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Monograph: Information Technologies for Visually Impaired People (published jointly with Novática*)

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An Overview of Handheld Computerized Technologies For People with Visual Disabilities

Philippe Foucher

Handheld computerized tools can be used to provide technical assistance to improve the autonomy of people with visual impairments. Many projects have brought solutions to the special needs of blind people everywhere. Those handheld tools use mainly non-specific devices such as PDAs and smartphones. Speech interfaces (synthesis or recognition) and/or haptic-enabled communication between user and device. Applications concern the daily life situations of blind people: mobility and written or symbolic information access. Concerning the mobility of blind people, many systems have been implemented: outdoor/indoor navigation (GPS/ GSM/WLAN/Bluetooth/RFID), travel assistance (planning, urban public transport access), video remote assistance, and adapted assistance. Written or symbolic information access is based in embedded OCR software, RFID tags identification, objects pattern recognition by using artificial vision.

Keywords: Handheld Computers, Information Access, Information Processing, Visual Disabilities.

1 Introduction

People use mainly visual information for indoor/outdoor navigation, public transport information, textual or symbolic indications access (bus lines, posters, packaging). Performing those daily tasks is very difficult and sometimes impossible for people with visual disabilities. They must perceive and interpret information by other senses (hearing, smelling, touching) and/or asking sighted people to help them. This human assistance is often welcome but is not always possible in real time and does not correspond to the precise needs of sight-impaired people.

Technical assistance has given partial autonomy to people with visual impairments in their daily life. Thus, urban devices installations (audio or haptic) and computer tools improvements (speech synthesis, Braille console), have brought some help to blind people. The boom of handheld devices such as PDA (*Personal Digital Assistants*), cellular phones, smart phones and IP cameras, has also opened the possibilities of many applications to help partially and totally non-sighted people at any time.

This contribution aims to provide a state-of-the-art review of handheld computerized tools for helping people with visual impairments. This article concerns only non-invasive technological tools which enable the identification of real objects or give information about localisation or environment. Concerning navigation systems, two complementary approaches are considered [1]:

- Obstacle avoidance systems and ultrasonic obstacle avoiders have been developed to assist visually-impaired travellers through the immediate or local environment. Those systems have been widely described in literature [2] [3] [4] and will be not detailed in this article.

- Navigation through the distant environment concerns location by GPS, GIS, GSM, Bluetooth, WLAN, RFID technologies.

Author

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After this introduction, this article is composed of four sections and a conclusion. Section 2 presents the problem of technical help for blind people. Section 3 presents the technical description of existing tools. Section 4 presents the applications which facilitate the mobility of visually-impaired people. Section 5 describes the research into visual information access (text, pictograms, environment).

2 Issue of Technical Assistance for Blind People

The issue of technical help for blind people consists of two aspects:

- The computerized assistance tool must give supplementary information to blind people. These supplements must be accurate, reliable and widely available. It is thus a question of defining the types of assistance according to daily life situations: area accesses, position knowledge, navigation, information access, travel planning. Knowledge of the advantages and drawbacks of technological tools enables the development of aids adapted to each need.

- How shall the aids communicate with blind people? Blind people must have Input/Output (speech recognition/

synthesis, tactile keyboard/screen) access to give indications and receive information. The adaptation of devices, human machine interface and contents is essential to obtain a usable and efficient assistance.

3 Technical Description of Aids

3.1 Location Tools

The choice of location methods depends often on the blind person's environment (urban or rural areas, outdoor/indoor situations). All the methods are generally used complementarily to combine accuracy, signal reception level and reliability in many areas.

The main location methods are based on a trilateration (a process analogous to triangulation) measurement between satellites and receiver device [5]. At the moment, only the GPS (*Global Positioning System*) enables geolocation by satellites. The European system Galileo will soon be operational (2008-2009). Trilateration calculates the electromagnetic signal's propagation time between mobile receiver location and at least three satellites. Location information given by GPS is free and receiver devices are ubiquitous and inexpensive. Location information corresponds to latitude and longitude coordinates and navigation software such as GIS (*Geographical Information System*) or Map Matching is generally proposed with GPS to navigate on a map.

