The Development of a Pedestrian Navigation Aid for the Blind

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Abstract — An Electronic Travel Aid is a form of assistive technology having the purpose of enhancing mobility for blind individuals. This paper examines a pedestrian navigation system for the Blind, which is based on a microcontroller with synthetic speech output. This aid is a portable, self contained system that will allow blind people to travel without the assistance of guides. It is designed for a battery-powered portable model. In addition, it is focused on low power consumption, small size, lightweight, and easy manipulation. The proposed system provides information to the user about urban walking routes using spoken words to indicate what decisions to make.

Index Terms — Acceleration measurement, Distance measurement, Global positioning system, Microcontrollers, Speech synthesis, Switch.

I. INTRODUCTION

As life becomes more abundant, the desire of human welfare is being increased. Hence interests in the life quality becomes high not only for normal people but also for handicapped people. Handicapped people that have problems in the sensory systems live through various hardships, since human protect themselves from danger and respond to external stimuli with recognition of environmental information.

There are currently many different research projects worldwide looking into many forms of accessibility to mobility and orientation information for visually impaired people. These involve technologies as diverse as GPS, sound signs, vision substitution systems, obstacle detection and avoidance, vision enhancement, optical recognition, and computer networking, through to vision research at NASA, biotechnology, genetics and nanotechnology.

As computers become smaller and faster, and with the vast improvements in voice input and output, revolutionary navigation devices[1-2] for blind and other disabled individuals no longer need to be special high-priced, small-market units. Accessible mainstream navigation technology represents the potential for nothing less than a quantum leap in independence and social integration.

A serious problem for visually impaired persons is hardship of walking. Some kinds of conventional aiding methods have been used to solve this problem. The most widely used method is a white stick, which a person should train for a long time to use. The other solution is a guide dog, which is very expensive, but can not provide so much information. Hence during the last several decades, some models of blind mobility aids have been developed. Sonic-Guide [3], Sonic Pathfinder [4], Mowat- Sensor [5], and Guide-Cane [6] are called clear path indicators or obstacle detectors since the blind can only know whether there is an obstacle in the path ahead [7]. 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 and NavBelt [8], however, are called an environment sensor since it has wide directivity enabling it to search for several obstacles at the same time.

The main efforts to find technical solutions to blind people’s mobility and orientation problems have been undertaken during the last century.

In this paper, the proposed pedestrian navigation 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 a speech synthesizer to point out what decisions to make. In addition, the software permits the blind to explore the electronic map as well as planning the optimum route to the desired destination.

In order to overcome the imperfections of existing electronic travel aids, the proposed method of measuring distance 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 [9] and suffers from drift problems caused by the double integration and offset of the accelerometer which are overcome by the switch [10-11]. When the foot where...
the switch is attached to the leg is on the ground, the acceleration and the velocity are known to be equal to zero and this can be used to apply a correction.

II. OPERATING PRINCIPLE

The navigation aid consists of a microcontroller, an accelerometer, a smart sensor used as a switch, a speech synthesizer, a push-button switch, a mode switch and a power switch. Fig. 1 shows the block diagram of the system. The smart sensor is represented by the portion of the figure outlined with dashed lines and contains a microcontroller PIC 10F200, an ultrasonic transmitter-receiver, an amplifier and an adapter.

As the ‘Micromap’[12], the system has two modes of operation, record and playback. The user selects then, one of these two 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 to initiate recording of decision word within the speech synthesizer. 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 recorded in the speech synthesizer.

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, a corresponding decision word generated by the synthesizer is given to the blind. The audible signal indicates what action the user should take at this point, for instance turn left.

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).

III. SYSTEM DESCRIPTION

In this section, we describe in some detail the components of the proposed pedestrian navigation aid.

A. 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[13] from ‘MICROCHIP’.

Its main features are:
- 8 k of 14 bits program memory.
- 368 bytes of RAM.
- 256 bytes of data EEPROM.

B. Accelerometer

The accelerometer used is the ADXL202[14] 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 analogue 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 specifications are as follows:
- Duty cycle output with user adjustable period.
- Range: ± 2 g.
- Sensitivity: 312 mv/g.

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[16] from ‘ChipCorder’ and is used as an audio output. The chip is a low power, single-chip solution offering digital storage capability and up to 16 minutes of high quality, audio record and playback functionality, along with a new integrated voice-band CODEC. The technical specifications of this speech synthesizer are:
- Voice and digital data record and playback system on a single chip.
- Industry leading sound quality.
- Low voltage operation.
- Message management.
- Non volatile message storage.
- 8, 10, 12 and 16 minutes duration.
- 100 year message retention (typical).

