A NAVIGATION SYSTEM FOR BLIND PEDESTRIANS

Mounir Bousbia-Salah, Mohamed Fezari, Rachid Hamdi

BADJI Mokhtar University, Annaba
Faculty of Engineering
Department of Electronics
Laboratory of Automatic and Signals,Annaba
BP 12, Annaba 23000
Algeria
Phone/Fax : +213 38 876565
E-mail: mbousbia_salah@yahoo.com,
mouradfezari@yahoo.fr, hamdi_rach2004@yahoo.co.uk

Abstract: An electronic travel aid is a form of assistive technology having the purpose of enhancing mobility for the blind. This paper describes the development of a microcontroller based navigation system for blind pedestrians. It is a portable, self contained portable electronic system that will allow visually impaired individuals to travel through familiar and unfamiliar environments without the assistance of guides. In addition, this system can supply the blind person with assistance about walking routes by using coded sounds to point out what decisions to make.

Keywords: Accelerometer, Inertial navigation , Integration, Switch, Microcontroller, Navigation system, Obstacle detection, Speech.

1. INTRODUCTION

There have been many developments in the provision of navigation aids (Pissaloux, 2002a, b; Capp and Picton, 2000a, b; Petrie, et al., 1996) for visually impaired people. These have ranged from the simple cane to advanced electronic aids.
While the development of other devices to aid visually impaired people in their everyday life has been increasing and in some cases adequate solutions to providing sensory supplementation have been very effective (from Braille through to "electronic reading machines"), truly adequate solutions to travelling as a visually impaired person have not yet been developed.
Consequently, complex sets of devices and aids have been produced to aid easy and successful travelling. These range from planning aids like maps and charts, to orientation aids such as street signs, pedestrian markings and road furniture.
A number of devices have already been developed to address some of the difficulties faced by visually impaired people with regard to travel.
For instance, simple Electronic Travel Aids have been in development since 1897 (Brabyn, 1985).
Real and more complex developments occurred after the Second World War and through the 1950s and 60s (Heyes, 1983). With the advent of the possibilities of remote sensing in the form of ultrasound and radar more research effort was directed at the problems of remote sensing of the environment for visually impaired people. Advances in electronics and circuit miniaturisation also aided the development of these devices into portable mobility machines and a number of devices using these technologies were developed such as the 'Mowat Sensor' (Kay, 1984), and the 'Sona' (Kelly, 1984).
Through the 1960s and 70s obstacle detection devices continued to be developed using a variety of

sensing methods, notably lasers. However advances in the pre-planning of routes were also taking place and with the advent of ‘capsule paper’ (which expands when heated) tactile maps could be produced more easily than previously existing methods.
Later in the 1980s and 1990s further research allowed a form of tactile map (Jacobsen,1994) that talked to be developed.
Recently through the early 1990s the focus has switched from mobility and obstacle detection to orientation and location (Kawai, et al.,2000; Loomis, et al., 1998). These systems, called ‘Audible Signs’ (Bentzen and Mitchell, 1995) , ‘Sound Buoys’ (Blenkhorn and Evans, 1997) etc, transmit some form of remote signal once a user gets into range of the device, which then delivers an audible message, either as a tone or speech. While these systems do solve some problems and despite being relatively inexpensive, it can be expensive to place these signs extensively in an environment.
In this paper, the proposed navigation system involves a microcontroller with coded sound output. It is a self contained portable electronic unit. It can supply the blind person with assistance about walking routes by using coded sounds to point out what decisions to make. In addition, the software permits a blind person to explore the electronic map as well as planning the optimum route to the desired destination.
In this system, the proposed method of measuring distance, 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 (Fournier and Hamelin, 1983) and suffers from drift problems caused by the double integration and offset of the accelerometer which are overcome by the footswitch (Bousbia-Salah, et al., 2003, 2004). 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.
For the purpose of this method, the accelerometer needs to have a very low frequency response (down to approximately zero hertz).

2. SYSTEM OPERATION

The system consists of a microcontroller, an accelerometer, a footswitch, an audio output, a set of 10 push-button switches, a mode switch and a power switch. The block diagram of the system is shown in figure 1.
As for the ‘Micromap’(Freeston, et al., 1984), the system provides 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.

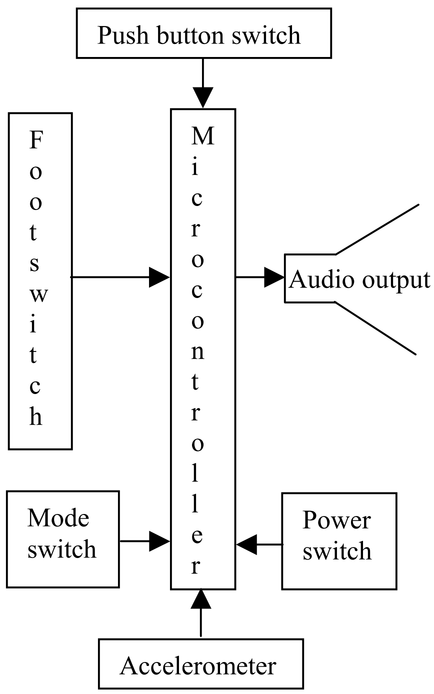

Fig.1. Block diagram of the system.