Some factors have an influence on GPS receivers in terms of accuracy (location given by GPS is very close to real location) and satellites reception level (GPS is accessible anywhere).

- GPS signals are deflected and reflected as they pass through the Earth's atmosphere. This introduces a location error.

- GPS receivers can only see satellites which are above the horizon, and obstructions caused by vegetation, buildings, mountains, or canyon walls can block satellite signals. A study has revealed very poor reception conditions in dense urban areas [6]. In this urban environment pedestrian navigation may be thus problematic because of the walls of large buildings.

- Canyons, both natural and urban are also notorious for the multipath (the reflection of signals off canyon walls). GPS receivers work by calculating the time it takes for signals to be received from GPS satellites, so signals bouncing off canyon walls are delayed slightly, thereby introducing error.

- There is no GPS signal reception for indoor location.

Some methods have enhanced GPS measurement and satellites reception level. DGPS (*Differential Global Positioning System*) corresponds to Global Positioning System (GPS) with an additional correction (differential) of the location. DGPS compares the GPS location at a fixed station with the actual known location of the station. It transmits then this difference to mobile GPS receiver which automatically correct the positioning. AGPS (*Assisted Global Positioning System*) refers to a system where resources other than satellites, such as a fixed assistance server and refer-

ence network, GSM (*Global System for Mobile Communications*), UMTS (*Universal Mobile Telecommunications Systems*), help a GPS receiver calculate its position. The receiver can operate more quickly and efficiently than it would unassisted, because a set of tasks that it would normally compute is shared with the assistance server. For example, the assistance server can take into account precise GPS satellite information (orbit and clock), initial position and time estimation. This information is computed by the assistance server and communicated to the receiver through the mobile network. AGPS also works when signal reception is low. It is thus particularly interesting in dense urban areas or in buildings. Moreover, the use of AGPS decreases necessary time computation for position calculation.

In general, GPS Location gives the most accurate results. However, other location systems, using mobile networks (GSM, UMTS) and terrestrial stations enable greater location accuracy in urban and indoor environments.

Those positioning systems are based on different location methods [7]:

- The basic location method is Cell Identification (Cell-ID). It is based on the fact that mobile networks can identify the approximate position of a mobile handset by determining which cell beacons the mobile device is using at a given time.

- Specific antennas arrays and location receivers in Base Transceiver Stations (BTS) determine the angle of arrival of the signal from the mobile device. The intersection of apparent arrival directions determines the mobile device location. This method needs at least two BTS but three or more BTS stations are generally used to increase the accuracy of the system.

- The Mobile device signal is received by three or more BTS which measures the Time of Arrival. Trilateration computation determines the mobile device location.

This technology is supported by all mobile handsets but the location accuracy highly depends on the environment. It is much higher in urban areas than in rural areas. The same methods (Triangulation or IP Address Identification) are used for location using WLAN (*Wireless Local Area Network*), Bluetooth networks. These technologies are available on standards PDA. Triangulation of Infrared or Ultrasonic signals is also used for location especially for indoor location. Research by Pandya *et al.* [8] has evaluated location accuracy by Bluetooth or WLAN networks. Location by Bluetooth seems to give better results than location by WLAN network.

RFID (*Radio-Frequency Identification*) systems are composed of RFID microchip (RFID tags) mounted on or inside a support and a RFID reader which read and/or write RFID microchip information by a remote activation (10 meters) [9]. The data derived from accurate RFID tag locations can be used to determine the location of the RFID reader. This method is generally used for indoor location or navigation. A complete navigation system could consist of GPS for outdoor locations and RFID systems for indoor navigation [10].

All location systems (GSM, UMTS, WLAN Bluetooth, RFID), excluding GPS, are usable in urban areas or indoor places. However, those systems need a large number of terrestrial stations or antennas to obtain good location accuracy. Figure 1 below, sums up the advantages and limitations of systems.

