other adult:

> *"Honey, come take a look at this. Should we maybe have used some more money and removed that wall there? The others [buildings around their house] solution looks really smart" [Soe28-m]*

They then continued to discuss their decision back and forth for some time. This shows us how the context can have an effect in the decisions that has to be made. *HouseView* was inspiring the user to change and think about details in and around the house. As a female participant said:

> *"It makes you think about a lot of things, when you can walk around and see the house" [kaer151-f]*

This could for instance be everything from how the garden should look like to where in the living room the plugs for the TV should be placed. The context was inspiring. It helped the participant with placement of windows or how the house should be placed on the lot.

#### Refined Mutual Understanding

The participants got a refined mutual understanding from the fact that *HouseView* gave them a common reference point. *HouseView* facilitated a common understanding between parents, children, friends and family. Several interesting social interactions were identified during testing. Couples called each other over to see what the other person was viewing on the screen and asked for feedback on some change to position or material. It seemed like couples strived to gain an increased common understanding on the ongoing project. Like participants expressed it during the interview:

> *"I could imagine it would make it easier to reach an agreement about details, because you discuss based on the same foundation" [kaer37-m]*
>
> *"The only thing I could have wanted, was to have had this system earlier in the process, as there at that point was many disputed points" [kaer37-m]*

Findings suggest that *HouseView* could possibly be a facilitator for solving conflicts, or at least act as a visualizer to substantiate a claim. Furthermore, as soon as children were presents, the mother involved them by showing where their future room would be and what view they would have. A picture of this can be seen on Figure 5. The children thought it was awesome to see something visual they could relate to. The parents, when asked about it, expressed their happiness about involving their children in something as big as building a house. They spend a lot of time on it, and often the child was just sidetracked along the way.

Another social aspect discovered were the need to present ones house and seek affirmation of their decisions. It became evident that a lot of couples both had presented their building to friends and families and they had tryed the same act themselves. But there was one major problem when showing of a house to others, like one participant explained it:

> *"We have been out with friends to look at their building project. They proudly presented their blueprints at the lot, but it's simply impossible to get more than a vague idea on how it's going to look from that" [kaer151-f]*

*HouseView* was mentioned as a great tool in such situations and several participants asked for the possibility to borrow the system in one way or another. Either to help them make decision later on or to simply present their project to friends.

#### Genuine Dimensional Insight

The physical movement used in *HouseView* gave the participants a more genuine understanding of dimension, by visualizing a building in its actual size. This changes how users are able to interact with and alter the view of the building. A typical setting for visualization, mentioned by the participant, was to sit around a table or in front of a computer looking at blueprints or 3D models. In these settings participants express a lack of reality, because of the challenge of transforming 10 centimeters on a drawing to its actual size of 10 meters in the real world. In general this indicated a missing physical understanding of the size of the house, as a participant revealed:

> *"A 3D house model on a computer screen appear smaller than in the real world" [bir32-m]*

This lack of or wish to gain a better physical understanding of the building is expressed in the results as a common behavior among the male participants. They pace out the size of the house while looking at the blueprint view in *HouseView*, to check how close the house will be to boundaries of the lot. Participants emphasize this aspect of physically walking around the lot as the most important feature to improve their visual understanding, with comments like:

> *"... it was a lot easier to understand when you were in it [the physical surroundings]" [kaer37-m]*
>
> *"... it's great to 'touch' the house with my body" [bir32-m]*

A contradiction to these findings is answers from our questionnaire, where the lowest scoring assertion is: “HouseView gave me a better understanding of dimensions”. This assertion only scored an average of 3.6. We tie this to two different aspects of dimensional understanding. The first, which had worked great in *HouseView*, was the mapping between movement and what was shown on the screen. The second, which was problematic, was the depth perception damaged by a faulty FoV and real world perspective cues.

It was interesting how fast participants grasped the physical interaction form we have chosen for *HouseView*. In just a few minutes of instructions they began walking around investigating the house. Walking around the lot entails contemplating the building from different angles and distances. This induce the problems regarding registration mentioned by Azuma [1]. When testers walked in close proximity of the house, it was observed that problems of this kind was unlikely to occur - but mowing to a greater distance could damage the illusion of walking around a real house, because of mismatch between the size of the surroundings and the house. In these situations participants identified the need for depth cues indication the distance to the house in meters.

## DISCUSSION

In the following we discuss our finding in relation to relevant research. *HouseView* was designed to explore the influence of mobile technologies for doing situated elucidation in the house construction area. A handheld approach of AR was implemented based on the definitions by Azuma [1]. In essence *HouseView* explains the context by visualizing hidden information in-situ, with the same goal as Pedell and Vetere [13]. Where Pedell and Vetere use static images to visualize the contextual influence, *HouseView* use coexisting worlds - letting the user feel the context on his own body [1]. This approach lead to the discovery of both contradiction and verification of others findings associated to aspects like how the registration problem relates to the purpose of use and how visualization in context influence visual comprehension.

Like Junghanns et al. take paper plans of underground infrastructure into the realm of 3D using AR [17]; *HouseView* takes the concept of blueprints and moves them to a three-dimensional understanding. Our findings both contradict and verify the findings of Junghanns et al. on the point of the registration problem [17]. They emphasize the importance of good registration with the expense of photo realism, whereas our participants requested the direct opposite. We tie this finding to a clear distinction in purpose. Where the electrician laying cables want to avoid cutting old lines, the family deciding on the house wants to see how their building fit in. A two meter deviance of placement is not damaging for the family, since their focus is on the major lines. On the contrary; the house extension group expressed the same need of having exact mapping between the real and virtual world. It is hereby the real world depth cues, the existing house, which weaken the believability, as in [17] where the visualization took place in an urban setting with many depth cues.

Based on our findings, we would like to extend the work of Azuma by underlining areas of use where the registration becomes less important. The area of use has central influence on the believability. Using AR in an environment with few depth cues enables the visualization to reach a believable state with little accuracy, as is the case when using a smartphone, because of the limited hardware capabilities. Our findings substantiate this by demonstrating the effectiveness of AR in supporting users comprehend spatial information when using *HouseView* at an open lot, but fell short when visualizing house extensions.

Our findings go hand in hand with the findings presented by Feiner and White in their evaluation of SiteLens [19]. Their system, designed for urban planners, showed how the users found it useful to capture combined images of the physical and virtual scene to create a single “real” image when documenting the lot. *HouseView* findings show the same tendency of excitement of mixing the real and virtual to get a better spatial understanding. We can furthermore make a special emphasis on the physical movement of the user. It was shown that even with AR registration issues; the physical movement was enough to assist the participant with enhanced understanding of the spatial characteristics.

Furthermore, our findings showed another aspect of this enhanced perception. It was discovered that situated elucidation can be used to create a common understanding between couples, friends and children, just like how Battarbee mention “Co-experience” as a major part of digital products [2]. It is an experience that users themselves create together in social interaction, which can be both creative and fun. Battarbee argue that people enjoy the company of each other more than their products, and we tend to agree. *HouseView* was used by parents to create a fun relation to their children, since the visual representation was understandable by both parties. Furthermore the parents had a creative “Co-experience”, by walking around showing each other different visual appearances and discussing possibilities.

This leads to the comparison of situated elucidation to an extended bodystorming. Kankainen et al. argues that bodystorming should be seen as a way of working with data in embodied ways, just like “being there” [12]. While walking around in-situ defiantly can be innovative fruitful, we imagine the use of digital situated elucidation would increase the tangible property of ideas. It could be by the cost of totally new ideas, but we also imagine the use of systems like *HouseView* a bit later in the idea generation process.

## CONCLUSION AND FUTURE WORK

This paper introduce the term Situated Digital Elucidation and address the challenges of elucidating a situated object through mobile technologies. *HouseView*, a mobile AR application, was implemented to do in-situ visualization and thereby seek an elucidation of a construction process. Based on a user study with 40 participants, we found that *HouseView* enhanced the users visual perception, primed the contextual influence, refined their mutual understanding and gave them a genuine dimensional insight. Results in this paper are closely linked to the *HouseView* system. Other aspects could have been analyzed and interpreted in different relations and resulted in different findings. Furthermore, the evaluation is based on many subjective statements and assumptions.

To improve discovered issues with 3D registration, physical markers could possibly remove some inaccuracies in the system. This would introduce the accuracy versus mobility tradeoff. A more precise reading could be achieved, but would require more tools, and therefore be more cumbersome. We acknowledge the need of a bigger screen for visualization of things like buildings. Especially when looking at the visualization process as a social act, a larger screen would be preferred. Solutions are on the horizon with release of Apples iPad and similar systems like WePad and Gemini. To investigate the impact of *HouseView* in regards to decision making in the building process a longitudinal study could be beneficial. Several germs of decision changes were found in our user study, but the short-range nature made it impossible to investigate the outcome of these findings. A deeper insight into this social co-experience created by *HouseView* would be fruitful for future visualization designs.

**ACKNOWLEDGEMENT**

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APPENDIX

# C

# PHOTOWORLD SCREENSHOTS

In this section we illustrate the different views in the *PhotoWorld* application, that the user can encounter when using it.

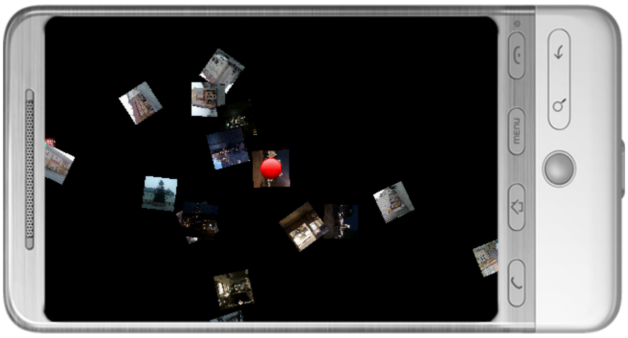


Figure C.1:
**Compass View**
Screenshot of the Compass View at the maximum zoom level. The red dot is the user's position. The images position around the red dot indicates in what direction from the user the image is located. The rotation of the image indicated whether the image is orientated towards the user or away from the user.

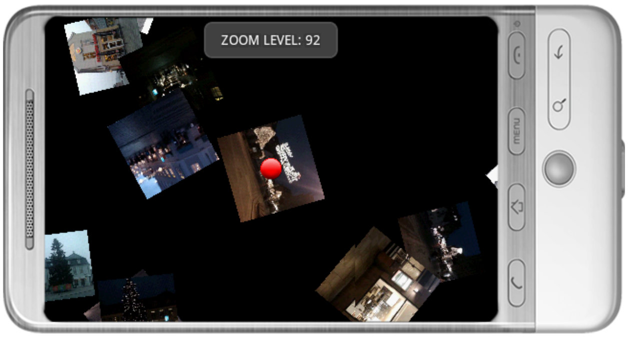



Figure C.2:
**Compass View**
Zooming in the Compass view at 92% zoom where the maximum is 100%.

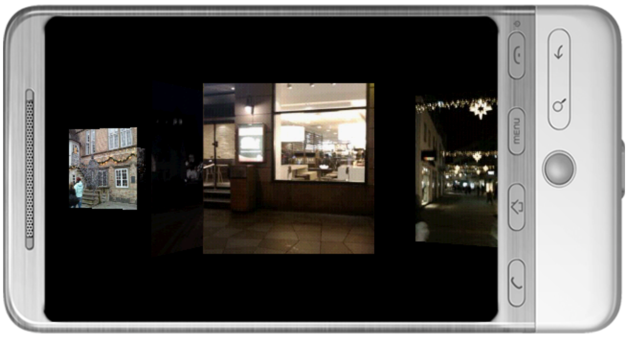


Figure C.3:
**Panorama View**
Three images displayed in Panorama View. The size of the images indicates the distance from the user to the image. The orientation of the images indicate at what angel the image was captured according to the users position.

Figure C.4:
**Panorama View**
This screenshot is taken at the same place at the above image, but at a different direction.

APPENDIX

# D

## HOUSEVIEW SCREENSHOTS

In this section we illustrate the different views in the *HouseView* application, that the user can encounter when using it. There are several different types of materials on a house, that the user can change, but in this section we will only show how to change the wall texture. It is the same procedure when changing other types of textures of a house model.


Figure D.1: The splash screen in *HouseView*. The first thing the user sees after he starts the application.


Figure D.2:
**Model selection view**
After the splash screen the user is prompted to choose a house model. The user can select a house model by sliding left or right until he finds at house he wants to see. When the user has found the model he wants to view he can click the “Vælg hus” button to start loading the model.


Figure D.3:
**Loading screen**
Loading the model, this can take some time.

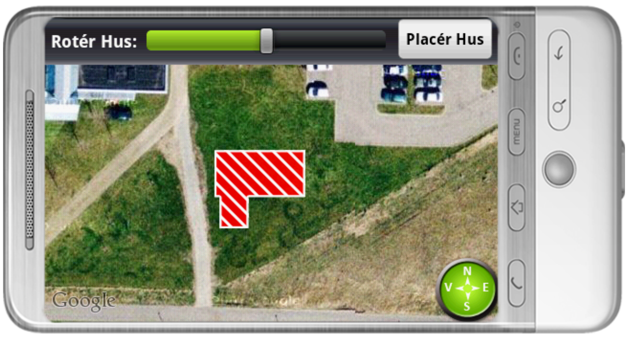



Figure D.4:
**Placement View**
When the model is loaded the user is prompted to select the placement and rotation of the house. The placement of the house is selected by clicking on the map. In the top of the screen the user can select the rotation of the house by moving the bar left or right.

Figure D.5:
**3D View: Outside**
When the placement and rotation have been selected the user is presented in 3D.

Figure D.6:
**3D View: Outside**
The user can inspect the house from the outside like shown on this photo.

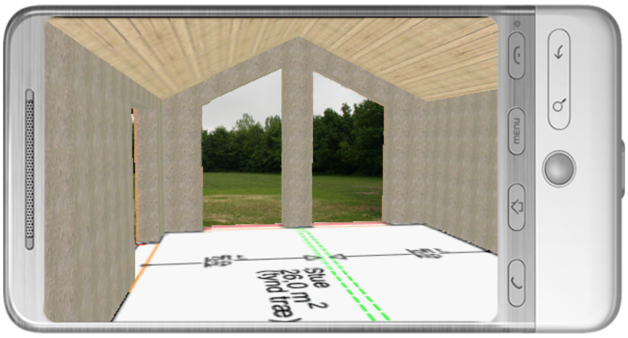


Figure D.7:
**3D View: Inside**
The user is free to explore the house. This is a photo from inside the house looking out of the big windows.

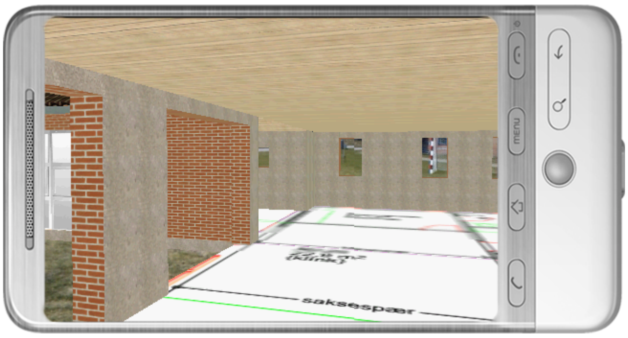


Figure D.8:
**3D View: Inside**
In this house model there is no inside walls. Our software can easily handle inside walls, but because of the hardware limitations we have decided not to add them.

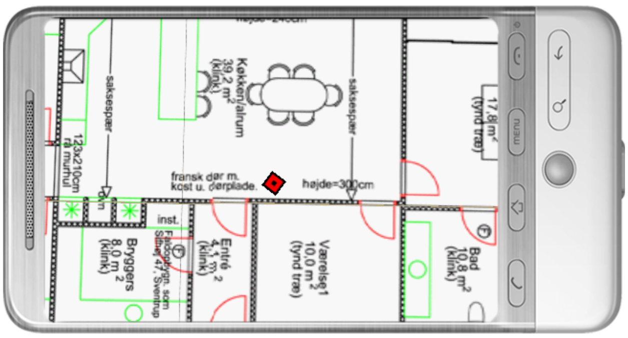


Figure D.9:
**Blueprint View**
When inside the house the user can look down and see a blueprint of the house. The red dot is the user's location inside the house. If the user starts moving around in the house, the dot will move with him.


Figure D.10:
**Main Menu**
The menu is displayed on top of the 3D View. In the menu the user can chose the materials on the house, change the house models or move/rotate the house.


Figure D.11:
**Matireal View**
In this view the user can change the materials on the house. The user can browse the materials by sliding right or left on the screen. When the user has found the materials he wants to see, the user have to click on it to change it. There is a material view for each type of material.


Figure D.12:
**Matireal View Dialog**
When the user has selected the material he wants to see this view is displayed. The user is presented with some information about the material. The user can either select the material or go back to the material view.

Figure D.13:
**3D View: Outside**
Close up of the bricks after the material has been changed.

APPENDIX

# E

# USER STUDY - PHOTOWORLD

## E.1 Participants

In this section a shot description of the participants in the user study of *PhotoWorld* can be found.

