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Naviah: A Smart Electronic Aid for Blind People

Renupriya A[*1], Kamalanathan C[#2], Kirubakaran S[#3], Valarmathy S[**4]

[*]M.E. Applied Electronics, Bannari Amman Institute Of Technology.
[#]Assistant Professor, Dept.of ECE, Bannari Amman Institute Of Technology.
[**] Professor, Dept.of ECE, Bannari Amman Institute Of Technology.

Abstract

A theoretical model and a system concept to provide a smart electronic aid for blind people. Blind students all over the world need guidance to navigate around the city or university campus. It is estimated that 374,400 visually impaired students attended colleges at some point in the United States alone. With the rapid technological advancement, new opportunities are emerging to make life easier for blind students. Motivated by the problem, the objective of this project is to design, prototype and evaluate a smart guidance system to help blind students navigate from all places**.** The system is intended to provide overall measures – Artificial vision and object detection. The aim of the overall system is to provide a low cost and efficient navigation aid for blind which gives a sense of artificial vision by providing information about the environmental scenario of static and dynamic objects around them. Ultrasonic sensors are used to calculate distance of the obstacles around the blind person to guide the user towards the available path. Output is in the form of voice which the blind person can hear e.g., right, left etc. The hardware consists of Development board, ultrasonic sensors and speaker.

Keywords: *DC motors, Navigation, Sensors, Speech recognition****,*** *smart guidance system.*

I. INTRODUCTION

It is well known that a blind person daily encounters many difficulties such as walking on the road, finding right path and taking a bus [1]. Escorting blinds is a social activity closely tied to our Islamic teachings and traditions. Barriers may harm the blind when they are walking on the street. The "World health organization" [2] presented important statistics related to blind people. 285 million people are virtually impaired: 39 million blind and 246 million having low vision. 90% of the visually impaired population lives in developing countries. Blind people do eventually go to work or school. Blind people may find it easy to move within a small area such as a room but it is challenging to navigate outdoors. Blinds all over the world need some help navigating from one place to another. Many traditional techniques are used to guide a blind person. Some blind people prefer using guide dogs and others prefer a real person to guide them instead. People may not be available all the time to help the blind. Hence, it is required to have a system that will help blind people navigate their way without the need of a guiding person or a pet.

Another problem is to detect objects on the blind person's walking path. Blind people usually hold a white cane to make sure nothing obstructs the path. So, detecting obstacles in the path is an important requirement.

The objective of this project is to design and prototype a navigation system to help blind students navigate to and from classrooms. The student should communicate with the system through voice commands. Additionally, the system should be safe to use.

A. Related Projects

Many alternative ways of guidance exists. The first one is known as Seeing-Eye dog. A Seeing-Eye dog is a dog that has been specially trained to help blind people navigate. The dog must be well trained to guide the blind person. Some blind people use a white cane to navigate their way around. The cane works as an object detector. A blind person usually swings the cane as he/she walks to help him/her find and avoid any obstacles in the pathway.

Today's technological advances simplified people's life. Several researches and projects exist in the field of navigation. Global Positioning System (GPS) added an important value to navigation technology. Many systems developed and tested to meet navigation requirements specialized for blind people. Place Recognition for Indoor Blind Navigation thesis [4] was done. The thesis focused on indoor navigation by exploring place recognition and navigation algorithms accessible via handheld devices to guide blinds inside unfamiliar buildings. The outcome of the work is a camera-based indoor blind-navigation model that can recognize previously mapped locations.

The authors in [5] published an article detailing a system that consists of a pair of glasses equipped with cameras and sensors. The system produces a 3D map of the wearer's surroundings and his/her position. The system is able to generate up to 10 maps per second then send it to a braille device to be displayed as a dynamic tactile map. On the Bus [6] is an Android application designed to help blind users reach their destination by taking the bus. The application guides them from their present location to the closest bus stop. The app informs the blind user on how much time to wait before the bus arrives. When blind users take the bus the system informs them on how many stops are left and alert them when they arrive. After getting out of the bus, the app resumes giving directions to guide the blind user outdoors only.

Most of the previous projects depend on smart phones to gain access to its features such as GPS, accelerometer and Internet connection. An important property of smartphones is that they are portable and lightweight which makes it easy for blind person to use. Smartphones provides the best communication results with a greater functionality performance. Capability of sharing information over a network such as the Internet makes life easier and capitalizes on smartphone's capabilities.

B. Engineering Requirements of the Proposed System

The proposed system should meet the following engineering requirements:

1. As a measure of performance, the response time should be less than 10 seconds.
2. The system should be available upon demand.
3. Due to the importance of the user's location, accuracy should be within (+/-) 5 meters of the target.
4. The system should be able to operate for 10 hours.
5. Because blind people will use the system, the system should be easy to learn and should not take more than an hour to learn how to operate and use.
6. System should be designed to permit upgradability in the future.
7. A physical button should be automatically generate on the system.

C. Engineering Constraints

Engineering Constraints are special type of requirements and should be considered to achieve successful and realistic design. Design constraints are:

- Economic constraint: The cost of the system should not exceed 20 OMR.
- Health and Safety constraint: The system should detect stationary objects that may harm the blind person.
- Ethical constraint: Communications between the device and the blind person must be private.
- Social and Cultural constraint: The system should support Arabic language.

II. SYSTEM DESIGN

Designing a system involves extensive research to find the best solution that matches the requirements. Many design alternatives exist, but constraints force designers to a specific design direction. During the course of the project, we thought of three different design alternatives. Those alternatives are: web application based system, development board based system and a hardware system interfaced with a module. Each alternative has its own set of advantages and drawbacks. However, the latter alternative was selected because the required I/O components (such as Camera, microphone, etc…) are integrated and accessible.

