Monitoring System of Assisted Movement of Visually Impaired

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Abstract: - In this paper, the monitoring system of an integrated environment that improves the mobility of blind persons into a limited area is presented. The proposed solution is capable to track the movement of a group of visually impaired, each of them moving on a specified pathway, in order to reach the desired target. A Service Center (SC) acquires the actual position of each subject, determined by a GPS system, using a GSM/GPRS communication system. The same unit checks, than that the movement of all subjects to the target is in progress and no dynamically changing of environment or even case of emergencies occurred. The obtained results and further developments are, also presented.

Key-Words: - visually impaired persons, autonomous navigation, supervising system, GPS/GPRS system.

1 Introduction

In the last years, much research activity has been invested in order to substitute the traditional tools, used by visually impaired to navigate in real outdoor environments (white can and guiding dogs [1]) with electronic travel aid (ETA) [2], [3], [4], [5], [6], [7]. These devices, based on sensor technology and signal processing, are capable to improve the mobility of blind users (in terms of safety and speed) in unknown or dynamically changing environment. Laser C5 cane, Mowat sensor and Sonicguide [2] are the most representative examples of ETA tools, known from the literature.

However, up to date, no ETA tools have been implemented in practical applications; the visual impaired and blind people still prefer to use the traditional tools, i.e. the white can and the guiding dogs. There are some reasons, which limit the spreading of the new developed tools:

- The limited capability of ETA tools to detect obstacles like steps and even common obstacles, frequently meet in a real outdoor environment, but placed on the surface of the ground.
- A low performance man-machine interface, used for the communication between the user (the impaired or blind person) and the equipment; we have to take into account here not only the technical problems but also some other aspects, specific to this category of people (people with disabilities). Otherwise, a technical good solution can be rejected by the blind people community.
- The above mentioned solutions have no Monitoring System (MS), capable to supervise the movement of subjects in order to reach the desired target.

All these drawbacks has been already addressed by the author's research team, and the Integrated Environment for Assisted Movement of Visually Impaired, proposed in [8] and [9] seems to be the most performance ETA tool developed up to day. Based on the valuable experience of the research team in the field of mobile robotics and signal processing, including processing with cellular neural networks (CNN) [10], [11], the new solution not only overcome some of the already mentioned drawbacks but promotes some original ideas. Among them, the principle of acoustical virtual reality, used as a man-machine interface, and the monitoring system are the most valuable and important one.

In this paper, the problem of the monitoring system included in ETA tool will be addressed. After a short introductory presentation of the problem, the general architecture and the functionality of the whole system will be analyzed. Some experimental results and further extensions will be than presented in the final part of the work.

2 The General Architecture of the Monitoring System

There are at least two reasons to track the subjects as they are moving in the supervised area:

- The first one, to be sure that the movement of all subjects is in progress and they are capable to reach the target,

- The second one, it is important to know in every moment the actual positions of subjects, in order to be able to help them in case of dynamically changing environments or even in case of emergency.

In order to meet the above mentioned requirements, a monitoring system has been included in the Integrated Environment for Assisted Movement of Visually Impaired [9]. The general structure of the MS is depicted in Fig. 1.

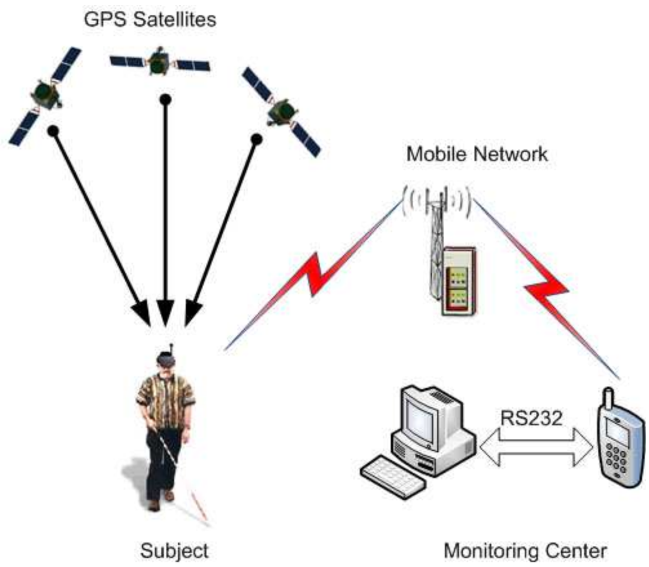

Fig. 1. The general structure of the Monitoring System.