### Participant 1

ID: 1

Tidspunkt: 17:00
Startlokation: Uden for studenterhuset

Test leader: Glen
Observer: Michael

Alder: 24
By:Aalborg?
Beskæftigelse: Student

### Path

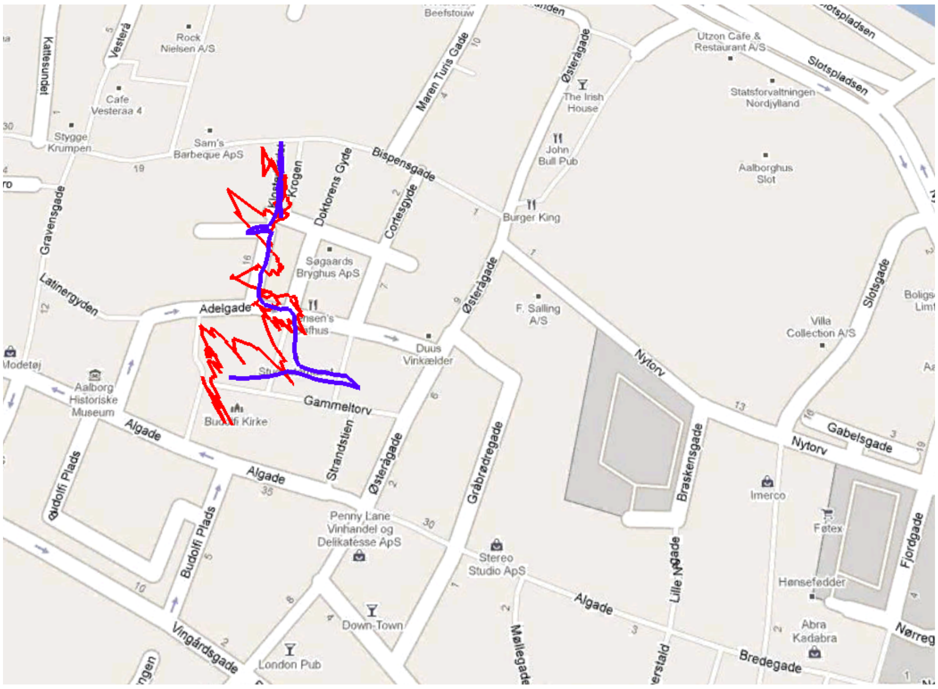



Figure E.1: Red = GPS path , Blue = true path

## Participant 2

ID: 2

Tidspunkt: 17:00 8/12 2009
Startlokation: Burger King nytorv

Test leader: ST
Observer: KP

Alder: 26
By: Aalborg
Beskæftigelse: Research Assistant

### Path

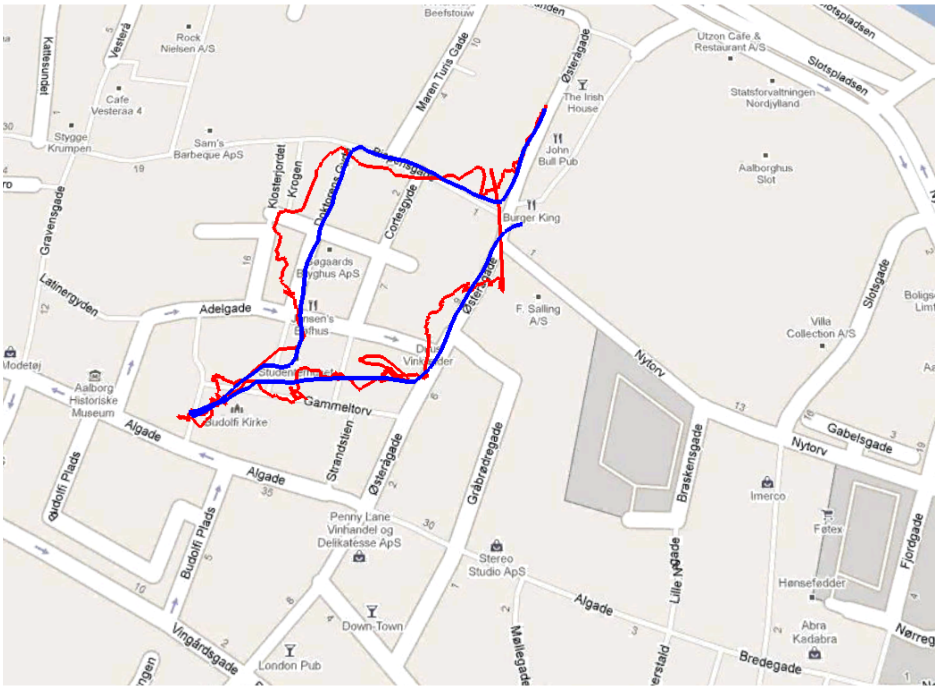



Figure E.2: Red = GPS path , Blue = true path

### Participant 3

ID: 3

Tidspunkt: 8. december 17:00
Startlokation: Ved siden af Aalborg Slot

Teat leader: Jacob Nørskov
Observer: Niels Husted

Alder: 26
By: Shiraz
Beskæftigelse: Studerende

### Path

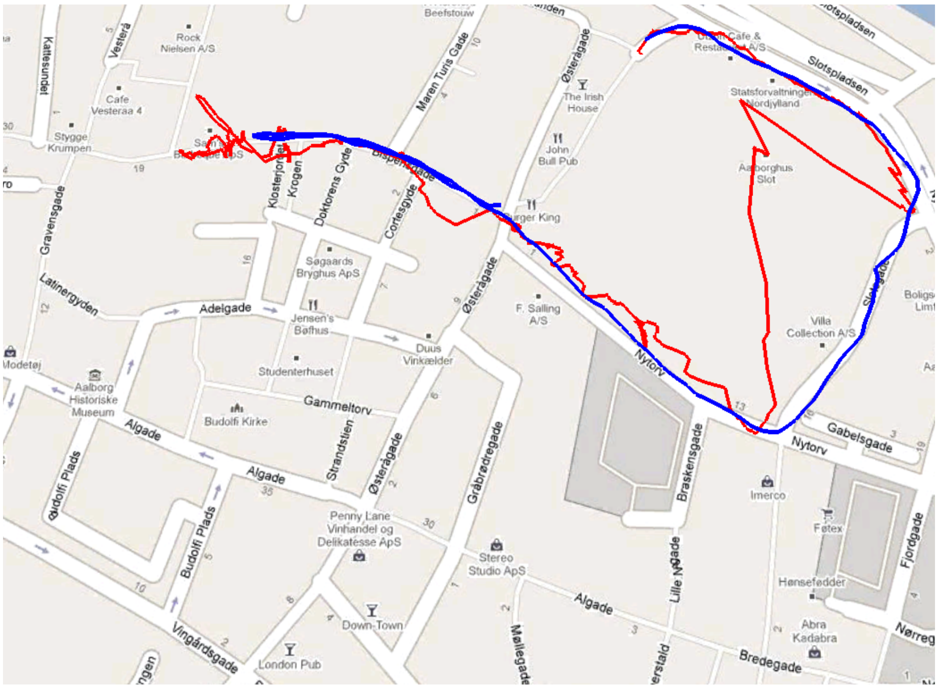



Figure E.3: Red = GPS path , Blue = true path

### Participant 4

ID: 4

Tidspunkt: 9:00 9/12 2009
Startlokation: Burger king

Teat leader: ST
Observer: KP

Alder: 26
By: Aalborg
Beskæftigelse: Student

#### Path

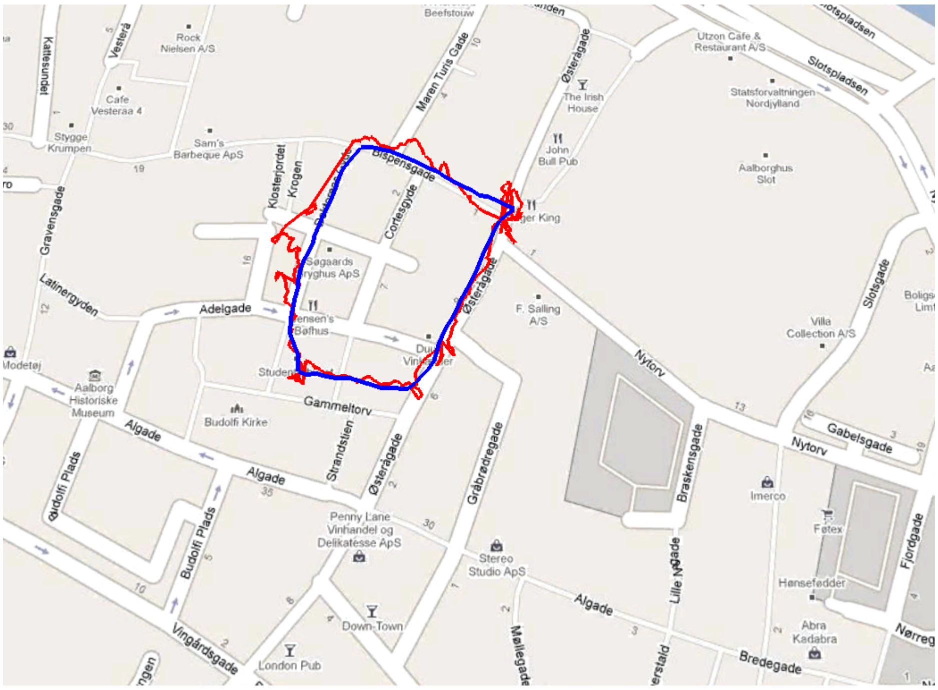



Figure E.4: Red = GPS path , Blue = true path

### Participant 5

ID: 5

Tidspunkt: 9.12.2009 kl 15:00
Startlokation: Burger King

Teat leader: Glen
Observer: Michael

Alder: 25
By: Aalborg
Beskæftigelse: Studerende

### Path

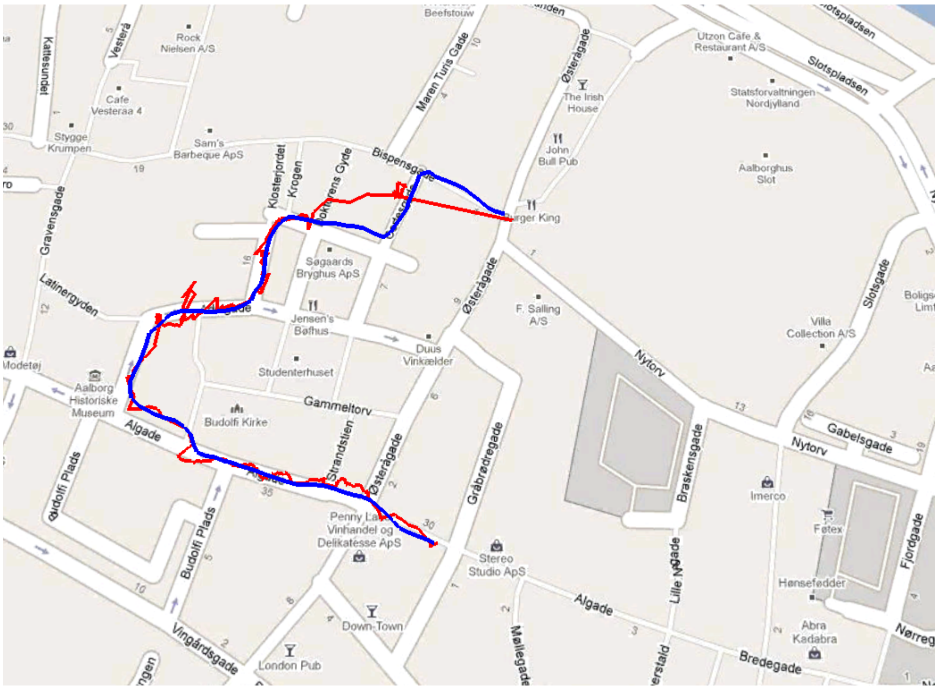



Figure E.5: Red = GPS path , Blue = true path

### Participant 6

ID: 6

Tidspunkt:13. december 16:00
Startlokation: Burger king

Teat leader: Glen
Observer: Michael

Alder: 23
By: Aalborg
Beskæftigelse: Studerende

#### Path

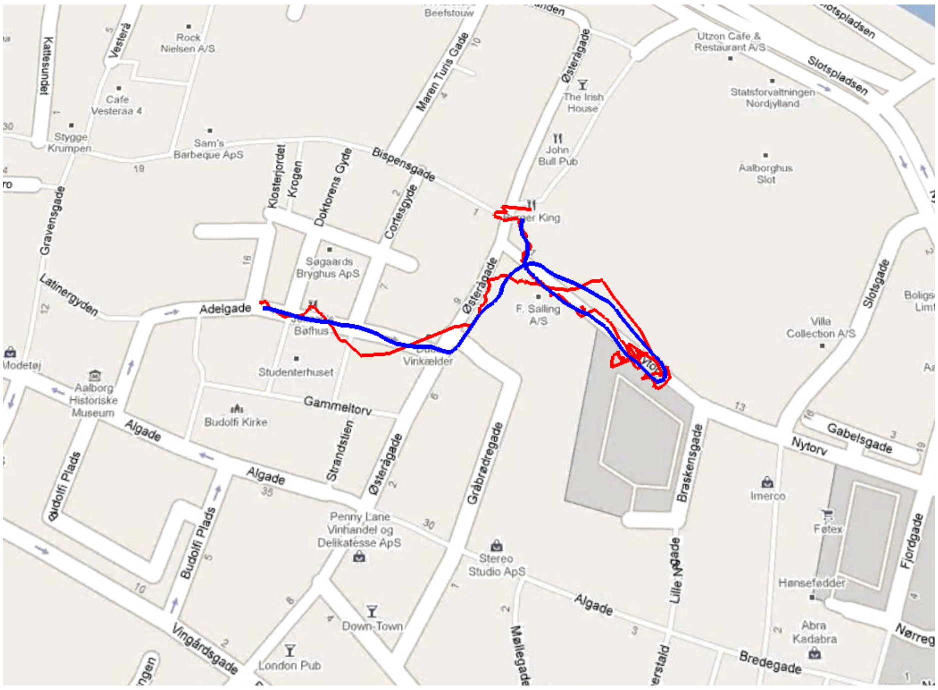



Figure E.6: Red = GPS path , Blue = true path

### Participant 7

ID: 7

Tidspunkt: fredag 11. december 12.00
Startlokation: Burger King

Teat leader: Niels
Observer: Jacob

Alder: 20
By: Aars
Beskæftigelse: AAU BA

### Path

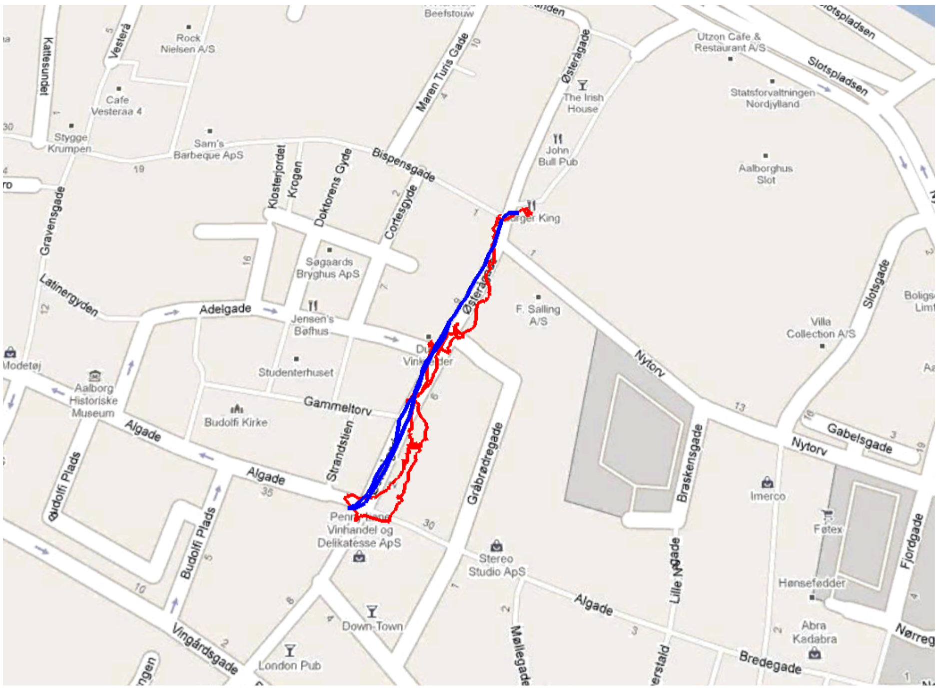



Figure E.7: Red = GPS path , Blue = true path

### Participant 8

ID:8

Tidspunkt: 11. december 11:05
Startlokation: Budolfi

Teat leader: Glen
Observer: Michael

Alder: 50
By: Fredericia
Beskæftigelse: Kontorass.

#### Path

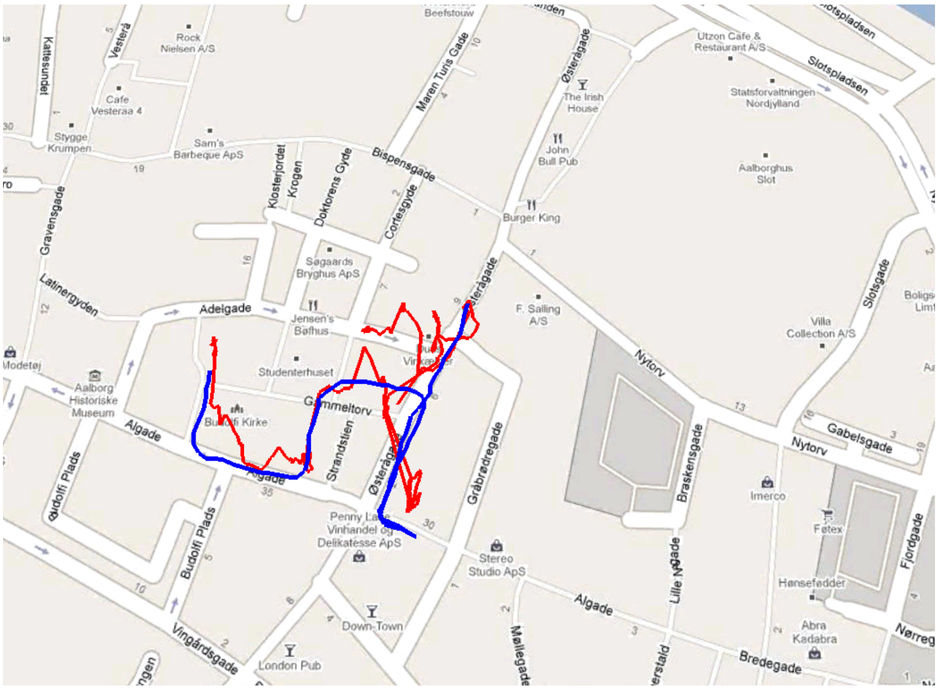



Figure E.8: Red = GPS path , Blue = true path

### Participant 9

ID: 9

Tidspunkt: Fredag d. 11 kl. 12.00
Startlokation: Burgerking

Teat leader: Søren
Observer: Kenneth

Alder: 19
By: Aalborg
Beskæftigelse: Studerende

### Path

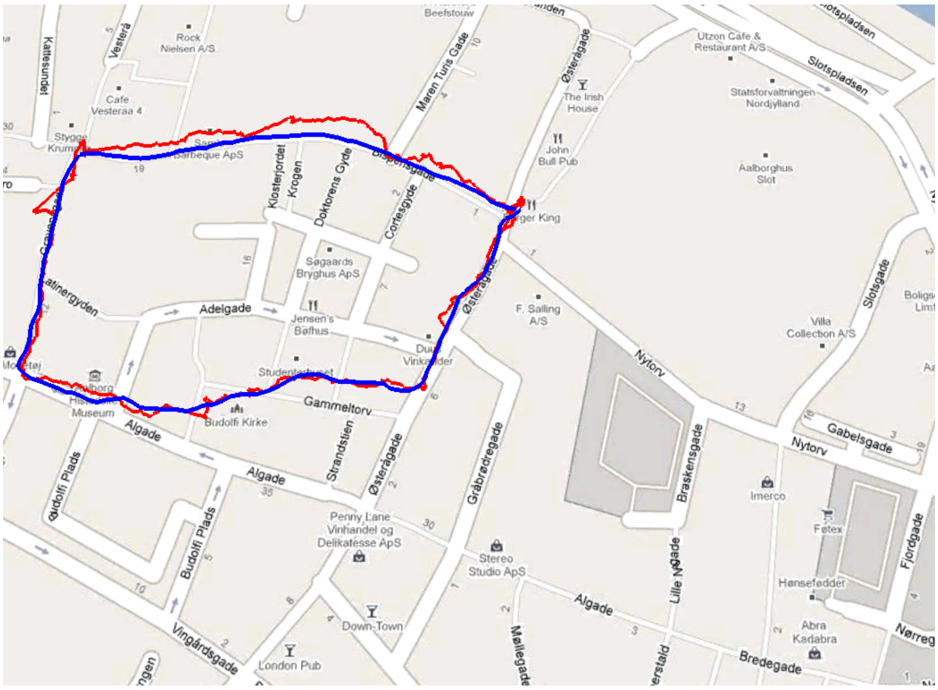



Figure E.9: Red = GPS path , Blue = true path

### Participant 10

ID: 10

Tidspunkt: Fredag d. 11 Dec. kl 11:00
Startlokation: Burger king

Teat leader: NH
Observer: JN

Alder: 24
By: Aalborg
Beskæftigelse: Fysioterapoit

#### Path

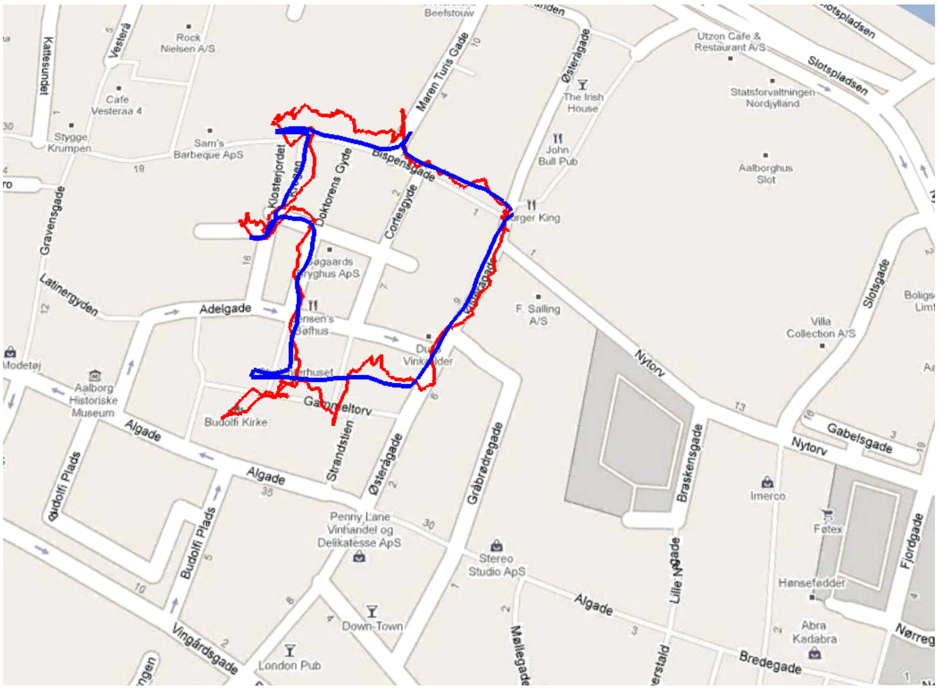



Figure E.10: Red = GPS path , Blue = true path

### Participant 11

ID: 11

Tidspunkt: Fredag d. 11. december 12:00
Startlokation: Burger King

Teat leader: Glen
Observer: Michael

Alder: 20
By: Aalborg
Beskæftigelse: Studerende

### Path

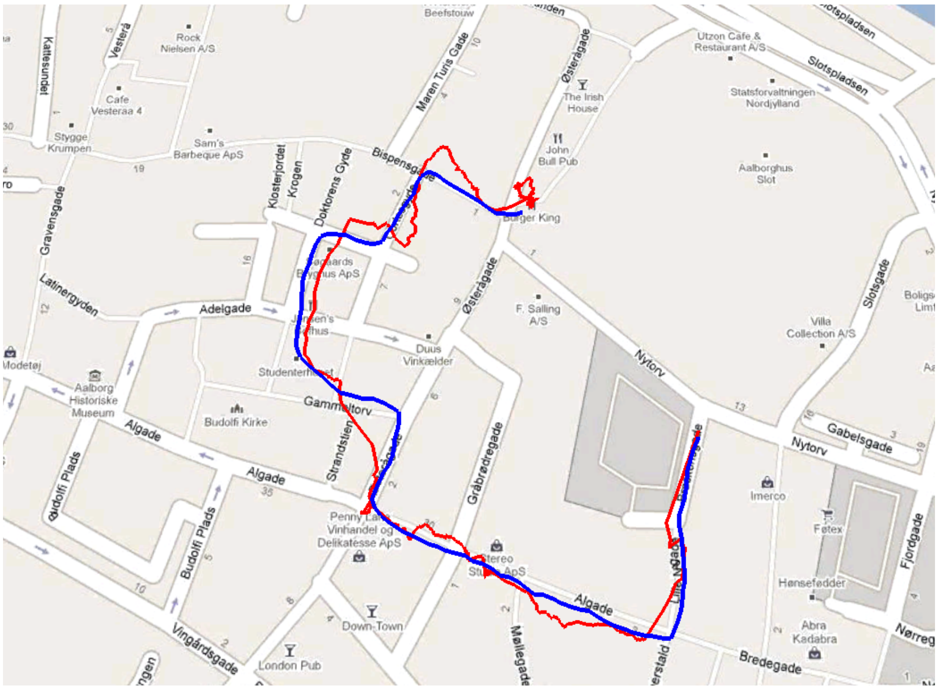



Figure E.11: Red = GPS path , Blue = true path

## E.2 User Study Introduction

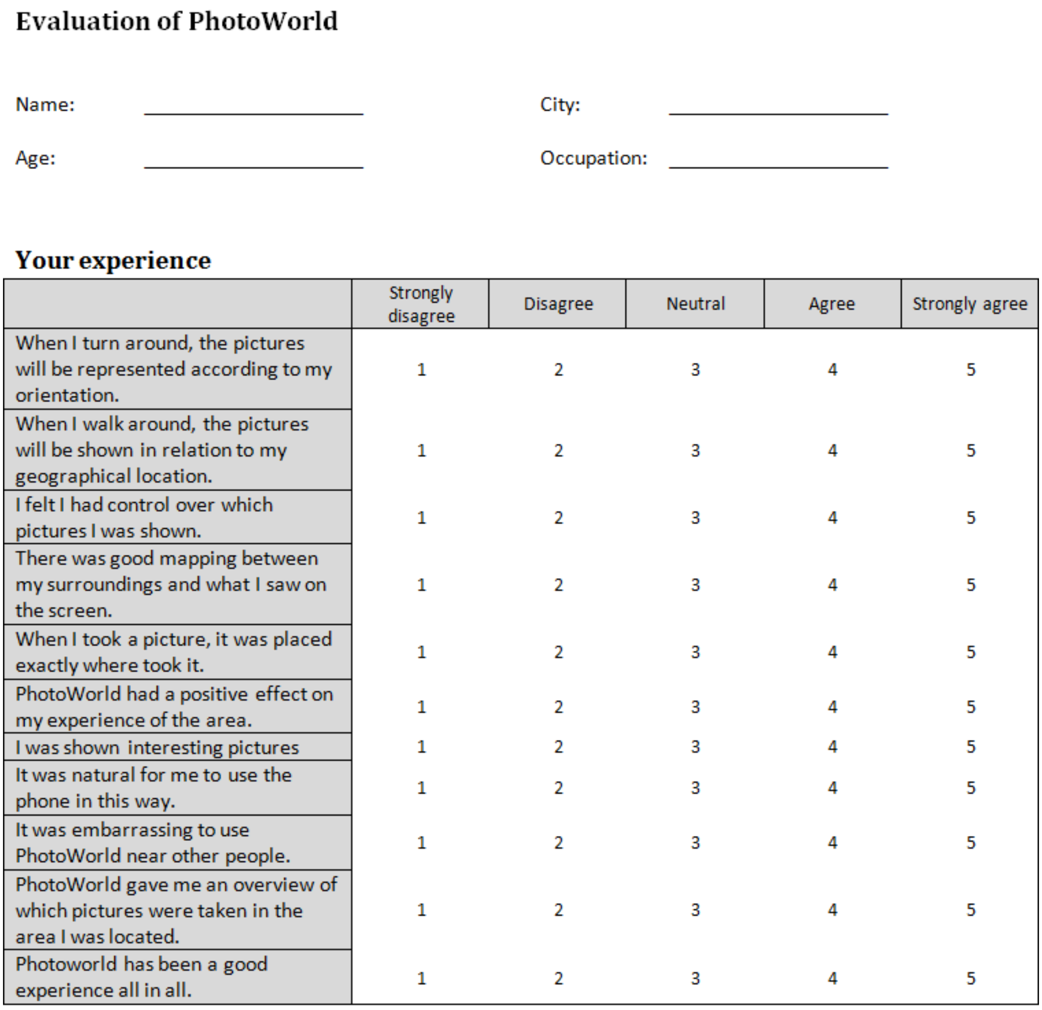
### Introduction GB

You have roughly twenty minutes you want to use to explore the city of Aalborg. You have got hold of this new application for your phone, which makes it possible to see photographs taken by others exactly where you are walking. We want you to freely explore the possibilities of this new application. Feel free to walk around as you like and look at pictures that may interest you. You choose you own path based on what you find interesting in the city. We encourage you to contribute with more images by taking some yourself through the application. We encourage you to "think aloud" as much as possible. We will walk with you and ask questions once in a while, but please do not hesitate to comment on anything you may experience. Remember, it is not you we are testing. It is the phone application. You will now get a short presentation to the actual application running on the phone.

