Diploma Thesis Assignment

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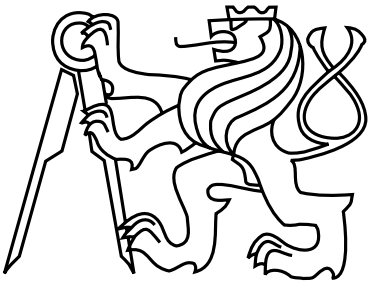

Diploma Thesis

Adaptive automatic assistance center for blind users who lost orientation

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Declaration

I hereby declare that I have completed this thesis independently and that I have listed all the literature and publications used.
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Abstract

This thesis focuses on the problem of navigation of visually impaired people, especially in urban areas. The main objective of this thesis is to provide help to visually impaired people in situations when they lose orientation and to reduce their dependence on passers-by. To this purpose, an extensive qualitative research was carried out. The research focuses on the general problem of navigation of visually impaired people in urban areas, as well as on situations when the visually impaired lose orientation and thus become dependent on other people's help. The outcome of this research was a series of hypotheses that were subsequently verified in a quantitative ethnographic field study. On the basis of the knowledge gathered in this study a concept of an automatic assistance center based on the principle of mutual cooperation among visually impaired people was proposed. The center would also offer to visually impaired people a new form of help in situations when they lose orientation.

Abstrakt

Tato práce se zabývá problémem navigace nevidomých lidí, zejména v městské zástavbě. Hlavním cílem práce je nabídnout těmto lidem pomoc v situaci, kdy ztratí orientaci, a omezit tak jejich závislost na kolemjdoucích lidech. Za tímto účelem byl v rámci práce proveden rozsáhlý kvalitativní výzkum, který byl zaměřen jak na obecný problém orientace nevidomých v městském prostředí, tak i na situaci, kdy nevidomí ztratí orientaci a jsou odkázáni na pomoc ostatních lidí. Výstupem tohoto výzkumu byla série hypotéz, které byly následně ověřeny v rámci kvantitativní etnografické studie. Poznatky nashromážděné během této studie pak umožnily navrhnout koncept automatického asistenčního centra, které by bylo založené na principu vzájemné spolupráce nevidomých lidí a které by jim v praxi nabízelo novou formu pomoci v situaci, kdy ztratí orientaci.

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1 Introduction

Such situations when orientation is lost are mentally demanding for everyone. This is particularly true for visually impaired people. Anyone who loses orientation experiences a strong feeling of insecurity and uncertainty and this feeling is even stronger in the case of visually impaired people. Therefore, it is important to find a way that would help them in such situations.

Nowadays special aids, which can be used by visually impaired people when they lose orientation, do exist. However, these aids are not suitable for everyone and in practice it also appears that there are some situations in which these aids are useless. Therefore, the main aim of this thesis is to research the problem of the navigation of visually impaired people and to offer them an alternative that would expand the range of currently available aids.

1.1 Main objectives of the thesis

The main objectives of this thesis are to research the problem field of navigation of visually impaired people, especially in an urban area, to identify their behavior patterns in situation when they lose orientation and to provide them with a new form of help in such situations. The ambition of this work is to propose an assistance center that enables visually impaired people to solve their problem of losing orientation by their mutual cooperation. Moreover, the service in this center should be provided by an adaptive automatic system that should be able to automatically learn and adapt itself to the individual users and to communicate with them in a natural and unconstrained speech.

In summary, the main objectives of this thesis are:

- To research the problem of navigation of visually impaired people.
- To identify behavior patterns of visually impaired people in situations when they lose orientation.
- To propose the concept of an assistance center for visually impaired people.

1.2 Organization of the thesis

The thesis is divided into 6 sections. In the second section the most relevant resources from the field of the navigation of visually impaired people are presented. Furthermore, papers that provide the initial insight into the issue of spoken dialog systems are presented. In the third section a detailed analysis of the fields at which this thesis is aimed is presented. In the fourth section a practical realization of several subparts of this work is presented. The fifth section contains detailed descriptions of all performed researches. The final sixth part summarizes the outputs of this thesis and it also presents a prospective future work.

2 State of the art

Naturally, problems on which this thesis focuses are not new. There are many papers and studies in the field of the cognition of visually impaired people, their orientation in space and spoken dialog systems. There are also some projects that are focused in a similar way like this thesis. On the other hand, there is not any existing project attempting to combine these issues and to use them for the practical improvement of ordinary lives of visually impaired people, which is the main ambition of this thesis.

Nevertheless, the above mentioned papers and projects are very important sources of information and inspiration and can be used as the basis for the work in this thesis. Therefore, several interesting papers that are appropriate for getting the initial insight into particular issues are introduced below. In addition, the most relevant paper in each issue was selected and then it was used for a detailed description of a particular domain in the following subsections.

A valuable paper in the field of cognitive mapping of the visually impaired, i.e. their ability to orientate in a space, is the one written by Simon Ungar [1]. It provides extensive and understandable introduction to this issue. For a better understanding of this issue, at first it is important to appreciate what an important role in our orientation the vision has [7] and to compare it to other ways of orientation [3, 6, 9]. It is also important to learn about the strategies that people without vision use for the recognition of the space around them [5, 8, 34].

For the main thought of this thesis, the possibility of mutual cooperation of visually impaired people, which has already been mentioned in [10], is also important.

A very useful paper in the field of spoken dialog services is the one written by Michael F. McTear [11]. It provides a complex insight into this issue. Nevertheless, this topic consists of many sub-problems that have to be considered and solved. In the beginning it is important to understand the problem of speech recognition [13, 15, 18, 19, 20]. The speech recognition, however, is also a very complex problem containing a lot of sub-problems, such as understanding the structure of human conversation [28] and spoken language [14, 16, 17, 29], which have to be considered. Moreover, in the particular case of this thesis it is also very important to deal also with certain problems that may occur in the Czech language [12, 21, 22].

It is also possible to find several existing projects [23, 24] and interesting related papers [25, 26, 27, 30, 31] dealing with a similar subject matter.

2.1 Cognitive mapping of the visually impaired

This section is based on the paper of Simon Ungar [1].

For sighted people vision is the most dominant sense in their everyday life. And for these people it is very difficult to imagine how they could orientate without sight. However, visually impaired people, especially blind people, have to solve this problem all the time in their daily lives. Their experience of space comes only from other senses, especially from touch, but also from hearing and movement, and yet they are able to engage in engage in quite all the activities all the activities that sighted people are. And how is this possible? It is because they use different strategies to explore and represent the space around them.

However, these strategies may differ greatly. For example, there has to be a clear distinction between people who have lost their sight during life, and thus have some visual experience, and those who are blind from birth and have no such prior experience. This assumption comes from the fact that people who lost their sight later generally tend to navigate themselves in a similar way as people without any visual impairment. Another important distinction is between tasks that require participants to make a response based on a spatial relation that has been directly experienced and tasks that require participants to infer a new relation based on their direct experience. The former simply requires some form of spatial coding, while the latter requires that a transformation be performed on the coded information. And these are only examples of features which have to be taken into consideration in the field of cognitive mapping of visually impaired people.

Another important aspect is the difference between near and far space. The near space, the so called haptic space, relates to a small-scale or manipulatory space: areas that can be explored without changing the location of the body. Conversely, the far space, the so called locomotor space, relates to a medium- or large-scale space: areas in which locomotion is required for exploration. Differences between these spaces are very important for the performance of spatial tasks.

2.1.1 Coding Strategies in Haptic Space

In performing any spatial task in haptic space, one of the options is to code the location of an object either by reference to our own body and/or movements, or relatively to some external framework. For example, one can determine the position of a cup on their desk either by its distance and direction from where one is sitting simply by extending their arm or by its position in relation to other objects on the desk.

Typically, people with little or no visual experience tend to code spatial relations by reference to their own body co-ordinates and/or their arm movements during exploration of the experimental space. On the other hand, for sighted people it is more natural to code the position of an object in relation to other objects.

Generally, coding strategies based on the reference to a body are more reliable at haptic space and prove to be functionally equivalent to strategies used by sighted people. However, such strategies prove less effective when tasks are very complex or when tasks require some kind of mental reorganization.

2.1.2 Wayfinding and Cognitive Maps: Locomotor Space

There are a lot of techniques that are used to investigate the cognitive maps of blind people. One of the most common methods is the direct reproduction of a route.

For example, in one study [34] blind and sighted schoolchildren were asked to produce a plan of their school campus. It was found out that the blind participants were generally less accurate than sighted participants. But there were also some individual blind participants who were very accurate. So the results of this study were inconsistent. Nevertheless, on the basis of this study it was later proven that the congenitally blind participants had the tendency to linearize curved paths. In addition, their maps were segmented and the features on familiar routes were more accurately represented than those on less familiar routes.

However, a very important problem of testing people in their familiar environments is that it is impossible to control individual differences in previous experiences of participants. Therefore, a number of studies prefer testing people in novel environments. Unfortunately, the results of these studies were often inconsistent as well, and there were also significant individual differences between particular participants. Nevertheless, the most studies agree that early-blind participants perform as well as late-blind and sighted participants on tasks that involve spatial memory. Unfortunately, in tasks that involve spatial inference the results are very inconsistent.

Other studies [33, 6] were focused on the problem of the exploration of an unknown space. These studies tried to identify strategies which blind people use to learn a large-scale layout objects in a space. Based on the observation of the participant's behavior, these studies identified a number of different strategies:

Perimeter: Explored the boundaries of an area to identify the area's shape, size and key features around its perimeter by walking along the edge of the layout.

Grid: Investigated the internal elements of an area to learn their spatial relationships by taking straight-line paths from one side of the layout to the other.

Object to object: Moving repeatedly from one object to another or feeling the relationship between objects using a hand or a cane.

Perimeter to object: Moving repeatedly between an object and the perimeter.

Home base to object: Moving repeatedly between the home base (origin point for exploration) and all the others in turn.

Cyclic: Each of the four objects visited in turn and then returning to the first object.

Back-and-forth: Moving repeatedly between two objects.

It has been found out that perimeter and gridline strategies used in isolation gave good knowledge of object location, but in the test of integrated spatial knowledge these strategies had poorer results. The most successful participants tended to use object to object, perimeter to object or home-base to object strategies, and they also often used a wider range of different strategies.

It was also found that the cyclic patterns were used mainly by early blind participants, whereas blind people who lost their sight later in life and blindfolded sighted participants tended to use the back-and-forth strategy, which was associated with good performance. In contrast, cyclic exploration was associated with poorer performance.

2.1.3 Explaining the Data

On the basis of the text above, it is possible to create a better idea about the spatial cognition of blind and visually impaired people. We can state that there is not any universal theory that can be applied to each visual impaired person. But we can also state that lack of visual experience does not prevent the acquisition of spatial representation. It was proven that totally blind participants perform spatial tasks at the same level as sighted participants do, including tests of spatial inference.

Thus, we can definitely state that spatial information is not the exclusive domain of only one sensory modality. Spatially relevant information is available through senses other than vision, such as through hearing, touch and movement, and this information can form the basis for spatial coding. It is important that the processing of spatial information by congenitally blind people is not necessarily less efficient than by sighted people. Generally, for visually impaired person the most reliable forms of coding of spatial information are based on the body and on movement of the limbs. It has been proven that these strategies are most reliable for many spatial tasks. Conversely, there are also some tasks for which coding in relation to external frameworks is advantageous.

2.2 Communication and collaboration during the navigation of the visually impaired

As Balata et al. mentioned [10], currently there are a lot of aids and tools which visually impaired people can use in situations when they lose orientation. But there is still a big potential for improvement in this field.

The common problem of existing navigation solutions is the lack of environment description especially created for visually impaired people. Because in the problem of the navigation of visually impaired people, especially blind people, it is necessary to take into account that these people use different landmarks than sighted people for navigation . Typical examples of these landmarks are guardrails, signs, bollards, building corners but also sound from traffic, smells, direction of heat from sun and types of ground material. Therefore, for the navigation of visually impaired people it is necessary to use special route descriptions. But the creation of such descriptions requires trained navigation instructors who have enough experience with work with visually impaired people. Unfortunately, there is typically very limited number of such instructors.

Nevertheless, there is also another option how to obtain route descriptions suitable for the navigation of visually impaired people. Most visually impaired people know very detailed descriptions of routes which they often use. And most of them are also able to present this description to other people. There are definitely much more visually impaired persons than specially trained instructors available.

Therefore, a very interesting option is to facilitate direct collaboration between visually impaired people and to allow them to share their knowledge about certain places. The mutual collaboration of visually impaired people has a great potential and can be a very interesting option in the field of navigation of these people. Because, it is just visual impaired person who knows the best way to help another visually impaired person.

Currently there are researches which show that the majority of visually impaired people already collaborate on navigation and consider environment description from the other visually impaired. An example of these researches is [10]. In this research it was proven that there are satisfactory basic conditions for the creation of collaborative navigation system for visually impaired people. It was shown that lost visually impaired people prefer information from another visually impaired person than information from sighted person who does not have any experience with navigation of the visually impaired. It was also shown that most of visually impaired people are able to navigate or to be navigated by another visually impaired person and also have experience with remote navigation by phone. Other important finding is that most of visually impaired people have no concerns about location tracking for

the purpose of the help to other visually impaired persons.

From these findings we can decide that navigation system based on the mutual collaboration of visual impaired people should be realizable. However, there are of course a lot of important questions and issues which have to be answered and verified. This is also one of the tasks of this thesis.

2.3 Spoken dialogue system

This section is based on the paper of Michael F. McTear [11].

The computer which will be able to communicate with human through spontaneous and unconstrained speech has been the goal of researchers in speech technology and artificial intelligence for more than 30 years. Currently there are some spoken dialogue systems which get us closer to this goal. And all these systems consist of several functional parts which will be described in sections below. However, all these systems have still several limitations which must be taken into consideration and which will be highlighted in the corresponding sections.

The spoken dialogue system itself can be classified into three main types, according to the method which is used to control the dialogue with a human:

Finite-state based system: The most of commercially available systems use this type of dialogue control strategy. In these systems the user is taken through a dialog consisting of sequence of pre-determined steps. It means that the flow of the dialogue is defined as a set of states with transitions denoting various alternative paths. System produces questions or prompts at each dialogue state, then it recognizes the user's response of user and according to this response it produces some actions. Generally, these systems restrict user's input to pre-determined single words or phrases. Verification of recognized information can be done either at each state or at the end, after obtaining all necessary information. Here is a small example of an interaction with the finite-state based system which verifies the user's response at each state:

System:	*What is your destination?*
User:	*London*
System:	*Is that London?*
User:	*Yes.*
System:	*What day do you want to travel?*
User:	*Friday.*
System:	*Was that Sunday?*
User:	*No.*
System:	*What day do you want to travel?*

Frame based system: In these systems the user is asked questions that enable the system to fill slots in a template in order to perform a particular task. It is important that the dialog flow is not pre-determined but depends on the content of the user's response and pieces of information that the system recognize from it. Verification of recognized information is typically done at the end of

the dialogue, after obtaining all necessary information. Here is a short example of an interaction with the frame based system:

System: *What is your destination?*

User: *London*

System: *What day do you want to travel?*

User: *Friday.*

System: *When do you want to travel?*

User: *Around 10 in the morning.*

System: *You want to travel from London on Friday around 10 in the morning?*

User: *Yes.*

System: *I have the following connection ...*

In the example above the user provides always only one item of information at a time. Therefore, the interaction with the system is practically the same as the interaction with the finite-state based system.. But the advantage of the frame based system is that the user can also provide all the necessary pieces of information only in one response, here is a short example:

System: *What is your destination?*

User: *London on Friday around 10 in the morning.*

System: *You want to travel from London on Friday around 10 in the morning?*

User: *Yes.*

System: *I have the following connection ...*

Agent based system: These systems are designed to perform complex communication between the system, the user and the underlying application in order to solve a particular task. There are many variants of these systems based on what specific aspects of intelligent behavior included. The communication itself is viewed as an interaction between two agents, each of which is capable of reasoning about its own action and sometimes also about actions of another agent. The system is able to take into account the previous context and dynamically adapt to it. Typically there are also mechanisms for error detection and correction, and also for prediction of the next user's utterance. Another important feature of these systems is that the user's input is practically unlimited, so the user can take control of the dialogue and use spontaneous and unconstrained speech to interaction with the system. Therefore, the system has to be able to understand to natural human language. Here is only a small example of an interaction with the agent based system in which the system is trying to adapt to the user's input and to offer another alternative to his request:

User: *I'm looking for a job in the Calais area. Are there any servers?*

System: *No, there aren't any employment servers for Calais. However, there is and employment server for Pas-de Calais and an employment server for Lille. Are you interested in one of these?*

2.3.1 Speech recognition

The main task of the speech recognition component is to convert the input speech into a string of words. But within this process it is necessary to consider the high degree of variability in the speech signal. Below are some of the most important factors which have to be taken into account:

Linguistic variability: Effects on the speech signal caused by various linguistic phenomena. Typical example of these effects is co-articulation - same phoneme can have different acoustic realization in different context.

Speaker variability: A very important factor are also the differences between particular speakers. There are many attributes which have to be considered. For example physical factors, age, gender, regional origin, etc.

Chanel variability: The effect of background noise and transmission channel, such as phone and microphone. The ideal system should be able to extract sequence of words regardless of environmental disturbances.

Properly functioning speech recognition is crucial for the spoken dialogue system because other components of the system depend on the correctness of conversion of the speech input. Therefore, a speech recognition component should comply following properties:

Speaker independence: Recognition should be able to properly work for as wide range of potential users as possible. Therefore, the recognizer cannot be tested only on small group of speakers, but must be tested on wide variety of speakers who should represent all potential users of the final system. Unfortunately, speaker independent systems are generally more error-prone than speaker dependent systems.

