"VOICE MAPS" – SYSTEM SUPPORTING NAVIGATION OF THE BLIND

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Improving comfort of life of blind people is a problem of great importance. Neither a white cane nor a guide dog, although both very useful, can be considered as a navigation tool, as they provide only a slight increase of independence in everyday movement around the city. On the market there are some navigation tools inspired by car navigation systems, but they have many flaws, ranging from positioning inaccuracies to high prices. A novel solution is presented in the article - a prototype application for casual smartphones. It utilizes electrocompass, built-in GPS receiver and optional DGPS receiver, which ensures acceptable accuracy. Main spatial data source is the popular OpenStreetMap system. Extra batch of spatial data can be added by users or community. Software part of the system guides users to desired target, using speech synthesis.

INTRODUCTION

Navigation is a process of finding the way from the current position to any chosen destination and guiding user along that way. The evolution of satellite positioning systems and digital maps, as well as a rapid development of mobile devices caused unprecedented growth of significance of navigation systems. Before, they were used only in certain, specific areas, mainly in military service, naval and air navigation. Nowadays, they serve casual users in the areas of car navigation or tourist support.

Many new and fresh possibilities of navigation systems' application are currently investigated. One of them is navigation system for the blind people. The paper describes current state of the prototype system implemented by the authors, presenting its most interesting parts and main features that distinguish their solution from standard navigation systems.

1. STATE OF THE ART

The key problem of blind people is the fact, that in the unknown terrain they have no information about their surroundings. They are able to identify objects in the range of their white cane, but they have absolutely no knowledge about anything else. Therefore, every blind person is helpless in places, which were not carefully investigated and remembered by them before and needs assistance of sighted guide in that circumstances. The main goal of navigation systems for the blind is to provide the user with a tool that can makes him more independent. That tool must be able to obtain user's position, describe his surroundings and guide him to any place he needs to reach. What is more, dedicated user interface is required.

Nowadays there are only some solutions more or less fulfilling criteria described above, mainly Sendero GPS (Fig. 1.) [1] and Trekker [2]. Unfortunately, they have many flaws:

- Those systems are dedicated mainly for the North American market.
- They use only one sensor type – the GPS receiver – which does not ensure very high accuracy of positioning in urban area.
- Those systems are characterized by very high purchase cost.
- No dedicated direction sensors are used – the GPS receiver can be used to obtain azimuth, but that method is highly inaccurate during very slow movement of the pedestrian.
- Spatial data used in those solution do not satisfy all the needs of the blind people.

There are more systems for the blind, for example Loadstone GPS [3] or polish Navigator [4], but their capabilities are even lower, as they use sets of points instead of full maps.

Fig.1. Sendero GPS in action.

2. ARCHITECTURE

The system architecture is presented in Fig. 2. The developed system is composed of the following parts:

- Street Navigation Supporting System (the main system) responsible for direct, automatic assistance during the movement of the blind user.
- Database, responsible for collecting and delivering necessary spatial data.
- Application for “in situ” data acquisition, used by operator that collects precise spatial data.
- OpenStreetMap service, that is used as a data source for areas which haven't been visited by operators yet.

