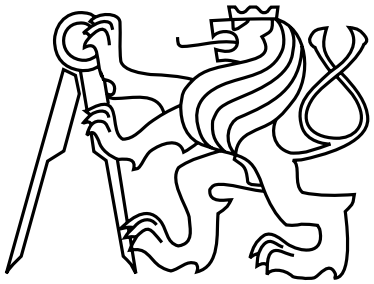
Czech Technical University in Prague
Faculty of Electrical Engineering
Department of Computer Science



Master's Thesis

Indoor navigation system main terminal

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Supervisor: Ing. Miroslav Macík

Study Programme: Open Informatics

Field of Study: Software Engineering

May 26, 2016

Czech Technical University in Prague
Faculty of Electrical Engineering

Department of Computer Science and Engineering

DIPLOMA THESIS ASSIGNMENT

Student: **Bc. Eva Lorencová**

Study programme: Open Informatics
Specialisation: Software Engineering

Title of Diploma Thesis: **Indoor navigation system main terminal**

Guidelines:

Individuals with special needs have difficulties with navigation and orientation in both indoor and outdoor environment. At the CTU there is an ongoing project [1][2] that aims to support indoor navigation of individuals with navigation and orientation difficulties in the indoor environment.
Perform a user study focused on needs and preferences of visually impaired and seniors regarding indoor navigation and hospital visits. Analyze current status of corresponding navigation system design and implementation. Analyze information exchange between navigation system terminals and users, focus on main navigation terminal (Smart Kiosk).
Using User-centered design (UCD) [3] methodology design and implement prototype of Smart kiosk. In accordance with UCD, evaluate individual prototypes with target user audience. Integrate implemented Smart Kiosk into complex indoor navigation system.

Bibliography/Sources:

[1] Macik, Miroslav, et al. "Software architecture for a distributed in-hospital navigation system." Proceedings of the 2015 Conference on research in adaptive and convergent systems. ACM, 2015.
[2] Fixova, Katerina, Miroslav Macik, and Zdenek Mikovec. "In-hospital navigation system for people with limited orientation." Cognitive Infocommunications (CogInfoCom), 2014 5th IEEE Conference on. IEEE, 2014.
[3] Abras, Chadia, Diane Maloney-Krichmar, and Jenny Preece. "User-centered design." Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications 37.4 (2004): 445-456.

Diploma Thesis Supervisor: Ing. Miroslav Macík

Valid until the end of the summer semester of academic year 2016/2017

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Prague, January 15, 2016

Aknowledgements

I would like to express my profound gratitude to my supervisor Ing. Miroslav Macík for his expert guidance and encouragement throughout my work on the project. Finally, I want to express deepest thanks to my family for supporting me during my studies.

Declaration

I hereby declare that I worked out the presented thesis independently and I cited all the sources used in this work in accordance with Methodical instructions about ethical principles for writing academic thesis.

In Prague on May 26, 2016 .....

Abstract

This thesis focuses on the development of indoor navigation system, namely the main terminal. We concentrate on navigation in hospitals for people with limited navigation and orientation abilities, namely visually impaired and seniors. First part of the thesis focuses on the analysis of current approaches for indoor navigation. Next, the qualitative user study with target user audience is performed in order to reflect users' needs and preferences to design. Low-Fidelity and High-Fidelity prototypes are created and evaluated with corresponding target user audience. Finally, design recommendations are proposed for further development of the system.

Keywords: indoor navigation, navigation system, User-Centered Design, user research, usability testing, visually impaired, seniors.

Abstrakt

Tato práce se zabývá vývojem navigačního systému pro interiéry, konkrétně hlavního terminálu. Zaměřujeme se na navigaci v nemocnicích pro osoby se sníženou schopností navigace a orientace, a sice nevidomými a seniory. První část práce ze zabývá analýzou konkrétních přístupů k navigaci v interiérech. Dále jsme s naší cílovou skupinou provedli kvalitativní uživatelskou studii, aby mohli být požadavky uživatelů promítnuty do designu. Vytvořili jsme a vyhodnotili Low-Fidelity a High-Fidelity prototyp. Na závěr jsme předložili doporučení k designu pro další vývoj systému.

Klíčová slova: navigace v interiérech, navigační systém, User-Centered Design, uživatelký výzkum, testování použitelnosti, nevidomí, senioři.

Contents

Chapter 1

Introduction

In the outdoor environment, the position of user can be determined by global navigation satellite systems, such as GPS. However, these systems cannot be used for the indoor navigation. In case of complex buildings like hospitals, the navigation can be very challenging, especially for the people with limited navigation and orientation abilities. Considering the possible health issues of the hospital visitors, the navigation might be even more complicated.

Many indoor navigation systems have been developed recently. They employ various localization techniques. However, they cannot be usually used by visually impaired or even by seniors. Most indoor navigation systems require their users to carry some special single-purpose device or smartphone, at least. Many systems also require installation of special devices into the environment. We want to develop our own navigation system which would not be dependent on users carrying some devices and would be tailored to our target user audience – visually impaired and seniors.

This thesis focuses on the development of indoor navigation system main terminal (called Smart kiosk) using User-Centered Design methodology [2]. The work is divided into several chapters. Chapter 2 describes the analytical part of the system development. First section describes the User-Centered-Design methodology. Next, existing approaches for indoor navigation are discussed and findings from the field study in one of the hospitals in our country are listed. Moreover, current status of our navigation system is described. The chapter also focuses on user study with visually impaired and seniors. Finally, the system requirements are defined. Chapter 3 describes the design of Smart kiosk. At first, the user interface is formally described. Then the design of Low-Fidelity and High-Fidelity prototypes is introduced. Chapter 4 mentions the development tools used for creating the prototypes. Moreover, the implementation of High-Fidelity prototype is described. In chapter 5, the evaluation of prototypes with corresponding target user audience is discussed. The usability tests execution is described and usability issues discovered by the testing are listed. Furthermore, their possible solution is proposed. Finally, chapter 6 concludes this work and suggests the direction of future development of Smart kiosk.

1.1 Motivation

The indoor navigation might be very problematic in case of complex public buildings, such as hospitals. The current approach for the navigation includes various maps, plans and signs. Speaking of hospitals, possible health issues of the visitors can make the problem with navigation even worse. For the people with limited navigation and orientation abilities, namely visually impaired and seniors, current approaches may not be suitable. Visually impaired are often dependent on help of passers-by and hospital staff since there is almost no information in some form suitable for them. Seniors may experience problem with understanding the plans as they can be complicated in case of complex hospitals. Considering these facts, we suppose that navigation system designed to address their needs would be very helpful for them.

Many indoor navigation systems have been developed so far. They are not usually designed for a specific target audience, but for general public. This approach to design something for "everyone" may cause that the system cannot be actually used by anyone [30]. On the other hand, some of the systems are designed for visually impaired and cannot be used by sighted users. We have decided to develop our own navigation system which would be tailored to visually impaired and seniors, but would be also available for other people.

1.2 Objectives of the thesis

The goal of this thesis is to design and implement Smart kiosk – the main terminal of the indoor navigation system currently developing at Czech Technical University in Prague. The system focuses on the navigation in hospitals and is designed for visually impaired and seniors. The current state of the project as well as the specific components of the system are described in section 2.4.

The development of Smart kiosk will consist of several steps. These steps correspond to the objectives which should be accomplished within the scope of this thesis. The list of these objectives follows:

1. Discuss existing approaches for navigation and orientation.
2. Analyze the current status of our navigation system.
3. Discuss the information exchange between navigation system terminals and users.
4. Perform the user study with corresponding target user audience – i.e. visually impaired and seniors.
5. Define system requirements according to needs and preferences of target user audience.
6. Design Low-Fidelity and High-Fidelity prototypes with respect to user requirements.
7. Describe the implementations of particular prototypes.

8. Integrate the implementation of Smart kiosk into the navigation system.

9. Evaluate the prototypes with corresponding target user audience.

The first five objectives are the subject of analytical part of the thesis (chapter 2). The following three objectives focus on realization of the Smart kiosk are discussed in chapters 3 and 4. The last objective is addressed in chapter 5. The discussion of fulfillment these objectives is a matter of chapter 6.

Chapter 2

Analysis

In this chapter, User-Centered Design methodology is described. Moreover, the chapter focuses on current approaches for navigation and orientation in complex public buildings, in particular big hospitals. Related approaches are listed in section 2.2. We focus on solutions suitable for people with limited navigation and orientation capabilities. Follows description of our field study which aimed to investigate situation regarding navigation and orientation in the biggest hospital complex in the Czech Republic. Next section focus on our approach to navigation in hospitals. Section 2.5 describes user study we performed in which visually impaired and seniors were interviewed. Finally, functional and non-functional requirements are listed.

2.1 User-Centered Design methodology

When creating a product, the end users are often omitted from the process of designing and the designers often focus only on their own ideas. Therefore, final product is not always intuitive for the end users. They can be frustrated which might cause even more serious problems with using the product as frustration has negative impact on achieving the goal [7].

User-Centered Design (UCD) [2] is a term to describe the design processes in which end users influence the design. In fact, the product is designed to support user's needs instead of require the user to adapt. The term User-Centered Design was originally used by Donald Norman's research laboratory in the 1980s. In [29], he offers basic recommendations which place the user at the center of the design.

Figure 2.1 illustrates how the phases of UCD look like according to [28]. The whole process of creating a product is iterative – i.e. its particular phases are repeating. In each phase, the user requirements are taken into consideration.

The development of a product begins with its vision, which also includes the definition of the target audience – i.e. the end users of the product. In designing a new product, it is crucial to understand users' needs and preferences. Therefore, the user research, which includes field study and interviews, should be the initial phase of UCD.

Before the users' needs and preferences are reflected in design, the user research is summarized. Its results can be used for creating user profiles and personas. The requirements

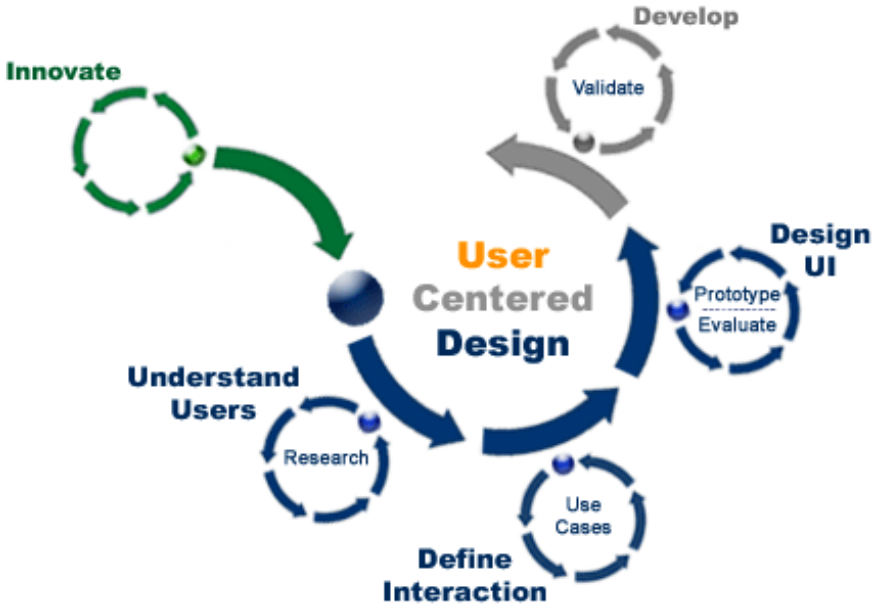

Figure 2.1: User-Centered Design methodology, from [28]

should be specified and the interaction between the user and the product should be defined and transformed into use cases.

Next phase is to design the user interface. When designing, the main concern could be not to get locked into a single solution too early. Thus, before the final product is designed, Low-Fidelity and High-Fidelity prototypes of it should be made and usability tests should be performed. Both types of prototypes enable fast and effective improvement of the user interface. Low-Fidelity prototypes allow rapid prototyping, evaluation and creation of new versions. High-Fidelity prototypes are quite close to the final product, at least from a user point of view. However, some functionality only seems to be implemented. In fact, the communication between the user and product can be done by a human. This method is often called OZ paradigm or The Wizard of Oz [23].

The last phase of UCD is final development of the product. The completed product is formally tested for usability to monitor ongoing improvement over time.

2.2 Related work

Many indoor navigation systems based on various technologies have been developed so far. Some of them are designed for a specific environment, such as hospital or airport; some of them for interiors in general. This section focuses on the systems which could be used for the hospital navigation or are tailored to our target user audience.

One of the hospital navigation systems was designed by Panasonic [31]. The outpatients are given a pager which shows them the way to the required destination with respect to the possible limitations of the users. Apart from the navigation, the system can also register

the patients and do basic paperwork. As each user has to be equipped with a single-purpose pager, the scalability of this solution is questionable.

IndoorSpirit [33] is mobile indoor navigation software which uses data from various smartphone sensors. It uses multiple technologies (geomagnetic fingerprinting, pedestrian dead reckoning and Wi-Fi fingerprinting) to determine the position of a user. As the application runs on smartphone, usage of this system could be problematic for our target user audience.

Another system introduced in [5] relies on a smartphone and two-dimensional bar codes placed in key points of a building. The initial position of the user is determined by scanning a bar code using smartphone camera. When the user starts walking, the system uses an accelerometer to track the number of steps taken. Based on this number, the position is estimated. When the user reach some anchor point, the system informs them that they should recalibrate the system using smartphone camera again. As the recalibration is crucial part of the navigation process, using this system could be problematic, especially in the case of a visually impaired user.

In [3], the hospital navigation system for elderly people is introduced. It is based on Personal Handy-phone System (PHS) [13] and smartphone. First, the PHS device samples Received Signal Strength Indication (RSSI) [42] of radio waves from PHS base stations. Then, the RSSI is transmitted to the smartphone. The position of user is estimated from the received RSSI and sensors in smartphone. The user receives the navigation instructions using the application on smartphone. Although the target audience is supposed to be elderly people, the system requires using smartphone, which could be problematic for this target audience. Moreover, each user has to borrow another device (i.e. PHS) at the reception for the purposes of navigation.

Tsirmpas et al. [35] propose a navigation system for elderly people and visually impaired. In the paper, the localization and obstacle avoidance algorithm is described. The localization is resolved by using Radio Frequency Identification (RFID) [38] technology. Each user wears a module with the RFID reader on the leg, which scans the RFID tags in the floor. According to their position, they can be navigated to the required destination. Although this RFID-based solution is applicable to both seniors and visually impaired, the RFID tags have to be embedded in floors. Moreover, the users have to wear a special one-purpose device.

Flores and Farcy [12] present a navigation system for visually impaired based on dead reckoning [40]. The system uses various sensors in smartphones and external Inertial Measurement Unit (IMU) [41]. It provides simple audio instructions in order to navigate visually impaired users. Main limitation of this system is the fact the user has to be trained to understand the specific way in which the instructions are given. Another system also based on IMU is proposed in [16]. Besides IMU, ultrasonic range sensors are used to improve the accuracy of the system. These two systems require no additional devices in the environment. However, there could be a problem with precision of dead reckoning methods.

PERCEPT [15] is a navigation system based on passive RFID tags placed in the building. First, the user specifies the destination at the kiosk in the entrance hall. Then, they scan the RFID tags using the scanner embedded into special glove. The glove sends information to a smartphone. The instructions are provided in audio form. However, the scalability of this solution is questionable as each user needs to wear special glove.

System	Target group	Positioning	Changes in the environment	Special device for user	Smartphone
Panasonic [31]	General public	Bluetooth	YES	YES	NO
IndoorSpirit [33]	General public	Smartphone sensors	NO	NO	YES
Atzori et al. [5]	General public	Smartphone sensors	YES	NO	YES
Aoki et al. [3]	Elderly people	RSSI, dead reckoning	YES	YES	YES
Tsirmpas et al. [35]	Elderly people, visually impaired	RFID tags	YES	YES	NO
Flores and Farcy [12]	Visually impaired	Deduced reckoning	NO	YES	NO
Girard et al. [16]	Visually impaired	Deduced reckoning	NO	YES	NO
PERCEPT [15]	Visually impaired	RFID tags	YES	YES	NO
Feng et al. [9]	Visually impaired	Wi-Fi fingerprinting	NO	NO	YES
Nakajima and Haruyama [27]	Visually impaired	Visible light communication	YES	YES	YES
Fukasawa et al. [14]	Visually impaired	RFID tags, RGB sensor	YES	YES	YES
Guerrero et al. [17]	Visually impaired	Infrared beacons	YES	YES	YES

Table 2.1: Indoor navigation systems

In [9], the indoor navigation system is based on RSSI measurements. RSSI is measured at different points and is collected in a database. When a new reading of RSSI is made, it is compared with the database, and the current location of the user is estimated. According to the authors, the accuracy of the system is limited by the low sampling rate of the RSSI signal.

Another indoor navigation system is introduced in [27]. It utilizes visible light communication technology. The positional information is sent from LED lightning and is received by the receiver which communicates with a smartphone using Bluetooth. The system provides user with audio navigation instructions. Although geomagnetic field sensor estimating the

direction of walking is used to reduce the error range, the system can be still inaccurate as the smartphone is not in fixed position during the navigation.

The navigation system described in [14] is based on using the intelligent white cane. The cane includes a RGB colour sensor, a transceiver for RFID tags, a vibration motor, and a voice processor. The navigation lines of different colours on the floor determine different routes. The colours can be recognized by the cane and the correct direction is signaled by vibrations. When an RFID tag is reached by the user, the information about the current position is provided by the voice processor in the cane. An augmented white cane is also a part of system described in [17]. The cane is equipped with several infrared LEDs in order that the infrared cameras in the environment could detect it. The system communicates with the user by smartphone. As both systems requires users to be equipped with the augmented white cane, it can be inapplicable not only to sighted users, but also to many visually impaired.

Table 2.1 compares the above mentioned systems from different perspectives. It shows who is the target audience. Then, the positioning technique is mentioned. The table also says whether there have to be some additional devices or sensors installed in the target environment. Furthermore, it shows whether users have to carry some special device or smartphone at least.

As it can be seen in the table, not all the systems are suitable for visually impaired. On the other hand, some of them are suitable only for them. The systems are based on various positioning techniques. Some of them employs more than one technique in order to reduce the number of errors or improve the accuracy of position estimation. Many systems requires some changes in the environment, which could be very expensive. On the other hand, the installation costs could be reduced if their installation was considered during the construction of building. Some systems requires users to carry a special one-purpose device. Other systems require users to use their own smartphone. Therefore, each user has to prepare the visit in advance by installing some special application.