Vocabulary size: Within the interaction with the system, the user should not be constrained by the limited size of system vocabulary and should be able to use all words which commonly uses during the normally communication. Therefore, flexible system should be able to work with vocabulary which consists of thousands words at least.

Continuous speech: User should be able to speak normally to the system, not only in isolated words for example. However, generally it is very difficult to detect boundaries in continuous speech because there are not some physical separations.

Spontaneous conversational speech: The user should be able to communicate with the system through natural and unconstrained speech. System should be also able to extract from the user's speech the relevant sequence of words, from which the user's meaning could be computed.

The basic process of speech recognition involves finding a sequence of words, using a set of models acquired in a training phase, and matching these with the incoming speech signal. The models are typically some units of sounds such as phonemes. Recognition itself is typically based on the principles of probability because all the above described factors have to be considered.

2.3.2 Language understanding

The main task of the language understanding component is to analyze a sequence of word, which is an output of the speech recognition component, and determine the meaning of these words. This process involves mainly syntactic analysis, which enables to determine the constituent structure of recognized string, and semantic analysis, to determine the meanings of the obtained constituents.

One of the basic principles of language understanding is the principle of compositionality, which can be in this particular case understood as „the meaning of a sentence is a function of the meanings of its parts". This means that the sentences are analyzed on the basis of their constituent structure because each syntactic rule has a corresponding semantic rule and the analysis of the constituent structure will lead to the semantic analysis of the sentence as the combination of the meanings of the individual constituents identified by the syntactic analysis.

The language understanding itself is a very complicated process. And this process is further complicated by the fact that the sequence of words, which should be analyzed, often does not have a grammatically well-formed form. There are typically features of the spontaneous speech, such as sentence fragments, emotional expressions, afterthoughts, slips of tongue, ungrammatical combinations, etc. Therefore, there is an effort to develop techniques, which will be able to solve all these problems.

The exact realization of the language understanding can be among particular systems different, but all of them usually contain two basic parts - lexicon and grammar. The lexicon consists of concrete words and descriptions of their relevant syntactic characteristics. The grammar consists of phrase structure rules and equations which determine how particular words from the lexicon can be combined in well-formed sentences.

2.3.3 Dialogue management

The main task of the dialogue management component is to control the flow of the dialogue with the user and potential external application. Therefore, dialogue manager, among other things, have to be able to determine whether all necessary information has been already obtained from the user, or whether it is necessary to ask the user for some further details.

A typical problem which the dialog manager has to solve is an incorrect input from the user. This can be caused by the absence of some necessary information, but also by their incorrect form. The simplest way to deal with this problem is to inform user about and ask him for the reformulation of his input. But this solution is often unsuitable and for many users can be also annoying. Therefore, a number of different solutions have been proposed. And because of user's input is at first processed by the speech recognition and language understanding modules, these solutions can also utilize some higher level knowledge sources to better interpretation of the user's input. And thanks to this, the dialogue manager can be able to use information even from the incorrect inputs. These knowledge sources use interpretations based on various principles:

Interpretation based on speech acts: A speech act is defined as the function of an utterance. Speech acts analysis involves a higher level of analysis than syntactic and semantic analysis because considers also refer to external information, such as dialogue context, user's desires, etc. For example, utterance „it is cold in here" can be understood as a description of the level of temperature. But in

another context it can be also understood as a request for some action, such as closing a window.

Interpretation based on the discourse context: Discourse context is often used to interpret items which refer to other items that have been mentioned previously in the dialogue, such as pronouns (he, she, etc.) and deictic expressions (the next one, the previous flight, etc.). But discourse context is also important to interpret the input that is incomplete due to ellipsis because the missing parts can be recovered only from the previous context. For example, to the question „which flight do you wish to book?" the user says „the London one" - on the basis of preceding question can be user's incomplete answer in this case interpreted as „I wish to book the London flight".

Interpretation based on the dialogue structure: This kind of interpretation is based on the expectation. The main idea is that at each section of the dialogue there are constraints on what can be said in the following section. And these constrains can help to determine which grammatical and semantic rules need to be active in each particular section of the dialogue. For example, if a closed question is detected in some section of the dialog, the system will expect yes/no answer in following section and therefore can work only with a very limited vocabulary there.

Interpretation based on a user model: The Information about user itself is further important knowledge source which can be used for more precise interpretation of his utterance. Detailed user model, contains his beliefs, goals, plans, etc., enables the system to guess the meaning of the incorrect input from this user.

Techniques described above enable the dialog manager to compensate and guess the meaning of an incorrect input without further consultation with the user. But it is obviously necessary to use some kind of verification to confirm that the assumption obtained by these techniques actually corresponds to what the user originally intended to say. There are several different ways in which the dialog manager can perform this validation:

Explicit verification: The simplest way to verify correctness of obtained assumption is to ask straightly to the user. This can be realized directly by a simple question, to which user answers yes or no, for example: „Do you want to go from Trento to Milano? Yes or no?". Although this is a very robust authentication method, there are also some disadvantages, such as annoyer for the user and increasing the length of the dialog.

Implicit verification: In this case, the system embeds into the next question also a repetition of its understanding of what the user said. It is important that the user can still correct the repeated statement. But if the user answers the question without any correction, the assumption is implicitly confirmed. Here is a short example of this strategy:

User:	*I want to travel from Milano to Roma.*
System:	*At what time do you want to leave form Merano to Roma?*
User:	*No I want to leave from Milano in the evening.*

This verification strategy is closer to a natural conversation, but there are also some problems which have to be taken into consideration. The main problem is that this technique can lead to a wide range of possible responses which may put greater demands on the recognition and understanding process. Another important problem is also the complexity of the generation of itself question which should contain several potentially independent information because the system has to be able to generate it on the fly.

A precise dialogue management component is for the spoken dialogue system crucially important. But due to the above described problems its practical realization is very complicated because there are many issues and factors which have to be considered.

2.3.4 Communication with an external system

Spoken dialogue systems typically require some form of communications with an external source of information. This source is commonly a database, but it can be, for example, also some knowledge base or a planning system. In the following sections typical possibilities of the communication with external systems are described:

Communication with a database: In the context of the spoken dialogue system is the communication with a database often regarded as a simple and straightforward process. But there are many aspects which can complicate this process. In the following sections some typical problems that may occur are described:

Vocabulary of the dialogue doesn't match the vocabulary of the system: One of the possible solutions of this problem is to add to the system architecture special component called Information manager, as is shown on figure 2.1. In this architecture are separated dialogue and information aspects of the system and all complex information processes are performed by the Information manager which is responsible for the associations in vocabulary, such as synonyms, homophones, etc., the manipulation of database hypotheses, such as scoring of partial and complete entries, and the interaction with the database itself.

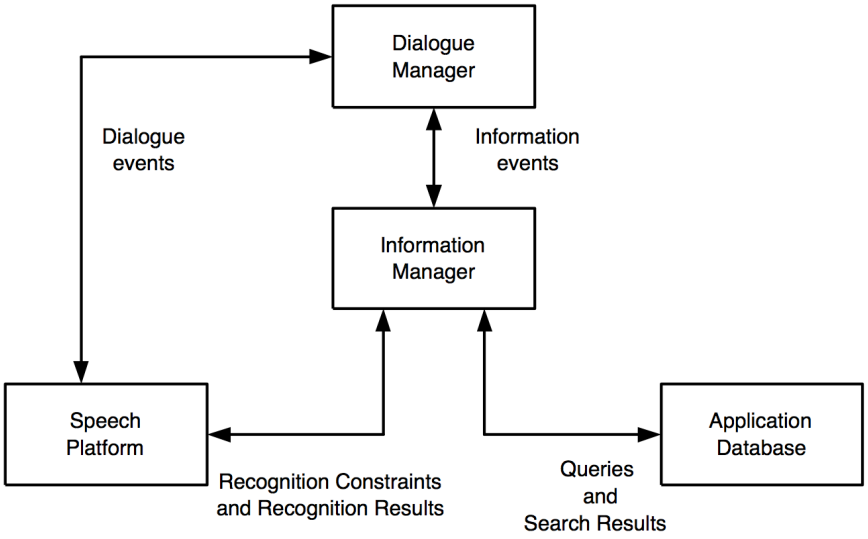

Figure 2.1: The system architecture including the Information manager. Taken from [11].

No straightforward response is possible: While working with a database it has to be considered that the user typically knows neither the world model which is represented in the database nor the database content. Therefore, it cannot be expected that the queries from the user will be properly formulated, but it is necessary to presuppose general and ill-formed queries.

Retrieved data is indeterminate: While working with a database it is also necessary to consider that data retrieved from the user can be ambiguous. For example, the phrase „in 7 hours" can be understood as „in 7 am", but also as „in 7 pm".

Communication with a knowledge base: Communication with a knowledge base is required for the systems which support problem solving rather than only information retrieval. The architecture of these systems typically involves several additional components which are necessary for the solving of particular problem. An example of such architecture is shown on figure 2.2. In this case, there are a domain processor which is a application-dependent component and contains all important information about application domain, a general reasoning component which is a domain-independent component and contains the general mechanisms for reasoning with the knowledge from the domain processor, and a knowledge component which is also application-independent and contains knowledge relevant to task-oriented dialogues, such as how a complex actions can be decomposed into series of sub-actions. The cooperation of these components is controlled by a dialog controller.

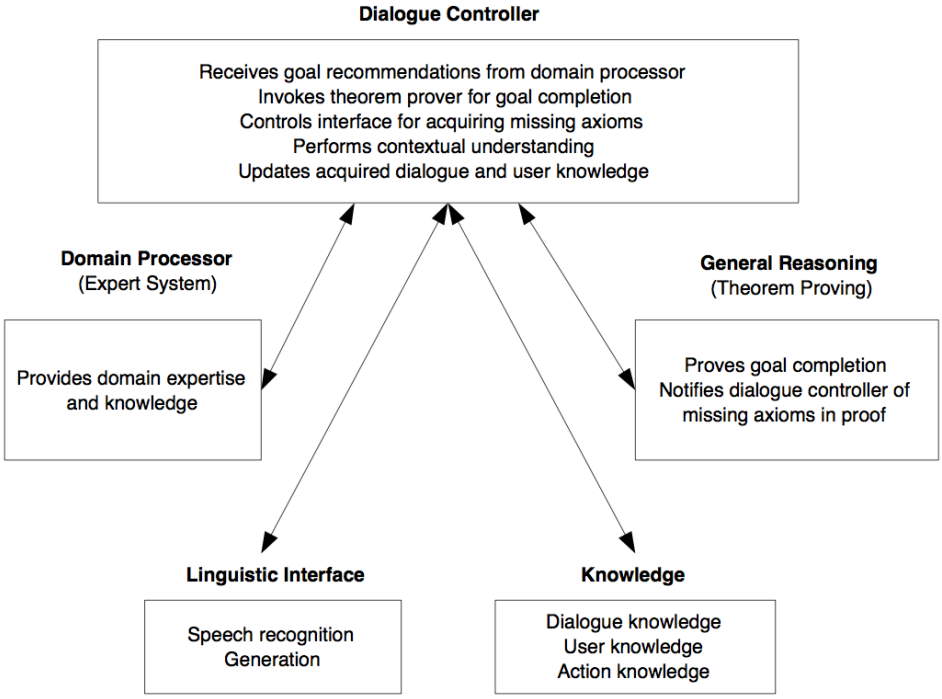

Figure 2.2: The architecture of the problem solving system. Taken from [11].

Communication with a planning system: Problem solving can be also achieved through the use of a planning system. The main difference from the previous case is that the knowledge base systems have typically an explicit goal at the beginning of the dialog and the way how to achieve it is practically still same. Contrary to this, the planning systems support reasoning about goals so the user's goals, believes, desires and intentions are reasoned during the course of the problem solving. These systems generally include two main algorithms - the incorporation algorithm which is focused on the plan recognition, and the elaboration algorithm which supports construction of the plan by means-ends planning.

2.3.5 Generating a response

The main task of the response generation component is to construct the message which should be spoken to the user. In order to have this done it is necessary to specify information that should be contained in the message, structure of this information and the form of the message itself, such as particular words and a syntactic structure.

Generally, from the perspective of the construction of a message, there are four main categories of the message content:

Unchanging text: Parts of a text which are always present in a message.

Directly-available data: Information which has been retrieved from a database or knowledge base.

Computable data: Information which is from the data as a result of some computation or reasoning.

Unavailable data: Extra data which supplement the main information.

Each dialogue system should be able to use at least the first three content categories. The unchanged text forms the constant parts of a message, direct-available data conveys the information that was requested and computable data summarizes the information or requires some more specific choice form the user.

Currently there are several possible techniques how to generate a message. The simplest is insertion of the retrieved data into pre-defined slots in some prepared template. But it is also possible to use more complex methods based on a natural language generation techniques. These methods are able to take into account user's goals, knowledge and also the previous dialog content, so they can provide a response which is consistent and coherent with the user's input. But it is necessary to consider that the realization of these methods is much more complicated because they have large computation demands.

2.3.6 Speech output

The main task of the speech output component is to translate message generated by the response generation component into a spoken form. In the simplest cases it is possible to use pre-recorded messages into which some necessary content can be inserted, for example:

You have a call from <Jasopn Smith>. Do you wish to take the call?

In this case, a variable content is in angular brackets and it is the only part which must be synthesized, the rest of the message is pre-recorded.

The previous technique works well for constant messages, but more complex spoken dialog systems require the ability to synthesize variable and unpredictable messages, because a large amount of information have to be processed and spoken out for the consistence of the dialog with a user. Therefore, in these cases it is necessary to use text-to-speech synthesis.

The process of the text-to-speech synthesis consists of two main parts, the text analysis and the speech generation. The text analysis involves the analysis of the text that result in a linguistic representation which enable to synthesize a speech waveform in the speech generation stage. The text analysis itself consists of four tasks:

Text segmentation and normalization: In the phase of the segmentation text separated into units such as paragraphs and sentences is given. Sometimes, this structure can already exist in the given text, but it is often necessary to process some ambiguous markers - such as dot which can be understood as a finishing of the sentence, but also as a mark of abbreviation, a component of a date or a part of an acronym. The normalization involves the interpretation of abbreviations and other standard forms, such as dates, times, currencies, etc., and their conversion into a form that can be spoken. In this phase is also often necessary to solve ambiguity, for example, „st." can be interpreted either as „street" or as „saint".

Morphological analysis: The morphological analysis is required to deal with a problem of the pronunciation of a large amount of words that are morphological variants of one another. Because a pronunciation dictionary typically contains only the root form of each word, such as the word

„write", and related forms of this word, such as „writes" or „writing" in our example, are derived by morphological rules.

Syntactic tagging and parsing: Tagging is required to determine the parts of speech of words in the text and to permit a limited syntactic analysis. It is necessary to consider that some words can have alternative pronunciations depending on their part of speech. And the part of speech can also affect stress assignment within a word.

The modeling of continuous speech effects: The main objective of this task is to achieve a naturally sounding speech when words are spoken to the user in a continuous sequence. In this task is necessary to deal with weak forms of words which involve mainly function words, such as preposition, determiners, etc. These words are often unstressed and therefore have reduced articulation in continuous speech. Another problem is co-articulation that affects word boundaries which have the effect of deleting or changing sounds.

For the purpose of a naturally sounding speech, there is an increasing concern with a generation of prosody in speech synthesis. The prosody involves phrasing, pitch, loudness, tempo and rhythm, and has a large impact on user's feeling of interaction with the system.

The speech generation involves mapping from an abstract linguistic representation of the text to a parametric continuous representation. Two main methods which can be used to model speech, are articulator synthesis which models characteristics of the vocal tract and articulators, and formant synthesis which models characteristics of the acoustic signal. Alternatively, it is also possible to use an older method which uses a database of pre-recorded units of speech and combines them to reach a final message.

2.4 Related project

Currently there are some existing projects which have a similar vision like this thesis. A very interesting example of these projects is LUNA [23].

LUNA is a three-year international project focused on the problem of real-time understanding of spontaneous speech in the context of advanced telecom services. The main objective of LUNA is the creation of a robust natural spoken language understanding toolkit for multilingual dialogue services, able to carry out human-computer communication with a good degree of user satisfaction. The vision of LUNA is to improve current automated telephone systems allowing easy human-machine interactions through spontaneous and unconstrained speech, replacing menu-driven voice recognition. The project aims to enhance the users' experience, helping callers in using vocal services quickly and accurately [23].

The most interesting thing on the LUNA is the very similar goal of this project. The vision of LUNA is to improve current automated telephone systems. There are differences in intended domains, this thesis is aimed at the problem of navigation of visually impaired people and LUNA is focused on the field of public transport. But both projects aim to allow easy human-machine interactions through spontaneous and unconstrained speech and replace classic sequence telephone automats which are often unsuitable and unpleasantly for many users.

Another important point is that one of the languages, with which the LUNA works, is Polish. The Polish language is very similar to Czech, so there are many very similar problems that are necessary to

consider, such as inflection and shortening of proper names, informal terms, emotional expressions, etc. Due to this similarity it is possible to use some findings and techniques from LUNA project within the solving these problems in this thesis.

On the example of LUNA project is also possible to prove that the vision of this thesis is truly realizable. And it is even realizable by current technological resources because a team from LUNA project was able to create functional prototype. This finding is very important for the further work on this thesis.

2.5 Summary

On the basis of the above mentioned resources, it is possible to say that currently there already exist technologies that are necessary to realize the main vision and also all particular objectives of this thesis. There are also some researches that provide the basic insight into the problematic of navigation of visually impaired people and that can be used as a base for the further research that will be necessary for the purpose of this thesis. On the other hand, there is not any existing project that tries to use these available resources and put them together to really improve of ordinary life of visually impaired people, which is the main ambition of this thesis.