The Monitoring System includes a GSM/GPRS module (Global System for Mobile Communications/General Packet Services), connected to the USB port of a personal computer (PC) and placed in a fixed place (Monitoring Center in Fig. 1.). A similar module equips the Portable Equipment (PE), placed on the head of each subject which navigates in the supervised area. PE includes, also, a GPS system that gives the actual position of the subject (in terms of Cartesian coordinates X and Y).

From time to time, the computer of the MC interrogates the portable equipment in order to receive the position of the subject. The received coordinates are then placed onto a map displayed on the screen of the personal computer, and compared with the desired path that should be followed by the blind person, in order to reach the target (displayed on the same map).

Any significantly, deviation of the movement of the subject from the imposed path is detected and a warning message is sent to the subject, to correct his movement accordingly.

The desired pathway represents a linear piecewise approximation of the way to a specified target and is stored in a Spatial Data Base, resident on the PC. Multiple desired paths for multiple subjects can be handled in the same time.

It should be noted here that GSM modules, included in both MC and PE respectively, can be use like a mobile phone, for full-duplex voice communication. In this way, the subject can apply MC at any moment, for additional information, for help, etc.

2.1 The software application resident on the PC

The block diagram of the software application running on the PC of the MC is presented in Fig. 2.

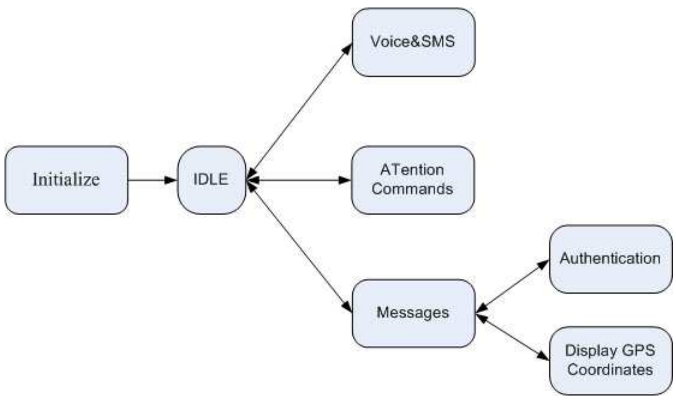

Fig. 2. The flowchart of the software application resident on the PC placed in the MC.

It results from Fig. 2, that after some initialization operations, the software application enters an IDLE state and waits for one of the following events to occur:

- A request to execute a voice communication or to transmit/receive a short message (SMS). No restrictions are for the partners involved in these tasks (any phone number - including the phone number of the subjects, and communication network are allowed).
- A request from the operator of the PC to execute AT (ATtention) commands [12]; such commands are used in order to control the functionality of GSM/GPRS module, for debug or upgrade purposes.
- A request for message exchanges. This request may come :
    - From the PE of a visual impaired, in the form of an Authentication Message,
    - From a timer, which periodically initiates the procedure of the acquisition

of the coordinates corresponding to the actual position of each subject.

The authentication process takes place in two steps.

In the first step, an Authentication Message of the form: ***$AUTH***, from the PE of the visual impaired will be received. As a result, it will be initiated a procedure of searching the phone number of the sender in a data base with access rights. If the sender has been included in this data base, then an acknowledge message: ***$OK AUTH*** will be sent to the PE. Otherwise, the message will be ignored.

In the second step, the MC is informed on the desired pathway to the target. For this purpose, a message having the form: ***$PATH=XXX*** is sent from PE of the visual impaired who requests services to the MC; ***XXX*** represents here the code associated to the desired pathway. If the map of this pathway can be find in the spatial data base stored on the PC, an acknowledge message: ***$OK PATH*** is sent to the PE of the subject and since that time his movement to the target will be supervised.

The most frequently event that occurs is, perhaps, the acquisition process of the coordinates of each subject moving in the supervised area. Periodically, a message of the form: ***$GPS REQ*** is sent to the each subject and as a result, the corresponding PU responds with the message: ***$RET <UTC> <Data> <Lat> <Long>***; here, the parameters ***UTC, Data, Lat*** and ***Long*** represents time (in UTC format), date, latitude and longitude respectively. These data are used then to represent on a map the trajectory of subjects in their movement to the target and to take the necessary decision if some deviations from the imposed pathway occur.

2.2 The software application running on the PU

The general structure of the software application running on the PU is presented in Fig. 3.

