Blobby: How to Guide a Blind Person Indoors

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Abstract
For the majority of blind people, walking in unknown places is a very difficult, or even impossible, task to perform, when without help. The adoption of the white cane is the main aid to a blind user's mobility. However, the major difficulties arise in the orientation task. The lack of reference points and the inability to access visual cues are its main causes. We aim to overcome this issue allowing users to walk through unknown places, by receiving a familiar and easily understandable feedback. Our preliminary contributions are in understanding, through user studies, how blind users explore an unknown place, their difficulties, capabilities and needs. We also analyzed how these users create their own mental maps, verbalize a route and communicate with each other. Structuring and generalizing this information, we were able to create a prototype that generates familiar and adequate instructions, behaving like a blind companion, one with similar capabilities that understands his "friend" and speaks the same language. We evaluated the system with the target population, validating our approach and orientation guidelines, while gathering overall user satisfaction.

ACM Classification Keywords
H5.2. User Interfaces: User-centered design.

Authors Keywords
Blind, Orientation, Instructions, Familiar, Accessibility, Mobile, Evaluation.

Introduction
For the majority of blind people, walking in unfamiliar indoor places is very difficult, or even impossible, when without help. Orientation and mobility are essential skills for a blind person. Mobility depends on skillfully coordinating actions to avoid obstacles in the immediate path, whereas spatial orientation depends on coordinating ones actions relative to the further ranging surroundings and the desired destination. Orientation refers to the ability to establish and maintain awareness of one's position in space relative to landmarks in the surrounding environment and relative to a particular destination.

Well-established orientation and mobility techniques using a cane or guide dog are effective for following paths and avoiding obstacles, but are less helpful for finding specific locations or objects. As possible solutions, we find tactile maps and Braille signs, but both are insufficient and sometimes inadequate to user's needs. While there are some new advances in location-based guides for the blind, they are still too generalist. By focusing the design on the users, we focus our contribution in offering blind users a familiar feedback, so they can easily follow and understand all the given instructions and reach their destination successfully. To achieve this goal, we performed studies with a group of blind users and a mobility instructor, gathering a set of guidelines and strategies aligned with the focus group common language, habits and requirements.

Related Work
This research area has been a target of attention for the past two decades. There have been different approaches and systems that differ, especially, on their location technology.

The GPS is the most common system used in mobile guides [5]. However this technology is only available in outdoor environments. As an alternative to GPS in indoor environments, we find the Radio Frequency Identification (RFID) based approaches. Usually, in this kind of systems, multiple tags with geographic information are spread over an indoor environment and the user carries an RFID reader. This way, the system can locate him and offer the appropriate feedback [6]. Also, both Bluetooth [1] and WLAN [4] technologies use a radio frequency signal, which can be analyzed in order to infer the user's position. There are also some approaches that place a camera in the user's head or white cane in order to identify some objects in the room and therefore guide the users to their destination [2].

Generally, the systems designed to outdoor environments use GPS, due to its advantages. However, because GPS is unavailable in indoor environments, different approaches can be used and each one has its own advantages. This indicates that an orientation system has to be modular and flexible enough to allow the use of different location technologies, depending on the scenario. Almost all the projects in orientation systems that we have seen, tried to create an approach that would allow them to locate the user with a higher precision. On the other hand, the interaction process and, specially, the feedback that is offered are often forgotten. Our main interest and this paper's contribution is to close this gap, by understanding the what, when and how of a guiding system for the blind. We achieve this by studying the users, their needs, habits and using their own orientation abilities to improve the system's familiarity and adequacy.

Orientation System for Blind People

In an orientation system, the way the user is guided and the feedback he receives is crucial to his performance. However, this task is often forgotten. It is necessary to give blind users an appropriate interface. Our approach tries to give a familiar feedback by studying the users' capabilities and needs. Following a user centered design (UCD) approach we were able to identify common capabilities and behaviors among the target population, when exploring an unknown place. On the other hand, we also studied the way these users described and guided other blind users.

User Studies

The main contribution of this paper relies in the results obtained from studies with the target population. UCD is a philosophy that puts the person in the center and in all stages of the design process, trying to gather as much information from the user and his surroundings as possible, in order to guarantee quality.

