A Navigation Tool for Blind People

Chapter · April 2007

DOI: 10.1007/978-1-4020-6268-1_59

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***Abstract*-This paper describes the development of a navigation aid in order to assist blind and visually impaired people to navigate easily, safely and to detect any obstacles. The system is based on a microcontroller with synthetic speech output. In addition, it consists of two vibrators, two ultrasonic sensors mounted on the user's shoulders and another one integrated into the cane. This aid is able to give information to the blind about urban walking routes and to provide real-time information on the distance of over-hanging obstacles within six meters along the travel path ahead of the user. The suggested system consists then in sensing the surrounding environment via sonar sensors and sending vibro-tactile feedback to the user of the position of the closest obstacles in range. For the ultrasonic cane, it is used to detect any obstacle on the ground.**

I. Introduction

Mobility is one of the main problems encountered by the blind in their daily life. Over time, blind and visually impaired people have used some methods and devices, such as the long white cane and guide dog, to aid in mobility and to increase safe and independent travel. Due to the development of modern technologies, many different types of devices[1] are now available to assist the blind to navigate. There are commonly known as electronic travel aids. Among these aids are Sonic Pathfinder [2], Mowat- Sensor [3], and Guide-Cane [4] which are called clear path indicators or obstacle detectors since the blind can only know whether there is an obstacle in the path ahead [5]. These devices are used to search for obstacles in front of the blind person, and they operate in a manner similar to a flashlight, which has very narrow directivity. Sonic-Guide[6] and NavBelt [7], however, are called an environment sensor since it has wide directivity enabling it to search for several obstacles at the same time.

The purpose of this project was to create a prototype of a device that can help blind people to travel with increased independence, safety, and confidence.

The proposed system involves a microcontroller with speech output. It is a self contained portable electronic unit. It can supply the blind person with assistance about walking routes by using spoken words to point out what decisions to make.

In addition, and in order to overcome the imperfections of existing electronic travel aids, the suggested method of measuring distance travelled in this system, is to use the acceleration of a moving body which in this case is the blind person. An accelerometer, followed by two integrators is used to measure a distance travelled by the blind. This technique is considered in inertial navigation systems [8] and suffers from drift problems caused by the double integration and offset of the accelerometer which are overcome by the footswitch [9]. When this footswitch is closed, the acceleration and the velocity are known to be equal to zero and this can be used to apply a correction.

In order to help blind travellers to navigate safely and quickly among obstacles and other hazards faced by blind pedestrians, an obstacle detection system using ultrasonic sensors and vibrators has been considered in this aid. The proposed system detects then the nearest obstacle via streoscopic sonar system and sends back vibro-tactile feedback to inform the blind about its localization. On the other hand, an ultrasonic cane equipped with wheels is considered to detect any obstacle which may be on the ground.

The system has then an environment recognition and a clear path indicator functions.

II. Requirements

Portability, low cost, and above all simplicity of controls are most important factors which govern the practicality and user acceptance of such devices.

The electronic travel aid (ETA) is a kind of portable device. Hence it should be a small-sized and lightweight device to be proper for portability.

The blind is not able to see the display panel, control buttons, or labels. Hence the device should be easy to control: No complex control buttons, switches and display panel should be present. Moreover, the ETA device should be low-price to be used by more blind persons.

Our system is developed for portable (small size and lightweight), inexpensive and easy to use, and low-power consumption (supplied by battery).

III. Principle Of Operation

The aid consists of a microcontroller as processor, an accelerometer, a footswitch, a speech synthesizer, an hexadecimal keypad, a mode switch, three ultrasonic sensors, two vibrators and a power switch. Fig. 1. shows the block diagram of the system.