2.5.1 The project workflow

From the above mentioned resources, especially from the LUNA project, it is also possible to make a better idea about tasks that need to be solved and phases that will be necessary to pass through in the realization of the vision of this thesis. Therefore, we can prepare a basic workflow of a further process:

- At first, it will be necessary to realize detailed initial research that provides a complex insight into the issue of the navigation of visually impaired people and investigate the possibility of realization of intended objectives of this thesis. This research should focus especially on the navigation of visually impaired people in a urban area, possibility of recovering via phone in a situation when visually impaired people lose orientation and willingness of visually impaired people to mutual collaboration.
- Then it will be necessary to deal with many practical problems relate to spoken dialog system. At first, it will be the speech recognition because it will be necessary to convert spoken words into a plain text. Such conversion is a very complex and sophisticated process, but currently there already exist many possible solutions for this, so in this task we will collaborate with some external subject.
- The most important issue related to spoken dialog system will be the practical realization of language understanding. The ability to understand human speech is crucially important for the intended system, but simultaneously the language understanding is one of the most difficult areas of natural language processing. Therefore, at first it is necessary to process detailed analysis of intended domain. To reach this, it is required to prepare corpus of human-human dialogs from target domain which enable us to define precise ontology of this domain through which will be possible to learn the final system to understand to human speech. To achieve this, it is necessary to perform the following steps:

1. Prepare a corpus of human-human dialogs from target domain. Because of the quality of results, it is generally necessary to obtain at least dozens of dialogs.
2. Segmentation and transcription: Recorded dialogues will be converted into plain text and consequently processed. Output of this process will be XML files which include the dialog text and also other metadata referring to articulation distortions, speaker and non-speaker noises, and time-stamps. To make the further processing of these data easier and the form of files more uniform, it is suitable to define and apply some conventions here.
3. Morphosyntactic annotation: In this phase will be dialogs annotated with morphological tags. At first morphological characteristic of particular words will be identified. Then the text of the dialogs will be segmented into syntactic chunks. After this process words will be grouped into basic nominal phrases and verbal groups.
4. Semantic annotation: The semantic annotation of natural language is very difficult as it requires preparing a detailed model of the target domain and then also a method of assigning its elements to the particular words. Therefore, this phase will consist of the following subtasks:
   (a) Domain ontology: The domain ontology is one of the possible methods for the representation of semantics. It will be necessary to describe a typology of classes and their properties, such as type of values and cardinality.
   (b) Attribute level annotation: This is the first level of the semantic annotation. Names and values from defined ontology are assigned to phrases which realize them.
   (c) Predicate level annotation: Due to the fact that a predicate structure is generally represented in a FrameNet, which is a format for a connection between phrases and roles that they realize, it will be necessary to find out whether it is possible to use some existing Czech FrameNet in this task. And if not, it will be necessary to extract all domain related verbs from the dialog corpus and define all needed frame patterns.
   (d) Anaphoric relations: On this level of the semantic annotation is performed annotation of anaphoric relations. Expression is marked with a label „new" or „given" depending on whether the related to it concept appears in a dialog for the first time, or it refers to a previously mentioned concept. It is also possible to express some relations between concepts assigned to phrases here.

- In the next phases of the project it will be necessary to implement also other parts of the dialog system. This means particularly to define dialog manager to control the flow of the dialogue, determine communication with some external system and deal with the generating a response and the consequent speech output.

3 Analysis and design

This section presents the detailed analysis of the issue of the navigation of visually impaired people and also the first approach to the proposal of the intended assistance center.

3.1 The intention

At the beginning it is suitable to present the context of this work - you can see a simplified situation schema in the figure 3.1. This thesis aims to research the problem of the navigation of visually impaired people and on the basis of the outputs of this research it proposes the new way the new way of help in situations when they lose orientation. Therefore, this work stems from currently existing studies in this field and tries to expand them and bring some new relevant findings. The prospective outputs and findings from this thesis would be useable for example in the project NaviTerier [36] which tries to propose the navigation system for visually impaired people, especially in the work of Jan Balata who tries to propose the collaborative navigation system for visually impaired people [35].

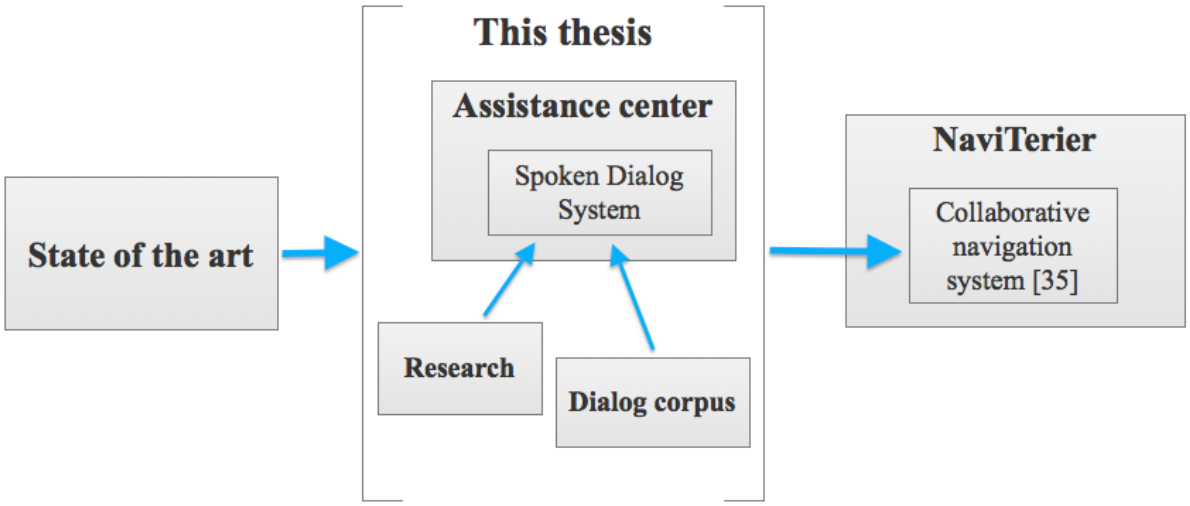

Figure 3.1: A simplified situation schema of the context of this thesis.

Due to the workflow mentioned in section 2.5.1 on page 16, it is at first necessary to deal with the realization of the initial research that would provide a complex insight into the issue of the navigation of visually impaired people. This research will be divided into two separated parts, a qualitative and a quantitative study. At first the initial qualitative study that provides the desired insight into the intended problematic will be realized. The main output from this study will be a series of hypothesis that will be consequently verified in the quantitative study. Because of accuracy and precision of results, this study will have a form of ethnographic field study. This approach ensures the maximal correctness of final results because it is realized directly in the natural environment of the researched people.

The results from the performed research enable us to understand better the issue of the navigation of the visually impaired people and thanks to this step up to proposal of the system for the intended assistance center. At first it will be necessary to deal with the problem of spoken language understanding to ensure interaction between the user and the intended system through natural and unconstrained

speech. To reach this, it will be necessary to understand the structure of communication between humans, concretely communication between a visually impaired person who lost orientation and some other person who try to help him via phone. But understanding to the structure of this communication requires a sufficient corpus of relevant dialogues that makes it possible to identify and describe basic communication patterns. These patterns can be consequently converted into a system-readable form and thus makes it possible to teach the future system to communicate with a human through natural speech.

3.2 The initial research

The main objective of this research is to obtain the initial insight into the issue of the navigation of visually impaired people.

3.2.1 An analysis of the problem

Strategies that blind people use for the orientation may differ greatly. Some people use a cane for the blind, others have an assistance dog. For their own navigation they can also use many different landmarks that people without visual impairment do not notice. Some blind people use only their familiar routes and they take unfamiliar routes only with an assistant. Others use a variety of aids for navigation, or walk by special descriptions of routes from assistance centers. And some of them do not go out at all.

But the fact is that a loss of orientation is a very stressful situation for all blind people. This of course applies to all people, but for the blind this stress is multiplied by the fact that they cannot simply look around, so recovery is very difficult for them. They are often dependent only on the help from a neighborhood in such situations. Therefore, the main aim of this research is to find the best way to help them in such situations.

3.2.2 The target group analysis

Blind people are a very specific target group. There are several facts which are necessary to take into account while working with them. In the first place it is, of course, their blindness. This study focuses primarily on people with practical and total blindness, so on those persons who are unable to perceive practically any suggestions through their eyes. Therefore, it will be necessary to adapt some of the methods of data collection - such as a questionnaire, in which questions will need to be either read or written in Braille, however not all blind persons are able to use Braille.

It is also necessary to expect a certain distrust of blind people because communities of these people are typically relatively closed. Therefore it is necessary to expect, especially at the beginning, their natural wariness and mistrust. To overcome this initial distrust it would be appropriate to avail the contact with some person who already has their trust. For example, this person can be another blind person, who we already know, or with whom we have worked in the past and who is willing to get us into their community. If such a person is not available, we can try to contact organizations which work directly with blind people. Example of such organizations is the United Organization of the Blind and Visually Impaired of the Czech Republic (SONS) [37]. Through workers of these organizations, it

is possible to get into their community and overcome the initial distrust. These workers may also be because of their experience, very valuable source of information about blind people.

Another thing which must be taken into consideration, is the mental state of the people with whom we collaborate in this study. It is necessary to approach to each potential participant individually and work with him accordingly to condition of his mind. For persons who are blind from birth, it can be assumed that their mental state is better than for the people who have lost sight during their lives. Of course, it is not applicable in general. But we can suppose that people who are blind from birth are already reconciled with their condition, accepted it and they are also able to work with this fact. However, for people who have lost their sight during their life, the situation may be different. This is especially true for those people who have lost their sight recently. These people are going through an enormous shock and they must to cope with totally new situation at first. Therefore they are often very distrustful and have no interest in any communication or cooperation with the outside world. This peril can be partially limited, for example, by selecting participants in organizations such as SONS. We can suppose that people in these organizations have already overcome this initial stage, and now they are interested in working with their condition and developing themselves. Thus they could have a bigger interest in possible cooperation.

It is also necessary to adapt the chosen method of data collection to several practical problems. One of these problems is impaired motoric skills, which often accompanies the blindness. Therefore, during the data collection, it is advisable to not use methods which require finer motor skills of participants or the precision work of their fingers. Another practical problem is these people's reluctance to be recorded by a camera. For example, recording of the face can be uncomfortable for blind people because their eyes are often affected in some way. Therefore, we must always forewarn them before recording and allow them, for example, to use dark glasses.

3.2.3 A qualitative study - The first phase

To gain the initial insight into the problem of the navigation of visually impaired people a qualitative study has been realized. In the following text the most important findings from this study are pointed out and analyzed, the detailed specification and setup of the study is described in section 5.1 on page 33

The study was attended by the total of 4 participants. Due to the fact that these participants were quite different, it was possible to observe interesting differences which exist between them in particular topics. The differences in what landmarks particular blind persons use for the navigation were very interesting. There are crucial differences between the navigation of blind people who use only a cane and who use an assistance dog. Blind people who use only the cane often use for the navigation points which can be termed as barriers on the route. This is essentially a guardrail, signs, bollards, as well as building corners and niches. But blind people who have an assistance dog use usually substantially different strategies in the navigation. Therefore, they practically do not use these landmarks for the orientation, but they typically use similar points like sighted people, such as streets, blocks of buildings, parks, etc. Therefore, there is fundamental difference in the descriptions of routes which blind people use depending on whether the particular person uses assistance dog or not. However, all participants agreed that special radios for the blind are very useful. These radios are able to add sound to some important points at the route, such as transitions, stops, or outputs of the metro.

The aim of the study was to find out how blind people behave in a situation when they lose orientation. All participants agreed that they have been in such situation several times. Participants agreed that this situation is unpleasant for them, but, unfortunately, relatively common. Participants also agreed that the best solution in such situation is to accept help from the passers-by. This form of help is the most natural and reliable for them. But the manner in which they would behave in case that such form of help was unavailable was depended on the personal preferences of each participant. For example, participant P3, who can be termed as a technical type, would use GPS in such case. Conversely, participant P2 rejected the use of the GPS.

All participants also agreed on the possibility of help through the phone. Currently, it is possible to use some special assistance center. Example of such centers is an assistance line which is operated by SONS. But in this case, it is typically necessary to carry a special GPS transmitter which must be purchased. Without this transmitter participants do not suppose that an assistance center could really help them. They see the main problem in their ability to describe their current position. So they are not sure that, in the situation when they lose orientation, they would be able to describe to someone over the phone their current location precisely enough to make him able to navigate them. At the same time, however, all participants said that if the situation was reversed - if someone called them and asked them for help in a situation when they lost orientation - they would be definitely able to navigate him. However, it must be a route which they know well and also often use. In this case, they believe that they would be able to lead them to the correct way.

This is a very interesting finding because it leads to the possibility of a new service which could help to blind people in a situation when they lose orientation, and which could extend the range of services which are already available to blind people in such situation. This service would be based on mutual collaboration of blind people. In practice, the service could work in a similar way like a standard assistance center. But this center would have a database of blind persons and also routes which these people know. And if someone who loses orientation calls to this center, they would be connected directly to the person who knows the place where he currently is and who would be able to help him.

For the purpose of extension and specification of this finding, the interview script was modified and the second phase of the qualitative study has been realized.

3.2.4 A qualitative study - The second phase

To extend and specify findings from the first phase of study the second phase of qualitative study has been realized. In the following text the most important findings from this study are pointed out and analyzed, the detailed specification and setup of the study is described in section 5.2 on page 44.

In this phase of the study it was again revealed that a loss of orientation is a common situation for visually impaired people. Especially in conjunction with a public transport in Prague where are often problems with special aids for visually impaired people. Presented imaginary story was real for all participants and most of them have also already had a similar experience.

In performed interviews it was also revealed that most of visually impaired persons rely on help from passerby people when they lose orientation. Participants were asked how would they deal with a situation when they lost orientation in an outdoor environment and a help from passerby persons was mentioned by all participants and for most of them it was their first option. For the rest of them it

was their second option which they would use in the event that they would not unable to resolve the situation themselves.

For all participants it was difficult to say how would they solve that situation if there were no passers-by. Reactions of participants about uses of a mobile phone for call someone in such situation were interesting. Some participants mentioned using a mobile phone in that situation. The rest of the participants were directly asked whether they would use a mobile phone to call someone in such a situation. Some of them answered that they would use it, rest of the participants rejected this option.

However, those participants who rejected using a of mobile phone said, on the other hand, that if they knew someone who knew a place where they lost an orientation, they would probably call them. But there are several conditions which should be met. At first, visually impaired people must believe that the person, who they should call, will be able to navigate them. It means that called person would be able to identify their exact position from their utterances, help them to find some unambiguous point in their nearby and describe them a route from this point to a place which they would already know. Visually impaired people also expect that a called person will use for a description of the route same orientation points that they know and commonly use. These points can be various for particular persons, fundamental differences are for example between persons who use a cane for the blind and persons who use assistance dogs, as it has been already described in the first phase of the study. But performed interviews revealed that for most visually impaired people are the most important those points that is possible to detect by a cane. Other orientation points, such as acoustic points for example, are by the most of visually impaired people perceived as an additional information that can be helpful in some cases but are not crucial for them.

These findings are very important for a further work because on their base it is possible to decide that a remote help through a mobile phone is really applicable for visually impaired people and can be a important aid in the case when other options fail. But it is necessary to deal with the above described conditions. As the most natural solution for this seems to be the use of another visually impaired person at the position of the called person. This solution can really work in practice because visually impaired people have a very detailed knowledge about routes that they regularly use. Moreover, visually impaired people know exactly how to navigate a person with visual impairment and in performed interviews it was again found out that they are convinced of their ability to navigate another visually impaired person by phone.

The above described findings lead again to the possibility of the creation of a assistance center based on idea of mutual collaboration of visually impaired people, as it was already suggested in the first phase of the study. From performed interviews it is also possible to create a basic idea about prospective communication between visually impaired people and such center, but exact form of this communication will always depend on a specific person. Some people for example prefer direct leading by a phone and if they lost an orientation and call to the center, they would hold a called person on a phone until they find their way again. In contrast, other people prefer only one-shot information that would enable them to find a correct route and after obtaining of this information they would end the call and thenceforth continue individually. This approach can be caused by several factors. At first, visually impaired people have often a feel that they bother the called person and do not want to waste his time. Some of participants also said that for them it is difficult to concentrate on a conversation through a phone and walk at the same time. For many of them it is also very important to maintain

the feeling of independence.

One of the intentions of this thesis is the potential automation of communication between visually impaired person and prospective assistance center. For this, it is important to find out how visually impaired people perceive interaction with some automatic system through a phone. In this issue are very important personal preferences of particular people. Some participants would prefer automatic operator. These preferences are again caused by the fact that visually impaired people do not want to bother called person and waste their time because these concerns people do not feel towards an automaton. But most of the participants prefer a human operator because they are afraid that automatic operator would not to be able to understand to their situation and really help them. For many people is also important absence of emotions at an automatic operator because they want to feel an empathy from the second side in a situation when they have some problem. All these findings imply that prospective automatic operator would have to be very advanced because it should be able to adapt to inputs of calling person, communicate with them through a natural speech and also act and react as a human beings.

For the idea of assistance center that would be based on a mutual collaboration of visually impaired people the finding that all participants confirmed their willingness to share their route with other visually impaired people is also important. Many of them even talked about their willingness to participate on a such prospective service. In contrast, against this idea is a fact that the most of participants expressed a concern that in a situation when they lose orientation they would not be able to describe their situation on a phone precisely enough to enable to a called person to really help them. But this statement is in a contrary to a finding that all participants were convinced of their ability to navigate another lost visually impaired person through a phone. Clarify this issue is crucially important for a further work, but this clarification can be reached only through practical experiment in which participants would be really exposed to a situation that they lost an orientation and have to use a phone for the recover. In this experiment would be able to deal with this issue, but also verify a whole idea of the prospective assistance center. Therefore, were formulated described hypotheses that you can see in section 3.2.5.1 and prepared a quantitative research that enable to verify them in a practice.

