



Assistive Technologies for Visually Impaired People

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Abstract: In this paper an overview of different types of assistive technologies is presented. Some of the most important aspects for the visually impaired are the solutions and assistance devices for the daily life. A simple categorization of this type of assistance devices is presented. Another important aspect for the visually impaired people is the indoor/outdoor navigation in dynamically changing environment. The technological advancement made possible the creation of different electronic equipments to help visually impaired/disabled persons in their navigation, such as different navigation systems, obstacle avoidance, object/obstacle localization, orientation assistance systems, in order to extend or change the basic support of guidance dogs and the white cane. In the paper a solution to integrate different assistive technologies is proposed, focusing on navigation and object detection, with the use of intelligent feedback by Human Computer Interfaces (HCI) with implication of Head-related transfer function HRTF functions. The paper is composed of three sections. In the first part a general description of the paper is presented. In the following section, entitled “Assistive technology”, two main aspects are discussed: assistive technology for daily life and assistive technology for navigation and orientation of visually impaired. From the assistive systems for daily life, the following most important aspects/subjects are presented: personal care, timekeeping, alarms, food preparation and consumption, environmental control/household appliances, money, finance and shopping. Finally some conclusion is presented. The paper is a comprehensive overview of the literature and it does not contain implementation results.

Keywords: Assistive Technology, Navigation systems for visually impaired.

1. General information

The main objective is the presentation of a system for detection and avoidance of obstacles that assists visually impaired/disabled persons in their movement. In order to achieve the proposed results, the paper will focus on the presentation of different assistive technology solutions.

The concept is to integrate a multi-sensorial input system for distance measurement, and to determine from the measured signals if there are any obstacles in the path of the user. Artificial intelligence and neural networks have an important role in an adaptive learning of the dynamically changing known or unknown environment.

Although many scientists are preoccupied to obtain results regarding the improvement of the comfort of visually impaired persons, the research in this field remains an open subject, as there are many aspects of it that are unresolved.

In the detailed presentation of the paper the technologies used for assistance, monitoring and navigation electronic equipment are presented. Different methods and sensors are presented for the perception of the environment and the detection of objects, for the fusion of different sensors, navigation maps, decision modules and man-machine interfaces, in order to inform the user of the wrong direction of movement, appeared obstacles etc. Equipments and methods used by the person to transmit commands to the assistive system are also discussed.

An interesting section that is of great importance in the process of user localization, will be studied, with the implication of neural networks in environment modeling and decision making. The application of hardware implemented artificial neural networks for achieving an intelligent interface based on acoustical virtual reality for informing the person will also be presented.

2. Assistive technology

The motivation of the project is the interdisciplinary research of a very complex topic of assistance of orientation and navigation of visually impaired people, in a known or unknown indoor environment.

Although many researchers are concerned with obtaining results to improve the comfort of people with visual disabilities, the research topic still remains an open issue. With the advancement of technology concerning computer systems and of information technology, development of technologies to assist people with visual disabilities has also improved. Although such problems have been studied intensively, there are still many unsolved issues.

Assistive Technology is a generic term incorporating technology, equipment, devices, appliances, services, systems, processes and environmental change (Environmental Modifications) used by people with disabilities or older people to overcome social, infrastructural barriers, to actively participate in society and to perform activities easily and safely [22].

From the point of view of visually impaired people the perception of the surrounding environment is very important, even essential, in order to facilitate their mobility.

Assistive technologies for environmental perception and for navigation in the surrounding environment are advancing day by day. In the last decade a variety of portable navigation systems have been designed to assist people with visual disabilities during navigation in the indoor/outdoor known/unknown environments (STIPER [50], electronic cane for navigating in indoor environment [46], AudioMUD [49], SMART Vision [39], VONAVS[40], E-Glass [27], BLI - NAV [34], Tyflos).

Another important aspect concerning visually impaired people is the need for common information and its fulfillment by using modern assistive technologies: audio transcription of printed information, accessing documents and books, music software, communication and information access, computing, telecommunications, tactile access of information, speech, text and Braille conversion technology [1].

A. Assistive technology for daily life

Assistive technologies and development of tools for education, personal care, assistive technology in everyday life (cooking and eating, money, finance, shopping), systems for time management, entertainment (games, visiting museums) and recreation of visually impaired people also plays an important role in terms of research [1].