On a first stage, we performed eight interviews to get a first contact with the users. After the interviews analysis, we conducted eighteen questionnaires in order to obtain the user's profile, current limitations and needs, degree of independency and technological knowledge. The target population has more than forty five years old and a low educational background (below the 12th grade). All the users have one cell phone and use it daily to make and take phone calls. According to the questionnaires results, despite the users walk alone most of their time, 35% of the users require constant help in a public building.

In order to efficiently guide the user, an orientation system has to give him an easily understandable feedback. Therefore, we decided to perform a user observation that had the following goals: analyze their behaviors, difficulties, capabilities, needs and techniques, when exploring an unfamiliar place; analyze the evolution of the user's mental maps; identify the most important information for the user; study the verbalization of a route; study the way the users communicate a route to a blind colleague.

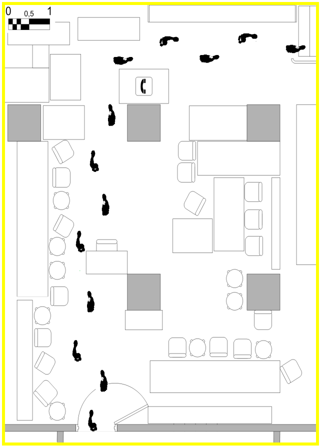

figure 1. Map and route chosen for the user studies.

Three participants volunteered to this experiment and the main goal was to explore and get a total knowledge of an unfamiliar place, in order to guide someone. Figure 1 represents the chosen map and route. The main conclusions of this experiment were: users scan the whole place using an attempt-error approach; obstacles impede the correct perception of reality; the users can easily memorize a route; users do not like to explore new routes, leading to an incomplete mental map of the place; reference points are crucial and have to be easily identifiable; when the user is disoriented, he turns back and tries to locate some reference point.

After this observation phase, we conducted a group meeting with the three participants and a former instructor of orientation and mobility (O&M) techniques for blind users, in order to consolidate and discuss all the obtained results. In this meeting, we were able to construct one (the "best") story of the predefined route (figure 1). We were also able to identify the main elements that must be present to contextualize the user in an unknown building: structure - place characteristics (e.g. dimensions, shape or number of floors); interest points - corresponds to all the possible destinies (e.g. shops, offices, building services or toilets).

As mentioned before, reference points are crucial to guide blind users. A reference point is some infra-structure element or other artifact that cannot be easily moved. All other artifacts are obstacles. The usage of reference points to communicate a route is a natural way to guide someone. However these reference points have to be chosen very careful, so blind users can be able to identify them (usually with their white cane). Moreover, this is the only way they have to build their mental map of the place. When a blind user is lost his first reaction is to turn back and try to find a reference point, so he can continue. The vocabulary used in the instructions is also crucial to the user's performance. An instruction and all its vocabulary cannot be ambiguous. For example the instruction, "*go ahead until the end of the ramp and turn right*", is clearly ambiguous. The reference point that is given (i.e. end of the ramp) may be hard to identify, leading the user to unexpected places. Another example is the instruction, "go around the table by the right side and go ahead …". In this case, the instruction is ambiguous because the user does not know how much around is he supposed to go. Finally, during the observation and group meeting phases, all the users stated that they prefer a short and simple feedback, over too many descriptions.

Familiar Feedback

Through a study of how blind users verbalize a route, we were able to identify the main elements and rules for the automatic building of instructions:

Action: this element corresponds to the verb of the instruction (e.g. turn, go, enter or leave).
Direction: some of the previous actions need a direction so they can make sense. For instance, the action turn needs to be complemented with the respective direction, left or right.
Side: sometimes, we need to explicitly identify the side, in which the user should walk, in order to identify a reference point or avoid dangers.
Time/Distance: usually, a reference point is associated to a decision point (i.e. direction shift). The reference to these points is done through time or distance elements. For example, "turn right after you pass a door" or "follow three steps forward ..."
Object: this element can be any artifact existent on the local (e.g. doors, stairs, tables or walls).
Depending on the place, reference points and the user's position, the instructions may vary. Concluding, all the

instructions can be defined through the following regular expression [3]:

Action Direction? ([Time Distance Side])* Object?