3.2.5 A quantitative research

From the previous qualitative studies basic hypotheses that are introduced in the following subsection were formulated. For the purpose of practical verification of these hypotheses quantitative ethnographic field study with total 21 participants has been realized. To ensure the validity and correctness of results was this study divided into two parts, both parts have been realized in a different environment. You can see the results and analyze of data obtained within both parts of the study in the subsection 3.2.5.2.

3.2.5.1 Hypotheses for verification

Here is the list of hypotheses that were defined from the findings from the performed qualitative research and which will be verified in the following quantitative research:

- H1: There is a crucial difference between the navigation of visually impaired people who use a cane for the blind and who use an assistance dog.
- H2: When the orientation is lost, visually impaired people are able to describe their situation by

a phone precisely enough to enable the called person to identify their position.

- H3: It is possible to navigate a visually impaired person who lost their orientation by a phone.
- H4: For the remote navigation of visually impaired people the most important orientation points are those that are possible to be detected by a cane.
- H5: When visually impaired people who lost orientation receive the help by a phone, they tend to verify the given information in some way.

3.2.5.2 An analysis of the obtained data

In both parts of this study total 21 phone calls between participants and prepared help-lines were performed. In all these dialogs was proven that the most critical part of communication between visually impaired person, who lost an orientation, and second person, who tries to help him remotely via phone, is the exact identification of the place where the lost visually impaired person actual is. To reach this, it is necessary to lost person describes his position precisely enough to enable the second person to identify the particular place. Of course, there is the fundamental assumption that the second person knows very detailed the particular place where the lost person actual is. Without this assumption is remote help via phone practically impossible without some other additional information, such as GPS coordinates of lost person for example.

The concrete ways how a lost visually impaired person can describe his exact position on a phone can be mutually different, but there are several common factors. All participants use for the description of their environment only those points that can be detected by a cane. The only other information that they often use was the intensity of traffic in their neighborhood. Another orientation points, such as smells or hearing points, participants did not use. These findings confirm the hypothesis H4.

Within the attempt to describe their actual location into a phone, all participants also described the way how they got to their current position. In this issue was again proven that there is a crucial difference between navigation of visually impaired people who use a cane and who use an assistance dog. In the group of participants were two people who regularly use an assistance dog. Both these people did not successfully reach the target of the route, one of these people even did not able to describe his position precisely enough to enable to the called person to identify his position. It was shown that people who use an assistance dog had a significantly greater problem to describe their position than people who use a cane. This phenomenon is caused by the fact that visually impaired people with an assistance dog are typically not accustomed to perceive as many details from the route as people with a cane are. Therefore, these people have generally significantly fewer details that they would tell on a phone. Due to this fact, it is possible to say that hypothesis H1 was confirmed.

The hypothesis H2 was also confirmed because total 18 participants out of 21 described their position into the phone sufficiently precise to enable to the second person accurately identify their position. In total 3 cases wasn't the exact position of particular participants successfully identified by the operator - in 2 cases it wasn't identified at all, in 1 case was identified incorrectly, so the participant was navigated to the wrong place.

Out of 18 cases, in which the exact position of calling person was successfully identified by the operator, were total 17 participants navigated to the right place, concretely to the restaurant Lemon

Leaf. The failure in the remaining case was caused by the fact that the participant felt too tired to continue to the next phase of the route and therefore finished the call with the operator. These findings confirm the hypothesis H3 because it was proved that it is possible to successfully navigate the lost visually impaired person via phone. But only with the assumption that the called person successfully identifies the exact position of the calling person.

In the research it was also found out that most of the participants tended to verify the information that they got from the phone. This fact was proved in several aspects. Practically all participants were moving during the receiving of information and tried to find out the points that the called person told about. Total 11 participants either required a repeat of given information or repeated the information and asked for their confirmation. Total 7 participants even held the called person on the phone to the end of the route and constantly checked the accuracy of their course. All these findings confirm the hypothesis H5. This approach was anticipated because all people who lost their orientation experience strong feelings of insecurity and uncertainties and this state is even stronger in the case of visually impaired people. Therefore, they feel the eminent need to eliminate this feeling by the identification of some points in their neighborhood and due to this they regain the sense of certainties.

3.3 Communication patterns

Inspired by the initial research and state of the art analysis we attempt to define the general dialog structure in this section.

3.3.1 An analysis of the problem

Human communication is a complex discipline that consists of many elements, from which the verbal and nonverbal communication are surely the most important. But also the verbal communication itself, on which this work is aimed, is a very complex issue. There are many elements and factors that must be considered, such as context of a whole dialog, relationships between actors and their current state of mind, but also individual dispositions and characteristics of particular people or disruptive effects for example.

Also communication skills and abilities of particular people are mutually very different as well as their approaches to the communication. Therefore, it is practically impossible to identify some general communication patterns that would be applied to all people. But it is possible to reach this on some specific and exactly defined domain and this is precisely the case of this thesis. Therefore, the main aim of this part of work is to identify general structure and patterns in communication between visually impaired person who lost orientation and some other person who try to help him via phone.

3.3.2 The general dialog structure

As it has been mentioned above, a generalization of the structure of human dialogs is a very complex problem. To deal with this problem it is necessary to obtain sufficient corpus of relevant dialogs from the target domain that enables to identify and describe general dialog patterns. In the case of this work, the corpus was obtained during the quantitative research - it was collected total 21 dialogs in which lost participants called the prepared helpline and tried to find the way to the target of the route in

cooperation with the operator. On the base of these dialogs, that is possible to find in the attached files, was identified the general dialog structure which is shown in the figure 3.2.

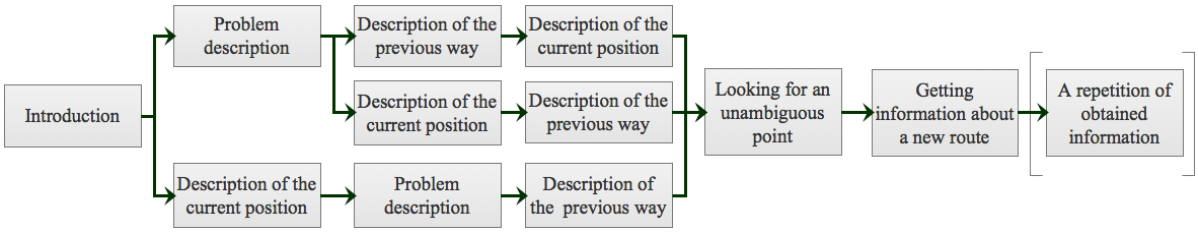

Figure 3.2: The general structure of the obtained dialogs.

Collected dialogs confirmed that very important aspect of communication between lost visually impaired person and some other person who try to help him via phone are individual abilities of particular people. Some people were able to precise and understandable describe their situation and exact position, but for others was the passing of such information very difficult. It was also unveiled that the most important part of the dialog is the identification of the exact place, where the calling person currently is. Without successful identification of this point the called person is not able to navigate the calling person correctly. It was also revealed that for exact identification of position of calling person is necessary to find some unambiguous point on which both sides would agree. The identification of such point enables to the called person to recognize the precise position of calling person and consequently also navigate him from this point.

In practically all collected dialogs were also present the same dialog sections, as is possible to see in the figure 3.2. The order of these sections was in individual dialogs various, but their content was still same:

The introduction: The dialog is commonly started with the greeting that is followed by introduction of calling person, eventually information about where the calling person intends to call.

The problem description: In this section calling person typically gives basic information about his problem, such as that he has lost and the place to where he wanted to go. This section typically follows immediately after introduction section and often is connected with the information about current position of calling person and his previous way.

The description of a previous way: In this section of the dialog calling person describes how he has got into his current position. For this description uses calling person all details about the passed route that he was able to remember. This section is typically connected with the description of current position of calling person because he typically tries to specify his position by all available information.

The description of the current position: In this section calling person typically describes all points that he has been able to identify in his neighborhood - that means all points that he has been able to detect by his cane. For more precise specification the calling person often describes also how he has got into this position.

Looking for an unambiguous point: This section is crucial important for the success of whole call. In this section both sides try to find some unambiguous point in the neighborhood of the calling

person on which they would agree. Without finding of this point, the called person can't successfully navigate the calling person because he isn't able to identify his exact position. Sometimes, the called person is able to identify this point only on the base of the description of current position of the calling person, but more often is required mutual communication and intensive effort of both sides to identify such point.

Getting information about a new route: When the called person successfully identifies the exact position of the calling person through some unambiguous point, he can describe him the right way to place where the calling person originally wanted to go. In this description is the important to the called person use the same orientation points that the calling person knows and commonly uses.

The repetition of obtained information: This section is optional. Some people tend to verify the information that they receive from a phone. They are typically moving during receiving the information and try to find out the points that the called person is talking about, or they repeat the obtained information themselves and ask for their confirmation. Some people also tend to hold the called person on the phone to the end of the way.

4 Implementation

In this section practical implementations that were realized within this thesis are presented.

4.1 A mobile navigation application

For the purpose of the quantitative research a functional prototype of mobile navigation application was implemented.

4.1.1 Visual design

The application is designed primarily for blind users. But target group of application includes also visually impaired people and there is also possibility of using by sighted people yet. Therefore visual design of the application cannot be ignored. Accordingly, emphasis is placed mainly on simplicity and lucidity of the interface.

For that reason, the user interface of the application consist of only one main screen (see figure 4.1). This screen contains a matrix of buttons with two columns and three rows. These buttons are ordered by lines from the top left corner. First five buttons represents key points on the route, the last button allows direct connection with an assistance center.

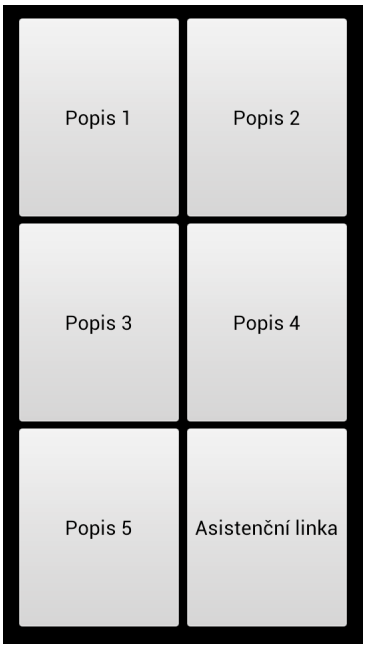

Figure 4.1: The main screen of the application.

4.1.2 The application control

The user can operates application by sliding his finger over the display and listening to the speech output which reads the label of the button which is currently located under the finger. By releasing the finger

the appropriate button is activated. When the user's finger stays above the same button for more than 5 seconds, label of this button will be read again.

4.1.3 The application functionality

The application is designed especially for the part A of the quantitative research (see section 5.3.3.1), therefore the concrete content of the application is related to the route presented in section 5.3.3.1 on page 56. The first five buttons represent key points on the route. After activation of one of these buttons, the description of appropriate point will be read.

The last button - in the bottom right corner - allows direct connection to the prepared assistance center. After its activation the application will immediately call the number of this center. The concrete phone number of the center can be anytime changed in text file that is included in applications directory on SD card (/StructCom_TestApp/phone.txt).

4.1.4 Technical requirements

The application is written for mobile phones with Android OS [38] v 2.1 and higher. The application supports touch-screens with any resolution - size of buttons will be automatically adapted to current screen. For proper functioning of the application it is recommended to have installed SVOX Czech [39] on the phone, eventually other text-to-speech module which enables synthesis in Czech language.

4.1.5 The evaluation of the application

The Application was tested during the quantitative study (see section 5.3). Within this test it was proved that the application is fully functional and provides easy and natural handling for users.

4.2 The assistance center

In this section the first approach to realization of the proposed assistance center is presented.

4.2.1 The concept of the assistance center

The vision of this thesis is the creation of a specialized assistance center for visually impaired people that will enable their mutual collaboration in the situation, when some visually impaired person lose orientation and needs to recover from this situation by using a phone. The basic principle of the intended assistance center is simple - lost visually impaired person calls to the center, describes his problem and current position and consequently will be connected with another visually impaired person who knows the place where he currently is and who is able to help him. Performed researches proved that this model of cooperation is realizable and can be functional in the practice.

The part of the vision of this thesis also is that the intended assistance center will be operated by the automatic adaptive system that will be able to communicate with the user by the natural and unconstrained speech. The automation of the operation of the assistance center has several advantages. At first, it is surely availability of the future center because system without human operation is able

to work 24 hour a day, 7 days a week. Another important advantage is also elimination of unpleasant feelings on the side of calling person because as was unveiled in the performed research, many visually impaired people do not ask for help through the phone because they have a feel that they bother the second person and waste his time. These feeling are eliminated in the case of the machine.

But a use of automatic operator has also some disadvantages. The main disadvantage is the distrust of the people because as was revealed in the performed research many people believe that inhuman operator would not be able to understand to their situation and help them. Another disadvantage of the automatic operator is absence of the feelings because for many people is very important empathize from the second side. Therefore, the prospective system that will act as the automatic operator would have to be very advanced because it should be able to adapt to inputs from calling person, communicate with him through a natural speech and also act and react as a human beings. But to reach this, the system has to deal with several very complex problems, such as speech recognition and spoken language understanding. The simplified schema of important components of such system and its interaction with the user are shown in the figure 4.2.

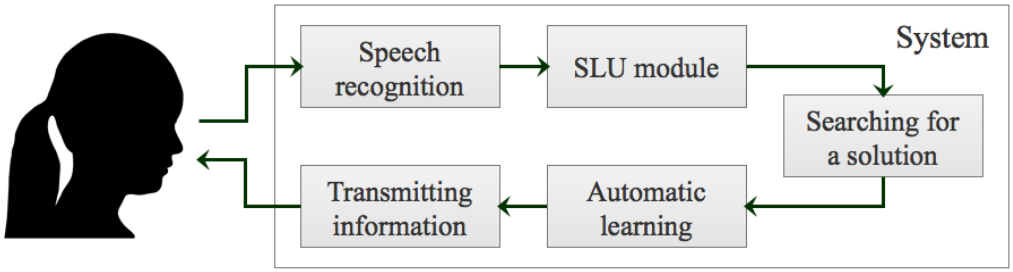

Figure 4.2: The schema of the system structure.

The system would also change the basic model of an interaction between the calling person and the second person. A calling person will be connected directly with the system that will identify all necessary information from his utterance. Subsequently, the system will automatically contact the most suitable person from the prepared database of visually impaired people, give him the all relevant information and receive the solution from him. Subsequently, the system will give this solution back to the calling person. It means that the system will figure as a mediator between both people. This interaction model brings one important advantage. The system in this position will process all information from both people and thanks to this it will be able to learn. It means that the system should be able to itself solve repetitive problems.

But the ability of learning is very important also for another reason because the system have to be able to adapt to the user and interact with him in a wide range of possible situations. But hand-crafted design of such system requires a large amount of time and of course it is practically impossible to prepare the system to all possible situations that may occur in practice. Therefore, the system should be able to automatically learn and adapt to the user on the base of his utterances.

On the basis of the above mentioned characteristics, it is evident that the future assistance center should meet the following features to achieve the vision of this thesis.:

- The assistance center should enable the mutual cooperation of visually impaired people in the situation when a visually impaired person loses orientation and needs to recover from this situation

by using a phone.

- The assistance center should contain the database of participating visually impaired people and also the places which these people know.
- The assistance center should be operated by the automatic adaptive system that will be able to communicate with the calling person in a natural and unconstrained speech.
- The automatic system in the assistance center should be able to adapt to the inputs from the calling person and also act and react like human beings.
- The automatic system in the assistance center should be able to automatically learn the information from utterances of calling people and solve repetitive problems by itself.

4.2.2 The realization of the assistance center

As it was already mentioned in the workflow in section 2.5.1 on page 16, the implementation of the system for the assistance center will divided into several parts. At the first part will be necessary to deal with the problem of speech recognition because at the beginning will be necessary to convert spoken words into a plain text. Such conversion is a very complex and sophisticated process, but currently there already exist many possible solutions for this, so in this part we will collaborate with some external subject.

Due to this, the most important current issue is to learn the system to interact with the user. To reach this, it is necessary to identify the general dialog structure of the communication between the user and the future system and convert it into machine-readable form. With this knowledge, the system will be able to interact with the user in a natural way.

The general dialog structure was identified and described in the section 3.3.2 on page 25. Now it is necessary to convert this structure into a format that is readable for the future system. For this purpose is the most suitable VoiceXML [40]. The abbreviation VoiceXML means the Voice Extensible Markup Language which is the W3C's [41] standard XML format for specifying interactive voice dialogues between a human and a computer.

A VoiceXML is designed for creating audio dialogs that feature synthesized speech, digitized audio, recognition of spoken input, recording of spoken input, telephony, and mixed initiative conversations. A VoiceXML document (or a set of related documents) forms a conversational finite state machine. The user is always in one conversational state, or dialog, at a time. Each dialog determines the next dialog to transition to. Transitions are specified using URIs which define the next document and dialog to use. Execution is terminated when a dialog does not specify a successor, or if it has an element that explicitly exits the conversation [40].

Due to the limited size of the current corpus of dialogs, it is not possible to define complete model of the future communication between the intended system and the user now. Therefore, it was selected one representative dialog from the corpus (this dialog is possible to find in the attached files) and on the base of this dialog was prepared the prototype of the dialog model that presents the possibilities of this approach. The dialog model was divided into 4 separated documents that is possible to find in appendix E. The simplified schema of the model is shown on the figure 4.3.