2.3 Field study

We have decided to visit the hospital environment in order to understand how the navigation and orientation can look like there. We also want to know what are the possible issues the visitors have to deal with. We have chosen the University Hospital in Motol [26] as it is the biggest health care facility in the Czech Republic so the navigation there is considered to be challenging.

University Hospital in Motol [26] has more than 5 000 employees and treats more than 70 000 inpatients and 860 000 outpatients per year. It consists of few buildings and pavilions and, according to our own experiences, the indoor navigation as well as the outdoor navigation among the buildings can be very problematic.

After entering the main entrance of Motol hospital, there is a large entrance hall. The visitor can decided whether to go to the building for children or for adults. However, these two entrances are poorly marked. The building for adults is divided into five parts. The visitor

Figure 2.2: Orientation plan in Motol University Hospital

can follow the coloured navigation lines to get into the required part, but there are not always updated.

Another confusing thing for the visitors could be the different signs describing the same part of the building (see figure 2.3). Firstly, the description of specific floors varies. Secondly, the name of the first floor below ground differs.

Visually impaired visitors must also contend with many problems. As they cannot find the desired destination on plans and cannot follow the signs, they are dependent on help of passers-by and employees of the hospital. The building for adults is symmetrical, has wide corridors and open spaces. This could make their navigation even more complicated. Moreover, there are no navigation lines to be followed.

In lifts, there are no Braille labels or are damaged. However, the lifts in some buildings provide the audio information. Unfortunately, the audio information is missing for instance in the electronic waiting system of the emergency department. Thus, visually impaired are dependent on help of someone else once again.

According to our visit of Motol University Hospital, the visitors have to deal with complicated navigation which can be even more annoying if they have some health issues. The navigation might be very challenging, especially for visitors with limited ability of orientation, such as visually impaired and seniors. Visually impaired are dependent on help of other people in hospital as there is almost no information in some form suitable for them. The seniors can struggle with complexity of buildings, complicated plans and disunited signs. Considering these facts, we believe that some navigation system would be very helpful for them.

Figure 2.3: Disunited signs in Motol University Hospital

2.4 Hospital navigation system

When designing our own hospital navigation system, we had to consider how the users would be identified and how they would be localized. Many systems developed in recent years require users to carry some special device. According to [18], this could stigmatize them. Furthermore, as out target user audience are seniors and visually impaired, we cannot rely on the fact they own a smartphone.

Our system does not require users to carry any special device. The system employs face recognition to localize a user and provides him/her with personalized navigation instructions to the next navigation point. User's face is used only for the purposes of navigation and is stored only for the time of his/her presence in hospital. Therefore, when the user prepares the visit at home using Web portal, he/she has to identify by the insurance card in order that the information about him/her could be used by the system (see details below).

There are several ways how to navigate in an unknown building. One can ask passers-by, search for the destination on the plan of a building or follow signs. The latter two strategies cannot be used by visually impaired. Moreover, remember the whole route to the destination could be a problem for both visually impaired and seniors. Therefore, we have decided not to force them to remember the whole route, but to provide them with simple navigation instructions and navigate them step-by-step to the destination (see details below).

The system should also contain a receiver for input from the transmitter for visually impaired [4]. This device is commonly used by visually impaired in the Czech Republic. It is used to trigger various devices in the environment in order to obtain some audio information about them. In our case, it could be used to inform visually impaired that there is a navigation system in the building and how they could use it.

2.4.1 In-hospital navigation system terminals

The system consists of few kinds of terminals (see figure 2.4). *Web portal* can be used to prepare the hospital visit at home. The user can define the desired destination in the hospital building, make an appointment or plan the way to hospital. Information from visit preparation simplifies the cooperation with terminals in hospital and also enables terminals to adapt their user interfaces to users' needs.

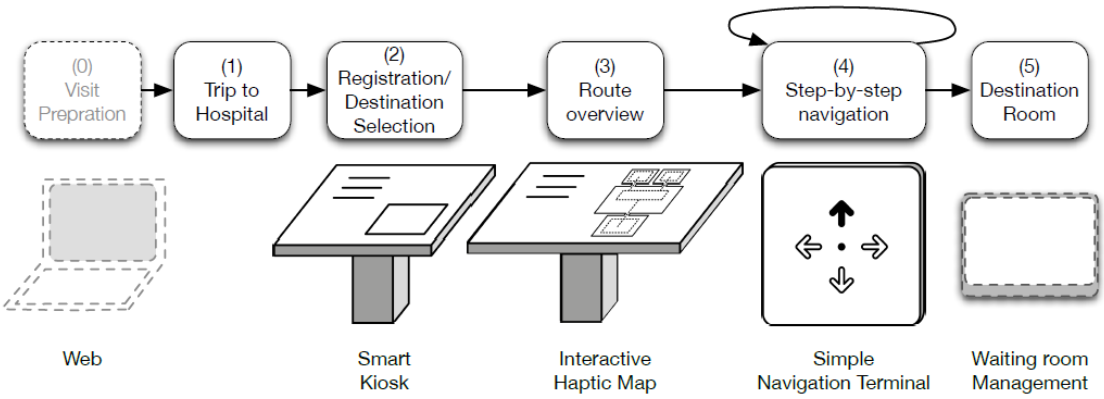

Figure 2.4: Navigation process, from [24]

Smart kiosk is the terminal located at the main entrance of hospital. Its main purpose is to enable the user define the destination. The user can either select the destination from the menu or if the visit was prepared, they can select it from the list of prepared visits. In this case, they have to identify using the insurance card in order the system could access the corresponding list of prepared visits. Moreover, information from visit preparation enables terminals to adapt their user interfaces to users' needs. After the destination if defined, they receive navigation instructions to the first Simple navigation terminal on the way. Before the user leaves the terminal, the photo of their face is taken in order that other terminals could recognize them and provide them personalized navigation instructions.

Interactive haptic map helps user to orient and build mental model of the environment. It provides topological information about a large part of the hospital, such as a floor. Unlike ordinary map, it is suited for both sighted users and visually impaired as the user can explore the map both by vision and by touch. Interactive haptic map also provides information about obstacles and terrain changes, which could be very useful, especially for visually impaired.

Simple navigation terminal provides short directional instructions for reaching the next Simple navigation terminal on the route to the destination. The terminals are placed at corridor junctions. Thus, the user is navigated step-by-step to the destination. The face recognition technology is used in order that each user could be provided with personalized navigation instructions. The instructions are given either in audio form for visually impaired or in a form of N arrow showing the direction for sighted users. At each Simple navigation terminal, there is also another version of haptic map. The map has quite unique design as it is curved and the current position of the user is always at the highest point of the map. Therefore, even the visually impaired can easily find their position on the map.

Waiting room kiosk informs the user about his/her number on the waiting list, estimates the waiting time or helps visually impaired with finding free seat. In can be also used for defining new destination. Therefore, this terminal also employs the face recognition.

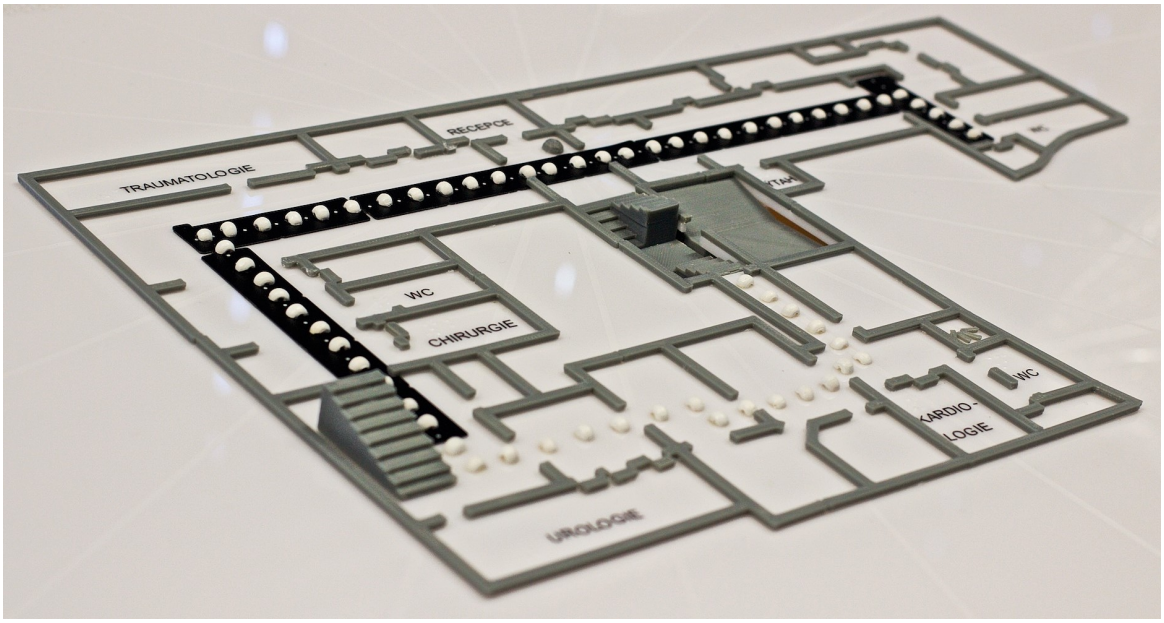

Figure 2.5: Interactive haptic map

2.4.2 Current status of the navigation system

In recent years, many people have been working on the development of our indoor navigation system within the scope of some subjects ([19, 20, 21, 22]) or as a bachelor's degree project ([10, 34]) or master thesis ([32]). Some papers were also published ([11, 24]).

Table 2.2 shows what is the current status of specific parts of our navigation system. Some of the terminal have been developed so far. Some of them are currently in development. Note that the Interactive haptic map and Simple navigation terminal were designed by students of industrial design at Faculty of Architecture, Czech Technical University in Prague.

System part	Current status
Web portal	Currently in development as a subject of Master's thesis
Smart kiosk	Currently in development as a subject of this thesis
Interactive haptic map	The prototype was developed as a subject of Bachelor's degree project [34]
Simple navigation terminal	The prototype was developed as a subject of Master's thesis [32]
Waiting room kiosk	Currently in development as a subject of Master's thesis

Table 2.2: Current status of our navigation system

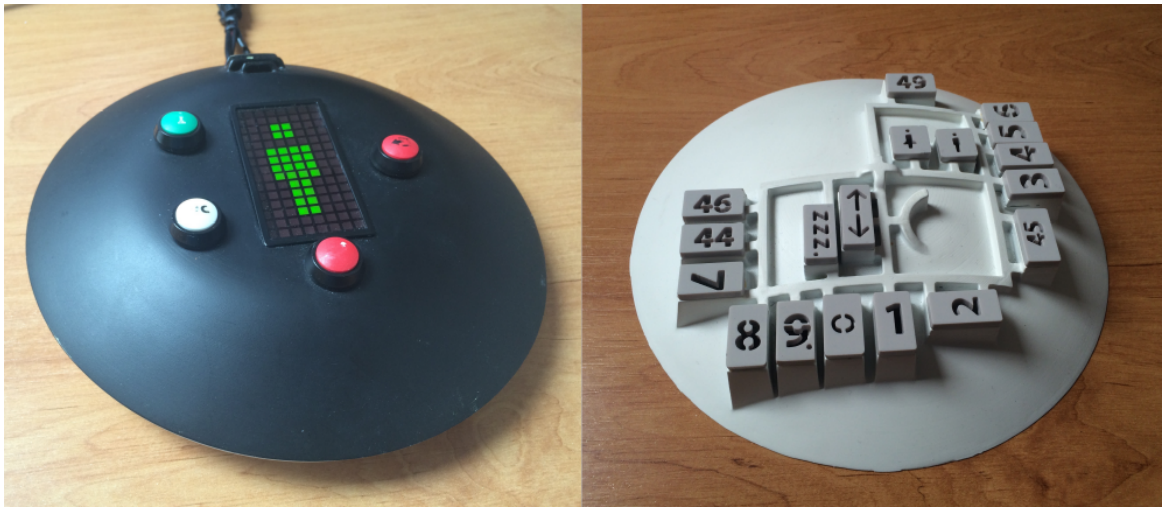

Figure 2.6: Simple navigation terminal together with the haptic map

2.4.3 Information exchange between terminals and users

The important part of our system is its adaption to users' specific needs. To enable the adaption, the system has to know some information about the user which is specified using Web portal. This information is exchanged among the terminals. When a user identify at Smart kiosk by the insurance card, their first name, last name and date of birth are used to obtain the information from their profile on Web portal.

Using Web portal, users specify their physical limitations in order that the system could provide personalized navigation instructions – e.g. choose the route without stairs for wheelchair users. Moreover, the user interface can adapt to users' needs. For instance, the audio output can be activated by default for the users who suffer from visual impairment.

Besides the information from the Web portal, the system also shares the photo of user's face in order that the specific terminals could provide the personalized navigation instructions. However, the photo is stored only for the time user spends in the hospital and then, it is deleted. The only stored data is the information from the user profile created on Web portal, i.e. personal data, stated limitations of the user that could help to adapt to user's specific needs, and the information about the prepared visits. Thus, if the user do not prepare the visit and have not the profile on Web portal, there is no information about them permanently stored.

2.5 User study

The goal of the user study is to obtain qualitative data about the target user audience (visually impaired and seniors). We have used the interviews as a method for data collection. The main reason to use it was to get the insight into the problem of visiting a doctor and things related to it.

2.5.1 Target user audience

As it was mentioned before, our target user audience are visually impaired and seniors. The user study was performed with visually impaired of categories 4 (near-total visual impairment) and 5 (total visual impairment) [39]. It was conducted both with visually impaired who are blind from birth (congenitally blind) and who lost their sight later (late blind). Although the self-selection method for recruitment was used, we required the equal representation from the point of view of the gender and age. Furthermore, we looked for the people who maintain their active life despite their impairment.

For purposes of this work, a senior can be described as a person over 60 who is retired. The participant were selected using screener (appendix A). The screener excludes inappropriate participants from the user study. Moreover, it guarantees the equal representation from the point of view of the gender and age.

We preferred seniors who visit a doctor at least few times per year. The people both from cities and countryside were interviewed as they can have a different character (especially when we are talking about seniors). We also searched for the participants with different experiences with technologies. Finally, we preferred seniors who have not anyone to accompany them since we can assume that their accompaniment would take care of the navigation.

2.5.2 Interviews

The interviews were semi-structured, i.e. the participants were asked prepared open-ended questions focused on several topics, but some complementary questions were also asked. The list of questions is available in appendix B.

Five five visually impaired (PVI1-PVI5) and five seniors (PSI1-PSI5) were interviewed. The whole transcription of particular interviews is available in appendix C whereas their summary follows. Note that the summary contains references to specific participants who provide the particular information.

2.5.2.1 Visually impaired

Five visually impaired were participated in the user study (two male, three female, average age = 48). Three of them are classified to the fourth category of visual impairment whereas two of them to the fifth. We were looking for the people who maintain an active lifestyle despite their impairment.

Orientation at unknown places

- They asks at the reception and/or the passers-by to get the navigation instructions (PVI1, PVI2, PVI3, PVI4, PVI5). They also ask them when they get lost (PVI1, PVI2, PVI3, PVI4, PVI5). This situation can be unpleasant for them (PVI3, PVI4, PVI5).

- The passers-by want to help them (PVI1, PVI2, PVI4, PVI5).

- Almost all of them prepare in advance when they want to visit an unknown building. Their strategies differs (use services of the navigation centre for visually impaired (PVI1), ask friends for the route description (PVI3, PVI4), visit the building in advance to learn the route (PVI5)).

Before the visit of a doctor

- They are not nervous when they go to the doctor (PVI1, PVI2, PVI3, PVI4, PVI5).
- They prefer to make an appointment (PVI1, PVI3, PVI4). They think that they have to make it if it is not the case of emergency. They make it by phone (PVI1, PVI2, PVI3, PVI4).
- They travel by the public transport (PVI1, PVI2, PVI3, PVI4, PVI5). Some of them also travel by car when someone accompanies them (PVI1, PVI3).
- They sometimes have a family member to accompanies them (PVI1, PVI3, PVI5).
- They sometimes use the services of assistant for visually impaired (PVI1, PVI3).

Visit of hospital

- Some of them visit a doctor approximately once per month (PVI1, PVI5); some of them few times per year (PVI2, PVI3, PVI4).
- When they are sent to another doctor, someone usually accompanies them (when it is in the same building (PVI1, PVI2, PVI3, PVI4, PVI5)) or the doctor give them the address and some instructions (when it is at another place (PVI1, PVI2, PVI3, PVI4)).
- The way through the hospital building is not such a problem for them as they expect some obstacles like flowers, open doors etc. (PVI1, PVI2, PVI3, PVI4). The only problem can be some hanging signs as they cannot be detected with the white cane (PVI3).
- It is not such a problem for them to find the way in a building. The most difficult thing is to find the way from one building to another one among the buildings of a big hospital complex (PVI1, PVI4, PVI5).
- When they enter the hospital building, they usually go to the reception at first (PVI3, PVI4). They can use the transmitter for visually impaired to obtain some initial information, but these information are not available in hospitals (PVI1, PVI3, PVI5).
- There are usually no aids for visually impaired – no guiding lines, no Braille labels etc. (PVI1, PVI3, PVI4) or they are not updated (PVI2).
- The staff want to help them with the navigation, but they usually do not know how. They do not even know the basic navigation techniques for visually impaired (PVI1, PVI2, PVI3, PVI4, PVI5).

- Some of them change their doctors (for the better health care (PVI5) or better accessibility (PVI1)).
- Some of them use other services connected to the health care in the hospital building, such as chemist's (PVI1, PVI2).

Technologies (in hospital/in public buildings)

- They are not able to work with the electronic waiting list as it is not suitable for visually impaired (no Braille labels, no audio output). They do not have to use it. They just notify someone of their presence (PVI1, PVI2, PVI3, PVI4, PVI5). Sometimes they are taken in advance even though they do not want to overtake anyone (PVI2, PVI3).

Technologies (in general)

- Some of them have a phone with buttons as they do not like touch screens (PVI1, PVI2, PVI4). The rest of them have smartphones (PVI3, PVI5). However, some of them have it only because of the better functionality of it (PVI5). Therefore, their opinion on the touch screen differs, but in general, most of them prefer buttons to touch screen (PVI1, PVI2, PVI4, PVI5).
- Some of them use a mobile phone only for calling, writing the SMS and writings some notes (PVI1, PVI2, PVI4). Some of them (who own a smartphone) also use some applications, browse the Internet etc (PVI3, PVI5).
- They have computers (PVI1, PVI2, PVI3, PVI4, PVI5). They use it for various things, such as browse the Internet, look for the various information, writing email, writing some notes or listen to the audiobooks and music.

