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# A facial recognition application for elderly care

## Caregiver verification and identification


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# Abstract

Interest in facial recognition has increased rapidly during the past decade. This has made facial recognition both possible and useful. Bio-metrics and identity recognition are common applications for facial recognition.

The population in Sweden is aging. Moreover, many people remain living on their own until old age. This introduces new challenges to society. How do we maintain the autonomy of elderly, and support their well-being despite of the challenges introduced by aging?

This thesis presents a study of the potential of facial recognition in elderly care. In the thesis work a need for facial recognition system in elderly care is identified, a system architecture to meet the need is presented, the implementation process of such system's prototype is described, and the feasibility of the prototype is evaluated.

One of the results of the study indicates that there is a need in elderly care to help seniors to verify and identify caregivers who visit them. The study shows that a facial recognition system which presents information about the visiting caregiver to the elderly would support them in their daily life. The user interface of the developed prototype is feasible, but as it is now, the facial recognition part of the program is not accurate enough to be used in a real life context. Ways of improving the facial recognition functionality of such a system should be studied in future research.


**Keywords:** facial recognition, elderly care, caregivers, identity verification

# Sammanfattning

Intresset för ansiktsigenkänning har ökat snabbt under det senaste decenniet. Detta har gjort ansiktsigenkänning både möjlig och användbar. Biometri och identifiering är vanliga användningssätt för ansiktsigenkänning.

Sverige befolkning åldras. De äldre fortsätter dessutom att i hög grad bo ensamma. Detta introducerar nya utmaningar för samhället. Hur kan vi bibehålla de äldres autonomi and stötta deras välmående, trots ålderns krämpor?

Denna uppsats presenterar en studie om potentialen för att använda ansiktsigenkänning inom äldrevården. I arbetet identifieras behovet av ett ansiktsigenkänningssystem inom äldrevården, en systemarkitektur för att tillgodose detta behov presenteras, implementeringsprocessen av en prototyp av ett sådant system beskrivs samt genomförbarheten av ett sådant system utvärderas. Ett av studiens resultat indikerar att det finns ett behov inom äldreomsorgen att hjälpa seniorer att identifiera och verifiera den personal som besöker dem. Studien visar att ett ansiktsigenkänningssystem som visar information om besökande personal till seniorerna skulle kunna hjälpa dem i deras dagliga liv.

Användargränssnittet i den utvecklade prototypen är användbar, men i dess nuvarande stadie är ansiktsigenkänningsdelen av programmet inte exakt nog för att kunna användas i verkligheten. Metoder för att förbättra ansiktsigenkänningsfunktionen i ett sådant system är ett uppslag för framtida forskning.

**Nyckelord:** ansiktsigenkänning, äldreomsorg, vårdgivare, identitetsverifiering

# Forewords

The authors of this thesis would like to thank the examiner Anne Håkansson for pointing out the interesting artificial intelligence subject within facial recognition and elderly care. In addition the authors would like to thank the supervisor Johan Montelius for general guidance in the thesis process.

# Contents

# Chapter 1

# Introduction

With the increased computational power and rising interests in artificial intelligence, facial recognition applications have become popular innovation in bio-metrics and identity recognition [1]. Facial recognition is used for example in crime prevention, person verification, information security and access control [2]. Facial recognition works by detecting a face from an image and then trying to match the found face with models of people's faces stored in the system's database. [3] [4]

## 1.1 Background

According to Sweco's 2016 forecast, the proportion of elderly care in the urban areas of Sweden will double by 2040.[5] Because the number of seniors in the society is increasing constantly, it is important to find solutions which facilitate autonomy and well-being for them. With the vast improvements in information and communication technology, these solutions could be sought from such technology. For example, facial recognition could have huge potential in facilitating better elderly care services. Despite its potential, this area lacks a lot of research.

In order to find out how facial recognition could be used in elderly care, a collaboration with Rinkeby-Kista elderly care and Royal Institute of Technology, School of Electrical Engineering and Computer Science is carried out. A Rinkeby-Kista elderly care employee is interviewed in order to identify areas where facial recognition would be helpful.

## 1.2 Problem

In Rinkeby-Kista elderly care a recurring problem of seniors not recognizing visiting caregivers exists. This causes confusion and feelings of insecurity among the seniors. The inability to recognize the visiting caregivers is related to general uncertainty of whether the visitor works for the elderly care or not, as well as not knowing the person's identity. Difficulty in recognizing the visiting caregivers is due to two reasons: aging and temporary staff. Aging can cause decrease in memory functions, thus affecting the seniors' ability to remember all the different caregivers. The number of temporary staff in Rinkeby-Kista elderly care is high, leading to many different caregivers visit the elderly weekly. [6] [7]

The aforementioned issue could potentially be solved with a facial recognition system. Even though the need for a smart system is identified, it is not self evident how such a system would work in the given context and what it would contain. Thus the research question for this study is: **"How can facial recognition system be used to support seniors' recognition of visiting caregivers?"**

## 1.3 Purpose

The purpose of this thesis is to present how a facial recognition system could be used to support seniors' recognition of visiting caregivers. In this thesis, a literature review of related research is presented, and one design solution for facial recognition system, to help seniors recognize visiting caregivers, is proposed. The implementation process of such system's prototype is described. Additionally, the thesis presents an evaluation of the prototype's feasibility and raises topics for future research .

## 1.4 Goal

The goal of this degree project is to provide a facial recognition system that can be used to help seniors in their every day lives, therefore supporting their autonomy and well-being. This goal is reached by implementing a prototype of the facial recognition system, which can help seniors to recognize visiting caregivers.

## 1.5 Ethics, Benefits and Sustainability

Ethical questions can arise from privacy issues. The facial recognition system demands implementation of a camera which is accessible from the senior's door. Requirement of picture taking and storing before every elderly visit can cause concern among the caretakers.

Additionally, implementation of General Data Protection Regulation (GDPR) within European union imposes new regulations on storing, protecting and transporting of personal data. Every company handling personal data must comply with the GDPR, hence it is of utmost importance to consider what data, and why and how it should be stored in the facial recognition system. [8] Additionally, concern may arise from wether it is possible to integrate technology with elderly's everyday life in such a pervasive way. Whenever any artificial intelligence technology is discussed, questions of artificial intelligence eventually replacing humans in the job markets, and replacing human to human interaction, are inevitable.

The ethical aspect of working with informants is taken into consideration by making sure that all participants were informed that participation was voluntary, that the participants were informed of what was going to happen during the tests and for what purpose, and that the personal data of the participants was handled with care.

By proposing a facial recognition system and describing its prototype's implementation process and evaluation, this degree project aims to encourage future studies on similar systems. A successful implementation of the facial recognition system would support achieving of United Nations sustainability goal 3.Good health and well-being. [9] Good health and well-being of the elderly could be achieved with the help of the system by allowing them to more easily recognise visiting caregivers, thus bringing them a higher sense of security and peace of mind. Further, by presenting the elderly with information about who is visiting, the system enables the elderly to make informed decisions about who they let in their homes. This support the autonomy and inclusion of the elderly in society, regardless of their additional needs. Additionally, this could help the visiting caregivers in performing their work by making the elderly calmer and more at ease.

## 1.6 Methodology

Research methods can be divided into quantitative and qualitative research methods depending on whether they process numerical or descriptive data, respectively. The goal of quantitative methods is to measure the phenomena somehow. Numerical data is often analyzed with the help of statistical methods. In quantitative research the amount of collected data is often extensive. [10]

In qualitative research methods the data is collected in natural language format. Instead of measuring and explaining phenomena, the focus is on describing, categorizing, understanding and interpreting of phenomena. Qualitative research is carried out for example if the researcher is interested in the subjective experiences of individuals. [10]

By combining quantitative and qualitative data, one can gain a more thorough understanding of a phenomena. This method is called triangulation, and is often used to ensure the correctness of results by increasing the credibility and validity of the results. Even though both quantitative and qualitative methods are used, normally only methods and strategies of one type are applied at a time. [11]

In this thesis the main focus is on qualitative methods, since the goal of the thesis is to provide a facial recognition system prototype for elderly care. In order to find feasible ways of implementing the prototype literature reviews of other systems were performed, and interviews with Rinkeby-Kista elderly care were conducted in order to gain in-depth knowledge of possible system architecture, people's needs, thoughts of what kind of system would be needed and attitudes towards such system. Triangulation is used in the evaluation of the prototype. Since both the performance of the system, and the user experience of the system are important for the system's feasibility both quantitative and qualitative methods are used in the prototype's evaluation.

Quantitative methods are used in the evaluation of the prototype's performance, since quantitative methods are well suited for measuring things like average performance and accuracy. Qualitative methods are used for user testing of the prototype, since qualitative methods are typically good for understanding individual's thoughts, attitudes and emotions.

Inductive approach works its way up from data to general theory. It is an approach used with qualitative research methods. Inductive approach is used to induce conclusions from the extracted data. The purpose of inductive approach is to formulate theories and propositions with alternative explanations from observations and patterns. It can also be used in development of an artifact. Understanding a phenomena based on behaviour, opinions and experiences is central to the inductive approach. [11] [12] [13] [14]

The deductive approach works its way down from general theory to testing hypothesis with the help of collected data. Deductive approach is used with quantitative methods. [15] Deductive approach tests theories to verify or falsify hypothesis. It explains how the variables are to be measured and what the expected outcomes are. It also aims to explain causal relationships between the variables. [12] [13] [14] Deductive approach is concerned with deducting conclusions from premises or propositions. The advantage of deductive approach is that it offers a possibility to measure concepts quantitatively and that it makes it possible to generalize research findings to a certain extent. Characteristic for choosing deductive approach to research is abundance of sources, whereas inductive approach is often chosen if scarcity of sources is a problem. [16]

In this thesis work an inductive approach is used in designing and building the prototype, since the collected data is used to come up with a feasible prototype. An inductive approach is also used in the evaluation of the prototype's user experience. Additionally, quantitative methods are used in the evaluation of the prototype's performance.

## 1.7 Stakeholders

This thesis is carried out in collaboration with the Royal Institute of Technogy, School of Electrical Engineering and Computer Science and with Rinkeby-Kista elderly care. Rinkeby-Kista elderly care is one of Stockholm's largest businesses within elderly care. There are about 150 employees in the department and the company provides support to approximately 1100 customers. Rinkeby-Kista elderly care wants to bring technology, innovation and research closer to their services, thus showing their interest in solutions that promote and facilitate the every day lives of seniors and employees with the help of artificial intelligence. Rinkeby-Kista elderly care works as a test bed for the facial recognition system prototype which is implemented in this project. [5]

## 1.8 Delimitations

In this degree project only one prototype of a possible facial recognition system for helping seniors to recognise visiting caregivers is built, presented and used to evaluate the feasibility of such systems. The prototype is not complete, but the essential parts for feasibility testing were implemented. Outlines of the whole system were designed, but many functional details were discarded. The focus of the prototype was narrowed down to the facial recognition functions, reliability of the facial recognition functions, and the ease-of-use of the senior's user interface.

The implemented prototype is only one facial recognition solution to the presented problem, and other solutions, which use facial recognition in a different way, may be more or less feasible than the one presented in the thesis work. Therefore, the results of this study might not be fully generalised to all facial recognition systems in elderly care.

Only 20 pictures per person were used for training the facial recognition models. Even though the aim was to take pictures from all different angles, some of the angles may be absent from the training data. Furthermore, the pictures for the training data were taken in normal daylight or room lighting. These factors may affect the accuracy of the facial recognition function in the prototype and hence affect the results of the study of the feasibility of the system.

The feasibility of the user interface of the system was evaluated through tests in Kista elderly homes. The tests were carried out with test groups of under 10 participants. The small sample size and the fact that all the data was collected from only one elderly care centre might affect the reliability of the generalisation of the test results.

The facial recognition system will not aim to stop unauthorized people from entering the senior's apartment, since it is usually the seniors themselves opening the door to a visitor. The facial recognition system's only purpose is recognising the person at the door and informing the senior about the identity of that person.

The security aspect of the system is not taken into consideration for this prototype. Aspects like proper encryption of information, storing and transferring of data and General Data Protection Regulation compliance are neglected. For future work these aspects should be assessed.

## 1.9 Outline

In chapter 2 used technologies and theories are explained, and related works are presented. In chapter 3 research methodologies are discussed and the used software development methods are presented. In chapter 4 the project management of the degree project is explained, detailed background description of the project is given, the system architecture of the facial recognition system for supporting elderly in recognizing visiting caregivers is proposed, and the implementation process of the system's prototype is described.

Chapter 5 presents evaluation of the prototype. The test plan of the prototype is described, the test results are presented, and finally the meaning of the test results is analysed. In chapter 6 the evaluation of the whole prototype is discussed further and a summary of the whole degree project is given. In the end of chapter 6, topics for further work are discussed and a final conclusion of the study is presented.

# Chapter 2

# Theoretical background

In this chapter some of the vital underlying techniques for facial recognition are explained, and frameworks and tools used in the prototype implementation are described. Additionally, some scientific background behind designing for elderly users is mentioned and related work is presented.

## 2.1 Machine learning

In the field of computer science, use of machine learning is rapidly increasing. Machine learning is a subset of artificial intelligence. The definition of machine learning is to learn from given data and then perform tasks based on what have been learned. [17][18] The training data used in machine learning can have different data types, from text and graphs to images and numbers.

Nowadays there are many machine learning applications. Search engines are one of the more popular applications of machine learning [19]. Some other applications of machine learning are computational finance, credit storing, algorithm training, speech recognition, facial recognition, natural language processing, spam filter, and recommendation systems. [18].

Two common techniques for machine learning are supervised and unsupervised learning. In supervised learning the input data is labelled, and it could for example be a picture of a face with their name being the label. In unsupervised learning unlabelled input data is given to the program in clusters.

The output value of the training algorithm can commonly be discrete or continuous. If the output is discrete, then the machine learning model is called a classifier. If the output is continuous, the machine learning model is called a regression model. [20][18]. In this degree project, supervised learning with a classifier model is used. This is because the input data of the facial recognition system is images of faces labelled with names.

## 2.2 Bio-metric identification

Bio-metric identification techniques are techniques that can be used to identify a person's identity based on their physiology [21]. Some biometric tools include finger print recognition, speech recognition, hand geometry analysis, and facial recognition. The aforementioned techniques have different attributes, and thus they are preferred in different types of applications. For example, facial recognition is commonly used for crime prevention, verification of a person's identity, information security, and access control.[2] [3]

## 2.3 Facial recognition

Facial recognition is a bio-metric technique that recognises a person by their face. [22] [23]. Facial recognition analyses image data and recognises faces from that data. This is done by comparing the input data to the data stored in the facial recognition system's database. The database contains data about the trained faces.

Facial recognition is divided into two parts, identification and verification. Face identification means identifying who is in the input image. The identification is done by comparing the face in the input image with the trained data set of labelled faces in the system's database. For example, if the input is an image of a person, then the output is the name of the person. Face verification means verifying that the person in the input image is the one they claim to be. For example, an image of a face can be presented to the program claiming a certain identity, then in the program the face is recognized and matched to some identity. After this the matched identity is checked against the claimed identity and the program outputs the result of this match, which can be for example "yes" or "no". [3][4]

Implementing high performance facial recognition may be challenging. The challenges are usually caused by differences in lighting conditions, by variations in face pose, different image angles, and different facial expressions. Differences in lighting conditions arise from the different ways light is present when images are taken. Face pose variations indicate the distances and angles among eye, mouth, and other features in the face. Images of the same person but from different angles can be recognized as a completely different person. Different facial expressions, for example smiling expressions or angry expressions, have an impact on the shapes of the facial-features, which further complicates recognition. [4]

## 2.4 Facial recognition system architecture

A facial recognition system is a system combining the different steps which are needed in order to achieve a complete identification or verification functionality. Different ways of designing the system exist. In the study "A Study based on Various Face Recognition Algorithms" the facial recognition program is divided into the five following steps: detection, alignment, normalization, representation, and matching [22]. In other studies, the facial recognition algorithm is divided into input image, face detection, feature extraction, face recognition, and verification/identification [4] or into acquiring image, face detection, face recognition, and recognizing the person's identity [23].