### Introduktion DK

Du har cirka 20 minutter du gerne vil bruge på at udforske Aalborg. Du har fået en ny applikation på din telefon, som gør det muligt at se billeder taget af andre når du er i nærheden af hvor de er taget. Vi vil gerne have dig til frit at udforske hvordan denne applikation virker. Gå frit rundt, som du har lyst til, og se de billeder der er taget. Du vælger helt selv din rute, baseret på hvad du finder interessant i byen. Vi vil opfordre dig til at bruge applikationen til at tage dine egne billeder til systemet undervejs. Vi vil opfordre dig til at "tænke højt" så meget som muligt. Vi vil følge dig på turen rundt og stille dig spørgsmål en gang imellem. Tøv ikke med at kommentere på hvad du oplever. Husk, det er ikke dig vi tester, men applikationen. Du vil nu få en kort præsentation af applikationen.

## E.3 Likert Scale Questionnaire



**Evaluation of PhotoWorld**

Name: ____________________ City: ____________________

Age: ____________________ Occupation: ____________________

**Your experience**

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| When I turn around, the pictures will be represented according to my orientation. | 1 | 2 | 3 | 4 | 5 |
| When I walk around, the pictures will be shown in relation to my geographical location. | 1 | 2 | 3 | 4 | 5 |
| I felt I had control over which pictures I was shown. | 1 | 2 | 3 | 4 | 5 |
| There was good mapping between my surroundings and what I saw on the screen. | 1 | 2 | 3 | 4 | 5 |
| When I took a picture, it was placed exactly where took it. | 1 | 2 | 3 | 4 | 5 |
| PhotoWorld had a positive effect on my experience of the area. | 1 | 2 | 3 | 4 | 5 |
| I was shown interesting pictures | 1 | 2 | 3 | 4 | 5 |
| It was natural for me to use the phone in this way. | 1 | 2 | 3 | 4 | 5 |
| It was embarrassing to use PhotoWorld near other people. | 1 | 2 | 3 | 4 | 5 |
| PhotoWorld gave me an overview of which pictures were taken in the area I was located. | 1 | 2 | 3 | 4 | 5 |
| Photoworld has been a good experience all in all. | 1 | 2 | 3 | 4 | 5 |

Figure E.12: Likert scale questionnaire page 1

### Views

The questions below ask you to consider the following views:

- **Compass-view** is shown on the screen when the phone is held flat with the screen facing directly upwards and you see the pictures from above.
- **Panorama-view** is shown when you hold the phone up in front of you and the pictures are shown in 3D.

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| I prefer to use the panorama-view compared to the compass-view. | 1 | 2 | 3 | 4 | 5 |
| I could easily understand the placement of pictures in the panorama-view. | 1 | 2 | 3 | 4 | 5 |
| The pictures placement corresponded to where I would expect them to be placed in the real world. | 1 | 2 | 3 | 4 | 5 |
| I could easily understand the view angle of the pictures in the panorama-view. | 1 | 2 | 3 | 4 | 5 |
| In the panorama-view, the pictures were smaller the more distant they were from me. | 1 | 2 | 3 | 4 | 5 |
| It made sense to switch between compass and panorama-view by tilting the phone up and down. | 1 | 2 | 3 | 4 | 5 |

Figure E.13: Likert scale questionnaire page 2

## E.4 Semi-structured Interview

### Interview

Kendskab til Aalborg: ____________________

Erfaring med trykfølsom skærm: ____________________

Bruger telefon til at tage billeder med?: ____________________

Bruger nettet via tlf.: ____________________

Har før set fotos på Google Maps eller lignende: ____________________

Lagde du mærke til at der var nogle billeder som forsvandt og hvorfor tror du at de forsvandt?

Hvad viser rotationen af billederne? Synes du denne rotation giver mening?

Hvad afgjorde hvor du gik hen? Interessante billeder? "stierne" på kompas-visning? Systemet?

Var der nogle bestemte billeder du fandt specielt interessante?

Kunne du se dette system brugt i en anden sammenhæng?

Spørg ind til hvilken indflydelse kvaliteten/interessen i billederne har haft på oplevelsen?

Figure E.14: Semi-structured Interview questions

## E.5 Logging

In this section an example of how the log files looked can be seen. From these files the maps of the user GPS paths have been generated.

```
08/12 14:30:45 Log running!
08/12 17:05:16 #   57.04793572425842 9.919270277023315 Yaw:15
08/12 17:05:17 #   57.04802691936493 9.91917371749878 Yaw:18
08/12 17:05:18 #   57.04802691936493 9.91917371749878 Yaw:24
08/12 17:05:19 #   57.04805910587311 9.91913616657257 Yaw:16
08/12 17:05:21 #   57.04803764820099 9.91915762424469 Yaw:355
08/12 17:05:22 #   57.04805910587311 9.919125437736511 Yaw:327
08/12 17:05:23 #   57.04808592796326 9.919093251228333 Yaw:305
08/12 17:05:24 #   57.04808592796326 9.919093251228333 Yaw:236
08/12 17:05:25 #   57.0480215549469 9.91915762424469 Yaw:195
08/12 17:05:26 #   57.04803228378296 9.919130802154541 Yaw:205
08/12 17:05:27 #   57.04803228378296 9.919130802154541 Yaw:214
08/12 17:05:28 #   57.0480215549469 9.9191415309906 Yaw:214
08/12 17:05:29 #   57.04804301261902 9.919114708900452 Yaw:215
08/12 17:05:30 #   57.04804301261902 9.919114708900452 Yaw:224
08/12 17:05:31 #   57.04806447029114 9.919087886810303 Yaw:199
08/12 17:05:33 #   57.0480751991272 9.919071793556213 Yaw:234
08/12 17:05:34 #   57.0480751991272 9.919071793556213 Yaw:237
08/12 17:05:34 Device horizontal
08/12 17:05:35 #   57.04809129238129 9.919050335884094 Yaw:239
   .
   .
   .
08/12 17:06:00 #   57.048123478889465 9.919023513793945 Yaw:110
08/12 17:06:01 Device vertical
08/12 17:06:01 #   57.048096656799316 9.919061064720154 Yaw:37
08/12 17:06:02 #   57.04808592796326 9.919071793556213 Yaw:50
08/12 17:06:03 #   57.04808592796326 9.919071793556213 Yaw:23
08/12 17:06:05 #   57.04808592796326 9.919071793556213 Yaw:41
08/12 17:06:06 #   57.04808592796326 9.919071793556213 Yaw:49
08/12 17:06:07 #   57.04805374145508 9.919098615646362 Yaw:37
08/12 17:06:08 Showing menu
08/12 17:06:08 #   57.04801619052887 9.919120073318481 Yaw:13
08/12 17:06:09 #   57.04805374145508 9.919077157974243 Yaw:8
08/12 17:06:10 Capture view loaded
08/12 17:06:15 Trying to take a picture
08/12 17:06:17 Picture saved
08/12 17:06:18 Is in 3D view
08/12 17:06:19 #   57.04794645309448 9.919200539588928 Yaw:10
08/12 17:06:20 #   57.04794645309448 9.919200539588928 Yaw:1
08/12 17:06:21 #   57.04794645309448 9.919200539588928 Yaw:359
08/12 17:06:22 #   57.04794645309448 9.919200539588928 Yaw:15
```

## E.6 Overview maps

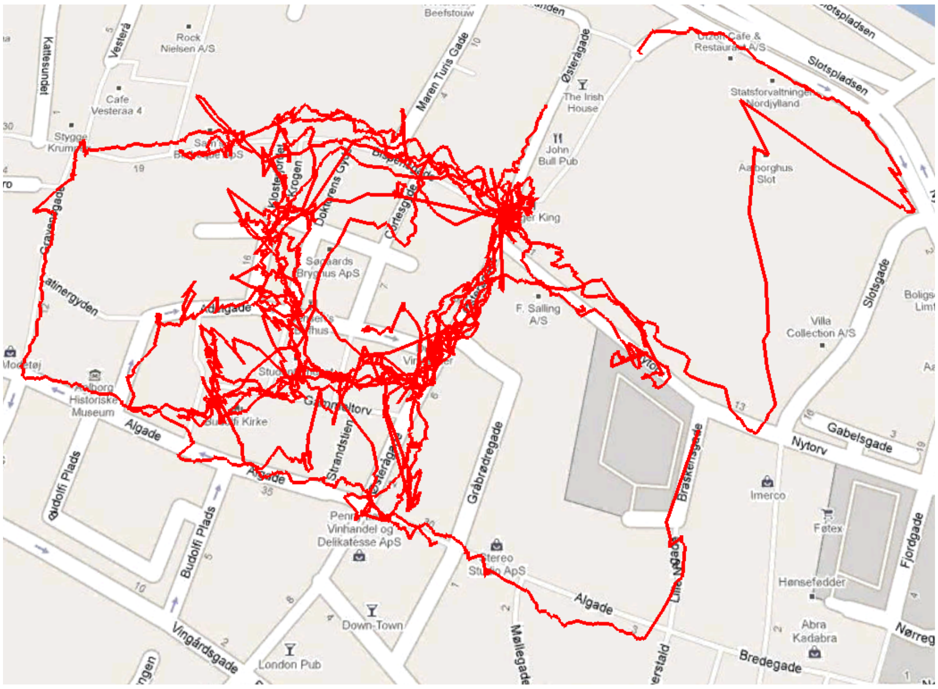



Figure E.15: GPS paths

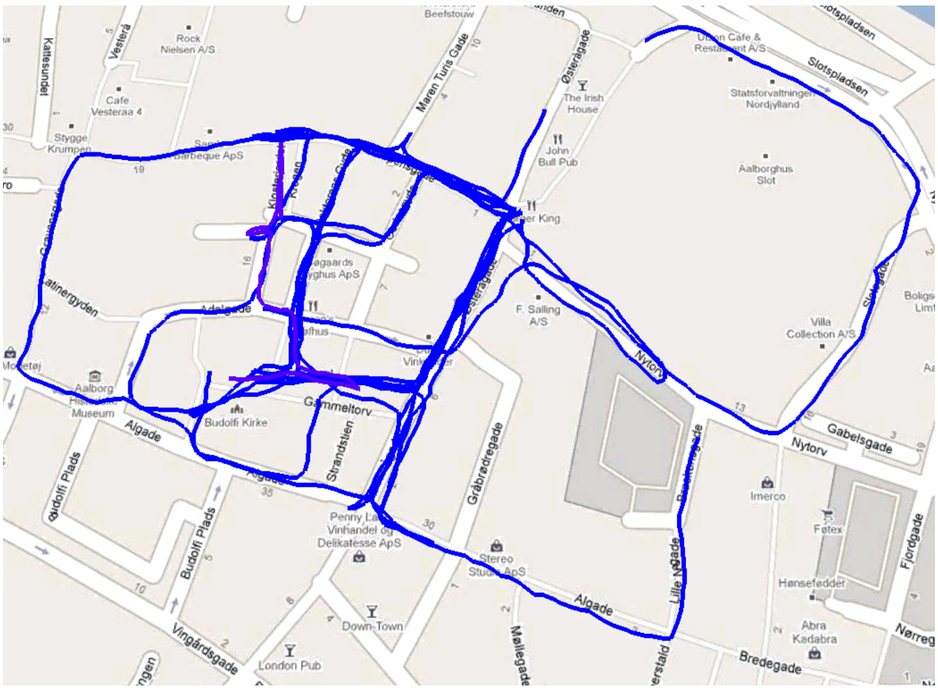



Figure E.16: True paths

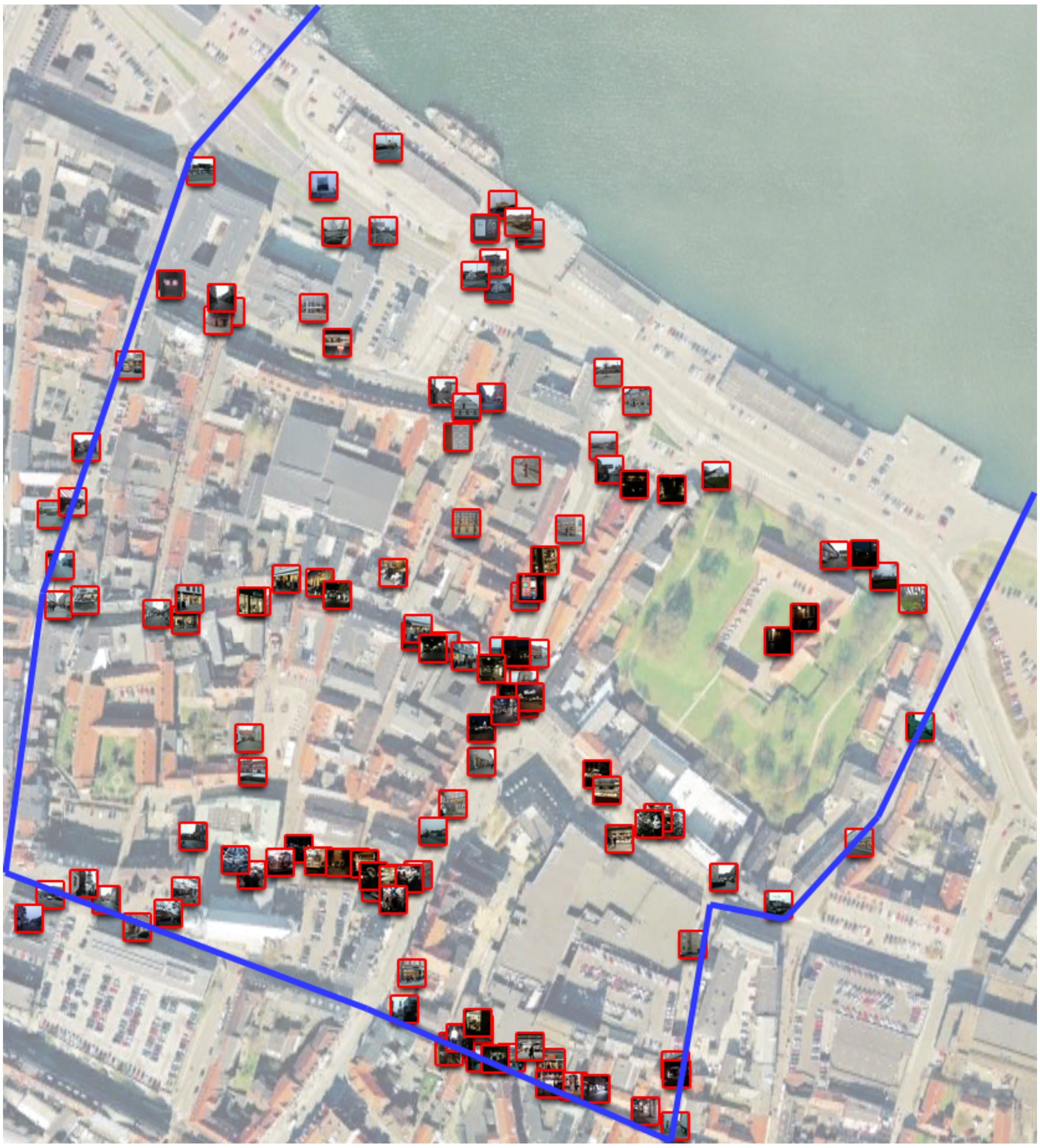


Figure E.17: Test area and test photos.

## E.7 Grounded Analysis

### Open Coding

## Ønsker at se større billeder

| | |
|---|---|
| 1 | Trykker på skærmen og tager telefonen tættere på hovedet |
| 1 | Prøver at zoome i 3D viewet ligesom i 2d view |
| 1 | Klikker på skærmen, sandsynligvis for at zoome |
| 1 | Vil gerne kunne zoome ind på sit billede |
| 3 | Han bruger zoom på top view, men brokker sig lidt over at billeder er for små. Han vil godt kunne se billederne i større format. |
| 3 | Zoom i panoramo view manglede. |
| 3 | Ønskede at kunne se billeder i full-screen ved at klikke på dem. |
| 3 | Det var tydeligt personen konstant gerne ville tættere på billederne. Når han var i kompas view blev han ved med zoome ind, men virkede irriteret over den zoomede imod den røde prik og ikke imod det billede han ville se. Det samme skete i panorama, hvor han flere gange ville zoome mod et billede imens han stod stille. |
| 4 | TP ”Kan jeg se de billeder er langt væk?” – han vil gerne kunne se et billede er langt i større format. |
| 4 | Zoom funktion til panoramaview (han prøvede at zoome nogle gange under testen) |
| 5 | Billeder i kompas-visning var for små. Når man zoomer ind kan man kun se de billeder der er tæt på i stort, og derfor mister man overblikket. Så der er ingen grund til at zoome ind. |
| 6 | Forsøger at zoome i 3D viewet |
| 8 | Vil gerne kunne forstørre enkelte billeder, uden at skulle helt hen til det. |
| 9 | ”Kan man vælge et billede?” TP vil gerne se det i stort. |
| 9 | TP: Jeg vil gerne kunne vælge billederne, så jeg kan se dem større. |
| 10 | Prøver at zoome med 2 fingre (iPhone style) |
| 10 | Kan ikke forstå billederne ikke kan blive større |
| 10 | Zoom manglede rigtig meget. Det blev forsøgt rigtig mange gange |
| 10 | De små billeder i 2D view er alt for små bliver der givet udtryk for. |
| 11 | Billeder er meget små |
| 11 | PhotoWorld gav mig et godt overblik... Størrelsen var for lille. Vil gerne kunne zoome ind på enkelte billeder. |

## Forventer at kunne interagere ved at klikke på skærmen

| | |
|---|---|
| 1 | Trykker på skærmen for at vælge billede |
| 1 | Klikker på skærmen, sandsynligvis for at zoome |
| 3 | Prøver at flytter billederne med hans finger i pan view |
| 3 | Ønskede at kunne se billeder i full-screen ved at klikke på dem. |
| 4 | TP ”Kan jeg se de billeder er langt væk?” – han vil gerne kunne se et billede er langt i større format. |
| 6 | Forsøger at zoome i 3D viewet |
| 9 | ”Kan man vælge et billede?” TP vil gerne se det i stort. |
| 10 | Prøver at zoome med 2 fingre (iPhone style) |
| 11 | Trykker på billedet på skærmen |

## Ønsker at se billeder der ikke er på nuværende gps-position

| | |
|---|---|
| 3 | Prøver at flytter billederne med hans finger i pan view |
| 4 | TP ”Kan jeg se de billeder er langt væk?” – han vil gerne kunne se et billede er langt i større format. |
| 4 | Mulighed for at flytte centrum/prikken so der kan zoomes mere ud men stadigvæk se billederne i |

| | |
|---|---|
| | rimelig størelse |

## Ønsker bedre overblik 2D view

| | |
|---|---|
| 3 | Han ønskede en større radius i compas view. |
| 4 | TP ”Kan jeg se de billeder er langt væk?” – han vil gerne kunne se et billede er langt i større format. |
| 5 | Billeder i kompas-visning var for små. Når man zoomer ind kan man kun se de billeder der er tæt på i stort, og derfor mister man overblikket. Så der er ingen grund til at zoome ind. |
| 8 | Går ad nye / alternative veje, for at finde et bestemt billede |
| 8 | Synes at hun mangler gader i 2D viewet, for at kunne finde rundt i omgivelserne |
| 11 | Kort under billedet mangler, til at finde rundt |