T. Sobh (ed.), Innovations and Advanced Techniques in Computer and Information Sciences and Engineering, 333–337.

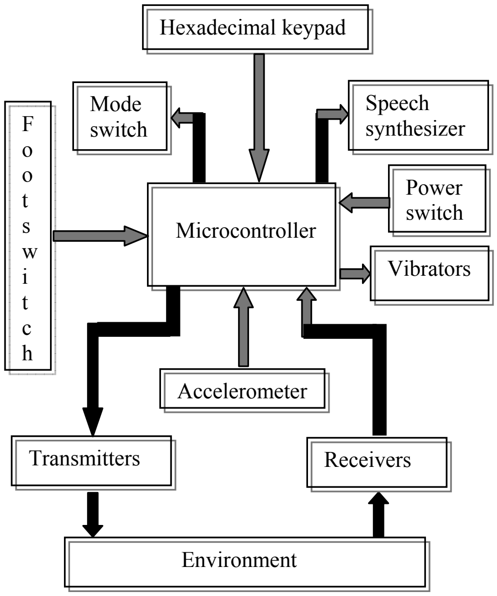

Fig. 1. Block diagram of the system.

The obstacle detection part of the system contains three ultrasonic transmitters-receivers and two vibrators.
Two pairs of these ultrasonic sensors are mounted on the blind's shoulders[10] as shown in fig. 2.

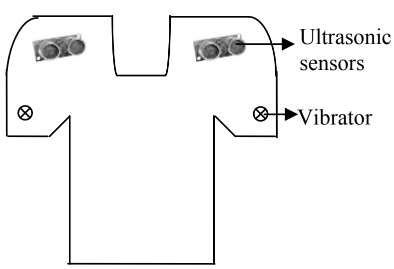

Fig 2. Sonars mounted on shoulders.

The other is cane type subsystem[11] as shown in fig 3. It is equipped with ultrasonic sensors and wheels. The user walks with holding this cane type system in front of him like the white cane. The cane type system notifies whether any obstacle is in the middle of the walking direction. Since the wheels are always contacted with ground, the user can recognize the condition of ground such as depression, cavity, and the stairs with his hand's tactile sensation intuitively.

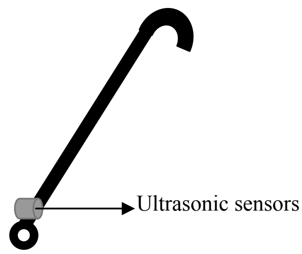

Fig 3. The ultrasonic cane.

This obstacle detection system use a 40 KHz ultrasonic signal to acquire information and can detect the presence of any obstacle within the specified measurement range of approximately 0.03 to 6 meters. It operates by sending out a pulse of ultrasound. Eventually the pulse is reflected from a solid object in the path of the pulse. The time between the outgoing pulse being transmitted and its echo being received corresponds to the distance between the transmitter and the object or the obstacle. This information is then relayed to the blind in some vibro-tactile way and speech way(for the cane).

On the other hand and as the 'Micromap'[12], the system has two modes of operation, record and playback. In addition, the playback mode has two directions, forward and reverse. The user selects then, one of these three possibilities by a switch.

In the record mode, the blind walks the route of interest, and the aid measures the distance travelled by the user. When the blind reaches a decision point, for instance a point at which the route takes a left turn**,** the user presses a key on the aid coded with a left turn instruction. This has two effects:
- The distance travelled is stored in memory of the ;microcontroller, and the counter reset to zero.
- The left turn instruction is stored.

Afterwards, the blind walks to the next decision point and the above procedure is repeated.

In the playback mode, the aid measures again the distance travelled by the user. When this is equal to that stored in the memory for that particular section of the route, an audible signal is given to the blind. The audible signal is coded to indicate what action the user should take at this point, for instance turn left. In the reverse direction, the procedure is exactly the same except that the route information stored in the memory is used in reverse order, and that right and left are interchanged.

At decisions points, the blind can make any of the following decisions:
Turn right; Turn left; Cross road; Cross road junction; Pedestrian crossing; Steps; Pause; Stop.
Each of these decisions has separate key. There are also two extra keys available, which are undefined in the present software, but which the blind could have available for their specific use.