For pedestrian applications, the use of inertial units with other positioning systems (GPS or GSM) improves the accuracy [11]. The basic idea of inertial unit is dead reckoning navigation. It determines successive positions by estimating the distance and the angle the person has moved since the previous computed position. The computation takes into account thus the characteristics of the person's gait. Inertial units are composed of embedded sensors such as accelerometers which measure acceleration rate, gyroscopes to measure angular speed and magnetic compasses to indicate the direction. A drawback is that computed positions are likely with time to deviate from real positions (cumulative errors) since inertial units are based on relative positioning. An advantage is that it does not depend on terrestrial stations or antennas.

3.2 Information Access

The adaptation of visual information content and a judicious choice of devices, information processing software and human-machine interfaces are necessary to implement systems usable by blind people. Information Access tools concern handheld computerized devices and adapted software used to help blind people everywhere and in many situations.

Cellular phones and PDAs are standard, autonomous, non-specific, handheld and increasingly cheaper devices. PDAs are real and powerful computers. A standard PDA is

composed of a microprocessor with a frequency over 600Mhz and extensible RAM of 128 MBytes. Cellular phones are less powerful than PDAs but are more widespread. Smartphones combine PDA and cellular phone functionalities. The microprocessor power and storage capacity enhancement and wireless transmission have facilitated applications integrations: GIS outdoor navigation, RFID readers, data processing systems (text, audio, image, signals). Moreover, most standard PDAs are equipped with a GPS receiver, WLAN or Bluetooth access, Multimedia tools (Input/output audio systems, camera...) and GSM or UMTS networks for smartphones.

Computers research has improved human-machine interfaces so that they may be used by people with visual disabilities. Speech recognition or synthesis and haptic interfaces can be implemented on handheld devices. A haptic interface is an interactive communication system which enables to the user to "perceive" the texture of 2D objects. The system is an interface which can be similar to a pen or a mouse [12].

Lastly, the knowledge of visual information (text/pictograms) can be essential to identify objects (posters, products, places) in many situations (at home, outside, at shopping)... A first approach consists in tagging objects with barcodes or RFID and storing information in a data basis (Bar code is a read only memory, while RFID tag contains erasable and repeatedly writable memories in it). A handheld device with barcode or RFID reader is then used to get information identifying the objects. The second approach is the visual information processing using pattern recognition methods. This approach presents the interest to be applied for a high number of applications (location, public trans-

Systems	Advantages	Limitations
GPS / DGPS	Accuracy (< 10 meters) Available in non urban area	No indoor Navigation Canyon walls Specific systems
GSM / UMTS ...	Indoor /outdoor navigation Non specific systems (Cell-phone)	Low accuracy in non- urban area
Wireless / bluetooth	Indoor /outdoor navigation	Low accuracy in non- urban area
RFID	Indoor /outdoor navigation Environment information	RFID tags equipment Accuracy

Figure 1: Advantages and Limitations of Location Systems.

port information, text / pictograms reading...) without any equipments such as stations, RFID tags, etc.

4 Mobility of Visually Impaired People: Handheld Computerized Assistance

This section presents handheld computerized assistants to facilitate the mobility of visually impaired people.

4.1 Urban Guidance and Pedestrian Navigation

Many research projects have been proposed for people with visual impairments. Loomis *et al.* [13] and Brusnighan *et al.* [14] are considered to be the first research works on GPS navigation for blind people commenced in the nineteen-eighties. In Brusnighan's experiment, the GPS system located the blind person's position and calculated the distance and the time to go to a previously defined place. It was the first urban guidance system but the research was conducted during the early deployment of GPS. However, the poor positioning accuracy and technical limits of handheld devices were incompatible with assistance for visually impaired people. Makino *et al.* [15] used a mobile phone to transmit blind pedestrian GPS coordinates to an assistance server which returned the position vocally using speech synthesis. The cost, the weight and the computer power of the handheld device was thus highly reduced.