## Forventer flere billeder

| | |
|---|---|
| 4 | TP fortsætter med panorama visning – drejer rundt om sig selv, og opdager at der ikke er billeder over alt. ”Hvorfor er det ikke billeder over alt?” |
| 4 | TP finder noget virkeligt, som han gerne vil se billeder af, men der er ikke nogen (Gammel bygning). |
| 5 | Undrer sig over der ikke er taget nogle billeder af budolfi kirken |
| 9 | Spørg ind til hvilken indflydelse kvaliteten/interessen i billederne har haft på oplevelsen? Der skulle være flere billeder. |

## Går målrettet efter bestemte billeder

| | |
|---|---|
| 1 | Beslutter sig for at finde stedet hvor et bestemt billede er |
| 1 | Leder igen efter et bestemt billede |
| 2 | Går mod et billede, under bevægelse anvendes kompas visning |
| 2 | Var der nogle bestemte billeder du fandt specielt interessante? Han så et billede af en karusel og gik der hen for at se den. Han kunne lide billederne hvor man kunne se inde i bygninger |
| 3 | Efter det går op for test personen hvad det går ud på begynder han er gå meget målrettet mod de billeder han kunne se i topview |
| 8 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Gik mod det nærmeste billeder. |

## Går på opdagelse i billeder (leder ikke efter noget bestemt)

| | |
|---|---|
| 1 | Ser ud som hun går på opdagelsestur i omgivelserne |

## Ruten bestemmes efter populære steder

| | |
|---|---|
| 4 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Populære steder (gågaden og budolfi) |
| 11 | Var der nogle bestemte billeder du fandt specielt interessante? Genkendelige billeder. (genkendelig på trods af størrelsen) |

## Ankommer til bestemt sted, og udforkser området uden tlf.

| | |
|---|---|
| 2 | Har nu fundet pariserhjulet og de andre jule ting der: bruger ikke telefonen nu, men ser sig i stedet bare omkring. |

## Ankommer til bestemt sted, ønsker at se billeder af stedet, men der er ingen

| | |
|---|---|
| 4 | TP finder noget virkeligt, som han gerne vil se billeder af, men der er ikke nogen (Gammel bygning). |

| | |
|---|---|
| 5 | Undrer sig over der ikke er taget nogle billeder af budolfi kirken |
| 8 | Leder efter et billede af kirken og undrer sig over der ikke er noget billede af kirken |

## Forsøger at forstå billeder ud fra virkeligheden

| | |
|---|---|
| 1 | Billedet er for lille og det ligner hun har svært ved at se hvad det er, i det at hun forsøger at finde ud af hvad det forestiller i omgivelserne |
| 1 | Hun udforsker området hvor billederne er taget, for at finde ud af hvad det lige præcis er taget af |
| 6 | Hun ville gerne have en mere naturlig placering af billedet, altså det kan være svært at gennemskue når billedet er placeret hvor det er taget og ikke af det der er taget af. |

## Finder hen til et billede i 2D view, ser nærmere på det i 3D view

| | |
|---|---|
| 1 | Hun beslutter sig for at finde et af de billeder hun kan se i 2D viewet, i 3D viewet |
| 2 | Vil forsøge at se et billede i panorama, holder derfor telefonen op og forsøger at se billedet lige på. |

## Udforsker området i 3D-view

| | |
|---|---|
| 1 | Bruger 3D viewet til at gå på "opdagelse" |
| 2 | Står stille og prøver at finde billeder med panorama visning. |
| 4 | TP følger efter billederne i panorama visning. |
| 4 | >>TP søger efter billeder i panorama visning igen.<< Han vælger nu at gå i en retning hvor der rent faktisk ikke var billeder på skærmen. |
| 4 | TP benytter stadig kun panorama visning. |
| 5 | 2Dview bliver brugt til hurtigt overblik og navigering. 3Dview bliver brugt til at se billederne i stort samt at navigere |
| 5 | Bruger 3Dview til at "lede" efter hvor billederne er. |

## Forstår IKKE sammenhæng mellem vinkling og viste billeder

| | |
|---|---|
| 1 | >>Spørger meget ind til hvordan man skal forstå vinkel<< og finde billederne hun kan se i 2D viewet |
| 1 | Mener at have gennemskuet rotationen i 3D. Det er dog ikke helt rigtigt. Hun troede at de vinklede billeder "pegede" i den retning billederne befandt sig, hvilket er en misforståelse. |
| 3 | Lagde du mærke til at der var nogle billeder som forsvandt og hvorfor tror du at de forsvandt? Testpersonen mente billederne forsvandt når han skiftede retning. |
| 5 | Kigger om hjørner efter billeder |
| 5 | Hvad viser rotationen af billederne? Synes du denne rotation giver mening? Synes at rotationen af billederne gav mening. Lød til at testpersonen mente at billederne vendte efter hvorfra man så dem, og ikke at de havde en fast placering. Tespersonen udtalte noget i denne stil: "De vendte sig i forhold til gps'en og ikke i forhold til nord. Det er man vant til fra andre gps'er" |
| 6 | Hun undrer sig over hvorfor hun ikke kan se billederne fra 2D i 3D. Billeder var taget i en retning mod hende |
| 6 | Hvad viser rotationen af billederne? Synes du denne rotation giver mening? Rotationen viser vej til billeder. "Peger" over mod billedet. |
| 8 | Lagde du mærke til at der var nogle billeder som forsvandt og hvorfor tror du at de forsvandt? TP gjorde udtryk for at det udelukkende var placeringen der bestemte om billederne blev vist. |
| 8 | Hvad viser rotationen af billederne? Synes du denne rotation giver mening? Tp bemærkede ikke dette. |
| 10 | Vinklerne på billederne er der ikke fuld forståelse for |

## Uklar mapping mellem by og 3D

| | |
|---|---|
| 2 | Kan ikke gennemsku hvorfor det ikke er muligt at se et billede(Er taget fra en anden retning end hans synsvinkel, men gps signal er dårligt, så billederne ligger ikke rigtigt i forhold til virkeligheden). |
| 8 | Igen kommer hun ind på at det ikke er tydligt hvor billederne er, i forhold til gaderne. Svært at gennemskue den præcise placering uden et kort. |
| 8 | I panorama-visnings er billederne mindre... Lagde slet ikke mærke til billeder længere væk. |
| 9 | TP: jeg mangler lidt en kort, synes ikke min relation til billeder er særlig god, når jeg ikke kender stedet. |
| 10 | Mappingen imellem program og by er ikke helt gået op for hende |

## Uklar interaktionsmetode i forbindelse med manurering i 3D verden

| | |
|---|---|
| 5 | Testpersonen følte at han skulle stå og "vride" tlf. for at se vinklede billeder. Følte ikke at der var god respons. Når han prøvede at få billede ind på skærmen ved at "vride" tlf. bevægede billedet sig væk fra skærmen igen, hvilket var det modsatte af hvad testpersonen havde forventet. |
| 8 | Finder et halvgennemsigtigt billede, som hun ikke kan få til at være helt klar |
| 10 | Akavet at gå efter pan.view |

## Forstår sammenhæng mellem vinkling og viste billeder

| | |
|---|---|
| 2 | Opdager at han kun kan se billeder der er taget i samme retning, som hans synsretning. |
| 3 | Hvad viser rotationen af billederne? Synes du denne rotation giver mening? Han forstod at rotationen var billedernes egentlig retning og han synes det gav fin mening. |
| 5 | Testpersonen virker til at have forstået hvordan vinklerne på billederne skal forstås |
| 5 | Lagde du mærke til at der var nogle billeder som forsvandt og hvorfor tror du at de forsvandt? Billederne forsvandt når de var bag dig. Taget i en anden retning. Generelt forvirende og ikke intuitivt. |
| 6 | Fandt ud af at bevæge sig sidelens for at se billederne ordentligt. |
| 7 | Tror billederne forsvinder når de er længere væk. Rigtig fin forståelse! |
| 7 | Hvad viser rotationen af billederne? Synes du denne rotation giver mening? GPS og retning. Hvordan billedet var taget. |
| 9 | Viser forståelse for 3d verdenen i forhold til den virkelige, ved at dreje og bevæge sig for at se et billede. |
| 9 | Lagde du mærke til at der var nogle billeder som forsvandt og hvorfor tror du at de forsvandt? Ja, det var i forhold til min synsretning. |
| 9 | Det var fedt at man stod samme sted i forhold til billederne og den virkelige verden. |
| 11 | Finder den rigtige retning, i forhold til at kunne se billedet lige på og stort |
| 11 | Han virker til at have forstået billederetningen |
| 11 | Hvad viser rotationen af billederne? Synes du denne rotation giver mening? Rotationen viser at billedet er taget i en >>lidt<< anden retning. Ellers vises billedet slet ikke hvis det er mere end lidt. |

## Har forstået rotationen, men synes det er lidt mærkeligt

| | |
|---|---|
| 2 | Hvad viser rotationen af billederne? Synes du denne rotation giver mening? Han vidste hvorfor billederne var roteret, men det var irriterende og han kunne ikke lide det |
| 9 | TP holder telefon op foran ham, men billedet forsvinder. ”Hmm der er noget med de her billeder, som man kan se i kompas men ikke panorama – det er lidt forvirrende” |
| 11 | Jeg følte at jeg havde kontrol... De billeder der forsvinder, er ikke let at se, da orienteringen i kompas-visninge er umulig at se pga. billedernes størrelse. |

## Forstår ikke sammenhæng mellem hvilke billeder der vises i 2D og 3D view

| | |
|---|---|
| 1 | Spørger meget ind til hvordan man skal forstå vinkel og >>finde billederne hun kan se i 2D viewet<< |
| 1 | Et billede hun leder efter forsvandt. Hun får lidt hjælp til at finde det igen. |
| 3 | Han prøvede på at finde et bestemt billede af utzon i pan. view. Han finder det ikke, har tydeligvis ikke forstået bed med vinkler på billeder |
| 5 | Undrer sig over nogle billeder forsvinder. Han kan se et billede der er på samme gade han står på i 2Dviewet, men når han kigger i 3D forsvinder det. I første omgang er han ikke med på hvorfor, men finder ud af det da testlederen begynder at spørge ind til det. |
| 6 | Hun undrer sig over hvorfor hun ikke kan se billederne fra 2D i 3D. Billeder var taget i en retning mod hende |
| 11 | Kunne ikke se billederne fra 2D viewet i 3D viewet i Algade - han kigger i modsat retning af hvad de er taget i |

## Færre billeder i 3D view pga. billede rotation

| | |
|---|---|
| 4 | Vores rute er modsatrettet af hvad mange af billederne er blevet taget i, der er derfor kun få billeder at se. |

## Testpersonen går uden for området

| | |
|---|---|
| 1 | Hun er ved at komme udenfor området med billeder, og testlederen foreslår vi går tilbage mod et andet billede |

## Ser det at finde billederne som en udfordring

| | |
|---|---|
| 1 | Det ligner lidt at hun finder en udfordring i at finde billederne og det bliver spændende at se om man kan finde den nøjagtige lokation hvor billedet er taget |
| 8 | Hun sammenligner det at gå rundt og tage billeder med at lave en form for skattejagt, hun kan "gemme" billeder af spændende ting rundt om i byen |
| 10 | Var der nogle bestemte billeder du fandt specielt interessante? Nej, Men det var inerssant når hun fandt et billeder |

## Svært ved at se mørke billeder på mørk baggrund

| | |
|---|---|
| 1 | Har lidt problemer med at få billedet vist helt stort |

## Navigere via 2D view

| | |
|---|---|
| 1 | Bruger i sidste del af testen >>2D view til at navigere rundt<< og 3D view til at se billederne, i starten var der ikke samme fordeling |
| 2 | Går mod et billede, under bevægelse anvendes kompas visning. Opdager at der er et pariserhjul på et billede: "Uhh det har jeg ikke set før, lad os se det". Går mod billedet af hjulet. |
| 3 | Når test personen bevæger sig bruger han top view. Han stopper op og bruger pan view. Han går aldrig med pan view |
| 5 | 2Dview bliver brugt til hurtigt overblik og navigering. 3Dview bliver brugt til at se billederne i stort samt at navigere |
| 5 | Brugte mere topview end 3Dview |
| 6 | Bruger 2D viewet til at navigere |
| 6 | Navigere videre primært i 2D viewet |
| 8 | Bruger meget 2D viewet til at navigere rundt |
| 9 | Bevæger sig mens han bruger kompasvisning |

| | |
|---|---|
| 9 | Bevæger sig igen, mens han bruger kompas visning. |
| 11 | Går rundt med 2D viewet og kigger på det |

## Ser billeder i 2D view

| | |
|---|---|
| 11 | Bruger 2D viewet til at se billeder |

## Ser billeder via 3D view

| | |
|---|---|
| 1 | Bruger i sidste del af testen 2D view til at navigere rundt og >>3D view til at se billederne<<, i starten var der ikke samme fordeling |
| 3 | Når test personen bevæger sig bruger han top view. Han stopper op og bruger pan view. Han går aldrig med pan view |
| 5 | 2Dview bliver brugt til hurtigt overblik og navigering. 3Dview bliver brugt til at se billederne i stort samt at navigere |
| 6 | Ser billeder i stort i 3D viewet |
| 7 | Står hele tiden stille ved brug af 3D view |
| 8 | 3D til at se billeder taget tæt på / i stort format. |
| 9 | Ser billeder i panorama visning |

## Ændrer interaktionsform efter tid

| | |
|---|---|
| 1 | >>Bruger i sidste del af testen 2D view til at navigere rundt og 3D view til at se billederne, i starten var der ikke samme fordeling |
| 10 | Hun finder til sidst ud af at hun langt nemmere kan gå efter billeder i 3D end 2D. |

## Billeder der ikke viste hvad tp kunne se nu, var mest interessante (fx aften vs dag)

| | |
|---|---|
| 1 | Var der nogle bestemte billeder du fandt specielt interessante? - Billeder der var taget i dagslys |
| 2 | Ser billeder fra et andet tidspunkt, sammenligner det med en tidsmaskine. |
| 2 | Var der nogle bestemte billeder du fandt specielt interessante? Han så et billede af en karusel og gik der hen for at se den. Han kunne lide billederne hvor man kunne se >>inde i bygninger<< |
| 4 | Var der nogle bestemte billeder du fandt specielt interessante? Billeder med mennesker, situationer og begivenheder. Ikke så meget bygninger |
| 5 | Fandt billeder fra aften mest interessant, da det ellers ikke er noget han umiddelbart kunne se når han gik rundt |
| 5 | Så julelys på billederne og ærgede sig over at der ikke var lys mens han gik (da det var om eftermiddagen). |
| 6 | Var der nogle bestemte billeder du fandt specielt interessante? Nej. Julebelysning var nok det mest interessante. |

## Vil gerne have oplevet det billederne viser

| | |
|---|---|
| 5 | Så julelys på billederne og ærgede sig over at der ikke var lys mens han gik (da det var om eftermiddagen). |
| 5 | Synes at det var mærkeligt at der var et tog på et af billederne, da han ikke kunne se det i "virkeligheden". |

## Synes billeder af populere steder var mest interessant

| | |
|---|---|
| 2 | Går mod et billede, under bevægelse anvendes kompas visning. Opdager at der er et pariserhjul på et |

| | |
|---|---|
| | billede: ”Uhh det har jeg ikke set før, lad os se det”. Går mod billedet af hjulet. |
| 5 | Undrer sig over der ikke er taget nogle billeder af budolfi kirken |
| 8 | Var der nogle bestemte billeder du fandt specielt interessante? Julebyen. Forsøgte at finde billede af kirke. Fandt det aldrig. |
| 6 | Var der nogle bestemte billeder du fandt specielt interessante? Nej. Julebelysning var nok det mest interessante. |

## Bevæger sig rundt hvor der er flest billeder

| | |
|---|---|
| 2 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Han ville se julemarkedet og ellers gik han der hvor der var flest billeder |
| 3 | Test personen var på vej ned af en gade men vælger er vende om da han ikke kan se nogen billeder. |
| 7 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Mængden af billeder |
| 9 | Vi ankommer til udkanten af billedområdet, TP vender sig om og anvender panorama for at finde en retning med billeder. |
| 9 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Billedmængden |
| 10 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Hvor der var noget plus områder hun ikke kendt |

## Bevæger sig hen hvor der ingen billeder er

| | |
|---|---|
| 4 | TP søger efter billeder i panorama visning igen. >>Han vælger nu at gå i en retning hvor der rent faktisk ikke var billeder på skærmen.<< |
| 5 | Finder et sted hvor der ikke er mange billeder, og tager et der |
| 5 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Fandt steder uden billeder, hvor han kunne tage nogle billeder og udfylde det "sorte område". Gik ikke ned på gammel torv fordi der var for mange mennesker. |
| 6 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Der hvor der ikke var nogle billeder, så jeg kunne tage nogle. Muligvis fordi jeg kender byen. |

## Bevæger sig tilfædig rundt

| | |
|---|---|
| 3 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Det var fuldstændig tilfældigt. Han mente også han opfordrede til at blive dirigeret flere gange. |
| 11 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Tilfældigt. Og hvor der ikke var så mange mennesker. Tog billeder hvor der ikke var billeder i forvejen. |

## Bevæger sig uden om steder hvor der er for mange mennesker/billeder

| | |
|---|---|
| 5 | Vælger en rute uden om alle menneskerne på gammel torv, da han ved der er trængt på dette tidspunkt af dagen |
| 5 | Opdager at billederne i sig selv egentlig skaber et kort i 2Dviewet, da alle billederne er taget langs gaderne |
| 5 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Fandt steder uden billeder, hvor han kunne tage nogle billeder og udfylde det "sorte område". Gik ikke ned på gammel torv fordi der var for mange mennesker. |
| 6 | Man ville nok gå en anden vej hvis man var ny i byen. (Hun gik efter områder hvor der ikke var så mange billeder.) |
| 11 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? |

| | |
|---|---|
| | Tilfældigt. Og hvor der ikke var så mange mennesker. Tog billeder hvor der ikke var billeder i forvejen. |

## Opdager nye ting, og går efterfølgende derhen

| | |
|---|---|
| 2 | Opdager at der er et pariserhjul på et billede: "Uhh det har jeg ikke set før, lad os se det". Går mod billedet af hjulet. |
| 2 | Hvad afgjorde hvor du gik hen? Interessante billeder? "stierne" på kompas-visning? Systemet? Han ville se julemarkedet og ellers gik han der hvor der var flest billeder |

## Forstår systemet som en navigator

| | |
|---|---|
| 1 | Kunne du se dette system brugt i en anden sammenhæng? - Til at vise billeder af byen for turister. >>Kunne være smart hvis der var ikoner på skærmen der viste retningen til fx post-kontoret<< |
| 2 | Sammenligner med google maps: "Det brugte jeg inden jeg kom her til DK. For at få et overblik over Aalborg" |
| 4 | Kunne du se dette system brugt i en anden sammenhæng? Information om motiverne på billederne. Inkludere NSØV kompas og noget navigation/rute |
| 4 | Highlight af udvalgte steder som man på forhånd har angivet at man gerne vil se + steder af generel interesse |
| 5 | Fortæller at han havde en forventning om at der var et kort under 2Dviewet (ala gmaps). |
| 5 | Kunne du se dette system brugt i en anden sammenhæng? Til tuister. Med kort under billederne, og med tydelig identifikation af seværdigheder i byen. Man skulle kunne tagge billeder af fx en bank. Ville også gerne kunne tage et billede og få mere information om hvad man har taget billede af. |
| 7 | Kunne du se dette system brugt i en anden sammenhæng? Finde rundt. Se steder |
| 8 | Synes at hun mangler gader i 2D viewet, for at kunne finde rundt i omgivelserne |
| 8 | Vil gerne kunne se et kort bag billederne. Kunne ikke "finde vej" til billederne. |
| 9 | TP efterspøger en kort funktion: "Jeg kan de se billede der, men hvordan kommer jeg over til det nemmest?" |
| 11 | Kort under billedet mangler, til at finde rundt |

## Forstår systemet som en turistguide

| | |
|---|---|
| 1 | Kunne du se dette system brugt i en anden sammenhæng? - >>Til at vise billeder af byen for turister.<< Kunne være smart hvis der var ikoner på skærmen der viste retningen til fx post-kontoret |
| 2 | Kunne du se dette system brugt i en anden sammenhæng? For tourister og for eksempel i en bil på udflugt for at se hvad der er på vejen. Man kunne udforske byen hvis der var flere billeder |
| 5 | Kunne du se dette system brugt i en anden sammenhæng? Til tuister. Med kort under billederne, og med tydelig identifikation af seværdigheder i byen. Man skulle kunne tagge billeder af fx en bank. Ville også gerne kunne tage et billede og få mere information om hvad man har taget billede af. |
| 6 | Kunne du se dette system brugt i en anden sammenhæng? Turistguide. Der skulle måske være nogle tekstbeskrivelser af hvad billederne forstillede. Turistkontor burde tage billederne, men muligvis også privatpersoner, med kendskab til spændende steder. |
| 7 | Kunne du se dette system brugt i en anden sammenhæng? Finde rundt. Se steder |
| 8 | Digital turistguide. |
| 9 | Kunne du se dette system brugt i en anden sammenhæng? Til at finde information som turist. Database med billeder. |
| 10 | Mener ikke selv hun ville bruge det, men kunne godt se systemet med noget mere tekst i blive brugt. Hun sammenligner det lidt med en bog. |

| | |
|---|---|
| 10 | Kunne du se dette system brugt i en anden sammenhæng? Info system for ersatning for the torist bog |
| 11 | Kunne du se dette system brugt i en anden sammenhæng? Guided tur med tagged billeder. |

## Mener at systemet kan bruges til at udveksle billeder mellem hinanden

| | |
|---|---|
| 3 | Han kunne se det være rigtig fedt hvis der var en social forbindelse igennem applikationen. Hvis det var muligt at se andres med applikationen og deres position og man kunne tage et billede og vise de andre at man står på præcis dette sted lige nu. |
| 8 | Spurgte om de næste kunne se hendes billeder |
| 8 | Foreslår at man kan bruge systemet til at dele rejsebilleder med folk man kender |
| 8 | Man skulle kunne sende billeder, og se venners billeder når man er ude og rejser. Billederne kunne være af de ting som venner finder interessant. |