The system can store a number of routes, each of which is numbered, and be selected using the same set of keys as for the decisions. In practice the number is likely to be set by the size of the available memory.

IV. TECHNICAL DESCRIPTION

This section describes in some detail the components of the proposed navigation aid.

A. Microcontroller

The microcontroller used in the aid is the PIC 16F876[13] from 'MICROCHIP', with 8 k of 14 bits program memory, 368 bytes of RAM and 256 bytes of data EEPROM.

B. Accelerometer

The accelerometer used is the ADXL213[14] from 'Analog devices'. It has a range of ±1.2 g and a sensitivity of 30%/g. With this accelerometer, no A/D converter is then required as the output is digital.

On the other hand, the accelerometer needs to be attached to the shoe or to a rigid part of the leg where the condition of both acceleration and velocity equal zero is applied.

C. Speech synthesizer

The speech synthesizer device chosen is the ISD 5216[15] from 'ChipCorder' and is used as an audio output. The chip is a single-chip solution offering digital storage capability and up to 16 minutes of high quality, audio record and playback functionality.

On the other hand, the speech synthesizer is activated by pulses from the microcontroller. The output represents the different actions to be taken (e.g. road right turn, left turn…). The speech synthesizer chip with a small vocabulary tells then the blind person about travelled distance, present location and decisions to make. Information about the route is stored in the memory in the form of a digital map of the device to guide the user to his destination via the planned routes.

For obstacle detection, an increase of distance to an obstacle results in a decrease in vibration, while a decrease of distance results in an increase in vibration.

D Headphones

Since hearing for blind people is very important, the headphones would dull this sense. For this system, it has been decided to consider headphones used for walkman. Spoken words from the speech synthesizer which represent the different action to be taken will therefore be heard by the blind.

E. Hexadecimal keypad

In order to input information an hexadecimal 4x4 keypad is used in this aid. It is placed on the side of the case, and can be seen in fig. 4. The keypad switches enable the user to select routes and to enter decision. It is of course possible to label these keys with Braille symbols if it is thought necessary.

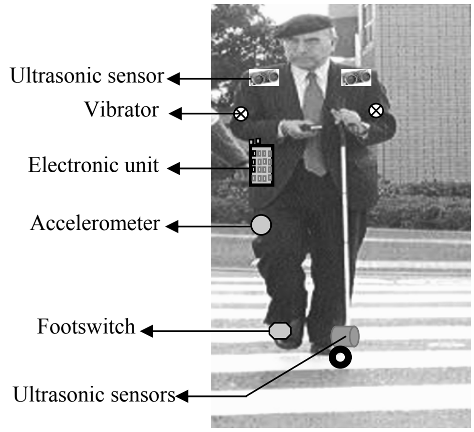

Fig. 4. The navigation aid worn by the blind.

F. Footswitch

The footswitch is used to allow the PIC 16F876 to provide frequent corrections of drift effects. This footswitch 'S' needs to be attached to the heel of the shoe. When the blind starts to walk, 'S' is equal to zero. The microcontroller estimates then the acceleration and calculates the distance.

When the footswitch is on the ground, 'S' is equal to one. The microcontroller estimates and calculates the errors. Afterwards, corrections are made.

The micro-switch is one example of switch which can be used because it is more flexible.

V. OBSTACLE DETECTION

For obstacle detection and as aformentioned, the aid is provided with an ultrasonic system attached to the jacket and an ultrasonic cane. It is is based on three ultrasonic sensors and two vibrators.

A. Ultrasonic sensors

The sonar system is based on two ultrasonic sensors mounted together. One emits an ultrasonic wave while the other measures the echo. By differentiation of the input and output signals, the PIC16F876 computes the distance to the nearest obstacle. Then this information is transmitted as a Pulse Wide Modulation (PWM) signal to the receiver.