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. Some guidelines for synthesized speech include:
- Voice warnings should be presented in a voice that is different from other voices that will be heard in the task situation.
- If synthesized speech is used for other types of information in addition to warnings, the user needs to be able to distinguish between these messages.
- Maximise the intelligibility of the messages.
- Make the voice as natural as possible so people are more likely to accept it.
- If the message is missed, it is beneficial for people to be able to replay it.
- If the message is familiar, the ability to interrupt the message would be beneficial for experienced users.
- Use synthesized speech where it is appropriate and acceptable to users.
- Computer generated speech is appropriate for situations that require different messages to be generated.
- Where the choice of messages is relatively limited, human voices are preferred because synthetic speech is less intelligible and less preferred.
- Use non speech audio messages only for the purposes of alerting.
- Make a headphone socket available for private speech output.
- A volume control is beneficial.

D. Push–button switch

This switch indicates recording of decision word. It is placed on the side of the case, and can be seen in Fig.2.

E. Switch

The switch is used to allow the microcontroller PIC 16F876 to provide frequent corrections of drift effects. When the blind person starts to walk, which means that the foot where the switch is attached, is off the ground, this microcontroller estimates then the acceleration and calculates the distance travelled by the blind. On the other hand, When the foot is on the ground, the PIC 16F876 microcontroller estimates and calculates the errors. Afterwards, corrections are made.

The smart sensor is one example of switch which can be used for this pedestrian navigation aid. It is based on a new small microcontroller, the PIC 10F200[15] from ‘Microchip’ corporation with the following characteristics:
- Low-cost.
- High performance.
- 8 bit flash-based CMOS microcontroller.
- Only 33 single-word instructions to learn.
- All single-cycle instructions except for program branches, which are two- cycle.

This smart sensor is developed for hardware modelling of an electromechanical switch, which is used in electronic navigation system to detect the leg movement of the user. Thus, in this case, it should be portable by the blind, where it is fixed on his leg. On every step taken by the user, the system generates a pulse.

First, at power reset the system computes the reference distance which represents the distance of the system position to the ground, by emitting and receiving
ultrasonic pulses. When it detects a vibration of the blind leg, it computes a new distance and then compares it with the reference distance. If there is a considerable difference which means a step has been taken by the user, a pulse is then generated.

IV. USE OF THE SYSTEM

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 appropriate mode and starts to walk.

V. FLOWCHART

The system flowchart is shown in Fig.3.

VI. ADDITIONAL FUNCTION

The utility of the navigation aid can be further enhanced by other advanced feature, although this feature is not necessarily unique. The aid can therefore be equipped with a Global Positioning System (GPS). Outdoors, commercially available GPSs can provide global positioning information to within 20 meters accuracy. This makes it possible for the blind individual to prescribe a desired target location (for example, the supermarket or the post office) to the system and to have the aid automatically guide the user to that location.

Alternatively, the system could learn a desired path by recording path segments during an initial “lead-through” run with a sighted person. Indoors, where GPS is not effective, the same path programming or lead-through techniques can be used to have the aid automatically guide the user to a desired location, using dead-reckoning based on encoder and compass readings. This latter method of dead-reckoning is not suitable for long distances because of the unbounded accumulation of odometry errors, but it is suitable for shorter indoor paths.

VII. CONCLUSION

We have investigated in this paper, the development of a pedestrian navigation aid for the blind which helps blind and visually impaired people in order to increase their independent mobility travelling in unknown environments. The use of the switch is highly advantageous[17] 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. This system will then enhance the independent mobility of blind individuals, and thus improve the quality of their lives. In addition, to help blind or visually impaired travellers to navigate safely and quickly among obstacles and other hazards faced by blind pedestrians, an obstacle detection system[18] must be added to this aid.

However, it is difficult to know where the blind is globally. The global positioning system (GPS)[19] will be employed to get the user position information. Further research is required to determine the utility of this aid, how best to take advantage of the extended preview it provides and how best to selectively determine its value to blind travellers.

All blind people who need navigation to a specific destination in these settings could profit from the availability of this aid. Their disability being unfamiliar with their surroundings would thus be served by such a system. Hence, technology for the blind and visually impaired people will be of service to all.
ACKNOWLEDGEMENT

The authors wish to thank the laboratory of automatic and signal for its contribution in the development of this project.

REFERENCES


