Integrated Environment for Assisted Movement of Visually Impaired

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Abstract: *In this paper an integrated environment that improves the mobility of blind persons into a limited area is presented. The proposed solution includes wearable equipment, placed on the subject, which guides the blind user to navigate autonomously with obstacles avoidance and stationary equipment that supervises the motion, in order to avoid some unexpected events.*

Keywords: *visually impaired persons, autonomous navigation, GPS/GPRS supervising system, intelligent man-machine interface, artificial neural networks.*

I INTRODUCTION

There are many types of devices used by impaired or blind persons in order to navigate into the real environment [1] [2] [3] [4] [5] [6] [7].

The white cane is the most successful and widely used travel aid to detect obstacles on the ground, uneven surfaces, and other hazards. This device has some advantages (lightweight, small dimensions) but the users must be trained in its use for more than 100 hours. More ever, the white can require the user to actively scan the area in front of him; the white cane also is not capable to detect potentially dangerous obstacles at head level.

Another solution relies on the guiding dogs, which are capable guides for the blind, but they require extensive training. The cost of trained dogs is quite high and they are only useful for about five years. Furthermore, many blind and impaired people are elderly, and find difficult to care appropriately for another living being.

In the last decades, several devices based on sensor technology and signal processing have been developed. These devices, named electronic travel aid (ETA), are capable to improve the mobility of blind users (in terms of safety and speed) in unknown or dynamically changing environment.

The functionality of the most of these devices is similar to the radar systems: a laser or ultrasonic fascicle is sent in the investigated area and the echo, generated by obstacles, is detected.

The time of the flight is a measure of the distance from the subject to the obstacles. In generally, obstacles not far than five meters ahead the subject are detected.

In the most cases, the acquired data are local processed and then, the relevant information is transmitted to the blind person. Different methods (tactile, vocal messages) are used for this purpose.

Let's examine now, in more detail, some representative examples of ETA equipments.

The laser C5 cane [2] is one of the most known ETA devices. Its functionality relies on the principle of optical triangulation.

Three laser diodes are used to generate laser fascicles and three optical diodes receive the reflected wave. In this way, the system measures the distance to the obstacles on three channels:

"UP" channel, this is detecting obstacles at head level;

"AHEAD" channel, detects obstacles ahead of the subject (1.5 – 3.5 meters);

"DOWN" channel, this is responsible for obstacles on the ground and uneven surfaces.

Another example, a hand-held device – Mowat sensor [2] – is capable to inform the user upon the distance to the obstacles in front of him. The relevant information is transmitted to the blind person like tactile vibrations. The frequency of vibrations is inverse proportional to the measured distance.

It is recommended to use this device as a complementary aid to the white cane or guide dog.

A more complex system, known as Sonicguide [2], has been developed as a pair of eyeglasses.

Three ultrasonic sensors, a transmitter - placed in the center of the device, and two receivers, located on both side of the transmitter, measure the distance to the obstacles. More, in this case, the difference in time of the flight of the two echoes gives useful information regarding the direction of the obstacle.

From the above examples we can conclude that impaired or blind persons have to overcome the same problems and difficulties as mobile robots in their movement in an unstructured environment. Actually, the principles of proposed devices are very similar to the methods and techniques well known in robotics. Considering the experience of our team in mobile robot navigation [8] [9] [10] [11], we decided to develop a more capable device, in order to overcome the drawback typically to the already developed devices, i.e.:

- The users have to explore actively the environment in his neighborhood, in order to detect possible obstacles;
- Some additional measurements are needed when obstacles are detected, to determine the shape and the dimensions of the object;
- In the case of ETAs based on acoustic feedback, the interference with sound cues from the surrounding environment reduces the blind person's ability to hear the essential cues.

II THE STRUCTURE OF THE INTEGRATED ENVIRONMENT

The above mentioned disadvantages are avoided in the solution proposed by authors. The architecture of the new equipment, depicted in Fig. 1, includes all the elements necessary to navigate to the target with obstacles avoidances: PERCEPTION1 and PERCEPTION2 blocks, PLANING and ACTION elements. The same architecture

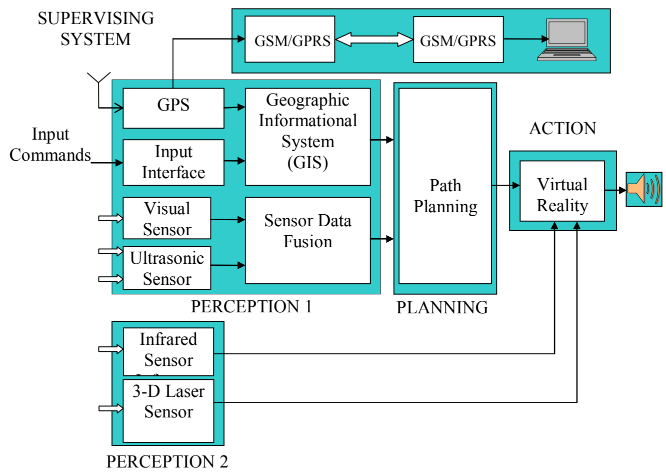

Figure 1
The architecture of the proposed device

provides the necessary resources to supervise the movement of subjects (blind persons) in the area of interest: GSM/GPRS modules (Global System for Mobile Communications/General Packet Radio Services), a GPS (Global Positioning System) and the personal computer with special application software running on it.

