MOBILE GPS NAVIGATION APPLICATION, ADAPTED TO VISUALLY IMPAIRED PEOPLE

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Abstract: Java mobile application for GPS outdoor navigation and orientation, adapted for visually impaired people, is presented. The application will satisfy the special needs of the target user group – blind and visually impaired people. The main advantages of proposed application are: can be installed on low budged mobile phones with Java Virtual Machine (JVM); works with any external GPS receiver with Bluetooth interface or with integrated in mobile phone GPS; route planning without WEB server need; speech enabled multi-level menus in Bulgarian; speech navigation in an unknown environment; user can send alarm in case of danger or lost route.

Key words: GPS navigation for visually impaired, Java mobile applications.

INTRODUCTION

The number of visually impaired people is about 180 millions of which 45 millions are totally blind. Every 5 seconds a man goes blind. For the children this frequency is 1 minute [1]. The orientation and navigation of the visually impaired people in urban and suburban environment, necessary for their normal life, are very difficult and create serious limitations. These limitations are partially overcome with the specially trained dogs, white canes, and adapting the environment to the people with visual disabilities. This supposes that the social adaptation of people with visual impairments require large investments.

The modern level of the mobile communications allows for the development of applications for navigation of visually impaired people at relatively low cost. The combination of mobile technologies, satellite navigation systems and the algorithms for digital speech processing allows the creation of multimodal interfaces [16] which might be successfully used for orientation and navigation of the visually impaired people [5, 6]. At present, dozens of mobile applications exist that enable GPS navigation for visually impaired people. All of them are based on C++ for operation systems like Symbian [2] and Microsoft Windows Mobile [9]. The main reason for the selection of C++ is the easier adaptation of already existing similar applications for personal computers. The selection of C++ presupposes the usage of a mobile terminal, such as a smartphone, PDA or Pocket PC. However, due to their still high prices, the wide usage of such applications is presently impossible.

The paper describes a Java mobile application for GPS navigation, adapted to visually impaired people. The platform independence of the J2ME technology used allows for the application to be installed on any mobile terminal of the medium price segment with integrated JVM and the necessary application program interfaces.

PROBLEM STATEMENT

One of the major problems in the GPS navigation is the insufficient accuracy - (10-15)m. When the number of visible satellites is large and there is no reflected signals, the accuracy reaching (4-5)m. Improvement in accuracy can be achieved through the use of Differential GPS (DGPS). In this case, through correction of the GPS data from the terrestrial stations accuracy better than 0.4m is achieved. Unfortunately, DGPS on the territory of Bulgaria for non-military purposes is not supported. A good alternative, especially for city navigation, is Assist GPS (AGPS). It gives good results when the GPS signals are too week and there is a presence of reflected signals. The most of mobile terminals with built-in GPS receiver supports AGPS.

The alternatives of GPS technologies for navigation are:

- Usage of Bluetooth transmitters, sending information for their position. This solution requires an additional hardware part which needs autonomous power supply.
- Localization through usage of Wi-Fi networks (the position of the Wi-Fi transmitters is necessary). This solution has a practical sense only for indoor navigation.
- Usage of Radio Frequency Identification (RFID) tags. This solution enables localization with accuracy of about 0.4m. Because of the low price of the RFID tags, no internal power supply needed and the possibility for incorporation into the mobile terminals of Near Field Communication (NFC) modules, this technology has its future primarily in order to correct location of objects such as stations, institutions, traffic lights, and etc.

Currently, the GPS navigation (AGPS, DGPS) has no alternatives in the development of mobile applications for outdoor navigation.

Existing developments in the field of GPS navigation systems for the blind are mainly C++ applications for Symbian and Microsoft Windows Mobile. For them the realization of the Text To Speech (TTS) transformation is by means of an additional application (screen reader), for example Mobile Speak [7] and Talks [8]. This implies that the user interface should not be graphical and therefore the application would not be used by people without visual impairments. Table 1 described the advantages and disadvantages of some of the most widely used mobile applications for GPS navigation, adapted to people with impaired vision.