Assistive systems for daily life can be classified as follows:

- personal care,
- timekeeping, alarms and alerting,
- food preparation and consumption,
- environmental control/ household appliances,
- money, finance and shopping.

The personal care assistive technology refers to two main aspects: labeling and health care monitoring systems.

Concerning personal care, visually impaired people need assistance in identifying different elements of their clothing. Labeling can be grouped in the following types of systems: Tactile Labeling Systems (tactile labels using Braille, tactile labels using the Moon and Fishburne alphabets), Radio Frequency

Labeling Systems, Barcode Labeling Systems (BarTalk, ScanTell, Scanacan for Windows Deluxe, Scanacan Professional Deluxe, Scanacan Professional Elite).

Tactile labeling in general is based on different alphabets used for visually impaired like Braille, Moon or Fishburne alphabets.

The Radio Frequency Identification (RFID) is an automatic identification which retrieves data remotely using RFID tags or transponders. The tag contains silicon chips and antennas to enable to receive and respond to questions from a radio frequency transceiver RFID. Current induced in the antenna by the radio signals provides enough power for CMOS integrated circuit in the tag to send the response. The role of the antenna is to collect power from the input signal and to transmit information of the label.

The bar code readers include the following main components: bar code scanner, database application and voice synthesizer.

In order to assist visually impaired people in monitoring their general health, one can find a series of devices with audio and/or tactile output for measuring temperature, blood pressure, body weight, blood glucose level, devices for insulin measurement and delivery.

One can meet different types of time devices that exist for blind and visually impaired people. Many of these have speech output, but there are also timers with Braille or other tactile display.

From the alarms and alerting devices used by visually impaired people some can be mentioned: Talking Appliance Timer (count up and countdown timers), talking smoke and carbon monoxide detectors and alarms, freezer alarm.

Food preparation and consumption can be a real challenge for visually impaired and blind people. The solution for this problem can be a simple change in the design of common cookers, cutlery and kitchen tools in order to make them safe to use.

From the devices used in food preparation and consumption there can be mentioned: talking kitchen scale, talking measuring jug, liquid level indicator, talking microwave oven, talking kitchen and remote thermometers.

The control of the immediate home environment of the visually impaired people is a condition for their independent life. This means that they have to control a number of home devices and that they have a constant need for feedback from their environment, so that they can accommodate to changes. Light probe and color probe devices can be used to get information from the environment. In the category of environmental control and use of appliances there can be enumerated the following most important devices: talking and tactile thermometers and barometers, washing machine with special functions for visually impaired, talking vacuum cleaner.

Money (cash, debit and credit cards and cheques) is another important aspect of independent life. Accessing it by visually impaired people can be difficult

because of different currency systems. Traveling abroad means that blind or visually impaired people get into contact with different currencies, but most of the existing devices can recognize only one sort of currency. Thus the development of tools that can recognize more, or at least the most commonly used, currencies is an important aspect of assisting visually impaired people in gaining independence. Electronic money identifying devices have an important role in managing money by the visually impaired.

B. Assistive technology for navigation and orientation of visually impaired

Navigation of visually impaired people raises questions about orientation, the appropriate route selection, objects and obstacles detection and avoidance. The advancement of technology has allowed the implementation of various equipments helping visually impaired people in their navigation, such as different obstacle avoidance, localization of objects/obstacles, guidance support systems to extend the basic support provided by means of guide dogs and use of the white cane. Most existing systems do not replace the use of guide dogs and the white cane, but are helpful in taking decisions in navigating/orientation in unusual situations.

Electronic systems used in navigation can be grouped into three categories:

- electronic help for traveling (electronic travel aids, ETAs),
- electronic orientation aid (electronic orientation aids, EOAs),
- position location (position locator devices, PLDs) [48].

In recent years the traditional tools used by visually impaired people for navigation indoors and outdoors (white cane and guide dogs) have been extended/replaced by the use of electronic navigation aid systems. These systems, based on sensors and signal processing are able to improve mobility of persons with visual disabilities in unfamiliar or continually changing environment. By combining the ETA systems [3] [4] [7] and the Man Machine Interfaces based on virtual acoustic reality major successes were achieved in the navigation of visually impaired people.

ETA systems are complex tools to support navigation and are composed of several basic modules:

- obstacle detection system (obstacle detection systems inspired by biological systems) [5], [9],
- trajectory planning module,
- computer-man interface,
- monitoring system.

