THE MEANING OF GPS FOR VISUALLY IMPAIRED PEOPLE

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Abstract: The aim of this paper is to explain what GPS technology can mean for visually impaired people. We take a look at the accessibility of general market devices but also at some specifically designed GPS receivers. What about the accuracy and can it be further improved? We come across some promising technologies that may lead to a better use of GPS for the target group.

Keywords: accessibility, blind, design, GSM, GPS, mobility, navigation, orientation, PDA, visually impaired.

1. Introduction

Mobility of blind and low vision individuals is a combination of two related techniques: local navigation and global wayfinding.
Local navigation is about sensing with white canes, relying on surrounding sounds, tactile clues from the ground surface and the use of guide dogs.
Wayfinding is a matter of experience and/or training. Mostly, blind people must rely on the assistance of sighted persons to find their way or need an accompanying person to give instructions on the way to follow. At least during a training period.
This means that the majority of visually impaired people can not find their way autonomously in an unknown area.
Let’s take a look how GPS technology can assist to improve independent mobility of the visually impaired.

2. Global Positioning System (GPS): the technology at a glance

The GPS is an electronic system for location determination, planned and financed by the US Army. It consists of 24 satellites turning around the earth in fixed orbits. Each of these satellites produces a specific electronic signal that can be received by a small GPS receiver, not bigger than a small mobile telephone.

One can get information on his/her position on earth by using a GPS receiver that calculates its position based on the signals of satellite-based transmitters. The precision that can be obtained routinely is in the order of 5 to

10 meters, depending on the strength of the signals that can be received. This positional information (in geographical co-ordinates such as e.g. N 54°37,297 / E 4°39,624) can be transformed in human understandable information, using computers and map software.

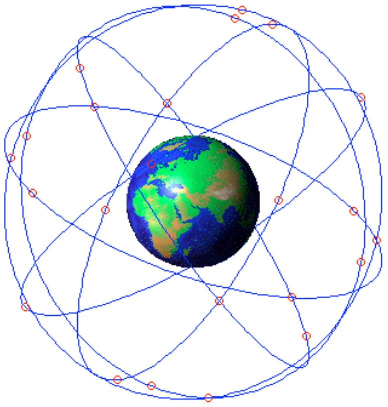

Figure 1: 24 satellites circling around the globe.

The receiver calculates the distance to the satellites by measuring the time difference between sending the signals and receiving them. Using the signals of three satellites the location of the receiver anywhere on earth can be calculated through a process called triangulation. The GPS receiver also contains a kind of logbook with descriptions of all the 24 satellite orbits. By consulting this logbook, the receiver knows more or less where to look for the signals at a certain point in time.

It suffices to say that the GPS system can provide you with your location details as well as with information about the direction to follow to reach a certain destination. This is possible because the GPS receiver knows where you are and, if you indicated where you want to go, it can determine which direction to follow. A GPS receiver is NOT a compass but a purely electronic and computerized device that can provide you with extra information such as speed, probable arrival times, distances travelled and the time (with milliseconds precision) at that moment.

A GPS receiver needs signals from minimally three satellites in order to be able to calculate its location. If sufficient signal strength from a fourth satellite is available, also the height of the receiver above the earth's surface can be determined. Most modern receivers can handle up to 12 satellite signals simultaneously. Having still more channels is useless as due to the spherical form of the earth, no more satellites can be seen at any point in time. One must be aware that all receivers need an antenna with sizes ranging from 5 by 1 cm to 5 by 5 cm.

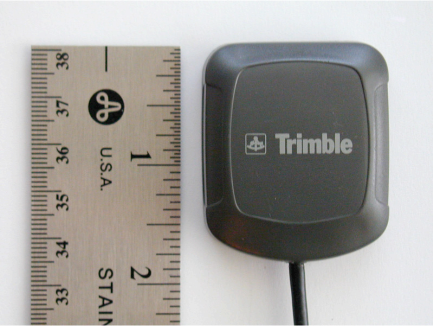

Figure 2: GPS antenna next to measuring rod.