However, all the different approaches for facial recognition algorithm have a step for face detection. Hence, face detection plays an important role in a facial recognition systems. The input images and the training images might not only contain the target face, but also other information, like objects in the background or a full body image of a person.

The meaning of face detection can be interpreted in three different ways: face detection, face localization, and face tracking. Face detection means detecting a face from an image. Face localization means detecting the feature like eyes, nose and eyebrows from an image, and face tracking means detecting a face from a video sequence. Different face detection algorithms include for example knowledge-based algorithm, feature invariant algorithm, appearance-based algorithm, and template matching algorithm. [4]

## 2.5 CoreML

A facial recognition system requires a machine learning model so that training of data can be done and that facial recognition can be performed. CoreML is a framework provide by Apple Developer. This framework facilitates integration of the trained machine learning model into a mobile or web application [24]. A trained model is the result of applying a machine learning algorithm to a set of training data. The model can then be used to make predictions from new data sets. [24]. The functionality of Core ML can be used for scene classification, handwriting recognition, translation, and music tagging. CoreML uses different types of machine learning models, for example feed forward, neural networks, tree ensembles, and support vector machines.[25]

Figure 2.1 shows how the CoreML model is used for a mobile application. After the CoreML model has been trained, it can directly be added as a ".mlmodel" file to an Xcode project. Xcode automatically creates a custom interface for the model [26]. Through the interface, different methods can be called in order to execute the CoreML model in the mobile application.

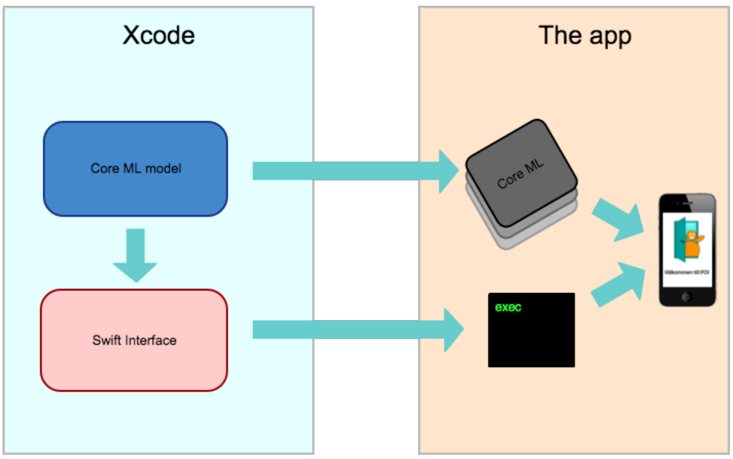



**Figure 2.1:** How CoreML can be used in Xcode projects

## 2.6 Turicreate

To create the CoreML model, the Turicreate framework was chosen [27]. The framework takes a data-set that contains the images of different caregiver and a machine learning model as inputs. The framework uses 90% of the data-set as training data and 10 % as testing data. Having both the data-set and the ResNet-50 machine learning model, a trained machine learning model is created. One advantage of the Turicreate framework is that it presents the accuracy of the training model. This means that the developer can choose to use the trained model which has the highest accuracy. Turicreate also helps with exporting the CoreML model into the file format ".mlmodel". This file can then be directly added to a Xcode project.

## 2.7 ResNet-50

ResNet-50 is a residual neural network. It uses convolution neural network architecture, which is a subset of deep neural networks. ResNet-50 can be used for image classification for different applications.[28]

## 2.8 Firebase

Servers and databases are important parts of software development. A variety of back-end servers and databases exist in today's markets. Firebase is a platform that provides the developer with a set of high quality tools for developing mobile and web applications [29]. Among other things, Firebase provides a cloud server, a cloud database, and cloud storage for mobile development. The Firebase database stores and syncs data across all clients in real-time. A benefit of Firebase's way of handling data is that the data does not get lost when the application is offline. Instead it remains available in the clients device. The data is stored in JSON objects and is synced with the NoSQL cloud database. In the cloud storage the developer can store user-generated data like photos, videos, or voice recordings. Other services that Firebase provides are authentication, cloud messaging, and cloud Firestore. Firebase provides the developer with software development kits for iOS, Android, and JavaScript projects. [29]

## 2.9 Presenting information to elderly

Today, many different kinds of channels for providing information output are available. From a human-computer interaction perspective, the elderly is a relatively different target group than young people. With increased age, loss in static and dynamic visual acuity can take place. Typically, aging can lead to loss of contrast sensitivity, decrease in dark adaption, decline in colour sensitivity, and a heightened susceptibility to problems with glare. Such decrements in visual perception can lead to elderly having difficulties in perceiving small elements on displays, reading small text on screens, or locating information on complex screens. Aging is also related to decline in auditory acuity. For example older people may find it hard to understand synthetic speech. [30]

Seniors may, due to aging, experience changes in motor skills leading to slower response time, declines in ability to maintain continuous movements, decrease in coordination and balance, and loss of flexibility. [31]

Moreover, elderly often have difficulties in using touch screens. This is because senior's skin is normally drier than younger people's skin. Dry skin conducts electricity worse than more moisturized skin. Many modern touch screens work by recognizing the electrical conductivity of a user's finger [32]. Unfortunately, not many screens are made to bring into consideration the decreased conductivity of old people's skin.

Because of aforementioned challenges, interaction design for elderly should be simple, intuitive, use big screens, and minimize the need for complex interaction. System output can be provided through visual, aural or tangible interfaces. In general it is advisable to provide vital information through multiple modalities [30].

## 2.10 Related works

Not many studies of facial recognition for elderly care are found. However, facial recognition has been applied in a few systems which support people with impaired vision or hearing. Impaired vision or hearing are also common among old people. Thus, the presented related work could also be applied in support systems for elderly people.

One of such applications is a wearable facial recognition system called Smartwatch [33]. The application is used to support blind or low vision people. The functionality of Smartwatch helps the disabled people recognise people in the surrounding area. This facial recognition system contains a Samsung Galaxy GEAR which takes a photo, K-NN algorithm for the facial recognition with histogram of oriented gradients, and a voice recording for the feedback. The system performance has an accuracy of around 83%.[33]

In the article "Design of a Mobile Face Recognition System for Visually Impaired Persons" [34], Chaudhry and Chandra propose a facial recognition system to assist visually impaired people. The system takes advantage of mobile devices and provides a simple user interface. The facial recognition system consists of an Android device, internet infrastructure, and support servers. The Android device is used to capture an image. The captured image is then detected. Android library is used for the face detection and facial recognition algorithms. For example, OpenCV object detector is used for facial detection and Local Binary Patterns Histograms is used for the facial recognition model. Google TalkBack [35] is used to give an audio feedback to the users. The result of this facial recognition system has an accuracy of around 70% for the facial recognition and an accuracy of around 93% for the face detection.

Another interesting facial recognition system is the system proposed in the article "Smart Doorbell System based on Face Recognition" [36]. The smart door bell system has an ability to distinguish and recognise faces, and then give feedback to the users. The system contains a face detection function, which uses a haar-like filter algorithm to detect a face from photo captured by a camera. The detected face is then given as an input to a facial recognition function in order to identify the person. Independent component analysis is used for facial recognition. The feedback is given to the users in the form of a notification containing information about the visitor. [36]

In the article "Facial Recognition Enabled Smart Door Using Microsoft Face API" [37] Maheshwari and Nalini present a smart door system, which based on facial recognition automatically grants or refuses access to visitors. The picture of a visitor is captured using a live HD camera. A desktop application operating over Microsoft Visual Studio IDE detects the face in the picture and gives it to Microsoft Face API for facial recognition. The feedback is given to the users via visual and aural output. A screen together with voice from a Raspberry Pi ARM are used for the feedback. A set of electromagnets are controlled by a micro controller in the Rasberry Pi ARM and is used as a lock, which can be controlled by the facial recognition output. [37]

# Chapter 3

# Scientific methods and software development methods

In this chapter theoretical description of the methodologies and methods and how these are applied in the degree project are given. More specifically, the research strategies, data collection method, and data analyzing methods which are used in the thesis work are described.

## 3.1 Research strategies

Research strategies are guidelines for carrying out research. Research strategies commonly used for quantitative research are Experimental Research, Ex post facto Research, Surveys (Longitudinal and Cross-sectional), and Case Study. The research strategies used for qualitative research are commonly Surveys, Case Study, Action Research, Exploratory Research, Grounded theory, and Ethnography. [11]

In this thesis work, case study and experimental methods are used as research strategies. Case study is used for the whole thesis work in finding out what kind of a system is needed, and for the design and the implementation the facial recognition system's prototype. The user experience of the prototype is also evaluated using the case study strategy. Experimental research strategy is used in the performance testing of the prototype.

### Case Study

Case studies can be used both in qualitative and in quantitative research. Case study is empirical study that investigates a project or process in real life context. The boundaries between the project or process and context are not always clearly evident in case studies. [11]

Case studies provides a very engaging, rich exploration of data, since the studies are done in the real-world. [38]. Furthermore, case studies aim to examine in depth the context and other complex situations related to the selected phenomena. The case study method can be applied in three different situations. [39]

The first situation is when the research question is descriptive or explanatory. Example of a descriptive question can be in the format of "What is happening?" and explanatory questions can be in the format of "How did something happen?" [39] The second situation where a case study can be applied is when conducting an evaluation study. [39] The third and final situation where a case study can be applied is in a study concerning a phenomenon in a real-life context and collection of data in a natural setting. [39]

In order to conduct a case study, three steps need to be taken. The first step is to define the "case". The cases can be for example studying a person, an organization or an event. The second step is to choose the case study type. There are four different case study types. Simple, multiple, holistic (single unit of analysis) and embedded type (multiple unit of analysis). The third step is to choose whether to include a theory in the study work or not. Choosing a theory helps organising initial data analysis and general findings of the case study. [39] Some data collection methods used in case study are direct observations, interviews, studying documents, and studying physical artifacts. [39]

### Experimental research

Experimental research strategy is used together with quantitative research methods. Experimental research methods can be used to investigate a systems' performances and establishing relationships between of variables, normally by manipulation one variable and seeing how it affects the other system variables. [11] [40] [12] [13] [14] Experimental strategies can be used to verify or falsify hypotheses, and provides cause-and-effect relationships between the variables.
Important for the experimental research strategy is that the researchers have control over all factors that may affect the result of an experiment.

[11] Different factors may interfere with the relationship between the independent and the dependent variable and can cause a confound effect. In order to eliminate this, experiments are often carried out in laboratory environment where different variables can be more easily monitored than in a real-life context. [41] The experiments are used to collect data and statistical methods are commonly used for analysing the data from the experiments. [11]

## 3.2 Data collection

Data collection methods are methods used to collect data for research. The most commonly used methods for quantitative research are Experiments, Questionnaire Case Study, and Observation. Whereas commonly used methods for qualitative research are Questionnaire, Case Study, Observations, Interviews, and Language and Text. The different methods collect data for different purposes. [11] In this thesis work experiments, observations and interviews are used as data collection methods.

### Experiments

Experiments can be used to collect a large data set of variables which are gathered according to guidelines from the experimental research strategy. An experiment is a quantitative data collection method. In this thesis, experiments are used for collecting data about the prototype's performance. Furthermore, a quasi-experimental method is used in order to simulate a user situation for the prototype, and collect data about the usability of the prototype.

### Interviews

One of the most common ways of collecting data in qualitative research is to conduct interviews [42]. In general, there are three types of interviews: structured interviews, unstructured interviews and semi-structured interviews . Structured interviews consist of pre-determined questions to which all the interviewees answer in the same order. Data analysis is normally quite straight forward for this type of interview because the different answers given to the same questions can be compared. In unstructured interviews no questions are prepared beforehand, and the nature of the interview is more conversational. From a research point of view an unstructured interview is the least reliable data collection method, since comparison of answers from differently asked research questions can be hard. Furthermore, data collected with unstructured interviews can be associated with a high level of bias. [43]

Semi-structured interviews consist of pre-defined set of questions but the interviewer can ask clarifying questions and further expand issues. The advantage of semi-structured interviews is the full control over data collection process the researcher has. Disadvantages lie in need for long time requirements, difficulties in arranging interviewing times, and getting interviewees. In conducting interviews it is important to refrain from showing emotion, commenting on the interviewees answers, or leading the interview in a certain direction. Interviews should be carried our in a relaxed and friendly environment. The anonymity and confidentiality of the interviewees should be assured when possible. [43]

In this thesis interviews are used in order to gain knowledge of the requirements for a facial recognition system for elderly care, as well as for gaining a more nuanced understanding of the quasi-experiment assessing the user experience of the prototype.

## 3.3 Data Analysis

Different data analysis methods can be used to analyse the collected material. Analysing data is a process of inspecting, cleaning, transforming, and modelling data. Data analysis supports decision making and drawing the conclusion of the research. The most commonly used data analysis methods for quantitative research are Statistics and Computational Mathematics. For qualitative research Coding, Analytic Induction, Grounded Theory, Narrative Analysis, Hermeneutics, and Semiotic are commonly used. [11] In this thesis, coding and statistics are used for data analysis. Coding is used for analysing the interviews whereas statistics are used to analyse the prototype's performance.

### Coding

Coding as a data analysis method usually analyses transcriptions of interviews and observations, turns qualitative data into quantitative data, and names and labels concepts to numerate them for statistical analysis [11]. A code in qualitative research is a word or a short phrase, which symbolically assigns a summative, salient, essence-capturing, and an evocative attribute for a portion of language-based or visual data. The goal of the code is to capture the primary content and essence of the topic. [44]

### Statistics

Statistics analyses how different research results can be handled and described by using mathematical methods, as well as how different conclusions can be drawn based on the analysed results. The goal of statistical analysis is to summarize large amount of data to key figures, like mean or different percentage ratios, so that the big data sets can be better understood. Plotting different kinds of graphs with the data set can also be used in statistical analysis, since visual presentations of numbers are often easier to understand than just raw numerical data. [41]

## 3.4 Quality assurance

In order to guarantee the quality of the research, aspects like validity, reliability, replicability and ethics need to be considered. [11] The different aspects vary slightly between quantitative and qualitative research. Since triangulation is used in this thesis, the meaning of quality assurance for both the quantitative methods and the qualitative methods is presented below.

### Quality assurance of quantitative methods

The validity, reliability, replicability, and ethics are discussed for assuring the quality of the performance testing of the prototype. The purpose of validity is to make sure that the test instruments actually measure what they are expected to measure [45] [46]. Reliability means the stability of the measurements and the consistency of the results for every testing [45]. Replicability means the possibility, by another researcher, to repeat the same research and get the same result [14].