Monitoring systems follow the movement of persons to ensure that they are moving/progressing and are capable to reach their target. It is also important to know in every moment the current position of the subject, to help in case of a changing environment, or, more importantly, in case of emergencies. The path

planning module is responsible for generating the route to the intended target, combined with the avoidance of obstacles. Position of obstacles in front of subjects is determined through a 3D obstacle detection system.

The components specified must meet requirements similar to those encountered in the case of mobile robots for trajectory planning and detection of obstacles. The man-computer interface provides information extracted from the environment in a friendly manner and assists visually impaired people by navigating "hands free" in their work environment and everyday life.

As it results from the literature a system that integrates different technologies for the support of visually impaired people may have the structure presented in Fig. 1. The system is composed of two basic modules:

- a personal computer connected to the Internet (called service center),
- a portable equipment [5] [6] [7] [9].

Real-time communication between the two modules is achieved through a wireless communication module (GSM [3] [8] [18], GPRS [36], WIFI).

The personal computer serves as a support for various functions (technologies): navigation assistance, information, etc.

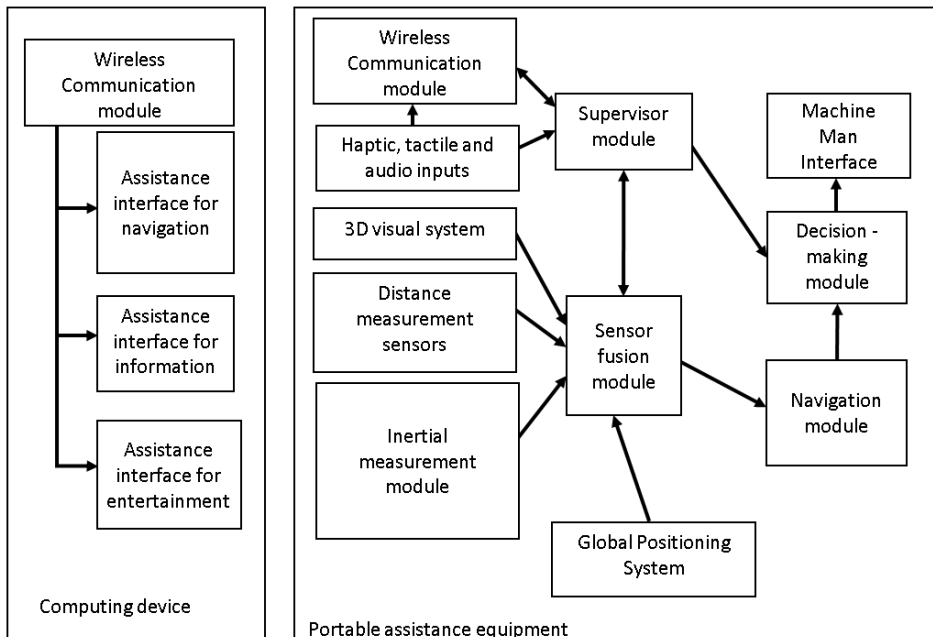


Figure 1: Block diagram of the proposed system.

It should always be checked (monitored) whether the person has reached the destination, has avoided being blocked in his/her movement because of changes

in the environment. This module stores the database of the environment (ex. GIS [42]), the defined trajectory and the current position of the person.

Through the information assistance interface, special information technologies can be accessed (reader of printed documents, access of documents and books, music software, communication, computer systems, telecommunications) [1].

The portable device serves several functions and involves the use of embedded systems of control and processing. Communication with the personal computer (connection type) is achieved by a real-time communication module (GPRS) [36], GSM [3] [8] [18], WiFi [37], RF, etc.).

The input interface has the role of introducing “specific commands”. This unit can contain Braille keyboard, voice input unit, etc. Through this interface different commands can be addressed to the computer (examples: target specification, starting playing music, connection to a radio channel, different questions addressed to the system, voice communication interface [37], speech recognition [44], Braille reader).

For the visually impaired people the detection of objects and obstacles arising during route following is very important, but equally important is the location of the person and following his/her trajectory, because the location of the person must be correlated to the stored environment in the navigation environment's interface. Ultrasonic systems for distance measurement [21] [27] [41] [47] [37], visual systems (stereo vision systems [37]), infrared sensors, etc. can be used to detect obstacles.