3. Optimizing GPS accuracy for way finding as a walking blind person

There is a discussion in progress on the precision **required** for urban walking. Commonly it is accepted that minimally 2 meters are needed, e.g. to know on which side of a road one actually is.
Another point of discussion is the precision that can be **obtained** with GPS receivers. The US Army controls the satellites and they can deliberately diminish the precision at any time (War in Iraq).

One of the techniques to improve the precision of GPS receivers is to have extra information broadcasted to the GPS receivers by other systems. One of these, **D-GPS** (Differential GPS) improves the precision to less than one meter. But one should be close to a D-GPS transmitter. Such a transmitter is not a satellite but a fixed transmitter on earth.

On a national scale specialised companies sometimes provide customers with additional information to improve GPS precision. One of these is the **Dutch LNR Globalcom** that can guarantee centimetre precision for fixed receivers (and this solution is therefore not useful for walking...)

The European Space agency has recently started broadcasting extra information for GPS receivers via another satellite network, the one used for radio and TV broadcasts. This **EGNOS** system is very useful for airplanes and ships, but for terrestrial applications (e.g. navigation by blind persons in town) it is quite useless as this type of so-called geostationary satellites has a very poor coverage in cities. But solutions are forthcoming. We will come back on this when describing the Spanish ONCE-EGNOS solution.

The mobile phone network (GSM) works with fixed receivers/transmitters. The position of a person whose mobile phone is switched on can be calculated from the signal strength and location of the used receiver/transmitter from the network operator. However, this option is far too imprecise to be used by visually impaired pedestrians. The precision that can be obtained is a few hunderd metres. There is one exception; after permission of the court of justice, one particular mobile phone can be located with a higher precision. However, this is a pure theoretical way of working because the person with the mobile phone must know his position, not the persons that are trying to locate the cellular phone. It is clear that this way of working is not usable for our target audience.

4. Requirements for accessible GPS-devices

Existing GPS equipment is developed for well-sighted persons who can read fairly small displays and manipulate tiny keyboards. Since we are talking about portable devices, the displays must be small. For users with low vision, displays can be made better readable by using high-quality TFT colour screens like the ones used for today’s notebook PC’s. However, this screen-technology uses more energy and therefore diminishes the autonomy from the batteries.
For the blind user, everything that appears on the screen should be made accessible by speech synthesis or Braille presentation.
The keyboards should have separate keys, not a membrane keyboards where all keys are under a plastic cover and can hardly be distinguished by touch. The keys preferably have inscriptions with a high contrast for optimal readability and are well separated from each other. When pressing the buttons, one must feel a clear “click” to be sure the button is pressed; this can be supported by a small beep-signal.
Good accessibility of the keyboard and the display, as described above, guarantees practical usability for the visually impaired. Most of the items to improve the accessibility are also appreciated by the general public; e.g. bright colour screens and clearly imprinted keys. Let this be a hint for the manufacturers of GPS systems.

5. Accessibility of general market devices with GPS

GPS systems became more and more popular for the general public. Probably, the most well known form nowadays are the talking GPS-systems in cars. The next most known form is the handheld GPS for people who undertake adventurous trekkings in remote areas. The military and sea-traffic are using GPS for a long time.
During the last years, we had some experience with general market GPS-devices. We can be brief about it: not a single device is accessible for our target group!
However, we discovered a few devices with features that are promising towards the visually impaired users. That is, if the manufacturers would be willing to spend a reasonable effort to improve the accessibility.

5.1 NavTalk from Garmin

Figure 3: NavTalk device with on-screen display of navigation sample.

This combination of a mobile telephone, personal digital assistant (PDA) and GPS has the shape and size of a medium-sized mobile telephone. Only the route guidance of the GPS-part is spoken aloud. If everything that appears on the display could be read out, the NavTalk probably would be an accessible device; not only a GPS but also the mobile telephone and the PDA. This suggestion is forwarded to the local Belgian distributor from whom we received the testing device.

5.2 PDA's with GPS

Figure 4: iPaq PDA with GPS extension.

Personal Digital Assistants (PDA's) are small handheld computers with a touch screen. They become more and more available at reasonable prices. Also, the features of these PDA's improve almost every day. The combination of GPS with a PDA (like the Visuaide Trekker, see below) is something that seems to become quite popular. Since most of the PDA's are using a reduced version of Windows, it could be expected to have a screen reader that makes the device accessible by speech output. Until today, we have no knowledge of a universal screen reader for Windows CE or Windows for Pocket-PC's.