Some new features of the proposed architecture should to be also mentioned here.

We will observe, first, that different kind of sensors have been included (visual, ultrasonic, infrared, laser range finder) in order to acquire the necessary information from the surrounding medium. An appropriate data fusion will cumulate the advantages and eliminate the disadvantages of different type of sensors.

The planning method of the movement trajectory is also quite sophisticated; it combines a global path planning, implemented by a GPS and the Geographic Information System (GIS) and a local path planning, based on the information acquired using different kind of sensors.

The controller of the device has been inspired from the mobile robotics domain. A hierarchical controller (PERCEPTION1, PATH PLANNING, ACTION) and a reactive controller (PERCEPTION2, ACTION) are used together to guide the subject to the target and to avoid collisions with obstacles.

Based on the static information, queried from a spatial data base (GIS) and dynamic data, received from visual and ultrasonic sensors, the hierarchical controller constantly guides the blind user to navigate. The environmental conditions and landmark information are provided to the user on the fly, through a virtual reality approach. The man-machine interface includes, also, an input module for the subject's commands.

On the other hand, the reactive controller prevents from accidents occurring in a dynamically changing environment.

III THE SUPERVISING SYSTEM

In the following it will be presented, in more detail, the structure and the functionality of the supervising system.

There are at least two reasons to track the subjects (blind persons) as they are moving to reach the target:

- 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 position of subjects, in order to be able to help them in the case of dynamically changing environments or even in case of emergency.

Responsible for both of these requirements is so called Service Center, which exchanges information with subjects by GSM/GPRS modules. From time to time, the computer of the Service Center interrogates the portable equipment by means of a message "where are you?" (Fig. 2).

As a result, the portable equipment provides the geographical location in the form of Cartesian coordinates X and Y. Based upon these coordinates and the location of the desired path way of the subject, resident in the personal computer, a software application is capable to keep track of the position of each blind person which navigates in the supervised area.

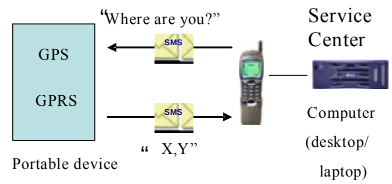

Figure 2
The tracking procedure of the subject

The following figure depicts the internal architecture of the supervising system placed on the portable equipment.

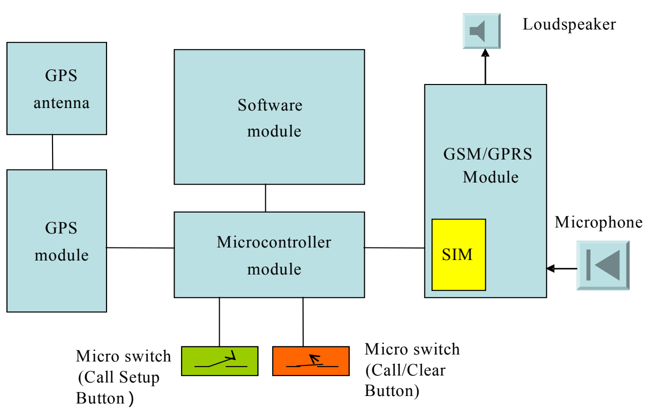

Figure 3
Detailed structure of the supervising system

The GSM/GPRS module receives a message "Where are you?" and forwards it to the microcontroller system. The software application, residing here, analyses the message and converts it in a valid command for the GPS module. As a result to this command, the GPS provides back its response to the microcontroller system. The software module extracts the X and Y information out of the response and a message with these data will be sent then to the Service Center, by GSM/GPRS module, in order to accomplish the job.

The system depicted in Fig. 3 is also capable of call handling. This feature is useful especially in the case of an emergency. Both, Service Center and subjects can initiate an outgoing call (Call Setup Button) and to receive an incoming call (Call/Clear Button).

IV EXPERIMENTAL RESULTS

The proposed system is still under development. The research team has focused to develop first the supervising system, according to the Fig. 3, and the ultrasonic module; both of these modules are already done.

Three ultrasonic sensors, a transmitter and two receivers have been used, and the acquired information is processed using artificial neural networks [8]. In this way, a single pulse and the resulting echoes are needed in order to locate all the obstacles in front of the subject.

The development of the rest of the modules, included in the architecture presented in Fig. 1, is in progress.

A general view of the supervising system, included in the wearable equipment, is given in Fig. 4.

Figure 4
A general view inside the portable equipment

Conclusion

In the present paper an integrated environment that improves the mobility of blind persons in to a limited area has been presented. The proposed solution includes wearable equipment, placed on to the subject, which guides the blind user to navigate autonomously with obstacles avoidance and stationary equipment, which supervises the motion, in order to avoid some unexpected events.

The proposed architecture includes all the necessary modules to implement in an efficient way a global path planning, based on the GIS system, with a local path finding, using acquired sensorial data.

Future work of the research team will be focused on the sensorial data processing and data fusion, using neural networks and the man-machine interface (virtual reality).

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