For trajectory tracking, and orientation of the person, GPS tracking systems and tracking systems based on inertial movement sensors are used. A very important issue is the location of the person, because both GPS systems and inertial systems introduce significant measurement errors. GPS systems get the absolute position of the person but with errors of a few meters and a low sampling rate. GPS systems can be used only in outdoor navigation.

Inertial positioning systems based on accelerometers and gyroscopes introduce positioning error resulted from the integration of measurement and quantization noise. By using magnetic compasses (with which absolute orientation can be obtained) as an extension of accelerometers and gyroscopes, superior results can be obtained. Research results related to positioning and navigation systems used in mobile robots can be used to locate people, detect obstacles.

By merging measurement data from several types of sensors, superior results can be obtained in the tracking of persons. Merging several types of sensors requires a very complex computation process. In order to solve these types of problems the Kalman Filter or the Extended Kalman Filter is used. The sensor fusion module is responsible for integrating different sensors.

Trajectory design is guided by detection or non-detection of obstacles. If there are no obstacles detected, the trajectory is dictated by the general

navigation system. In case of detected obstacles, the general navigation system is overwritten according to the position of obstacles. By the man-computer interface module orders (indices) are transmitted to the person.

There are several possibilities to implement the man-computer interface (Man Machine Interface, MMI) [5] [12] [4] [5] [6] [8]. In accordance with this principle, the proposed interface replaces the visual reality with the acoustic virtual reality.

The presence of various obstacles in the environment is indicated by a beeping sound based on the virtual position that suggests the real position of the obstacles. Various obstacles are differentiated by the different frequency of the sounds. The intensity and frequency of occurrence of the signal depends on the distance to the obstacles. A pilot signal of constant intensity and frequency indicates the direction of the route to follow. The module mentioned requires the implementation of a Head Related Transfer Function which differs depending on the frequency of the sound, head orientation and distance to the obstacle. Practical implementation of the AVR concept [3] requires knowledge of the Head Related Transfer Function for each point of the 3D space for each subject. Often, artificial neural networks are used for the implementation of HRTF functions [4] [5] [7] [13] [14] [28] [52] [54] (54 without RNA). A study on the use of Multi-layer Perceptron Networks for modeling HRTF functions is presented in [4].

Another example for the orientation of the person is the use of a voice processor which, by direct verbal commands directs and warns the person concerned [37]. Often the ultrasound module of object detection is combined with vibrators for informing the user [41] [47] (eg. vibro-tactile feedback for information, usually operating with two vibrators). There is also an interface with a simple keyboard and a voice synthesizer [42]. There are also systems in which the environment is described by spoken text [49], and navigation commands are transmitted by voice [34] to alert the user of the distance from the obstacles or from the destination [12]. There are also systems used for character recognition in real time in case of touching labels, restaurant menus and other printed materials. The network outputs are used to create a Braille matrix, driving the top of the fingers of blind persons, or converting into spoken text told by a regular Personal Digital Assistant (PDA) device [50].

A challenging problem for navigation support systems for visually impaired people is the instant and precise location of the user. Most of the proposed systems based on GPS sensors were found to be insufficient for usage for pedestrians and are limited to the external environment, with serious errors in urban areas.

The possibilities offered by neural networks as a tool to study spatial navigation in virtual worlds include methods to predict the next step for a

predefined path, obtaining basic spatial knowledge based on “landmarks” and configure a spatial “layout”. The question is how to develop a spatial representation of the virtual world, other than a cognitive map. The possibility of extending the methodology to study navigation in human-computer interaction (Human Computer Interaction, HCI), calculation methods of navigation, the potential usage of cognitive maps in the navigation process modeling, non-visual models for learning the special world by exploring the virtual world space and their applications are studied in the literature [2].

For the implementation of the sensorial interface, the related literature and the sensors used in case of mobile robots will be studied. The sensorial interface used for localization and object detection includes a sonar system, infrared sensors, inertial measurement unit, magnetic sensors, stereo vision system. For modeling of the environment (the position and orientation of detected obstacles) we propose to use of artificial neural networks. The surrounding space will be scanned and distances to the object will be recalculated/learned in real time in the neural network.

The decision making module, based on the results of the environment modeling, will take a decision regarding the orientation of objects and will inform the user by the man machine interface.

3. Conclusion

The assistive technologies used by visually impaired people are very complex. A wide range of different electronic assistive technologies exist and are used by visually impaired. Some of these tools are unreachable by most of the visually impaired persons.

The integration of different assistive solutions in a single assistive system is a great challenge.

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