2.2 New technologies to help people with disabilities and elderly people

2.2.1 Safe navigation with wireless technology

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Background

How can I be sure to find my way? Can I walk safely here? What happens if I get lost? Do I dare to try a new route? What if I suddenly fall ill and need help? The lack of good answers to these and similar questions have prevented a number of vulnerable people to move around in outdoor as well as indoor environments which they are not familiar with.

And who is not vulnerable? Basically, all of us sometimes are in need for help because we have lost our way or feel unsafe or have made a mistake in our way-finding effort. Among us, however, are people who feel more at risk than others, not least people with various kinds of disabilities. And among these, people with visual disabilities and those who suffer from cognitive impairments have expressed strong interest in finding solutions to overcome their problems.

Historically, blindness and partial sight have inspired engineers and psychologists to find solutions to way-finding problems for these groups, both in terms of personal navigation aids and landmarks in the environment. Early on, the long cane became a well known attribute to blind pedestrian's navigation, and later efforts have been made to improve the cane by adding remote sensors. Examples are laser emitting diodes end sensors, magnetic field probes and – most recently – RFID[1] detecting devices. Other ideas have been to simulate bat's navigation technique, i.e. the development of various kinds of ultra sonic devices to scan the environment and get some idea of what it looks like.

The common denominator for all these examples has been the individual characteristics of the solutions. Also, they only provide information about the very near environment.

Given these historical facts, over the last few decades, navigation problems of other groups have been acknowledged. An example is the large group of people with cognitive impairments, including e.g. those with dyslexia, mental disabilities, dementia and stroke, but also people with mobility problems, including wheel chair

[1] Radio Frequency Identification

users. The problems here are wide ranging from being able to read and understand a map or remember information to learning in advance about obstacles, on-going road works and similar matters. Even people who are deaf or hard-of-hearing have experienced great problems in moving from their home to e.g. a school or working site by public transport as so much information is given about changes in time tables and alternative means of transport, etc., has been given orally. Slow improvements have come about in society as much information has successively been given both as voice information and presented on visual displays. These solutions, however, have been generic, and not been of much help to people who suffer from dementia, mental disabilities and other cognitive disorders.

A break through came about with the installation of the American Global Positioning System – GPS, that has been used since the late 1980s for positioning purpose, mainly as a tool for finding the way for car drivers and boat and aircraft navigation. As it will be discussed later, the GPS system per se does of course not solve the problems displayed above, but it forms a basis for further development that can lead to powerful tools for all groups with significant navigation problems.

Positioning, orientation, navigation, communication and localization

Mobility outdoors

Knowing one's position is important, but not enough for safe moving around in an unknown environment. A system should also make it possible for users to orientate themselves, i.e. to know in which direction they are standing in relation to, for example, the points of the compass, to navigate independently, i.e. be able to move from one given position to another, and also if necessary, raise an alarm or communicate with an information or alarm centre for personal support and assistance. It should also be possible, for those who so wish, to be found without having to consciously trigger a localization function themselves.

Positioning

Satellite systems

The most widely used and available system – the GPS system – is based on the use of radio signals transmitted from satellites orbiting the Earth and with whose assistance it is possible, with the use of special receivers, to get a position on the

Earth's surface in the form of coordinates. This kind of reference can be transformed into, for example, an indication on an electronic map on a GPS receiver. This can be linked to a mobile telephone, handheld computer or the like.

At present there are two existing systems in use: the American GPS (Global Positioning System) and the Russian GLONASS (Global Navigation System). The latter does not have any marketing in Europe and is currently being extensively updated. For many years, a system has been planned in Europe known by the working name Galileo. This system is designed to be well-adapted for European environments in particular. However, it is still presently at the development phase and will not be fully accessible until 2008 at the earliest.

GPS is designed to provide the best possible coverage some hundred miles north and south of the equator. This means that the further north and south one goes, the worse coverage one gets with GPS owing to the satellites all appearing to lie rather close to the horizon.