Thus, clearly documenting of the research is very important. Ethics are concerned with moral principles in planning, conducting, and reporting the results of the research. Ethics cover protection of the participants and maintenance of privacy. [47] [12]

### Quality assurance of qualitative methods

Validity, dependability, confirmability, transferability, and ethics of the research are assessed. Validity for qualitative research means making sure that the research has been conducted according to the existing rules, and that it can be validated and confirmed that the results are correctly understood [14]. Dependability corresponds to reliability of quantitative research methods. It is the process of judging the correctness of the results [47].

Confirmability means assuring that the research has been performed in good faith without personal assessments affecting the results. Transferability means creating of rich descriptions of the research so other researches can use the information for their work. [47] As in quantitative research, ethics are concerned with moral principles in planning, conducting, and reporting the results of the research. Ethics cover protection of the participants and maintenance of privacy. [47] [12]

## 3.5 Software development methods

Different software development methods exist to support the development process of information technology artifacts. There are different types of methods, from waterfall models and V-models to agile software development methods like Scrum [48] [49]. There are also different approaches for developing user interaction design as well as many existing theories on how the interaction design should be.

In the development process for the prototype of the facial recognition system, the agile product development method Scrum was used. In the development of the graphical user interface for the prototype iterative design methods, paper prototyping, and user experience testing were used.

### Scrum

Scrum is a team collaboration framework for addressing complex adaptive problems while creatively developing products. The idea of Scrum is to build autonomous teams, which iteratively work towards developing a product. A Scrum team consists of a Product Owner, Scrum Master, and the development team. The aim is that the cross-functional team has all the competencies needed to accomplish the work. Scrum defines a set of events which should be followed during the usage of Scrum methodology. These events are designed to create regularity and to minimise meetings which are not defined in the Scrum. The events are sprints, sprint plannings, daily scrums , sprint reviews, and sprint retrospectives. Scrum also defines three artifacts which are designed to guarantee transparency and mutual understanding of the main objectives of the team during the development process. The three artifacts are product backlog, sprint backlog, and increments. [50]

### Iterative design process

The idea of an iterative design process for interaction design is to first conduct a user research where the user's needs are identified, then develop a prototype which meets the required needs. After the development of the prototype, it is tested with real users to see how well it performs. After the user testing, the test results are analysed and the prototype design is improved according to the test results. After that a new iteration of the design process stars with a new user testing, evaluation, improvement, and so on. The iterations keep going until the test results are satisfying and the design is good enough for market release. The earlier the iterative design process is conducted in the products life cycle, the more cost effective it usually is. [51]

### Paper prototyping and User Experience testing

Paper prototyping is a technique that allows creating and testing of user interfaces quickly and cheaply. Its main idea is that it is much cheaper to change and improve the paper prototype than the design on the final product. Paper prototyping can either be done by low fidelity prototype testing with hand sketches or with higher fidelity prototype testing with computer-created prototypes. All manners of interaction can be simulated and tested with paper prototyping. [52]

User experience is everything that happens to the users when they use an information technology (IT) system. It includes the users' behaviour, thoughts, and emotions when using the system. Paying attention to the user experience is important because if the user does not know how to use the system, or does not like using it, the user will not use it. Traditional user experience testing includes a test participant using the system and carrying out given tasks while the user experience tester observes the behaviour and asks the test subject questions.

Another method for testing is A/B testing, which can be used to evaluate the best user experience design. In A/B testing different versions of the interaction design are presented to the users and differences in behaviour and opinions towards the different versions are recorded. This type of testing is good for selecting the optimal design from many different alternatives. [53]

# Chapter 4

# Project design

In this chapter management of the project is discussed, background information from Rinkeby-Kista elderly care is given, and the design decisions of the facial recognition system architecture are presented.

## 4.1 Project management

Scrum method was followed in the project management. The project work was divided into 13 sprints, each sprint one week long. The sprints were defined by epics. Most of the times the epics included both some implementation of the prototype and writing the thesis report. In the start of each sprint, each epic was broken into smaller user stories and a timeline for that week's sprint was planned. In the end of each sprint the progress of that sprint was evaluated and any possible undone tasks were moved to the future sprints.

## 4.2 Background information from Rinkeby-Kista elderly care

According to Swecos prediction from 2016, the share of the population in the city area that consumes/uses elderly care will have doubled by the year 2040. At the moment, the Rinkeby-Kista elderly care supports approximately 1100 senior citizens in total, regardless of form of support. [5]

Rinkeby-Kista elderly care faces constant problems of elderly not recognising visiting caregivers. Complaints are constantly received from the seniors. Rinkeby-Kista elderly care has a lot of temporary staff, so it is hard for the seniors to know who is actually working for the Kista elderly homes and who is not. This causes worry and insecurity among the elderly. The elderly do not know who has been in their homes. Not recognizing visitors happens both because of poor memory and because of changing staff. [6] Some sort of system with facial recognition and cameras could be used to solve the aforementioned problem. Cameras installed in the spyholes of the doors could be used. This raises some ethical and legal concerns, but those prolems can be minimised by only activating the camera when someone presses a button or stands in front of the door. [7]

For the system, the most important information it provides should be informing the elderly that the person who wants to enter their apartment is actually employed by the Ribkeby-Kista elderly care. The elderly often knows why someone is coming in but might not recognize the person. Authentication of a working caregiver would be needed by the senior's door. A screen of some short would be good for this kind of system. [6]

To get into the senior's apartment the caregiver normally knocks on the door and the senior comes to open the door, at least during the day time. If the elderly can move on their own, they usually open the door by themselves. Some elderly need assistance and thus cannot open the door by themselves. [6]

## 4.3 The system architecture

Based on the background interviews with Rinkeby-Kista elderly care [6] [7] the system requirements were defined. The system should have some way of authenticating the caregivers and some way of presenting information about the visitors to the seniors. Based on the previous studies of similar systems [33] [34] [36] [37], a system with a camera on the outside of the door and with a screen and a speaker on the inside of the door was designed. Additionally a server, which works between of the camera and the screen and speaker, is needed.

In the figure 4.1 the system architecture is shown. On the caregiver's side an iPhone is used to take a picture of the caregiver and match the picture with a name. The name is then sent to the server's database. The server then sends information to an iPad on the senior's side. For the purpose of this essay, the caregiver's side and the server are referred to as back-end and the senior's side is referred to as front-end. The information, which is sent from the server, tells if the visitor who originally authenticated with the iPhone on the caregiver's side is working for elderly care or not. If the visitor is working for elderly care, the caregiver's name and image are shown. In addition, a voice recording of the caregiver introducing himself is played. Details of each part of the system architecture are discussed in the following chapters 5 and 6.

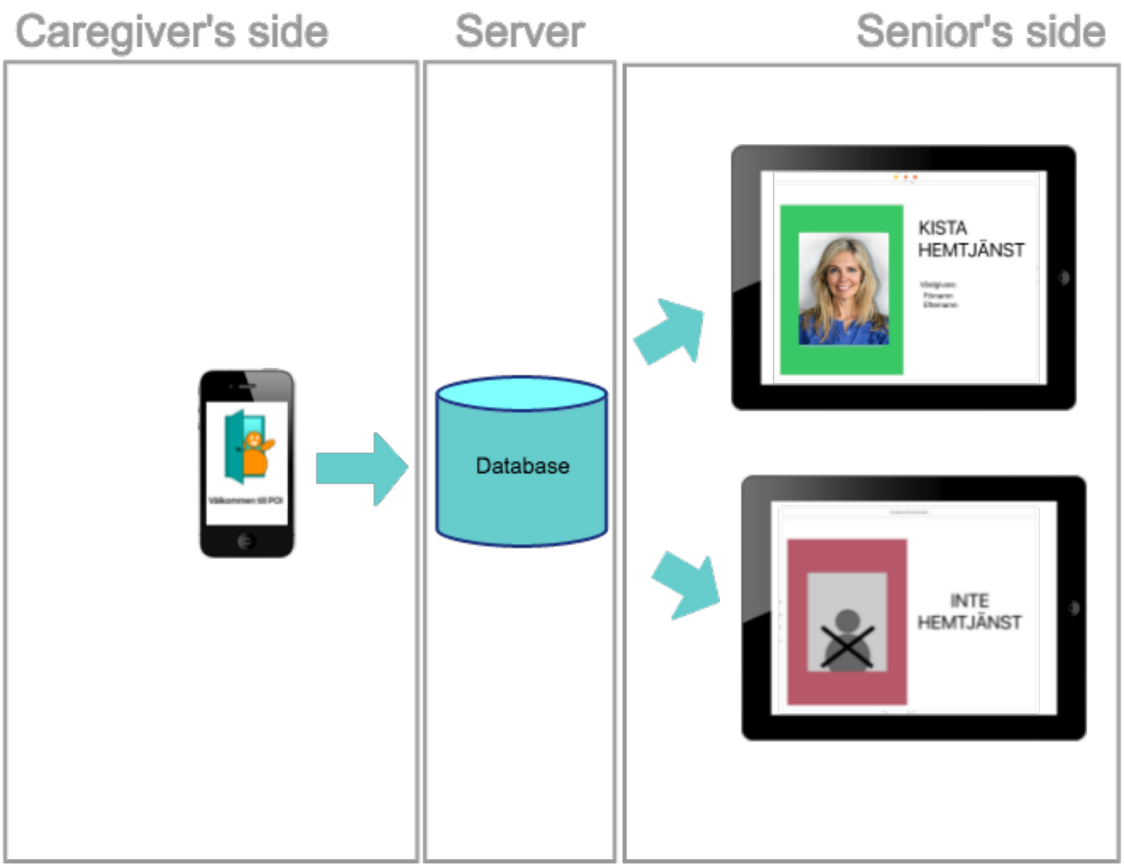



**Figure 4.1:** The system architecture[1]

[1]Image inside the green frame is from https://pixabay.com/en/woman-girl-blond-smile-beauty-509958/

# Chapter 5

# The prototype: back-end

In this chapter the back-end implementation of the prototype is presented. More specifically, the implementation of the facial recognition part of the system and the implementation of the server are described. Additionally, a "fake" back-end functionality, which is implemented for prototype testing purposes, is explained.

## 5.1 Facial recognition system

There are different ways to design a facial recognition system [23][4][22]. The approach to facial recognition system was chosen based on the previous work found in the literature review. As shown in figure 5.1 in the chosen approach the facial recognition system is divided into four steps: taking a photo, face detection, resizing the image, and facial recognition.

The step "taking a photo" describes the step where the caregiver takes an image and sends the image to the face detection function. Then "face detection" takes the image, detects the face in the image and crops it. The cropped image is sent to the step "resizing the image". In this step the image is re-sized to the size required by the facial recognition function. "Facial recognition" is the last step which takes the re-sized image of a face and identifies who is in the image by comparing the input with a stored data set. The output from the facial recognition is then sent to the server.

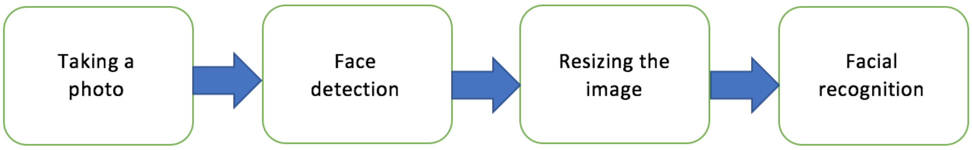



**Figure 5.1:** Facial recognition system

1. **Taking a photo**
   In the application, which is installed on the caregiver's iPhone, Apple's UIImagePickerController class is used to access the phone's camera and take a picture of the caregiver. In some cases the image's orientation might be flipped 180 degrees from normal, that is having the face upside down. In that case, the orientation needs to be checked and, if necessary, rotate the image before sending it to the face detection function.

2. **Face detection**
   Face detection is an important step in a facial recognition system. In the prototype, facial detection is used to crop the taken photo around the person's face. Swift's CIDetector is used to detect a face from the image by using the detector type "CIDetectorTypeFace". The CIDetector identifies facial features, like eyes and mouth, from a still image and provides access to their positions. The input image is cropped around the facial boundaries provided by the face detection. After the cropping is done, the image is sent to the resizing function.

3. **Resizing the image**
   The resizing function takes the cropped image and adjusts the image's sizes to meet the required dimensions of an input for the trained CoreML facial recognition model. The model requires input images which are 224 pixels wide and 224 pixels high.

4. **Facial recognition**
   Since the prototype is implemented for an iPhone, Apple Developer's CoreML tools are used for the facial recognition. In this project ResNet-50 is used to train the data-set. ResNet-50 is a residual neural network which can be trained for image classification. The training data is provided to a facial recognition training program written in Python. The Turicreate framework [27] is

used for training and exporting the trained model. In that program, the training data is divided to a training set (90% of the data) and to a test set (10% of the data). The program is trained until the results are satisfactory. After that the model is exported to the ".mlmodel" file format. This file is then added to the prototype's Xcode project. In Xcode, the model can then be directly called and used to classify new images.

A CoreML prediction method can be called from the iPhone application's code. This method takes in the image and compares it with the trained model's images. The prediction method returns prediction probabilities for all of the people in the trained model's database and the name of the person with highest prediction probability. The prediction probability of each person indicates how high the probability is that this person is the one in the input image. Thus, the program picks the person with the highest prediction probability as a result of the recognition. For example, if the people in the database are person1, person2 and person3, with a certain input image they might get following prediction probabilities as results: person1 = 0.80, person2 = 0.15 and person3 = 0.65. In this case person1 would be returned as the result of the facial recognition of the input image. After the recognition, the name of the person with highest prediction probability is sent to the server.

## 5.2 Server

In order to communicate between the caregiver's side (iPhone application) and the senior's side (iPad application) a server is needed. A Firebase [29] server is used for the prototype. In order to facilitate the communication between the iPhone and the iPad, a project is created for them in Firebase. The same bundle ID, which is used in the Xcode, is used in the Firebase project in order to connect the Xcode project with the Firebase project. After creating the project, a GoogleService-Info.plist file, created by the Firebase SDK, is added to the Xcode project. The data stored in Firebase's database is managed in the Xcode project through Firebase APIs.

Firebase is used in the prototype for storing the images and voice recordings of the caregivers, and for storing other information on the caregivers. Storing the images and audio recordings of the caregivers happens in the Firebase Storage. The images and audio records are uploaded to the Firebase Storage and the URLs of the data are used to retrieve them. Storing other information on the caregivers is done with Firebase's real-time database service. This database synchronises and stores data in real-time [29]. The first name, last name, the caregiver image's URL, and the caregiver's voice recording's URL are stored in the database. The database uses JSON trees as its data structures and the data is stored in JSON objects. When a new node in the tree is created, an associated key with the node is generated or manually added to the node. This key can then be used to fetch the data from the node.

In figure 5.2, one can see how the data for the prototype is stored in the Firebase's real-time database. The nodes "Caregiver1" and "Caregiver2" are examples of the stored caregiver data. The "Result" node in figure 5.2 is used to store the information of the caregiver predicted by the facial recognition function.