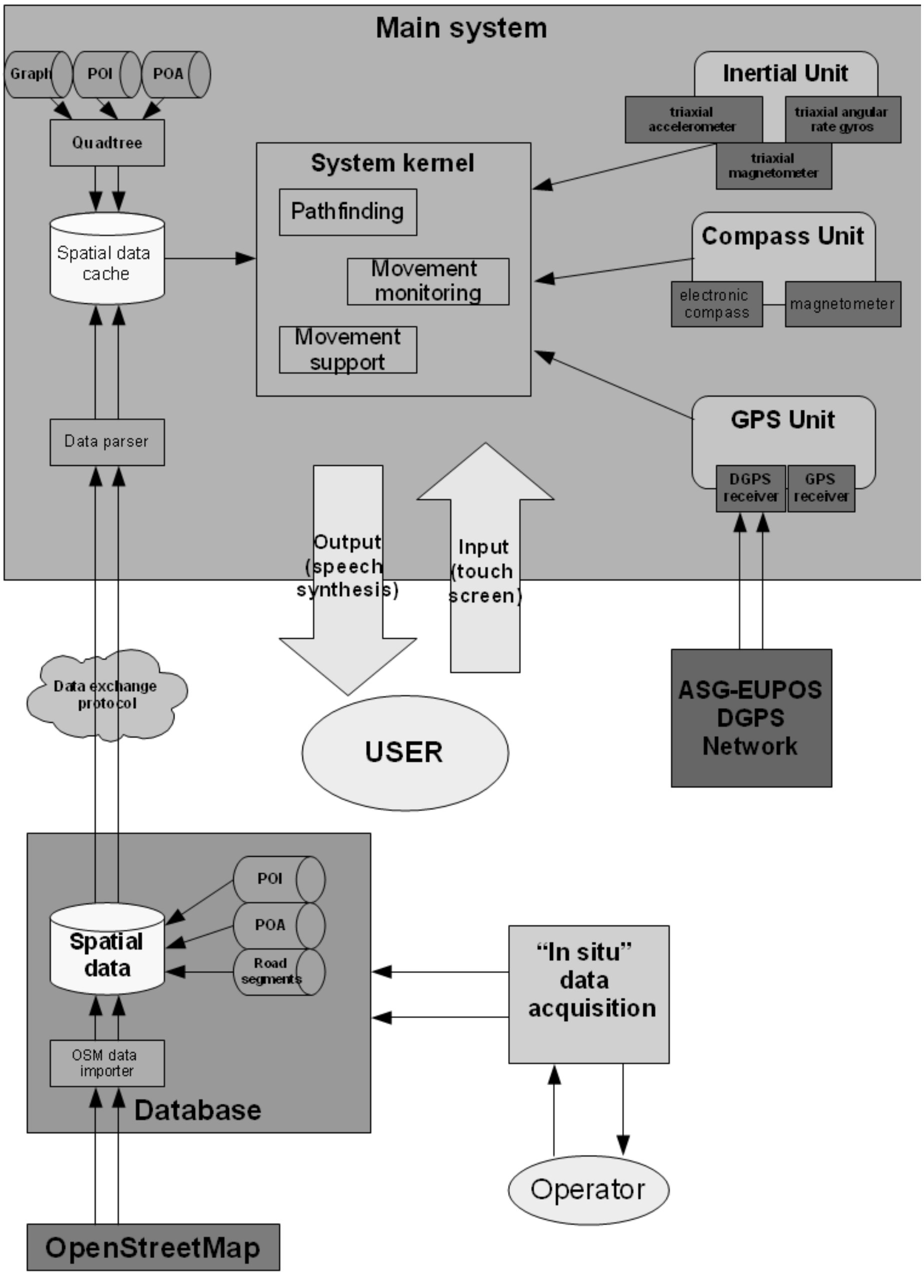

Fig.2. Architecture of the system.

The main system's crucial modules are:

- Spatial Data Cache, that stores the data in the devices persistent memory. There are three main types of data: graph representing a network of road segments accessible for pedestrians, Points of Interest (POI) and Point of Attention (POA), representing obstacles, dangers and any other objects that systems should inform user about. All types of data are arranged in a quad-tree data structure in order to improve system's efficiency.
- System Kernel implementing the algorithms for path-finding and supporting user's movement.
- GPS Unit providing the position of the user, using GPS and DGPS receivers, as well as a prototype version of inertial unit for places, where signal from GPS satellites is not available.
- Compass Unit delivering the user's azimuth, using either built-in or external sensors, mainly magnetometers and electronic compasses (it may depend on the platform)
- Dedicated user interface, based on modern smartphones capabilities (touch screen, vibrations, speech synthesis etc.).

The system has a set of data pre-installed in its cache, containing main districts of Gdańsk city. As long as the user won't leave that area, the application will work autonomously, and no connection with an external database is required.