Table 1. Comparative analysis of GPS navigation systems adapted to visually impaired people

Applications	Advantages	Disadvantages
Wayfinder Access of WayFinder Systems AB [10]	Very good functional possibilities. Over 20 million points of interest.	Only for smartphones with Microsoft Windows Mobile. Operates with screen reader. Requires GPS maps.
Trekker of HumanWare [11]	Good functional possibilities. Built-in TTS.	Only for Pocket PC. Requires GPS maps.
Street Talk на Freedom Scientific [12]	Good functional possibilities.	Only for PAC Mate devices. High price of hardware.
Drishti of University of Florida [15]	Very good accuracy - 22cm (DGPS is used).	Notebook is required. High price.
Trinetra of Carnegie Melon University [13]	Combines GPS navigation and RFID localization.	Only for smartphones. Additional hardware required. Connection with WEB server required (must pay the network traffic). Operates with screen reader.
Mobile Geo of Code Factory [3]	Very good functional possibilities.	Only for smartphones, PDA or Pocket PC with Microsoft Windows Mobile. Operates with screen reader. Requires GPS maps.
Loadstone GPS of Loadstone GPS team [4]	C++ open code. GPS maps are not required.	Only for Nokia smartphones (S60 platform). Operates with screen reader. Limited possibilities. Unstable operation.

APPLICATION ARCHITECTURE

Fig.1 shows the general view of the application architecture.

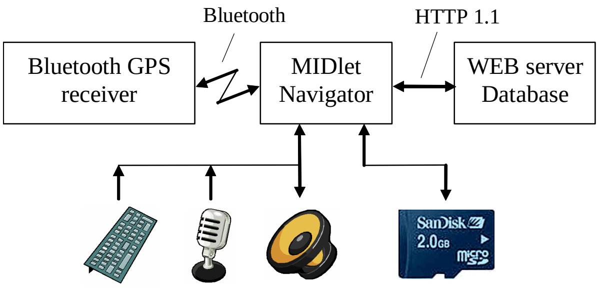

Fig.1. General view of the application architecture

The navigation system has typical 3-layer client-server architecture. The platform independence is guaranteed by the usage of Java technology only: J2ME at the client's side and J2EE at the server's side. Availability of connection with WEB server is not necessary. Through it, the following can be realized:

- Downloading GPS maps. When a GPS map is unavailable, a virtual map is used or a route, planned by the client.
- Recording information for architecture and geographic objects (landmarks) into the database.
- Downloading landmarks information, depending on the position of the client. Each client has access to the landmarks, inserted by the other users of the WEB service.

In SOS mode (alarm in case of danger or route lost), a notifying SMS or MMS is being sent. It is possible to make a snapshots with the camera of the mobile terminal, to present information about the client's location and/or leave audio message.

A. Application characteristics

The main features that the application proposes are consistent with the requirements of a control group of people with impaired vision:

- For the greater part of the Bulgarian territory there aren't sufficiently detailed and actual GPS maps. The application allows to work with virtual maps (information about objects in the specified radius and navigation on the route chosen).
- Possibility for self-planning a route without the need for access to a WEB server. The route planning can be automatically, without client interaction, manually using the GPS maps, manually without using GPS maps and a combination of automatic and manual.
- Recording of speech markers: names of landmarks, route waypoints, route names. For that purpose the signal from microphone is captured and sampled (Fs=8kHz, 8b PCM).
- Speech enabled multi-level menus in Bulgarian.
- Route speech navigation.
- Possibility to work with mobile terminals from the medium price segment.

B. Program requirements

At the client's side the application is installed only when the mobile terminal supports: profile MIDP 2.0, configuration CLDC 1.1, Bluetooth API, File Connection API, MultiMedia API and Wireless Messaging API. If Location API is supported, the application can operate with the GPS receiver built in the mobile terminal.

C. Program architecture

Program architecture of the application in the form of relations between the main classes and interfaces is shown in Fig.2.