2.5.2.2 Seniors

For the purposes of this project, five seniors were interviewed (three male, two female, average age = 73). Only one participant is always accompanied by someone when he visits hospital. Two of them visit a doctor approximately few times per moth whereas three of them few times per month. Moreover, they have not much experiences with technologies.

Orientation at unknown places

- They prefer human contact (PSI1, PSI2, PSI3, PSI4, PSI5).
- They use signs to navigate (PSI1, PSI3, PSI4, PSI5) and/or ask at the reception (PSI1, PSI2, PSI3, PSI5). One of them also uses the coloured navigation lines (PSI2).
- When they get lost, they ask passers-by or the staff (PSI1, PSI2). Some of them feel slightly unpleasant (PSI1, PSI4).

- They do not look for the information about the building in advance (PSI2, PSI3, PSI4, PSI5). One of them sometimes calls to the office of a doctor to make sure that the doctor has not holiday (PSI1).

Before the visit of a doctor

- Some of them are nervous when they go to the doctor (PSI1, PSI4, PSI5).
- They make an appointment when a doctor wants it (PSI1, PSI3, PSI4). However, they prefer to make it when it is possible (PSI1, PSI2, PSI3, PSI4, PSI5).
- Some of them make an appointment by phone (PSI1, PSI4, PSI5) and some of them prefer to make it personally if it is possible (PSI2, PSI3).
- They travel by the public transport / by foot (PSI2, PSI3, PSI5) or by car (PSI1, PSI4).
- One of them has an accompaniment to visit a doctor (PSI3). The rest of them has not (PSI1, PSI2, PSI4, PSI5).
- They visit almost all their doctors in health centres (PSI1, PSI2, PSI3, PSI4, PSI5).

Visit of hospital

- Some of them visit a doctor few times per month (PSI2, PSI3, PSI4); some of them few times per year (PSI1, PSI5).
- When they are sent to another doctor, they usually want to know the address (PSI3) or the address together with the route description (PSI1, PSI2, PSI4, PSI5).
- The way through the hospital building is not a problem for them (PSI1, PSI2, PSI3, PSI4, PSI5).
- They have positive experiences with the hospital staff (PSI1, PSI2, PSI3, PSI4, PSI5). However, some of them have also negative experiences (PSI3, PSI5).
- They are satisfied with the health care so they did not change their doctors from this reason (PSI1, PSI2, PSI3, PSI4, PSI5).
- Some of them use also other services in the hospital building, such as various shops (PSI1, PSI5).

Technologies (in hospital/in public buildings)

- They can work with the electronic waiting list (PSI1, PSI2, PSI3, PSI4, PSI5).
- They do not need help of someone else to work with it (PSI1, PSI2, PSI5). One of them needed a help for the first time he used it (PSI4). One of them does not work with it as his accompaniment do it instead of him (PSI3).

- Some of them use the devices they have to (e.g. the electronic waiting list). However, some of them do not want to try the new ones when they do not have to (PSI1, PSI3).

Technologies (in general)

- Almost all of them prefer a phone with buttons (PSI1, PSI2, PSI3, PSI4). One of them owns a phone with the touch screen and she likes it (PSI5).
- Some of them use the mobile phone only for calling (PSI2, PSI3) and some of them also for writing SMS (PSI1, PSI4, PSI5).
- Almost all of them have not a computer and cannot work with it (PSI1, PSI2, PSI3, PSI4). If they can, they use it hardly ever. They do not think they need it (PSI1, PSI2, PSI3, PSI4).
- One of them has a computer, but only for calls with family (PSI5).
- Some of them have experiences with a phone with touch screen (PSI4, PSI5).
- Some of them have experiences with the touch screen only on the devices, such as ATM, electronic waiting list (PSI1, PSI2). If there were also buttons on them, they would prefer to use them (PSI1, PSI2).

2.5.3 Interviews summary

Visually impaired and seniors from this research prefer to ask the people for help with navigation (either the staff or passers-by). When they get lost, they can solve this situation, but some of them can be in stress. Seniors do not prepare in advance when they want to visit an unknown building whereas visually impaired do.

Some of the participants can be nervous when they have to visit a doctor. Most of them prefer to make an appointment if it is possible. Some of the visually impaired have an accompaniment when they visit a doctor.

Both visually impaired and seniors have positive experiences with the hospital staff in general, but some of them can also remember a negative experience. However, the visually impaired think that although the staff and passers-by want to help them, they do not know how. Moreover, most of them think that there are no aids for visually impaired in hospitals (e.g. navigation lines or Braille labels). Some of them can also have problems with obstacles on corridors (e.g. with hanging signs) whereas the seniors have not.

Seniors from the user study can work with the electronic waiting list whereas the visually impaired cannot since it has no audio output.

Almost all of the seniors and visually impaired prefer phone with buttons to smartphone. Seniors cannot work with a computer whereas visually impaired can and they use it in everyday life.

2.5.4 User requirements

In this section, user requirements gathered during the interviews with visually impaired and seniors are summarized. Each requirement refers to the participants who mentioned it during the interview. These requirements will be also taken into consideration when defining the system requirements (see section 2.6).

- Provide route overview – plan of building/level (PSI1, PSI3, PSI4, PSI5).
- Provide information about other places in hospital, such as the pharmacy (PSI1, PSI5, PVI1, PVI2).
- Provide additional information – office hours (PSI1).
- Navigate the user between different buildings of the hospital complex (PVI1, PVI4, PVI5).
- Provide user interface with buttons (PSI1, PSI2, PSI3, PSI4, PVI1, PVI2, PVI4, PVI5).
- Provide audio output (PVI1, PSI2, PVI3, PVI4, PVI5).
- Provide font which is big enough (PSI2).
- Minimize users' effort required for the interaction with the system (PSI1, PSI2, PSI3, PSI4, PSI5, PVI1, PVI2, PVI3, PVI4, PVI5).

Although the following requirements should be also met by our navigation system, Smart kiosk is not suitable terminal to fulfill them. However, they will be met by the different part of the navigation system.

- Enable to prepare the visit at home (PVI1, PVI3, PVI4, PVI5).
- Do not require to prepare visit at home (PSI1, PSI2, PSI3, PSI4, PSI5).
- Enable to prepare the visit by a doctor/nurse, i.e. make an appointment (PSI1, PSI2, PSI3, PSI4, PSI5, PVI1, PVI3, PVI4).
- Provide assistance for people who got lost (PSI1, PSI4, PVI3, PVI4, PVI5).
- Provide information about obstacles at corridors (PVI3).
- Provide information about public transport (PSI2, PSI3, PSI5, PVI1, PVI2, PVI3, PVI4, PVI5).
- Provide the functionality of electronic waiting list (PSI4, PSI5, PVI2, PVI3).

2.6 Analysis summary

From the previous sections, the functional and non-functional requirements can be derived. We pay attention especially on user requirements gathered during the interviews. They are listed in the previous chapter.

Functional requirements

- Enable user to select specific departments, doctor's offices and other places in hospital, such as reception and pharmacy.
- Provide navigation instructions to the first Simple navigation terminal on the way.
- Provide overview information about destination – room number and floor, map of the floor.
- Provide office hours of doctors.
- Provide navigation among particular buildings of the hospital complex.
- Enable user to choose the destination from list of prepared visits if they are identified and their visit was prepared.
- Enable user to activate/deactivate the audio output.
- Enable user to call medical help if needed.
- Enable user to "restart" the system – i.e. to start searching from the main menu again.
- Enable user to go one step back when searching in the menu.
- Provide more language versions of user interface.
- Provide information about the functionality of buttons.
- Provide the interaction with the transmitter for visually impaired.
- Provide personalized navigation instructions – e.g. choose the route without stairs for wheelchair users.
- Adapt the system according to users' needs – activate audio output for visually impaired, change language for foreigners.

Non-functional requirements

- Provide interaction method that uses hardware buttons.
- Use font which is big enough.
- Use sans-serif font.

- Use contrasting colors for text and its background.
- Provide the design resistant to possible strain in hospital.
- Provide the interaction suitable for the noisy environment.
- Provide the interaction which would not disturb other visitors of hospital.
- Provide the interface which would respect the privacy of users despite the noisy environment.

Although the majority of system requirements will be taken into account in prototype designing, some of them will be employed when the final implementation will be created. For instance, the personalized navigation instructions will be provided when the real data of specific building will be added. Thus, the intelligibility of specific navigation instructions will be fully tested after the deployment of the system. Moreover, some aspects of user interface could not be evaluated under laboratory conditions, e.g. the interaction in target environment.

Chapter 3

Design

In this chapter, the user interface of Smart kiosk is described. Furthermore, Low-Fidelity and High-Fidelity prototypes are designed according to the system requirements (section 2.6). Moreover, the findings from the usability testing of Low-Fidelity prototype were taken into consideration when High-Fidelity prototype was designed.

3.1 Formal description of user interface

The interaction between user and Smart kiosk can be derived from the user study. In this section, use cases, Hierarchical Task Analysis and scenarios are proposed in order to describe the user interface of Smart kiosk.

3.1.1 Use cases

Figure 3.1 illustrates the use cases of Smart kiosk. The description of each use case follows.

Identification

1. User uses the insurance card to identify.
2. System recognizes user's name.
3. System informs the user about successful identification.
4. System add some functions to menu available for identified users only.

Alternative:

1. User uses the insurance card to identify.
2. System informs the user about unsuccessful identification.
3. System ask the user to identify once again.

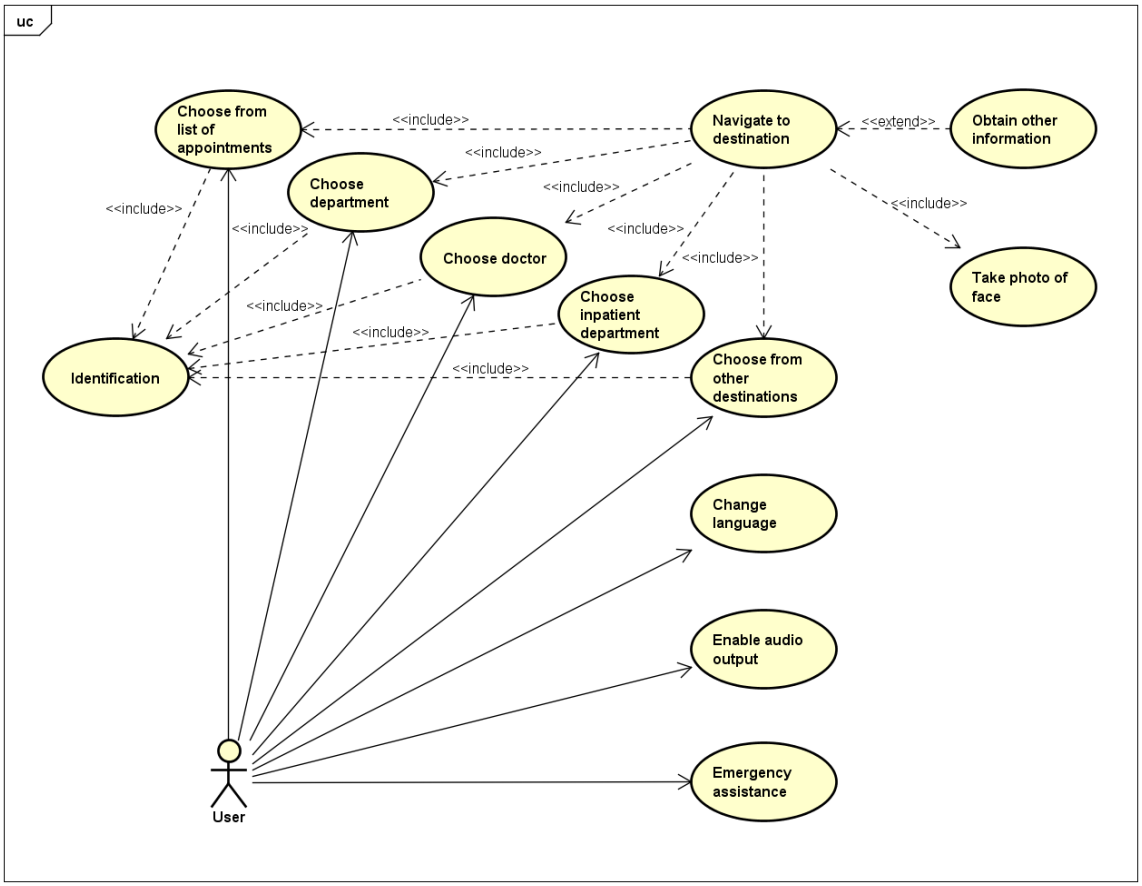

Figure 3.1: Use cases of Smart kiosk

Choose from list of appointments
Preconditions: user was identified, user prepared the visit (solved by different part of the system).

1. User chooses required doctor from the list of appointments.

Choose department
Precondition: user was identified.

1. User selects option for choosing a department.
2. System shows the list of departments.
3. User chooses a department.

Choose doctor
Precondition: user was identified.

1. User selects option for choosing a department.
2. System shows the list of departments.
3. User chooses a department.
4. System shows the list of doctors from the department.
5. User chooses a doctor.

Choose inpatient department
Precondition: user was identified.

1. User selects option for choosing an inpatient department.
2. System shows the list of inpatient departments.
3. User chooses an inpatient department.

Choose from other destinations
Precondition: user was identified.

1. User selects option for choosing other destination.
2. System shows the list other destinations.
3. User chooses the destination.

Take photo of face
Precondition: user chose the destination.

1. System takes a photo of user's face.
2. System match the face with the name of the user.

Navigate to destination
Precondition: user chose the destination.

1. System provides the navigation instructions.

Obtain other information
Precondition: user chose the destination.

1. System shows other information about the destination.

Change language

1. User selects option for changing the language.
2. System shows available languages.
3. User chooses preferred language.

Enable audio output

1. User presses the button for enabling the audio output.
2. System enables the audio output.

Emergency assistance

1. User presses the emergency button.
2. System informs the user about the help on the way and how to cancel it.
3. System informs the staff about the user who needs medical help.

3.1.2 Hierarchical Task Analysis

Hierarchical Task Analysis (HTA) [36] is another method how to describe the user interface. It says how a specific goal is accomplished through the tasks and actions. HTA of Smart kiosk can be seen in figure 3.2.

3.1.3 Scenarios

Scenarios illustrate the situations where the user can interact with Smart kiosk to achieve the desired goal. Five scenarios follow in order to cover the most important use cases.

Scenario 1 (Search for a doctor)
Mr. Pospíchal was sent to hospital by his general practitioner. He should have a specialized examination there. His doctor gave him just the name of the doctor, which he should visit. When Mr. Pospíchal came to hospital, he saw Smart kiosk in the hallway. Since he had never been in this hospital, he could not know where the doctor had his office. He decided to find it using Smart kiosk. He selected the option for choosing a department. Then, he chose the required doctor. In the list of doctors working in this department, he chose the

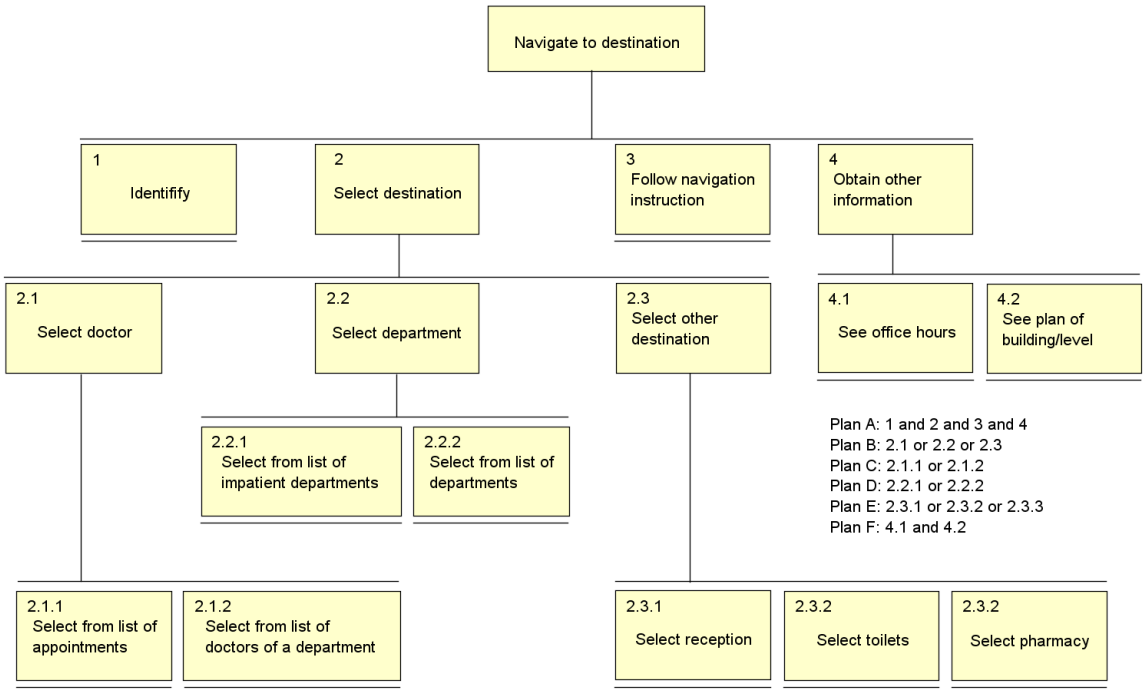

Figure 3.2: Hierarchical Task Analysis

doctor he should visit. He checked the office hours and took a look at the map of the floor, where the doctor's office was located. He read the navigation instructions and followed them to find the next terminal.

Scenario 2 (Search for an inpatient department)
Mrs. Součková came to the hospital to visit her husband who was hospitalized there. She only knew in which department he had been admitted. She decided to find where her husband is using Smart kiosk. She identified and chose the required department from the list of inpatient departments. As she always had a problem with understanding maps, she decided to follow the navigation instructions immediately.

Scenario 3 (Prepared appointment)
Mrs. Horská should visit her doctor in hospital. As she has not been there for a very long time, she knew that she would probably have a problem with finding his office. She remembered that there is a navigation system in this hospital. When she was there for the last time, the nurse at the reception gave her an advice that she can prepare her visit at home so she did it. After she came to the hospital, she identified and Smart kiosk proposed her to navigate to the doctor she wanted. She was glad that it took such a short time and she hit the road.