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, 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, forward direction, 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 (Routing is halted temporarily).
- Stop (End of route).

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.

3. DETAILED DESCRIPTION

In this section, are described the navigation system components and how these components are used to provide the desired functional capabilities.

3.1. The Accelerometer

The accelerometer used is the ADXL202 from Analog devices. It was specifically designed to work with low cost microcontrollers.
This accelerometer is low cost, low power and a complete dual axis acceleration measurement systems on a single monolithic IC. It contains a polysilicon surface-micromachined sensor and signal conditioning circuitry to implement an open loop acceleration measurement architecture.
For each axis, an output circuit converts the analog signal to a duty cycle modulated (DCM) digital signal that can be decoded with a counter/timer port on a microcontroller. With this accelerometer, no A/D converter is then required.
Its characteristics are as follows:
- Measures static acceleration as well as dynamic acceleration.
- Duty cycle output with user adjustable period.
- Low power <0.6 mA.
- Faster response than electrolytic, mercury or thermal tilt sensors.
- Bandwidth adjustment with a single capacitor per axis.
- 5 m g Resolution at 60 Hz Bandwidth.
- +3 V to +5.25 V single supply operation.
- 1000 g shock survival.
- Range: ±2g.
- Sensitivity:312mv/g.

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

3.2. The Footswitch

The footswitch is used to allow a microcontroller 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.

3.3. The Microcontroller

The choice of processor is the major factor affecting the design of the unit, since it is central to system operation. The microcontroller used in the aid is the PIC 16F876 (Tavernier, 2001) from MICROCHIP.
Its main features are:
- CMOS RISK architecture.
- 8 k of 14 bits program memory.
- 368 bytes of RAM.
- 256 bytes of data EEPROM.
- 3 timers.
- 5 channels of an analogue to digital converter.
- I2C and USART interfaces.
- PWM generator via 2 pins.
- 3 I/O ports.

3.4 The Push –button switches

These switches enable the user to select routes, and to enter decisions. They are placed on the side of the case, and some of them can be seen in figure 2. It is of course possible to label these keys with Braille symbols if it is thought necessary.

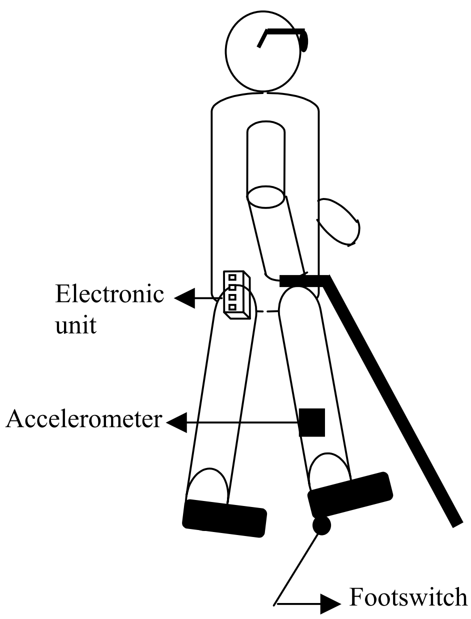

Fig.2. The navigation system worn by the blind.

3.5 The Audio output

A piezo- electric device is used as an audio output. It is activated by pulses from the microcontroller.
The output is coded to represent the different actions to be taken (e.g. road right turn, left turn…) using different frequencies and modulations of the sound output.

4. FUNCTIONAL DESCRIPTION

The system is 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 button has been considered to enable the blind person to make the aid repeat the audio signal 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.
The system has been used on some preliminary trials. In the near future, it is planned to carry out more extensive tests.

5. CONCLUSION

In this paper, we have developed a system which helps blind and visually impaired people to increase their independent mobility travelling in unknown environments. The use of the footswitch is highly advantageous (Bousbia-Salah and Bedda, 2003) because without it, drift errors due to the accelerometer and double integrators would be considerably greater in magnitude and would reduce the effective range of navigation system.
This device will then enhance the independent mobility of blind individuals, and thus improve the quality of their lives.
In order to enhance the performance of the system, a speech synthesizer (Donovan, et al., 1999) chip with a small vocabulary can be added to the device to tell the blind person about travelled distance, present location and decisions to make. Information about the route can be 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.

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