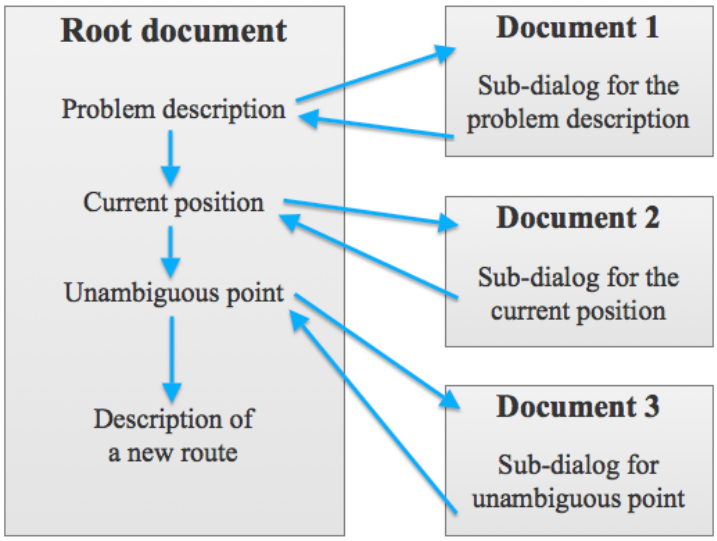

Figure 4.3: A simplified schema of the dialog model.

The first document is the root document that controls the flow of the whole dialog. This document contains the important variables, such as problem description and description of current position of the calling person which must be filled before further process of the dialog. These variables can be filled immediately after initial prompt in the initial section of the document, if not the system will start sub-dialogs that are designed for the obtaining of the necessary information from the user. Models of these sub-dialogs are placed in the separated documents that are called by the root document, after successful obtaining of all relevant information sub-dialogs return this information back to the root document.

After getting information precise enough for both variables, the root document will start another sub-dialog that is designed to identify some unambiguous point in the neighborhood of the calling user. The model of this dialog is again placed in the separated document. After identification of some unambiguous point, the sub-dialog will return information about it back to the root document.

After identification of unambiguous point, the root document will prompt to the user information about the new route. After this, the user can either finish the dialog or continue in it and ask for repetition of the information.

As it has been mentioned above, the presented dialog model is only the prototype prepared for the demonstration purpose and therefore is not able to work with all variants that can occur during the dialog process. In the current dialog model also missing the grammatical rules that would describe the exact rules for the acceptation of user's utterances and conditions for the switching between particular parts of the dialog. These rules were not implemented because their exact form greatly depends on the concrete system for which is the dialog model designed and on which will be subsequently launched. Therefore, the implementation of these rules would be premature in the current phase of the work.

5 User tests

In this section detailed descriptions of particular researches performed within this thesis are presented.

5.1 A qualitative study - The first phase

In this section the detailed specification and test setup of the first phase of performed qualitative study are described.

5.1.1 The goal of the study

The main objective of this phase of the study is to get initial insight into an issue of navigation of visually impaired and determine how visual impaired people are behaving in a situation when they lose orientation. What do they feel in such a situation, how they exactly react to it and how it would be possible to help them in such a situation.

5.1.2 The target group

The study is focused on visual impaired people especially on practically and totally blind people (so, on those people who are unable to perceive practically any suggestions through their eyes) with no difference in gender and age. Although age is not strictly limited, the study is primary focused on people who are able to move independently in an outdoor environment.

5.1.3 The test setup

5.1.3.1 A screener

For the purpose of this study is necessary to recruit 4 to 6 participants from the target group described in section 5.1.2. Because of the quality of study, it is also appropriate that these participants were mutually as varied as possible. Therefore, concrete participants will be selected accordingly to their answers in the screener.

The public part

The screener is divided into two separate parts: Part A which includes contact information of participants (first name, surname and email), and Part B which includes only own answers. Participant will be asked to complete both parts at once - after completing of both parts will be these parts separated. Part A will be used only for logistical purposes, and Part B will be used only as anonymous - the link between parts will provided by an identification number which will be pre-filled and will be same in both parts.

Here is an English version of concrete questions from Part B - original Czech version is available in appendix A. The participant will be asked to select only one option:

1. Gender:

   (a) Male.
   (b) Female.

2. Age:
   (a) Less than 20 years.
   (b) 20 - 35 years.
   (c) 36 - 50 years.
   (d) 51 - 65 years
   (e) More than 65 let.

3. Degree of visual impairment:
   (a) Without visual impairment.
   (b) Partially sighted.
   (c) Low vision.
   (d) Very low vision.
   (e) Practically blind.
   (f) Totally blind.

4. Length of visual impairment:
   (a) Without visual impairment.
   (b) I'm visually impaired from the birth.
   (c) I have lost a sight during my life.

5. I use:
   (a) Cane for visually impaired.
   (b) Assistance dog.
   (c) None of these aids.

6. Choose the statement that is the most suitable for you:
   (a) I don't move in the outdoor environment.
   (b) I move in the outdoor environment only accompanied by an assistant.
   (c) I move independently in the outdoor environment, but I always use only those routes that I know well. New routes I always go through with an assistant at first.
   (d) I move totally independently in the outdoor environment.

7. Do you have some experience with a movement in an unknown environment only by a description of route - for example, from an assistance center?
   (a) Yes, I already have such an experience.

(b) No, I haven't such an experience.

8. Do you use some orientation aids within the movement in an outdoor environment (such as mobile phone, GPS navigation, route description from an assistance center, etc.)?

   (a) Yes, I use such aids.

   (b) No, I don't use such aids.

   (c) I don't move in the outdoor environment.

9. Do you visit some organizations specialized in working with blind people?

   (a) Yes, these organizations I visit regularly - at least once a week.

   (b) Yes, these organizations I occasionally visit.

   (c) No, do not attend any such organization.

10. Have you ever lost in an outdoor environment?

    (a) Yes, I already have such an experience.

    (b) No, I haven't such an experience.

The private part

As it was already pointed out, the variability of a final group of participants is an important factor. Therefore, there are questions 1 and 2 for an ensuring that in the final group will be diversity in gender and age. In the rest of questions the following criteria will be used:

Question 3: Due to the defined target group only those participants who choose answer (e) or (f) will be selected - at least one participant from each option.

Question 4: Due to the defined target group only those participants who choose answer (b) or (c) will be selected - at least one participant from each option.

Question 5: Due to the defined target group only those participants who choose answer (a) or (b) will be selected - at least one participant from each option.

Question 6: Due to the defined target group only those participants who choose answer (c) or (d) will be selected - at least one participant from each option.

Question 7: At least one participant from each option.

Question 8: Due to the defined target group only those participants who choose answer (a) or (b) will be selected - at least one participant from each option.

Question 9: All options are possible here - it will be interesting to notice possible differences between these people. Therefore, I will try to select at least one participant from each option.

Question 10: All options are possible here - it will be interesting to notice possible differences between these people. Therefore, I will try to select at least one participant from each option.

5.1.3.2 A session guide

On the basis of their answers in the screener the final group of participants will be selected. These participants will be invited for an interview. Each interview will take from 50 up to 90 minutes and within its progress will be recorded audio. The interview itself will be preceded by a pre-interview part of a session, then will follow actual interview and whole session will be closed by a post-interview part of session.

For each session I will try to provide same conditions. Therefore all session will be realized in prearranged room that ensures peaceful and undisturbed progress of whole session.

The pre-interview part

10 - 15 minutes.

The interview itself will be preceded by a pre-interview part of a session in which a participant will be welcomed and thanked for his willingness to participate on the research. Of course, to the participant will be also offered some refreshment.

In this part of the session I will also try to disperse prospective fears of participants and ensure that they feel comfortable and loosely. After this, to the participant will be described purpose and further process of the session.

Participant will be also asked for oral agreement with a recording of audio within a process of a following interview. If the participant refuse recording, session will be finished because recording of the interview is necessary in further phases of the research. Participant will be also assured of anonymity and fact that a recording will be used only for the purpose of this research.

The interview script

30 - 60 minutes.

The interview will have a form of a semi-structured dialog and within its process an audio will be recorded. Interview itself will be divided into five main parts. An aim of these parts will be find out as many information about a particular field as possible. Gained information should also contain answers to questions that are appointed in particular fields. But because of intended form of the dialog, participant will not be asked for a direct answer for these questions, but at first he will be given a space to express himself about each field. This approach enables us to find out much more information about particular fields than only simple answers to direct questions. And of course, it is still possible to ask these questions when it will be necessary.

The interview will be divided into following parts:

The verification of information from the screener: The main aim of this part is to verify and extend information obtained from the screener. Second important aim is to open a dialog with the participant and also prompt and encourage him by simple questions to formulate his thoughts. Concrete questions in this part will be various according to participant's answers in the screener. Typical examples of questions in this part are:

- Where are you from?
- What exactly is the degree of you visual impairment?
- How has your visual impairment evolved?
- Which organizations specialized in work with visually impaired do you visit?
- How often do you visit such organizations?
- What is your typical program in such organizations?
- How often do you meet with other visually impaired people?

Movement in an outdoor environment: The main aim of this part is to find out detailed information about how often and in what ways are participants moving in an outdoor environment. Typical examples of questions in this part are:

- How often do you move in an outdoor environment?
- How do you move in an outdoor environment? - are you typically move alone or accompanied by another person?
- Could you describe one of your typical routes?
- Which problems do you typically have to solve within a move in an outdoor environment?
- Do you have some experience with a move in an urban area?
- Which orientation points are important for you?
- What else can help you with your orientation?
- How do you move in a known environment?
- How do you move in an unknown environment?
- What do you do if you need to go to an unknown place?

Orientation aids: The main aim of this part is to find out which aids and tools are participants using for an orientation in an outdoor environment and how they are exactly using them. Typical examples of questions in this part are:

- Which orientation aids do you use in an outdoor environment?
- Can you show me one of these your aids?
- Do you have these aids still with you?
- How often do you use these aids?
- How exactly do these aids help you with orientation?
- Are these aids suitable to be used by visually impaired people?
- Can you describe your experience with these aids?
- Do you know any other aids - why do you not use them?
- How could these aids help you even more?
- Do you have some experience with movement by a description of the route?
- Which form do these descriptions typically have?

- What do these descriptions have to contain to be useful for you?

Experience with a loss of orientation: The main aim of this part is to find out whether participant has ever lost in an outdoor environment, how he typically deals with such situations and how would be possible to help him. Typical examples of questions in this part are:

- Do you have any experience with a loss of an orientation in an outdoor environment?
- What do you feel in such a situation?
- Can you describe such a situation that you experienced recently?
- How often do you experience such situations?
- How do you deal with such situations?
- Which aids are the most useful for you in such situations?
- How exactly can people who are around you help you?

Ideal form of help in situations when orientation is lost: The main aim of this part is to find out what kind of help would participant prefer in a situation when orientation is lost in an outdoor environment and how would be possible to help him in this situation. Typical examples of questions in this part are:

- When you lose orientation in an outdoor environment, what help would you like to get?
- What exact form should this help have?
- How would you like to get this help?
- Can you describe me your experience with help that you typically get in such situations?
- Could you try to tell me how would you help someone in such a situation?

The post-interview part

10 - 15 minutes.

After finish of the interview will follow post-interview part of the session. In this part will be participant again thanked for his willingness to participate on this research. Participant will be also assured of anonymity and fact that all data obtained during interview will be used only for the purpose of this study.

In this part will be also important to find out participant's feelings and opinions about whole session. Very important will be also ensure that participant will leave the meeting with positive minds and without any frustrations. After this assurance I will say goodbye to the participant and accompany him to the place that he would wish.

5.1.4 Data collection

The practical realization of research was performed with regard to principles that were appointed in previous section. That means that each potential participant filled out the screener at first and on the base of evaluation of the screener was the participant invited to session itself. The final list of participants is shown in section 5.1.4.1 on the next page, collected data are presented in section 5.1.4.2 on the following page.

5.1.4.1 A list of participants

For this phase of study were selected 4 participants with whom was performed the interview. For the purpose of this study were these participants labeled as participant P1 - P4. In the following list are presented the basic information about these participants:

The profile of participant P1: 35 years old man who has lost his sight during life and currently is totally blind. Participant is able to move totally independently in an outdoor environment but always uses only those routes that he knows well. Never goes alone on unfamiliar places and new routes goes through with an assistant at first. During a movement uses a cane for blind, other special aids for an orientation participant doesn't use. Participant already has some experience with a movement by a description of route and with a loss of orientation. Participant also regularly visits centers specialized in a work with visually impaired.

The profile of participant P2: 65 years old woman who has lost her sight during life and currently is totally blind. Participant is able to move totally independently in an outdoor environment. During a movement uses a cane for blind and also an assistance dog. The only other aid for an orientation that participant regularly use is a special radio for blind, other special aids uses participant only exceptionally. Participant already has a lot of experience with a movement by a description of route and with a loss of orientation. Participant has also a rich social life and regularly visits centers specialized in a work with visually impaired.

The profile of participant P3: 31 years old man who is totally blind since birth. Participant is able to move totally independently in an outdoor environment. During a movement uses a cane for blind and also other aids for an orientation such as special radios for blind and GPS navigations. Participant already has some experience with a movement by a description of route and a lot of experience with a loss of orientation. Centers specialized in a work with visually impaired attends participant only occasionally but has many of others social activities.

The profile of participant P4: 59 years old man who has lost his sight during life and currently is totally blind. Participant is able to move totally independently in an outdoor environment. During a movement uses a cane for blind, other special aids for an orientation uses participant only exceptionally. Participant already has some experience with a movement by a description of route and with a loss of orientation. Participant also regularly visits centers specialized in a work with visually impaired.

5.1.4.2 Collected data

For the purpose of presentation of obtained data was selected a part of grounded theory that is introduced in [32]. In this method are for each participant presented only the key notions for each of particular topics. These notions are introduced in following subsections. The original recordings of particular interviews can be found in the attached files.

The first interview

The first interview was performed with the participant P1. The length of interview: 70 minutes.

Movement in an outdoor environment:

- Participant moves in an outdoor environment every day.
- Participant uses only routes that he already knows, he never uses unknown routes.
- During a movement participant uses combination of touch and hearing in conjunction with counting of steps.
- For an orientation uses participant mainly physical points on a route that can be detected by a cane, such as signs, handrails, curbs. In some cases uses participant also hearing points.
- Main problems are unexpected changes on routes.

Orientation aids:

- Participant has some experience with GPS navigations, but doesn't use them.
- Regularly participant uses only a cane and a special radio for blind.

Experience with the loss of orientation:

- Loss of orientation is a common situation.
- For prevent a loss of orientation it is necessary to be concentrated during the entire route.
- When lose orientation, participant typically asks passerby people for help.
- For recovery requires participant some exact information.

Ideal form of help in situations when orientation is lost:

- The most important is unambiguity of used points.
- Participant prefers help from passerby person, alternatively GPS navigation, description of route or some kind of remote help.
- Participant prefers points that can be detected by a cane. Hearing points uses participant only as complementary information.
- In some cases prefers participant help from sighted person, but in other cases rather prefers help from another blind person - depends on concrete situation.
- Participant is sure that he is able to navigate another blind person on his familiar route.

The second interview

The second interview was performed with the participant P2. The length of interview: 65 minutes.

Movement in an outdoor environment:

- Participant moves in an outdoor environment often and without any limits.
- Participant often uses routes that she already knows, but she hasn't problem to adapt to unexpected situations.
- If the participant needs to use some unknown route, she uses assistance from navigation center that prepares description of particular route for her.
- For an orientation uses participant similar points like sighted people, such as buildings, parks, streets, blocks of building, etc. Smaller points participant practically doesn't use.

Orientation aids:

- Participant regularly uses an assistance dog and a special radio for blind.
- An assistance dog practically compensates for eyes for her.

Experience with the loss of orientation:

- Loss of orientation is a common situation for her.
- When lose orientation, participant typically asks passerby people for help.
- For recovery requires participant some exact information that enable her to return to the route.

Ideal form of help in situations when orientation is lost:

- Participant prefers help from passerby person.
- When a help from passerby people isn't available, participant is able to imagine a help through a mobile phone - but only from a person who very good knows that place.
- Concrete form of help is not such important, more important is precision of given information.
- Participant is sure that he is able to navigate another blind person on his familiar route.

The third interview

The third interview was performed with the participant P3. The length of interview: 60 minutes.

Movement in an outdoor environment:

- Participant is able to perceive the light, so he is able to sidestep some barriers.
- Participant moves in an outdoor environment often and without any limits.

- Participant doesn't afraid to go to places that he doesn't know.
- For an orientation uses participant terrain and points that can be detected by a cane, such as signs, handrails, curbs, corners, bollards, etc. Hearing points uses participant only as complementary information.

Orientation aids:

- Participant regularly uses a cane and a special radio for blind.
- Participant is also accustomed to walking by GPS navigation in his phone.

Experience with the loss of orientation:

- Loss of orientation is a common situation for him.
- When lose orientation, participant typically asks passerby people for help or uses navigation in his phone.

Ideal form of help in situations when orientation is lost:

- Participant prefers help from passerby person, alternatively GPS navigation.
- Participant is able to imagine a help through a mobile phone - but only from a person who very good knows that place and in combination with GPS.
- Participant is sure that he is able to navigate another blind person on his familiar route.

The fourth interview

The fourth interview was performed with the participant P4. The length of interview: 45 minutes.

Movement in an outdoor environment:

- Participant moves in an outdoor environment when it is necessary, but it is almost every day.
- Participant uses only routes that he already knows.
- During a movement participant uses combination of touch and hearing.
- For an orientation uses participant mainly terrain and physical points on a route that can be detected by a cane, such as signs, handrails, curbs. Participant also uses hearing for better orientation.