6. Explicitly developed GPS equipment for the visually impaired

Since general market GPS devices are not accessible, specific developments are necessary. Let's take a look what is available on the market (situation April 2004).

6.1 BrailleNote GPS


Figure 5: Lady walking with white cane and BrailleNote GPS on shoulder strap.

The BrailleNote GPS is a combination of a standard handheld GPS device from Garmin and the already existing note taker Braillenote (or Voicenote) form Pulse Data that runs Windows CE. In the USA, we know of a few user-tests with this device. Generally, users are pleased when they get acquainted with the BrailleNote GPS. The precision depends on the level of detail that the local map info contains. Global GPS signals give an accuracy of about 7 meter (best case), but local info like street & alleys, schools, restaurants and railway stations must come from a local map database. This local information informs the user while he or she is walking in his direct neighbourhood.

6.2 Visuaide Trekker


Figure 6: Gentleman with white cane and Trekker on shoulder strap.

The Visuaide Trekker is a combination of a standard GPS receiver and a standard PDA running Windows for Pocket PC's: iPaq 3950. Local street maps are stored on flash-cards that can easily plugged into the iPaq. On the shoulder strap we can also find the GPS-receiver, a loudspeaker and an extra battery to extend the autonomy. First practical tests reveal that this kind of devices should be used together with a cane or even better, with a guide dog. The guide dog gives you information about nearby obstacles and warns you for dangerous situations; the GPS system provides information to walk the right way to reach your destination. If there are many small streets close by, the GPS system can be confusing. When it begins to rain, the user will have to protect the whole system against the water.

6.3 Demor game

Figure 7: Man carrying Demor-system in backpack.

The two previous examples described navigation and oriëntation aids. Now, its time for a little bit of fun. Demor is a location-based, three-dimensional audio shooter computer game that uses a GPS module to calculate the location and walking direction of the player. This highly innovative game was developed by a multi-disciplinary team of seven students for the Dutch Bartimeus Institute for the Blind. Demor does not only focus on the entertainment aspect of computer gaming, but also attempts to contribute to the emancipation of the blind and visually impaired people in order to enhance their integration with the 'sighted' world. It is a proof of concept developed on the basis of theoretical and practical research.
In order to be able to play Demor, several hardware components are needed alongside the software. A GPS module, attached to the backpack, transmits the player's actual location; a head tracker in turn is used to determine the player's head angle, according to 2 axis (tilt is not used). The information of both the GPS module and the head tracker is constantly sent to the computer which is carried in the player's backpack. The Demor audio-engine in turn uses this information to determine in real-time the right audio feedback, which is heard on the player's headphones. Reacting on this feedback the player then uses a joystick (to trigger his weapon) to shoot the monsters. The game must be played on a open space that is large enough (e.g. football field).

7. Promising technology for the visually impaired GPS user

It is only since about a year that accessible GPS systems become available in reasonably practical designs: elegantly wearable in a non-striking way and very light. To be used within the target group, a few aspects must be further improved to be more successful.
First of all, we have the accuracy of a portable GPS-system. An accuracy of about 2 meter should be aimed at because then the blind user could feel himself reasonably safe en self-assured. At the moment the accuracy is 7 meter, at its best.
A second main issue is the availability of local detailed street maps in a compact electronic form so that they can easily be implemented in the portable devices. Often they are available but only in copyright protected format for certain types of devices.
A last item is the current high price of a complete accessible GPS-set. Although, we can notice that the price is decreasing over the past years.

7.1 EGNOS and Tormes


Figure 8: Gentleman with guide dog an Tormes on shoulder strap.


Figure 9: Tormes against street plan background.

