Will GPS Finally Bring the Solution to Wayfinding in Cities?

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The mobility of visually impaired persons in a city requires a combination of two related techniques, namely local navigation and global wayfinding. Local navigation refers to the skills and information needed *to move in a place*, while global wayfinding refers to information and skills needed to move *from one place to another*.

Local navigation or short distance mobility is based on techniques such as white cane sensing, relying on sounds (street noise, reflection of sounds on walls), tactile clues from the ground surface (including purposely installed elastic tiles or other tactile feedback) or the use of guide dogs. *Wayfinding* or medium distance mobility in cities, even nowadays, is often a matter of experience or training. Blind persons often need other people's help to find their way or need an accompanying person to give instructions on the way to follow, at least during a training period.

This implies that, with a few exceptions, visually impaired persons can still not find their way autonomously in an unknown city. (cf. also the section on "Orientation and Mobility" in G. Bellefroid, "Having a Visual Impairment while moving through town" in this book)

WAYFINDING IN THE PAST

For problems of wayfinding, many solutions have been devised in the past, including talking road signs, talking bus stops or railway track information systems. Dozens of these solutions have been proposed over the last decades but, curiously enough, almost none has gained any popularity.

There are two major reasons for this. First, a wayfinding system requires the installation of electronic beacons in a public space. This is quite expensive however and only a few governments were willing to make these investments. Second, there are no accepted standards for the hardware needed to get information from beacon-based systems. This means that for every technical approach, another receiver should be carried around by a blind person, a quite unrealistic expectation. For this point, a solution may come up in the near future through the cheaper availability of wireless Bluetooth-based devices. Bluetooth is a modern telecommunication standard, conceived for short range communication between simple devices (e.g. a wireless headset connected to an audio source, linking PDA's or portable computers to mobile phones). Wayfinding for blind travellers could gain popularity is the beacons would talk to their mobile phone instead of to a special device.

THE GLOBAL POSITIONING SYSTEM: GPS

Introduction

A system that, at least in principle, counters both of the above objections is based on the GPS system. In a nutshell, 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 50°51,729 / E 4°41,166) can easily be transformed in human understandable information, using modern computers and map software.

GPS

The Global Positioning System 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.

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 doing so the receiver knows more or less where to look for the signals at a certain point in time.

Possibilities

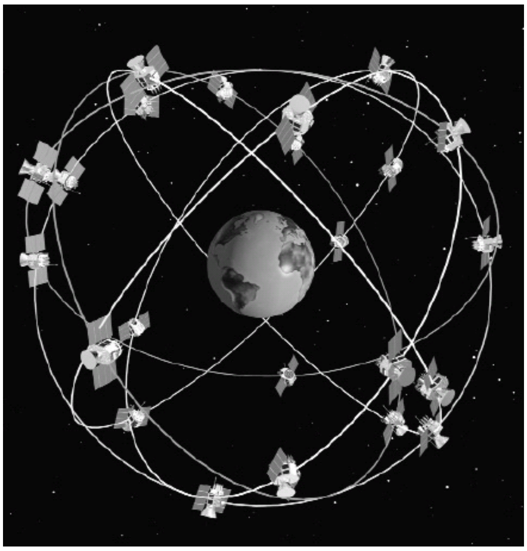
The above explanations may seem already quite technical but it suffices actually to say that the GPS system can provide location details as well as the information about the direction to follow to reach a certain point. This is possible because the GPS receiver knows where you are and, if you indicated 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 extra information such as speed, probable arrival times, distances travelled and the time (UTC, coordinated universal time - with milliseconds precision!) at that moment.

In the past, the precision of the location information was deliberately diminished for civilian users. Since May 2, 2000 however this selective availability (SA) has been abolished. This made it possible that even simple GPS receivers could determine locations to within about 5/10 meters. But it is possible to do even better (cf. below).

Technical background

The satellite network

The satellite network for GPS consists of 24 satellites orbiting once around the globe in about 12 hours. From calculations and from the orbit scheme on the drawing below, one can derive that at any position and any moment in time 6 satellites are visible (sometimes more), if no hills or buildings block the line of sight.



Specification of a GPS satellite

Name:	NAVSTAR
Manufacturer:	Rockwell International
Height above the earth's surface:	20 186 km
Weight:	900 kg

Dimensions:	a square with sides of about 5,1 m (solar energy panels switched open)
Other details:	One revolution in about 12 hours
	Contains an atomic clock (rubidium) that can be adjusted from time to time from the ground.

The GPS receiver

As said before, 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, the height of the receiver above the earth's surface can also 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, more satellites cannot be seen at any point in time.

Miniaturized GPS receiving modules for 12 channels are produced by only a few companies and are built into many types of receivers by equipment builders. One must be aware that all receivers also need an antenna with sizes ranging from 5 cm by 1 cm to 5 by 5 cm.

Is GPS threatening the use of a guide dog?

Recent GPS receivers can talk, e.g., "*Go straight forward for thirty meters, then go to the left. And at the next crossing: take right.*" This is what a person might hear when walking in a park. However, this is a case in which the blind person has made a choice amongst different routes. The condition for this choice is that the person has recorded in his device one or several routes. This recording presupposes that the person walked these routes before, probably assisted by sighted person.