In it simplest form, GPS provides a positioning accuracy of some tens of meters. However, there is an extensive system of terrestrial stations that can take care of and process signals before they are received in the individual GPS receiver. This is known as Differential GPS or DGPS. With such support, it is possible to get down to an accuracy of just a few meters. In principle, it is possible to achieve even greater accuracy in this way (to within centimetres) but, for various reasons, it is not practically feasible for the navigation application in question. One reason is that access is not available everywhere to the terrestrial stations required for processing the signal. Another reason is that it may take up an unacceptably long time to process the signal – sometimes several seconds, which is too long in a real orientation situation.

Another possibility is Assisted GPS – AGPS – which can be used in situations where the signals from the satellites are too weak. This may be appropriate indoors, but also outdoors under less favourable circumstances. Examples of such circumstances are when only a small number of satellites can be reached or when moving around on narrow streets surrounded by high buildings or other similar environments – the so called canyon-effect.

It should be pointed out in this context that GPS receivers with much greater sensitivity than before – iGPS – are now starting to come onto the market, which may allow navigation with sufficiently good precision even in environments that are currently problematic from a radio perspective[2].

[2] www.gpsworld.com and www.esa.int/esa websites can be consulted for more information about GPS, DGPS and AGPS.

Mobile telephone cells

A less precise, but not uninteresting method is what's called 'Cell Global Identity', CGI. This is based on the possibility to register and identify the communication between a telephone and its activated base stations. There is consequently a technical possibility to determine the approximate position of a particular mobile telephone at any given moment. However, the technology is far too imprecise and is not yet adequately established to be of interest in the present context.

The utilization of GPS and CGI results in some form of coordinate references. These are only meaningful if they can be related to reality in the form of an appropriate map reference. Accordingly, access to maps and an appropriate user interface is necessary. This must be available in several alternative designs in order to adapt to the user's special capacities, for example people with visual impairments, people with reading and writing difficulties, people with cognitive problems and people with intellectual disabilities.

Landmarks

A landmark means here some kind of identifiable point in the surroundings that one can relate to in order to determine ones position. Such points are virtually everywhere for people who have sight and full control of their surroundings – it may be a familiar sign, a church tower or a distinctive large tree.

For people with visual impairments, different kinds of acoustic landmarks (sound beacons) have been tested for position determination. Examples are the ticking devices at pedestrian crossings that both confirm a position and to some extent guide the user to the post. Among the more exotic ones are recorded bird's songs used in Japan!

Today, there are various technical possibilities to provide this kind of guidance:

- *One is based on Bluetooth technology. This means that small radio transmitters are positioned at strategic points in the environment. When one approaches such a transmitter carrying an appropriate receiver, pre-recorded information will be read out, which could include anything from advertising to the identification of, for example, a bus stop. Bluetooth transmitters need an energy supply in the form of, for example, an integral battery*

- *Another technology is based on what is called RFID – Radio Frequency Identification. This is based on a passive or active radio circuit that transmits information when approached by a special combination of transmitter and receiver. As the fixed transmitter normally is passive, it does not need to have its own energy supply*

- *A third possibility is WLAN – Wireless Local Area Network – which are local, radio-based networks that send information to, for example, a mobile telephone or PDA about what is located in the vicinity.*

All these systems have pros and cons for the user.

- *The WLAN concept provides a rather inaccurate position determination if not calibrated at the spot where it is intended to offer positioning capabilities. It is most appropriate for information about, for example, what a shopping centre offers in the form of shops and connections for adjacent public transport. It is consequently more of an information system than a positioning system*

- *Bluetooth technology is significantly more precise from a positioning perspective, but it still allows quite a number of meters of deviation without 'losing' the receiver. To bear in mind is that Bluetooth technology does not support information concerning direction or relative distance between the user and the Bluetooth unit, but merely if a user is within range*

- *The RFID circuit is the most accurate, often functioning at very short distances – in the region of a few decimetres.*

WLAN and Bluetooth technology are already commercially available and have been implemented in various contexts, while the most common usage of RFID applications is in logistics. All have the advantage of functioning both indoors and outdoors. The disadvantage is that they require varying degrees of attention and maintenance.