## Mener at systemet burde give oplysninger om hvad billederne forestiller

| | |
|---|---|
| 4 | Kunne du se dette system brugt i en anden sammenhæng? Information om motiverne på billederne. Inkludere NSØV kompas og noget navigation/rute |
| 5 | Foreslår at man kan tagge billeder |
| 5 | Kunne du se dette system brugt i en anden sammenhæng? Til tuister. Med kort under billederne, og med tydelig identifikation af seværdigheder i byen. Man skulle kunne tagge billeder af fx en bank. Ville også gerne kunne tage et billede og få mere information om hvad man har taget billede af. |
| 6 | Kunne du se dette system brugt i en anden sammenhæng? Turistguide. Der skulle måske være nogle tekstbeskrivelser af hvad billederne forstillede. Turistkontor burde tage billederne, men muligvis også privatpersoner, med kendskab til spændende steder. |
| 9 | ”Det er fedt, at billederne passer så godt – men synes der mangler lidt mere: f.eks. at man som turist kunne tage et billede og så få noget info” |
| 9 | Kunne du se dette system brugt i en anden sammenhæng? Til at finde information som turist. Database med billeder. |
| 10 | Mener ikke selv hun ville bruge det, men kunne godt se systemet med noget mere tekst i blive brugt. Hun sammenligner det lidt med en bog. |
| 10 | Info på billeder, en form for bog |

## Ønsker filtrering af billeder

| | |
|---|---|
| 4 | Highlight af udvalgte steder som man på forhånd har angivet at man gerne vil se + steder af generel interesse |
| 11 | Han foreslår at man kan tagge billeder, for på den måde at kunne finde billeder indenfor en bestemt kategori |

## Starter med at tage et billeder

| | |
|---|---|
| 1 | Starter med at tage et billede |
| 2 | Starter med at tage et billede |

## Tager billeder hvor der ikke er nogle i forvejen

| | |
|---|---|
| 4 | Tager billede af skøjtebanen, fordi der ikke er nogle i forvejen. |
| 5 | Finder et sted hvor der ikke er mange billeder, og tager et der. |
| 5 | Tager igen et billeder hvor der "mangler" et billede. |
| 5 | Eksperimentere med at "fylde" billederne ind hvor der er tomt og ser på sit billede i 3Dview |

| | |
|---|---|
| 8 | Tager et billede af noget nyt, som ikke er i systemet |
| 11 | Tager billede af "tomt" sted i systemet |
| 11 | Tager billeder af et par "nye" steder |
| 11 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Tilfældigt. Og hvor der ikke var så mange mennesker. Tog billeder hvor der ikke var billeder i forvejen. |

## GPS-problemer gør at positionen ikke bliver opdateret

| | |
|---|---|
| 2 | GPS position er meget upræcis. |
| 2 | Kan ikke gennemsku hvorfor det ikke er muligt at se et billede(Er taget fra en anden retning end hans synsvinkel, men gps signal er dårligt, så billederne ligger ikke rigtigt i forhold til virkeligheden). |
| 3 | Oplevede at et af billederne forsvandt hvorefter han ønskede at "gå" tilbage, men det var ikke muligt. |
| 5 | Jeg havde nemt ved at forstå (rotation)... Gik i mod billeder på gå gaden og forstod ikke at han ikke kunne se dem. Da han havde passeret billederne, spurgte TL om han kunne forestille sig at billederne var bag ham. Først der kiggede han tilbage så han dem. TP mente stadig at billederne var placeret foran ham på kompasvisningen, men at han skulle vende sig om for at se dem. |
| 6 | Der er problemer med et dårligt GPS signal. |
| 6 | Går frem og tilbage for at finde et bestemt billede. |
| 6 | Ender med at opgive, primært pga. GPS signalets dårlige kvalitet som gør det svært. |
| 6 | Opgiver at finde billedet i 3D |
| 8 | GPS signalet er dårligt |
| 8 | Finder et billede som hun mener burde være inde i en bygning i forhold til hvad hun ser på 2D viewet |
| 8 | For upræcis når den bevæger sig i ryk. |
| 10 | Har svært ved at finde det billede hun lige har taget. Billedet var ikke at finde muligvis pga gps. |
| 10 | GPS meget upræcis i starten |
| 11 | Dårligt GPS signal giver lidt problemer |

## Tror at billederne fosvinder pga. gps-signal

| | |
|---|---|
| 2 | Lagde du mærke til at der var nogle billeder som forsvandt og hvorfor tror du at de forsvandt? GPS problemer og begrænsning i hvor mange billeder der kan vises på skærmen |

## Rotation af billeder er mere "for sjov" end nyttig

| | |
|---|---|
| 5 | Rotation af billeder i Panorama visning er mere sjovt end funktionelt. Testpersonen stod og legede lidt med det inden vi startede. |

## Ved ikke at red dot er ham selv

| | |
|---|---|
| 4 | TP har ikke opdaget at ”Red dot” er ham selv. |

## Opgiver at tage billeder efter crash

| | |
|---|---|
| 4 | TP tager ikke flere billeder efter den mislykkedes første gang |

## "Kompas" for langsomt til at opdatere

| | |
|---|---|
| 4 | kompasset reagerede for sløvt |

## Interface

| | |
|---|---|
| 5 | Testpersonen har svært ved at bruge knapperne med handsker på - foreslår at man gør brug af større knapper. Årstiden og handsker passer ikke godt sammen |

## Ønsker mulighed for at tage billeder op og nedad

| | |
|---|---|
| 5 | Opdager problemer med at tage billeder op af. Efter at testlederen har spurgt ind foreslår testpersonen at billeder taget op af skal vinkles sådan at de "peger" op af |

## Det var naturligt at bruge

| | |
|---|---|
| 7 | Virker meget naturligt for ham |

## Billeder var ikke interessante

| | |
|---|---|
| 7 | Var der nogle bestemte billeder du fandt specielt interessante? Nogle var brugbare. Virkede ellers tilfældigt |
| 7 | Spørg ind til hvilken indflydelse kvaliteten/interessen i billederne har haft på oplevelsen? Ja, kvaliteten var fin. Billederne var ikke interessante. |

## Skal hele tiden se på skærmen

| | |
|---|---|
| 8 | Det var naturligt... Skal hele tiden gå og se på skærmen. |
| 10 | Akavet at gå efter pan.view |
| 10 | Ikke vandt til at bruge en telefon på den måde, ikke let at gå efter. |

## Drejer tlf. uafhængigt af sig selv

| | |
|---|---|
| 9 | Prøver at dreje telefonen uden selv at dreje. |

## Synes fotos bliver placeret præcist hvor det bliver taget

| | |
|---|---|
| 9 | ”Uhh når man tager billeder kommer det jo helt perfekt ind.” |

## Tager først billede når tlf er i panoramavisning

| | |
|---|---|
| 9 | Tager et billede: TP holder telefonen stille indtil han kan se det i panorama visning. |

## Går hen hvor man ikke er kendt

| | |
|---|---|
| 10 | Hvad afgjorde hvor du gik hen? Interessante billeder? ”stierne” på kompas-visning? Systemet? Hvor der var noget plus områder hun ikke kendt |

## Axial Coding

**Konceptforståelse**
- Svært for testlederen at forklare hvordan personen position havde indflydelse på billederne
- De mange "automatiske data" var ikke intuitiv (gps, gyro, compass)
- Forstod ikke de var den røde prik
- Manglende billeder i startområdet gjorde det vanskeligt at forklare konceptet omkring applikationen
- Problemet med forståelsen af billeder taget i modsat retning af "se-retning". (Troede det var manglende GPS signal der fik dem til at forsvinde)

**Tekniske problemer**
- Ukorrekt GPS signal var meget generende
- Crash ved forsøg på at tage billeder
- Billderne er af ringe kvalitet.

**Billedstørrelse**
- Prøvede hele tiden at flytte telefonen tættere på hovedet
- Prøvede ofte at zoome i panorame view
- Prøvede at klikke på billedet for at se full-screen
- Det var forsåelse for man kunne gå igennem billederne - det virkede godt de blev større.

**Zoom**
- Prøvede ofte at browse i radar view, men blev irriteret over at man kun zoomede ind på den røde prik
- Der blev forsøgt at bruge zoom i begge perspektiver, men overordnet virkede funktionaliteten mangelfuld.

**Navigering**
- Et billede bliver fundet i 2D view, hvorefter det bliver forsøgt fundet i 3D view.
- Der blev set at en person brugte telefonen til at finde et spændende billede, bevæge sig derhen, for derefter egentlig at ligge telefonen væk og koncentrere sig om den virkelig verden hvor billedet var taget.
- Billedmængden styrer bevægelserne.
- Det blev valgt at gå direkte modsat, da personen så der ikke var billeder i det område.

**Bevægelse**
- Stod ofte stille når der blev brugt panorama view, imens radar view blev brugt i bevægelse.
- Udefra så personens bevægelser ofte noget særegen ud.

**2D vs 3D view**
- Meget forskellige brugsmønstre i forhold til hvornår de brugte de forskellige views. Det er vanskeligt at sige noget generelt om at 2D view blev brugt til ene og 3D til det andet.

**Indhold**
- Sammenlignede konceptet med en tidsmaskine. Det var spændende at kunne se billeder fra andre tidspunkter på dagen.

**Encitament for brug**
- Applikationen blev brugt til at udfylde "sorte områder" uden billeder. Der blev taget en masse nye billeder. Formålet var derfor at tilføje mere information til andre.
- Formålet for brugeren var at se billeder af "kendte" steder i byen. Der blev efterlyst en form for interaktiv tour guide.
- Opdagelsestur i byen. Se noget man ikke har set før.
- Der blev efterlyst ikoner. Point-of-Interest ligesom i GPS systemer.
- Anden gik meget tilfældigt og følte sig mere dirigeret igennem byen, da han helt generelt var usikker på hvad han skulle.

**Test**
- De manglende opgaver gjorde det meget vanskeligt at sætte folk i gang. Især for folk hvor der var en sprogbarrierer var det meget vanskeligt at forklare testen med at vi bare ønskede at de skulle gå rundt.

**Billede i 3D rum**
- Oplevede at et billede hurigt poppede ind på skærmen i panorame view, men at det ikke kunne findes igen, da det var i en meget skæv vinkel.
- Forstod ikke helt konceptet med at placere sig med retning imod billedet. "At skulle strafe hen imod billedet for ikke at få det skævt". 3D rum grafik (FPS shooters)
- Giver det merværdi at billederne er roteret?
- Mapping imellem ens egne bevægelse og det der sker på skærmen er ikke umiddelbar nem at forstå for alle.
- Flere forsøgte at stå samme sted og og bare dreje telefonen for at ligestille et billede.
- En testperson troede billedernes drejning repræsenterede en pil.

