Phase 2 - System Specification

Project

GUIDE BLIND

A report by

Team 37

Team Members
Janhavi Digraskar
Gauri Ajay Dani
Vivek Bhalla
Anuj Garg
Abhinav Bhardwaj
Anuj Kaul

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Problem Statement

Navigation in a space is a complex motor skill. Human's navigation and way finding consists of two distinct components – sensing of the immediate environment for impediments to travel (e.g., obstacles and hazards) and navigating to remote destinations beyond the immediately perceptible environment. Thus this involves updating one's position and orientation during travel with respect to the intended route or desired destination and in the scenario of losing the sight of route, reorienting and resuming the travel towards the destination [1]. Navigation is a product of motor, sensory and cognitive skills supplemented with mental mapping of spaces. This mental map is created using the visual senses and thus blind are at a loss when it comes to navigating independently [2].

Further, people with visual impairment are dependent on other senses to gain the information for bypassing obstacles, hazards and also have relatively little information about landmarks, heading and, self-velocity - information that is essential to sighted individuals navigating through familiar environments who have knowledge of these environments or who are navigating through unfamiliar environments on the basis of external maps and verbal directions [1]. The fundamental issues of cognition of blind and research on blind people's mobility in known and unknown spaces indicates that facilitation for the acquisition of spatial mapping and orientation skills that should be obtained in a hierarchy : Perceptual and Conceptual. Perceptual information refers to substitution of the sense of vision with the use of other senses (touch and hearing). Moreover haptic information encompasses touch as kinesthetic information which is supplied by cane, palms and fingers. Auditory channel provides information about events and presence of others. Conceptual information is required to aid in path planning. Blind mainly use route strategies although map strategies are holistic providing multiple perspectives of the target space[3].

The problem lies in providing perceptual and conceptual information to the target group as well as a user-friendly interface which assists the user in absorbing the information. Further, identifying the design of the spaces where blind navigates, elements of design which could be plausible threats must be identified (lighting conditions, acoustics, sharp edges near the stairs) and modified to suit their environment. In summary the problem involves the following steps:

1. Gather information about the environment.
2. Communicate the information to the user.
3. Monitor the progress of the user and consider the situations where movement is impeded.

These essential steps are the backbone of the solution to the problem and in the further sections we focus on detailing the problems pertaining to each step mentioned above.

History & Current Solutions

The cane has been used by the blind worldwide as the primary mobility tool for centuries (Kelly, Pat, 1999), but it was not until World War I that the white cane was introduced. The white cane alerts others of the bearer's visual impairment and also helps in navigation in a limited way. There are many drawbacks of the cane. It can only detect obstacles on the ground and has a very small range. While guide dogs, the other major mobility aid for the blind, can interact more with the user and environment, white canes are preferred for reasons like price, care and sometimes allergies. Also since dogs are partially color blind, they are incapable of interpreting street signs. Hence, the white cane remains the most widely used mobility aid even today.

There have been widespread attempts to use GPS to aid the visually impaired in navigation. Some devices like Trekker and BrailleNote GPS [4] have been developed, which use GPS to pinpoint the user's location and use maps to guide him to his point of interest. The problem with relying heavily on GPS systems to navigate is that they are not always detailed or accurate enough to distinguish between, say, a sidewalk and a street. Moreover, GPS is not available in places like parking garages and underground transit stations and it cannot pick up dynamic changes in the environment like people and cars.

There are other devices like iGlass [5] that use ultrasonic waves to detect obstacles inside 3 meters and give feedback about those obstacles using vibration. They are worn like a pair of sunglasses and are useful for head and upper body protection. They will be useful when used in combination with a white cane, but feeling vibrations on the forehead isn't really comfortable.

There are other solutions being developed that use cameras and a process called visual odometry to get information about direction and distance from the images captured by the cameras [6]. It is, as of now, unclear, as to how well these systems will perform in a real world environment.