Where there is a risk of radio black spot, the possibility of using landmarks like RFID, Bluetooth and WLAN for secure navigation indoors and outdoors should be considered.

Orientation

Some kind of compass is required for orientation. A traditional type of magnetic compass, i.e. a needle compass, can of course be used, but this is not particularly practical, especially for people with visual impairments. In this context, it would probably be more practical to have a magnetic field sensor and presentation in a visual or acoustic form. However, all magnetic compasses are affected by fields of magnetic disturbance – a strong deviation may be directly misleading and thereby be dangerous for the user. A more secure way is to make use of 'inertial navigation' in some form, but accessible systems are voluminous, expensive and require a lot of power. A further possibility is to utilize the compass function offered by the GPS system. The principle for this is that the system registers two consecutive points and calculates the angle between the points on the basis of these measurements, which in general is the same as the angle of travel. However the disadvantage is that this only functions when one is moving. It is consequently not possible to start from a given point and at that point determine which direction one is facing.

At present, the GPS system offers the best opportunities available for direction orientation while moving and an integral digital compass function in a handheld unit when stationary.

Navigation

The GPS system constitutes the basis for navigation, i.e. support to move from point A to point B. The simplest form of navigation means that one receives almost continuous backup support – visually or acoustically – in the form of appropriate road descriptions. However, this can also mean information about what is available on the route during the journey, in the form of ancillary information, for example the shops that are available in the vicinity and the range of products that they offer. These facilities will probably use local transmitters based on, for example, Bluetooth technology, RFID or WLAN.

How the system is used can vary according to need. In general one knows where one is and wants to go, but needs feed back during the route. It should also be possible to tell the system where one wants to go and let the system find the best route. An extreme case is when one has got lost and just wants to get back to the starting point – the 'back to base function'.

Maps

Maps are of great importance for navigation for most people. This applies not least for people with different disabilities. For people using wheelchairs, for example, it is important to have an overview of the route to be taken and, if possible, to assess any slopes, the nature of the route, etc. For people with visual impairments, this is perhaps even more important. Here, it is necessary to assimilate a mental map of the route to take. This can basically be done in two ways:

- *For those with partial sight, maps with good contrast, preferably with different scales for overall and detailed information respectively are necessary. This is relatively simple to do now that maps are digitally stored. It is also possible to show them in colour and at the desired size on a computer screen and get a print out on a colour printer*

- *For people who are blind, the visual information must be translated into tactile information in the form of raised-line maps. There is no special simple technique to achieve this. It requires preparation in good time and access to special technical equipment.*

There are digitally-stored maps for satellite-based systems that can be entered into the navigator. One of the many advantages of these is that they can be kept up-to-date and, in certain systems, are almost continuously fed into the navigator.

Both digital and analogue maps are required. It should be possible to download digital maps onto the user's handheld unit and onto a computer at a service centre. Analogue maps in visual and tactile form – raised-line maps – are provided primarily when planning a travel route.

Most digital land-maps of today are intended for car drivers. They are of very limited use for pedestrians, especially those who are visually impaired. Therefore, maps must be developed that show safe ways for pedestrians, i.e. sidewalks, pathways, stairs etc.

Another method for people with visual impairments is a verbal description where the route is explained in sequence of the type: "Go along Main Street towards Main Square. Go past two street crossings. Take a right at the third. Walk for approximately 100 meters. You are then close to a pedestrian crossing with a ticking acoustic signal. Cross at this pedestrian crossing." This kind of information can, for example, be recorded on a pocket memory and be retrieved subsequently as the user is moving along, which however requires that someone assumes the role of recording the information. One disadvantage is that there is no help if something goes wrong on the way – there is nothing to put the user back 'on track'. Nor is there, of course, anything that gives a warning of impediments in the form of road works and the like.