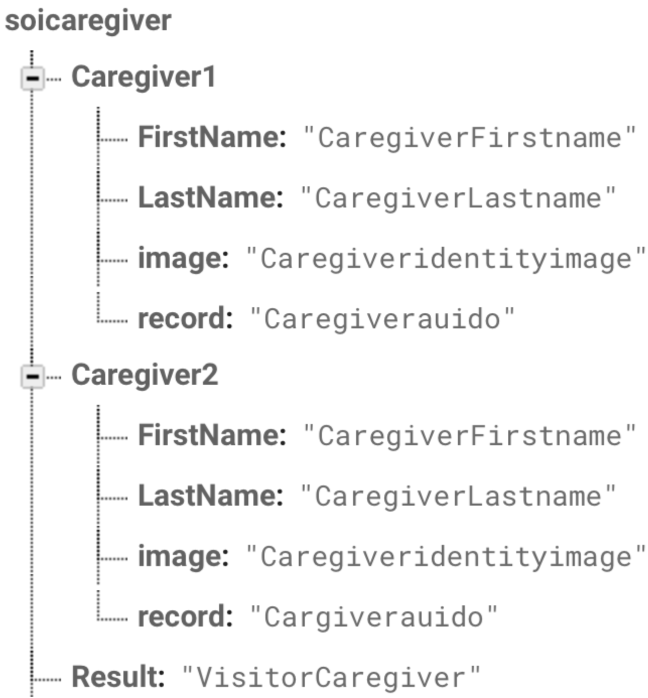



**Figure 5.2:** Database structure

The prototype works in the following way. First the caregiver's side of the prototype sends the name of the recognized caregiver to the server. Then the name is stored in the "Result" node. The senior's side of the prototype listen to the "Result" node for newly added values. When a new value is added in the "Result" node, the senior's side of the prototype retrieves the added value. The value in the "Result" is used by the senior's side to fetch the information of the visiting caregiver (first name, last name, image and recording). After fetching the information, it is presented to the senior through the iPad.

## 5.3 Fake back-end for testing purposes

In order to properly test the front-end, any recognition errors due to low accuracy in the implemented facial recognition function need to be eliminated. Since the accuracy of correct predictions from the real facial recognition function cannot be guaranteed to be high, a fake back-end was built for the front-end user testing. The fake back-end was implemented as a mobile application for an iPhone by using Xcode and Swift. The application contains only one view, which takes in the first name of the caregiver as a text input. The name is then sent to the server and stored in the "Result" node. The rest of the prototype works as described above.

# Chapter 6

# The prototype: front-end

The senior's side of the prototype presents information about the visitors to the senior. A recommendation from the Rinkeby-Kista elderly care was to somehow inform the senior if the visitor works for the elderly care or not [6] . Additionally, the system should provide information about the identity of the visitor. In this chapter the design process and design decisions for the frond end are described. The development of the front-end part was done in following steps. 1. Studying user experience design for elderly people, 2. Selecting hardware, 3. Design.

## 6.1 Studying user experience design for elderly people

First research on user experience design for the specific target group consisting of the elderly was carried out, which gave the following information. The elderly, or seniors, are a relatively different target group compared to the young. Aging can lead to loss of contrast sensitivity, decline in colour sensitivity, difficulties in recognizing small objects, and locating information on complex screens. In addition, seniors might find it hard to understand synthetic speech and experience a decline in ability to maintain continuous movements. Further the seniors often have difficulties in using touch screens. In general it is good to provide important information through multiple modalities. [30] [31] [30]

Because of this, the senior's side of the system was designed to be as simple and as intuitive as possible. The senior's side was designed to require zero interaction from the elderly. Big text, simple symbols, and basic colours were used in the design. The different views of the information screen were designed to be as simple as possible and contain as little amount of different components as possible while still providing all the desired information.

## 6.2 Selecting hardware

Research on different hardware, which could be used to present desired information to the elderly, was made. Since the elderly need information about the visitor's identity and if the visitor is working for Rinkeby-Kista elderly care or not, a screen was selected to be the output medium of the prototype. Because some elderly might have difficulties seeing the screen, it was thought that outputting information through voice in addition to the visual screen would be good. With these two requirements in mind, the search for output device was carried out. The found and feasible output mediums were smart photo frames [54], tablets [55], digital spy holes [56] [57] [58] [59] [60] and TFT displays [61].

The price of the different output devices varies between approximately 160SEK and 1400SEK, the TFT displays being the cheapest mediums and tablets among the most expensive mediums. TFT displays are cheap but they do not provide the possibility for voice output or have built-in WiFi capabilities. Tablets are expensive, but mobile, lightweight, provide a speaker for voice output, and enable WiFi connectivity as well as many other built-in functionalities.

The digital spyholes seem practical with the combined camera, which is embedded in the door's peeping hole, and screen, which can show the image from the camera. Down side of the digital spy holes is that the screen is small and might be too small for the elderly's needs. Additionally, the screen is embedded in the door, so the senior would have to move to the door to check the presented information. Many elderly have difficulties to move around, hence a mobile screen would be more beneficial. A tablet was chosen to be the output medium on the senior's side of the system, because of the reasoning above, and because Rinkeby-Kista elderly care could provide iPad-tablets for the prototype implementation. In the end, the pricing of the different output devices was not considered in the decision making.

## 6.3 Design

When the appropriate knowledge of user design for elderly was gathered and the output device selected, designing for the information screens could begun. Iterative design process was used to develop the graphical user interface of the system. Paper prototyping and user experience testing were used to design a functional and intuitive interface. Below the different design iterations are described.

### First design iteration

In figure 6.1 the first hand drawn sketch can be seen. The screens can be divided into green screens and red screens. Green screens tell that the visitor is working for Rinkeby-Kista elderly care (Kista hemtjänst in the figures). The red screens tell that the visitor is not working for Rinkeby-Kista elderly care and that the visitor is unknown.

The green screens are constructed from three elements: a picture of the visiting caregiver, the caregiver's name, and a 'check' symbol signaling that the person is from Rinkeby-Kista elderly care. In figure 6.1 on the top left green screen a green frame around the caregiver's image is added to convey the information more efficiently. Additionally, text under the person's name is added to provide more information about the person. The green screen on the bottom left is kept simpler in order to provide less complicated input to the viewer.

The two right images show the first version of the red screen. In the top right screen an unknown person in a red frame is shown in order to signal that this person is not known. Descriptive text is included stating: "The person is not from Rinkeby-Kista elderly care". A symbol with a red circle and a black cross over the circle is added to emphasise that the person is not from Rinkeby-Kista elderly care, and in order to provide the information quickly without the need to read the text above. The bottom right screen is a simplified version of the top right screen. It is made simpler to provide a clearer and calmer design in order to avoid confusing the user.


**Figure 6.1:** First sketch of the information screens

After the initial hand sketching the ideas were taken further by designing paper prototypes with a prototyping software called Pencil. The designs can be seen in figure 6.2. Seven different screens were designed, where five of them are green and two of them are red. The colourful frames were added around each image to add more of the wanted colour (green/red) to the view, in order to convey wanted information faster. The design was altered slightly between the views so that the user's attitudes towards the designs could be assessed later using the A/B method in the user experience testing.

| Screen | Screen no. | Screen | Screen no. |
|---|---|---|---|
|  | 1.1 |  | 5.1 |
|  | 2.1 |  | 6.1 |
|  | 3.1 |  | 7.1 |
|  | 4.1 | | |

**Figure 6.2:** Front-end design iteration 1

The user experience for the first design iteration was tested with real users from the target group. The testing was carried out on site at Rinkeby-Kista elderly care. The testing was carried out by showing life-size printouts of the different screens to the seniors and gathering information with a semi-structured interviews. Four independent groups of volunteering elderly people at Rinkeby-Kista elderly care were interviewed. Their thoughts and feelings regarding the different screens and different components on the screens were recorded. Finally the seniors were asked to pick the most understandable screen from both the green and the red screens. The screens selected by most of the test participants are shown in figure 6.3.

The compiled test results showed the following. On the green screen the image of the caregiver with the green frame was good. The name of the caregiver and the text "Kista hemtjänst" under the green circle were both perceived as useful. The information that the visitor was from Kista eldelry care was perceived more important than the person's name. The text was big enough for the seniors to read. However, the green circle with the white tick mark was perceived as confusing. Many of the seniors did not know what it meant, if it was a button or not, and what the functionality of that component was. On the red screen the red frame around the image of the unknown person was perceived as helpful, as well as the red colour in general in indicating that this visitor is not from Rinkeby-Kista elderly care and should not be let in. The text "Inte hemtjänst" was perceived as useful and the text was large enough to read. The red circle with the black cross was perceived as confusing and the meaning of it was not clear to many of the seniors.


**Figure 6.3:** Front-end design iteration 1 winners

## Second design iteration

The second design iteration was based on the results from the first iteration's user testing. Because the green and red circles were perceived as confusing, they were removed completely. The amount of red and green colour on the screen was increased to convey the wanted messages faster. Some of the screens were coloured entirely green or red, but it was speculated that this would decrease the contrast between the text and the background so much that it would impede seeing the text clearly.

Different layouts of the screen components were explored in order to find the best possible composition. Because the information about the visitor working for Rinkeby-Kista elderly care was perceived as more important than the person's name, the order and size of these two texts were swapped.

On the red screens different images representing the unknown person were designed. The cross from the red circle in design iteration one was moved to the top of the image of the unknown person. On the bottom right screen (see figure 6.4) the image of the unknown person was removed completely in order to assess if this image was needed.

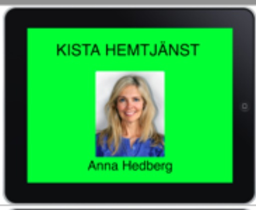
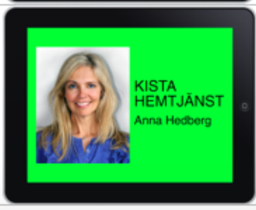
| Screen | Screen no. | Screen | Screen no. |
|---|---|---|---|
|   | 1.2 |   | 5.2 |
|   | 2.2 |   | 6.2 |
|   | 3.2 |   | 7.2 |
|   | 4.2 |   | 8.2 |

**Figure 6.4:** Front-end design iteration 2

The user experience testing for the second iteration was done in similar manner as the first iteration's user testing. This time seven volunteering seniors were interviewed in semi-structured interviews. Thoughts and feelings regarding the different screens and the different components on the screens were recorded. The seniors were also asked to pick the most understandable screens from the green and from the red screens. Most of the seniors chose the screens shown in figure 6.5.

The user testing confirmed the suspicion that the green background behind the text would reduce readability. The text on the white background was perceived as the most readable one. It was perceived as helpful that the screens gave the written information "Rinkeby-Kista elderly care" ("Kista hemtjänst" in the figure) and "Not elderly care" ("Inte hemtjänst" in the figure). On the red screen the image of the unknown person with the cross was perceived as the clearest for indicating that this person is a stranger and should not be let in.


**Figure 6.5:** Front-end design iteration 2 winners

## Final design and implementation

After the second design iteration the final graphical interface was designed. In figure 6.6 the green screen indicating that the visitor is working for Rinkeby-Kista elderly care can be seen. In figure 6.7 the red screen indicating that the visitor is not working for elderly care can be seen.

Additionally, a start screen for the prototype was designed. A design was made for both the iPad on the senior's side, and the iPhone on the caregiver's side. This design was not tested, since it was not perceived as vital for the usability of the system. The start screen designs can be seen in figure 6.8 and 6.9.

The final designs were directly implemented in the system prototype in Xcode by using Xcode's graphical user interface design tools. Voice recordings of the different caregivers introducing themselves was added to the prototype to provide important information not only through visual interface but also via sound.

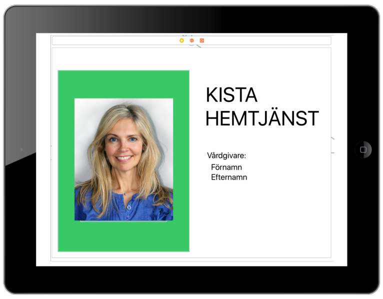



**Figure 6.6:** Final design of the screen, which is displayed when a caregiver is recognised.


**Figure 6.7:** Final design of the screen, which is displayed when the visitor is recognized as someone else than a caregiver.


**Figure 6.8:** A start screen for the iPad.


**Figure 6.9:** A start screen for the iPhone.

# Chapter 7

# Evaluation of the back-end

In this chapter the test plan and test results of the back-end functionality are presented. In addition, analysis of the test results is discussed.

## 7.1 Test plan

The purpose of the back-end evaluation is to assess the reliability of the face detection and facial recognition algorithms components. The reliability is evaluated by giving the program test data of labelled images and checking if the output is correct. Two experiment were performed. The first experiment was carried using images of known people representing the caregivers. The second experiment was carried using images of strangers. The results of the experiments are divided into four categories: match-true, match-false, no match-true and no match-false. The meaning of the categories is explained in the chapters below.

The facial recognition function outputs the known people's names together with a prediction probability for each person. A threshold variable is set to determine when the highest prediction probability is high enough to assume that the person has been identified correctly and when the prediction probability is so low that the person should be identified as a stranger. In the experiments the threshold variable is increased in 0.05 increments within the range of zero to one.

The test program for the experiments was provided with a set of labelled images. The images contained a picture of a known person or a stranger. These test sets were independent from the training data. Moreover, pictures of developer and other volunteers were used. No pictures of actual caregivers were used for the experiments due to concerns about the difficulty of acquiring the necessary amount of pictures.

1. **Experiment: Known people**

   In this experiment the accuracy of identifying the correct caregiver was assessed. More specifically, this experiment showed how many caregivers were identified as themselves compared to how many were matched to a different caregiver than themselves.

   The output of the test program was the following. If the input labelled image was matched correctly and the prediction probability was higher than the current threshold, the output was categorized as match-true. If the input labelled image was matched incorrectly, or the prediction probability was lower than the current threshold, the output was categorized as match-false. For example, if the program is given Caregiver A and it recognises the person to be Caregiver A with a prediction probability higher than the current threshold, a match-true happens. If the program is given Caregiver A and it recognises the person to be Caregiver B, or if the program is given Caregiver A and it recognizes the person to be Caregiver A with a lower prediction probability than the current threshold, a match-false happens.

   The test program iterates through the different thresholds from zero to one. For each threshold, 40 pictures of known people are given, with 10 pictures per person. The match-true and match-false are checked for each picture and corresponding counters are increased. After all 40 pictures for a specific threshold are looped through the match-true and match false -counter values are recorded to a file together with the corresponding threshold, the counters are cleared and the current threshold is incremented by 0.05. Then the same pictures are looped through the program with the new threshold.

2. **Experiment: Strangers**

   In this experiment the accuracy of identifying a stranger correctly is assessed. Meaning, that an unknown person is identified as a stranger versus that this unknown person is matched to a caregiver in the system.

The outputs of the test program were the following. If the input image of a stranger was identified as a stranger, The output was categorised as a no match-true. If the input image of a stranger was identified as a caregiver, the output was categorised as a no match-false. For example, if the program is given Stranger A and it recognises the person to be Caregiver A with a prediction probability lower than the current threshold, a no match-true happens. This means that the stranger is identified as a stranger. If the program is given Stranger A and it recognises the person to be Caregiver A with a prediction probability higher than the current threshold, a no match-false happens. This means that the stranger is identified as a caregiver.

The experiment follows the same steps as the experiment for the known persons, except that this time the no match-true and no match-false counters are increased and these values are recorded for each threshold.

## 7.2 Results

The result of the first experiment is shown in figure 7.1. The first column of the table shows the different values of the threshold variable. In the second and third column of table 7.1 distribution of the 40 different images between match-true and match-false, respectively, is shown.