Certain solutions that focus on giving location information to the users inside buildings involve using technologies like radio signal triangulation, radio signal (beacon) emitter and signal fingerprinting. A new way to do this is to use Radio Frequency Identification (RFID) tags [7]. These tags can be embedded almost anywhere without an energy source. The tags store location information and give it to any reader that is within a proximity range of 10-15 meters. The navigation device (reader) carried by the user, communicates with a routing server using GPRS networks.

All these solutions are very innovative and illuminate different ways of tackling the same problem. Though when used individually, they have some drawbacks like high cost, low practical application, discomfort and limited scope which do not make them reliable or the top choice for navigating independently for the blind. Hence, we explore various possibilities like using a combination of these technologies in this project to try to alleviate the problem of independent mobility of the visually impaired.

Objectives & Goals

The objective of the project is to facilitate the user with optimal information necessary for navigation in a building. Optimal information is defined as the information necessary to navigate with ease considering the pace and response time of the user. Research suggests that visual inputs provide tools for building and remembering spatial information required for selection of path for traversal [3]. However, in the absence of visual sensory organs, a tool aiding the user must mimic the cognitive system through use of various technologies. Thus the goal of the project is to use the current technology to provide the users with comprehensive information for path traversal. This includes the following tasks considering multiple aspects:

1. Facilitating the user with route information must ensure safety, accuracy, time constraints (shortest path) and resource constraints (situations where routes are not safe for traversal).
2. In addition emergency situations such as fire or medical assistance needed by the user must be considered.
3. Further, the events where the user is unable to understand the instructions must be identified and rectified to help them resume their travel.
4. The system must be user-friendly with minimal requirements of maintenance, cost for all the buyers.

The solutions discussed in the previous section, have one thing in common heavy dependence on the blind to use the technology. Thus our objective is to design an environment to facilitate the navigation of blind. Our buildings are designed for the users who are able to use visual perception. However, when it comes to the visually impaired, the buildings have provisions for tactile perception by the use of signage at the entrances of rooms. Important considerations for the environment of blind are the lighting system, and the acoustics [8]. Depending upon the type of blindness, different intensity of lights are suitable for the blind [8]. General guidelines suggest avoiding glares, formation of shadows for their traversal [9]. The building in turn must be able to modify the lighting conditions to help the navigation. Detectable warning signs are used to warn the blind about the plausible dangers in their vicinity. Further use of audible pedestrian signals is deployed in some places to assist the blind in crossing the paths [9]. These are the elements of Universal Design which must are incorporated for safe navigation of the blind [8]. The problem is not simply related to designing a software for assistance, but integrating the elements of the environment can aid in devising a better solution for the problem.

To summarize, our objective is to provide a protective environment along with an interface to communicate with the blind. The problem of blind navigation is an interdependent problem, which has multiple inputs and stimuli for the user. Thus our focus is to identify the external elements which contribute to the navigation and use it for our solution.

Functional Requirements

Audio Interaction

1. System should interact with the blind user with audio instructions through an application on smart phone/tablet or a wireless microphone set.
2. Whenever user needs guidance and starts the application, it should ask the user the desired destination with audio instructions.
3. System should guide the user according to the instructions comprehensible by the users, such as “Go to your left by 5 steps”.
4. System should constantly update the user with current scenario, instructions about staircase, elevator and places on the way.
5. The system should warn the user about the status of the device, if there are any missing functionalities required for operation of the application.

Guidance according to the requirements of user

1. System should calculate the shortest path to the destination and lead the user from this path towards the destination.
2. Depending on the type of destination, system should convey additional details to the user. For example, if the user wants to go to the food court, after reaching there, system should tell user about the location of “Trash”, “Water fountain”, “Cutlery section”.
3. The pace of instructions must be according to the user’s convenience.

Smart Building

1. The system should also be connected to some structures of the building to make the building smart enough to detect the presence of the blind users and provide them with certain comforting services.
2. For example, when the system is on, then it should also signal the doors on the way to open automatically when the blind user reaches near door.
3. Or if the user is near an elevator, the elevator door should open for the user and system should notify this to the user.
4. System prototype can be restricted to smart acting of doors but then we can make the building smarter and enable easy navigation for the blind user within the building.
5. The lighting system of the building must be adjusted according to the needs of the user, to avoid glares, shadows or any optical illusions.