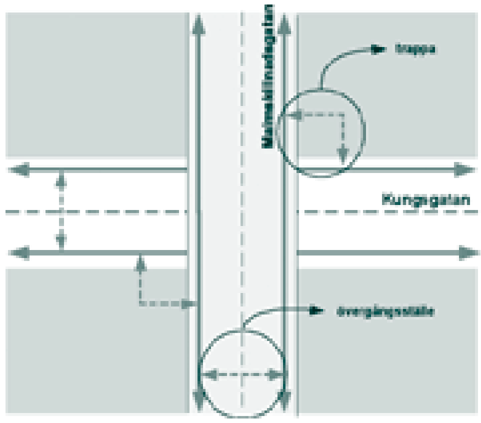

Figure 2.1 Digital map showing the importance of including sidewalks and stairs for pedestrian safety.

Communication

For communication – everything from a call to an alarm – it is necessary to have a manned centre with which users can communicate. In its simplest form, this comprises a person who can answer the telephone and by talking to the user can assist with orientation. In a more advanced system, a 3G telephone can be used, where users can send pictures or video clips from their surroundings to a support person, who can then assist them more easily. In its more advanced form, the support person has access to an electronic map on a screen, where the user's position is automatically entered as a point of reference.

Localization

The function 'localization' aims at being found if lost and not able to call for help. In principle, there are two ways of achieving this.

One is to use a combination of GPS and mobile communication in such a way that the user's own mobile telephone automatically transmits information to a service or an alarm centre, where the position is shown on a map on a screen terminal.

Figure 2.2 Position determination on a digital screen map, for example at a service centre.

The other way is radio direction finding, which means that a transmitter position is located with the help of one or more antennae for radio direction finding. In this case, the user has to wear a special transmitter designed much like a wrist watch. These transmitters can be activated via Minicall[3], after which the transmitted radio signals can be picked up by a special radio direction finding receiver.

Users have stressed the importance of it being possible to locate them when they have lost the capacity to orientate themselves during a journey. Methods for position determination on a map on a computer screen through, for example, a service centre have been developed and implemented by, among others, the Swedish police.

Indoor navigation issues

One condition for the use of a GPS receiver is that it can be reached by signals from at least three satellites. Basically, a clear line of sight to the satellites is required from the receiver as the signal strength is very weak. This means that reception indoors cannot be deemed reliable. AGPS can to some extent be used for indoor orientation. More reliable, however, is an inertial navigation system – gyrocompass and accelerometer in combination with a system for 'dead reckoning' – to keep track of where someone is located. However, the situation may rapidly change. Technology is developing towards increasingly sensitive receivers and, as mentioned earlier, the European Galileo system will allow reception where the current GPS system is too weak. However, it is wise for the moment to rely in practice on other methods for indoor navigation.

The most obvious is to rely on transmissions of radio signals from locally placed transmitters, for example, in shopping centres and arcades. – The disadvantage of

[3] Minicall is an RF-based technology, used for distribution, e.g. of text messages on 169,800 MHz

this method is that it requires the placement of transmitters at many sites. This requires a great deal of organization, standardization, maintenance, etc., something which has not been established completely today.

Many of the technologies and assistive devices that have been described in the Landmarks section are of course also applicable for indoor environments. This applies not least to maps, which can be essential to enable users to find their way around shopping centres and arcades.

The user's device

User devices utilizing the GPS system have been on the market for several years, and today stationary as well as hand held navigators are available for private use in boats and cars. Most of them are dedicated for the purpose, integrated in a device with a screen in full colour. There are also some separate units to be connected to PDAs (Personal Digital Assistants) or Mobile telephones.

Figure 2.3 An example of a hand held GPS navigator.

There are ergonomic advantages with the integrated solutions. The drawback is that it might be difficult to find an optimal position for the GPS receiver at the same time as the device should be manipulated or the screen read. An interesting compromise has been developed in the Canadian Trekker, where the GPS receiver is mounted on a belt to be hung on the shoulder and the processing device – in this case a PDA – is positioned at hand level. The output device – in this case a loudspeaker – is also mounted on the belt close to the ear of the user.