In figure 7.2, the result of the second experiment is shown. The first column of the table shows the different values of the threshold variable. In the second and third column of the table 7.2 distribution of the 40 different images between no match-true and no match-false, respectively, is shown.

```
------------------KNOWN PEOPLE------------------
True-Match: input=caregiver1, output=caregiver1
False-Match: input=caregiver1, output=wrong_caregiver2
or probability for caregiver1 is lower than threshold
Threshold--------match-true----------match-false
0.0,                    5 ,            35
0.05,                   5 ,            35
0.1,                    5 ,            35
0.15,                   5 ,            35
0.2,                    5 ,            35
0.25,                   5 ,            35
0.3,                    5 ,            35
0.35,                   5 ,            35
0.4,                    5 ,            35
0.45,                   5 ,            35
0.5,                    5 ,            35
0.55,                   4 ,            36
0.6,                    3 ,            37
0.65,                   2 ,            38
0.7,                    1 ,            39
0.75,                   1 ,            39
0.8,                    0 ,            40
0.85,                   0 ,            40
0.9,                    0 ,            40
0.95,                   0 ,            40
1.0,                    0 ,            40
```

**Figure 7.1:** Experiment: Known people raw result data.

```
-------------------STRANGER--------------------------
True-NoMatch: input=stranger, output=caregiver1 with
lower probability than threshold(In our case GOOD
because we avoid entering of a stranger as a caregiver.)
False-NoMatch: input=stranger, output=caregiver1 with
higher probability than threshold(In our case it will
let the stranger enter as being a caregiver1. This is
BAD.)
Threshold--------no match-true------no match-false
0.0,                    0 ,            40
0.05,                   0 ,            40
0.1,                    0 ,            40
0.15,                   0 ,            40
0.2,                    0 ,            40
0.25,                   0 ,            40
0.3,                    0 ,            40
0.35,                   0 ,            40
0.4,                    0 ,            40
0.45,                   1 ,            39
0.5,                    2 ,            38
0.55,                   4 ,            36
0.6,                    8 ,            32
0.65,                   10 ,           30
0.7,                    14 ,           26
0.75,                   15 ,           25
0.8,                    16 ,           24
0.85,                   18 ,           22
0.9,                    24 ,           16
0.95,                   27 ,           13
1.0,                    40 ,           0
```

**Figure 7.2:** Experiment: Strangers raw result data.

## 7.3 Analysis of the results

The raw data in figure 7.1 and 7.2 is analysed in the following way. All the data is plotted in the figure 7.3. The graph is analysed and one threshold was picked for further inspection. This was done because one threshold needs to be picked and used in the program in order to prevent recognition of strangers as some of the caregivers. The purpose of further inspecting one threshold was to assess what kind of performance the system would give with this threshold. A table (figure 7.1) and a histogram (figure 7.4) were constructed with data points corresponding to the picked threshold. The histogram is discussed and analysed.

The graph 7.3 shows the relationship between the different thresholds and the amount of people categorized as match-true, match-false, no match-true or no match-false. The x-axis shows the different thresholds and the y-axis shows the number of people. The four different categories (match-true, match-false, no match-true and no match-false) are represented by different colours (blue, green, yellow and red respectively). Below the different curves of graph 7.3 are analysed.

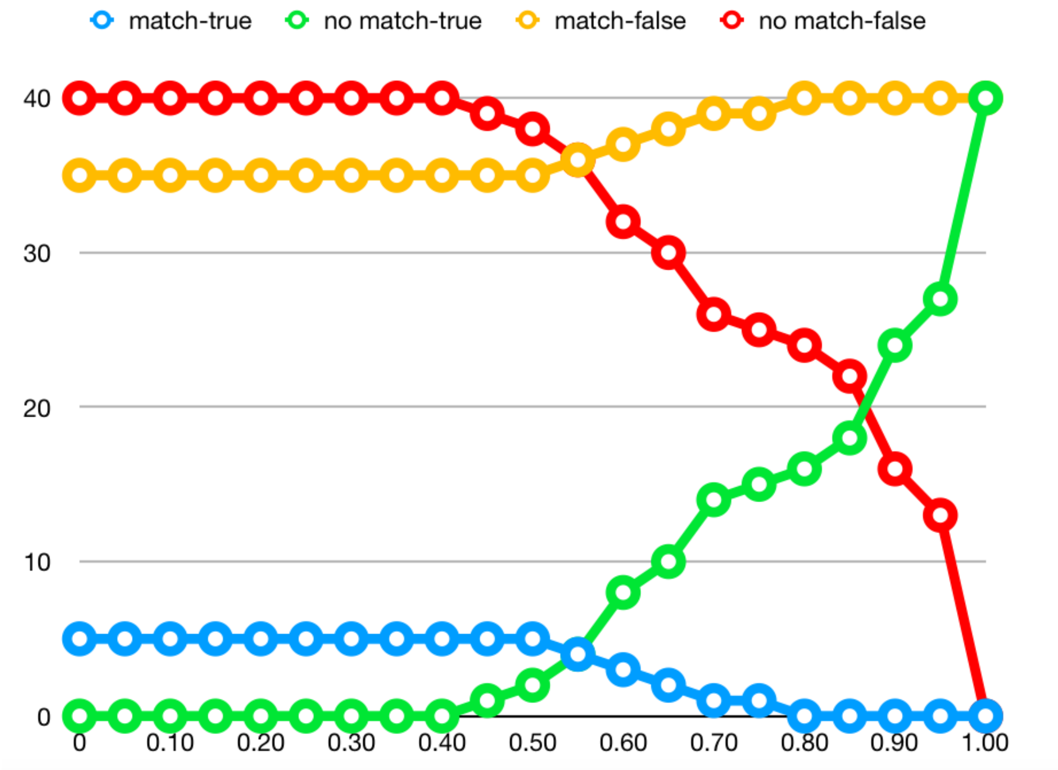



**Figure 7.3:** Different categories with different thresholds.

The category match-true can be seen as a blue curve in graph 7.3. This curve represents the amount of known people that have been recognised correctly and whose prediction probability has been higher than the current threshold. In general, the blue curve is desired to be constant and as high in the y-axis as possible. This is because ideally the facial recognition program would always recognise the caregivers correctly, regardless of the threshold. Nevertheless, the system prototype gives low values for the match-true through all different thresholds. This indicates that in the system prototype, the prediction probability for each image is very low. This shows that the system prototype often does not recognise people correctly. At the threshold 0.50 the blue curve starts to descend. This is because when the threshold is increased, the amount of prediction probabilities being higher than the threshold decreases.

The category match-false can be seen as a yellow curve in graph 7.3. This curve shows the amount of known people that were recognised incorrectly, or whose prediction threshold has been lower than the current threshold. In general, the yellow curve is expected to be low when the thresholds are low and stay low even when the thresholds are high. This is because in an ideal case, the facial recognition program recognises the input images with a high prediction probability and thus categorises them as match-true, not match-false. Nevertheless, from the graph one can see that the amount of people categorized as match-false is very high (35/40 people) with thresholds from 0.00 to 0.50 and increases to 40/40 people when the threshold 0.80 is reached. This trend indicates that all the prediction probabilities given by the system prototype are below 0.80, which shows that the facial detection and facial recognition part of the system is not working as well as desired in order to be feasible for the elderly care. The match-true and match-false show opposite sides of the same phenomenon, hence when the match-true decreases, the match-false increases.

The category no match-false can be seen as a green curve in graph 7.3. This curve shows the amount of unknown people who were recognised as strangers. Generally, the no match-true curve is desired to be as high as possible. This would indicate that strangers are recognised correctly. From the graph one can see that even though the curve is very low between thresholds 0.00 and 0.50, it starts ascending and is above 50% of the people at thresholds 0.90 - 1.00. The cause of this is probably in the prediction probability of the system prototype. The prediction probability of the system prototype seems to be generally low. The rise of the green curve can be interpreted in the way that if the strangers are desired to be recognised correctly, the threshold should be set as high as possible.

The category match-false can be seen as a red curve in graph 7.3. The red curve shows the amount of unknown people who were recognised falsely as caregivers. Generally, the red curve is desired to have as low values as possible with all the different thresholds. A high trend of this curve could mean the senior letting in unknown people and thinking that they are trustworthy caregivers. This could lead to confusing or even dangerous situations. From the graph one can see that the red curve is very high (40/40 people) at thresholds from 0.00 to 0.40. From the threshold 0.40 the curve turns downward. Nevertheless, even at the threshold 0.95, the number of people categorized as match-false is over 10 out of 40. The conclusion that can be drawn from this is that the system is not necessarily very safe to the elderly due to the inaccuracy of correctly recognising people. The no match-true and no match-false show opposite sides of the same phenomenon, hence when the no match-true decreases, the no match-false increases.

When graph 7.3 is examined, one can see that at the threshold 0.55 the match-true curve and the no match-true curve intersect. After that point the match-true starts to get lower values and no match-true higher values. Hence, the threshold 0.55 was chosen to not compromise too much in either match-true performance or no match-true performance. Similar trends can be seen with the match-false curve and the no match-false curve. These curves intersect at point 0.55 and after that match-false keeps increasing and no-match-false decreasing. Neither one of those values are desired to be high. By considering all the aforementioned trends, the threshold 0.55 was picked for further inspection.

The values the different categories get at threshold 0.55 can be seen in table 7.1. The values of the table are plotted in a histogram, which can be seen in figure 7.4

**Table 7.1:** Results from the experiments with known people and strangers with threshold set to 0.55

| | true | false |
|---|---|---|
| match | 4 | 36 |
| no match | 4 | 36 |

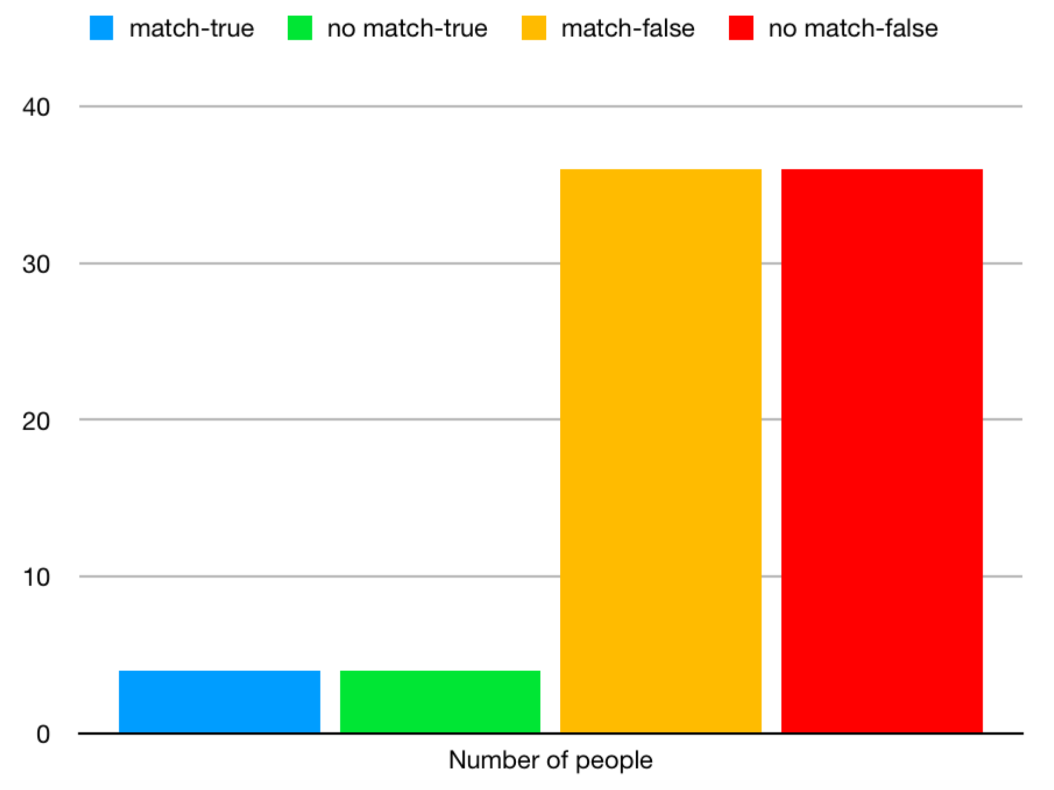



**Figure 7.4:** Known people and strangers: analysis of how the threshold affects the number of match-true, match-false, no match-true, and no match-false results. Threshold is set to 0.55

From the histogram one can see that the values of match-true and no match-true are very low compared to the values of match-false and no match-false. This indicated that the system, as it is now, would not give the desired accuracy and performance. In conclusion, the match-true and the no match-true are desired to have as high values as possible. This would indicate that the system matches the persons correctly independently of them being known or unknown people. In the current system prototype, the accuracy of recognising known people and strangers is very poor.

Furthermore, in the ideal system the match-false and the no match-false are desired to have as low values as possible. This would indicate that the system does not match people incorrectly. Nonetheless, both of these values are very high. This confirms that most people using the system are recognised incorrectly.

# Chapter 8

# Evaluation of the front-end

In this chapter the test plan and test results of the front-end design are presented. In addition, analysis of the test results is discussed.

## 8.1 Test plan

The purpose of the front-end evaluation was to assess the usability of the part of the system, which provides information about visitors to the elderly. The usability was evaluated by performing user testing on the target group. Since the performance of the back-end was not guaranteed to be accurate enough as to not affect the test results of the front-end, a fake back-end was implemented for the user testing. In the fake back-end a correct name of the caregiver is directly sent to the database, without any facial recognition functionality in between. This way a 100% accuracy was guaranteed in detecting the visitor. The testing can be divided into five parts:

1. **Set up**

   A test environment, including a volunteering caregiver, a volunteering senior, a translator between Swedish and English, and a room with a door, was set up in Rinkeby-Kista elderly care. During the test one usability tester stayed with the senior in one side of the room and another tester stayed with the caregiver, who was located outside of the room in the start of the test. The caregiver was given an iPhone and the senior was given an iPad. In the start of the test the purpose of the test was explained to the participants. What type of data was recorded during the test was described to the participants. The caregivers were asked for a picture, a first name and a first letter of the last name. Additionally, voice messages of the caregivers introducing themselves were recorded. The caregivers were informed that all personal information would only be used for testing purposes and would be deleted after the test. The image, name, and voice recording were inserted into the database.

2. **Simulation of a real life situation with a known caregiver**

   After initial set up, the start screen of the program was shown to the senior on the iPad. The caregiver's name was then sent from the iPhone to the database. The iPad then showed an informative screen with the caregiver's name and image. In addition, the voice message from the caregiver was played. The senior was asked if they would open the door. The actions of the senior were observed through the entire test and recorded through notes. After the senior either opened the door or not, the simulation of the real life situation was over and the caregiver was instructed to leave.

3. **Interviewing the senior after the real life simulation**

   The seniors were interviewed. They were asked about their thoughts and feelings regarding the different parts of the simulation and the system design.

4. **Simulation of a real life situation with a stranger**

   After the first real life simulation with a known caregiver was performed, the system was tested with a stranger at the door. Everything was done the same way as for the known caregiver, except that this time the person behind the door was a stranger and the "Inte hemtjänst" screen was shown on the iPad.

5. **Interviewing the senior after the real life simulation**

   The same questions as in the first test round with the known caregiver were asked.

## 8.2 Results

First the prototype was tested with a known caregiver. When the start screen was shown to the elderly all of them looked at it. One of them tried to click around the screen to see if something happened. No one got scared by the voice of caregivers introducing themselves. One person said without being asked that it was good that the system gives the information also through voice. When the information of a caregiver was shown on the screen, one senior answered to the screen: “Yes, you can come in”. One of the seniors said that she recognised the person displayed on the screen. According to her that caregiver had visited her before. All of the four elderly let the person on the green screen in and none of them seemed confused when the caregiver stepped in. It seemed that they knew to expect whoever came in through the door. Two of the seniors were very happy to meet the caregivers. One of them asked if the caregiver was the same as shown on the display and one of them said that he recognised that the caregiver who came in was the same as on the display.