Orientation aids:

- Participant regularly uses a cane and a special radio for blind.
- Participant also sometimes uses assistance from navigation center.

Experience with the loss of orientation:

- Participant has some experiences with a loss of orientation.

- When lose orientation, participant asks passerby people for help.

Ideal form of help in situations when orientation is lost:

- Participant prefers help from passerby person, alternatively a description of route from a navigation center.
- The most important is precision of given information.
- Participant is able to imagine a help through a mobile phone - but only in combination with some other information such as GPS coordinates, or from a person who knows that place.
- Participant is sure that he is able to navigate another blind person on his familiar route.

5.1.5 Data Analysis

The main objective of this phase of study was to get an initial insight into an issue of navigation of visually impaired person and especially in a situation when they lose orientation. For this purpose were performed 4 interviews with mutually quite different participants. From these interviews revealed some interesting findings that were common to all participants and which are very important for further work. For this reason was this phase of qualitative study finished and was prepared second phase which will extend and more specify these findings.

The complete analyze of collected data is presented in section 3.2.3 on page 20, revealed findings are introduced in following subsection.

5.1.5.1 Findings

- There are crucial differences between the navigation of blind people who use a cane and who use an assistance dog.
- Blind people with a cane typically use barriers for navigation - such as signs, handrails, curbs, corners, bollards, etc.
- Orientation points that blind people who own an assistance dog use are similar to those that sighted people use - they typically use streets, blocks of buildings, parks, etc.
- Blind people know every detail of the route which they often use - they are able to restore the whole route from their memory.
- The loss of orientation is a common situation for blind people.
- If they lose orientation, blind people prefer to receive help from passers-by.
- If they lose orientation and there are no passers-by, blind people accept help by phone.
- A blind person is able to navigate another blind person by phone - but only at those routes that they know and use regularly.

5.2 A qualitative study - The second phase

In this section the detailed specification and the test setup of the second phase of the performed qualitative study are described.

5.2.1 The goal of the study

The main objective of this phase of the study is to extend and specify findings from the first phase of the qualitative study. Especially those findings that relate to situation when visual impaired people lose their orientation and try find their way again by phone in cooperation with an assistant center.

5.2.2 The target group

Due to above described objective of this phase of study, the second phase of qualitative study will be focused on the same target group like the first one. You can find description of this target group at section 5.1.2 on page 33.

5.2.3 The test setup

5.2.3.1 A screener

For the purpose of this phase of study it is necessary to recruit 10 to 12 participants from defined target group. Concrete participants will be selected on the base of their answers in a screener that verify if they really satisfy the conditions defined at section 5.1.2 on page 33.

The public part

Screener is divided into two separate parts: Part A which includes contact information of participants (first name, surname and email), and Part B which includes only own answers. Participant will be asked to complete both parts at once - after completing of both parts will be these parts separated. Part A will be used only for logistical purposes, and Part B will be used only as anonymous - the link between parts will provided by an identification number which will be pre-filled and will be same in both parts.

Here is an English version of concrete questions from Part B - original Czech version is available in appendix B. The participant will be asked to select only one option:

1. Gender:
   (a) Male.
   (b) Female.
2. Age:
   (a) Less than 20 years.
   (b) 20 - 35 years.

(c) 36 - 50 years.

(d) 51 - 65 years

(e) More than 65 let.

3. Degree of visual impairment:

   (a) Without visual impairment.

   (b) Partially sighted.

   (c) Low vision.

   (d) Very low vision.

   (e) Practically blind.

   (f) Totally blind.

4. Length of visual impairment:

   (a) Without visual impairment.

   (b) I'm visually impaired from the birth.

   (c) I have lost a sight during my life.

5. I use:

   (a) Cane for visually impaired.

   (b) Assistance dog.

   (c) None of these aids.

6. Are you able to move independently in an outdoor environment?

   (a) No, I don't move in the outdoor environment.

   (b) Yes, I move in the outdoor environment but only accompanied by an assistant.

   (c) Yes, I move in the outdoor environment.

The private part

Questions 1 and 2 are presented only for ensuring diversity in a final group of participants. In the rest of questions the following selection criteria will be used:

Question 3: Due to the defined target group only those participants who choose answer (e) or (f) will be selected - at least one participant from each option.

Question 4: Due to the defined target group only those participants who choose answer (b) or (c) will be selected - at least one participant from each option.

Question 5: Due to the defined target group only those participants who choose answer (a) or (b) will be selected - at least one participant from each option.

Question 6: Due to the defined target group only those participants who choose answer (c) will be selected.

5.2.3.2 A session guide

On the basis of their answers in the screener the final group of participants with whom will be performed the interview will be selected. Each interview will take from 10 up to 15 minutes and within its progress will be recorded audio. The interview itself will be preceded by a pre-interview part of a session, then will follow actual interview and whole session will be closed by a post-interview part of session.

For each session I will try to provide same conditions. Therefore all session will be realized in prearranged room that ensures peaceful and undisturbed progress of whole session.

The pre-interview part

1 - 3 minutes.

The interview itself will be preceded by a pre-interview part of a session in which a participant will be welcomed and thanked for his willingness to participate on the research. Of course, to the participant will be also offered some refreshment.

In this part of the session I will fill out the screener with a participant. If answers of the participant satisfy the conditions defined in section 5.2.3.1 on page 44, I will ask him for oral agreement with a recording of audio and then perform the interview itself. Participant will be also assured of anonymity and fact that a recording will be used only for the purpose of this research.

The interview script

10 - 12 minutes.

At the beginning of this part of a session will be to a participant introduced the following short imaginary situation:

> *„Imagine that you are going by the bus. Reporting of stations is turned off, and you have miscalculated passed stations, so you get off at a different station than you think. But neighborhood of the station is very similar to a place where you originally wanted to get off. Therefore, you will proceed by a way which you think that you know. You will go for a while and then you find out that a route does not continue as it should. But you are not sure why that is - if you mistook a station, or made a mistake somewhere along the route."*

A reason, why this imaginary situation is introduced to the participant, is to empathize him into this situation and also raise his imagination, and by this achieve more precise results in the rest of the interview. After introduction of the imaginary situation, the interview itself will be performed. The interview will have a form of a semi-structured dialog, participant will be asked following questions:

- How realistic is the presented situation for you?
- Have you ever got into a similar situation?
- How would you deal with the presented situation?
- How would you proceed if there were no passers-by whom you could ask for help?

- Would you use a mobile phone in such a situation? - Whom would you call?
- How would you describe your situation on the phone?
- What kind of help would you need to get on the phone? - What information would you need?
- If you knew someone who would know that place, would you call them in such situation?
- What kind of help would you prefer on the phone?
- Would you be able to navigate someone over the phone? - And what about on a route that you know?
- Would you be willing to share your routes? - For example some places that you personally use?

In each question enough space will be given to the participant to express themselves about the particular issue. This approach enables us to find out much more information about particular issues than only simple answers to direct questions.

The post-interview part

1 - 2 minutes.

After finish of the interview will follow post-interview part of the session. In this part will be participant again thanked for his willingness to participate on this research. Participant will be also assured of anonymity and fact that all data obtained during interview will be used only for the purpose of this study.

5.2.4 Data collection

Practical realization of research was performed with regard to principles that were appointed in previous section. That means that each potential participant filled out the screener at first and on the base of evaluation of the screener was with participant performed the interview itself. The final list of participants is shown in section 5.2.4.1, collected data are presented in section 5.2.4.2 on the following page.

5.2.4.1 A list of participants

For this phase of study 12 participants with whom was performed the interview were selected. For the purpose of this study were these participants labeled as participant P1 - P12. In the following list are presented the basic information about these participants:

The profile of the participant P1: 37 years old woman who is practically blind since birth. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P2: 47 years old woman who is totally blind since birth. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P3: 37 years old woman who has lost her sight during life and currently is practically blind. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P4: 46 years old woman who has lost her sight during life and currently is practically blind. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind and an assistance dog.

The profile of the participant P5: 65 years old woman who has lost her sight during life and currently is totally blind. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind and an assistance dog.

The profile of the participant P6: 30 years old man who has lost his sight during life and currently is totally blind Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P7: 46 years old man who has lost his sight during life and currently is totally blind Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind and an assistance dog.

The profile of the participant P8: 56 years old woman who is practically blind since birth. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P9: 27 years old man who is practically blind since birth. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P10: 24 years old woman who is totally blind since birth. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P11: 35 years old man who has lost her sight during life and currently is practically blind. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

The profile of the participant P12: 26 years old woman who is practically blind since birth. Participant is able to move independently in an outdoor environment. During a movement uses a cane for blind.

5.2.4.2 Collected data

For the purpose of the presentation of the obtained data a cluster method that is introduced in [32] was selected. In this method are answers from all participants aggregated under particular questions. Due to this approach, this method enables better understanding to the obtained data and also provides a option to compare answers from all particular participants at one place. The original recordings of particular interviews can be found in the attached files.

- Is the presented situation real for you?

  P1: *„Yes, definitely."*

  P2: *„Yes, sure."*

  P3: *„Real is that I get off on wrong station. But I recognize it when I get off."... „I recognize it after a few steps"*

  P4: *„Yes, it is possible"*

  P5: *„Yes, it can happens"*

  P6: *„Yes, it is realistic, definitely"*

  P7: *„Yes, but it wouldn't happen to me because I always ask people"*

  P8: *„Very real"*

  P9: *„Yes, it is real"*

  P10: *„Yes, I thing that yes"*

  P11: *„Yes, much"*

  P12: *„Yes, this situation is real"*

- Have you ever got into a similar situation?

  P1: *„Yes, that thing happen to me."*

  P2: *„Yes, definitely."*

  P3: *„Several times"*

  P4: *„Yes"*

  P5: *„No because I have a dog, but I can imagine it"*

  P6: *„No exact situation like this, but I have already mistook station"*

  P7: *„No because I always ask people"*

  P8: *„Yes, definitely"*

  P9: *„Yes"*

  P10: *„I think that yes"*

  P11: *„Yes"*

  P12: *„Yes, but I recognize that I run over"*

- How would you deal with the presented situation?

  P1: *„In cooperation with some people around."*

  P2: *„I always try to go back to a bus."... „And I always ask people."*

  P3: *„I would try to solve it myself."... „I would look for some passerby people."... „Maybe, I would call to some assistance center."... „at first me, then people and then phone."*

  P4: *„I would try to go back to some place where I would be sure that I am rightly"... „I would try to find some person and ask him"*

P5: *„At first I would try to catch some people, definitely"*

P6: *„I would go back to the station and ask driver or people"... „cooperation with people"*

P7: *„I would ask people"... „I would definitely try to go back"... „I always ask"*

P8: *„I generally try to go back"... „I would try to ask some people"*

P9: *„I would try to use my phone at first"... „or ask some people"*

P10: *„I ask some people or ask someone for help"*

P11: *„I ask for help some passerby people or I call to some my friend"*

P12: *„I ask some people if there are"... „I went back"... „I would try to solve it myself, then ask some people and then phone"*

- How would you proceed if there were not passerby people whom you could ask for a help?

P1: *„That's crazy. I would probably try to go back to the station and wait for some people or another bus."*

P2: *„I don't know, I would stupidly wait for a bus."... „I would look for some people."*

P3: *„I would try to solve it or to call to some assistance center."*

P4: *„At first I would try to quiet down myself, concentrate and listen environment"... „discover place around me"*

P5: *„I don't know"*

P6: *„I would wait for another bus"... „I would try to orient by hearing"... „I would still try to find someone"*

P7: *„I would wait for someone"... „Maybe, I would use navigation in a phone"*

P8: *„I would wait for some next bus"... „mobile phone maybe"*

P9: *„I would try to use maps in my phone"*

P10: *„I would try to use GPS in phone"... „I would try to go back to the station"... „I would try to find someone"*

P11: *„I call to some my friend"*

P12: *„I would use navigation in my phone"*

- Would you use a mobile phone in such a situation? - To call someone? - Who would you call?

P1: *„I don't know. I never do this. I don't know to who call."*

P2: *„Hardly - he wouldn't know where I am"... „I don't know how to use it."*

P3: *„yes - assistance center for example"*

P4: *„Probably no"... „I don't use assistance centers"... „I can imagine navigation by phone"... „It is a last option"*

P5: *„I don't know"... „How he could know, where I am"... „I would try to use everything"*

P6: *„I can imagine it, GPS for example"... „but calling no because I don't know where I am"... „it is a last option"... „but it is a good idea"*

P7: *„Probably no"... „because I don't know where I am"*

P8: *„yes, I would try to call to someone who knows that place or who has a map"*

P9: *„as last option"... „once I call to my brother"*

P10: *„no because he can't localize me"*

P11: *„Yes, I would call to some friend"... „I don't want to bother strange people"*

P12: *„Yes, I can imagine it, but I don't know who to call"*

- How would you describe your situation on the phone?

P1: *„I would tell him where I went - target of my route, and also station where I get off."... „I would try to describe how I get to that place and also my route."... „I would tell him for example that I get off, turn to left and there should be sign, but wasn't."*

P2: *„I went by bus and signalization was turned off and I probably get off on another place. I would roughly know the station - 6th or 7th - and I try to describe the station and abnormalities there."... „I would use direction of drive"... „things around me"*

P3: *„I would describe that I went by bus from Kobylisy and that I wanted to get off on some station"... „I would try to describe route."*

P4: *„I would tell that I am on some station, that there is a broken walkway, behind walkway is a grass and about 1 meter behind station along direction of the bus is a bench"*

P5: *„that I get off somewhere and I think that he didn't stop somewhere and I don't know if I get off sooner or later"... „terrain, roads, grass, walkway, buildings"... „everything what would be there"*

P6: *„I would try to tell him where is conducting line, building, road"... „the way I went"*

P7: *„In unknown place I think that I am not able to describe something"... „maybe some percepts of blind"... „to hill, from hill, some building, where is a road"... „I went along direction of the bus, meters"... „terrain points, walls"*

P8: *„I would tell him that I went by the bus and that I don't know if I get off for stop sooner or later"... „I would describe environment around me"... „what is on the left and right"... „everything"*

P9: *„it is difficult"... „once a photograph the station for my brother"... „I would try to recognize if I get off sooner or later, by time for example"... „I would describe the way I went"... „if there is a street or some open space, buildings"... „how I get to that place"... „terrain, sound conducting lines"*

P10: *„I don't know"... „I could tell him that I went to station that and that, I get off on wrong station and went there and there"... „I would tell him that I get off the tram, let it go, then rotate by 180 degrees to the right, across tramlines, go to building and go along it"*

P11: *„I have a problem to describe my position"... „I would use some application to get some information about my position"... „it depends where it would be"... „walkway, road, sounds, grass, tree "... „I don't know, how to solve it"... „I would use a sound, what I detect by cane and also a way I went"*

P12: *„I try to identify points around me, it means to find some street near me, how it looks around - like cars, building, grass"... „I would have some idea about place where I am"... „road as I said, grass, noise, if there are people, buildings"... „I would try to tell everything what occurs to me"*

- What kind of help would you need to get on the phone? - What information would you need?

P1: *„I never going with a phone in hand, I haven't multitasking."... „I need something like: Hey, you get off the train, let it behind you, and turn around and go through crossing."... „For me are important concrete points."... „such as signs, walls, shops, etc."... „Points that can be detected by cane."*

P2: *„I expect leading because I have a problem with memory"... „I definitely hold him on phone"... „That I probably went to wrong stop and so I have to go back to previous stop. And also where the station is and how I could get there. "... „Same points like I use"*

P3: *„Rather one-shot information than leading"... „to find some unambiguous point"... „I need to recognize a place, where I am."... „I need to orient myself to be able to continue"... „I am able to see something in a daily light, in a night I use only a cane"... „points that I can detect by a cane"... „terrain, sounds, grass"*

P4: *„for me would be enough when we find some unambiguous point and then he tell me where I should go"... „bus station, stair, etc."*

P5: *„rather one-shot information than leading"... „we have to agree on some concrete point at first"... „post of station for example"... „and where I should go"*

P6: *„He would tell me to go there and there and there should be this and this and describe me it"... „if it was there, he could navigate me"... „road is a very good for orientation"... „hearing, main road is easy to hear"... „terrain, walls, parking, conducting lines"... „stable things"... „I would like to hear what I should looking for"... „one-shot information at first, then I would like to be led"*

P7: *„He would navigate me and tell me what I should find there"... „he has to orient me"... „I would probably hold him on phone"... „I prefer blind person"*

P8: *„I would hope that he would be able to navigate me"... „he would describe me previous and next station"... „it is difficult to say, it depends on the situation"*

P9: *„It would help me, if he tried to find my position"... „I would like to hear if he has some idea where I could be"... „I would like to get a detail description from him"... „at first we have to agree where I am, like that I get off the bus, behind me is a road and I would definitely want to know direction to where I should go"... „leading no, rather description"*

P10: *„to describe me right route"... „signs, sound of buildings, terrain, conducting lines"... „you need to go back, to place that and that"... „turn to the left, go along the building, across the tramlines and there will be station that and that"... „I can't imagine it"... „leading no, only simple points - brief, practical points"*

P11: *„Ideally, I would need to detect a place where I am"... „identify some unambiguous point"... „tell me the street where I am and where I should go and navigate me"... „I can't remember a lot of information because I concentrate on the place where I am and I can't to remember whole route"... „I prefer to be on phone"*

P12: *„Description of route, to join me to some route that I know or nearest station"... „it depends, how much time would he has"... „Maybe if he be on phone with me till I will find route that I know or some station"... „where is a route, some building"... „to use my points"*

- If you knew someone who would know that place, would you call them in such a situation?