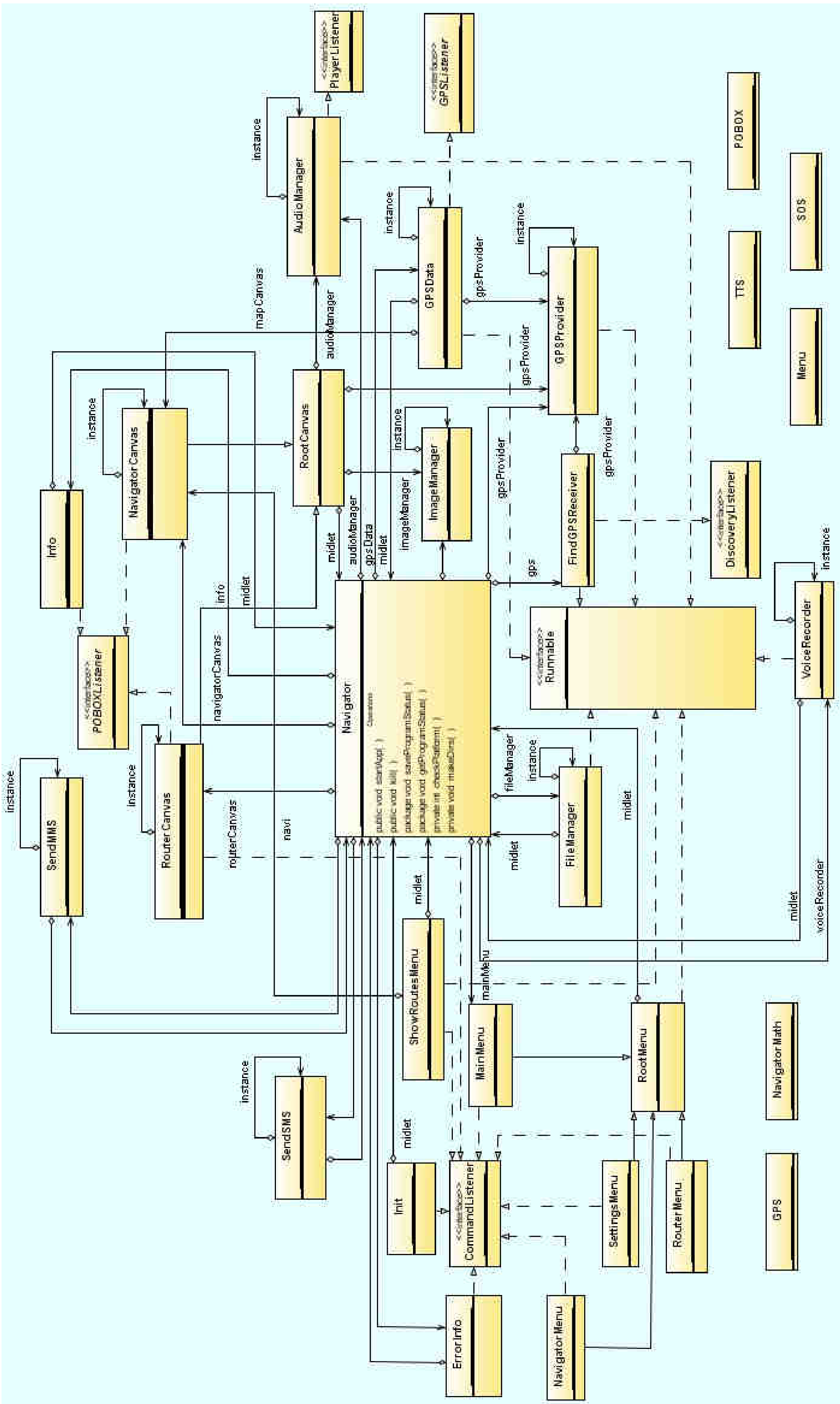

Fig.2. Unified Modelling Language (UML) class diagram

Next, the description of the more important classes and interfaces follows:

Class GPSProvider is used in order to realize communication with any external GPS receiver with Bluetooth interface. GPSProvider contains NMEA parser which extracts information from the following NMEA-0183 sentences: GPRMC, GPGGA, GPGSV and GPGSA. The information obtained is: GPS data validity flag, latitude and longitude, altitude, speed, course and accuracy. The access to this information is possible via GPSListener interface. The objects that require GPS information receive it by class GPSData. The notification for new data is realized through a message: every given time interval, after a given path has been passed, and adaptively, depending on the speed of movement. The type of notification is set upon registering the usage of the service. The searching of a GPS receiver is realized with class FindGPSReceiver. It is entirely automatic, without the interaction of the user.