Scenario 4 (Search for the pharmacy)
Mr. Koukal visited his doctor in hospital. He found the doctor's office using the nav-

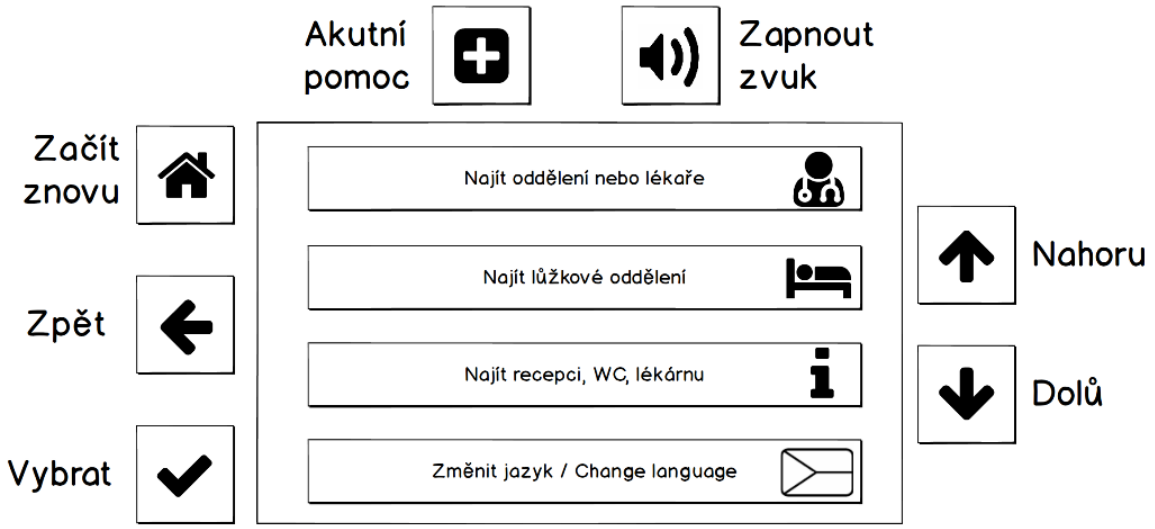

Figure 3.3: Low-Fidelity prototype for seniors

igation system. After the examination, he remembered that he received a prescription so he should go to the hospital pharmacy. He used Smart kiosk once again to find the way to it.

Scenario 5 (Emergency help)
Mr. Dočekal went to hospital to visit his doctor. He came to Smart kiosk to be navigated. Suddenly, he did not felt very well. He was scared so he decided to press the emergency button. He waited until a doctor came. The doctor examined him and fortunately, Mr. Dočekal was fine and nothing bad happened to him.

3.2 Low-Fidelity prototype

Low-Fidelity prototype was created in a paper form. The main reason was that the possible changes of user interface could be made very quickly.

According to [1], in 2015, 90% of seniors used a mobile phone. It is high percentage in comparison to the usage of other information or communication technologies, such as computers (32.1%) or tablets (1.6%). Therefore, the user interface and control of the prototype were intended to be similar to the mobile phone as much as possible.

The prototype is controlled by buttons. This type of control was chosen since most visually impaired and seniors prefer to use a phone with buttons rather than a phone with touch screen or they cannot even work with it, according to our user research. Prototype control can be seen in figure 3.3. The figure also shows the main menu after the user is identified.

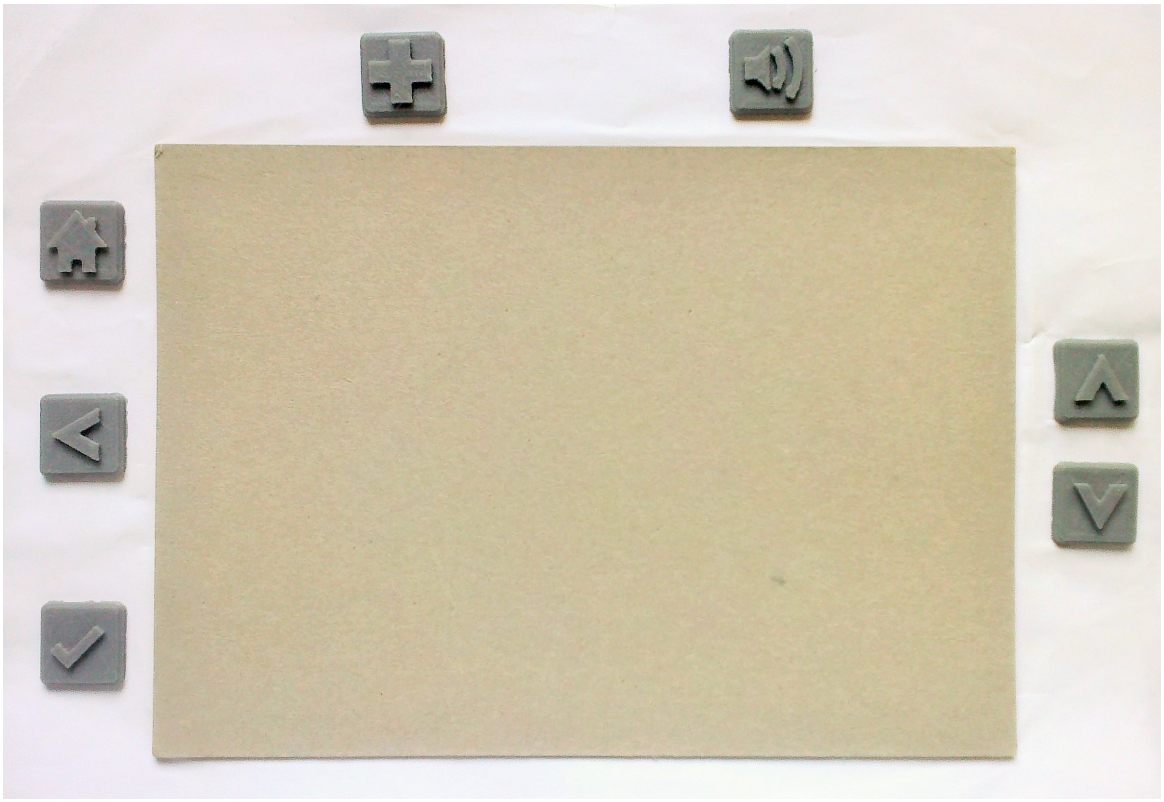

Figure 3.4: Low-Fidelity prototype for visually impaired

The prototype has seven buttons and they have the following functionality:

- Home button – start again from the main menu.
- Back button – go one step back.
- Confirmation button – confirm selected choice.
- Up button – go up in a list.
- Down button – go down in a list.
- Emergency button – call for medical help.
- Audio button – activation/deactivation of audio output.

Above the screen, there are the emergency and the audio buttons. These two buttons are considered not to be used very often. On the left side, there are the returning buttons (i.e. home and back button) and the confirmation button. On the right side of the screen, there are the up and the down buttons.

The most used buttons are considered to be the confirmation button, up button and down button. The confirmation button is on the opposite side of the the screen as the user could use both hands to control these three buttons.

The font should be big enough to be readable for the seniors. However, it highly depends on the size of the prototype screen. Moreover, sans-serif font was used since it is easier to read it than serif font [30]. This also applies to High-Fidelity prototype design.

Low-Fidelity prototype for visually impaired has different physical appearance in order that the participant could interact with the terminal. The button were printed using 3D printer (see figure 3.4). The information was provided in a form of simple audio messages that were played by the moderator according to the participant's interaction with the prototype.

The transcription of evaluation of Low-Fidelity prototype with visually impaired and seniors is can be found in section 5.1.

3.3 High-Fidelity prototype

High-Fidelity prototype of Smart kiosk was designed with respect to the findings of the usability testing of Low-Fidelity prototype (section 5.1.4). Furthermore, from the user perspective, the interaction should be similar to the final implementation of Smart kiosk as much as possible.

The prototype consists of the screen, identification device and seven buttons. Their functionality is the same as in Low-Fidelity prototype (see section 3.2). However, their position has changed according to the requirements of users. The buttons are no more above the screen. On the left side of the screen, there are the buttons that are considered not to be used very often (the emergency, audio, home and back button) whereas, on the right side, there are the most commonly used buttons (the up, down and confirmation button). The prototype can be seen in figure 3.5.

The buttons are bicoloured. Their base is gray whereas the symbols on them is bright green in order to be clearly visible. However, the cross symbol on the emergency button is red to be distinguishable from the rest of the buttons.

The text and the background on screen should be as contrasting as possible since seniors have lower contrast sensitivity, according to [30]. Therefore, the text is black and the background is either light blue or light gray. Items in menus, from which the user can select, have light blue background whereas titles and other texts have light gray background. One of the screens, namely the screen with navigation instructions, can be seen in figure 3.6.

The transcription of evaluation of High-Fidelity prototype with corresponding target audience can be found in section 5.2.

Figure 3.5: High-Fidelity prototype

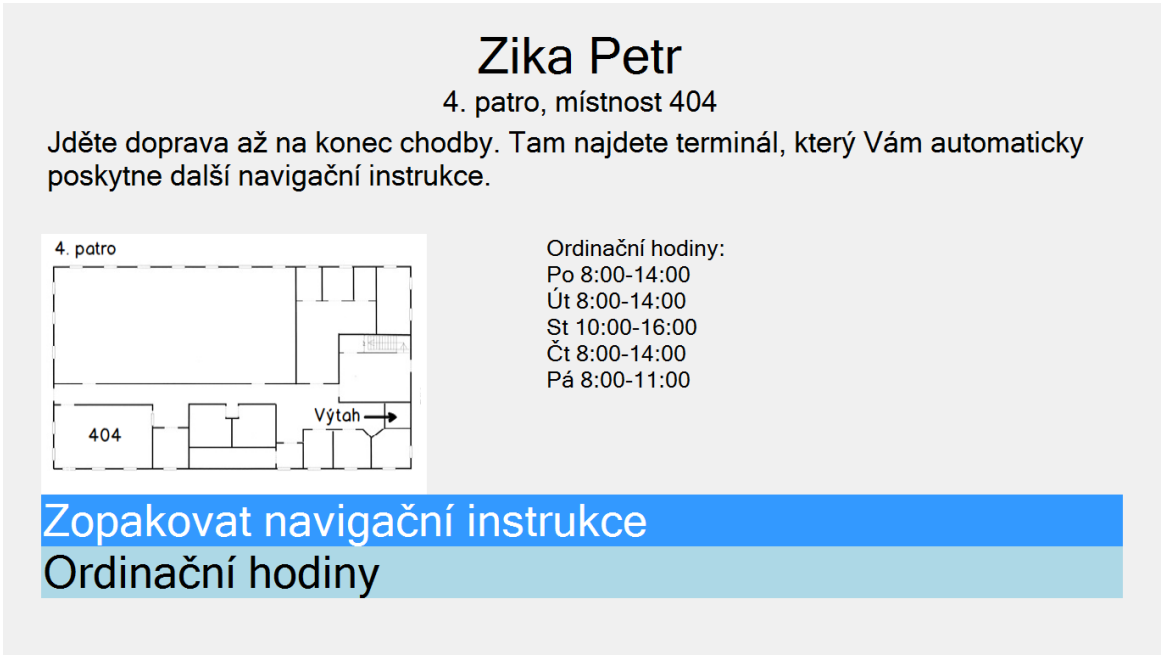

Figure 3.6: High-Fidelity prototype navigation instructions

3.4 Design summary

In this chapter, the user interface of Smart kiosk was described. Low-Fidelity prototype was designed according to the system requirements. Furthermore, the findings from the usability testing of Low-Fidelity prototype were taken into consideration when High-Fidelity prototype was designed. The evaluation of both prototypes with visually impaired and seniors is available in chapter 5.

Chapter 4

Implementation

In this chapter, the development tools user for creating Low-Fidelity and High-Fidelity prototype are discussed. Moreover, the implementation of High-Fidelity prototype is described. We pay attention to relevant aspects of the implementation and some problems which occurred during the development. Note that the implementation of Low-Fidelity prototype is not discussed there as the prototype is only the presentation of screens. It was tested in a form of paper prototype and the interaction was simulated by human. Therefore, there are no computations behind it.

4.1 Development tools

For the purposes of creating prototypes, a few development tool were used. Balsamiq Mockups [6] (version 3.3.14) was used to create Low-Fidelity prototype. This prototyping tool provides many components, such as buttons, containers or icons. Therefore, the desired user interface can be made very quickly and the possible changes can be rapidly integrated.

Low-Fidelity prototype communicates with visually impaired by audio records. They were made using open Text-To-Speech (TTS) synthesis platform Epos [8].

For development of High-Fidelity prototype, .NET framework (version 4.5) was used as the prototype can be later used as a basis of final implementation. It was also chosen since it provides class `Speech Synthesis` which can access the functionality of an installed speech synthesis engine. As Czech voices are not shipped with Windows operating system, the Epos platform was installed.

4.2 High-Fidelity prototype implementation

The prototype was implemented in C# language using `Windows Forms` class. The prototype works on the basis of finite state machine – i.e. upon user's selection, it jumps from a state to another by following the given transition. Every time the transition is made, particular components are adjusted to the new content of the screen. More detailed description of the implementation follows.

4.2.1 User interface controls

The High-Fidelity prototype consists of one window`Form`. Its content changes according to the data to be displayed. The most significant control which have been used is definitely `ListBox`. It shows the items which could be selected in various menus. Its height changes according to the number of items to be displayed. Besides `ListBox`, other controls were used, such as `Labels` to display various captions or `PictureBox` to show the map of a level.

The hardware buttons are mapped to the keyboard letters so when they are pressed, the overridden method `ProcessDialogKey` is called. The identification process is simulated in a similar way. When a card is inserted into the slot, the button inside is pressed and the identification process is simulated. In the final implementation, the data from insurance card should be read using Optical Character Recognition (OCR) approach [37]. Some systems employing this approach already exists (see for instance [25]).

4.2.2 XML files

Data displayed on particular screens is stored in XML files. Moreover, the files also partially describe the user interface. Each file contains a parameter which defines how the data should be displayed. Thus, the parameter classifies screens into several categories. All the screens in one category are to be displayed using the same controls with the same properties.

When the item from the menu is selected, the XML file provides the corresponding screen to be displayed. Current language of user interface is also taken into consideration to select the desired language version of the file.

4.2.3 Text-To-speech system

The audio output was generated using the `Speech Synthesis` class. This class provides access to the functionality of the installed speech synthesis engine. Czech voices are not shipped with Windows operating system so the Epos platform was installed. Czech female voice *violka* from Text-To-Speech system Epos was used. Since the prototype is also available in English version, one of the Microsoft Text-To-Speech voices provided with Windows is used, namely female voice *Microsoft Hazel Desktop*. If this voice is not available, the first voice from the list of installed voices is used.

The contents of some screens can be also different when audio output is activated/deactivated, as it can be seen in figures 4.1 and 4.2. Some buttons, such as "Repeat the functionality of buttons" do not make sense in case the audio output is not activated. Therefore, when displaying new contents of the screen, it has to be taken into account whether audio is activated or deactivated.

4.3 Implementation summary

In this chapter, the development tools used for creating Low-Fidelity and High-Fidelity prototype were discussed. Moreover, the implementation of High-Fidelity prototype was described. We paid attention to relevant aspects of the implementation and some problems occurred during the development.

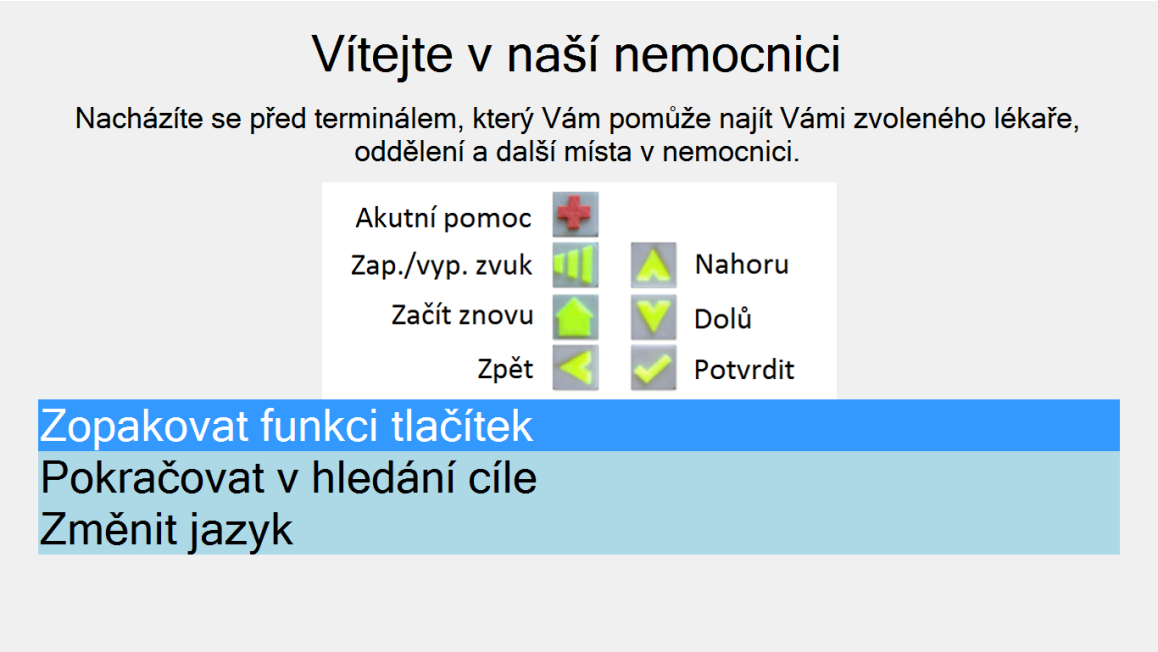

Figure 4.1: Initial screen when audio is activated

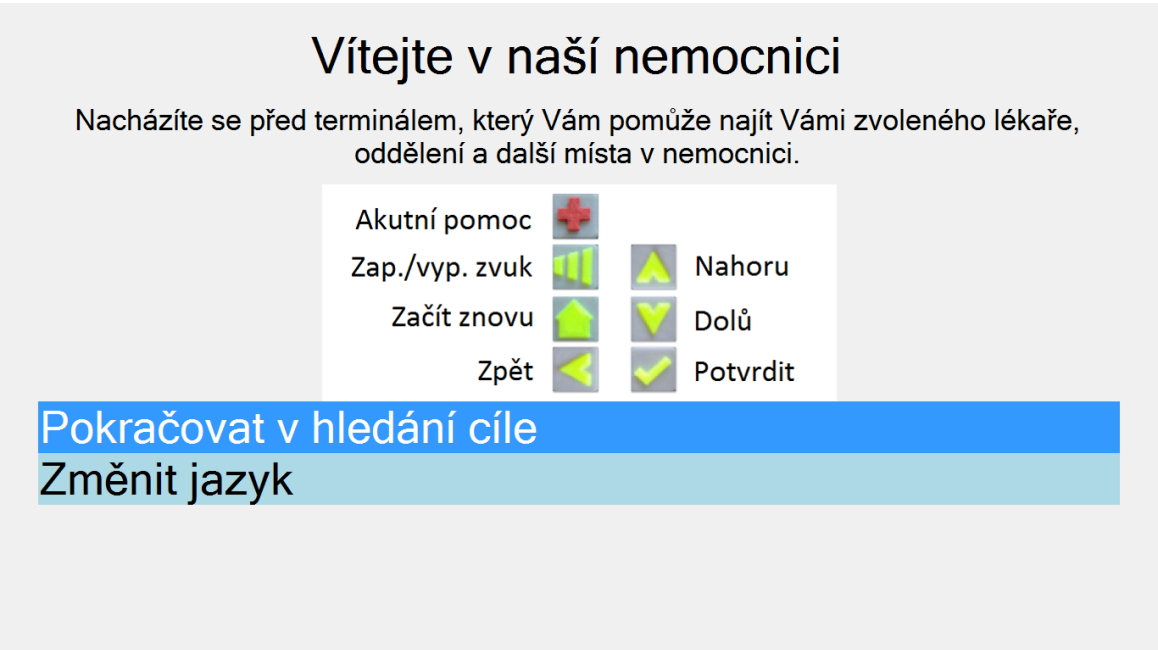

Figure 4.2: Initial screen when audio is deactivated

Although the High-Fidelity prototype of Smart kiosk was implemented, it was not integrated into the navigation system as the background of the system have not been implemented yet. However, the information exchange among specific terminals was discussed and Smart kiosk is prepared to be integrated as soon as the background of the system will be implemented and all the parts of the system will be created.