P1: *„I don't know. May be, if he would live close and know that place."... „But I have a blind friend and she is able to perfectly navigate - so, she would be probably able to navigate me well."*

P2: *„Yes, in such case probably yes, of course."... „He will probably tell me some details."*

P3: *„If I known that he knows that place, I would call him"... „it depends if he is my friend"*

P4: *„It depends. If I went to someone, who could go for me, I would call him."... „It should be someone who is able to navigate me"*

P5: *„If I know someone, I would try to call him"*

P6: *„Maybe, but I don't know what to tell him"*

P7: *„I would call him in advance"... „maybe, but I don't know what to tell him"... „I am not sure, if I am able to describe my situation"... „I would call him, surely"*

P8: *„Yes"... „to some my friend"*

P9: *„yes, if he knows the place"*

P10: *„if he very good knows the place and would be able to navigate me, that maybe yes"*

P11: *„Yes, I would call him"*

P12: *„I probably call my friend"*

- What form of help would you prefer on the phone? - Do you prefer a person or a machine?

P1: *„I prefer my friend. "... „Someone who knows me."... „But I always prefer some operator."... „Automat is not unpleasant for me, but can't help me."*

P2: *„Automat should bother me because he doesn't thinking."... „I don't like them generally"... „and sentiments are important"... „human factor is also important"*

P3: *„Automat absolutely no"... „I want a personal approach, I prefer operator."*

P4: *„If I could, I prefer human"*

P5: *„I can imagine some machine, but information has to be unambiguous"*

P6: *„it doesn't matter"... „Automat would be better maybe, if it would really work because I wouldn't have to hurry"*

P7: *„Probably human"... „I can arrange by talking with a human"... „speak with a machine is exhausting"*

P8: *„I would have a bad feel from machine"... „I prefer some my friend"*

P9: *„Machine is OK - maybe some Automat is better for me"*

P10: *„definitely human"... „it is difficult to agree with a machine, how to tell him something"*

P11: *„If the machine would have a brain, I don't care - if would know where I am"*

P12: *„Machine doesn't bother me"... „Human or machine - doesn't matter"*

- Would you be able to navigate someone over the phone? - And what in a route that you know?

P2: *„Definitely"... „On my route definitely."*

P3: *„I think that yes"*

P4: *„Probably yes"*

P5: *„sure, 100%"... „on my routes, perfectly"*

P6: *„sure, definitely"*

P7: *„Definitely, if I know that place, I am sure"... „safely, especially blind"*

P8: *„If he described me his position and I knew that place, I would be able"*

P9: *„blind person definitely"... „it works"*

P10: *„I think that yes, if I would know, where he is"*

P11: *„Yes, I do this often"... „I am able to navigate people"*

P12: *„If I know that route, I thing that it is OK, that I am able"*

- Would you be willing to share your routes? - For example some places that you personally use?

P2: *„Yes, but I haven't a lot of routes."... „Not problem for me"*

P3: *„Sure"... „I would like to help"*

P4: *„Yes, I am"... „I like it"*

P6: *„Yes, I would be willing"... „it's perfect idea"*

P7: *„I don't know, I am lazy"*

P8: *„Certainly, it is a very good idea"*

P9: *„Yes, it works so well"*

P10: *„Yes, it is perfect"... „we share routes with my friends"*

P11: *„Yes, I haven't problem with this"*

P12: *„Yes, no problem"*

5.2.5 Data Analysis

The main objective of this phase of study was to extend and more specify findings from the first phase of the qualitative study. For this purpose were performed 12 interviews with participants from defined target group. It is possible to say that objective of this phase of study was completed because performed interviews revealed several finding that enable us to create better and more precise conception about

navigation of visually impaired people in urban area and also about their behavior and needs in situation when they lose orientation.

The complete analyze of collected data is presented in section 3.2.4 on page 21, revealed findings are introduced in following subsection.

5.2.5.1 Findings

- It was again revealed that a loss of orientation is a common situation for visually impaired people.
- When the orientation is lost, visually impaired people expect presence of passers-by whom they could ask for help.
- When the orientation is lost, visually impaired people either ask passers-by people for help or try to solve this situation by themselves, the order of these approaches depends on personal preferences of the particular person.
- When the orientation is lost, visually impaired people either use their mobile phone or they are able to imagine it, but they perceive it as the last option.
- When the orientation is lost, visually impaired people expect from the person on the phone that they would be able to navigate them - that he would identify a place where they are, help them to find some unambiguous point and then describe them the route which they should take.
- When the orientation is lost, visually impaired people expect from the person on the phone that they he would use same orientation points that they commonly use.
- When orientation is lost, a preferred kind of help by phone is not ambiguous - some people expect leading by phone and would hold a second person on the phone, others prefer only one-shot information that enables them to find right way.
- When the orientation is lost, the preferred form of help by phone is not ambiguous - most people prefer a human operator, but others prefer a machine on the second side. The main concern about a machine is that the inhuman operator would not be able to understand their situation and help them. The absence of emotion in a machine is also very important.
- When the orientation is lost, visually impaired people are not sure whether they would be able to describe their situation to a phone precisely enough to enable a second person to help them.
- When orientation is lost, visually impaired people would use all reachable information to describe their situation on a phone - such as how they got into that situation, what they are able to detect in their environment and where they originally intended to go.
- When the orientation is lost, for visually impaired people the most important orientation points are those that are possible to be detected by a cane - such as terrain, signs, curbs, buildings, conducting line, etc.
- When the orientation is lost, for visually impaired people acoustical orientation points are also important, but only as additional information.

- If they knew some person who knew the place where they lost orientation, visually impaired people would try to call them.
- Visually impaired people believe that they are able to navigate any lost person on their familiar routes by phone.
- Visually impaired people are willing to share their routes to help other people.

5.3 A quantitative research

In this section the detailed specification and test setup of performed quantitative research are described.

5.3.1 The goal of the research

The main objective of this research is to confirm or refute hypotheses defined in section 3.2.5.1 on page 23 which emerged from both phases of the qualitative study. Another important objective is to identify behavior patterns of visually impaired people in the situation when they lose orientation and try to recover in cooperation with another person through a phone - one of outputs from this research should be also recordings of these dialogs.

5.3.2 The target group

The research is focused on visual impaired people especially on practically and totally blind people (so, on those people who are unable to perceive practically any suggestions through their eyes) who are able to move independently in an outdoor environment and haven't significant problem with a verbal communication.

5.3.3 The test setup

For the purpose of this research were prepared two test scenarios. To ensure the correctness and accuracy of results will both tests have a form of the ethnographic study, it means that will be performed directly in a natural environment of the defined target group - in the streets of Prague. Moreover, tests will be performed on different places - this approach enables to analyze behavior of visually impaired people in different conditions and increase the accuracy and credibility of final results.

Below are described scenarios of both tests. Because of lucidity were tests labeled as Test A and Test B.

5.3.3.1 Test A

The test scenario

Participants will be brought to a prepared route in the streets of Prague (more details about the route you can find at the following section) and will be asked for testing our mobile navigation application there (more detail about the application you can find at section 4.1 on page 28). Application is created

especially for the purpose of this research and contains description of the route that is divided into six sections. Participant is navigated by the application from one section to the next one.

But there is a intentional mistake in the description of route and therefore a participant is navigated to the dead-end street and can't continue. This situation the participant can't solve himself so he is forced to ask for a help. And for this situation, the application contains a special button that connect participant with our prepared assistance center. There will be participant connected with the operator who will navigate him to the right way. The call between the operator and the participant will be recorded and thus obtained dialogs will be used in a next phases of this thesis.

The whole session will consists of the following parts:

A pre-test questionary At the beginning the participant will be brought to the point 0 that is situated into small park in the center of Prague. There will be verify that the participant satisfy requirements defined in the section 5.3.2 on the preceding page. Then will be participant acquainted with the further process of the session, and also get a mobile phone with prepared navigation application and will be instructed in its use. Then will be participant brought to the point 1.

The start of the route After pre-test questionnaire will be participant brought to the point 1 where is located the start of the route. From this point the prepared navigation application will navigate the participant to the route along the castle.

The loss of orientation In the point 2 will the navigation application navigate the participant to the dead-end street. Therefore in the neighborhood of this point is expected that the participant calls the prepared assistance center that will navigate him to the end of the route that is located in the point 3.

The finish of the route The finish of the route is located in the point 3 that is situated in another small park with a historic rotunda. To this point will be participant navigated by the prepared assistance center.

A post-test questionary After finish of the route will be at the point 3 performed short post-test interview with the participant. In this interview, each participant will be asked about his feelings and impressions from the route. Then will be participant brought to the nearest station of the public transport.

The route description

The route is situated directly in the center of Prague in the neighborhood of the church of St. Stephen in Stěpánská street. The initial part of the route, where will be each participant prepared for the route, is situated in the park that is next to the church. The start of the route is situated in front of the park near the side wall of the church. Then the route continues around the church and the end is situated to the park with the historic rotunda of St. Longin that is opposite of the church across the road Na Rybníčku. But participants are navigated by the navigation application to the dead-end street that is situated behind the church.

For the purpose of the navigation application is the whole route divided into six sections. On the figure 5.1 you can see the map of the whole route including particular sections. For a better

understanding to the route, you can see here English version of descriptions of particular sections that are used in the navigation application for the navigation of participants (original Czech version you can find in appendix C) :

Section 0 Initial part of the route, along this way the participant will be brought to the start start of the route.

Section 1 The description of this section: *In front of you is the Štěpánská street. On the right side is the church that forms the corner of the streets Štěpánská and Na Rybníčku. To the church lead two large staircases. Part of the church is surrounded by a metal fence with spikes. From both sides of the second staircase are niches. Go around the church to the second large staircase to the church in the street Na Rybníčku distant about twenty meters. Attention: The first staircase rises from the level of the sidewalk.*

Section 2 The description of this section: *You are standing at the edge of the street Na Rybníčku. On the right side is the second staircase leading to the church and continuing metal fence. At the end of the fence begins the smooth wall and then a stone one. At the end of the stone wall is a door. Go fifty meters along the wall to the door at the end of the stone wall.*

Section 3 The description of this section: *You are standing at the door at the end of a stone wall. On the left side is the streetlights lamp. On the right side is the house followed by a stone wall. Go thirty meters to the end of a stone wall.*

Section 4 The description of this section: *You are standing at the end of the stone wall. On the right side behind the corner are several waste containers. Turn right along the containers and go up the stairs to the park with a rotunda distant about ten meters.* This description leads the participant to the dead-end street.

Section 5 After a call to the prepared assistance center, the participant will be connected with our operator who gives them the following instructions: *Turn left and go to the zebra crossing that is behind the railing on the right side about thirty meters distant. After the crossing turn left and go about fifteen meters along the wall, at the end wall is back-staircase with door, pass through the door.*

Figure 5.1: The map of the route prepared for Test A.

5.3.3.2 Test B

The test scenario

Scenario for this test is inspired by the imaginary situation that was used in the second phase of the qualitative research and that was proven as realistic for all participants - you can find the description of this story at section 5.2.3.2 on page 46. Therefore, participants will be given following task:

> *You have an appointment with your friends in front of the restaurant Lemon Leaf. Go by bus from the station Karlovo náměstí over stations Chrám sv. Cyrila a Metoděje and Na zderaze to the station Dittrichova. From the station continue according to the route description in navigation NaviTerier that will lead you to the restaurant.*

The bus ride will be simulated by the assistant who will lead the participant, notify particular stations and inform him where he should get off. For the navigation of the participant from the station Dittrichova to the restaurant Lemon Leaf will be used mobile navigation application NaviTerier [36] that will be installed in Nokia 6120.

But reporting of stations in the bus will be shifted, so the participant will not get off at the station Dittrichova, but already at the station Na Zderaze. Therefore, navigation application will navigate the participant into wall and he will have to use prepared helpline - on the possibility of using of this helpline will be participant notified before the test itself.

In the helpline will be prepared an operator who has very detailed knowledge about the place where the participant will move and therefore is able to help him and navigate him to the right way. The call between the operator and the participant will be recorded again and thus obtained dialogs will be used in a next phases of this thesis.

The whole session will consists of the following parts:

A pre-test questionary At the beginning the participant will be brought to the point 0 that is situated in the center of Prague in front of building of CTU on the Karlovo náměstí. There will be verify that the participant satisfy requirements defined in the section 5.3.2 on page 56. Then will be participant acquainted with the further process of the session, and also get a mobile phone with prepared navigation application and will be instructed in its use.

The start of the route The route will started directly in the point 0 at Karlovo náměstí. At this point will start the simulated ride of a bus.

The bus ride The simulated ride of the bus will start at the station Karlovo náměstí at the point 0. Then will be participant taken over stations Chrám sv. Cyrila a Metoděje and Na Zderaze to the station Dittrichova where he will get off.

Getting off the bus The participant gets off the bus at the station Dittrichova at point 1. From this point the participant will be navigated by the navigation application to the restaurant Lemon Leaf. But reporting of station in the bus will be shifted, therefore the participant will get off at the station Na Zderaze.

The loss of orientation The navigation application will navigate the participant from the stations

Dittrichova to the restaurant Lemon Leaf, but the participant will get off the bus at the station Na Zderaze, so the navigation application will navigate him into the wall at the point 2. Therefore in the neighborhood of this point is expected that the participant calls the prepared helpline that will navigate him to the end of the route that is located in the point 3.

The finish of route The finish of the route is in front of restaurant Lemon Leaf that is situated in the point 3. To this point will be participant navigated by the helpline.

A post-test questionary After finish of the route will be at the point 3 performed short post-test interview with the participant. In this interview, each participant will be asked about his feelings and impressions from the route. Then will be participant brought to the nearest station of the public transport.

The route description

The route is situated directly in the center of Prague in the neighborhood of the building of CTU on Karlovo náměstí. The initial part of the route, where will be each participant prepared for the route, and also starting point of the route, from which participant will go by the simulated bus, are located directly in front of building of CTU. From this point will be participant taken by the simulated bus along the Resslova street over stations Chrám sv. Cyrila a Metoděje and Na Zderaze to the station Dittrichova that is located in the Na Zderaze street. From this place will be participant navigated by the navigation application to the restaurant Lemon Leaf. But navigation application will navigate the participant into the wall in the Na Zderaze street.

For the purpose of the navigation application is the part of the route which will the participant go after getting off the bus, divided into five sections. On the figure 5.2 you can see the map of the whole route including particular sections. For a better understanding to the route, you can see here English version of descriptions of particular sections that are used in the navigation application for the navigation of participants (original Czech version you can find in appendix D) :

Section 0 In this section will be the participants will be guided by an assistant who will simulate the ride of the bus.

Section 1 The description of this section: *Dittrichova Street, about 200 meters long. The sidewalk is about 4 meters wide paved and leads downhill. Walkway is flanked by curb on the right side, on the left side is a block of buildings. On the sidewalk longitudinally park cars. At the end of the street is the intersection. ACTION: Go to the end of the street Dittrichova to the intersection.*

Section 2 The description for this section: *The intersection of streets Dittrichova, Náplavní and Záhořanského. The sidewalks are flanked by curb. CAUTION: The intersection hasn't a pedestrian crossing. ACTION: Cross the intersection straightly to the other side.*

Section 3 The description of this section: *The Záhořanského Street, about 150 meters long. The sidewalk is about 4 meters wide, paved and flanked by curb. After about twenty meters is on the right side of the street pedestrian crossing indicated by a signal line and reduced curb. Closely behind the pedestrian crossing is about one meter from the curb placed a traffic sign. ACTION: Go to the pedestrian crossing after about twenty meters.*

Section 4 The description of this section: *The pedestrian crossing. It is indicated by a signal line and a reduced curb. ACTION: Go to the second side of the street.*

Section 5 At this moment, the participant is standing in front of the wall, but he will get the following description: *Na Zderaze street, about 100 meters long. The sidewalk is about 4 meters wide and paved. After about fifteen meters is on the left side the entrance to the restaurant Lemon Leaf. ACTION: Go straightly to the entrance to the restaurant.*

Section 6 After a call to the helpline, participant will be connected with our operator who will navigate them to the restaurant Lemon Leaf. The exact description of this section, which the participant will obtain from the helpline, will depend on the place from which will the participant call. But generally, he will be navigated back over the pedestrian crossing to the Myslíkova street, there the participant will cross the street and after about 5 meters they will find the entrance to the restaurant Lemon Leaf.

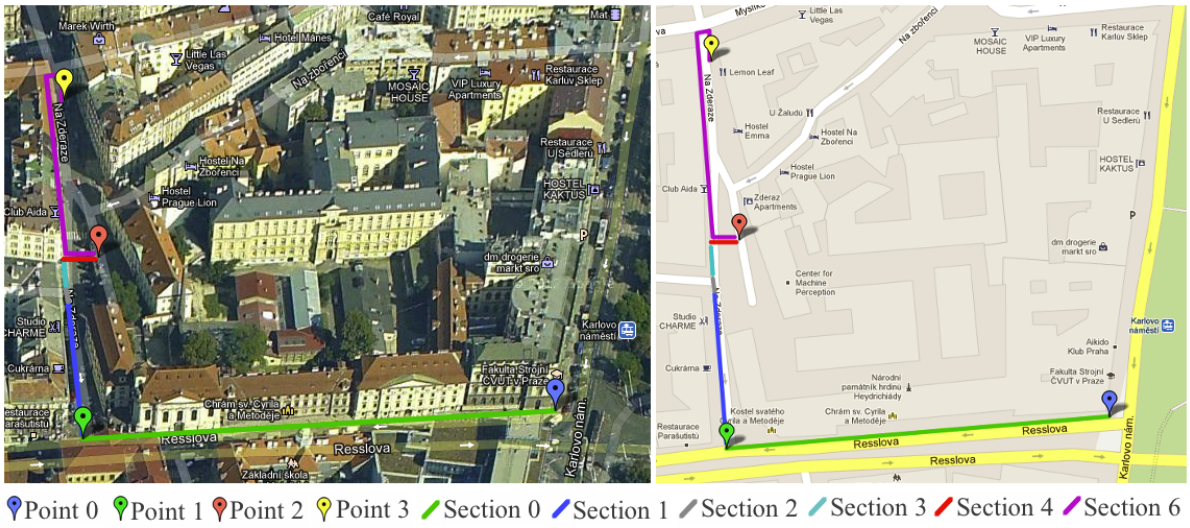

Figure 5.2: The map of the route prepared for Test B.