The second test round was with the stranger at the door. Everyone looked at the home screen. When the information “Inte hemtjänst” was shown, two seniors said that they would not let the person in. Two of the seniors said that they understand that the person behind the door is not from elderly care, but they would let the person in anyway. They were curious to see who the person was. They were thinking that maybe it would be someone else they know, like a family member.

Through the whole experiment the usefulness of the system was investigated through observations and questions. Three of the seniors said that it would be useful to have this kind of system. One of the seniors said that she hears the door bell ring often during the night and does not know why. She thinks that this kind of system would make her feel more secure. She also said that often she cannot go to open the door herself. She said that something which would give her information of who is in the house would be very helpful. One senior said that he does not see the need for such system, because it has not happened to him that he gets unwanted visitors. He lives in a different kind of an elderly housing than the other seniors. In that housing area access to the area is more controlled than in the housing for the other three seniors.

## 8.3 Analysis of the results

The test results show that this kind of a system would be well received and useful. The user interface provides the information as intended. The graphical interface gives understandable and useful information and the voice interface aids in conveying this information. The system is perceived as understandable and easy to use. A conclusion can be drawn that the prototype's user interface and the system with 100% recognition accuracy would be feasible for helping the elderly recognise visiting caregivers.

# Chapter 9

# Discussion

In this chapter the evaluation of the whole prototype is discussed, ideas for future work are presented and conclusion of the whole thesis work is given.

## 9.1 Evaluation of the whole system

According to the test results of the back-end and the front-end evaluation, a unified conclusion about the feasibility of the proposed system cannot be drawn. On one hand, the front-end part of the system is very feasible, but on the other, the back-end part of the system does not work as well as intended. Low performance of the back-end part of the system can be caused by many different things. The implementation of the back-end program might be flawed, the training dataset might be too simple or too small, the selected facial recognition algorithm might not be suitable for the purpose, or the testing dataset might be too simple or too small. As mentioned in the theoretical background, illumination variations have an impact on the accuracy of facial recognition, which was not taken into consideration in neither training nor test data. Moreover, face pose variations and different facial expression have not been considered when training the facial recognition model.

## 9.2 Future work

A possible future study could aim to make the performance of the back-end part of the system better. If the performance of the back-end could be increased so that the recognition of caregivers and unknown people reaches higher levels of accuracy, the whole system, according to the evaluation criteria of this study, would be feasible for use.

Another perspective, which has not been assessed in this thesis work, is the feasibility of using cameras, and what kind of cameras the system should use. Installing cameras in public and even private spaces introduces questions about privacy and data security. These aspects of the system should be further studied in order to gain a holistic view of the feasibility of the whole system.

Additionally, the caregivers' opinions on the system were not assessed. For the usability of the system, it would be very important to know if the proposed system would be accepted by the caregivers, since they are a crucial part of the user group. Further design studies of the graphical user interface on the caregiver's side should also be conducted. Research could also be extended from recognising only caregivers to also recognising friends and relatives, since this could provide additional support to the elderly, especially to the ones suffering from impaired vision, memory loss, or dementia.

In general, more studies about how facial recognition systems could be used for supporting the aging population could be performed. This study could be used as a stepping stone for such future research.

## 9.3 Conclusion

In this report one design solution for a facial recognition system, which helps seniors recognise the caregivers who are about to visit them, was presented. The system architecture, design process, and prototype evaluation were described. The result of the evaluation was that the front-end of the system was feasible and the back-end part of the system was not feasible for the purpose of supporting seniors in recognising visiting caregivers.

When designing user interfaces for old people, user testing through the design iterations is of utmost importance. Simplicity, use of large figures and text, contrast between of the background and text, as well as use of symbols should be carefully considered. Implementing functional facial recognition is not trivial. High accuracy of recognition is vital for a good facial recognition system, yet it is not easy to achieve even with the help of already existing facial recognition and machine learning tools. Many different variables affect the performance of facial recognition systems, from training data and selected machine learning algorithm to the test data set.

If the facial recognition part of the system would work accurately, the system could ease the lives of seniors and caregivers. The system could make seniors feel safer and give them the tools to make informed decisions about whether they should let their visitors in or not. Thus, the system could support senior's autonomy and well being. At the same time the system may ease the work of caregivers. When the seniors know beforehand who to expect in their homes, they would likely be more cooperative and happy to see the visiting caregiver. Together these factors could help to reach one United Nation sustainability goals: Good health and well-being.

Further research should be carried out on the performance of facial recognition functions, safety, privacy, data protection, and the attitudes of caregivers if such systems are desired to be deployed in elderly care.

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%7DorigPageSize=25%7B%5C&%7Dsimi=94.65 (visited on 03/28/2018).

# Appendix A

# Background Information

Title: Background_interview_on_22_03_2018_with_Jonas
Date: 22.3.2018
Time: 13.30
Place: Kistatorg 327
Type of interview: Semi-structured interview
Recorded: Interview For Thesis With Jonas 22.3.18.m4a
Interviewers: Katariina Martikainen, Kewser Said
Interviewed: Jonas Davidsson

# 1. Interview Questions For The Background

Is there any problems with elderly not recognising the visitors?

- Yes. It is constantly a problem.

If yes, please explain more in detail, what and why is it a problem?

- It is a constant problem. We have a lot of temporary staff. It is hard to know for the seniors if a certain person is actually working for us or not. This is not so much a problem with permanent staff, but it is with temporary staff. It causes worry for the elderly. Not recognising who is coming in makes elderly feel worried and insecure. They don’t know who has been home to them. Sometimes this is because they are confused. We receive complaints from elderly. Not recognizing visitors happens both because of poor memory and because of changing staff.

  We have this planning system where each visit is planned and stored.
  Might not be a good idea to tie this to visit though. Good idea to check that this person is an active employee.

# 2. Interview Questions For The Authentications System

Is there some suggestions from the elderly care on how to solve the problem?

- Some sort of system with cameras and facial recognition. ← This is a suggestion from Anne Håkansson to the elderly care. Jonas confirmed this in the end of the interview. It might be a problem logistically. Maybe Bluetooth could be used. We have a database of approved Bluetooth idees.
- Permanent staff has a permanent phone. Temporary staff has their temporar phone. Somehow you probably have to give personased login for the app you would develop.

- Staff has Android phones. They use it to read an NFC tag to start a visit and end a visit.

- Could maybe have a separate app in staffs phones. Only the people who are working have that phone and logging to that phone. The staff could be instructed to use the app after previous visit to inform the next visit.

- After a while the elderly do not remember who has been there. So some kind of logging system could be preferable.

Would it be possible to put the NFC tag outside of the apartment (at the moment it is inside of the apartment by the door)?

- The elderly who has need for care but are living outside of caretaking facilities might not want to advertise that they are receiving care.

Would it help to tell the senior that for example: “Maria was here last week as well and she is visiting you now”?

- Yes this could help. One could maybe get the data from logs from NFC tag which is installed already.

Is it possible to get 2 tablets for the prototype?

- We have some ipads you could maybe use.

Is it feasible to get tablets for each elderly apartment?

- I have to ask about this.

Is there some legalization we need to be concerned with?

- I have to check that about the cameras. Other than that I do not know.

How is the staff’s personal information stored in the database?

- I could probably find out but I don’t know right now. It is a very old system. It is in process to be replaced. I have to check with the IT people about the database.

Could their database be used later for this system? (We will not implement this, but just for further discussion)

- We are in a process for changing our database to something which is specified to use an open format.

Do the employees have to report if their phone is stolen, missing etc?
- Yes.

## 3. Interview Questions For Notification System

Suggestions from the elder care , on the content to be presented? A picture? A name? Purpose why the entering person is there? Something more?

- Mainly provide the information that the person is actually working for us. Provide verification that this is an active employee. Elderly often know why someone is coming, but they might not recognize the person. The system should just be a screen which e.g. shows a picture, should not require interaction to deliver information.
- Make an app for relatives as well.
- Best way would be good to block foreign idees in the database of yours.
- Temporary workers return a phone to the facility in the end of/ after each working day.
- Probably a screen of some short.
- Let's say the elderly have a tablet of their own. Maybe u could develop an app which can run on many different kind of phones.

## 4. Questions for understanding the context

Do all the caregivers have their own key to the senior apartments? Or how do they get in?
- We do have alarm keys. We have this alarm system. Alarm goes to us when elderly press a button. We can go and get alarm key and open the door.
- Normally they (the caregivers) knock, I don't know if they have keys at all times.
- Elderly comes and opens the door themselves, at least during the day time. It depends on the situation for the elderly if they can move on their own they will usually open the door by themselves. Some need assistance. The doors are normally always locked.

Where is the authentication need? At the front door to the whole building? At the senior apartments' doors?Both?
- In front of the personal home.

Are the seniors able to open the door to their apartment by themselves?

- Sometimes yes, sometimes not. Some cannot get out of bed by themselves etc. Caretakers have keys to those people's homes.

Please describe how the normal caregiver visit happens/looks like?

- They (the caregivers) start by knocking on the door. Elderly might refuse a visit if they want. Caretakers log it as such "visit has been rejected". Otherwise they will be let in or open the door with a key if that was required. When visit starts they scan NFC tag, which is located inside of the apartment by the outside door. Then they perform planned duties. When visit is done, they scan NFC tag again and exit.

# 5. General questions

Do the elderly homes have some budget for us? Would they provide us with the tablets/screens/speakers?

- Unable to answer this at the moment.

Does the caretaking company have a specific name for the type of homes where the elderly lives on their own?

- We have both types. We service private homes. Called hemkänst. Then we have these type of service homes where they live on their own and get help. This is a service home. Its like regular apartments. But we have our organization on the bottom floor and provide services to the ones living on top. Best place for testing your project work would be this type of service home like in Kista. Private homes might not want this kind of system. The Rinkeby home's seniors might be too gone and not able to answer to the system.
  People in the homes are about 70-80 old. Not so sure about more accurate age.

# 6. Requirements of the system

- There has to be some way for one to update it.
- To have a way of modifying who has been given access to and to verify who is an active employee and who is not.
- There has to be some way for the administration to do that.
- Jonas will check budget for feasibility.

Title: Interview_background_info_Jonas_Davidsson_29.03.18
Date: 29.03.18
Place: on the phone
Interviewer: Katariina Martikainen
Interviewed: Jonas Davidsson, Kista elderly homes
Note: Most important points highlighted in red

## Questions

1. **How many different seniors a caregiver normally visits/week?**

I looked at statistics for this March. The numbers vary wildly. The logged in visits are about 30-50clients/week or 5-10clients/week. I would say that between 20-30 different clients/caregiver/month.

2. **Is there some legalization we need to be concerned with e.g. with cameras on doors?**

I think you are allowed to have door hole cameras. At least if they are only active when someone presses a button or stands in front of the camera. I am not aware of any other legal problems.

3. **Can we have access to your database containing information about planned visits to seniors' homes? How is the information stored in this database?**

Not able to access the database. We only have the user interface to it. The database is bought service from Tieto. Bought from Fonero [1], Fonero care[2]. Our system is based on their system. We have an old version of their system. Now they have a cloud based system.
I can send you user manual of our database UI via email so you can see what data is stored in our database. The database has both senior and caretaker information.

[1] Is this the correct name?
[2] Is this the correct name?

4. **The Kista elderly care is moving to new database. Do you have information on how this new database looks like? Could you describe that to us.**

No, we have not decided a supplier for that system yet. We are changing our whole time planning system. We do not know yet how the system will look like. It It should be based on open technology.

5. **Can we have access to the information of how the phones are linked to the caregiver who has the phone at that moment? How is this information handled?**

The phone ties into the time planning system. Caregivers have their own log in. They log in to the system which is an app on their phones. The app fetches caregivers' work schedule for them. The info comes from administrative time planning system. In the schedule it says who to go next.

6. **Does Kista elderly home have a central server for their systems? What kind of server is this?**

No we do not. The service is not hosted in our place. We buy this service from service provider. We only access it through phone app and Sitrix[3] remote desktop system. We do not handle the servers. If you want to look at caregivers side of this, it is called Parago[4]. There are manuals available for this publicly. It is used for both private and public caregivers.

7. **Do all the Kista elderly home - building have wifi connection?**

It does. We have many different wifi systems. There is a closed wifi for the alarm systems. We are going to have the possibility to connect our clients to the wifi (in the new system). We have also our own wifi on the bottom floor. That one will be hard to connect to because it only accepts Stockholm stad computers. We also have guest wifi. All our wifi's might be a bit tricky to connect to. Public wifi requires log-in via captive portal. You would have to write some code to log in to this page.

**Do you have some other suggestions how we could do this communication between hardware and POI?**

Wired connection would be much easier to use. If we can find a place to install the equipment, which also have a wired connection. The wired connection does not need a certificate to be installed.

[3] Is this the correct name?
[4] Is this the correct name?

8. **What OS are your desktop computers using?**

Desktop computers are using Windows 7. I should add that our computers are locked down. You will not be able to install programs onto them.

9. **Do the elderly homes have some budget for us? Would they provide us with the tablets/screens/speakers?**

We do not have any funds to provide you with. So no.

10. **Are the tablets at elderly home iPads or Android tablets? Could we borrow e.g two tablets for the time of our project for development?**

They are iPads. Model: iPad air 2. You are able to borrow them for the time of the project.

11. **What model of Android phones the caregivers have? What operating system version they are running?**

They are usually model of Samsung Xcover. It has a build in cover so it is a bit stronger. They are using now Xcover 4.

12. **Other notes:**

**Testing the prototype:**

We have some empty apartments and offices on the bottom floor of our building, which we could maybe use for testing. There is no one living there. We could maybe test the cameras/digital spy holes there.

**User testing:**

Tuesday (3.4 and 10.4) Jonas is keeping tech course at 15.00 for 10-15 caregivers. We could maybe meet them then and do some user testing.

**Kata compiling last words before ending the phone call:**

We will get back to you about user testing on Tuesdays and you showing us the app interface for caregivers scheduling app. Could you send us the user manual for the database and find out the Android phones operating system version?