Urban guidance systems became more and more competitive with the technology's enhancement (geolocation, data processing, speech synthesis). A methodology was proposed by Gaunet and Briffault [16] to define specifications. The first commercial GPS-based system proposed by the Arkenstone Foundation [17] provides both information about the locations of nearby streets and points of interest and instructions for travelling to desired destinations.

MoBIC project (*Mobility of Blind and Elderly People Interacting with Computers*) [18] consists of two interrelated components:

- *MoBIC Pre-Journey System (MoPS)* to assist blind users in planning journey by storing information such as local maps, public transport timetables, opening hours of facilities, notes on the traversability of routes, specific surfaces, user preferences and address.

- *MoODS (MoBIC Outdoor System)* to help the user to navigate. The system is composed of a GPS/DGPS location system, magnetic compass and GIS software. The blind user asks a question via a handheld keyboard: where am I? Public transport timetable? Answers are received aurally through speech synthesis.

The entire journey is memorized to improve the database. The interface works on a cellular phone but the size and the weight (6 kilograms, mostly due to the batteries) is a critical factor in the acceptability of the MoODS system [19]. The guidance system of Guillet *et al.* [20] considers the trip length and specific impairments to propose an adapted path. The navigation integrates GPS, mobile phone and GIS.

In the Drishti project [21] [22], the researchers integrate several technologies to implement a navigation system. It consists of an outdoor navigation system by GPS/DGPS

and an indoor navigation system by ultrasonic signals triangulation. The location information is processed and speech-synthesized by an assistance server using WLAN network. Moreover, Drishti is a dynamic system which adapts the trip according to environment situation (traffic congestion, route blockage) or according to a changed decision of the user (new destination). The device is composed of a very light wearable computer, headphones and microphone. Willis and Helal [23] proposed an outdoor/indoor navigation system on a PDA with a RFID reader. They estimate that the concept of setting up RFID Information tags is economically feasible in buildings, in college campuses and corporate parks. RFID guidance is also studied by Ceipidor *et al.* [24]. They installed an RFID reader on a white cane. Collected data are transmitted to a PDA by Bluetooth and are processed and speech-synthesized by an assistance server using WLAN network. Bellotti *et al.* [25] have experimented with the use of RFID tags at the Euroflora 2006 exhibition. The system is composed of a PDA with embedded speech synthesis software. The RFID tags enabled navigation in the exhibition hall and a description of each stand. The 120 blind testers were satisfied by the system's utility and usability. However, the system will need to be made more accurate by increasing the number of RFID tags. Kulyukin *et al.* [26] have developed a Robot-assisted indoor navigation system for visually impaired people. A robotic guide moves automatically using RFID tags. Experiments have been undertaken in two indoor environments. All participants reached their destinations without a problem. In their exit interviews, the participants especially liked the fact that they did not have to give up their white canes and guide dogs to use robotic guide. Human-robot interaction, especially speech synthesis system is still problematic. Other limits concern robot velocity, the non-detection of route blockages and the static environment after the RFID tags are deployed.

Some research integrates both relative positioning by dead reckoning systems and absolute positioning by GPS [27]. This combination enables the commercialisation of a specific and lightweight (400 grams) device for visually impaired people. The system is called PNM: *Pedestrian Navigation Module*.

Other commercial projects have resulted in autonomous navigation devices for blind people. Navworks (in France)[28] and Smarteyes (in Greece)[29] projects aim at developing computerized and handheld systems to vocally guide people with visual disabilities. The systems use both GPS and GSM modules. The intent of the "Free Mobility Assistance" project [30] is to install RFID tags to help blind people to be directed in the city using vocal and audio messages. The city of Kobe (Japan) have experimented with a system by installing 4000 RFID tags. The Sendero Group society [31] has implemented a specific wearable device for GPS location for blind people. The HumanWare society [32] has commercialised the Trekker using a standard PDA with GPS receiver. This product proposes a tactile interface for blind people.