5.3.4 Data collection

The study was performed with the total of 21 participants - Test A was performed with 5 participants and Test B was performed with 16 participants. From all these sessions dialogs that is possible to find in the attached files were recorded.

The final group of participants consisted of 12 males and 10 females in age from 21 to 60 years with the average age 34,5 years, 14 participants were totally blind and 14 participants were blind congenitally. Total 2 participants regularly use an assistance dog.

5.3.5 Data Analysis

The main objective of this research was to confirm or refute hypotheses defined in section 3.2.5.1 on page 23 and identify behavior patterns of visually impaired people in the situation when they lose orientation and try to recover through a phone. For this purpose were performed quantitative ethnographic

field studies with total 21 participants in different environments. Within these studies were successfully identified some important behavior patterns of visually impaired people in the situation, when they lose orientation, and also collected dialogs between participants and our prepared helpline that will be used in further phases of this work. The complete analyze of obtained data you can see in section 3.2.5 on page 23. In the following subsection are introduced the most important outputs from this study.

5.3.5.1 Findings

- It has been proved that there is a crucial difference between the orientation of visually impaired people who use a cane for the blind and those who use an assistance dog. In the group of participants there were two people who regularly use an assistance dog - both these people did not successfully reach the target of the route. It was shown that people with an assistance dog are typically not accustomed to perceive as many details from the route as people with a cane.
- It has been proved that visually impaired people in the situation when they lose orientation are able to describe their situation on a phone precisely enough to enable the called person to identify their position - the operator on the prepared helpline successfully identified the position of 18 participants from the total of 21.
- It has been proved that it is possible to successfully navigate a visually impaired person who lost orientation via phone - the operator on the prepared helpline successfully navigated 17 participants out of the total 21 participants to the target of the route.
- It has been proved that the most important orientation points which visually impaired people use when communicating via phone, are those points that are possible to be identified by a cane - these points were used during the calls with our helpline by all 21 participants.
- It has been proved that visually impaired people who lost an orientation tend to verify the information that they receive by a phone - practically all participant were moving while they were receiving information by the phone and tried to find the points that the called person was talking about, 11 participants either required a repeat of the received information or repeated the information themselves and asked for their confirmation, 7 participants held the called person on the phone to very end of the route and constantly checked the accuracy of their course.

6 Conclusion

One of the main objectives of this thesis defined in section 1.1 was to research the problem of the navigation of visually impaired people, especially in urban areas. To this purpose a detailed qualitative research with the total of 16 participants who were divided into two separated parts was performed. From both parts of this research a series of findings that is possible to find in sections 5.1.5.1 and 5.3.5.1 emerged. The performed researches also enabled to formulate a series of hypothesis that is possible to find in section 3.2.5.1. For the purpose of verification of these hypotheses a quantitative ethnographic field study with the total of 21 participants, which was due to accuracy of the results divided into two separated parts, was performed. It is possible to find the outputs of this study in section 3.2.5. The realized researches prove that this objective of the work was successfully accomplished.

The performed researches also enabled to study the situation when visually impaired people lose orientation and also to observe them in such situations directly in the practice. Thanks to this, it was possible to identify the basic behavior patterns of these people in situations when they lose orientation. Thus identified patterns are contained in the findings of particular researches. Moreover, during the quantitative research the corpus of dialogs, in which visually impaired people who lost orientation try to recover from this situation in a cooperation with another person through a phone, was collected. Thanks to this corpus it was possible to identify the general structure of such dialogs that can be found in section 3.3.2. Due to this, it is possible to say that the other objective of this thesis, which demanded identification of behavior patterns of visually impaired people in the situation when they lose orientation, was successfully accomplished.

The last objective of the thesis was to propose the concept of the assistance center for visually impaired people. To this purpose the basic needs and requirements of visually impaired people in situations when they lose orientation were identified from the performed researches. On the basis of these findings the concept of the assistance center that would be based on the mutual cooperation of visually impaired people has been proposed. A detailed description of this proposal is possible to find in the section 4.2.1. It is possible to say that also this objective of the thesis was successfully accomplished.

The text above pointed out that all defined objectives of this thesis were successfully accomplished. Moreover, in the section 4.2 the first approaches to realization of the proposed assistance center are described. In other words, the thesis also outlined the way to the practical realization of the mentioned objectives.

6.1 Future work

As has been mentioned above, the first steps of a practical realization of the intended assistance center are presented in this thesis. The future work should build on them and proceed with the subsequent phases of the realization of this center. The further workflow of this process is outlined in the section 2.5.1. The main current task is to expand the corpus of collected dialogs and to use it to finish the practical implementation of the spoken language understanding component of the system for the intended assistance center.

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A Screener for the first phase of the qualitative study

This is the original Czech version of questions in the screener used in the first phase of the qualitative study (the description of this study can be found in the section 5.1):

1. Pohlaví.
   (a) Muž.
   (b) Žena.
2. Věk:
   (a) Méně než 20 let.
   (b) 20 - 35 let.
   (c) 36 - 50 let.
   (d) 51 - 65 let
   (e) Více než 65 let.
3. Stupeň zrakového postižení (podle Světové zdravotnické organizace):
   (a) Bez zrakového postižení.
   (b) Střední slabozrakost.
   (c) Silná slabozrakost.
   (d) Těžce slabý zrak.
   (e) Praktická slepota.
   (f) Úplná slepota.
4. Délka zrakového postižení:
   (a) Nejsem nevidomý/á.
   (b) Jsem nevidomý/á od narození.
   (c) Oslepl/a jsem až v průběhu života.
5. Při chůzi používáte:
   (a) Slepeckou hůl.
   (b) Asistenčního psa.
   (c) Žádnou z uvedených pomůcek.
6. Vyberte tvrzení, které Vás nejlépe vystihuje:
   (a) Ve venkovním prostředí se vůbec nepohybuji.
   (b) Ve venkovním prostředí se pohybuji pouze v doprovodu asistenta.

(c) Ve venkovním prostředí se pohybuji samostatně, ale držím se vždy pouze těch tras, které dobře znám. Nové trasy vždy procházím nejprve s asistentem.

(d) Ve venkovním prostředí se pohybuji zcela samostatně.

7. Máte nějakou zkušenost s pohybem v neznámém prostředí pouze podle popisu trasy - například z asistenčního centra?

   (a) Ano, takovou zkušenost mám.

   (b) Ne, nikdy jsem podle popisu nešel.

8. Používáte při pohybu ve venkovním prostředí nějakou pomůcku pro navigaci (například mobilní telefon, GPS navigaci, popis trasy z asistenčního centra, apod.)?

   (a) Ano, takové pomůcky používám.

   (b) Ne, nepoužívám žádné takové pomůcky.

   (c) Ve venkovním prostředí se nepohybuji.

9. Navštěvujete nějakou organizaci, která se specializuje na práci s nevidomými lidmi?

   (a) Ano, tyto organizace navštěvuji pravidelně - alespoň jednou týdně.

   (b) Ano, tyto organizace občas navštěvuji.

   (c) Ne, žádné takové organizace nenavštěvuji.

10. Ztratil/a jste se již někdy při pohybu ve venkovním prostředí?

    (a) Ano, s takovou situací již mám zkušenost.

    (b) Ne, do takové situace jsem se nikdy nedostal.

B Screener for the second phase of the qualitative study

This is the original Czech version of questions in the screener used in the second phase of the qualitative study (the description of this study can be found in the section 5.2):

1. Pohlaví.
   (a) Muž.
   (b) Žena.
2. Věk:
   (a) Méně než 20 let.
   (b) 20 - 35 let.
   (c) 36 - 50 let.
   (d) 51 - 65 let
   (e) Více než 65 let.
3. Stupeň zrakového postižení (podle Světové zdravotnické organizace):
   (a) Bez zrakového postižení.
   (b) Střední slabozrakost.
   (c) Silná slabozrakost.
   (d) Těžce slabý zrak.
   (e) Praktická slepota.
   (f) Úplná slepota.
4. Délka zrakového postižení:
   (a) Nejsem nevidomý/á.
   (b) Jsem nevidomý/á od narození.
   (c) Oslepl/a jsem až v průběhu života.
5. Při chůzi používáte:
   (a) Slepeckou hůl.
   (b) Asistenčního psa.
   (c) Žádnou z uvedených pomůcek.
6. Jste schopen pohybovat se samostatně ve venkovním prostředí?
   (a) Ne, ve venkovním prostředí se vůbec nepohybuji.
   (b) Ano, ve venkovním prostředí se pohybuji, ale pouze v doprovodu asistenta.
   (c) Ano, ve venkovním prostředí se pohybuji.

C Route description for Test A of the quantitative research

These are the original Czech descriptions of particular sections of the route prepared for Test A of the quantitative research (the description of this study can be found in the section 5.3):

Section 1 Před vámi je ulice Štěpánská. Po pravé straně je kostel, který tvoří roh ulic Štěpánská a Na Rybníčku. Ke kostelu vedou dvoje velká schodiště. Část kostela je obehnána kovovým plotem s hroty. Z obou stran druhého schodiště jsou výklenky. Obejděte kostel a zastavte se u druhého velkého schodiště do kostela v ulici Na Rybníčku vzdáleného asi dvacet metrů. Pozor schody prvního schodiště vycházejí z úrovně chodníku.

Section 2 Stojíte na kraji ulice Na Rybníčku. Po pravé straně je druhé schodiště kostela a pokračuje kovový plot. Na konci plotu začíná hladká zeď a poté kamenná. Na konci kamenné zdi jsou dveře. Jděte padesát metrů podél zdi ke dveřím na konci kamenné zdi.

Section 3 Stojíte u dveří na konci kamenné zdi. Po levé straně je lampa pouličního osvětlení. Po pravé straně je dům a na něj navazuje kamenná zeď. Jděte třicet metrů na konec kamenné zdi.

Section 4 Strojíte u konce kamenné zdi. Po pravé straně za rohem je řada popelnic na tříděný odpad. Odbočte doprava podél popelnic a vejděte po schodech do parku s rotundou vzdálených asi deset metrů.

D Route description for Test B of the quantitative research

These are the original Czech descriptions of particular sections of the route prepared for Test B of the quantitative research (the description of this study can be found in the section 5.3):

Section 1 Ulice Dittrichova, asi 200 metrů dlouhá. Chodník je asi 4 metry široký dlážděný a vede z kopce. Chodník je po pravé ruce lemován obrubníkem, vlevo je blok budov. Na chodníku parkují podélně auta. Na konci ulice je křižovatka. AKCE: Dojdi na konec ulice Dittrichova ke křižovatce.

Section 2 Křižovatka ulic Dittrichova, Náplavní a Záhořanského. Chodníky jsou lemovány obrubníkem. POZOR: křižovatka nemá přechod pro chodce. AKCE: Přejdi křižovatku rovně na druhou stranu.

Section 3 Ulice Záhořanského, asi 150 metrů dlouhá. Chodník je asi 4 metry široký, dlážděný a je lemován obrubníkem. Po asi dvaceti metrech je vpravo přechod pro chodce indikován signálním pásem a sníženým obrubníkem. Těsně za přechodem je asi jeden metr od obrubníku dopravní značka. AKCE: Dojdi k přechodu pro chodce asi po dvaceti metrech.

Section 4 Přechod pro chodce. Je indikován signálním pásem a má snížený obrubník. AKCE: Akce přejdi na druhou stranu ulice.

Section 5 Ulice Na Zderaze, asi 100 metrů dlouhá. Chodník je asi 4 metry široký a je dlážděný. Po asi patnácti metrech je po levé ruce vchod do restaurace Lemon Leaf. AKCE: Jdi rovně ke vchodu do restaurace.

E VoiceXML source documents

The following subsections present VoiceXM source documents of particular parts of the dialog model defined in section 4.2.2.

E.1 Root document source

```
<?xml version="1.0" encoding="UTF-8"?>
<vxml xmlns="http://www.w3.org/2001/vxml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.w3.org/2001/vxml http://www.w3.org/TR/voicexml20/vxml.xsd"
    version="2.0">
<meta name="author" content="Jan Novacek"/>
<form id="helpLine">
       <var name="problem_description"/>
       <var name="current_position"/>
       <var name="unambiguous_point"/>
       <var name="new_route_description"/>
       <assign name="new_route_description" expr="Postavte se prosím tak, abyste zed' se
           schody měla za zády a přejděte zpět po přechodu na protější chodník a dejte se
           doprava. Poté pokračujte po chodníku několik desítek metrů, po vaší levé straně
           budete mít domy, měl byste minout dvě restaurace, které jsou blízko u sebe. Na
           konci ulice dojdete až ke křižovatce s ulicí Myslíkova. Myslíkova je rušnější
           ulice, širší, bude přímo před vámi. Před touto ulicí přejděte po přechodu a
           vrat'te se kousek zpátky. Tam asi po 20 metrech už je restaurace Lemon Leaf. Vchod
           do restaurace poznáte tak, že jsou v něj dva květináče, které jsou úplně u zdi."/>
       <initial name="introduction">
              <prompt>Dobrý den, dovolal jste se na asistenční centrum pro zrakově postižené.
                  Jak vám mohu pomoci?</prompt>
              <help>Popiště mi prosím jak vám mohu pomoci.</help>
              <noinput count="1"><reprompt/></noinput>
              <noinput count="2">
                     <reprompt/>
                     <assign name="introduction" expr="true"/>
              </noinput>
       </initial>
       <field name="problem_description">
              <subdialog name="problem_description" src="problemDescription.vxml#basic">
                     <filled>
                            <assign name="problem_description"
                                expr="problem_description.value"/>
                     </filled>
              </subdialog>
       </field>
       <field name="current_position">
              <subdialog name="current_position" src="currentPosition.vxml#basic">
```

```
                        <filled>
                                <assign name="current_position" expr="current_position.value"/>
                        </filled>
                </subdialog>
        </field>
        <field name="unambiguous_point">
                <subdialog name="unambiguous_point" src="unambiguousPoint.vxml#basic">
                        <param name="current_position" expr="document.current_position" />
                        <filled>
                                <assign name="unambiguous_point" expr="unambiguous_point.value"/>
                        </filled>
                </subdialog>
        </field>
        <field name="description_of_new_route">
                <prompt>Dobře.<value expr="new_route_description"/></prompt>
                <filled>
                        <if cond="end_of_call")
                                <prompt>Není zač, nashledanou.</prompt>
                                <throw event="exit"/>
                        </if>
                        <prompt><value expr="new_route_description"/></prompt>
                </filled>
        </field>
</form>
</vxml>
```

E.2 Document 1 source

```
<?xml version="1.0" encoding="UTF-8"?>
<vxml xmlns="http://www.w3.org/2001/vxml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.w3.org/2001/vxml http://www.w3.org/TR/voicexml20/vxml.xsd"
    version="2.0">
<form id="basic">
        <field name="value">
                <prompt>Dobrý den, jak vám mohu pomoci?</prompt>
                <help>Popiště mi prosím váš problém.</help>
                <filled>
                        <return namelist="value"/>
                </filled>
        </field>
</form>
</vxml>
```

E.3 Document 2 source

```
<?xml version="1.0" encoding="UTF-8"?>
<vxml xmlns="http://www.w3.org/2001/vxml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.w3.org/2001/vxml http://www.w3.org/TR/voicexml20/vxml.xsd"
    version="2.0">
<form id="basic">
       <field name="value">
              <prompt count="1">Ja jsem dostal zpravu, ze jste se ztratil někde na trase.
                  Mužete mi popsat, kde se nacházíte?</prompt>   <prompt count="2">Popiště mi
                  prosím konkrétně místo, kde jste.</prompt>
              <help>Popiště mi prosím místo, kde se právě ted' nacházíte.</help>
              <filled>
                     <return namelist="value"/>
              </filled>
       </field>
</form>
</vxml>
```

E.4 Document 3 source

```
<?xml version="1.0" encoding="UTF-8"?>
<vxml xmlns="http://www.w3.org/2001/vxml"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="http://www.w3.org/2001/vxml http://www.w3.org/TR/voicexml20/vxml.xsd"
    version="2.0">
<form id="basic">
       <var name="current_position"/>
       <field name="value">
              <prompt><value expr="current_position"/>. Je ve vašem okolí ještě něco
                  jiného?</prompt>
              <help>Nyní se pokusíme najít ve vašem okolí nějaké jednoznačné místo.</help>
              <filled>
                     <return namelist="value"/>
              </filled>
       </field>
</form>
</vxml>
```

F Contents of the enclosed DVD

The enclosed DVD has the following structure:

dialog_model/	-	The folder containing the dialog that was used to define the dialog model described in the section 4.2.2.
qualitative_study/	-	The folder containing the dialogs that were recorded during the both phases of the performed qualitative study (the descriptions of these phases of the study can be found in sections 5.1 and 5.2).
quantitative_study/	-	The folder containing the dialogs that were recorded during the performed quantitative research (the description of this research can be found in the section 5.3).
text/	-	The folder containing the text of this thesis (including the source file).
readme.txt	-	The text file that contains the detailed description of the content of the DVD.