3. POSITIONING

Positioning with inexpensive GPS receivers is often inaccurate and unreliable [5], especially in urban areas. Therefore system's GPS unit was upgraded with additional, external DGPS receiver, which uses differential corrections obtained from ASG-EUPOS polish DGPS network (Fig. 3.). That receiver connects with smartphone using Bluetooth technology and improves positioning precision significantly (with mean error of 3-4 metres, depending on service used [8]). Additional accuracy gains are highly desired, so further improvements, based mainly on inertial navigation [6] are currently under our investigation.

Fig.3. External DGPS receiver connected to the Bluetooth adapter.

4. SPATIAL DATA

The system uses mainly OpenStreetMap portal as a data source. It offers significant amount of data with no charge. Both raster and vector data are served. As the application needs spatial data mainly for navigation purposes, only vector data are used. Spatial data are delivered together with attributes (meta-data), describing features of spatial objects. The set of tags is extensive, which is very important during the process of describing surroundings, which needs to be verbose in the case of blind user.

The main flaw of the OpenStreetMap portal is small amount of data describing POI and pavements. That is why acquisition of missing data must be carried out. A custom, mobile tool for additional data acquisition was implemented, as well as an editor for collected data correction. Our aim is to build community willing to improve existing set of data, and consequently performance of the system itself.

The precision of coummunity-driven data acquisition is usually not high, both due to possible mistakes of operators and because of weak accuracy of commonly used GPS receivers. Therefore spatial data collection with the use of precise, geodetic DGPS receivers was also tested (Fig. 4.). It is expensive and time-consuming, but extremely accurate. That is why it is planned to be used for spatial data acquisition in crucial and most dangerous areas in the city.

Fig.4. Precise data acquisition with geodetic DGPS receiver.

5. USER INTERFACE

The role of user interface is obvious – it helps user communicate with the system. Of course, the process of communication is bidirectional.

System generates instructions using mainly speech synthesis. The implementation of speech synthesis depends greatly on the platform that is used. Android offers the simplest solution – it has build in Text-To-Speech mechanism, which can be easily extended with cheap additional voices. TTS API is relatively simple, therefore dynamic speech synthesis was easy to implement.

JavaME platform is more problematic. We were unable to find qualitative mechanism that works without troubles and supports polish voice. Because of that, two alternative methods were prepared. The first one uses remote speech generation. Speech synthesis takes place on the central server, sound files are generated on demand, sent using wireless internet connection and then read by the device. That approach was tested with the Ivona Speech Synthesizer and API based on web services ("Software as a Service" technique). The main flaw is the fact, that system looses its autonomy – it needs instant internet connection in order to operate correctly. There is also one more issue – messages are read with an additional delay, which in certain conditions may reach a few seconds, what is unacceptable.

The second approach is to generate all the necessary sound files before, keep them in device's memory and read when they are needed. However, it requires more persistent memory and excludes low-end devices. What's more, data files become much bigger, as sound file needs to be generated for every name or attribute. It makes data download or update much more time consuming. The combination of those two methods, where most common sound files are kept in memory and other generated remotely, behaves better that any of the approaches used separately, but dynamic speech synthesis, available on the Android platform, is without a doubt much better.

Another interesting feature of Android is built-in speech recognition mechanism. Of course, it is still far away from being perfect and tends to recognize speech with mistakes (especially when polish language is used), but can be considered as a quick method of generating commands for the system, which in case of a mistake can be substituted with any of the more accurate methods described below.