Figure 2.4 Victor Trekker, designed and manufactured by Canada-based company VisuAid, was launched in March 2003.

The Trekker solution allows for independent navigation but does not supply any service or alarm function. For this a separate mobile phone has to be used.

Swedish activities

In Sweden, a study aiming at initiating a few trials was made in 2005. In the study, possible technologies were investigated and planned and on-going activities as well as available technical equipment identified. Also, representatives from Swedish handicap organizations were interviewed and given the possibility to put forward demands and desires on equipment and system.

Among other things it became clear that the functionality, reliability and easy-to-handle matters were priority tasks. Also, all interviewed persons wanted a kind of "life-line", i.e. the possibility to get help if the track was lost, some unexpected obstacles appeared or an emergency situation came about. Therefore, there was a demand for a kind of service centre which could be reached via a mobile telephone, preferably with video transmission facilities.

The persons interviewed also pointed out that they did not want another technical gadget to take care of, but preferably a mobile telephone with built in facilities for GPS-navigation and access to RFID- and Bluetooth based information[4].

[4] A report, "Navigation, alarming and positioning – A preliminary study conducted in Sweden by the Royal Institute of Technology (KTH), Department of Speech, Music and Hearing in the assignment of the National Post and Telecom Agency (PTS) 2005" is available at http://www.pts.se/Dokument/dokument.asp?Sectionid=&Itemid=5678&Languageid=EN

Swedish trials

The study revealed three on-going and planned pre-studies. These are localized in the three biggest cities of Sweden – Stockholm, Gothenburg and Malmoe.

In Stockholm, the focus is upon people with visual disabilities. A digital pedestrian map has been developed for an area in the city by name Sodermalm. The intention is to start a study towards the end of 2006 with a small group of people with visual impairments. The technology that will be used in the first phase of the study includes server based map and obstacle data, route planning functionality, a mobile phone and positioning technologies. Later on additional functionality such as individualization of required information, alarm functions and points of interest is intended to be added.

In Gothenburg the primary target group is people with cognitive impairments. Even here the study is intended to start late 2006, and embrace a small group of people to start with. The project will be linked to intentions by the local public transport authorities to facilitate the use of public transport by elderly and people with disabilities.

The study in Malmoe will aim at people with visual impairments as well as those with physical disabilities.

A service centre that can handle alarms and be contacted via the user's mobile telephone facility will also be included.

A schematic overview of the functions is shown in figure 2.5.

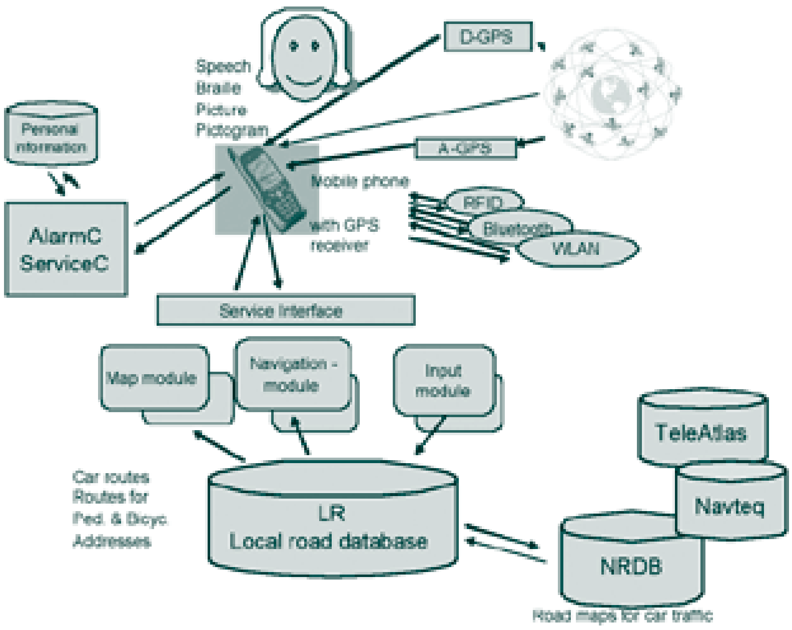

Figure 2.5 A schematic overview of the planned navigation systems in Sweden.