4.2 Public Transport and Journeys

Public transport access is essential to improve blind people's autonomy. The purpose of research work is mainly to communicate public transport information in real time to blind people. The Rampe project [33] [34] aims at making available an interactive system to assist people with visual disabilities to obtain public transport information. The project considers only bus and street car stations or stops. The user carries a smart handheld device (PDA) which communicates by a wireless connection with fixed equipment in the bus or streetcar stations. The information is vocally communicated to the user and indicates the proximity of a station, the bus lines, the timetable and alterations to arrival and departure times (public works, bus stop changes). A complementary project could be Ubibus [35]. In this project three entities interact by WLAN or Bluetooth: bus, bus stop/station and PDA of the user. The application allows the user to request in advance the bus of his choice to stop and to be notified when the correct bus has arrived.

Underground navigation system for blind people is also proposed using Bluetooth technology. The Blueeyes system [36] is composed of fixed Bluetooth stations deployed in the underground area and mobile phones with Bluetooth receivers. The user is located in the underground by Bluetooth and a message is sent to indicate his/her position and possible directions. The method works step by step and indicates the path by real-time computing. However, all underground stations and connections must be equipped with Bluetooth bases to inform the blind user.

NOPPA [37] navigation and guidance system is designed to offer public transport passenger and route information for the visually impaired. The system provides an unbroken trip chain for a pedestrian using buses, commuter trains and trams in three neighbouring cities. The Noppa system is implemented in a standard mobile phone and presents the following characteristics: Speech interface (speech and recognition), journey planning, real time information on public transport, real time information on geographical environment and, GPS location for outdoor navigation and Bluetooth and WLAN location for indoor navigation. The limits are that map data may include outdated information or inaccuracies, positioning may be unavailable or inaccurate, or wireless data transmission is not always available.

4.3 Remote Assistance

The 3G mobile phone using UMTS technology allows video assistance. Research in Brunel University [38] consists in a navigation system with two distinctive units:

- A Mobile Navigation Unit (MNU) carried by blind user. This unit is composed of a camera, a GPS receiver and an adapted interface on a smartphone.
- A stationary Navigation Service Centre (NSC) at the site of a sighted person (the guide). The NSC is composed of workstations with GIS data basis and a monitor to display the real time video image and the user's location on a digital map; these are the input information used by the sighted person to provide the vocally guided service.

Hestnes *et al.* [39] [40] have proposed a service through which visually impaired persons can obtain information on what is present in their surroundings with the help of persons who can see and act as guides. They have undertaken a series of studies which examined whether a mobile videophone (an "eyephone") can be a real help for people who are blind or severely visually impaired. 10 blind or severely visually impaired users have tested the system in 5 situations (bank, shopping, at a bus stop, finding something lost on the ground, being lost). All the tasks were accomplished with success and the satisfaction rate was very high. The system presented some problems in reading documents and finding very small objects. Lighting conditions must be sufficient.

4.4 Communication Interfaces

Representing and perceiving the environment brings some significant indications to help visually impaired people to move in this environment. In this way, the development of specific interfaces contributes to improve this representation and perception.

The Äänijälki project [41] is a platform for visually impaired people to exchange information about museums and exhibitions. The intention is to motivate visually impaired people to visit museums by providing a tool to get information about museum spaces, access, opening hours. The service is composed of two main elements: a handheld device (PDA) with tactile screen to be used in museums or exhibitions and an Internet website to obtain information. The PDA is equipped with headphones to receive audio comments in museums and exhibitions.

The goal of Coroama and Röthenbacher's [42] project is to use alternative means to present continuously and vocally the environment to the visually impaired user. It gives thus some of the information which the user would otherwise miss. The prototype is composed of the following elements:

- A large number of environment objects which are RFID-tagged,
- A device interacting with tagged objects when the user moves into the object environment,
- A real-world tagged object which has a virtual representation containing its information.
- Communication interface by Bluetooth and WLAN

All these methods allow visually impaired people to increase their autonomy in navigation and trip information processing. Some assistance projects also involve visual information processing to access textual data, pictograms, signboards and street name information.