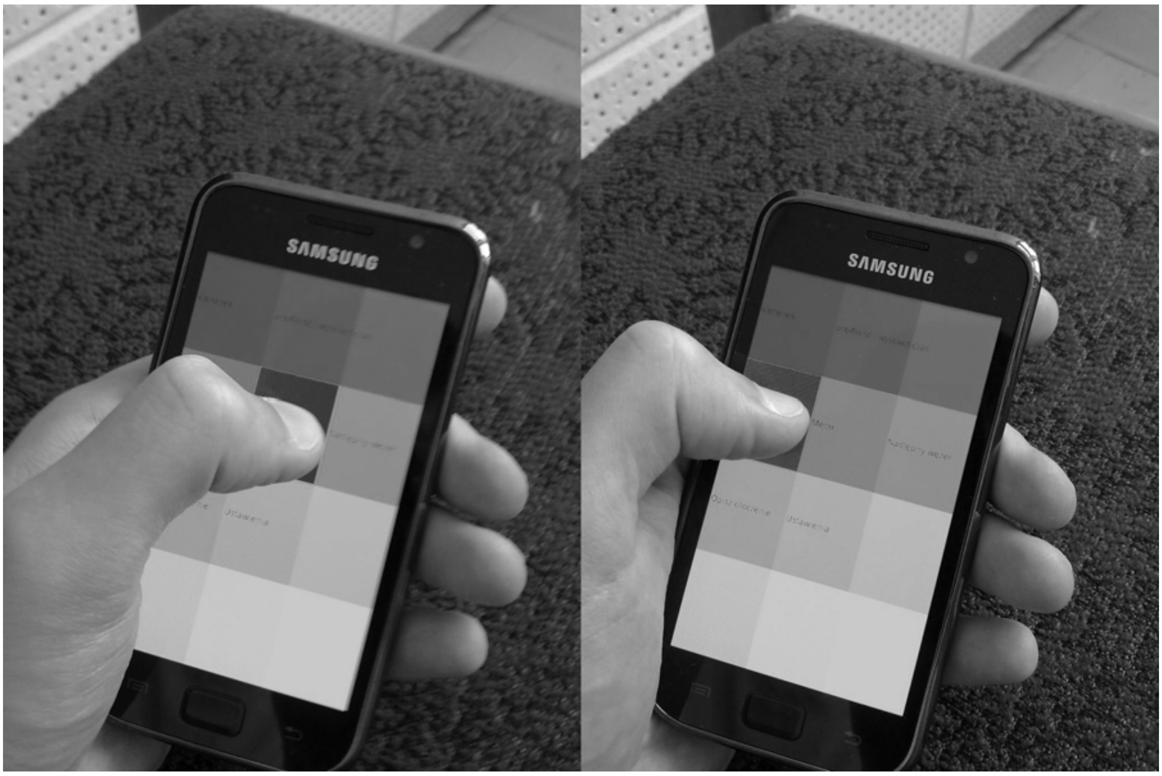

Fig.5. Touch menu for the blind.

Users communicate with the system using mainly touch screen. The menu is arranged in a form of a tree. The options of the current part of that tree (the part that the user has entered) are placed on the screen, each of them occupies a rectangular area of significant size. User moves his finger on the touch screen (Fig. 5.), feels vibrations when he leaves one rectangular area and enters another, and hears name of the option that he has just moved to. The last touched option is considered as a selected one. Double taping on the screen will activate selected option, either moving the user to another sub-tree of the menu, or triggering certain action, e.g. activating verbose mode of messages. On the right-bottom corner of the screen there is also “Back” option, which takes the user back to the upper/previous part of the menu. The menu can be also used on devices without touch screens. In that case, arrow keys are used to move around and one of the action keys replaces double tapping.

If the speech recognition mechanism fails, there are more precise ways to insert text. User can use either hardware keyboard or virtual touch screen keyboard. In both cases, system reads loudly every letter that is written by the user, so that he can identify his own mistakes and correct them quickly. Different text input methods were implemented, using gesture recognition mechanism, letter choosing technique (Fig. 6.) and motion sensing [7].

Fig.6. Sample text input method: based on gesture recognition (on the left) and letter choosing (on the right).

5. CONCLUSION

Authors believe that presented prototype of navigation system can significantly change everyday life of the blind. The system has been already successfully tested [8], new ideas are implemented on a regular basis and consulted with two representatives of blind people community. At the beginning of this year commercialization phase, carried out by external, geodetic company, was started.

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