Chapter 5

Evaluation

This chapter focuses on usability testing of Low-Fidelity and High-Fidelity prototypes. For each prototype, the main objectives of testing are mentioned. Furthermore, the tests execution is described. Problems occurred during the testing are listed and summarized, and their possible solution is proposed.

5.1 Low-Fidelity prototype evaluation

The main objective of the testing was to determine how participants interact with the prototype of Smart kiosk. We wanted to know if the meaning of the buttons and the terminology were understandable. Furthermore, we wanted to know if participants would prefer different positioning of the buttons. We tested whether the speed of recording for visually impaired suits them and whether they would prefer to use headphones. Moreover, the font and size of the components were also tested.

5.1.1 Usability testing execution

The prototype was tested with three visually impaired (PVL1-PVL3) and three seniors (PSL1-PSL3). Note that the visually impaired and seniors who attended the usability tests of all prototypes will be simply called visually impaired and seniors.

Similarly to the interviews, visually impaired of categories 4 (near-total visual impairment) and 5 (total visual impairment) [39] were interviewed. The user study was performed both with visually impaired who are blind from birth (congenitally blind) and who lost their sight later (late blind). Seniors from cities and countryside were interviewed.

Problems found during the usability testing of all prototypes were classified into three severity levels.

- *Critical* – prevents user from completing the task.
- *Serious* – delays user significantly, but eventually allows them to complete the task.
- *Minor* – delays user briefly or confuses them.

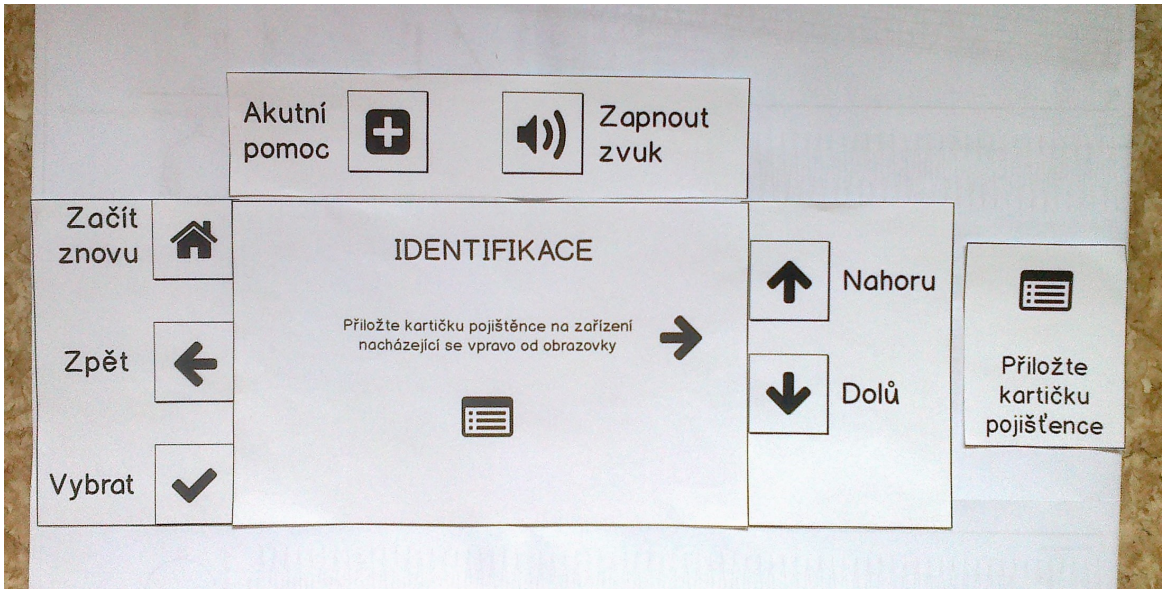

Figure 5.1: Set-up for seniors usability testing

Visually impaired tried to solve first three of five tasks described by scenarios from section 3.1.3. At first, they were asked to examine the buttons by touch. If they did not understand their meaning, they were told what the buttons meant. Seniors were asked to solve all five tasks corresponding with the scenarios. Unlike visually impaired, they also tested the identification process. Test set-up for seniors can seen in figure 5.1.

Before starting a testing session, the project was briefly introduced. The prototype was tested in a paper form. Thus, participants were informed that the interaction between them and the system would be simulated by the moderator. They were also asked to "think aloud" (i.e. they should have told us every thought out loud regardless it is positive or negative). Finally, they were assured that they were not tested, but the prototype was, and their opinion is very important for us. After all tasks were completed, problems occurred during the testing were discussed and potential questions were answered. The transcription of usability testing is available in appendix D.

5.1.2 Evaluation with visually impaired

The evaluation of Low-Fidelity prototype was conducted with three visually impaired (one male, two female, average age = 53). During the testing no critical and minor problems were detected. However, one serious problem was discovered:

- The navigation instructions are long and cannot be repeated using a single button. The only possible way is to go back and select the destination again (PVL1, PVL2, PVL3).

The possible solution of the problem is proposed in section 5.1.4.

5.1.3 Evaluation with seniors

Three seniors (two male, one female, average age = 67) were tested. No critical problem was appeared during the testing of Low-Fidelity prototype. Nevertheless, some serious problems were detected:

- The button for changing language on the initial screen is confusing (PSL1, PSL2).
- The meaning of the audio button can be misinterpreted (PSL1, PSL2).
- The user is not well informed about the emergency button (PSL1).

Few minor problems were also discovered:

- The position of buttons above screen is strange and confusing (PSL3).
- The picture of Simple navigation terminal on the screen with navigation instructions is confusing (PSL3).

The possible solution to the discovered problems during the testing with seniors is mentioned in section 5.1.4.

5.1.4 Prototype testing summary

Although all participants were able to completed all tasks without any help of moderator, there were few problems detected during the testing.

Visually impaired wanted to have some button to repeat the navigation instructions. However, they were able to obtain the information again by using back button and selecting the destination again. Nevertheless, we should consider to add the repeat button on the screen with navigation instructions.
Visually impaired were satisfied with the speed of records. Some of them are used to the higher rate, but they did not think they needed to change it as they would not use the terminal every day. Some of them would also prefer to use headphones due to the privacy and possible noise. They were also not able to recognize the meaning of buttons by touch. Some of them recognized only the up and down arrows. Therefore, the Smart kiosk has to inform them about the meaning of buttons.

The button for changing the language on the identification screen was surprising for two seniors. They thought they had to press it as it was the only button on the screen. Thus, we should consider to remove it from this screen. One participant did not notice the emergency button. It should be clearly visible in the next prototype. Another participant did not understand why there is a picture of Simple navigation terminal on the screen with navigation instructions.

The font and size of the components were sufficient for seniors even though the size of prototype was smaller than the size of future terminal is considered to be. They understood the meaning of buttons according to the text description of them. The only problematic one was the audio button. Its meaning was misinterpreted by one participant as a button to call some department/doctor. Therefore, we should think about different name. One participant also thought that the position of buttons above the screen is strange. We should consider to place the buttons on left and rights side of the screen only.

5.2 High-Fidelity prototype evaluation

The main objective of the usability testing was to determine how participants interact with the prototype of Smart kiosk and whether the problems occurred during the testing of Low-Fidelity prototype were resolved correctly.

We wanted to know if the meaning of the buttons and the terminology were understandable. The testing also included the identification using the insurance card. We also tested whether the audio rate is suitable for the visually impaired and whether they would prefer to use headphones. Furthermore, we wanted to know if they would appreciate the repeat button (i.e. the button which would repeat the content of a screen). The font and size of the components were tested with the seniors. Since the audio output is intended to be activated by default, we wanted to know whether it would be disturbing for them.

5.2.1 Usability testing execution

The prototype was tested with seven visually impaired (PVH1-PVH7) and six seniors (PSH1-PSH6). Similarly to the interviews, visually impaired of categories 4 (near-total visual impairment) and 5 (total visual impairment) [39] were interviewed. The user study was performed with visually impaired who are blind from birth (congenitally blind) and who lost their sight later (late blind). We also wanted to know whether they can read Braille or not as we were considering to add some Braille labels with the description of buttons to the terminal. Seniors from both cities and countryside were interviewed as they might have a different character.

Note that the user interface of the prototype was changed after the testing with visually impaired according to the problems occurred during it. However, the physical appearance remained the same. Thus, new version of High-Fidelity prototype was tested with seniors in order that the same problems would not appear again. Moreover, the changes that visually impaired required could be tested with seniors immediately.

Similarly to the testing of Low-Fidelity prototype, problems found during the usability testing of High-Fidelity were classified into three severity levels, i.e. critical, serious and minor (see section 5.1.1).

The participants were asked to solve five tasks corresponding with the five scenarios from section 3.1.3. In figure 5.3, test set-up can be seen. Apart from the prototype of Smart kiosk (middle), prototypes of Web portal (left) and Waiting room kiosk (right) were tested.

Before starting a testing session, the project was introduced. Participants were informed that it was the prototype testing. They were also asked to "think aloud" (i.e. they should have

Figure 5.2: High-Fidelity prototype initial screen

Figure 5.3: High-Fidelity prototype testing

told us every thought out loud regardless it is positive or negative). They were assured that they were not tested, but the prototype was, and their opinion is very important for us. After all tasks were completed, problems occurred during the testing were discussed. Moreover, the potential questions of participants were answered. The transcription of usability testing is available in appendix E.

5.2.2 Evaluation with visually impaired

Seven visually impaired (two male, five female, average age = 36) participated in the usability testing of High-Fidelity prototype. As a result, one critical problem occurred:

- The user is not well informed about the emergency button (PVH2).

During the testing with visually impaired, few serious problems were also detected:

- The description of the confirmation button is not clear (PVH4, PVH5, PVH6).
- The user would like to return to the initial screen to receive the instructions about buttons again (PVH1, PVH6).
- The user would like to know that after receiving the navigation instructions, they can leave the terminal and will be logged out (PVH1, PVH7) or they would like to use some button on screen with the navigation instructions to inform the terminal they are leaving it (PVH3, PVH5, PVH6).
- The user may want to know something about the system to understand the navigation instructions better (PVH1).

Other problems have been categorized as minor. Their list follows:

- The message which appears after the emergency button is pressed is not clear (PVH5).
- The user does not know when the identification card can be removed (PVH1).
- The location of the button for selecting language is confusing as it is in the main menu instead of on the initial screen (PVH1, PVH5).
- The user is not informed whether the identification was successful or not (PVH1, PVH3, PVH7).
- There is not a specific button to stop current audio message (PVH3, PVH5).
- The user would appreciate some message when the audio is activated/deactivated (PVH1).
- The emergency button is considered to be useless (PVH7).

- The user would appreciate if the meaning of buttons was repeated at the initial screen instead of the whole initial message (PVH3, PVH5).
- It is strange that the audio output is activated by default (PVH7).

The potential solution to the discovered problems is described in section 5.2.4.

5.2.3 Evaluation with seniors

The evaluation of High-Fidelity prototype was performed with six seniors (two male, four female, average age = 71). During the testing with one of them, a critical problem occurred:

- The user is not well informed about the emergency button (PSH5).

Several serious problems were detected during the evaluation of High-Fidelity prototype by seniors:

- The emergency button can be pressed only because it is the first button on the top left (PSH4, PSH5, PSH6).
- Name "Doctor's offices" for navigation to the part of a department where doctor's offices are could be misinterpreted as the list of doctors would follow (PSH3, PSH6).
- The user does not know that after receiving the navigation instructions, they can leave the terminal (PSH2).
- The meaning of the confirmation button is not clear (PSH2, PSH4, PSH5, PSH6).
- The symbol on home button can be misinterpreted as an arrow (PSH2).
- The user does not know why the identification is important (PSH1, PSH2, PSH6).
- The meaning of the map at the screen with the navigation instructions can be misinterpreted (PSH1, PSH2, PSH3, PSH6).
- The meaning of home button is not clear by name (PSH6).
- It is very disturbing that the audio button is activated by default (PSH6).

Two minor problems were also discovered:

- Text describing the route to the next terminal should be below the office hours (PSH1).
- Audio output can be disturbing (PSH6).

5.2.4 Prototype testing summary

Almost all participants were able to complete all tasks. However, the problematic task was to call the emergency help. Some participants were not able to remember that there is the emergency button on the prototype and tried to find the emergency help in the main menu. Moreover, some seniors pressed the emergency button only because it is the first button on the top left. Therefore, the emergency button should be separated from the rest of the buttons.

The description of the confirmation button should be changed as it was slightly confusing for some visually impaired. Few of them also wanted to return to the initial screen to receive the instructions about the buttons again, but the prototype did not allow to do it. Moreover, they would have appreciated if the meaning of buttons could have been repeated at the initial screen instead of the whole initial message.

Some of the visually impaired did not know whether they could leave the terminal after receiving the navigation instructions and would be logged out. Thus, they should be informed about it. The message which appears after the emergency button is pressed was not clear for one participant. Moreover, the way how to cancel the emergency help was not very good according to other participant.

Visually impaired wanted to be informed whether the identification was successful and when the identification card can be removed. Furthermore, the location of the button for selecting language is confusing as it is in the main menu instead of on the initial screen. The participants would have also appreciated some message signalizing the audio output was activated/deactivated and some sound signalizing the beginning/end of a list was reached.

Visually impaired were satisfied with the speed of records. Some of them are used to the higher rate, but they did not think they would have changed it since they would not use the kiosk every day. They would also prefer to use headphones due to the privacy and possible noise. They were not able to recognize the meaning of buttons by touch. Therefore, they have to listen to the initial instructions where their meaning was explained. Only few of them would have also appreciated the braille labels describing the buttons on the terminal.

The meaning of the map at the screen with the navigation instructions was misinterpreted by some seniors. Therefore, both map of floor where the Smart kiosk is and where the destination is should be displayed.

One senior was not sure if the terminal should have been left after receiving the navigation instructions. Two seniors also thought the button "Doctor's offices" meant the list of doctors follows. In fact, it should be used for navigation to the part of a department where doctor's offices are. Thus, the name of the button should be changed.

Many seniors did not identified although they were told their visit had been prepared. Therefore, the list of prepared visit was not available for them and they had to look for the destination in the main menu. The user should be informed why the identification is important.

The font and size of the components were sufficient for the seniors. Some of them were also able to read the text without wearing their reading glasses. Some of them did not understand the meaning of all buttons. The meaning of the home button was not clear for one participant according to its name and one participant misinterpreted the symbol on

home button as an arrow. Moreover, the meaning of the confirmation button was not clear for some seniors according to the symbol on it. Thus, the symbols on home and confirmation buttons should be changed.

5.3 Evaluation summary

In the previous sections, Low-Fidelity and High-Fidelity prototypes were evaluated. Many changes proposed in sections 5.2.2 and 5.2.3 have been already integrated into the design. However, some changes are to be integrated yet. In the following section, these changes are summarized. The next section focuses on the users' requirements which were not accepted for some reason .

5.3.1 Proposed changes to design

The biggest problems during the testing were caused by the emergency button. Some participants did not remember that there is the hardware button and tried to find it in the main menu. Other participants also did not remember the meaning of all buttons and press the emergency button just because it is the first button on the top left. Thus, the emergency button should be probably separated from the rest of the buttons or placed out of the terminal (for instance, on the wall next to the terminal).

The terminal should definitely provide headphone output. Even under the laboratory conditions, most of the participant could not imagine they should use it in the hospital because of the privacy and possible noise.

Many seniors from the usability testing could not recognize the buttons according to the symbols on them. Moreover, the visually impaired could not recognize them by touch. Thus, we should not rely on the symbols, but on the description on them. There should be labels directly on the terminal as the picture on screen describing them was confusing for seniors. The visually impaired were satisfied with the audio description of them. The Braille labels might be added although they would not required by visually impaired from our usability testing.

Many participant thought they could be better informed about what was happening. They would appreciate to be informed when the insurance card could be removed, whether the identification was successful, when they could leave the terminal and whether they would be logged out. Sometimes, the lack of information caused the problems with solving the task. The user could choose not to identify in case the visit was not prepared. However, the users were not informed why the identification is important and some of them did not identify even though they had the visit prepared and could not benefit from it. Therefore, the users must be informed about these things.

The understanding of the navigation instructions could not be deeply tested as the usability tests were performed under the laboratory conditions. Nonetheless, some problems occurred. The map of the floor with the final destination was misinterpreted as the map of the floor with the terminal. Moreover, some participant would not follow the instructions to the next terminal, but they would only follow the map. Thus, the user have to be better informed

he/she should follow the instructions and the map provides only some complementary information. Nevertheless, the understanding of the navigation instructions will be better tested during the usability tests performed out of the laboratory.

5.3.2 Not accepted requirements

Although we wanted to fulfill user's needs and preferences as much as possible, we have decided not to integrated some of their requirements. The reason was either the incompatibility with the current solution or the fact that we need to hear the opinion of other possible users.

Two visually impaired would appreciated if the would be a hardware button to stop the current audio message. We have decided not to add this button since it would not make sense if the audio would be deactivated and it could confuse other users. Each audio message can be interrupted by performing an action (i.e. by pressing any button). Almost all the user noticed it (including these two participants) so they could work with the terminal quite effectively.