Dynamic obstacle detection

1. The system is responsible for guiding the blind from their current location to the desired destination, by considering the dynamic events in the path.

2. The system should warn the user of the possible obstacles in the path, which include, walls, people in the way, tables, chairs, etc., and the possible objects which could deter the user's travel.
3. The dynamic events are crucial and the system response should be adequate to prevent happenings of mishaps. This requires the system to be quick and adaptive to the changes in the environment.
4. The tool must be user-friendly and easy to maintain. The system must guide the user according to the adequate requirements about its battery life, or other requirements which need to be facilitated.
5. The system should be easy to comprehend, with clear input instructions either audio or tactile to guide the user.

Emergency situations

These scenarios consider the emergency situations which a visually impaired person could face but would not be able to detect because of lack of visual input. Thus the following are needed:

1. Detection of possible threats - fire emergencies, health issues (need for doctor), absence of power supplies, possible repairs of construction work.
2. This also include keeping information about the escape routes, emergency contact numbers and nearby medical aid available.

System requirements

1. The system should be available to the user 24x7.
2. In case of inadequate resources (absence of wireless networks, battery), the system must warn the user appropriately with suitable instructions.
3. The guidance should be provided in the preferred language of the user or preferred mode of interaction.
4. The system should monitor the progress of the navigation and use the feedback to provide better routes or instructions. It is imperative to understand the learning curve of user to facilitate necessary information and thus feedback is necessary.

Our objective has been to provide maximum comfort to the blind while navigation in order for a safe traversal to the destination. There are environments with humans present to guide and they cannot be substituted by the machine, yet considering different possibilities encountered by the blind, we have tried to incorporate all of them.

User Profile & Deployment Environment

Users

As customers, we the university administrators are investing into a project for development of a guiding system for visually impaired. We classify our primary actors as visually challenged people. This category includes people who are partially or completely blind and the set of actors may be extended to assist night blind and snow blind people too. There are categories of visual impairments and our target group are the following -

1. Blindness - conditions where individuals have to rely on vision substitution skills. Reports suggest that legal blindness refers to acuity of 20/200. This implies that an impaired person can see at a distance no greater than 20 feet [10].
2. Low Vision - less degree of vision loss where individuals can be helped by vision enhancement devices. These individuals are not as restricted for navigation as the one suffering from complete loss of vision [10].

When a visually impaired person enters an unknown environment he has to either wait for someone who can guide him to the destination or tediously locate for braille signage on the wall. Our focus is to provide them with the technology that will both the users perceive the world independent of human assistance in an efficient manner and with ease of access.

Moreover, no matter how efficient a system is in assisting a visually challenged person nothing can substitute for human emotion or concern. Under various circumstances family, doctors, university administrators, employer or even a friend might want to keep track of a visually impaired person or respond to an emergency by locating them. This subset of people involved in the lives of a visually impaired person act as secondary actors to our system.

Deployment Environment

Currently, our focus is on making Davis Hall at the University at Buffalo an “eyes for all zone” by deploying and testing the system in it. This implementation model can be extended to other buildings and even open spaces in the university. The application of this system can be extended to airports, stations, malls, offices, hospital and even home for special people.

Future Scope

Proposed Solution

Our proposal primarily focuses on ease of access. Any smart device that could fit and be controlled with one hand. A Human computer interaction via voice and touch should be implemented using the smart device .We believe that the campus's ubiquitous WiFi network will prove to be useful in connecting these smart devices with the system.

Constraints

The system should make maximum use of the existing infrastructure to avoid unnecessary overhead in cost. The system application should be portable between devices.

Future plans

On the successful implementation of the system, it can be extended to open space mapping and predictive mapping according to user routine. We can expect the system to learn about a user and their schedules and integrate it as person management system for the visually impaired and well as anyone else requiring assistance to move about. It can be used as a holistic system which gives warning messages and check for faulty or uncertain changes in real time. Thereby, providing a system which can be implemented in various places frequented by people empowering the visually impaired to lead safe and normal lives. Thus making the system a life assistant rather than just a guide blind system.

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