# Appendix B

# System architecture

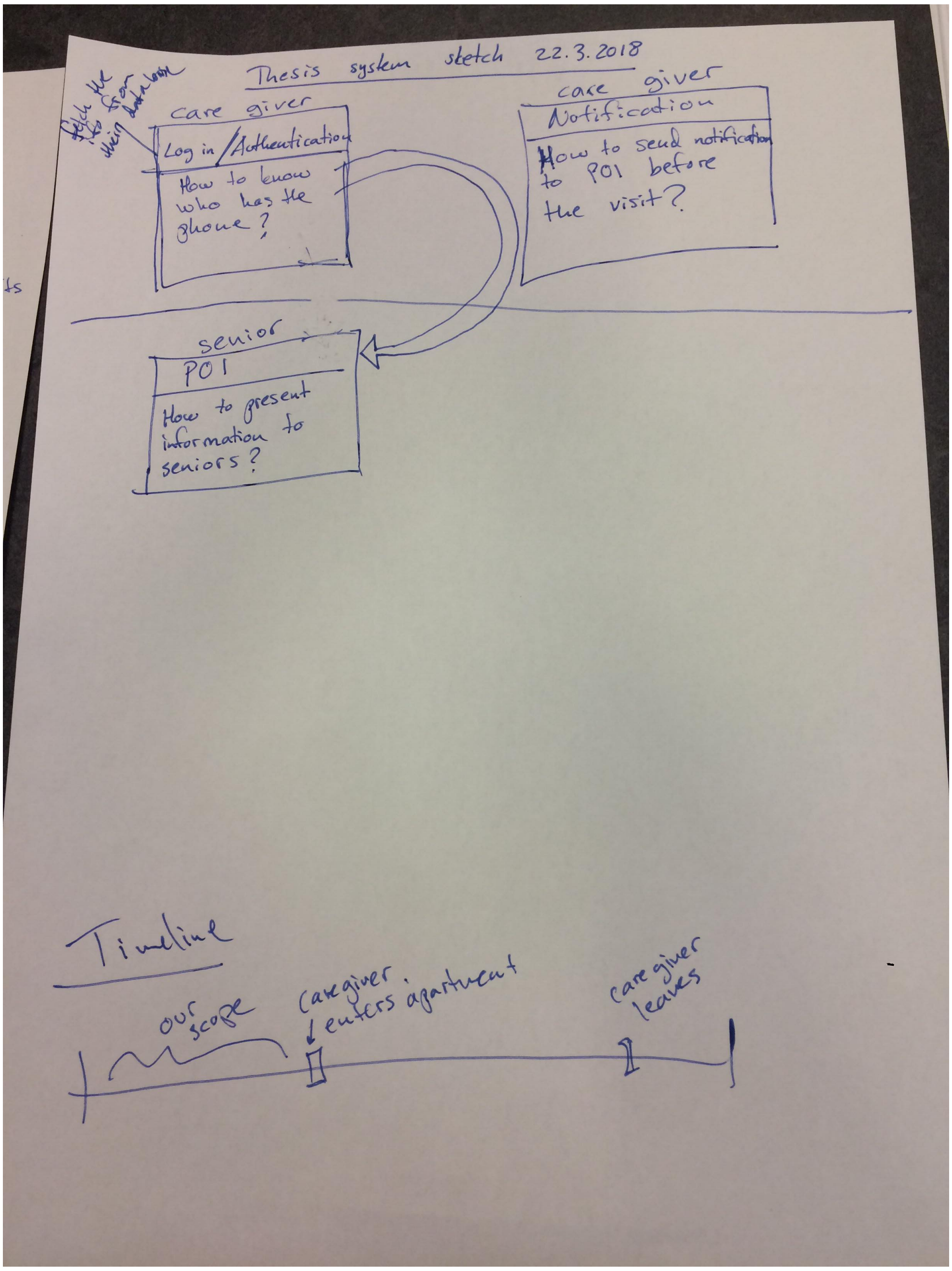


**Figure B.1:** 1sketch223.png

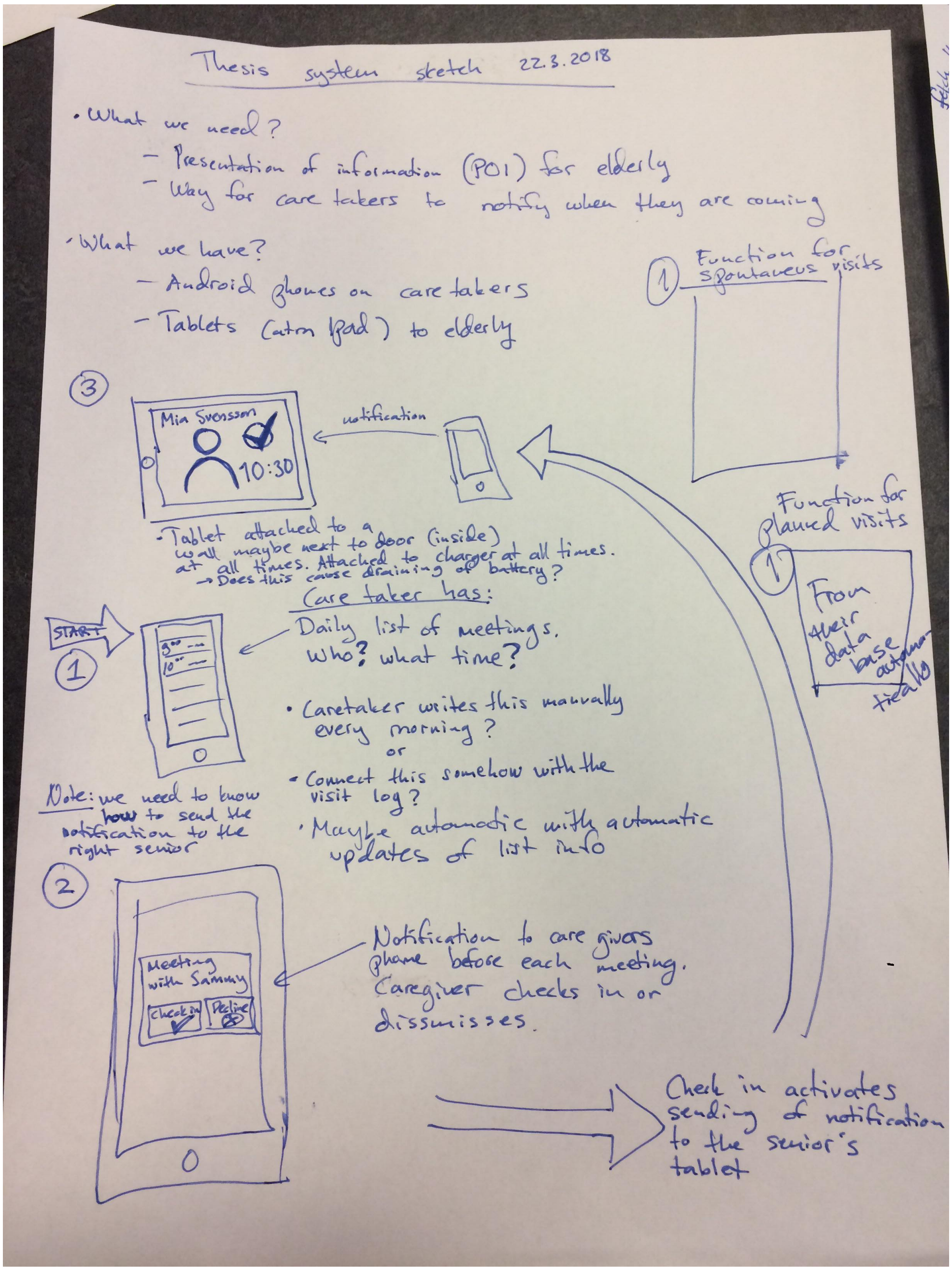


**Figure B.2:** 2sketch223.png

# Appendix C

# Front-end design: UX design and testing iterations

**Title:** Testing of paper prototypes of POI
**Date:** 23.04.2018 at 13.30-15.00
**Tester:** Katariina Martikainen
**Interview type:** semi-structured, almost open interview.
**Place:** Kista elderly home cafeteria
**Set up:** Volunteers at the cafe were interviewed. Jonas Davidsson from Kista elderly care translated the questions Katariina asked to the elderly in Swedish and translated the answers which Katariina may have not understood due to her limited skills in Swedish to English. Six seniors were interviewed. They were about 65-90 years old.

**The interview questions:**
1. What does the screen tell you? What information do you get from it?
2. How do you understand the green ball in the picture?
3. How do you understand the woman's picture on the screen?
4. How do you understand the image inside of the red square?
5. Do you see the "Kista hemtjänst" text? Do you see what it says? Do you understand the meaning of the text in this context?
6. Do you see the text on top (name of the person)? What does it say? What does it mean?
7. Do you see the green square/frame around the image?
8. How do you understand it (the green square/frame)?
9. Do you see the red square/frame around the image?
10. How do you understand it (the red square/frame)?
11. Do you see what it says in the text ("Inte hemtjänst")? Could you describe to us what it means?
12. Which picture do you like the best? (From red ones and green ones separately)

These questions worked as a guideline to the user testing interviews. The user testing was done in a relevantly informal manner and the interviewing was more conversational than strictly formatted due to the seniors needing repetitive explanations about the system's purpose. It was also easier to get the elderly to express their opinions, feelings and thoughts about the design when the conversation was dynamic and adapted to their questions and answers than if strict questionnaire template would have been followed.

**The introduction given to the seniors before the interviews:**
Katariina here is from KTH and is making a system for you as a school project. The system is supposed to tell if the person who wants to visit you is working for us (the Kista elderly care) or not and who that person is.

We will show you some pictures. Imagine that the picture is on a screen like TV or tablet. The pictures are intended to give you information about who wants to come in and visit you. We would like to know now if our pictures are clear and informative enough and if you like them.

We will ask you couple of questions. Just answer what you think/feel. The questions are not to evaluate you. They are to evaluate our pictures and if you do not understand or like something, please tell us so we can make it better for you.

---

**PERSON 1 (SENIOR MAN)**

**The interview questions:**
1. What does the screen tell you? What information do you get from it?
    - Hard to understand what type of person it is just from the picture. Hard to understand in general what the screen says.

2. How do you understand the green ball in the picture?
    - He did not understand the green ball.

3. How do you understand the woman's picture on the screen?
    - He did not understand the woman's picture.

4. How do you understand the image inside of the red square?
    - He did not understand the image.

5. Do you see the "Kista hemtjänst" text? Do you see what it says? Do you understand the meaning of the text in this context?
    - Yes he sees the text, what it says and understands what it means.

6. Do you see the text on top (name of the person)? What does it say? What does it mean?
    - Yes he sees the text and understands that it is the name of the woman in the picture.

7. Do you see the green square/frame around the image?
    -
8. How do you understand it (the green square/frame)?
    -
9. Do you see the red square/frame around the image?
    -
10. How do you understand it (the red square/frame)?
    -
11. Do you see what it says in the text ("Inte hemtjänst")? Could you describe to us what it means?
    - Yes he sees the text and understands what it means. That it is not elderly care.

12. Which picture do you like the best? (From red ones and green ones separately)
    -

**General comments from the senior:**
- Pictures 3,4 and 5 are pretty much the same. The different shade and shape of the green ball does not matter. The "Kista hemtjänst" text under the ball is good.
- From the red pictures picture 7 is better than picture 6 since the red ball is more clear.
- The picture of the caregiver/profile picture could be removed from both the green and red pictures and only display the green or red ball, because the senior knows what it is for anyway.
- Almost every elderly has a TV. Maybe the screen could be on TV.
- It was confusing that the "profile picture" figure was present in both red and green pictures. That made the pictures too similiar. (Pictures 6,7 and 1,2)

---

**PERSON 2,3 AND 4. (TWO WOMEN AND ONE MAN ANSWERING COLLECTIVELY)**

**The interview questions:**
1. What does the screen tell you? What information do you get from it?
    - The person who is shown on the screen works here.

2. How do you understand the green ball in the picture?
    - Yes. it is clear.

3. How do you understand the woman's picture on the screen?
    - Yes, it is clear.
4. How do you understand the image inside of the red square?

5. Do you see the “Kista hemtjänst” text? Do you see what it says? Do you understand the meaning of the text in this context?
6. Do you see the text on top (name of the person)? What does it say? What does it mean?
7. Do you see the green square/frame around the image?
8. How do you understand it (the green square/frame)?
9. Do you see the red square/frame around the image?
10. How do you understand it (the red square/frame)?
11. Do you see what it says in the text (“Inte hemtjänst”)? Could you describe to us what it means?
12. Which picture do you like the best? (From red ones and green ones separately)

**General comments from the seniors:**
- Number 2 from the green pictures was the best.
- Number 6 was better than number 7 because it has less graphical elements on the screen.
- The screen number 7 is confusing with the profile picture figure.
- Number 7 was confusing wing the x. It is not very clear what it means. Maybe it needs to be pushed? Maybe instead of the cross it should say “nej” or something else?

---

**PERSON 5 (SENIOR WOMAN)**

**The interview questions:**
1. What does the screen tell you? What information do you get from it?
    - Not understanding the screen initially.
2. How do you understand the green ball in the picture?
3. How do you understand the woman’s picture on the screen?
    - The screen with the picture on the screen seems friendlier than the red one.

4. How do you understand the image inside of the red square?
    - Do not let this person in.

5. Do you see the “Kista hemtjänst” text? Do you see what it says? Do you understand the meaning of the text in this context?
    - Yes.

6. Do you see the text on top (name of the person)? What does it say? What does it mean?
    - Yes, name of the person. Understood well.

7. Do you see the green square/frame around the image?
8. How do you understand it (the green square/frame)?
9. Do you see the red square/frame around the image?
10. How do you understand it (the red square/frame)?
11. Do you see what it says in the text (“Inte hemtjänst”)? Could you describe to us what it means?
12. Which picture do you like the best? (From red ones and green ones separately)
    - From the green pictures number 4 was better than number 2. From the red pictures number 7 was clearer than number 6. It is easier to see the red ball in that screen.
    - She also said that even though number 7 was better but didnt know what was the cross and wanted to press the red ball.

**General comments from the senior:**
- Want to know the name of the person who is coming in.
- The screen is better with the picture of the caregiver.
- Do not understand the tick in the green pictures or the x in the red pictures.

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**PERSON 6 (SENIOR WOMAN)**

**The interview questions:**

1. What does the screen tell you? What information do you get from it?
   - Someone who comes from the elderly care. It is understandable what the screen tells you.
2. How do you understand the green ball in the picture?
   - The green ball is clear but the v-looking tick inside of the ball is not clear. What does it mean?

3. How do you understand the woman's picture on the screen?
   - The person in the picture is the one at the door.

4. How do you understand the image inside of the red square?
   - Not really. But would close the door when she sees this picture.

5. Do you see the "Kista hemtjänst" text? Do you see what it says? Do you understand the meaning of the text in this context?
   - Yes she can see it. Again a comment about the v-looking thing being strange.

6. Do you see the text on top (name of the person)? What does it say? What does it mean?
   - The name presents the person. Not absolutely clear that the name is the name of the caregiver who is coming in.

7. Do you see the green square/frame around the image?
   - Yes

8. How do you understand it (the green square/frame)?
   - Yes

9. Do you see the red square/frame around the image?
   - Yes

10. How do you understand it (the red square/frame)?
    - It is a stop sign. Do not let the person in.

11. Do you see what it says in the text ("Inte hemtjänst")? Could you describe to us what it means?
    - "not homeware". It is clear what the text means.

12. Which picture do you like the best? (From red ones and green ones separately)
    - The number 7 is better than 6. It is more clear. Number 6 looks a bit scary. Number 2 is too crowded. The green images with the green ball are much better (pictures 3 and 4)

**General comments from the senior:**

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**Summary of all the results:**

- Maybe the screen should only have a picture and text or a picture and colour.
- Too many graphical elements on the screen should be avoided. Four elements (what the screens have at the moment) is too much.
- Everyone liked the text Kista hemtjänst.
- Most of the people liked the picture with the green ball over the one with the black figure with the tick (screen number 2).
- The tick and the x were found confusing and the meaning was not really understood.
- The balls reminded people of buttons and they were not sure if they should press them.
- Everyone saw the coloured frames around the pictures and understood their meaning.
- Everyone understood that green is good/yes and red is bad/no.