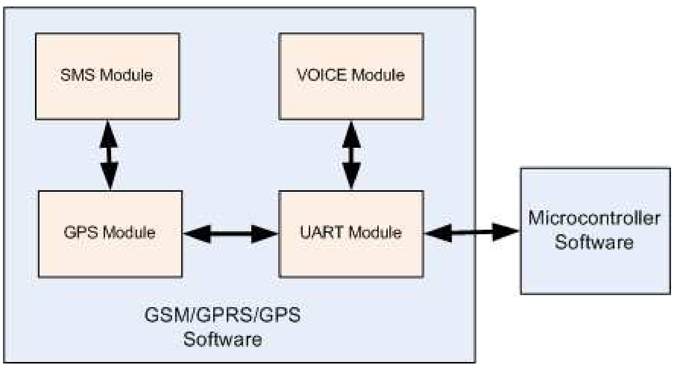

Fig. 3. The software application included in the PU

This application includes a number of software modules, each of them responsible for a well defined function:

- SMS Module, responsible for SMS messages exchanged with the MC;
- VOICE Module, capable to handle the bidirectional voice communication between the PU and the MC;
- GPS Module; this application is responsible for extracting the useful information from the data string delivered by GPS system.

It should be observed that all these software modules are implemented on the microcontroller system that controls the functionality of the GSM/GPRS and GPS systems in the PU. PU includes, also, a second microcontroller system, which is responsible for other tasks (sensor system management, path planning, man-machine interface, etc.). The information exchange between these microcontroller systems is assured by the UART Module (Fig. 3).

3 Obtained results and further developments

The software applications residing on both PU and PC of the MC have been tested and successfully implemented.

The software loaded on the PC have been developed using the well known graphical programming language LabView. In Fig. 4, it can be seen the corresponding graphical user interface (GUI).

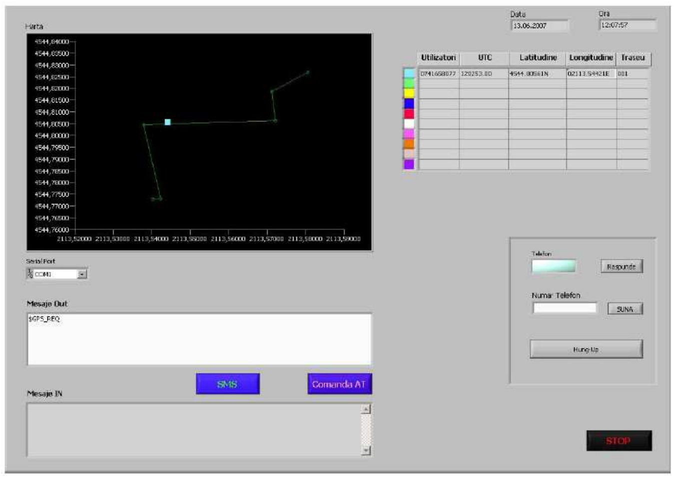

Fig. 4. The GUI of the software residing on PC

The software application meets all the requirements specified at 2.1. The application is capable to supervise in parallel the movement of up to ten subjects. The data received at a given moment from the PU of each subject (time, date, latitude and longitude) are visualized in a table (right-up corner); in the same time, the corresponding trajectories are marked by points of different colors on a map, along the desired pathway to the target (left-up corner).

The remaining elements are to be used for voice/SMS communication. No restrictions are regarding the

partners involved in these tasks (any phone number and communication network are allowed). The cluster of controls placed in the right-down corner of the GUI are devoted to dial-up the phone number, answer to a incoming call, hang-up, etc.. Two windows (left-down corner) allow sending and receiving messages.
As we have already mentioned, the software application resident on the PU is loaded in the same microcontroller system that manages the GSM/GPRS and GPS systems (these systems are included in a single WISMO Quik Q2501 module, manufactured by Wavecom [13]). A special IDE - Integrated Development Environment, OPEN AT® [14], [15], delivered by the same manufacturer, can be used for development, debugging and loading the software application without affecting the original firmware.
At least one improvement to the proposed solution is predictable now: the substitution of data exchange using short messages SMS with GPRS communication. GPRS procedures not only improve the quality of communication in terms of speed, reliability and response time but also significantly decreases the cost. The development of the new procedure has been already started and some results are expected soon.

4 Conclusion
Some of our experiments have shown that a Monitoring System should be included in each ETA tool, in order to assure a safety movement of visually impaired to the desired target. The Monitoring System proposed in this paper is based on the GSM/GPRS communication network and seems to be a reliable and low cost solution, having in mind the wide spreading of mobile phones. By using GPRS for data communication instead of GSM, the cost of maintenance can be even more decreased with some improvements of the quality of services.

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