One visually impaired participant requested to be informed about how the system works. As the interaction with Smart kiosk would be very prolonged and other users might not appreciate it, we have decided these information could be available on the Web portal where everyone can access them.

Another participant suggested to remove the emergency button as in his opinion, it is completely useless. As we disagree with this opinion, we have decided not to remove it. Even if a single person would benefit from the button, it is definitely useful.

During the usability testing, some participants were not satisfied with the fact that the audio output was activated by default. It is intended to be activated in order that the visually impaired would not have to search for the audio button to activate it when they came to the terminal. On the other hand, the activated audio output could surprise or even discourage potential users. Therefore, we leave the question of activated/deactivated audio open until other usability testing.

Chapter 6

Conclusion

The goal of this thesis was to design and implement Smart kiosk – the main terminal of the indoor navigation system currently developing at our university. The system focuses on the navigation in hospitals and is designed for visually impaired and seniors.

The development of Smart kiosk consisted of several steps. These steps correspond to the objectives to be accomplished within the scope of this thesis. The list of these goals follows together with the description of how they were accomplished:

1. Discuss existing approaches for navigation and orientation.

   The existing approaches for navigation and orientation were discussed in section 2.2. We focused on the systems which could be used for the hospital navigation and/or are tailored to our target user audience. These systems were also compared from different perspectives. As a result, we can say that none of the systems is entirely suitable for our target user audience. Thus, we have decided to design our own navigation system tailored to both visually impaired and seniors.

2. Analyze the current status of our navigation system.

   The indoor navigation system being developed at our university was introduced in section 2.4. Our approach to indoor navigation was discussed and specific parts of the navigation system were described. Furthermore, the current status of the system was described while considering the development of Smart kiosk as its important component.

3. Discuss the information exchange between navigation system terminals and users.

   The information exchange between navigation system terminals and users was discussed in section 2.4.3. Furthermore, information exchange between particular terminals and system backend was described as well.

4. Perform the user study with corresponding target user audience – i.e. visually impaired and seniors.

   The qualitative user study was performed with five visually impaired and five seniors in a form of interviews. The whole process of execution of the user study is described in section 2.5. Moreover, the transcription of the interviews is available in appendix C in order that the data could be used in future. Since the interviews were focused on the hospital visits as well as the navigation in public buildings, the data can be used for further development of all parts of the system.

5. Define system requirements according to needs and preferences of target user audience.

   The requirements of target user audience are summarized in section 2.5.4. They were gathered during the interviews. These requirements were be also taken into account when defining the system requirements (see section 2.6).

6. Design Low-Fidelity and High-Fidelity prototypes with respect to user requirements.

   The design of the prototypes is described in chapter 3. At first, the user interface of Smart kiosk is described. Then, the prototypes are designed according to the system requirements which also include user requirements gathered during the interviews. Furthermore, the High-Fidelity prototype was influenced by the findings from the usability testing of Low-Fidelity prototype.

7. Describe the implementation of particular prototypes.

   The implementation of prototypes is discussed in chapter 4. First, the development tools used for creating the prototypes are mentioned. Next, the implementation of High-Fidelity prototype was described in detail. We focused on relevant aspects of the implementation and problems occurred during the development.

8. Integrate the implementation of Smart kiosk into the navigation system.

   Although the High-Fidelity prototype of Smart kiosk was implemented within the scope of this thesis, it was not integrated into the navigation system as the background of the system have not been implemented yet. However, the information exchange among specific terminals was discussed and Smart kiosk is prepared to be integrated as soon as the background of the system will be implemented and all the parts of the system will be created.

9. Evaluate the prototypes with corresponding target user audience.

   The prototypes were evaluated with both visually impaired and seniors (see chapter 5). Low-Fidelity prototype was tested with three visually impaired and three seniors whereas High-Fidelity prototype was tested with seven visually impaired and six seniors. The problems occurred during the testing were listed and their solution was proposed. Moreover, the changes to design were proposed in order to be integrated into the final design of the system.

The navigation system including Smart kiosk described in this thesis is being developed using User-Centered Design methodology [2]. Therefore, the user requirements were taken into account in each phase of the development of Smart kiosk. First, the user study was performed to understand needs and preferences of our target user audience. Their requirements were taken into account when defining the system requirements and were reflected in the design of the prototypes. Next, the prototypes were evaluated with the target used audience and the problems occurred during the evaluation were taken into consideration when another prototype was designed. Thus, the final prototype was significantly influenced by the users' needs and preferences. The evaluation of system showed its usability for both visually impaired and seniors.

6.1 Future work

In the future, the recommendations to the design proposed in section 5.3 should be taken into account and integrated into the design of next system prototype. The final implementation should be made as well as other parts of the system. After the background of the the system is created, the Smart kiosk should be integrated with it.

The usability testing of the prototypes were conducted under laboratory conditions. Therefore, the system is intended to be deployed to perform the testing in the field, probably in the building of our faculty. After finalizing the system, it will be hopefully deployed in some hospital in order to bring benefits to the hospital visitors.

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Appendix A

Screener

The screener was used to hire seniors to the user study. At each answer, there is a number of participant attended the user study.

Gender

- Male [3]
- Female [2]

Age

- under 60 years [0]
- 60-70 years [2]
- 70-80 years [2]
- 80 and over [1]

Do you work?

- Yes [0]
- No [5]

Are you retired?

- Yes [5]
- No [0]

Where do you live?

- In the country [2]
- In the city [3]

Are you visually impaired

- Yes [0]
- No [5]

Are you a wheelchair user?

- Yes [0]
- No [5]

How often do you visit a doctor?

- Few times per month [2]
- Few times per year [3]
- Less often [0]

Do you have an accompaniment when you go to a doctor?

- Yes [1]
- No [4]

What do you use your mobile phone for?

- I do not use it [0]
- Phone calls [2]
- Phone calls and SMS [3]
- Phone calls, SMS and other functions [0]

Appendix B

Interviews – questions

Orientation at unknown places

- How do you orient at an unknown place / in an unknown building?
- What are your experiences with it?
- What are you doing when you cannot find your way?
- How do you feel when you cannot find your way?
- How do you prepare in advance if you know you will go to an unknown place?

Before the visit of a doctor

- How does your daily routine look like when you are to visit a doctor?
- How do you fell this day?
- What kind of transport do you use when you go to a doctor?
- How do you make an appointment to a doctor?
- Do someone accompany you? Who? How often?
- Do you usually visit the doctors at the same health centre?

Visit of hospital

- How often do you visit a doctor?
- What do you do when you enter the hospital building?
- Do you have some issues with the way through the hospital building?
- What do you do when your doctor sends you to another doctor / to different health centre?

- What are your experiences with the hospital staff?
- Have you ever change your doctor to another one? If so, then why?
- What services do you use at hospitals except from health services?

Technologies (in hospital/in public buildings)

- What are your experiences with electronic devices for hospital visitors / public building visitors? (Note: If participant did not know, what was meant by the question, give them an example -– electronic waiting list, electronic information kiosk etc.)
- Please, describe how you used it.
- What do you think about this technology?
- What discourage you from using it?
- Did someone help you with using this device?

Technologies (in general)

- What kind of mobile phone do you have?
- What are you use it for?
- Have you got a computer?
- What are you use it for?
- What are your experiences with the devices with touch screen?
- What do you think about this king of control?

Appendix C

Interviews

Visually impaired

PVI1

Female, age – 66, category of impairment – 4, onset – late blind

Orientation at unknown places
When she comes to the unknown building, she asks for help at the reception. She wants to know only the beginning of the route and then she asks passers-by to tell her the continuation of the route. Her experiences with this strategy differs. In Budějovická health centre, this strategy works. On the other hand, in Motol University Hospital it does not work as it is a big hospital complex.
When she knew that she will have to go to an unknown building, she tried to use the services of the navigation centre for visually impaired people. Sometimes, they were able to help her, e.g. with the navigation in Motol University Hospital (from one building to another one). However, they cannot help her with the indoor navigation since they have no plans of the building. Therefore, she prefers to use the services of an assistant.
When she gets lost, she asks passers-by. She does not ask the staff as they are usually not available or have not enough time to help her. This kind of situation is not stressful for her, because she tries to solve this problem using the common sense and the information about the route she remembers. She is able to return to the specific part of the building according to some sound or contrast colour of the wall. She also does not hesitate to ask passers-by.

Before the visit of a doctor
When she has to visit a doctor, she is not nervous. She uses the mobile phone to make an appointment. To visit a doctor without an appointment is usually not possible in Prague in her opinion.
She uses the public transport to visit a doctor, but her husband usually accompanies her to distant places (in different towns) so they travel by car.
She visits almost all the doctors she needs in the health centre near her place of residence.

Visit of hospital
She visits a doctor approximately once per month. It is not usually a problem for her to find the way in a building, but to find the way to the building. The first problem is not to be hit down by a car at the car park as it is sometimes near the main entrance of the hospital. Then there is no aid for visually impaired people to find the way to another building of the hospital complex.
When a doctor sends her to another doctor, the nurse usually accompanies her. When it is in another health centre, she gets the address of the building and find the way by herself.
Her experiences with the staff of a hospital are not very positive. Although they want to help her with the navigation, they usually do not know how. They do not even know the basic navigation techniques for visually impaired people ("some basic education would be good, but there is no money for it").
She changed her doctor for another one once because of the bad accessibility his office.
She also uses other services connected to the health care in hospital (e.g. chemist's).

Technologies (in hospital/in public buildings)
She has a negative experience with the electronic waiting list. She usually does not know that there is such a machine. If she knew it, she would not be able to use it as there is no audio output (or another kind of output suitable for visually impaired people). Thus, she just notifies the nurse of her presence and does not use it. "I relies on the people."
Other devices, such as electronic signs, can sometimes interact with the transmitter for visually impaired, but she does not use them since it would take a long time to find them and ask the passers-by is much quicker.

Technologies (in general)
She uses a mobile phone to make phone calls, send SMS and listen to the music. She also writes some notes although she prefers paper notebooks. She does not use it for outdoor navigation ("it is not good for visually impaired people").
She also owns a computer. She browses the Internet, writes emails, listen to the music and audio books.
She attend a workshop about the devices with touch screen. She is going to buy a new mobile phone ("probably with touch screen"), but she still prefers buttons to touch screen.

PVI2

Male, age – 37, category of impairment – 4, onset – late blind

Orientation at unknown places
When he enters the unknown building, he asks at the reception or passers-by. He has positive experiences with the passers-by as they usually want to help him. He has mostly negative experiences with aids for visually impaired people, namely with guiding lines at the post office because they led to the counter filled with concrete. In this situation, he feels a little bit annoyed and he thinks that guiding lines should be updated.
When he knows that he will go to an unknown building, he does not prepare in advance. The only thing he need to know is the address of the building. When he gets lost, he asks

passers-by. When there is nobody to help him, he does not wait until someone comes, but he just tries to use some way and find someone. It usually happens when he wants to return somewhere and he does not remember the way. It has happened to him recently when he find himself in the courtyard. "Fortunately, there was a lady smoking and she help me to return the entrance hall."

Before the visit of a doctor
When he has to visit a doctor, he is not nervous at all. He uses the mobile phone to make an appointment or he arrange the next appointment directly with the doctor's office. He prefers to make an appointment as he usually does not have to wait. He remembers that he had to wait once when the doctor had longer lunch break than he should have. However, the waiting did not bother him.
He uses the public transport to visit a doctor. He prefers to go earlier instead of using faster way, where he would have to change the train/bus. He needed the assistance of his family in the past two or three years. He does not need someone to accompany him nowadays as he has more experiences with the navigation. He never thought about using the assistant for visually impaired people.
His doctors have their offices at different places. It does not bother him. He has not changed them since he has been visually impaired.

Visit of hospital
He visits doctors approximately few times per year. He does not usually go to unknown places so he does not have to ask for help with the navigation. He was in some unknown building few months ago. Nobody was there so he had to find the office he needed intuitively. "Fortunately, I succeeded."
The way through the hospital building is not a problem for him. He expects some obstacles at the corridors so he is very careful.
When a doctor sends him to another doctor, the nurse usually accompanies him. When it is in another building, he gets the address of the building and some description of the way which is usually not suitable for visually impaired people. Thus, he finds the way by himself. He has visited another doctor recently when he had a broken leg. When he came there, the nurse told him that the doctor had a holiday. "It was really difficult for me to solve this situation with the broken leg. Thus, I prefer to call the ambulance now".
The staff of a hospital always want to help him with the navigation, but they usually do not know how. They do not know the basic navigation techniques for visually impaired people. However, he is satisfied with the health care.
He also uses other services connected in hospital (chemist's and the swimming pool).

Technologies (in hospital/in public buildings)
He does not use the electronic waiting list. He used it when he was in China with the assistance of his mother. In the Czech Republic, he does not even know that there is such a machine. He just asks who is the last and/or he notifies the nurse of his presence. Then they usually take him in advance even though he does not want to overtake anyone.
He has also experiences with electronic signs at the railway stations. He cannot use them as it is not compatible with the transmitter for visually impaired.

Technologies (in general)
He has got a mobile phone with audio output. He uses it to make phone calls and send SMS. He owns a computer. He browses the Internet and writes emails. He uses a software to convert the content of web pages to audio form. The only problem is that it usually converts the adverts too. Thus he prefers to copy the text to a word processor and then convert it.
He attend a workshop about the devices with touch screen. He does not prefer this kind of control. "But I realize that the world is going forward and it will be necessary to use it and I hope that there will be more suitable software for visually impaired people in future."

PVI3

Female, age – 30, category of impairment – 4, onset – congenitally blind

Orientation at unknown places
In the unknown buildings, she asks passers-by and at the reception. She uses the guiding lines and the transmitter for visually impaired, but not at hospitals as she never meet with them there.
When she knows that she will have go to an unknown building, she usually prepares in advance. She asks people about who she thinks they know that building. Moreover, she uses an application for planning the route (she also wants to know the distances). However, when she has some health issue, she does not want to solve problems with the navigation so she prefers someone to accompany her.
When she gets lost, she asks passers-by. When there is not anybody to help her she tries to return to the place where she knows it. It is not very pleasant for her, but she take it into account in advance.

Before the visit of a doctor
When she has to visit a doctor, she is not nervous. However, when she needs to visit her ophthalmologist, she is a little bit annoyed. She knows that she will spend there whole day even though she has made the appointment.
She uses a mobile phone to make an appointment and she travels by public transport or by car (with some family member). She prefers to make it.
She usually visits doctors on her own, but sometimes she needs the assistance of family. However, she does not need assistance for the outdoor navigation (even if it is an unknown place) as she uses the application called BlindSquare (she uses various filters) in combination with Google Maps.
Almost all her doctors have their offices in the health centre close to her place of residence.

Visit of hospital
She visits doctors only few times per year. However, this year it is more often as she is pregnant.
When she enters the hospital building she usually remembers the way from the previous visit. If it is an unknown place, she tries to find a reception. To travel from one building to another, she is able use the outdoor navigation system at her mobile phone. Also the fact that she is partially sighted helps her a lot.

She is very careful at the corridors in hospitals as there are chairs, flowers, open doors etc. The problem are also the hanging signs as they cannot be detected with the white cane.
When her doctor sends her to another office, she asks the nurse usually accompanies her. If they talk about it in the waiting room, sometimes happens that someone from patients wants to help her without her asking. When it is at some different place, she gets the address and the description of the way from the doctor. When she knows that the doctor is busy and has not time to give her these instructions, she has no problem to find the information by herself. "He would suffer and I would suffer too." Nevertheless, if the visit was at the same day, she would phone someone from her family to help her.
The staff of a hospital really wants to help her with the navigation, but they usually do not know how. They do not know the basic navigation techniques for visually impaired and how to communicate with them.

Technologies (in hospital/in public buildings)
She does not to use the electronic waiting list. She does not want to overtake anyone, but she is unable to use such a machine. Sometimes the people waiting here wants to help her, but she prefers not to use it as she would have to know her number and ask all the time who is next. So she has no motivation to use it, but she thinks she would use if it would be tailored to visually impaired too.

Technologies (in general)
She has got the iPhone (with voice over integrated). She use the Internet, emails, Skype, Internet banking, navigation and the common functions (phoning, SMS).
She also have a computer. She use it almost for the same purposes as her mobile phone. "I use computer at home and iPhone outdoors."
She like the devices with touch screen. When she worked with it for the first time, she was impressed by its functionality. "I cannot imagine to work with mobile phone with buttons any more."

PVI4

Female, age – 68, category of impairment – 5, onset – late blind

Orientation at unknown places
When she is in the unknown building, she passers-by. Her guide dog helps her to find the safe way.
She has positive experiences with the passers-by. They usually want to help her. However, in her opinion, there are no aids for visually impaired at hospitals (guiding lines etc.).
When she knows that he will have to go to an unknown building, she always prepares in advance. She asks friends to find her the way and then she writes the description of the way in Braille (or sometimes she records it on her voice recorder). She would like to have some information at website of the hospital (what is in particular floors).
When she lost, she asks passers-by. She does not feel pleasant, but she is not in stress. She cannot imagine the situation that there is nobody. "It would be a very big problem."

Before the visit of a doctor
She does not need to prepare in advance when she goes to the same (known) place to visit doctors. She just need to train her dog to learn the route so she ask the trainer of the dog for help. She is not nervous when she wants to visit a doctor. "It is better than to visit a photographer."
She uses the public transport to go to a doctor. She prefers to make an appointment and she makes it by phone. She wants to be independent so she hardly ever needs some assistant.

Visit of hospital
She visits doctors approximately few times a year.
After she enters the building, she finds the reception and asks at which floor the office of the doctor is. At the particular floor, she asks anyone who is there.
When she will have to visit a big hospital, she would probably ask someone to accompany her. The biggest problem is to travel from one building to another. In the particular building, the navigation is much easier.
The way through the hospital building is not a problem for her as she has her guide dog.
When a doctor sends her to another doctor, she wants him to describe the route in a very detailed way. When it is at the same building, someone accompanies her.
Her experiences with the staff of the hospital differs a lot. They usually want to help her, but they do not know how.

Technologies (in hospital/in public buildings)
She saw the electronic waiting list, but only at the post office. However, they know her there so she does not have to use it and she does not even try it.

Technologies (in general)
She has got a mobile phone with buttons. She uses it to make phone calls and send SMS. She cannot use it for the outdoor navigation as she has got the older one. She does not think she would need any navigator in the mobile phone.
She also owns the computer. She browses the Internet, writes emails and listens to the radio. She uses a software to convert the web pages to audio form.
She tries to use some devices with touch screen, but she does not like them.

