

Localized Visually Impaired Navigation System

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Abstract — In this paper, NavTech Inc. presents a new approach to assist the visually impaired navigate a university campus. The key concept is the use of a compass the user can feel which guides them in the desired direction, based on data received from the integrated hardware and software. The design consists of a GPS receiver, a hardware-software system, a rotational thumb guide, and a Braille display. This design was simulated and the results show a significant improvement in the mobility of a visually impaired person.

Index Terms — Global Positioning System, Microcontrollers, Navigation

I. INTRODUCTION

NavTech Inc. has sought to design a solution to assist in the navigation of visually impaired persons on a university campus. This system was designed to minimize cost, weight, and social/environmental impact, while maximizing battery life, simplicity, reliability, and accuracy. The main system constraints considered during the design process were as follows: it must provide a more feasible solution than current options, be ergonomically suitable for all users, have a minimum battery life of 9 hours, and a resolution of at least 5m. During our design process, several assumptions were made, including that the device will only be used outdoors, and only on the campus, and that the visually impaired user will have aide in downloading their schedule to the device. Navigation options for the visually impaired have only just moved past canes, guide dogs, and even guide horses. These solutions are not programmable, and are thus insufficient for our need. Newer solutions include GPS navigation systems, with quite an extensive list of readily available devices. That being said, the design we present offers greater simplicity to the user, with less user input required; also, the rotational thumb guide is head and shoulders above the competition in terms of reliability, as pre-recorded audio has many limitations. Initially, our company defined the problem, analyzed multiple solutions, and through extensive brainstorming, component analysis, and decision criteria, developed our final solution. This solution takes the form of a hand held PDA device that utilizes GPS technology to provide the data necessary to guide the user to their end destination.

II. CONCEPTUAL DESIGN/METHODOLOGY

A. Overall Design

The system is composed of two physical units. The PDA is the device the user will be carrying in their hand and serves as the means by which they are directed to the desired locations. The GPS housing contains the GPS receiver and the power supply for the system and is fitted with the appropriate connec-

tors to communicate to the PDA and a PC. These two components are physically connected together using a RJ-25 phone style connector. The device connects to the PC through a standard serial DB-9 connector. In both cases the RS-232 communication protocol is used. The major components comprising these units are illustrated in figure 1.

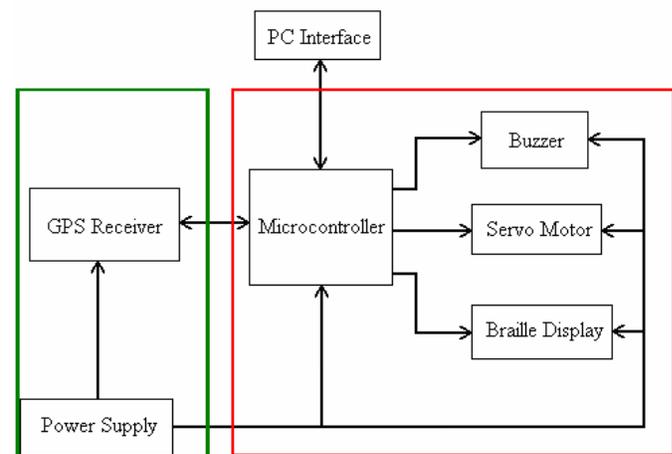


Figure 1: This figure demonstrates the interconnection of the significant components of the system.

A campus database regarding the locations of buildings and zones are stored in the PDA memory. Every location on campus has a set of predefined directions corresponding to the zones which are stored in memory. The GPS communicates the location of the user to the PDA, which is then translated to a corresponding location defined within a zone. With knowledge of the user position and orientation (which is also communicated to the PDA from GPS receiver) and the zone the user is currently occupying the PDA can guide the user in the correct direction by turning the servo motor to the appropriate heading. The PDA knows the user's schedule and guides them to the appropriate location at a specified time. The building/location code of the user's destination is communicated to the user through the Braille cells located on the front face of the PDA. In the event of errors occurring such as loss of GPS signal or out of zone errors, the user is notified by a warning tone from a buzzer and an error message is communicated through this display.

III. DETAILED DESIGN

A. MC9S12DT256 Microcontroller

The MC9S12DT256 Microcontroller [1] was chosen to run the navigation device. The microcontroller has 4k bytes EEPROM, 12k bytes RAM and 256K Flash EEPROM on

board memory. The main program is contained in the EEPROM and the database is contained in the Flash EEPROM.

B. Garmin 16 LVS GPS Receiver

This GPS receiver [2] is a complete stand alone unit with an integrated antenna and processing device. This particular model was selected due to customizability and the fact that it is very accurate, has sufficient weatherproofing to handle harsh climates, has reasonable power consumption and is relatively inexpensive in comparison to other models available.

C. Other Components

A servo motor [3] is used to relay directional data to the user through positioning of a directional dial on the servo, based on the user's current heading and the heading indicated by their current zone. The servo motor's position is controlled by the pulse width of the data input to the motor generated by the microcontroller.

The Braille cell display [4] is used to display the name of the destination the user is currently being guided to. The module contains four cells which display a total of four characters. These cells are controlled by the microcontroller through the serial peripheral interface.

The buzzer is used to indicate to the user any errors that occur. These include loss of GPS signal and out of zone errors. For errors, the two different errors are differentiated by the duration of the sound pulse.

The device is powered by four AA alkaline batteries connected in series to provide the appropriate voltage of 5V.

D. Software

The software involved in this design is comprised of the firmware that runs on the microcontroller and the PC application software.

The firmware deals with translating information received from the GPS into signals received by the servo motor and Braille display which communicates information to guide the user. This is achieved by looking up the zone occupied by the user based on the user's coordinates and then determining the correct direction of travel which is based on the end destination.

The function of the PC application is to create and download a schedule onto the PDA device. The software is also used to configure the routes taken to building entrances by specifying the direction of travel for zones. New zones can be created and existing ones modified through this interface.

IV. DISCUSSION

Interfacing the GPS, microcontroller and servo motor was a simple way to devise a navigational device for visually impaired students on a campus. A large portion of the design is the software, which delegates how the user will reach their final destination, where the data is being accessed and stored and how to download the user's schedule.

The purpose of splitting the device into two separate units has to deal with reasonable weight and size considerations of the handheld PDA. If all components were to be housed in the

handheld the device would be too bulky and cumbersome. Another benefit of moving the receiver off into a separate housing is that the user does not have to worry about the orientation of the handheld device allowing them to freely move their hand about without causing GPS signal loss. This would even allow them to keep the PDA device in their pocket.

The zone method was implemented primarily because of its simplicity and high degree of customization. Other systems typically involve the use of complex algorithms that are computationally expensive and require more resources to operate. Our method is very memory and computationally efficient thus allowing greater area coverage or resolution with less processing power and memory.

For future work, some components of the design could be altered and improved upon. There is no limiting factor other than memory that would allow the use of this device to cover uses beyond only campus navigation for the user. The memory limitation is easily overcome with expanding its size without causing any significant changes to the overall device.

To improve the user interaction with the device to allow for a more flexible scheduling system, future improvements could include a means for the user to select when to initiate an event. This would be included in conjunction with the current predetermined scheduling system to disallow for unforeseen events to throw off the user's schedule.

An indoor network add-on to the outdoor navigation system could be established which would extend the overall usability of the device.

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