APPENDIX

# F

## USER STUDY - HOUSEVIEW

## F.1 Participants: Signed Contract

### Bir32

**Participants:** Two adults of age 38/41 and two children

**Building project status:** Going to close the deal. A lot of design decisions still needs to be considered.

### Test One

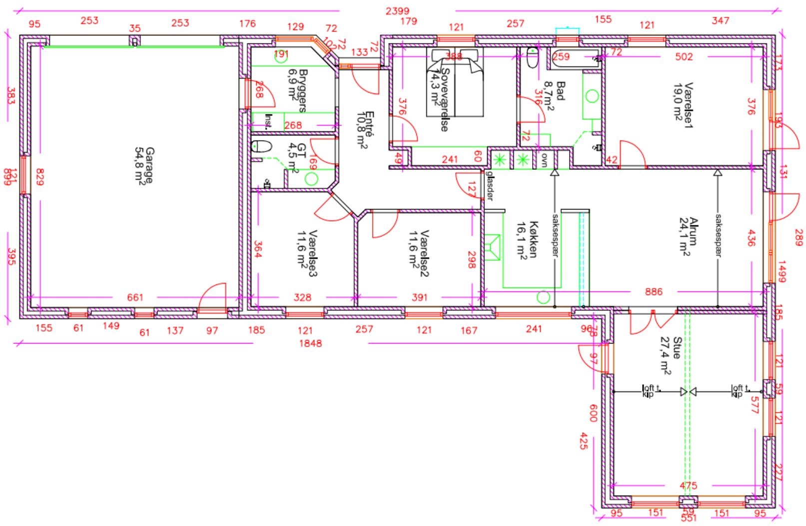



Figure F.1: Blueprint

Figure F.2: 3D house model picture export

**Test Two**

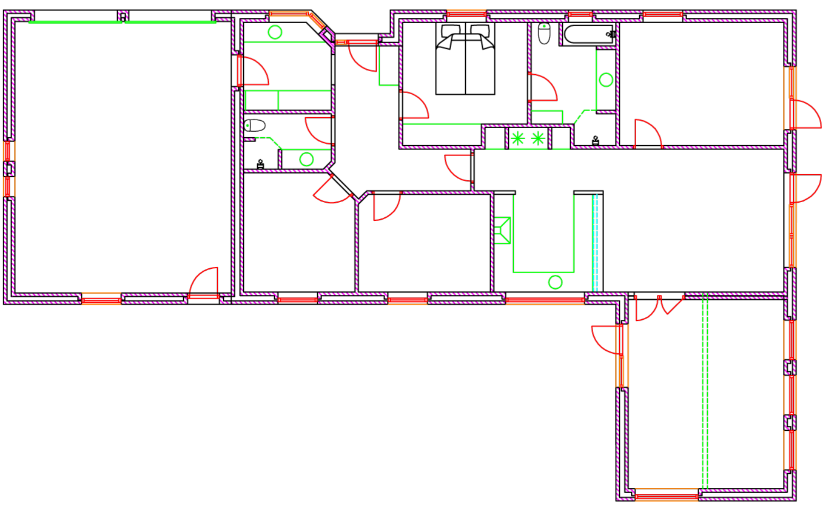


Figure F.3: Blueprint

Figure F.4: 3D house model picture export

## kaer37

**Participants:** Two adults of age 28/32

**Building project status:** Plot found and blueprints are done.

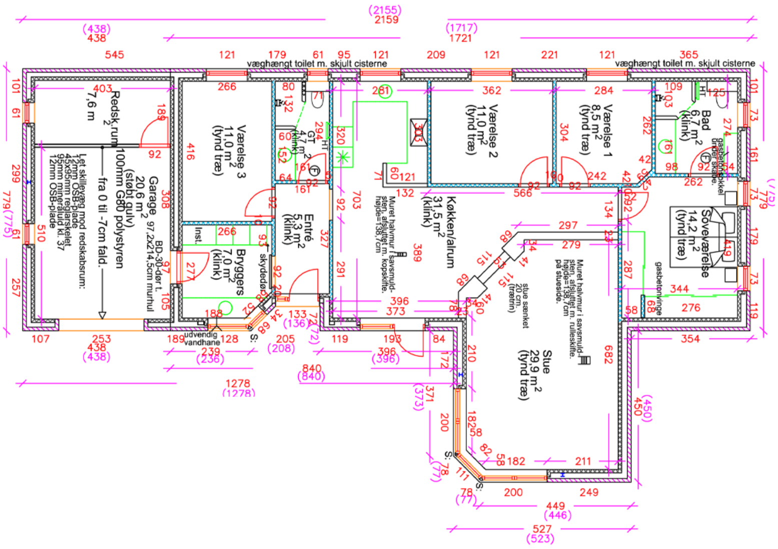



Figure F.5: Birkeagervænget blueprint

Figure F.6: Blueprint

### Kaer83

**Participants:** Two adults of age 36/38

**Building project status:** Plot found and blueprints are done.

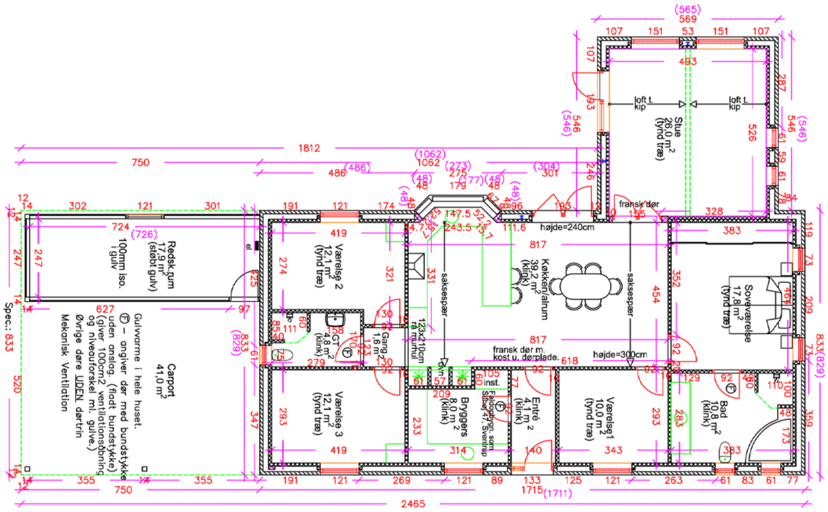


Figure F.7: Blueprint

Figure F.8: 3D house model picture export

### Kaer151

**Participants:** Two adults of age 35 and one child

**Building project status:** Plot found and blueprints are nearly done.

#### Test one

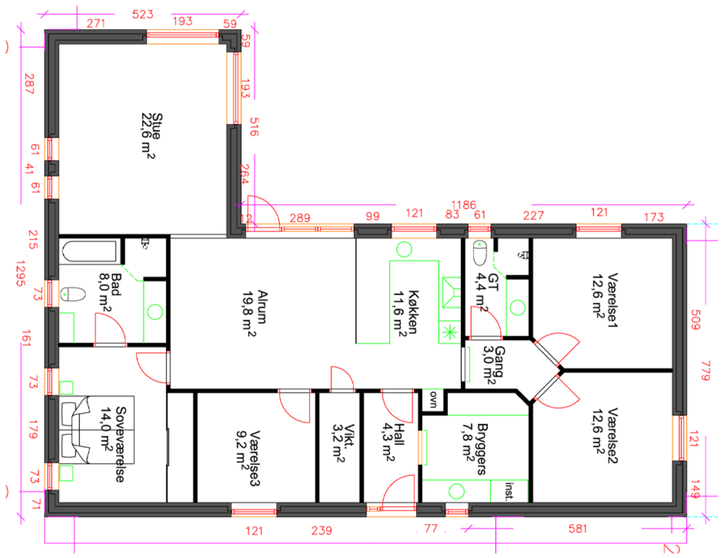



Figure F.9: Blueprint

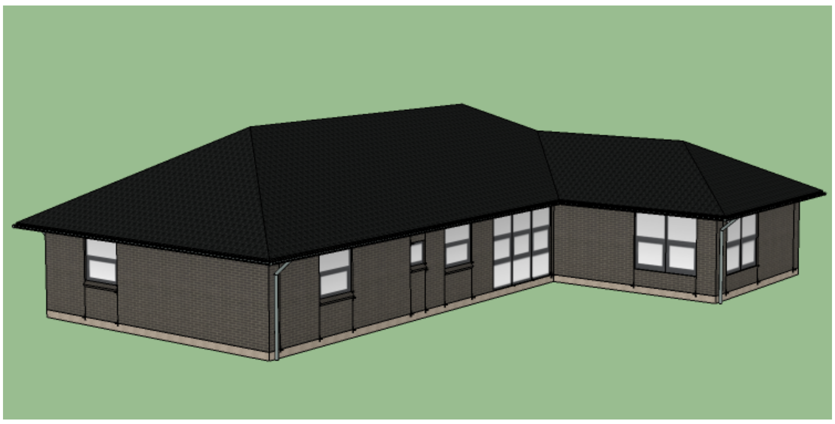


Figure F.10: 3D house model picture export

### Test Two

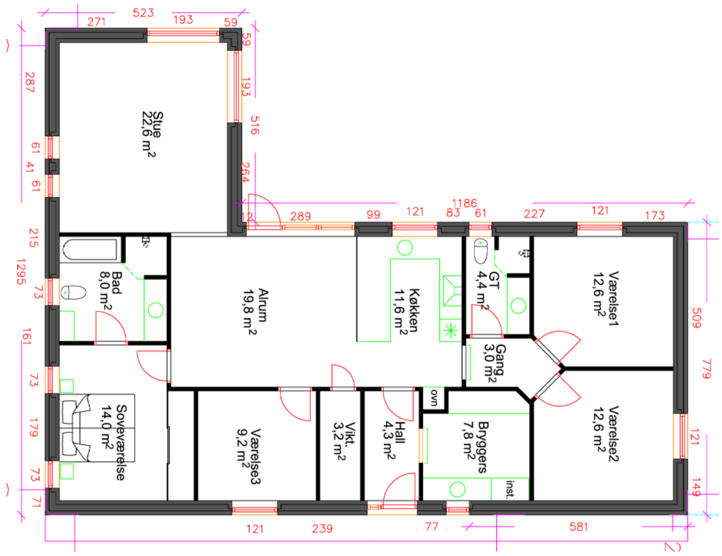



Figure F.11: Blueprint

Figure F.12: 3D house model picture export

### Sols88

**Participants:** Two adults of age 33 and one child

**Building project status:** Plot found and blueprints are done.

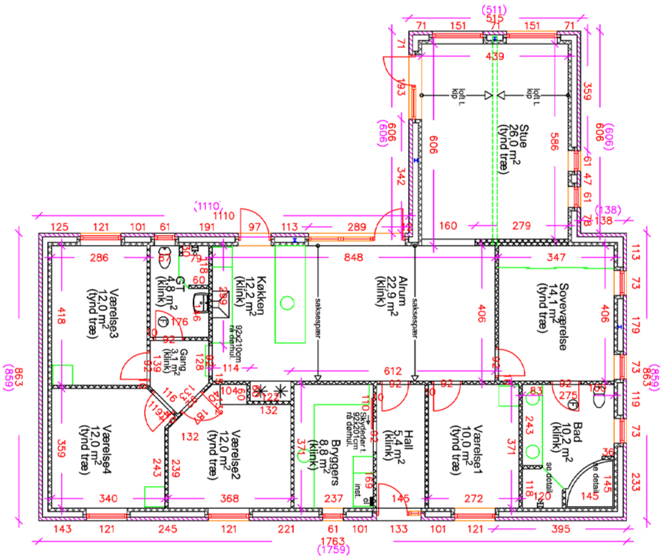


Figure F.13: Blueprint

Figure F.14: 3D house model picture export

## Soe28

**Participants:** Two adults of age 33/35 and two children

**Building project status:** Plot found and blueprints are done.

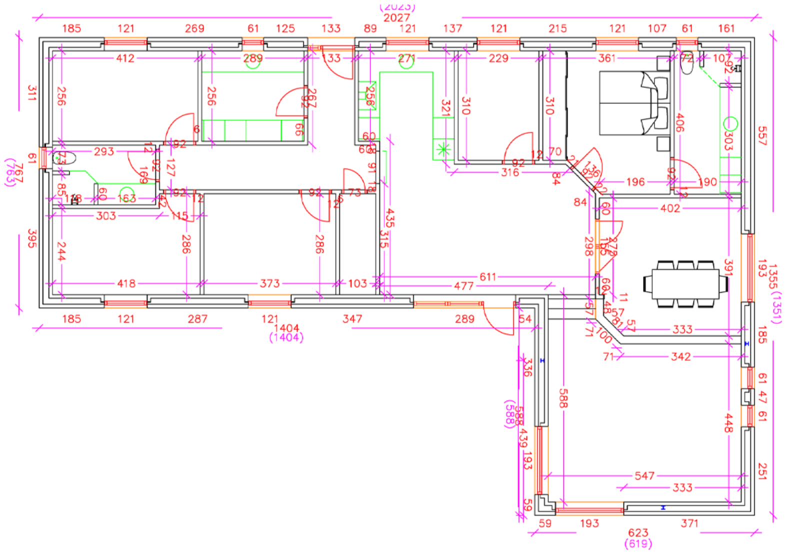


Figure F.15: Blueprint

Figure F.16: 3D house model picture export

## F.2 Participants: House Extension

### spi21

**Participants:** Two adults of age 38/41 and two children plus their architect.

**Building project status:** In the start phase have not seen any drawing yet.

#### Type 1

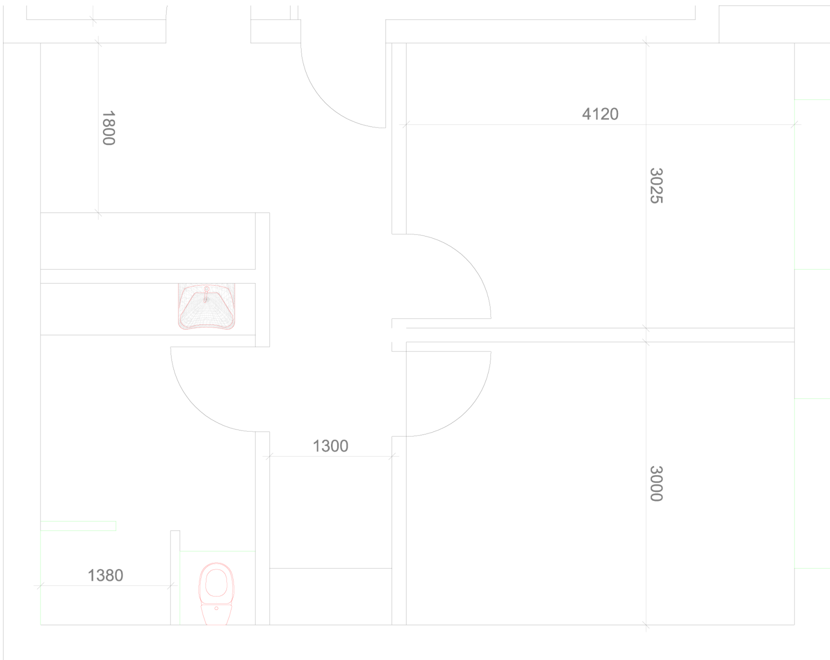



Figure F.17: Blueprint

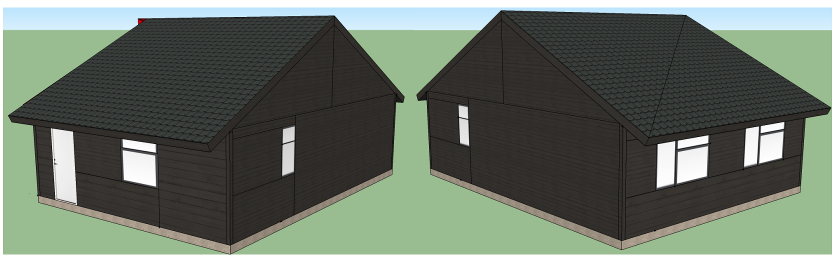


Figure F.18: 3D house model picture export

**Type 2**

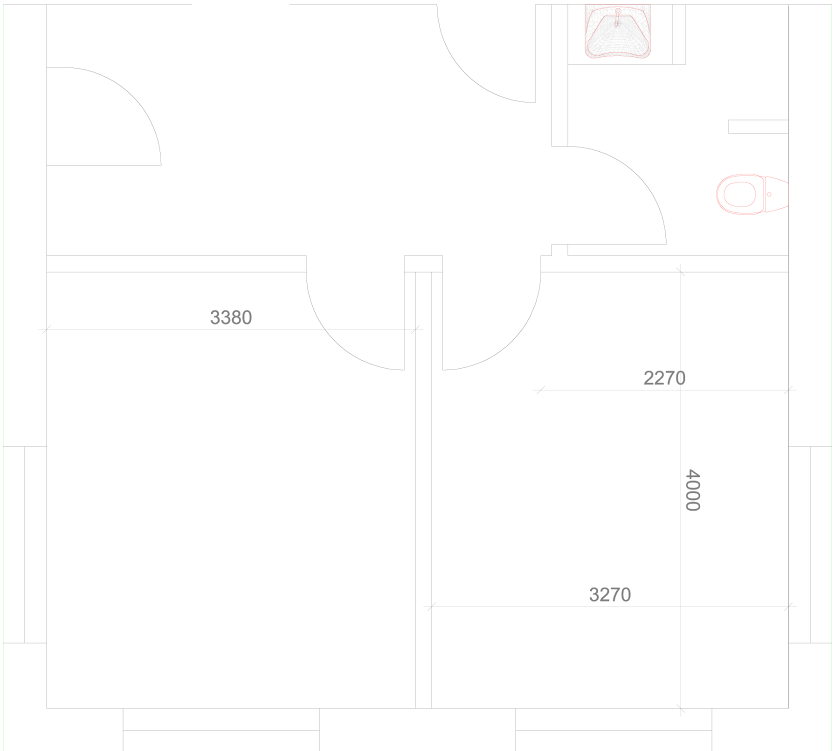



Figure F.19: Blueprint

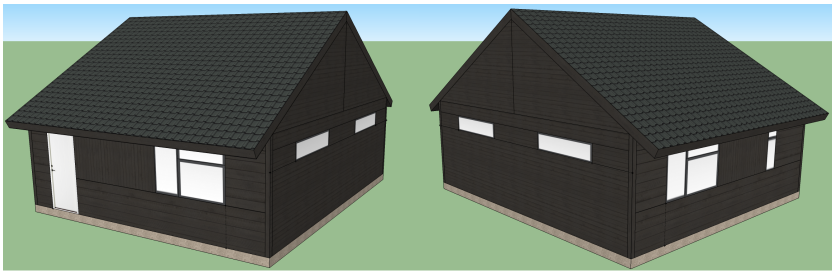


Figure F.20: 3D house model picture export

## kil6

**Participants:** Two adults of age ?/? and one child.

**Building project status:** In the start phase.

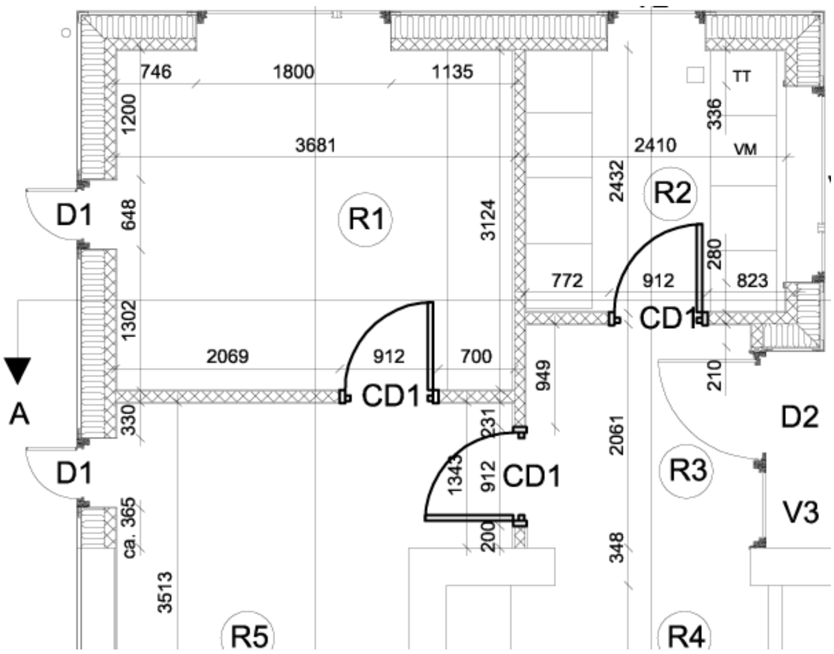



Figure F.21: Blueprint

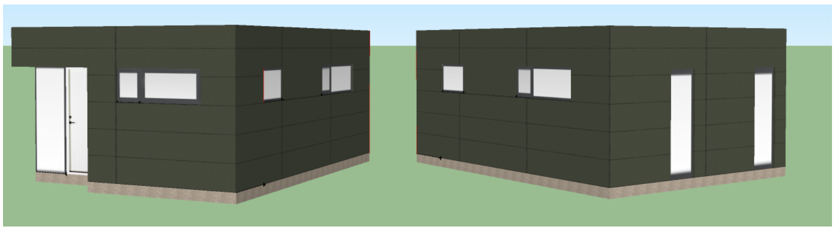


Figure F.22: 3D house model picture export

## F.3 Questionnaire

# HouseView Spørgeskema

Navn: ________________________________

Alder: _______

Status på byggeri: *(vælg den der passer bedst på dig)*

- ☐ Leder efter grund.
- ☐ Har grund, men undersøger muligheder for hus.
- ☐ Har grund og færdigtegnet hus.

| Spørgsmål | Meget Uenig | Uenig | Neutral | Enig | Meget Enig |
|---|---|---|---|---|---|
| Jeg har stor IT erfaring. | | | | | |
| Jeg har stor erfaring med brug af touch skærme. | | | | | |
| Jeg spiller mange 3D computerspil. | | | | | |
| Jeg bruger mobiltelefon mange gange dagligt. | | | | | |

| Spørgsmål | Meget Uenig | Uenig | Neutral | Enig | Meget Enig |
|---|---|---|---|---|---|
| Jeg har let ved at forestille mig husets placering på grunden. | | | | | |
| Jeg har let ved at visualisere husets facade og udtryk på grunden. | | | | | |
| Husets placering på grunden er vigtig for mig når jeg skal bygge. | | | | | |
| Omgivelserne påvirkede mine valg af mursten, tagsten og så videre. | | | | | |

| Spørgsmål | Meget Uenig | Uenig | Neutral | Enig | Meget Enig |
|---|---|---|---|---|---|
| Jeg har let ved at forestille mig husets placering på grunden. | | | | | |
| Jeg har let ved at visualisere husets facade og udtryk på grunden. | | | | | |
| Husets placering på grunden er vigtig for mig når jeg skal bygge. | | | | | |
| Omgivelserne påvirkede mine valg af mursten, tagsten og så videre. | | | | | |

| Spørgsmål | Meget Uenig | Uenig | Neutral | Enig | Meget Enig |
|---|---|---|---|---|---|
| Det er vigtigt for mig at kunne skifte materialer på det valgte hus igennem HouseView. | | | | | |
| At jeg skulle bevæge mig for at se alle husets sider i HouseView var vigtigt for mig. | | | | | |
| Bevægelse inde i huset med HouseView virkede stærkere på mig end bevægelse udenfor. | | | | | |
| HouseView gav mig en bedre forståelse af mulighederne for et hus på denne grund. | | | | | |
| Placering og rotation af huset i HouseView var vigtigt for mig. | | | | | |
| Visualiseringen af huset i HouseView var virkelighedstro for mig. | | | | | |
| HouseView gav mig en god forståelse af huset udseende. | | | | | |
| I HouseView var det vigtigt for mig at kunne se huset fra forskellige vinkler. | | | | | |
| Muligheden for at se husets grundplan i HouseView var vigtig for mig. | | | | | |
| HouseView gav mig en bedre forståelse af størrelsesforhold. | | | | | |

## F.4 Grounded Analysis

### Open Coding

**The screen is too small**

| | | |
|---|---|---|
| kaer83 | Kvinde | ”jeg ville få mere ud af det på en fladskærm.” |
| kaer83 | Mand | Jeg synes det er lidt småt/sol som hele tiden irriterer. |
| bir32-2 | Mand | Svært at se de helt små detaljer |
| kil6 | Kvinde | Ville være nemmere på en større skærm |
| spi21 | mand | "Skærmen gør, at detaljer er lidt svære at se" - han afbryder - "uh det[tilbygningen] ser jo godt ud". |
| kil6 | Kvinde | Det kunne være godt med en større skærm og for at se… |

**The screen is to sensitive to light**

| | | |
|---|---|---|
| kil6 | Kvinde | Det var svært at se farver pga. solen |

**Depth Perception is lost/Size of the virtual house does not correspond to real world**

| | | |
|---|---|---|
| kaer83 | Mand | Synes det er lidt svært, at afgøre afstande, jeg ved ikke om jeg er meget tæt på eller langt væk. |
| kaer83 | Mand | Man har ikke meget reference at gå efter. |
| kaer83 | Mand | Jeg kunne godt tænke mig at se afstande. |
| kaer37 | Mand | Synes størrelsen er lidt lille (her snakker han om huset) |
| kaer151-2 | Mand | Det er lidt svært, at forestille sig størrelse/længde når man ser hækken. |
| kaer151-2 | Mand | "Det er godt at kunne se fliser, men hæk lavede lidt forvirring, fordi størrelse var svært at se" |
| kaer151-2 | M | "Afstanden kunne jeg ikke se" han snakker om hækken |
| kaer151-2 | M | Hækken var urealistisk. |
| FM-1 | Kvinde | "Det er lidt svært at se afstand" |

**Having other virtual objects than the house improves the visualization**

| | | |
|---|---|---|
| kaer151-2 | Mand | "Fliser virker meget fornuftigt og realistisk." |
| kaer151-2 | K/M | Det gav mere at de kunne se fliser og garage |
| kaer151-2 | M | "Fliserne gav et meget realistisk indtryk af hvordan det kom til at se ud" |

**First impression is positive**

| | | |
|---|---|---|
| kaer83 | Mand | Det er sku smart det her |
| sols88 | Mand | "Det er rigtig sjovt det her, nu kan jeg se ideen idet" - under opstart var testpersonerne positioneret midt i en mur, så de fik en skærm fyld med ingen ting |
| sols88 | Mand | "Ej hvor er det fedt" - har lige skriftet, så systemet viser netop deres materialer |
| Soe28 | Kvinde | Første tanke: "Ej hvor vildt" |
| Soe28 | Mand | "Det er for vildt det her" |
| kaer37 | Kvinde | Sjovt legetøj/smart |

**Uses HouseView to understand the size of the house**

| | | |
|---|---|---|
| Soe28 | Mand | Forsøger at opmåle huset, ved at gå rundt i hele kanten af det. |

| | | |
|---|---|---|
| bir32 | Mand | Prøver at tjekke størrelsen ved at gå rundt på grunden og se huset |
| kaer151 | | Bevæger sig rundt om huset for at forstille sig, hvordan huset ligger på grunden i forhold til garage placering osv. Vil gerne undersøge om det er helt tosset. |
| Par1 | Mand | "Det her hus er for langt til den her grund" |

**Changing materials visualize the interplay between house and context**

| | | |
|---|---|---|
| sols88 | Mand | "Synes faktisk jeg blev bekræftet i mine valg, da jeg prøvede at ændre mursten til nogle af de typer vi havde snakket om og så sammenlignede med omgivelserne. Her passer vores gule valg langt bedre end sort" |
| sols88 | Mand/Kvinde | "Kan se nu at det var rigtige valg" i forhold til materialer |
| Soe28 | Mand | "Det er pisse fedt, at man kan ændre materialer og se de ændringer med det samme, samt i sammenhæng med omgivelserne." |
| kaer37 | Mand | "Det er fedt at sammenligne materialer med naboerne, så man ikke laver et lorte valg" |

**The exterior visualization is more useful**

| | | |
|---|---|---|
| kaer151 | | Fik mest ud af at gå rundt om huset |
| Par1 | Mand | "Jeg er mest vild med det udendørs, det er mest med at for fornemmelsen af huset på grunden" |
| kil6 | Kvinde | Jeg kan faktisk bedst li' at se det udefra, det er som om det indvendige er lidt for småt. |

**Making changes on the fly is great**

| | | |
|---|---|---|
| kaer151-2 | Mand | "Det er faktisk meget godt, at prøve og ændre ting. Det giver lidt en anden måde at se det på." |
| kaer151-2 | Mand | "Det var godt, at kunne ændre og se ting med det samme." |
| kaer151-2 | K | "Godt man kunne ændre i det mens man stod her ude." |
| bir32-2 | Mand | "Det er interessant at kunne ændre ting og se det." |

**Changing materials in the moment improves visualization of the interplay between materials**

| | | |
|---|---|---|
| kaer83 | Mand | Det kan spare meget i byggeprocessen, at man kan ændre ting mens man kan se det. |
| kaer83 | Mand | Det er fedt at ændre materiale |
| kaer83 | Mand | Der kan spares en masse i byggeprocessen, fordi man kan gå og ændre ting |
| kaer37 | Mand | "Det kunne havde været brugbart det med at man skifter materialer hurtigt så man lige kunne afprøve ting" |
| bir32 | Mand | Det er godt, at man kan ændre materieler og se huset med forskellige udsende. |
| bir32 | Mand | Prøver en masse materialer, for at se hvilken han bedst kan lide og bliver bekræftet i hans valg |
| kil6 | Kvinde | Tager to telefoner i brug, for at sammenligne mellem materialer. |
| kil6 | Kvinde | Hov er ikke pænere i sort end grå? Ej det skal være grå. |
| kil6 | begge | De står og diskuterer materialernes indflydelse. |

| | | |
|---|---|---|
| kil6 | Kvinde | Prøver hvide vinduer mod sorte: "Det er jo faktisk lidt mindre bombastisk" |

**Do not understand the concept of the virtual house and physical movement**

| | | |
|---|---|---|
| sols88 | Mand | "Kan jeg se ned af siden på huset?" |
| kaer83 | Kvinde | Svært ved at forstå rum / bevægelse |
| sols88 | Mand | "Man skulle vende sig til det" Problem at orientere sig når man starter tæt på huset (fx. hvis man kun kan se mursten). |
| Soe28 | Kvinde | Hvordan går jeg så ind |
| Soe28 | Kvinde | Det er lidt svært at navigere rundt inde i huset. |

**Inspects the house in detail**

| | | |
|---|---|---|
| sols88 | Kvinde | Virker utrolig interesseret, går hele tiden og ser på detaljerne huset |
| sols88 | Kvinde | "Det her kan jeg få lang tid til at gå med" |
| Soe28 | Mand | Forsøger at opmåle huset, ved at gå rundt i hele kanten af det. |
| Soe28 | Mand | Går rundt på grunden, for at opleve huset fra alle vinkler. |
| kaer37 | Mand | "Hvis vi ikke passer på, så går hun med det hele dagen" |
| bir32 | Mand | Prøver at tjekke størrelsen ved at gå rundt på grunden og se huset |
| kaer151 | | Bevæger sig rundt om huset for at forstille sig, hvordan huset ligger på grunden i forhold til garage placering osv. Vil gerne undersøge om det er helt tosset. |
| kaer151-2 | Kvinde | Går systematisk rundt og tjekker udsigt og detaljer på huset. |
| kaer151-2 | Kvinde | Tjekker vinduer og udsigt - "Hvor tæt er vi på naboerne?" "Vi er jo ikke bange for andre mennesker, men vi vil jo også gerne kunne være os selv." |
| bir32-2 | Mand | Går straks i gang med, at se på de ændringer der er lavet |
| FM-2 | Kvinde | Studerer grundplan grundigt |

**Understand the concept of physical movement**

| | | |
|---|---|---|
| sols88 | Mand | "Tror det er godt det her, man bliver langt bedre til at forstå bevægelserne efter lidt tid" |
| Soe28 | Mand | Forsøger at opmåle huset, ved at gå rundt i hele kanten af det. |
| kaer151 | | Det virker meget realistisk det her |
| kaer151 | Mand&Kvinde | Ønsker at se huset længere væk, bevæger sig derfor på afstand. |
| FM-2 | Mand | Kunne sagtens forstå hus/afstand/størrelse |