- People were divided on the matter what should be included on the screen and what is unnecessary.

| Screen | Screen number | How many test groups out of the 4 groups liked the screen | Comments |
|---|---|---|---|
|  | 1 | 0/4 | Too crowded. Hard to see the small green tick in the black figure. |
|  | 2 | 1/4 | Too crowded. Hard to see the small green tick in the black figure. |
|  | 3 | 2/4 | Was not sure what the green ball was for. |
|  | 4 | 3/4 | Kista Hemtjänst -text was good. Green colour was visible and clear. The meaning of the tick box was not clear. |

| Screen | Screen number | How many test groups out of the 4 groups liked the screen | Comments |
|---|---|---|---|
|   | 5 | 2/4 | This screen was not perceived much different from screen 4. |
|   | 6 | 1/4 | Hard to see the red ball on the image, because too much going on. |
|   | 7 | 3/4 | Confusing with x inside of the ball. Should it be pressed? Red colour on the ball is clear. |

From the analysis we can see that the best results were number 4 and number 7:


**Title:** POI_user_test_iteration2_240418.
**Date:** 24.04.2018 at 13.30-15.00
**Tester:** Katariina Martikainen
**Interview type:** semi-structured, almost open interview.
**Place:** Kista elderly home cafeteria
**Set up:** Volunteers at the cafe were interviewed. Jonas Davidsson from Kista elderly care translated the questions Katariina asked to the elderly in Swedish and translated the answers which Katariina may have not understood due to her limited skills in Swedish to English. Seven seniors were interviewed. They were about 65-90 years old. Some of the seniors were the same as in the UX test iteration 1.

**The interview questions:**

**Green screens**
1. Do you see what it says on top of the screen? (Kista Hemtjänst)
2. How do you understand this text? (Kista Hemtjänst)
3. What does the green colour tell you?
4. Who is the person in the picture?
5. What is the name of the person in the picture?
6. Which text do you see better, the one in white background or in the green background? Or the same?
7. Does it matter to you which colour background the text has?
8. Which of the green pictures is the most clear to you?

**Red screens**
1. Do you see what it says on top of the screen? (Inte Hemtjänst)
2. How do you understand this text? (Inte Hemtjänst)
3. How do you understand the gray image? What does it tell you?
4. What do you think about the cross? What does it mean? Do you understand what it says?
5. Which of the red pictures is the most clear to you?

These questions worked as a guideline to the user testing interviews. The user testing was done in a relevantly informal manner and the interviewing was more conversational than strictly formatted due to the seniors needing repetitive explanations about the system's purpose. It was also easier to get the elderly to express their opinions, feelings and thoughts about the design when the conversation was dynamic and adapted to their questions and answers than if strict questionnaire template would have been followed.

**The introduction given to the seniors before the interviews:**
Katariina here is from KTH and is making a system for you as a school project. The system is supposed to tell if the person who wants to visit you is working for us (the Kista elderly care) or not and who that person is.

We will show you some pictures. Imagine that the picture is on a screen like TV or tablet. The pictures are intended to give you information about who wants to come in and visit you. We would like to know now if our pictures are clear and informative enough and if you like them.

We will ask you couple of questions. Just answer what you think/feel. The questions are not to evaluate you. They are to evaluate our pictures and if you do not understand or like something, please tell us so we can make it better for you.

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**PERSON 1 (SENIOR WOMAN)**

**The interview questions:**

**Green:**

1. Do you see what it says on top of the screen? (Kista Hemtjänst)
   - Yes

2. How do you understand this text? (Kista Hemtjänst)
   - Yes, she understands that the text tells that Kista Hemtjänst is by the door on all of the screens

5. What is the name of the person in the picture?
   - The tester can see the name and the name on the screen is the name of the person in the picture

8. Which of the green pictures is the most clear to you?
   - Screen 'green3' because the text is more visible than in the others.

**Red:**

1. Do you see what it says on top of the screen? (Inte Hemtjänst)
   - It says "no homeware". I would not let the person in with this screen (from all the screens)

4. What do you think about the cross? What does it mean? Do you understand what it says?
   - It means it is not the right person at the door. The cross is clear. (screens red1 and red3)

5. Which of the red pictures is the most clear to you?
   - The screen 'red3" is most clear

**General comments from the senior:**

- It is clear what is the purpose of the picture and the screen
- It is a very good idea
- The tester has a bad eyesight but still sees everything well on the screen 'green1'

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**PERSON 2 (SENIOR MAN)**

**The interview questions:**

8. Which of the green pictures is the most clear to you?
   - Screen 'green3' is clearest in the text. He sees the green frame around the picture and understands that the person is from the home care and that the name of the person is displayed on the screen.

5. Which of the red pictures is the most clear to you?
   - Screen 'red3'. The text is most clear in that one.

**General comments from the seniors:**

- Would not let the person in when he sees the red screen

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**PERSON 3 (SENIOR WOMAN, SPANISH, SOME LANGUAGE DIFFICULTIES)**

**The interview questions:**

8. Which of the green pictures is the most clear to you?
   - screen 'green1'

5. Which of the red pictures is the most clear to you?
   - screen 'red1'

**General comments from the senior:** She says she does not understand Swedish well so she does not understand what we are saying.

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**PERSON 4 (SENIOR MAN) NOTE: THE PEOPLE 4,5 AND 6 SAT TOGETHER. THIS MIGHT AFFECT THE INDEPENDENCE OF THEIR ANSWERS**

**The interview questions:**

8. Which of the green pictures is the most clear to you?
   - screen ‘green3’
5. Which of the red pictures is the most clear to you?
   - screen ‘red3’

**General comments from the senior:**

- He understands the purpose of the screens. The message on the screen is clear (all the screens)
- He suggest to take the text from screen ‘green2 and put it to screen ‘green3’ so that it would say ‘vårdgivare’ on the screen ‘green3’

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**PERSON 5 (SENIOR WOMAN)**

**The interview questions:**

8. Which of the green pictures is the most clear to you?
   - screen ‘green3’
5. Which of the red pictures is the most clear to you?
   - screen ‘red3’

**General comments from the senior:**

- She suggest to take the text from screen ‘green2 and put it to screen ‘green3’ so that it would say ‘vårdgivare’ on the screen ‘green3’

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**PERSON 6 (SENIOR WOMAN)**

**The interview questions:**

8. Which of the green pictures is the most clear to you?
   - screen ‘green3’
5. Which of the red pictures is the most clear to you?
   - screen ‘red1’

**General comments from the senior:**

- She suggest to take the text from screen ‘green2 and put it to screen ‘green3’ so that it would say ‘vårdgivare’ on the screen ‘green3’
- The symbol in the ‘red1’ is good. Because there is a lot of red in the picture, one reacts more to the red background than in the screen ‘red3’

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**PERSON 7 (SENIOR WOMAN)**

**The interview questions:**

8. Which of the green pictures is the most clear to you?
   - screen ‘green4’. She sees everything the screen says and understands what it means. She would open the door when seeing this screen.

5. Which of the red pictures is the most clear to you?
   - screen ‘red3’ because the text is easiest to read in that one. She would not let the person in when seeing this screen. She sees the red square around the picture well.
2. How do you understand the gray image? What does it tell you? (on the screens rd1, red2 and red3)
   - “It means not to let in fat people," she says jokingly.

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**Summary of all the results:**

| Screen | Screen name | How many test groups out of the 7 people liked the screen | Comments |
|---|---|---|---|
|   | green1 | 1/7 | |
|   | green2 | 0/7 | |
|   | green3 | 5/7 | Best visibility of the text |
|   | green4 | 1/7 | |
|   | red1 | 2/7 | |
|   | red2 | 0/7 | |
|   | red3 | 5/7 | Best visibility of the text |
|   | red4 | 0/7 | |

From the analysis we can see that the best designs were screen ‘green3’ and screen ‘red3’. This is because the white background of the text and increased contrast seems to increase the readability of the text. The elderly still sees the red and green in the pictures clear enough. The text seems to play the most important role for the elderly as a way of communicating the purpose of the screens.

A group of three seniors (people number 4,5 and 6) suggested that on the screen ‘green3’ it should also say: ‘vårdgivare’ to make it more clear who is the person in the picture.

The best designs:


# Appendix D

# Front-end evaluation: user test data

Date: 11.05.2018
Caregiver 1: A man
Testers: Katariina Martikainen & Kewser Said
Description of the senior: Old, energetic woman. Around 70-90 years old.

| 1 | Observations and answers from senior (Known caregiver) | Answer/Notes |
|---|---|---|
| 1.1 | How does the senior seem/act when seeing the home screen? | Looked at the screen. Said that she understood what was on the screen. She tried to click on the screen to see what happens. |
| 2.1 | Did the senior get scared from the voice? | No. |
| 3.1 | What did the senior do when the information came? | She replied at loud to the tablet that: yes you can come in. When asked if she would open the door, she said yes she would. |
| 4.1 | What did the elderly do when they heard knocking on the door? | She said she would open the door. |
| 5.1 | Did the senior let the person in? | Yes |
| 6.1 | Did the senior seem confused after opening/not opening the door. | Not at all. |
| 7.1 | What did the senior do after opening the door? | She was happy to see the caregiver. |
| 8.1 | Free notes | She said she was a bit confused if she should have this tablet at home or how does it work. She asked if she would get the tablet for free from Kista hemtjänst or if she would have to pay for it. |

| 2 | Observations and answers from senior (Stranger) | Answer/Notes |
|---|---|---|
| 1.2 | How does the senior seem/act when seeing the home screen? | She looked at the screen. |
| 2.2 | What did the senior do when the information came? | She looked at the screen and concluded that she would not let the person in. |
| 3.2 | What did the elderly do when they heard knocking on the door? | She said she would not let the person in. |
| 4.2 | Did the senior let the person in? | No. |
| 5.2 | Did the senior seem confused after opening/not opening the door. | No. |
| 6.2 | What did the senior do after opening the door? | - |
| 7.2 | Free notes | She thinks that this kind of a system would be very good. She complained about that someone had stolen her golden watch and she thinks that it is someone who said that they are elderly care people. She understood both the green and the red screens very well. |

Date: 11.05.2018
Caregiver 2: A woman
Testers: Katariina Martikainen & Kewser Said
Description of the senior: Old woman. Difficulties to hear, speak and move. She is in a wheel chair.

| 1 | Observations and answers from senior (Known caregiver) | Answer/Notes |
|---|---|---|
| 1.1 | Observations and answers from senior (Known caregiver) | She looked at it. |
| 2.1 | Did the senior get scared from the voice? | No. |
| 3.1 | What did the senior do when the information came? | She looked at it and said that she recognises the caregiver. She said that the caregiver had been with her before. |
| 4.1 | What did the elderly do when they heard knocking on the door? | She said that she would let the person in and let Jonas (the Kista elderly care contact person) open the door for her. |
| 5.1 | Did the senior let the person in? | Yes. |
| 6.1 | Did the senior seem confused after opening/not opening the door. | No. |
| 7.1 | What did the senior do after opening the door? | She was happy to greet the caregiver. |
| 8.1 | Free notes | The senior had much difficulty to hear, move and talk. She recognised the caregiver who came in from the screen information before the caregiver stepped in. She thinks it would help to have this system. She says that the information on both screens was clear. She says that sometimes the door bell rings in the middle of the night and asks if that is why we are making this system. She says that a system like this would help her to feel more secure in situations like this (door bell ringing in the middle of the night). She understands well what the system is for. She says that she often cannot open the door herself so something which would show her who is inside of the house from where she is at that moment would help her a lot. |

| 2 | Observations and answers from senior (Stranger) | Answer |
|---|---|---|
| 1.2 | How does the senior seem/act when seeing the home screen? | She looks at the screen. |
| 2.2 | What did the senior do when the information came? | She said that she would open the door. |
| 3.2 | What did the elderly do when they heard knocking on the door? | She looked at the door. |

| | | |
|---|---|---|
| 4.2 | Did the senior let the person in? | Yes. |
| 5.2 | Did the senior seem confused after opening/not opening the door. | No. |
| 6.2 | What did the senior do after opening the door? | She said that she understands that the red screen shows an uninvited quest. She understands what the screen says but she still wanted to know who the person behind the door was. She wanted to see if the person was a stranger or a familiar person to her, like a family member, or homecare. |
| 7.2 | Free notes | |

Date: 11.05.2018
Caregiver 3: A woman
Testers: Katariina Martikainen & Kewser Said
Description of the senior: Semi-old man on a wheelchair/scooter. Jonas noted that this man lives in a different kind of housing that the rest. In that area it is more controlled who can come in and who can get to the area.

| 1 | Observations (Known caregiver) | Observations and answers from senior (Known caregiver) |
|---|---|---|
| 1.1 | How does the senior seem/act when seeing the home screen? | He looks at it. Understands it. |
| 2.1 | Did the senior get scared from the voice? | No. |
| 3.1 | What did the senior do when the information came? | He looks at it. |
| 4.1 | What did the elderly do when they heard knocking on the door? | He let the person in. |
| 5.1 | Did the senior let the person in? | Yes. |
| 6.1 | Did the senior seem confused after opening/not opening the door. | No. |
| 7.1 | What did the senior do after opening the door? | He asked: “Was it her who came in?”, while pointing at the image of the caregiver on the green screen. He said that the voice message was very good. |
| 8.1 | Free notes | |

| 2 | Observations and answers from senior (Stranger) | Answer/Notes |
|---|---|---|
| 1.2 | How does the senior seem/act when seeing the home screen? | He looks at it. |
| 2.2 | What did the senior do when the information came? | He says that this time the person is not from Kista home care. He says that now he does not know anything about the person who is coming in. |
| 3.2 | What did the elderly do when they heard knocking on the door? | He said ok to the door. |
| 4.2 | Did the senior let the person in? | Yes. |
| 5.2 | Did the senior seem confused after opening/not opening the door. | No. |
| 6.2 | What did the senior do after opening the door? | He said that he is curious. He wants to know who is behind the door. Maybe it is someone he knows. He says that he understands that the person is not from Kista elderly care. |

Date: 11.05.2018
Caregiver 4: A woman
Testers: Katariina Martikainen & Kewser Said
Description of the senior: Old man in a wheel chair. Does not show if he hears or understands what Katariina is saying. Answers the questions after a while of silence.

| 1 | Observations and answers from senior (Known caregiver) | Answer/Notes |
|---|---|---|
| 1.1 | How does the senior seem/act when seeing the home screen? | He looks at the screen. |
| 2.1 | Did the senior get scared from the voice? | No. |
| 3.1 | What did the senior do when the information came? | He looks at the information and when asked if he would let the person in, he says yes. |
| 4.1 | What did the elderly do when they heard knocking on the door? | Looks at the door. |
| 5.1 | Did the senior let the person in? | Yes. |
| 6.1 | Did the senior seem confused after opening/not opening the door. | No. |
| 7.1 | What did the senior do after opening the door? | He said that the screen told that elderly care staff is coming. He recognised that the in coming caregiver is the one in the image on the tablet screen. |
| 8.1 | Free notes | He says that it would be good to have this kind of information. That it would be useful. |

| 2 | Observations and answers from senior (Stranger) | Answer/Notes |
|---|---|---|
| 1.2 | How does the senior seem/act when seeing the home screen? | He looks at the screen. |
| 2.2 | What did the senior do when the information came? | He said he would not open the door. |
| 3.2 | What did the elderly do when they heard knocking on the door? | He looks at the door and says that it is not elderly care. |
| 4.2 | Did the senior let the person in? | No. |
| 5.2 | Did the senior seem confused after opening/not opening the door. | No. |
| 6.2 | What did the senior do after opening the door? | - |
| 7.2 | Free notes | - |