Class DownloadManager realizes the communication with the WEB server (protocol HTTP 1.1). If the client wishes to send and receive information, registration is required, after which ID code for access is received and recorded in RMS of the application. The access (reading, writing and deleting) to the Flash disk of the mobile terminal is realized with class FileManager. Class VoiceRecorder enables the creation of voice markers. The client pronounces the name of the marker after an urging signal and the Voice Activity Detector (VAD) algorithm finds the beginning and the end of the speech segment, transforms PCM data to WAV file (Fs=8kHz, 8b PCM), and records it on the disk with FileManager. The maximum duration of the voice markers is 4 seconds.

Class ImageManager is used for processing of all graphical resources with which the application operates. Currently, for the realization of speech navigation preliminary created audio resources are used, which are merged to the necessary expression by class AudioManager. This solution requires less memory in comparison with a real TTS, and allows for the application to be installed on a wider set of mobile terminals. In order to save memory, the audio resources are in AWB format.

The communication between the different classes is realized in the form of messages (commands and data). The necessary mail box is supported by class POBox and POBoxListener interface. Each object which has to receive messages, must realize an interface POBoxListener and define method newMessage. The messages may be unicast or broadcast. All algorithms for processing of GPS data (distance between two points, bearing, online optimization of the number of route points, search of the closest point to a route, adaptive Kalman filtering, and etc.) are realized with the static methods of the class GPS. The necessary transcendent functions (atan, acos and asin), which are not supported by the class Math, are realized in class NavigatorMath.

Class SOS contains methods for sending an SMS or MMS. The SOS mode is activated by holding key <1> pressed for more than 200ms. The navigation via GPS or virtual maps is realized with class NavigatorCanvas, and the planning of new route – with class RouterCanvas.

D. Resources used

The size of the application is 164KB, of which 103 KB are audio and graphic resources. The replacement of the speech synthesis (built-in TTS or screen reader) is justified by the following reasons:

- There is no screen reader in Bulgarian;
- The size of the application when using preliminary created audio resources is smaller as compared to the usage of TTS database;
- operation system such as Symbian and Microsoft Mobile is not necessary.

As the mobile application is started on platforms with limited resources, the size of memory used is very important. Table 2 shows the memory size necessary for the application at different stages of its operation.

Table 2. Memory used

Stage	**Used memory, KB**
Initialization	116
Access to main menu	123
Operation without GPS map	240
Operation with GPS map	363
Maximum consumption	**403**

EXPERIMENTAL RESULTS

A great part of the Java written GPS navigation systems has limited functional characteristics and unsatisfactory reliability. Inappropriate use of multiple communication channels operating in pseudo-parallel, the omission of on-line optimization of the used operative memory, inappropriate ways of inter-object communication and access to shared resources are the main reasons to block Java applications. Described application works stable and does not allow blocking of the user interface. The results obtained during the application testing are shown in Fig.3

Fig.3. Results obtained during the application testing

The snapshots, from top to down and from the left to the right are: main menu, settings menu, find GPS receiver, load new route, list of saved routes, alert message if user is far away from route, route is loaded (in red), planning of a new route in manual mode with usage of GPS map, planning of a new route in manual mode without usage of GPS map, automatic planning of a route, navigation with GPS map, and route navigation .

CONCLUSION

A mobile Java application has been developed which enables GPS outdoor navigation and which might be used by both people with and without sight problems. Unlike similar existing C++ applications, the proposed solution is characterized by the following main advantages:

- Can be used by a large number of users. The installation of the application requires hardware and software resources, which are supported by mobile terminals from the medium price range.
- Possibility for autonomous work, without need from connection to a WEB server.
- Operation with GPS and virtual maps.
- The client can plan routes.
- Supports voice landmarks.
- Program simulation of a panic button (SOS mode).
- Online optimization of the number of waypoints, that describe a route. Thus, the size of the files, containing customer routes gets drastically reduced (in average by over (10-20) times, depending of type of route) and the usage of the operative memory is minimized. The optimization algorithm is adaptive to the speed of movement and the current accuracy of the GPS receiver.

In the future, development of Java library is foreseen, for the realization of synthesizer of speech in Bulgarian. There are plans to adapt the TTS system Flite [14], developed in C++ for smartphones and Pocket PC. It is a diphone-based speech synthesizer (11 kHz, 8bit). The size of the feature database is under 1.2 MB.

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