**HouseView is used to gain shared understanding about the house between family members**

| | | |
|---|---|---|
| sols88 | Kvinde | Sætter sig ned i niveau med barn og viser huset og deres værelser. |
| Soe28 | Kvinde | Sætter sig ned i niveau med børnene og viser dem huset og deres værelser. |
| kaer37 | Mand | Til kvinde "Kom herned, så du kan se det ude fra" |
| kaer37 | Mand | "Kunne godt forestille mig at det gør det nemmere at blive enig om nogle detaljer, fordi man kan ændre og diskutere på samme grundlag." |
| bir32 | | De er ikke helt sikre på nogle detaljer, så de ser på vinduerne for at snakke om dem. |
| bir32 | Kvinde | De er ikke enige om nogle detaljer, men de gider ikke snakke om det |

| | | |
|---|---|---|
| kaer151-2 | Mand | De har børn med "De skal jo se deres værelse" |
| kaer151-2 | Mand | Viser huset til deres lille søn: "Skal vi bo derude?" |
| kaer151-2 | Begge | Ser på fliserne ude foran huset og diskuterer hvordan disse skal ligge. "K: Tror du ikke vi skal have lidt flere?" |
| kaer151-2 | Kvinde | Vi har ændret på fliserne, så der er flere foran huset: "K: Hva så hvordan ser det ud nu? M: Synes lidt det ligner en motorvej eller parkeringsplads - så der er nok lidt for mange." |
| kaer151-2 | Mand | Mand er gået til terrassen, for at se flise ændringerne: "Vil du ikke også lige se det her?" |
| kaer151-2 | Kvinde | "Ja nu passer det vist meget godt med den terrasse". |
| kil6 | Kvinde | Vil gerne vise det til datter |
| kil6 | Kvinde | Til datter: "Se her det er dit nye værelse" |
| kil6 | Datter | Jamen det kommer jo faktisk til at ligge der hvor bilen holder, hvordan kommer man så ind i huset? |

## HouseView helps avoid conflicts

"Kunne godt forestille mig at det gør det nemmere at blive enig om nogle detaljer, fordi man kan ændre og diskutere på samme grundlag."

| | | |
|---|---|---|
| kaer151-2 | Begge | Ser på fliserne ude foran huset og diskuterer hvordan disse skal ligge. "K: Tror du ikke vi skal have lidt flere?" |
| kaer151-2 | Mand | Mand er gået til terrassen, for at se flise ændringerne: "Vil du ikke også lige se det her?" |
| kaer37 | Mand | "Det eneste jeg kunne havde tænkt mig, var at vi havde prøvet det tidligere i processen, da der netop på dette tidspunkt var rigtig mange tvivls spørgsmål" |

## It is difficult to understand 2d blueprints

| | | |
|---|---|---|
| kaer151-2 | Begge | "Når andre har bygget var det svært, at forstå de tegninger, fordi man ikke …. |
| kaer151-2 | K | "Det ville være noget helt andet end de billeder man kunne sidde og vise folk" |
| kaer151-2 | K | "Det er svært at sætte sig ind i andres tegninger" |
| kaer151-2 | M | "Hvis man havde det nemt ville man vise det frem for andre" |
| kaer151-2 | K | "Man vil godt være interesseret i andres tegning med det er svært" |
| kaer151-2 | K | "Vi var med ude og kigge på deres grund med det er svært at sætte sig ind i selv om man har tegningerne med ude" |
| bir32-2 | | Når man sidder og kigger på en 2d plantegning giver det ikke et ret godt indtryk |
| bir32-2 | Mand | "Det er svært for andre at forstå plantegninger" |
| FM-1 | Kvinde | "Jeg kan ikke lide at se på grundplaner, jeg forstår dem ikke. Men det her er godt nok noget nemmere at forstå" |

## HouseView could improve visualization for friends

| | | |
|---|---|---|
| bir32-2 | Mand | Hvis vi havde haft det ville vi nok også havde vist det frem for venner og familie |
| bir32-2 | Mand | "Hvis man lige skulle ud og vise folk grunden så kunne man helt klar tage |

| | | |
|---|---|---|
| | | det her med det" det her = vores app |
| bir32-2 | Mand | "Det kunne være sjovt nok at vise det frem for andre" |
| kaer151-2 | K | "Det ville være noget helt andet end de billeder man kunne sidde og vise folk" |
| kil6 | Kvinde | Det er svært at visualisere andres valg, det er noget andet når det er ens eget. Det føler man mere for. |
| kil6 | Kvinde | Kalder på anden dame: "Prøv at komme herover" Hun vil gerne vise en bestemt detalje frem. |
| kil6 | Kvinde | Kalder igen veninden til sig: "Kom lige herover og se indgangen til huset" |
| kil6 | Kvinde | Til veninden: "Prøv at se her, tror du der kommer nok lys ind?" |
| kil6 | Kvinde | Til veninden: "Det var meget sjovt at se ik'?" |

## Being in context helps furtherance the visual understanding

| | | |
|---|---|---|
| sols88 | Mand | "Jeg tror helt sikkert, det at stå på grunden hjælper meget i min visualisering" |
| sols88 | Mand | "Det er super fedt at man kan gå rundt og se huset" |
| sols88 | Kvinde | "Giver en et helt andet forhold til huset. På den gode måde" |
| sols88 | Kvinde | Godt at se huset fra alle de forskellige vinkler "Det var fedt det der med at man kunne gå rundt" "Det var helt vildt godt" |
| sols88 | Kvinde | Troede faktisk jeg havde godt styr på, hvordan huset kom til at se ud, men det viste sig faktisk at der var ting som overraskede mig og hjalp mit til at forstå det - fordi man kunne se huset fra alle vinkler. "Havde en god forståelse af huset før, men det her giver en helt anden forståelse" |
| Soe28 | Mand | "Det er pisse fedt, at man kan ændre materialer og se de ændringer med det samme, samt i sammenhæng med omgivelserne." |
| Soe28 | Mand | "Det er fedt at jeg kan se ud af vinduerne, når jeg står i min stue og derved forestille mig hvilken udsigt jeg får |
| Soe28 | Mand | Det giver et godt helhedsindtryk "Man fik et meget bedre helhedsindtryk" |
| Soe28 | Mand | "Man her en stærk fornemmelse når man sidder der hjemme men når man så kommer ud og ser det så… " (han afslutter ikke hans sætning) |
| Soe28 | Kvinde | "Jeg kunne slet ikke forestille mig det før, så denne fysiske visualisering var ret realistisk" |
| bir32 | Mand | Det er godt at man går rundt om huset, for at se hvordan det ligger på grunden, da det er svært at forestille sig, hvor meget 10 meter er, når man ser det på en tegning eller på computeren. |
| bir32 | Mand | Fedt at se huset på stedet. |
| kaer151 | Mand | "Normalt når vi har været på grunden, har jeg sammenlignet vores hus med de andre og så forsøgt at flytte det hus over på vores grund inde i hovedet - for på den måde at prøve at forstille mig hvordan det kommer til at se ud, men det her er jo langt bedre" |
| Par1 | Kvinde | "Det er nemmere at forestille sig end når man sidder hjemme og ser på billeder" |
| kaer151-2 | Begge | De står ude på vejen ved indkørslen til grunden: "Vi har snakket om hvor hurtigt, man kan køre ind i garagen fra vejen - vi var lidt bange for at det blev lidt for racer. Men nu hvor vi kan se garagen osv., så tror jeg ikke det bliver noget problem." |
| kaer151-2 | Kvinde | Vi har ændret på fliserne, så der er flere foran huset: "K: Hva' så hvordan |

| | | |
|---|---|---|
| | | ser det ud nu? M: Synes lidt det ligner en motorvej eller parkeringsplads - så der er nok lidt for mange." |
| kaer151-2 | Begge | Ser på fliserne ude foran huset og diskuterer hvordan disse skal ligge. "K: Tror du ikke vi skal have lidt flere?" |
| bir32-2 | Mand | "Hov nu er kameraet væk - det er langt bedre med det til, så er det meget nemmere at forstille sig huset. Det virker mere som et rigtigt hus, fordi man ser de rigtige omgivelser" |
| bir32-2 | Mand | Det der med at man kan se det i omgivelser giver et eller anden<br>(Se næste) |
| bir32-2 | Mand | Man kan se det i forhold til de huse der ligger omkrig og med en baggrund |
| bir32-2 | Mand | "Det virker ikke så computer lavet" |
| kil6 | Kvinde | Synes godt nok den entre er lille, men det kommer jo også til at gå ind i husets nuværende, så kan være det kommer til at gå- |
| kil6 | Kvinde | Facade udtryk var meget nemmere at forstå nu. Samt hvor tæt udbygningen kommer på skel, vej osv. |
| kil6 | Kvinde | Vinduer skal være sorte i det eksisterende hus, men man kom lidt i tvivl når man så det hele i sort. |
| spi21 | mand | Det[tilbygningen] passer jo faktisk meget godt til huset. |
| spi21 | mand | "Det er fedt at se ud af vinduerne, så kan man fornemme hvordan man kommer til at kunne se ud." |
| spi21 | begge | De stiller sig sammen og ser på begge ideer: "Ide2 passer bedre i forhold til det eksisterende hus" |
| spi21 | kvinde | "Sammenligningen med det gamle hus og tilbygning var godt" |

## HouseView helps furtherance the visual understanding of the house

| | | |
|---|---|---|
| Soe28 | Mand | Det giver et godt helhedsindtryk "Man fik et meget bedre helhedsindtryk" |
| Soe28 | Mand | "Man her en stærk fornemmelse når man sidder der hjemme men når man så kommer ud og ser det så... " (han afslutter ikke hans sætning) |
| Soe28 | Kvinde | "Jeg kunne slet ikke forestille mig det før, så denne fysiske visualisering var ret realistisk" |
| sols88 | Kvinde | "Giver en et helt andet forhold til huset. På den gode måde" |
| Soe28 | Mand | "Det er pisse fedt, at man kan ændre materialer og se de ændringer med det samme, samt i sammenhæng med omgivelserne." |
| kaer37 | Mand | Man får et rigtig godt indtryk af huset. |
| kaer37 | Mand | "Der skulle sokkel osv. op, før vi egentlig begyndte at forstå huset, så det er rigtig godt med den grundplan man kan gå rundt på." |
| kaer37 | Mand | "Det er et godt værktøj. Inden jeg prøvede programmet følte jeg, at jeg havde en god forståelse af huset, men det var langt nemmere at forstå huset når man er i det" - altså at man ikke bare ser det på et stykke papir eller på en skræm |
| kaer37 | Mand | "Det var især billedet af, at man kunne gå rundt og se huset der hjalp på forståelsen" |
| kaer83 | Mand | Da jeg så hjørnet, blev jeg overbevist om at vores valg var ok. (De har diskuteret meget om de har valgt at lave en løsning rigtigt, et hjørne af huset.) |
| kaer83 | Mand | "Det gav mig en form for afklaring af hvordan det kom til at se ud" "især med der hjørne der over" |

| | | |
|---|---|---|
| kaer151 | Mand | Orienterer sig i stuen, for at få en fornemmelse af hvor tv skal stå/hvor der skal trækkes kabler |
| kaer151 | Mand | "Jeg tænker meget om hvor de forskellige stik skal sidde til tv, antenne osv." |
| kaer151 | Mand | Det hjalp på hans forståelse af huset at kunne gå rundt om det, man kunne se de ting der ikke så godt ud. |
| kaer151 | Mand | "Normalt når vi har været på grunden, har jeg sammenlignet vores hus med de andre og så forsøgt at flytte det hus over på vores grund inde i hovedet - for på den måde at prøve at forstille mig hvordan det kommer til at se ud, men det her er jo langt bedre" |
| Par1 | Kvinde | "Meget anderledes måde at opleve huse på" |
| kaer151-2 | M | Det var nemmere at visualiser med jeres i forhold til tegning uden farver |
| bir32-2 | Mand | Der har været noget ting jeg har været i tvivl om som jeg kunne se bedre i jeres |
| bir32-2 | Mand | Man kan se hvordan det hænger sammen - (Hvordan huset hænger sammen i de forskellige dele) |
| FM-1 | Kvinde | "Jeg kan ikke lide at se på grundplaner, jeg forstår dem ikke. Men det her er godt nok noget nemmere at forstå" |
| kil6 | Kvinde | Den facade virker meget som en stor flade. Det kan godt være at den skal være mere lys. |
| kil6 | Kvinde | Nu hvor jeg ser vinduet her i gangen, så virker det faktisk som om det sidder lidt for langt oppe. Der kommer nok ikke så meget lys ind. |
| kil6 | Kvinde | Facade udtryk var meget nemmere at forstå nu.  Samt hvor tæt udbygningen kommer på skel, vej osv. |
| spi21 | kvinde | Står inde i tilbygningen: "Arh går man ind her" |
| spi21 | kvinde | "Den side hvor der skulle være et smalt vindue, det så helt åndsvagt ud" |
| spi21 | kvinde | Hun er ikke sikker på at hun ville havde set at vinduet så åndsvagt ud hvis hun kan havde se tegninger |

## HouseView helps furtherance the visual understanding of the area around the house

| | | |
|---|---|---|
| kaer151-2 | Mand | "Fliser virker meget fornuftigt og realistisk." |
| bir32 | Mand | Det er godt at man går rundt om huset, for at se hvordan det ligger på grunden, da det er svært at forestille sig, hvor meget 10 meter er, når man ser det på en tegning eller på computeren. |
| bir32-2 | Mand | "Det giver en masse at kunne gå rundt i rummene og se omgivelserne." |
| bir32 | | Kunne have gælde af at se hvordan det passer sammen med omgivelserne. |
| bir32 | Mand | Det kan godt tænkes, at når man er på grunden, så ser man om huset passer ind. Det prøvede jeg i hvert fald. |
| kaer37 | Mand | "Der skal godt nok plantes nogle træer" - Det blæser meget i dag, og derfor kan de se at der ikke er meget læ på grunden. |

## HouseView helps with the placement of the house on the plot

| | | |
|---|---|---|
| bir32 | Mand | Prøver at tjekke størrelsen ved at gå rundt på grunden og se huset |
| bir32 | Mand | Det er godt at man går rundt om huset, for at se hvordan det ligger på grunden, da det er svært at forestille sig, hvor meget 10 meter er, når man ser det på en tegning eller på computeren. |

| | | |
|---|---|---|
| Soe28 | Mand | "I vores proces havde vi huset før grunden, så det kunne havde hjulpet os med at se vores hus på forskellige grunde" |
| sols88 | | Kunne havde hjulpet fra man ville finde grunden. Det med at kunne køre hen til grunden og se hvordan et hus af den type man har tænk på kunne se ud "Kanon fedt værktøj" |
| sols88 | Mand | Forestiller sig en situation, hvor man har systemet med og kører rundt til forskellige grunde man har udset sig, for at finde ud af om huset passer ind. |
| sols88 | | "Det med at se ud af vinduerne, ville kunne havde hjulpet med placeringen af huset." |
| kaer151 | | Kunne havde hjulpet med placeringen af huset på grunden. |
| kaer151 | Mand | Synes systemet passer bedst til, at prøve ens hus af på forskellige grunde, for at se om det passer. |

## HouseView supports users in finding a plot for at house

| | | |
|---|---|---|
| Soe28 | Mand | "I vores proces havde vi huset før grunden, så det kunne havde hjulpet os med at se vores hus på forskellige grunde" |
| sols88 | | Kunne havde hjulpet fra man ville finde grunden. Det med at kunne køre hen til grunden og se hvordan et hus af den type man har tænk på kunne se ud "Kanon fedt værktøj" |
| sols88 | Mand | Forestiller sig en situation, hvor man har systemet med og kører rundt til forskellige grunde man har udset sig, for at finde ud af om huset passer ind. |
| kaer151 | Mand | Synes systemet passer bedst til, at prøve ens hus af på forskellige grunde, for at se om det passer. |

**Physical interaction affect the visual understanding**

| | | |
|---|---|---|
| Soe28 | Kvinde | "Jeg kunne slet ikke forestille mig det før, så denne fysiske visualisering var ret realistisk" |
| sols88 | Mand | "Det er super fedt at man kan gå rundt og se huset" |
| Soe28 | Kvinde | "Det hjalp på min forståelse at jeg kunne gå rundt om det" (ikke helt det hun siger) "Det virker ret realistisk" |
| kaer37 | Mand | "Der skulle sokkel osv. op, før vi egentlig begyndte at forstå huset, så det er rigtig godt med den grundplan man kan gå rundt på." |
| kaer37 | Mand | "Det er et godt værktøj. Inden jeg prøvede programmet følte jeg, at jeg havde en god forståelse af huset, men det var langt nemmere at forstå huset når man er i det" - altså at man ikke bare ser det på et stykke papir eller på en skræm |
| kaer37 | Mand | "Det var især billedet af, at man kunne gå rundt og se huset der hjalp på forståelsen" |
| bir32 | Mand | Det er godt at man går rundt om huset, for at se hvordan det ligger på grunden, da det er svært at forestille sig, hvor meget 10 meter er, når man ser det på en tegning eller på computeren. |
| bir32 | Mand | 3D hus på computeren virker mindre ind når man selv går rundt idet, så det er fedt at prøve det på en krop. |
| kaer151 | Kvinde | Har bevæget sig rund i stuen og set den udefra, "Jeg synes ikke stuen er ret stor, det er nærmest bare en lille tut" |
| kaer151 | Mand | Det hjalp på hans forståelse af huset at kunne gå rundt om det, man |

| | | |
|---|---|---|
| | | kunne se de ting der ikke så godt ud. |
| kaer151 | Mand | "Normalt når vi har været på grunden, har jeg sammenlignet vores hus med de andre og så forsøgt at flytte det hus over på vores grund inde i hovedet - for på den måde at prøve at forstille mig hvordan det kommer til at se ud, men det her er jo langt bedre" |
| kaer151 | | "Det var noget helt andet at kunne gå rundt og se det på den måde" |
| Par1 | Kvinde | "Når jeg går rundt giver det et meget bedre indtryk af størrelsen på huset" |
| Par1 | Kvinde | "Det er nemmere at forestille sig end når man sidder hjemme og ser på billeder" |
| bir32-2 | Mand | Han har ikke opdaget, at der er kommet mure i huset, så han prøver det. I sidste test sagde han, at når han brugte hans 3d program, så virkede rum små. |
| bir32-2 | Mand | "Det er langt bedre at gå inden i huset på den her måde, det virker mere realistisk" |
| bir32-2 | Mand | "Det giver en masse at kunne gå rundt i rummene og se omgivelserne." |
| bir32-2 | Mand | "Man får en god rumfornemmelse" |
| bir32-2 | Mand | "Nu begynder man at kunne se størrelsen på huset indvendigt" (Med de indre mure) |
| kil6 | Kvinde | Jeg har haft svært ved at forstå størrelsen på udbygningen. |

## Using HouseView spawn ideas

| | | |
|---|---|---|
| kaer151 | Mand | "Jeg tænker meget om hvor de forskellige stik skal sidde til tv, antenne osv." |
| kaer151 | Kvinde | "Det sætter en masse tanker i gang, når man går og ser huset" |
| kil6 | Kvinde | Vi var faktisk ret enige om, at de skulle være sorte - men de hvide passer nu faktisk bedre |

## Being in context spawn ideas

| | | |
|---|---|---|
| kaer37 | Mand | "Der skal godt nok plantes nogle træer" - Det blæser meget i dag, og derfor kan de se at der ikke er meget læ på grunden. |
| Soe28 | Mand | Spørger kvinde: "Skulle vi måske have brugte nogle ekstra penge og få fjernet den mur der?" De har en mur imellem 2 vinduer i stuen. |
| kaer37 | Mand | "Det er fedt at sammenligne materialer med naboerne, så man ikke laver et lorte valg" |
| kaer83 | Mand | Vi ville sikkert ikke have købt den tidligere grund, hvis vi kunne smide et hus på den.(De har tidligere købt en grund, men den var alt for skæv/skrå til deres hus) |
| kaer151 | Mand | Sammenligner huset med nogle af de andre i området: "Vores minder lidt om det der over." |
| kaer151 | Mand | Bruger de andre huse som inspiration til at vælge vindues farve. |
| kaer151 | Kvinde | "Det sætter en masse tanker i gang, når man går og ser huset" |
| kaer151-2 | Begge | Ser på fliserne ude foran huset og diskuterer hvordan disse skal ligge. "K: Tror du ikke vi skal have lidt flere?" |
| kaer151-2 | Kvinde | Vi har ændrt på fliserne, så der er flere foran huset: "K: Hva så hvordan ser det ud nu? M: Synes lidt det ligner en motorvej eller parkeringsplads - så der er nok lidt for mange." |

| | | |
|---|---|---|
| kil6 | Kvinde | Det er faktisk kun på ydersiden af huset mod vejen, at jeg gerne vil have hvide vinduer. Der er ligesom kun sorte materialer der, op mod huset er det ikke noget problem for der er andre materialer(Røde mursten, hvidt træ osv.) |

### It is important to see the house with the right materials

| | | |
|---|---|---|
| kaer151-2 | Mand | Starter med at sætte de rigtige materialer op |
| kil6 | Kvinde | Spørger efter en sort dør, er det ikke muligt? (Ønsker at se huset i netop deres materialer) |
| kil6 | Kvinde | Det er lidt træls at den dør ikke er sort |
| kil6 | Kvinde | Har fået sort dør i nu" Det hjælper jo faktisk en del på helheden" |

### Missing physical understanding of normal 3D visualization

| | | |
|---|---|---|
| kaer37 | Mand | Svært at forestille sig huset i 3D "How much is 27m2 of livingroom" |
| bir32 | Mand | Det er godt at man går rundt om huset, for at se hvordan det ligger på grunden, da det er svært at forestille sig, hvor meget 10 meter er, når man ser det på en tegning eller på computeren. |
| kaer151 | Mand | Svært at forestille sig hvad 20 m er |
| bir32 | Mand | 3D hus på computeren virker mindre ind når man selv går rundt idet, så det er fedt at prøve det på en krop. |

### HouseView gives a better understanding than normal 3d on a computer

| | | |
|---|---|---|
| bir32 | Mand | Det ligner jo faktisk meget godt, faktisk bedre end det jeg har der hjemme på computeren. |

### Product samples do not show the interplay between materials

| | | |
|---|---|---|
| bir32 | Mand | "Man skal se et helt hus, man kan ikke bestemme sig ud fra små prøver. |
| kaer151 | Kvinde | "Man kan godt nogen gang blive lidt i tvivl om det er det rigtige |
| kaer151 | Mand | "Det betyder meget, at man ser huset med de rigtige materialer" |