The ultrasonic module used as sensor for this application is the MSU10[16] from 'Lextronic' and can be seen in fig. 5.

It has the following characteristics:

- Angle of detection: approximately 72°.
- Dimensions: 32 x 15 x 10 mm.

Fig. 5. The ultrasonic sensor.

B. Vibrators

In this system, vibrators from mobile phone technology have been used. Those devices are small and light enough to be fixed on cloth without any obstruction.

C. Ultrasonic Cane

The ultrasonic cane used for this system is based on an ultrasonic transmitter-receiver which detects obstacle on the ground.

D. Data treatment

The microcontroller gathers the information from the ultrasonic sensors as PWM signal directly proportional to the distance of the nearest obstacle. Afterwards, it measures the width of the transmitted pulses and converts it into empiric distance.

Following a calibration phase, the real distance between the sensor and the obstacle can determined . The direction is given by comparison of the signal from both sensors. This distance is then converted into a voltage command for appropriate vibrating feedback. The system redirects this information to the actuators via Serial Peripheral Interface. A multichannels D/A Converter recovers 2 integers (address and data) and sends the desired output voltage to the appropriate vibrator.

VI. Use Of The System

The system is easy and straightforward to use. It is attached to a belt which is fastened around the user's waist. There is provision for a test to ascertain that the blind person's step is detected by the accelerometer. The user then selects the route number, and the appropriate mode and direction.

A repeat key has been considered to enable the blind person to make the aid repeat the word indicating a decision. This is to ensure that the user can be certain of the decision, in case it is obscured the first time by, for example, traffic noise.

On the other hand, when an obstacle is detected, vibrotactile output occurs in pulses at a rate inversely related to the distance from the user. If there is no obstacle detected, no vibrational pulses are emitted.

In addition, the blind should know from which direction the obstacles are coming from. Localization on the horizontal plane is done by appropriate combination of vibration between the left and the right side. If the user feels a vibration on its right it means that the obstacle is on his right and vice versa. If the vibration is on both sides the obstacle is in front of him.

VII. Experiment Results

The first field trial of the route planning was tested on two blind persons. The test routes were of about 100 metres along roads and the results are shown in fig. 6.

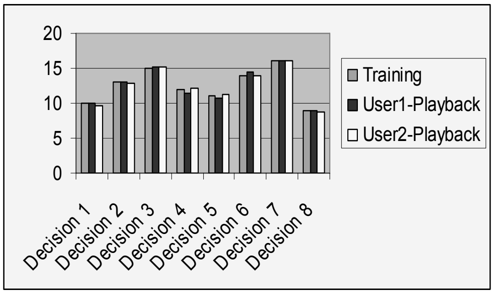

Fig. 6. Results of the test.

It can be seen a minor discrepancy from these results for the following two possible reasons:

- The aid may not have been correctly adjusted to detect every step.
- The user may have had a significantly different gait between the record and playback modes.

VIII. Conclusion

This paper has presented the development of a navigation aid in order to enhance the independent mobility of blind individuals. The technique well known in aircraft navigation used in this study has reduced errors caused by the accelerometer and double integration. The use of the footswitch is also highly advantageous because without it, drift errors due to the accelerometer and double integration would be considerably greater in magnitude and would reduce the effective range of the electronic travel aid.

The system has been used on some preliminary trials. The results obtained are encouraging and in the near future, it is planned to carry out more extensive tests.

Although the system detects the nearest obstacle, it cannot solve the blinds' ultimate problem of the environment perception. It has limits due to the characteristics of the ultrasound reflections such that many object can barely be detected, which have very small or soft surfaces. Despite these difficulties, it is hoped that the proposed system will efficiently aid the blind at navigation.

For future development, and as it is difficult to know where the blind is globally, it is then desirable to use the global positioning system (GPS)[17] in order to get the user position information.

Acknowledgment

The authors would like to thank the laboratory of automatic and signal at Annaba for its contribution in the development of this project.

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