PVI5

Male, age – 40, category of impairment – 5, onset – late blind

Orientation at unknown places
In the unknown building, he has to ask for help passers-by or some staff. He has the whole range of experiences with them.
When he knows he will visit the building regularly, he go there in advance to learn the route (or he can learn it within the first visit).
When he gets lost, he need to ask someone for help. When there is nobody, he has to wait until someone comes. When it takes a long time, he is in stress.

Before the visit of a doctor
When he has to visit a doctor, he is not nervous. He spends this day in a common way.
He uses the public transport or he goes on foot to visit a doctor.
He does not need anyone to accompany him. It sometimes happens, but it is someone who he knows. He thinks that he would not know what can other people offer him.
His doctors have their offices at different places.

Visit of hospital
He visits a doctor approximately once per month.
At the bigger hospital complexes, it is much more difficult to navigate (to travel from one building to another one). He need someone to help him. It usually happens that someone offer the help without his asking and accompanies him to the correct waiting room. However, they sometimes cannot solve the problem (find the right office).
When a doctor sends him to another office, he expects someone to accompany him.
The staff wants to help him with the navigation, but they usually do not know how.
He changed his doctor for another one once because of the better health care.

Technologies (in hospital/in public buildings)
In hospitals, he cannot receive any information using the transmitter for visually impaired. It is much better in the post office. He can ask the staff for help using the transmitter for visually impaired.
He does not use the electronic waiting list as it cannot be used by visually impaired. "I just come there and notify someone of my presence. I feel it as a problem on their side." The people waiting there usually want to help him, but he refuses their help as he would not be able to see the number of the next patient.

Technologies (in general)
He owns the iPhone. He uses it to make phone calls, send SMS and work with various applications. He also has an older phone to listen to the music.
He would prefer to have a mobile phone with buttons, but he need the functionality of iPhone. For the first time, he saw the touch screen device at his acquaintances. He thought that it would be necessary to use touch screen in future so he learnt it.
He has a computer to browse the Internet and as a notepad. "I use it instead of pen and paper."

Seniors

PSI1

Male, age – 62, lives in the village, visit a doctor few times per year, without accompaniment, use mobile phone for calling and writing SMS

Orientation at unknown places
He uses signs to orient in unknown buildings. He usually understands them. When he does not, he asks the staff. When he gets lost, he asks the staff or passers-by or he returns to the

initial point. He feels uncomfortable, but it is not so stressful for him.
He does not prepare in advance when he want to visit some unknown place. Sometimes, he call to the office of a doctor to make sure that the doctor has not holiday.

Before the visit of a doctor
When he has to visit a doctor, he is nervous. He usually lose his appetite. When he worked, he preferred to go there in the working time.
He always goes by car and without any accompaniment.
He makes an appointment by phone as he has not his doctor at the place of residence. He prefers to make it (when the doctor wants it).
He visits almost all the doctors he needs in the health centre (appart from his general practitioner).

Visit of hospital
He visits a doctor few times per year (usually as a preventive health care).
When he enters the hospital building, he need to go to the toilet at first as the visit could take a longer time. Then he go to the specific waiting room. When there is a lot of people, he is annoyed. That is why he prefers to make an appointment. If he had to wait although he had an appointment, it would bother him. However, he cannot remember if it ever has happened.
The way through the hospital building is not a problem, but it is more complicated for him in unknown buildings.
When the doctor sends him to another one, he try to think about how can he get there and then he go. The doctor usually help him with the route without his asking. He was always satisfied with the health care of the hospital staff. They always want to help him when he need something. He cannot remember any negative experience.
He changed his doctor for another one only because of his retirement.
He also uses other services in a health centre (buffet, florist's and barber's shop).

Technologies (in hospital/in public buildings)
He remembers the car park by the hospital. He has heart that he has to take the ticket at the barrier which has to be validate in hospital to get free parking. He thinks this system is complicated so he parks at the different car park more distant to the hospital. He thinks he could manage the system, but he does not want to try it at the first time.
He has also some experiences with the electronic waiting list in the different buildings than hospitals. He does not like it, but he finds it very simple ("for dummies"). He can work with it without the help of someone else. In the health centre which he visits, there is a waiting list "from the Middle Ages". There are big paper cards with numbers. They are not printed by some device, but prepared in advance for the visitors.
He also remembers the payment of regulatory fees. He was used to give the money to the doctor or nurse. When he had to use it in hospital, he did not know how and he had no coins. He wanted to change the banknote in some closed shop, but nobody could help him. Finally, some passer-by helped him to find the cash office which he could use instead of the machine.

Technologies (in general)
He has a mobile phone ("the one for dummies"). He uses it for phone calls and writing the SMS. He has also a computer at home, but he does not use it at all (he even cannot use it). He learned how to use it, when he want to find a job (to read some advertisements on the Internet). After he did not need it any more, he forgot how to work with it.
He thought that he work with the touch screen at work (the attendance system). Then he realizes that he had been wrong and that there had been the buttons. He remembers the ATM with the touch screen, but on them, there were the buttons too so he use the buttons instead. He cannot imagine why he should need it.

PSI2

Female, age – 77, lives in the city, visit a doctor few times per month, without accompaniment, use mobile phone for calling

Orientation at unknown places
When she comes to the unknown building, she asks the passers-by and she uses the coloured navigation lines.
She has good experiences with this strategy. She never prepares in advance before she wants to visit a doctor.
When she gets lost, she asks passers-by or the staff. This is not a stressful situation for her. "There is no reason why should I be annoyed."

Before the visit of a doctor
When she has to visit a doctor, she is not nervous. She prefers to make an appointment personally (even though she has to go by train) instead of using the mobile phone. This is some kind of trip for her similarly to the visit itself. However, she has no problem to use the mobile phone when it is necessary. She prefers to make an appointment, but sometimes happens that she has to wait anyway. It does not bother her.
She uses train and bus to visit a doctor or she goes by foot.
She visits the doctors at her place of residence, but also some doctors in the city where she used to live as she does not want to change them.

Visit of hospital
She visits a doctor approximately few times per month. It is not usually a problem for her to find the way in a building. When a doctor sends her to another doctor, she ask for the address and the route description when she does not know the place.
Her experiences with the staff are very positive. She cannot remember any negative experience. Thus, she never changes her doctor for another one because of the bad health care. "They do what they can."

Technologies (in hospital/in public buildings)
She saw the electronic waiting list few times. She has no problem to use it. She never need someone to help her working with this device.

Technologies (in general)
She has the mobile phone for seniors. She like it as she does not need to wear her glasses when working with it. She uses it only to make the phone calls. She does not own a computer. She thinks that she does not need it.
She has some experiences with the touch screen (electronic waiting list, ATM and some kiosks). She has not a problem with using them, but she use them only when there is not another possibility. However, she never use a mobile phone with touch screen. "It is for young people."

PSI3

Male, age – 85, lives in the city, visit a doctor few times per month, with accompaniment, use mobile phone for calling

Orientation at unknown places
When he comes to the unknown building, he asks at the reception. When there are some maps or plans, he also uses them. The people at the reception are ready to help him and they can do it. He does not prepare in advance before he want to go to the unknown building.
He cannot remember the situation that he get lost. "Why should I get lost when I know where to go from the reception?"

Before the visit of a doctor
When he needs to visit a doctor, he is not nervous. He goes almost always by foot as the health centre is not far.
He sometimes make an appointment, but sometimes does not (it depend on the preferences of the particular doctor). He prefers to make it personally as he visit almost all his doctors at the health centre near his home.
His son always accompany him on the doctor's recommendation.

Visit of hospital
He visits a doctor approximately few times per month.
It is not a problem for him to find the way in a building since he ask directly at the reception. When a doctor sends him to another one, he ask for the address. He does not need to know other information as his son help him to find the place on a map.
His experiences with the staff differs. Some nurses are nice and polite. However, some of them look like it is not their job description to help the patients. He has also some bad experience with one doctor. When he was younger, he had some bad accident. At the hospital, the doctor broke his leg. When he asked him why he did it, the doctor said that he had to do it because the bone was knitted badly. He was shocked that the doctor did it without his permission or without any information given in advance at least.
He changed his doctor for another one only because of his/her retirement.

Technologies (in hospital/in public buildings)
He saw the electronic waiting list at the post office and in the bank.
He tried it once and he managed to work with it. However, his son does it instead of him in

these days. He does not like this system as he thinks that it does not help to speed up the process. He also does not like to check the actual number every time.

Technologies (in general)
He has the mobile phone with buttons. He uses it only to make the phone calls.
He does not have a computer. He thinks that he does not need it. He does not want to buy it as it is expensive.
He cannot remember if he has some experiences with the touch screen (the electronic waiting list at the post and in the bank has the buttons). He thinks that it is too difficult for him when he saw how other people interact with it.

PSI4

Male, age – 66, lives in the village, visit a doctor few times per year, without accompaniment, use mobile phone for calling and writing SMS

Orientation at unknown places
He uses signs to orient in unknown buildings. He can understand them.
He does not prepare in advance when he want to visit some unknown building. However, he sometimes feels a little bit nervous since he knows that he will have to look for some office and it may take a long time.
When he cannot find the right office, he asks at the reception. He feels slightly embarrassed that he cannot find the way. He is also nervous because he wants to be at the right place in time and finding the right office may slow him down.

Before the visit of a doctor
When he has to visit a doctor, he is nervous a bit. He knows that the doctor will take his blood pressure. Since he is nervous, he knows he will have the high pressure. That makes him even more nervous.
He always goes by car to visit a doctor and he goes without an accompaniment.
He makes an appointment by phone. Some doctors does not prefer their patient to make an appointment so he does not make them. However, he prefers it especially when he needs for instance only to get a prescription. In these situation, he needs to wait a long time and after it he spend only few minutes in the doctor's office.
He visits all the doctors he needs in a health centre.

Visit of hospital
He visits his general practitioner once per month (to get the prescription) and he rarely visits other doctors.
The way through the hospital building is not a problem for him.
If the doctor sent him to another one, he would expected him/her to give him some instruction (address, route description etc.). However, he cannot remember if it ever happened to him.
He remembers that he had to wait in the emergency with his wife once (she had a broken arm). It takes few hours. He saw there also badly injured people who had to wait a long

time too. However, he thinks that it was not the fault of the staff. "They had a lot of work to do and there were so many people."
He never changed his doctor for another one. He is always satisfied with the health care.

Technologies (in hospital/in public buildings)
He has some experiences with the electronic waiting list in the different public buildings. He finds it better than to wait in a queue. "The people would argue who was the first." He can work with it, but he needed help once. It was the first time he worked with it. He chose the different service he wanted. Therefore, he asked some employee for help.

Technologies (in general)
He has a mobile phone. He uses it for phone calls and writing the SMS.
He does not have a computer. He think that he does not need it and he never tried to work with it.
His children have mobile phones with touch screen. He tried to work with it. He thinks that if his mobile phone is broken, he will buy a new one with the touch screen. "If I had this kind of phone, I would learn how to use it. I always think that something is difficult, but when I learn how to work with it, it is not difficult at all."

PSI5

Female, age – 73, lives in the city, visit a doctor few times per year, without accompaniment, use mobile phone for calling and writing SMS

Orientation at unknown places
She uses signs to orient in unknown buildings. She can understand them. Sometimes, she asks the staff.
She does not prepare in advance when he want to visit an unknown place.
When she cannot find her way, she asks the passers-by. She does not feel bad as she think she can handle these situations. "It is better to ask someone that to be lost. Although my husband would not ask. He would rather stand there and try to find his way by himself."

Before the visit of a doctor
When she has to visit a doctor, she is nervous as she does not know what the doctor will say to her.
She sometimes makes an appointment by phone. However, when it is some regular health care, she makes an appointment with the doctor during the visit. She prefers to make it.
She uses the public transport to go to a doctor and she goes without an accompaniment. The only time when she prefers the accompaniment are some acute cases.
She visits almost all the doctors she needs in a health centre.

Visit of hospital
She visits a doctor few times per year.
When she enters the hospital, she looks for some signs and plans. She also asks passers-by.
The way through the hospital building is not a problem for her.

Her experiences with the hospital staff are positive. However, she remembers a negative experience too. Once she had a medical examination. She waited in the cloakroom and she heart how the nurse spoke to a patient. She yelled at him and was very unpleasant. Therefore, she was slightly scared that the nurse will behave in a same way to her. And it actually happened. However, she did not tolerate this behaviour. "I think I can defend myself and I will not cry when somebody is mean to me."
When her doctor sends her to another one, she wants him to tell her the address and the route description (when she does not know where his/her office is). Sometimes, the doctor also make an appointment for her.
She never changed her doctor for another one. When she is in hospital she also uses other services (shops etc.).

Technologies (in hospital/in public buildings)
She has experiences with the electronic waiting list in the different public buildings. She can work with it and she finds it better than to wait in a queue. She also saw some information kiosk at the railway station. She has never used it (she does not even know why).

Technologies (in general)
She has a mobile phone with the touch screen (but not a smart phone). She uses it for phone calls and writing the SMS. Her family members also send her some photos on the phone.
She has a computer at home. She uses it only for calling (Skype). She does not browse the Internet as she prefers to get the information on the paper (the newspapers, books etc.). "I had to work with the computer at work. I was able to use it for the learned activities necessary for my work, but I was not able to use it in a more expert way. Now I am retired and I am glad that I do not have to use it."
She likes the devices with the touch screen. "At first, I did not want to work with my new phone with touch screen when my children gave it to me. But now, I like it more than the buttons."

Appendix D

Low-Fidelity prototype evaluation

Visually impaired

PVL1

Female, age – 40, category of impairment – 4, onset – late blind

Task 1 (Find cardiologist Jan Skála)
She was able to solve the task. The only problem would have been to follow the instructions. She was not able to remember everything, but in her opinion, the instruction message was not so long. She only wanted to repeat the instructions. Although there was no repeat button, she was successful in obtaining the instructions again (using the back button and selecting the destination again). Thus, she thought that the repeat button was not necessary, but it would have been nice to have it.

Task 2 (Find the inpatient cardiology)
She completed this task without any problem as the task was similar to the first one. She was able to work faster the during the previous task.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She was able to find her appointment in the list of prepared visits with no problem. She appreciated she could easily find the destination in the list of prepared visits.

The speed of records suited her and she did not think that she would change it. In some cases, she would prefer to use the earphones because the hospital environment could be noisy and some data could be too personal to be heart by someone else.
She could not recognize the buttons by touch at all. She would prefer to have the arrows and the confirmation button (i.e. the buttons which are used the most) at the same side of the terminal.

PVL2

Female, age – 68, category of impairment – 5, onset – late blind

Task 1 (Find cardiologist Jan Skála)
She found the desired destination. However, she was not able to remember the whole message with the navigation instructions. Thus, in her opinion, it would have been good to have the possibility to repeat the message.

Task 2 (Find the inpatient cardiology)
She completed this task without any hesitation.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She was able to find her appointment in the list of prepared visits. She appreciated it was easier to find the doctor that in Task 1.

The speed of records was convenient for her and she did not think that she would change it. She would not need to use the earphones. She is not worried that someone could hear which doctor she want to visit.
She recognized only the arrow buttons by touch.

PVL3

Male, age – 51, category of impairment – 5, onset – congenitally blind

Task 1 (Find cardiologist Jan Skála)
He was able to find the destination, but he had a problem to memorize the final instructions. He successfully used the back button and selected the destination to obtain the instructions again. He said that he did not need the repeat button as he could deal with the situation without it.

Task 2 (Find the inpatient cardiology)
He completed this task without any problem. He appreciated that at each screen, the terminal informed him about the number of items in the list.

Task 3 (Find cardiologist Jan Skála – visit prepared)
He completed the task with no hesitation.

The speed of records suited him, but he would like to make it faster when he would use it again. He would also like to use earphones because of the potential noise.
He recognized only the arrow buttons by touch. He would like to have the arrows and the confirmation button at one side of the terminal.

Seniors

PSL1

Female, age – 60, lives in the village

Task 1 (Find cardiologist Jan Skála)
She saw the option "Change Language" on the identification screen. She did not know what to do so she selected it. She realized that she did not want to change it and she pressed the button "Start again". Then she identified and continued successfully.

Task 2 (Find the inpatient cardiology)
She completed this task without any problem. She was able to work faster.

Task 3 (Find cardiologist Jan Skála – visit prepared)
After she identified, she was able to find her appointment in the list of prepared visits.

Task 4 (Find pharmacy)
She select the option "Find department of doctor". She cannot find the pharmacy in the list of departments. She pressed the "Audio output" button (she said that she did not know why). Then she realized that she had to return back and used the "Back" button. She found pharmacy in main menu and completed the task.

Task 5 (Call for help)
She identified and chose cardiology. She did not know which doctor to choose so she hesitated for a while. Then, she noticed the emergency button so she pressed it. After using it, she knew she could use it at the beginning of the task.

The size of components was sufficient for her. She understood the meaning of buttons except the audio button.

PSL2

Male, age – 63, lives in the village

Task 1 (Find cardiologist Jan Skála)
He did not know, why there was the choice to change the language in the identification screen. He thought that he had to change it even though he did not want to. After a while, he tried to identify and completed the task.

Task 2 (Find the inpatient cardiology)
After he successfully chose cardiology from the list of departments, he pressed the "Audio output" button. He thought that the button meant to call the department and he would spoke with someone from staff. Then, he realizes that he only activated the audio output.

Task 3 (Find cardiologist Jan Skála – visit prepared)
He was able to find required appointment immediately.

Task 4 (Find pharmacy)
He completed this task with no problem since he noticed the button for finding pharmacy during the previous tasks.

Task 5 (Call for help)
He pressed the emergency button without any hesitation.

The size of components was sufficient for him.
He understood the meaning of buttons except the audio button.

PSL3

Male, age – 79, lives in the town

Task 1 (Find cardiologist Jan Skála)
He found the desired doctor with no problem. However, he was slightly confused when he saw the picture of Simple navigation terminal on the screen with navigation instructions. He said that he did know almost nothing about the system so he could not see the relation between the instructions and the picture.

Task 2 (Find the inpatient cardiology)
He chose "Select department or doctor" and then cardiology. He was not sure if the option "Navigate to cardiology" meant the inpatient cardiology. Nevertheless, he chose it a then he saw he could choose to which part of cardiology he wanted to be navigated. Thus, he chose the inpatient part and completed the task.

Task 3 (Find cardiologist Jan Skála – visit prepared)
At first, he hesitated for a while as he thought why he should have looked for the same doctor as in Task 1. The, he tried to continue and selected the doctor in the list of prepared tasks. He appreciated it was easier to find him when the visit was prepared.

Task 4 (Find pharmacy)
He completed this task with no problem.

Task 5 (Call for help)
He pressed the emergency button with no hesitation.