The European Space Agency (ESA) and the Spanish ONCE (National Blind Organization) have developed Tormes. Tormes is again a wearable GPS-system that talks to the user, comparable with the BrailleNote GPS and Visuaide Trekker.
To improve the accuracy to 2 meter, a system called EGNOS (European Geostationary Navigation Overlay Service) is being developed. EGNOS signals are transmitted to the ground by means of geostationary satellites, so its signals are often blocked by buildings. This is called the canyon effect.
To solve this problem, ESA engineers had the idea of providing the corrective data through the internet via a GSM connection, a project called SISNeT (Signal In Space through Internet). This makes EGNOS available anywhere downtown. Blind people who have access to this information can now distinguish clearly street details. For a blind person walking in a town this will make all the difference because with an accuracy of 10 m (with standard GPS) the street is already crossed, with 2 m and less (with EGNOS) you know which sidewalk you are on.
Testing of the prototype is ongoing but already the results indicate that EGNOS can provide this precision for blind people in the street.
The expectation is that EGNOS will be fully operational in spring 2004. However, we could not find any confirmation of this at the moment of writing (April 2004).

7.2 NOPPA personal navigation system

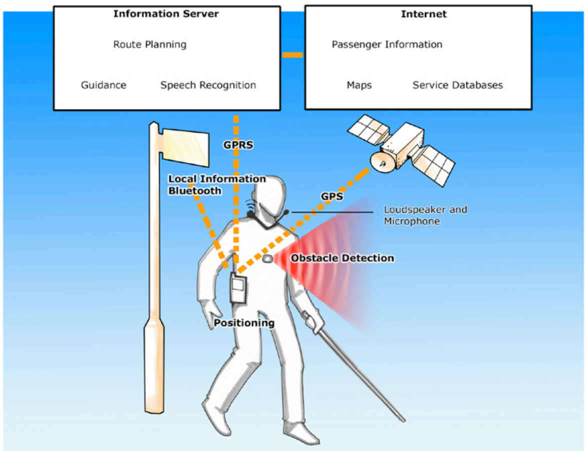

Figure 10: Drawing showing the different elements of the Noppa system.

The Finnish Noppa personal navigation system is developed in a three-year pilot project, which is part of the Ministry of Transport and Communications, Finland's Passenger Information Program (HEILI). The project started in June 2002 and ends in December 2004.
The system is designed to offer information to public transport passengers and pedestrian-guidance for the visually impaired. Noppa is based on available personal navigation components and services. Modularity enables constant development of the system.

Using public service databases over internet ensures that the information is up-to-date. Combining passenger information from various information sources and creation of general-use interfaces have high importance in the project.
Noppa is currently able to offer basic route planning and navigation services in the Finnish towns of Helsinki, Espoo, Vantaa, Kauniainen and Tampere. A more accurate demonstration including high-detail maps will be carried out near Itäkeskus (Helsinki), where a new service centre for the visually impaired is being built at the moment and near the Arla Institute in Espoo, which is a vocational training and development centre. Several public transport lines connect these areas.
The communication within the Noppa system is based on mobile telephony, SMS, Bluetooth, e-mail and mobile internet. All this combined with GPS-signals should result in a fairly complete information system to navigate around. An obstacle detection system for personal use will also implemented. We are looking forward to see if Noppa will lead to a good navigation system for the blind user.

8. Conclusions

It is always difficult to predict the future and this is especially so for technological evolutions.
Nevertheless it can already be seen that there is a booming market for location based services. One can expect improved GPS-GSM receivers to come on the market. This type of devices is e.g. very useful for elderly persons as they are always sure that somebody can help them to find their way back if lost somewhere during a walk.
The combination of PDA and GPS is another development to keep an eye on. PDA's have the capability to run a screen reader that makes them (more) accessible; besides the standard PDA functionality, the GPS function becomes accessible.

The European Union plans to build a competitive satellite location system, called Galileo. It would have better precision than GPS and, even more important politically, avoid total dependence from the US army. It is currently still so that one push on the (American) button can stop the whole GPS system. The EGNOS precision improvement, an initiative of ESA, the European Commission and Eurocontrol, for use in civil aviation and other new services, will definitely pave the way for new applications, also for visually impaired users.

Talking about accessible GPS systems should never supersede the training with a white cane our guide dog because it doesn't warn you for obstacles ahead or approaching cars & other traffic. But GPS definitely will be used as a tool for wayfinding: how to go from one place to another, to explore your familiar neighbourhood and also to find your way in a totally new environment.

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