5 Visual Information Processing

In this section, two approaches are proposed: object identification using RFID or barcoded tags and object recognition by artificial vision.

5.1 RFID and Barcode Methods

The purpose of the Trinetra [43] is to develop a cost-

effective solution to assist the blind and visually impaired with the task of grocery shopping. In the Trinetra-scenario, the blind shopper should not need to ask for assistance from a store clerk, and should be able to locate and browse products within the store on his/her own. Two solutions are proposed; the identification using barcodes on tagged individual products and RFID identification which holds more product information and is not yet prevalent in stores. The device is composed of a smart phone with Bluetooth and a text-to-speech module, a RFID reader, barcode reader and a remote assistance server with RFID database and barcodes database. In future developments, the authors would like to embed RFID tags into the environment to identify the correct aisle, rack and shelf in the grocery store. The use of artificial vision technologies (OCR systems) instead of barcodes or RFID is also investigated.

Tatsumi *et al.* [44] propose two solutions using PDA for textual information access:

- Information access via a notice board. A blind student uses a PDA equipped with a barcode scanner to read a bar code printed on the notice board. The bar code is sent to the server which automatically and vocally sends the notice board information back.

- Messaging systems between students and teacher using RFID tags on the teacher's office door. The blind student uses his/her PDA equipped with RFID scanner to read and/or write messages on RFID tags.

Coughlan *et al.* [45] propose an assistive technology system based on a camera cellular phone held by the blind user) to find and read specially designed signs in the environment. The signs are barcode locations on office or restroom doors. The use of distinctively coloured areas next to barcodes allows the rapid location of barcodes. A specific and robust algorithm has been implemented to read barcodes with poor resolution and in dim lighting. Preliminary tests have shown that blind users are able to locate barcodes using a standard cellular phone. The authors would like future developments to read barcodes at greater distances.

These solutions are attractive but the identification concerns only tagged objects with barcodes or RFID and the corresponding information must be regularly updated in the databases.

5.2 Computer Vision

The first application based on image processing methods is OCR (*Optical Character Recognition*). Kurzweil National Federation [46] presents a portable device to read textual documents anywhere. The device is composed of a PDA with a digital camera to scan any documents (restaurant menu, text, announcements), Text is decoded by embedded OCR software and audio converted by a text-to-speech software. Data are entirely processed by the PDA.

Dumitras *et al.* [47] present a handheld text recognition system to extract written information from a wide variety of sources. They use a smartphone (with an embedded camera) which sends the photograph of the object to an assist-

ance server using a GPRS network. The server sends the extracted textual information back to the smartphone where it passes through a text-to-speech converter.

The iCare-reader [48] is also a portable reading device. It is composed of a digital camera mounted in a spectacle frame and connected wirelessly to a PDA. OCR software decodes the text and a speech synthesizer converts it into audio format. New challenges concern the interaction between the reader and the user. A specific interface would be required to allow the reader device to train the user in pointing the camera at the reading material by head movements.

The portable device of Nakajima *et al.* [49] recognizes phrases on signboards and menus and translates them into other languages. A picture of a signboard or menu is taken by the camera of a PDA or cellular phone. It is then wirelessly sent to an assistance server for OCR decoding. The system resolves the difficulty of character sets such as Japanese and Chinese by using a language translation module.

Gaudissart *et al.* [50] [51] have developed a text recognition system on a PDA equipped with a camera for the imaging of textual documents (banknotes, CDs). Embedded OCR software translates text within image files into editable text files and information is transferred to a text-to-speech module for audio output. The system, called Sypole, gives encouraging results for text with uniform backgrounds but is not efficient enough for text detection in outdoor situations.

Image processing tools do not concern only communication and information accessibility using text recognition. Shape recognition algorithms could indeed be implemented on handheld devices to detect elements in the city such as pictograms, pedestrians' traffic lights, crosswalks where text data are totally lacking. In those situations, the mobility of visually impaired people could be facilitated by different types of electronic aids.