He found the size of components big enough. He also understood the meaning of all buttons. However, he thought that the position of buttons above the screen is strange. All the systems he saw had the buttons only on left and rights side of the screen.

Appendix E

High-Fidelity prototype evaluation

Visually impaired

PVH1

Male, age – 31, category of impairment – 4, onset – congenitally blind, can read Braille

Task 1 (Find cardiologist Jan Skála)
He listened to the instructions about the buttons twice to remember them. Then he continued and he was able to find the desired doctor without any problem. He also let the system informed him about the office hours. After it, he was slightly confused because he did not know if he would be logged out or not. Thus, he would like to obtain some kind of information about it. He would also like to know if the insurance card was accepted and when he can remove it from the identification device.

Task 2 (Find the inpatient cardiology)
He did not want to listen to the initial instructions again so he skipped them. Then he continued without any hesitation.

Task 3 (Find cardiologist Jan Skála – visit prepared)
He identified himself immediately to skip the initial instructions. From the list of prepared visits, he chose the desired appointment with no problem.

Task 4 (Find pharmacy)
He identified himself immediately and found the pharmacy. He also noticed the button for changing language in the main menu. He was surprised as he would expected to have it on the initial screen.

Task 5 (Call for help)
First, he identified himself, then he pressed the emergency button. He thought that his identification could help the doctor to know who he is. He thought that it is not a good idea to cancel the emergency help using the same button again. In his opinion, someone

who need medical help could press the button many times to show it is really an emergency situation.

He would like to be informed about how the system works to know what the further navigation would look like. He also thought that it would be good to allow the users return to the initial screen to obtain the information about buttons again.
In his opinion, he would not need to change the audio rate although he is used to the higher rate at his computer as he would not use this device every day.
He may appreciate some sound which would signalize the beginning/end of a list.
At the end of the session, he also tried to use the remaining buttons he did not used during the testing. After pressing the audio button, he would like to be informed that the audio was activated/deactivated.

PVH2

Female, age – 40, category of impairment – 5, onset – congenitally blind, can read Braille

Task 1 (Find cardiologist Jan Skála)
Although she listened to the initial instruction twice, she could not find the identification device. She would have preferred to use numeric keyboard to control the terminal instead of buttons. After she got used to the control, she was able to find to complete the task.

Task 2 (Find the inpatient cardiology)
She did not identify herself since she thought she did not have to, when she is not the patient in this case. Then she successfully found the desired destination.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She skipped the initial instructions. Then, she selected the appointment from the list of prepared visits without any hesitation.

Task 4 (Find pharmacy)
She chose not to identify herself and then she continued successfully.

Task 5 (Call for help)
She identified herself and she tried to find the emergency help in the main menu. She did not know what to do as she could not find it there. She knew that she heart about the button in some point of the interaction. Thus, she was informed about the button. In her opinion, she obtained much information in the beginning and she forgot them as she used only three buttons during the work with the kiosk.

She would prefer different voice instead of the used one (she considered this one too synthetic).
As she would not use the kiosk so often, she thought she would not need to change the audio rate.

She would prefer to use headphones because of the privacy and possible noise.
It is not necessary for her to hear some sound which would signalize the beginning/end of a list.
She did not know if she would appreciate the repeat button as she did not need to it during the testing.

PVH3

Female, age – 66, category of impairment – 4, onset – late blind, cannot read Braille

Task 1 (Find cardiologist Jan Skála)
Although she listened to the initial instructions twice, she did not examine the terminal/buttons by touch. She would have preferred not to hear the whole introduction message (just the meaning of buttons) when listened to them for the second time.
After inserting the card, she would like to know if the identification was successful or not.
She had many comments to the texts of audio messages. Although she could understand them, she thought that other people could not (e.g. the identification device should be called the slot for the identification card). After those comments, she tried to continue to complete the task.
Even though she was assured that necessary information for completing the task could be repeated to her at any moment of testing, she selected to navigate to surgery instead of navigate to cardiologist Jan Skála. Thus, Task 2 was not tested as its goal was almost the same.
She tried to find cardiologist Jan Skála again. After she found him, she listened to the office hours. She was not sure if she could follow the instructions and the terminal would log her out automatically. Therefore, she would like to use some button to say she is ready to go and the system would log her out.

Task 2 (Find the inpatient cardiology)
This task was completed during the Task 1.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She skipped the initial instructions and completed the task immediately. She appreciated that the terminal knew about her prepared visits.

Task 4 (Find pharmacy)
She decided not to identify as she thought it was not necessary when she just wanted to visit pharmacy. Then she was able to found it without hesitation.

Task 5 (Call for help)
She remembered the emergency button so she pressed it immediately.

She would appreciate some sound which would signalize the beginning/end of a list, but is is not necessary for her.
The form of initial instructions was sufficient for her. In her opinion, Braille labels at the

buttons would be useless. However, she would appreciate some button to stop the audio message on particular screen, but not the button to repeat the message.

PVH4

Female, age – 28, category of impairment – 5, onset – congenitally blind, can read Braille

Task 1 (Find cardiologist Jan Skála)
She wanted to repeat the initial instructions, but she was not sure how to do it (she was not sure if the button described as "Choose selected item from the list" meant "OK"). However, she tried it so she was able to listen to the instructions again. Then she used the home button and continued with searching for the demanded doctor successfully.

Task 2 (Find the inpatient cardiology)
She listened to the instructions again and then she was able to complete the task without any problem.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She listened to the instructions once again, she identified herself without the request of the system. Then she selected the required doctor from the list of prepared visits.

Task 4 (Find pharmacy)
She interrupted the initial instructions and continued without identification as she found it unnecessary to identify in case of searching for the pharmacy.

Task 5 (Call for help)
First, she identified herself, but she could not say why she did it. She continued to search for some help in the main menu. When she could not find it there, she realized that there is the physical emergency button. She was not sure which one from the buttons on the left side of the terminal is it. However, she got the right one. She mentioned that she was not able to remember all the buttons as she did not use them all during the testing.

In her opinion, she would not need to change the audio rate since she would not use the kiosk so often.
She would prefer to use headphones due to the possible noise and the her privacy.
She would not require some sound which would signalize the beginning/end of a list.

PVH5

Female, age – 30, category of impairment – 4, onset – congenitally blind, can read Braille

Task 1 (Find cardiologist Jan Skála)
She listened to the initial instructions twice (just to be sure she could understand them). She was just uncertain if the button described as "Choose selected item from the list" meant

"To confirm". Moreover, she would have preferred to hear just the meaning of buttons when listened to the navigation instructions for the second time. Then, she identified and she removed the card from the identification device. She continued successfully with solving the task. She listened to the navigation instructions twice and also listened to the office hours.

Task 2 (Find the inpatient cardiology)
She press the audio button by accident and the audio output was deactivated. She realized that she probably deactivated it and she pressed it again to activate it. Then she skipped the initial instructions and found the desired destination successfully. She would have appreciated some button to inform the terminal that she is leaving to be navigated.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She skipped the initial instructions and completed the task immediately. She appreciated that she could simply search for the destination in the list of prepared visits.

Task 4 (Find pharmacy)
After the identification, she was slightly surprised that the option to change language is in the main menu instead of the initial screen. Then, she continued and she solved the task.

Task 5 (Call for help)
She immediately press the emergency button. However, she was not sure about the kind of help she asked for. It should have been the emergency help as the button is called emergency button. On the other hand, after she pressed it, the message spoke about some help on thy way. Therefore, the message should be changed.

She would appreciate some button to stop the audio message on particular screen, whereas the button to repeat the message not.
She would prefer to use headphones as far as privacy is concerned.
Although the audio rate is slow to her, she would not need the option to change it as the interaction with the terminal is not so long.

PVH6

Female, age – 25, category of impairment – 5, onset – congenitally blind, can read Braille

Task 1 (Find cardiologist Jan Skála)
After the initial instructions, she was not sure if the button described as "Choose selected item from the list" meant "OK", but she used it correctly. Then, she continued successfully with solving the task. She also listened to the office hours. She would like to use some button to say she is ready to go and the system would log her out.

Task 2 (Find the inpatient cardiology)
She skipped the initial instructions. She identified herself and then she found the desired destination successfully.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She listened to the initial instructions once again since she thought there could be some change in functionality of buttons in case of prepared visits. The, she continued successfully in solving the task.

Task 4 (Find pharmacy)
She was able to find the pharmacy without any problem.

Task 5 (Call for help)
She pressed the emergency button so she was able to solve the task with no hesitation. However, she would appreciated if there was the option to repeat the instructions about buttons in the main menu.

In her opinion, she would not need to change the audio rate although she is used to the higher rate as she would not use this device so often.
She would prefer to use headphones because of the privacy and possible noise.
She may appreciate some sound which would signalize the beginning/end of a list. However, she would not expected that it would be possible (i.e. to continue at the first/last item when reaching the end/beginning of the list.).
She was satisfied with the form of the initial instructions as they could be repeated. She did not think it would be necessary to have the Braille labels at the buttons.
She would not need the repeat button as the information could be repeated in a different way.

PVH7

Male, age – 29, category of impairment – 5, onset – late blind, can read Braille

Task 1 (Find cardiologist Jan Skála)
He listened to the initial instructions twice. For the second time, he listened to the first half only and then he interrupted them. Although he solve the task without any hesitation, he had few comments. He wanted to be informed if the identification was successful or not. He also wanted to know how the insurance card should have been inserted into the identification device. In his opinion, the user should be informed that he/she would be logged out after leaving the terminal. He also thought the emergency button is useless and the audio output should not have been active by default.

Task 2 (Find the inpatient cardiology)
He described what would he have done to solve the task, but he did not want to do it as the task was similar to the first one.

Task 3 (Find cardiologist Jan Skála – visit prepared)
He solve the task with no hesitation. He appreciated that he could quickly find what he wanted in the list of prepared visits.

Task 4 (Find pharmacy)
After he identified himself, he was able to find the pharmacy without any problem.

Task 5 (Call for help)
He found the emergency button useless, but he knew its position on the terminal.

He would not change the audio rate as it could take more time that to find the destination.
He would prefer to use headphones because of the privacy and possible noise.
In his opinion, Braille labels at the buttons would be useless. He would rather listen to the instructions about buttons again.
He would not need the repeat button since he would have to remember another button.

Seniors

PSH1

Female, age – 70+, lives in the town

Task 1 (Find cardiologist Jan Skála)
She listened to the initial instructions and continued successfully. However, she was slightly confused why there was the map of the floor where the final destination was instead of the floor where the terminal was. She would have also preferred the office hours to be above the navigation instructions on the screen.

Task 2 (Find the inpatient cardiology)
She turned off the audio output and without the identification, she found the destination.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She did not identified herself and found the destination in the menu. After she was told, that she could try to identify herself, she completed the task again. She said she did not realize that she have to identify in order to receive the list of her appointments.

Task 4 (Find pharmacy)
She was able to complete the task with no problem.

Task 5 (Call for help)
She hesitated for few seconds. Then, she continued to the main menu. She did not know what to select so she returned to the initial screen. She noticed the emergency button and she pressed it. She did not remember that there is such button.

She would prefer to have the labels with the meaning of the buttons on the terminal.
It did not bother her that the audio was active by default. When someone works with it for a first time, it is better the audio to be active. Then, everyone can turn it off, when he/she wants.

In her opinion, the prototype was too small. However, she could read the text on the screen when she wear her glasses. Without them, she could not read anything as she has 5 diopter reading glasses.

PSH2

Female, age – 78, lives in the town

Task 1 (Find cardiologist Jan Skála)
She was not sure which button to use to confirm her choice according to the symbols on the buttons. Then, she looked at the text description of them so she knew, which one to use. She found the destination, but she was not sure whether she could leave the terminal or not. Therefore, she would have appreciated some information about it.
It was also confusing for her that there was the map of the floor where the final destination was instead of the floor where the terminal was. She would have preferred to have them both.

Task 2 (Find the inpatient cardiology)
She skipped the audio instructions and found the final destination without any problem.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She tried not to identify herself to see what would have happened. Then, she found the desired destination in the menu similarly to Task 1. After she was told, that she could try to identify herself, she completed the task. She found it good as it simplifies search for the destination. However, she would have appreciated some information why she should have identified.

Task 4 (Find pharmacy)
She accidentally click on reception instead of the pharmacy. Therefore, she want to go back. She press the home button as she thought it is the back button. She interpreted the symbol of house on the button as an arrow. After she start again, she select pharmacy successfully.

Task 5 (Call for help)
She searched for the emergency in the main menu. She did not know what to select so she returned to the initial screen. Then, she noticed the emergency button and she pressed it. She did not remember all the buttons as she did not use them in the previous tasks. She would have appreciated to have the labels describing the meaning of the buttons on the terminal instead of to have them on the screen.

She would prefer to turn off the audio as it could sometimes confuse her. However, in her opinion, it is all right to have it activated by default.
Although she has 1.5 diopter reading glasses, she could read the text on the screen also without wearing them.

PSH3

Female, age – 69, lives in the town

Task 1 (Find cardiologist Jan Skála)
She identified herself and continued with searching for the final destination. She selected "Cardiology doctor's offices" as she thought there would have followed a list of doctors. The name of the button was confusing for her and she would have preferred different name.
She realized that it is not what she was looking for and she returned to the initial screen. Then, she selected "Select cardiologist" and then the desired doctor. However, she thought for a while there was the map of the floor where she was instead of where the final destination was. In her opinion, it would have been better to have them both.

Task 2 (Find the inpatient cardiology)
She found the final destination without any problem.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She hesitated for few seconds. She identified herself and chose the doctor in the list of prepared visits. Then, she returned and found him in the main menu too (similarly to the first task). She did not realized that there was the list of her appointments and she could not see any difference between the prepared and unprepared visit. After it was told to her, she still could not imagine why should she prepare the visit since it took just a minute to find the doctor in the menu. However, she found useful that she could see all her appointments in the list.

Task 4 (Find pharmacy)
She identified herself and found the pharmacy without no problem.

Task 5 (Call for help)
She pressed the emergency button immediately without any hesitation.

She would appreciate to have the labels describing the meaning of the buttons on the terminal as she would not have to remember them all.
Although she knew how to turn off the audio output, she did not do it as it did not bother her.
She could read the text on the screen when she wear her glasses. Without them, she could read only the captions as she has 3 diopter reading glasses.

PSH4

Male, age – 64, lives in the village

Task 1 (Find cardiologist Jan Skála)
He listened to the initial instructions and identified himself (directly from the initial screen). Then, he did not remember which button was the confirmation one (he did not know the tick symbol meant to confirm). He tried the emergency button. He realized that he asked

for the emergency and cancel it. Then, he turned the audio off and on again. Then he tried another button (home). He looked at the picture describing the meaning of the buttons, turned off the audio and continued in searching successfully.
He said that he would have probably followed the map instead of the instructions describing the way to the next terminal as he was used to use them in buildings.

Task 2 (Find the inpatient cardiology)
He listened to the initial instructions once again (he could not say why). He identified and found the desired destination without any hesitation.

Task 3 (Find cardiologist Jan Skála – visit prepared)
He turned off the audio and found the doctor in the list of prepared visits with no problem.

Task 4 (Find pharmacy)
He was able to complete this task without any problem.

Task 5 (Call for help)
As he identified himself directly from the initial screen during all tasks, he skipped the screen which asked him to identify and he did not even know there was the option not to identify. Thus, he identified during this task too and then, he pressed the emergency button.

He would certainly appreciate the labels at the buttons since he could not remember them all. Moreover, he could not recognize their functionality according to the symbols on them.
He turned the audio off, but it was all right to have it activated by default for him.
He has 1 diopter reading glasses, but he could read the text without wearing them.

PSH5

Female, age – 61, lives in the village

Task 1 (Find cardiologist Jan Skála)
She listened to the initial instructions and then, she pressed the emergency button. She cancelled it, but she did not know how to continue. She tried to press home button. She listened to the initial instructions again. Then, she realized which button is the confirmation one and continued without the identification until she found the desired doctor.

Task 2 (Find the inpatient cardiology)
She listened to the initial instructions again. Then, she continued without the identification and completed the task successfully.

Task 3 (Find cardiologist Jan Skála – visit prepared)
She listened to the initial instructions once again. When she was asked to try to skip the instructions, she could do it. She said she was scared that she could broke the system by doing it. She supposed she had to identify herself. She was not sure if she should have inserted

the card without pressing any button as she thought she had to press some button on every screen and there was only one choice ("Continue without identification"). Nevertheless, she tried it and continued successfully by searching in the list of prepared visits.

Task 4 (Find pharmacy)
She was able to complete the task with no problem.

Task 5 (Call for help)
She searched for the emergency in the main menu. As she could not find it there, she pressed home button and started it again. She could not find it for the second time too and she did not know what to do. After she was told there was the emergency button on the terminal, she said she had forgotten there was such button.

She would prefer to have labels at the buttons because she could not remember them all. Moreover, she could not recognize their functionality according to the symbols on them.
She let the audio on during the testing as it did not bother her.
She has 2.25 diopter reading glasses. Although she could read the text on the screen without them, it was more comfortable for her to wear them.

PSH6

Male, age – 84, lives in the town

Task 1 (Find cardiologist Jan Skála)
He identified and removed the card. He was not sure how to continue. He pressed the emergency button. He cancelled it, but he did not know how to continue (which button is the confirmation one). Finally, he pressed home button. He tried to find the confirmation button again. After he found it, he was able to continue with solving the task. He selected "Cardiology doctor's offices" since he thought there would follow a list of doctors. The name of the button was confusing for him and he would have preferred different name.
He returned and selected "Select cardiologist" and then the desired doctor. However, he thought there was the map of the floor where he was instead of where the final destination was. Therefore, he would have preferred to have both maps there.

Task 2 (Find the inpatient cardiology)
He pressed home button few times. He was surprised that nothing happened since he was at the initial screen. He thought the start again button meant something else.
He did not identified. Then, he was able to find the destination with no problem.

Task 3 (Find cardiologist Jan Skála – visit prepared)
He tried not to identify. Then, he found the desired destination in the menu similarly to the first task. After he was told, that he should try to identify himself, he completed the task. He did not know that the identification is important. Thus, he would have appreciated some information why he should have identified.

Task 4 (Find pharmacy)
He was able to complete this task without any problem.

Task 5 (Call for help)
He pressed the emergency button immediately. He also knew how the help could be cancelled.

He would definitely appreciated to have labels at the buttons because he could not remember them all. Furthermore, he could not recognize the functionality of all of them according to the symbols on them.
The audio output was very disturbing for him. He would also appreciated the audio to be disabled by default.
Although he has 2.5 diopter reading glasses, he was able to work with the terminal without wearing them.