Building the Instructions

Our algorithm is an implementation of the rules already defined in the previous section. Given a route our algorithm will subdivide it, if there are any reference points or direction shifts in between two points. In an iterative process all the instructions will be built till the user reaches his destination.

If the next point in the route is a reference point, then the instruction is very simple, i.e. Action Direction Object, since the object is easily identifiable. On the other hand, when there is a direction shift, the user has no reference point. Therefore, we need to build a reference taking into account the nearest objects (e.g. doors). This way we can get an instruction like, "*turn right when you pass a door*". If we can't build a reference, then we need to use distances to guide the users (e.g. "*… and then turn right after three steps*"). In both cases the use of the side element can be necessary in order to help the user to find a reference point or other element easily. If the user is lost, strayed of the route or needing help, then the system will ask him to go back to the last reference point. According to our studies, this was the natural behavior of users when they were disoriented. That's one of the main reasons why the correct identification of the reference points is so important. If he can't go back, the system will guide him from the nearest localizable position.

Evaluation

To validate the presented approach a functional prototype was built and tested with six blind users. The evaluation was performed with a HTC TyTn's mobile device with Windows Mobile 5.0 and a TTS system (Loquendo, Portuguese voice). To fully evaluate our approach, we have chosen an unfamiliar place and route (figure 1). In this evaluation, we used a Bluetooth localization system, where each beacon corresponded to a reference point.

During the evaluation, one of the users needed external help to complete the task. In this particular case, the user had some difficulties distinguishing left and right directions, therefore the need for external help. All the remaining users were able to successfully complete the task. The mean time needed to complete the route was 146 seconds with a standard deviation of 76 seconds. Moreover, approximately 20% of this time corresponded to the Bluetooth discovery process, where the user had to wait near the last reference point for the next instruction. Despite the high waiting time and the difference between times to achieve the goal, all the users were able to understand all the instructions and clearly identify the reference points, so that they could wait for the next instruction (which indicates that the instructions were understandable). Figure 2 represents the average time that the users spent in each point of the route. Analyzing the obtained results, we can observe that all users followed a similar route and spent most of their time near reference points, waiting for the next instruction.

To assess the user's opinion about the given instructions, we performed a questionnaire in the end of each evaluation session. The obtained results showed an overall user satisfaction of 4.5 in a 5 point likert scale.

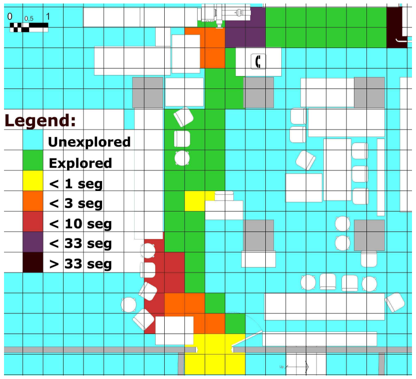

figure 2. Thermal map: average time that the users spent in each point of the route.

Conclusions

The actual orientation systems for blind people need an appropriate interface. Almost all of the work that has been done has the main goal of locating the user with a higher precision. Although this is a crucial component, it does not guarantee the system's success. New approaches that allow guiding the user and adapt the interface to their capabilities and needs are required. Therefore, our approach consisted in analyzing blind user's behaviors while exploring unknown places, so that we could build a more appropriate interface and dialogue system. In order to guarantee a familiar feedback we also studied how these users verbalize a route and communicate it. Moreover, we defined a set of elements and rules so we could generate these instructions automatically. The achieved results indicate that the users easily understand (without training) all given instructions and are able to follow them.

Future Work

In order to efficiently guide a blind user a good localization system is required. However this component of our prototype has to be modular enough to easily support different technologies (e.g. RFID, WLAN, Bluetooth …) and take advantage of each one of them. Moreover, our approach needs to be fully evaluated in different indoor/outdoor sceneries with different routes, obstacles and reference points.

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