### Context spawn questions about their choices

| | | |
|---|---|---|
| Soe28 | Mand | Spørger kvinde: "Skulle vi måske have brugte nogle ekstra penge og få fjernet den mur der?" De har en mur imellem 2 vinduer i stuen. |
| Soe28 | Kvinde | "Det var jo det jeg sagde" - De diskuterer og sammenligner med de andre huse omkring dem, her er muren fjernet. |
| Soe28 | Mand | "Det her er jeg meget imponeret over, men det er lidt synd at GPS hopper, ellers er det super fedt at sammenline med de andre huse." |
| kaer37 | Mand | "Det er fedt at sammenligne materialer med naboerne, så man ikke laver et lorte valg" |
| bir32 | Mand | Det kan godt tænkes, at når man er på grunden, så ser man om huset passer ind. Det prøvede jeg i hvert fald. |
| kaer151 | | Kunne havde hjulpet med placeringen af huset på grunden. |
| kaer151 | | "Kunne godt blive lidt i tvivl nogen gang" snakker om materiale valgs processen |
| bir32-2 | Mand | De står i stuen og ser på et vindue, hun mener ikke de har nok udsigt mod |

| | | |
|---|---|---|
| | | haven - han prøver at se det via houseView, og siger, "Jeg synes det er fint" |
| kil6 | Kvinde | Det er faktisk kun på ydersiden af huset mod vejen, at jeg gerne vil have hvide vinduer. Der er ligesom kun sorte materialer der, op mod huset er det ikke noget problem for der er andre materialer(Røde mursten, hvidt træ osv) |
| kil6 | Kvinde | Vinduer skal være sorte i det eksisterende hus, men man kom lidt i tvivl når man så det hele i sort. |

## Context is changing and therefore difficult to use

| | | |
|---|---|---|
| kaer151 | | De kunne ikke forholde sig til udsigten da der sker så meget i området for tiden |

## HouseView spawn questions about their choices

| | | |
|---|---|---|
| kaer151 | Kvinde | "Hov se det vindue der" Hun ser på bryggers vindue og siger "Det virker ret lille, det kunne jeg egentlig godt tænke mig større" |
| kaer151 | Kvinde | Vender tilbage til vinduet og siger "Det dur ikke med sådan et lille vindue der" |
| kaer151 | Mand | Kigger på facaderne og vinduerne |
| kaer151 | Kvinde | "Jeg synes det er rigtig sjovt at se huset: men det vindue er altså alt for lille" |
| kaer151 | | De vil ændre på vinduer pga. vores app. Mangel på vinduer på en side af huset |
| kaer151 | | "Kunne godt blive lidt i tvivl nogen gang" snakker om materiale valgs processen |
| bir32-2 | Mand | "Hov hvordan ser det tag ud, det er da tosset. Det burde vi godt nok overveje at ændre" |
| bir32-2 | Mand | "Det er egentligt slet ikke pænt med rulleskift og muret gavle" |
| bir32-2 | Mand | De står i stuen og ser på et vindue, hun mener ikke de har nok udsigt mod haven - han prøver at se det via houseView, og siger, "Jeg synes det er fint" |
| bir32-2 | Mand | skal have lavet gavlene om |
| kil6 | Kvinde | Vi var faktisk ret enige om, at de skulle være sorte - men de hvide passer nu faktisk bedre |

## Decision making is influenced by the context

| | | |
|---|---|---|
| sols88 | Mand | "Synes faktisk jeg blev bekræftet i min valg, da jeg prøvede at ændre mursten til nogle af de typer vi havde snakket om og så sammenlignede med omgivelserne. Her passer vores gule valg langt bedre end sort" |
| sols88 | Mand | "Men farve valg og de ting tror jeg det betyder rigtigt meget at stå her ude." |
| sols88 | Mand | "Det er jo fint nok at lave et pænt hus men hvis det ikke passe ind i området falder det jo lige udenfor" |
| sols88 | Mand | Det at se huset i forbindelse med omgivelserne, det var super fedt |
| sols88 | Mand | "Synes faktisk det flyttede lidt på nogle ting, at man fik denne form for visualisering" |
| Soe28 | Mand | "Vi vil ikke have noget, som falder ved siden af kvarteret"(Der ligger et |

| | | |
|---|---|---|
| | | træhus, som slet ikke passer ind mellem de andre huse) |
| Soe28 | Mand | "Træhuset passer f.eks. Ikke ret godt ind." En af naboerne har valgt at bygge et "bjælke hus", som ikke passer ret godt ind i kvarteret. |
| Soe28 | Mand | "I starten da vi begyndte at se på grunden, var vi meget betaget af det træhus - men nu hvor kvarteret er mere udbygget er det jo helt ved siden af." |
| kaer37 | Mand | "Det er fedt at sammenligne materialer med naboerne, så man ikke laver et lorte valg" |
| kaer37 | Mand | "Solen er i hvert fald vigtig" |
| bir32 | | Kunne have gælde af at se hvordan det passer sammen med omgivelserne. |
| kaer83 | Mand | "Man ville kunne være mere sikker i beslutningerne" Man ville kunne undgå misforståelser |
| spi21 | begge | De stiller sig sammen og ser på begge ideer: "Ide2 passer bedre i forhold til det eksisterende hus" |

## Decision making is influenced by HouseView

| | | |
|---|---|---|
| sols88 | Mand | "Synes faktisk det flyttede lidt på nogle ting, at man fik denne form for visualisering" |
| sols88 | Mand | Ville kunne havde hjulpet dem med valg at gavle mm. "Lige i forhold til sådanne noget som valg af facade og mursten der ville jeg godt havde haft det inden" "Det kunne godt havde ændret mit valg" |
| sols88 | Mand | "Valg af facade kunne godt påvirke mine valg" |
| bir32 | | Kunne godt træffe beslutning på baggrund af houseview... men der er flere ting der er vigtigt i valg. |
| kaer151 | | De vil ændre på vinduer pga. vores app. Mangel på vinduer på en side af huset |
| kaer151-2 | M | "Jeg er blevet bekræftet i nogen af vores valg efter vi har prøvet jeres" |
| kaer151-2 | Begge | Ser på fliserne ude foran huset og diskuterer hvordan disse skal ligge. "K: Tror du ikke vi skal have lidt flere?" |
| kaer151-2 | Kvinde | Vi har ændret på fliserne, så der er flere foran huset: "K: Hva så hvordan ser det ud nu? M: Synes lidt det ligner en motorvej eller parkeringsplads - så der er nok lidt for mange." |
| kaer151-2 | Mand | Mand er gået til terrassen, for at se flise ændringerne: "Vil du ikke også lige se det her?" |
| kaer151-2 | Kvinde | "Ja nu passer det vist meget godt med den terrasse". |
| bir32 | Mand | "man kunne havde brugt det til en form for grov sortering" |

## HouseView is missing features

| | | |
|---|---|---|
| sols88 | Mand | "Bliver det så muligt at sætte køkken ind? Det kunne være fedt" |
| sols88 | Mand | Muret gavl kontra træ, kunne være godt at se |
| kaer37 | Mand | Det kunne være fint med lys/compass, så man kunne se hvilken retning man ser i. |
| bir32 | Mand | Det kunne være fedt at ændre på gavl/mur |
| bir32 | Mand | Vil gerne kunne zoome - i stedet for at gå rundt. |
| kaer83 | Kvinde | Randerstegl: Der er fine muligheder, men det er alt for lille, så det kunne være meget godt at få det op på en stor fladskærm. |

| | | |
|---|---|---|
| kaer83 | Mand | Fotorealistisk er helt sikkert noget der er vigtigt. |
| kaer83 | Kvinde | Troede faktisk, at det var en form for projekter i havde lavet, så man kunne se huset uden at gå rundt med et device. |
| kaer83 | Kvinde | Jeg vil gerne have sådan nogle byggeklodser, så man kunne sammensætte huset og ændre i værelser/grundplan. |
| kaer83 | Mand | Det skal være tro mod grund/hældning, så det skal angive fald i meter. |
| kaer151 | | Vil gerne indrette huset |
| kaer151 | | Kunne godt tænke sig indervægge |
| kaer151 | Mand | "Vi er ved at snakke om en detalje i køkkenet - køleskabet - hvor skal det stå , så det kunne være sjovt at sætte det ind" |
| kaer151 | Kvinde | "Det kunne være fedt med en masse have ting, hæk, fliser osv." Ville godt havde kunne se deres carport |
| kaer151 | | Savner væggene indvendig |
| FM-1 | Kvinde | Vil gerne kunne sætte køkken ind |
| kil6 | Kvinde | Vil gerne kunne have prøvet at gå indenfor. |
| kil6 | Kvinde | Det kunne være super fedt at stå i det eksisterende køkken og så se hvor meget udbygningen kommer til at skygge. |

## HouseView is too ureliable

| | | |
|---|---|---|
| Soe28 | Mand | Er lidt synd, at GPS'en ikke er bedre. |
| Soe28 | Mand | "Det her er jeg meget imponeret over, men det er lidt synd at GPS hopper, ellers er det super fedt at sammenline med de andre huse." |
| bir32 | Mand | Det med at gå rundt, er en super ide, men det er lidt synd at GPS'en er buggy |
| kil6 | Kvinde | Det er som om det ikke er helt korrekt |
| kil6 | Kvinde | Hov nu skal jeg lige give det lidt tid til at falde i ro. |

## Virtual house does not match real world objects

| | | |
|---|---|---|
| kil6 | Kvinde | Det er som om det ikke er helt korrekt |
| spi21 | mand | Det ligger ikke helt rigtigt i forhold til det gamle hus, men man kan helt sikkert bruge det til noget |
| spi21 | mand | "Der har helt sikkert potentiale, men jeg kunne godt forestille mig at det er bedre uden det gamle hus til at forstyrre billedet" det er vigtigt, at der er en god relation mellem gammel og nyt |
| spi21 | mand | "En god overgang mellem eksisterende og tilbygning var vigtig for forståelsen" |

## Wonder how the house affect the neighbours

| | | |
|---|---|---|
| sols88 | | "Det med at se ud af vinduerne, ville kunne havde hjulpet med placeringen af huset." |
| sols88 | Mand | Da vi valgte grunden og placeringen af huset, tænkte vi meget over hvordan huset skulle vende "Kommer vi til at se direkte ind i nabo soveværelset" |
| kaer151 | Mand | Går ind badeværelset og ser ud af vinduet - Han undersøger hvilken udsigt han vil få i forhold til naboen, da deres stue ligger ret tæt på badeværelses vinduet. Naboen får altså mulighed for at se direkte ind i |

| | | |
|---|---|---|
| | | deres badeværelse |
| kaer151 | Mand | Er vendt tilbage til nabo stue/badeværelse problemstillingen. Han står nu ved naboens stuevinduer og ser over mod hans hus, for at forstille sig hvad de kommer til at se, og om deres hus vil genere naboen. Da de selv har valgt at ligge huset meget tæt på grundskel. |
| kaer151-2 | Mand | Der spørges ind til problematikken med nabo stuen: "Vi har snakket om det siden sidst ja, vores hus kommer til at tage meget af deres lys i stuen." |

## Wonder how the neighbours affect their house

| | | |
|---|---|---|
| sols88 | | "Det med at se ud af vinduerne, ville kunne havde hjulpet med placeringen af huset." |
| sols88 | Mand | Da vi valgte grunden og placeringen af huset, tænkte vi meget over hvordan huset skulle vende "Kommer vi til at se direkte ind i nabo soveværelset" |
| kaer151 | Mand | Går ind badeværelset og ser ud af vinduet - Han undersøger hvilken udsigt han vil få i forhold til naboen, da deres stue ligger ret tæt på badeværelses vinduet. Naboen får altså mulighed for at se direkte ind i deres badeværelse |
| kaer151 | Mand | Er vendt tilbage til nabo stue/badeværelse problemstillingen. Han står nu ved naboens stuevinduer og ser over mod hans hus, for at forstille sig hvad de kommer til at se, og om deres hus vil genere naboen. Da de selv har valgt at ligge huset meget tæt på grundskel. |
| kaer151-2 | Kvinde | Tjekker vinduer og udsigt - "Hvor tæt er vi på naboerne?" "Vi er jo ikke bange for andre mennesker, men vi vil jo også gerne kunne være os selv." |

## Regret that they did not have the tool earlier in the process

| | | |
|---|---|---|
| sols88 | Mand | Forestiller sig en situation, hvor man har systemet med og kører rundt til forskellige grunde man har udset sig, for at finde ud af om huset passer ind. |
| sols88 | | Kunne havde hjulpet fra man ville finde grunden. Det med at kunne køre hen til grunden og se hvordan et hus af den type man har tænk på kunne se ud "Kanon fedt værktøj" |
| sols88 | Mand | Ville kunne havde hjulpet dem med valg at gavle mm. "Lige i forhold til sådanne noget som valg af facade og mursten der ville jeg godt havde haft det inden" "Det kunne godt havde ændret mit valg" |
| sols88 | Mand | "Valg af facade kunne godt påvirke mine valg" |
| Soe28 | Mand | "I vores proces havde vi huset før grunden, så det kunne havde hjulpet os med at se vores hus på forskellige grunde" |
| Soe28 | Mand | "Vi havde huset tegnet før vi fandt grunde, med det her har vi kunne tage det med ud og prøve det på flere grunde" |
| kaer37 | Mand | "Det eneste jeg kunne havde tænkt mig, var at vi havde prøvet det tidligere i processen, da der netop på dette tidspunkt var rigtig mange tvivls spørgsmål" |
| kaer37 | Mand | "Kunne godt forestille mig at det gør det nemmere at blive enig om nogle detaljer, fordi man kan ændre og diskutere på samme grundlag." |
| bir32 | | Kunne havde hjulpet tidligere i processen med valg at hus type og materialer |
| bir32-2 | | Hvis vi havde haft der så vi kunne bruge det undervejs ville vi nok havde |

| | | |
|---|---|---|
| | | brugt det |

## Identify possibilities in using HouseView

| | | |
|---|---|---|
| Soe28 | Mand | "I vores proces havde vi huset før grunden, så det kunne havde hjulpet os med at se vores hus på forskellige grunde" |
| Soe28 | Mand | "Vi havde huset tegnet før vi fandt grunde, med det her har vi kunne tage det med ud og prøve det på flere grunde" |
| sols88 | Mand | Forestiller sig en situation, hvor man har systemet med og kører rundt til forskellige grunde man har udset sig, for at finde ud af om huset passer ind. |
| sols88 | | Kunne havde hjulpet fra man ville finde grunden. Det med at kunne køre hen til grunden og se hvordan et hus af den type man har tænk på kunne se ud "Kanon fedt værktøj" |
| kaer37 | Mand | "Hvis jeg var entreprenør ville jeg have dette produkt, er helt sikker på at det ville hjælpe i købs processen." |
| bir32 | Mand | Er sikker på det er en god ide, da man kan prøve forskellige ting "on the fly" i stedet for at skulle igennem en lang proces. |
| kaer151 | Mand | Synes systemet passer bedst til, at prøve ens hus af på forskellige grunde, for at se om det passer. |
| Par1 | Mand | "For sådanne nogen som os kunne det bruget til at flytte rundt på huset på grundet" |
| Par1 | Mand | "Det giver nogen helt andre muligheder" Se og placering af huset |
| kaer151-2 | Begge | "Når andre har bygget var det svært, at forstå de tegninger, fordi man ikke …. |
| kaer151-2 | K | "Det ville være noget helt andet end de billeder man kunne sidde og vise folk" |
| kaer151-2 | K | "Det er svært at sætte sig ind i andres tegninger" |
| kaer151-2 | M | "Hvis man havde det nemt ville man vise det frem for andre" |
| kaer151-2 | K | "Man vil godt være interesseret i andres tegning med det er svært" |
| kaer151-2 | K | "Vi var med ude og kigge på deres grund med det er svært at sætte sig ind i selv om man har tegningerne med ude" |
| FM-2 | Mand | "Kunne være fedt at få kunne lave hus på computeren og så få den rumlige fornemmelse i felten. |
| kil6 | Kvinde | Det er svært at visualisere andres valg, det er noget andet når det er ens eget. Det føler man mere for. |
| kil6 | Kvinde | Det kunne være super fedt at stå i det eksisterende køkken og så se hvor meget udbygningen kommer til at skygge. |

### Found it interesting to see the area around their house

| | | |
|---|---|---|
| kaer83 | Mand | Han får mulighed for, at se naboen, "Uh det kunne være sjovt at se" |
| kaer151-2 | M | "Fliserne gav et meget realistisk indtryk af hvordan det kom til at se ud" |

### Axial coding

**Technical limitations**
The screen is too small
HouseView is too unreliable
The screen is too sensitive to light

**Dept Ques**
Depth Perception is lost/Size of the virtual house does not correspond to real world
Having other virtual objects than the house improves the visualization

**Visual understanding enhanced by the context**
Being in context helps furtherance the visual understanding
HouseView helps furtherance the visual understanding of the area around the house
The exterior visualization is more useful

**Idea generation**
Using HouseView spawn ideas
Being in context spawn ideas
HouseView helps with the placement of the house on the plot

**Idea comparing**
Changing materials in the moment improves visualization of the interplay between materials
Making changes on the fly is great

**Useable tool**
First impression is positive
Regret that they did not have the tool earlier in the process
Identify possibilities in using HouseView
HouseView supports users in finding a plot for at house

**Contextual influence**
Context spawns questions about their choices
Context is changing and therefore difficult to use
Changing materials visualize the interplay between house and context

**Contextual responsibility**
Wonder how the house affects the neighbors
Wonder how the neighbors affect their house
Found it interesting to see the area around there house

**Verifying decisions**
Inspects the house in detail
It is important to see the house with the right materials

**Software limitations**
HouseView is missing features

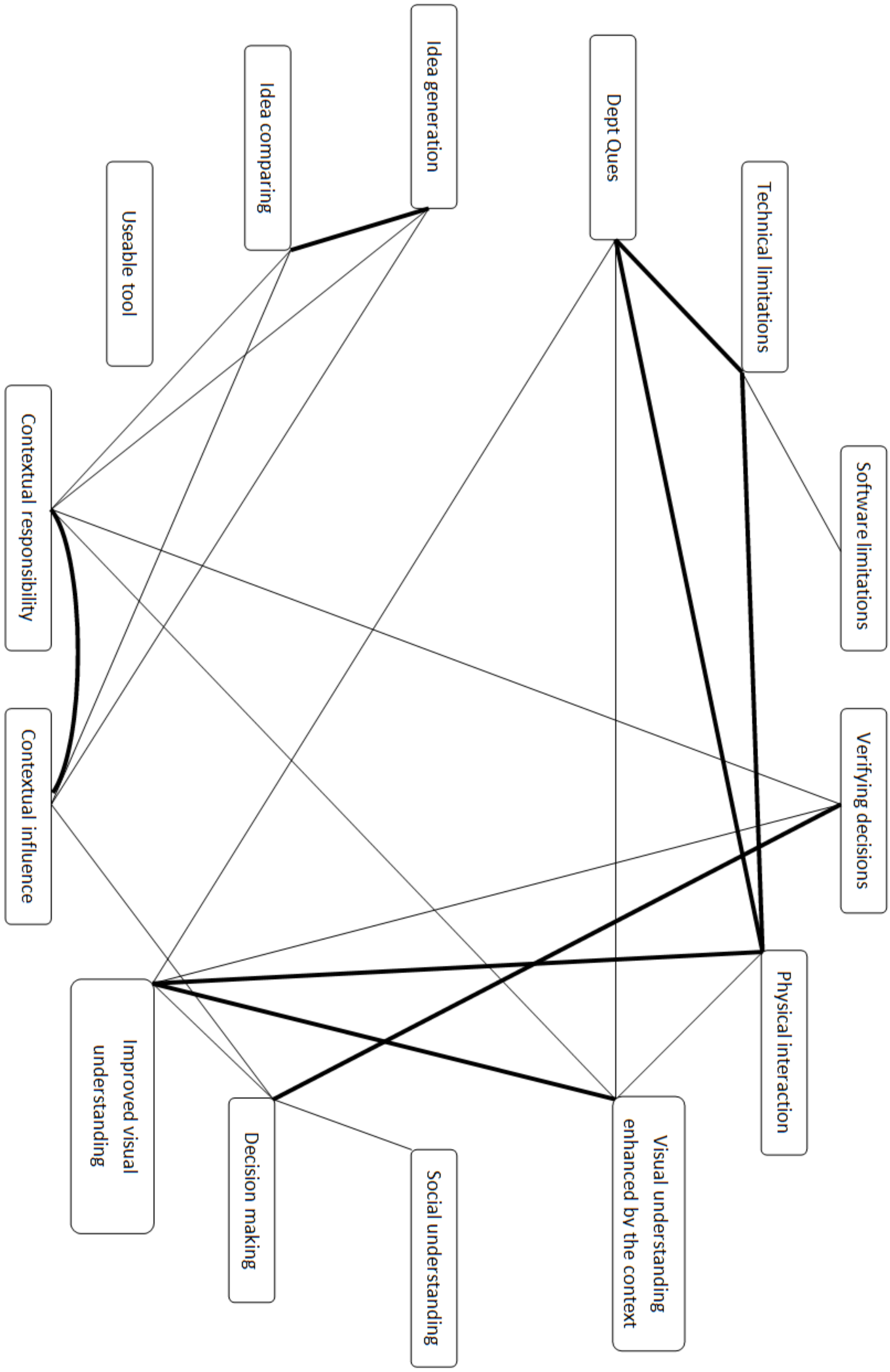
**Physical interaction**
Do not understand the concept of the virtual house and physical movement
vs
Understand the concept of physical movement
Physical interaction affects the visual understanding
Uses HouseView to understand the size of the house
Virtual house does not match real world objects

**Social understanding**
HouseView is used to gain shared understanding about the house between family members
HouseView could improve visualization for friends
HouseView helps avoid conflicts

**Decision making**
Decision making is influenced by the context
Decision making is influenced by HouseView
HouseView spawn questions about their choices

**Improved visual understanding**
It is difficult to understand 2d blueprints
Product samples do not show the interplay between materials
Missing physical understanding of normal 3D visualization
HouseView gives a better understanding than normal 3d on a computer
HouseView helps furtherance the visual understanding of the house

### Selective coding


Idea generation
Idea comparing
Dept Ques
Technical limitations
Useable tool
Software limitations
Contextual responsibility
Contextual influence
Verifying decisions
Physical interaction
Improved visual understanding
Decision making
Social understanding
Visual understanding enhanced by the context