In order to help partially sighted people, Everingham *et al.* [52] have proposed a technology combining the field of virtual reality with advanced artificial vision methods to create an enhanced image from an urban scene image. In this contribution, an eight-level grey scale image presenting objects of the scene classified in eight categories (road, sky, pavement, buildings, vehicle, vegetation, obstacles) is displayed to the low vision user on a head mounted screen. Methods have also been developed to help totally blind people. In this way, different methods have been proposed to detect crosswalks and stairs. Molton *et al.* [53] have developed thus a robotic system based on sonar and stereovision sensors for detection of obstacles whereas Se *et al.* [54] described an algorithm based on edge detection followed by a Hough transform. In this second contribution, the distinction between crosswalks and stairs is evolved by vanishing line methods. Those two papers do not discuss on the way to give information to the blind user.

The research of Snaith *et al.* [55] concerns a system using computer vision techniques to facilitate centre-path travel and to recognize doorways. The detection is based

on recognition of characteristic patterns of near- vertical and near-horizontal lines for doorways and the determination of dominant vanishing lines make possible the detection of main direction along a path.

The identification of pedestrian traffic lights is also taken into account in the literature. Some research works have shown an interest in this topic by presenting traffic light recognition systems. The first one [56] is based on a two step algorithm: extraction of candidates for the traffic light regions by colour analysis and shape recognition by using affine invariant moments. The results are highly encouraging but the authors do not propose a portable and cheap system (such as a PDA) and they do not give any information for transferring the output to visually impaired people. The second one [57] deals with the analysis of the colour histograms without calculating any shape features. The decision depends only on the colour criteria, making possible misclassification due to the lights of parked cars or others similar colour sources. The use of single colour information seems insufficient to detect the correct silhouette. The colour information is highly dependant on the colour illumination and similar colour (red or green) could be present at the scene. The combination of colour information and shape information seems preferable.

The researchers of the THIM laboratory have presented a PDA-based tool to recognize pedestrian traffic lights. Their algorithms use both shape information (by structural methods [58] or Fourier descriptors [59]) and colour information with very encouraging results (70% of good classification for red traffic light and 80% for green traffic light). The researchers have shown the complexity of a problem (recognize pedestrian's traffic light) that could be appear fairly simple [60]. For instance, locating the object of interest is not an easy task.

6 Conclusion

The growing volume of research into handheld computerized applications for persons with visual impairments is really interesting and encouraging. However, all the projects propose a partial solution to the needs of blind people: navigation/location, remote assistance, visual information and public transport. There is not yet a universal handheld tool to assist people with visual impairments in all conceivable situations.

At long-term vision, it seems to the author that the potential of artificial vision allows to elaborate very interesting, robust useful applications on portable devices for blind people assistance. Artificial vision could bring reliable solutions for location/navigation, visual information access, etc.

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Abbreviations and Acronyms

- AGPS: Assisted Global Positioning System.
 BTS: Base Tranceiver Station.
 DGPS: Differential Geographical Positioning System.
 OCR: Optical Character Recognition.
 GPRS: General Packet Radio Service.
 GPS: Geographical Position System.
 GSM: General System for Mobile Communications.
 MNU: Mobile Navigation Unit.
 MoBIC: Mobility of Blind and Elderly People Interacting with Computers.
 MoODS: MoBIC Outdoor System.
 MoPS: MoBIC Pre-Journey System.
 NOPPA: Nakovammaisten Opastusjarjestelman Pilotti Projekti [Navigation and Guidance System for the Visually Impaired].
 NSC: Navigation Service Centre.
 PDA: Personal Digital Assistant; a handheld electronic device providing database and communications facilities.
 PICRI: Partnerships Institution-Citizens for Research and Innovation [France].
 PNM: Pedestrian Navigation Module.
 RFID: Radio Frequency Identification.
 THIM: Laboratory, Paris 8 University (Technologies, Handicaps, Interfaces and Multimodalities).
 UMTS: Universal Mobile Telecommunications System
 WLAN: Wireless Local Area Network.