Therefore, the use of a guide dog is far from superfluous (remember our introduction on navigation *vs*. wayfinding): GPS still has a limited accuracy, especially in built areas. If one relies on satellites only, one would rapidly end up in the bushes. Furthermore no mapping system can cope with sudden obstacles on a road (such as the digging of holes in the ground for utility works, or blocking the sidewalk by a big van). In this case a trained guide dog will not only avoid the obstacle but also find a way around.

Problems with imprecise map information can be avoided to some extent if one uses a GPS to know his position and if he sends this information to other persons or to a specialised service using a mobile phone. Some devices integrating a GPS receiver and a mobile phone do exist.

The first GPS+GSM-set came on the market in 2001: the Benefon Esc!. If both parties have such a receiver, they can see on their respective screens their own position and the position of the person they are talking to.

Other GPS based systems are built as almost invisible extra equipment, e.g. into cars. Or one attaches them to containers with a very valuable content. From a distance you can switch them on and they transmit their position to you. Quite useful if your expensive car was stolen!

The GPS precision needed for wayfinding as a blind person

There is a ongoing discussion on the precision that is **required** for urban walking but commonly it is accepted that minimally 2 meters is needed. This would enable one to know for example on which side of a road one actually is. Another point of discussion is the precision that can be **obtained** with GPS receivers. As already mentioned, the Selective

Availability system was used until May 2000 to deliberately diminish the precision, but that belongs now to the past.

One of the techniques to improve the precision of GPS receivers is to have extra information broadcasted to GPS receivers by other systems. One of these, **D-GPS** (differential GPS) permits to improve the precision to better than one meter. The condition of course is that one should be close to a D-GPS transmitter.

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. 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. In general these techniques are called **WAAS** (Wide-area augmentation systems). The European **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 geo-stationary satellites has a very poor coverage in cities. But solutions are forthcoming. We will return to this when describing the Spanish ONCE-EGNOS solution.

How can GPS devices be made accessible for blind and low vision individuals?

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 the visually impaired users, displays can be made better readable by using high-quality TFT colour screens like the ones used for modern notebook PC's. However, this screen-technology uses more energy and therefore diminishes quicker the life of the batteries, and hence the autonomy of the user. 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 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 further supported by a small beep-signal.

Good accessibility from the keyboard and the display, as described above, guarantees practical usability for the visually impaired person. Most of the items to make it accessible 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.

General market GPS devices; how accessible are they?

During the last years, GPS systems became more and more popular for a large percentage of 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 do adventurous trekking in remote areas. The military and the shipping traffic have been using GPS for a very long time.

During the last years, the Infovisie and KOC organisations 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 visually impaired users. That is, if the manufacturers would be willing to spend a reasonable effort to improve the accessibility. One of these is the Navtalk.

NavTalk from Garmin

This combination of a mobile telephone, personal digital assistant (PDA) and GPS has the shape and size of a not-so-small 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. More info can be found at: www.garmin.com/products/navTalkGSM.

Specially developed GPS equipment for visually impaired people

Since general market GPS devices are not accessible, specific developments are necessary. Let's take a look what is available on the market and what is in the pipeline (situation August 2003).

BrailleNote GPS

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 (www.pulsedata.co.nz/products/blindness/braillenotegps.asp). 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 provides an accuracy of about 7 meter (best case), but local info like alleys, schools, restaurants and railway stations must come from a local map database.

Visuaide Trekker

The Visuaide Trekker is a combination of a standard GPS receiver and a standard PDA running Windows for Pocket: iPaq 3950 (www.visuaide.com/gpssol.html). 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 these 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 (have a look at the introduction to this paper!). If there are many small streets close by, the GPS system can be somewhat confusing. When it starts to rain, the user will have to protect the whole system against the water.

Promising Technology For The Visually Impaired GPS User

It is only since 2002 that accessible GPS systems become available in reasonably practical designs, i.e., elegantly wearable in a non-striking way and very light weighted. For use by visually impaired people, 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 it 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 -still- high price of a complete accessible GPS-set. Nevertheless, we can state that the price is descending over the past years.

Use of EGNOS

The European Space Agency (ESA) and the Spanish ONCE (National Blind Organization) have developed Tormes. Tormes is also 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 under development. EGNOS signals are transmitted to the ground via 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 getting the data through the internet via a mobile phone connection, a project called SISNeT (Signal In Space through Internet). This makes EGNOS available anywhere downtown. Blind people who are able to access this information can now clearly distinguish 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 pavement 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.

NOPPA personal navigation system

The 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 for public transport passengers and pedestrian guidance for visually impaired people. 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 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 whether Noppa will lead to a good navigation system for the blind user.

FURTHER DEVELOPMENTS

It is always difficult to foresee the future and this is even more so for technological evolutions. Nevertheless it can already be said that there is a booming market for location-based services. Although some of these are purely mobile phone-based (a mobile telephone can also determine its approximate position in relation to the transmitting antennas), one can expect improved GPS-mobile phone receivers to come on the market. This type of devices would be very useful for some elderly persons as they are always sure that somebody can help them to find back their way if lost somewhere during a walk. One of the already existing applications is in aeroplane navigation. Precision position knowledge will permit planes to fly closer to each other without compromising security.

Finally, the European Union plans to build a competitive satellite location system, called Galileo. It would have a better precision and, even more important politically, avoid total dependence from the US army. It is currently still the case 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.

THE BOTTOM LINE…

Talking accessible GPS systems should never supersede the training with a white cane or guide dog because they do not warn against obstacles ahead or approaching cars and other traffic. But GPS definitely will be used as a tool for wayfinding: how to go from one place to another.

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