The user – the focal point of the system – is assumed to have impaired vision, hearing, motor or cognitive functions. Software for implementing speech synthesis, speech control and Braille presentation (on a separate display) and the possibility of an individual design and adaptation of the visual presentation on the screen (for example, zooming in and pictograms) are required.

It is assumed that the user has a mobile telephone or handheld computer with mobile communications facilities with the above-mentioned adaptations. There are many different mobile telephones available on the market, appropriate for this purpose, for example Nokia Serial 60 phones, e.g.6630, N70 etc. but also Sony Ericsson UIQ phones or stronger Java phones.

A handheld computer (PDA) is interesting from many perspectives, but must be supplied with a telephony attachment. Only a few have integral telephone functionality. Regardless of what one chooses, a terminal with a digital compass, camera and Bluetooth function is recommended.

The telephones must have open operating systems. Symbian and Windows Mobile can both be used. The latter is more powerful and quicker, but requires more power. Symbian is considered to be preferable, not least because there are many telephone models to choose from with this system.

The telephone is linked to a GPS receiver. This can either be integral or separate. The latter is preferable, first because reception is generally better if the GPS receiver can be placed independently of the handheld communication unit and second for power supply reasons (the batteries last longer).

There is a large variety of software to choose from for navigation, for example various Garmin products, GPS Pilot Tracker, Mapmate, Navicore, Route 66, TomTom, Trekker and Wayfinder.

All systems have their pros and cons. Trekker is specially developed for people with visual impairments. Wayfinder is a system that can offer streamed downloading of route information, if this is required.

There are several digital road databases available in many countries, e.g. Navteq and TeleAtlas. They have limited wealth of details and actuality and are basically intended for vehicular traffic.

In Sweden an effort is made to collect and store more qualified data in a National Road Data Base – NVDB. Currently it's limited to road information for car drivers. At the beginning of 2007 road information for cyclists will be possible to store in the NVDB.

The local municipalities are building up Local Road Data Bases, LV:s. They have capacity for more sophisticated information, like accurate pedestrian routes, and the information can be frequently up-dated. This work has started in Stockholm with the development of a Digital Pedestrian Foot-path Network (DG).

It's important to point out, that the system is designed with open border lines so that other implementations can hook on.

Besides resources for autonomous navigation, it is expected that the user will need to communicate with a manned alarm or service centre via a mobile telephone. The centre should be able to take care of both 'soft' calls (including calls from camera mobiles) with oral and visual support information, and 'sharp' calls with a requirement for, for example, the support of rescue units. The alarm/service centre can be one and the same unit or they can be stationed at different locations. It is expected that the alarm centre will have rapid access to the rescue services. The service centre can be anything from a county alarm centre to a relative's home. In any event, it should be possible for all personal details to be extracted from, for instance, a database. It is also important that the alarm/service centre can locate the user.

Owing to the wide range of both hardware and software, a final decision on the choice of products must represent a balance between the various pros and cons. The most important thing, besides satisfying the needs of the user as far as possible and comprehensively, is to stick to non-proprietary solutions and, where this is not possible, to conclude contracts with those suppliers who will provide the greatest possible freedom for different component choices.

A system like this is generic and is the basis for all three trials in Sweden. It will be possible to use in any place in Sweden. It will be designed so as to be easily adaptable to local transport information systems.

Conclusion

Many groups of people with disabilities experience problems when moving around in an unknown environment. It has been anticipated that modern satellite navigation systems could form a basis for overcoming most of the problems.

A study has been made in Sweden on this issue. It concludes that there are significant possibilities to improve the situation for the groups in question with the aid of GPS-based navigation, combined with the use of mobile telephony and databases for storing maps, personal information etc. The study also suggests the National Post and Telecom Agency to support three pilot studies in Sweden to explore the pros and cons for a few groups of people with disabilities in the three largest cities in Sweden.