A. Functional Decomposition of the Design

Functional Decomposition describes the system functionality or behavior. Our system consists of several inputs such as; user's voice, ON/OFF button automatically, RFID reader and sensors. Voice instruction and vibration will be the output. A Radio Frequency Identification (RFID) tag is used to store its location as a reference point to an RFID reader. The RFID reader is used to solve the problem of determine the current location of the user and to check if he/she is in the correct destination. Figure 1 shows the interconnection between different modules and sub-modules in the system.

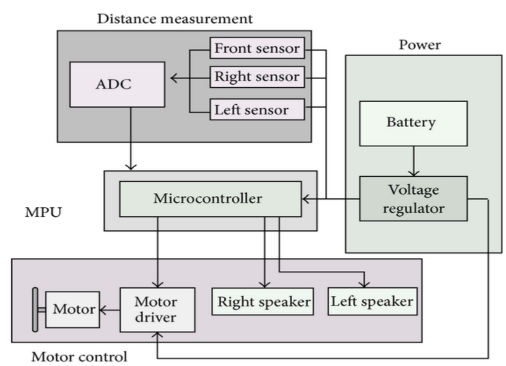

FIGURE 1
FUNCTIONAL DECOMPOSITION OF THE SYSTEM

In functional decomposition level 1, the system consists of main modules which are the smart cane module. User's voice, ON/OFF button automatically, RFID reader and sensors are the inputs to the cane module. The output of the smart cane module will be the voice guidance and specific as shown in Table II.

TABLE II
CANE MODULE

Module	Cane
Inputs	- Sensor, User Voice - RFID reader - Automatically Button - Power
Outputs	- Vibration, Voice Instruction
Functionality	The Cane will receive signals from the sensor an RFID reader. Depending on the coming signal, th cane will produce a specific vibration. The switch i used to turn automatically ON/OFF the Cane.

B. RFID Reader Flowchart

When the RFID reader starts, the camera will open and it will try to read the RFID tag image. Later this image will be processed and a result text will be stored. The flowchart is shown in Figure 2.

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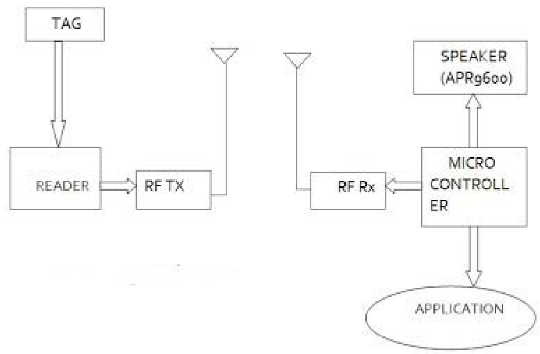

FIGURE 2
RFID Reader Module

C. Cane Module

The Cane detects any objects around the blind person using distance-measuring sensor. Then it alerts the user in case an obstacle is found. If the user deviates to the wrong direction, the smart handheld device will send a signal over Bluetooth to the cane to alert the user using vibrations. Figure 1 shows functional decomposition level 2 of the cane module. The microcontroller module accepts the signals from sensors or Bluetooth, and will process them and determine the pattern of turning on and off the motor to generate vibrations.

III. SYSTEM CIRCUIT DESIGN

After describing the functionalities of major system modules, this section sheds some light on the selection criteria of the components constituting the system.

A. Components Selection

System requirements and constraints such as cost, accuracy and functionality should be considered when selecting components. To do that, alternatives of every component are compared against each other to select the best option that will satisfy the requirements and constraints.

B. Microcontroller Selection

Many alternatives are available such as; AVR Atmega8 or Atmega tiny from Atmega Family. Atmega tiny has few ports not sufficient to be used in our system. In addition, it does not support serial communication such as RS232 and SPI. Atmega 16 and 32 supports additional functionality and extended ports. So, Atmel Atmega8 is a suitable choice.

C. Sensor Selection

There are two distance sensors alternative: Ultrasonic and InfraRed (IR) sensor. IR sensors are affected by the surrounding lighting and its range is limited compared to ultrasonic sensors. In addition, ultrasonic sensors are more accurate. Therefore, ultrasonic sensor is a suitable option for the project needs.

D. Motor Selection

DC motor or stepper motor is needed to generate vibrations. Stepper motor can rotate clock-wise or counter clock-wise in a step of 18 degrees. Stepper motor needs 12 DC V which is much larger than the voltage needed for DC motor (5-7 Volts). Stepper Motor provides functionalities that we don't need and consumes power greater than DC motor. Therefore, DC motor provides sufficient functionalities for the objectives of the project therefore it was chosen.

E. Constraints Effects on System Design

Previously mentioned constrains forced the design towards specific directions. Health and safety constraints forced the designers to add a cane to the system to detect obstacles. Cultural and social constrains resulted in adding extra program functions to support Arabic language. Economic constraints limited the selection of some components because the objective was to design a system affordable to people.

IV. SYSTEM IMPLEMENTATION AND TESTING

"Naviah" is the name of the designed blind guiding system. It consists of main modules which are; the smart cane module. Naviah will identify the places that have to be visited daily by the blind student and automatically generate the navigation path.

A. Voice Recognition Implementation

An additional Class has been added to record the voice of the user and handle the reply. The application depends on the resulted text to identify the user's request. Therefore, we have tried to recognize the same voice command and came up with several possibilities and tried to match them with single instruction to increase the reliability of the application.

B. Emergency Situation

The worst case that may happen to a blind student is when he/she gets lost while navigating from one point to another. The problem is to detect the current location during the navigation. The developed application can determine the starting location coordinates (latitude, longitude) and it can also keep track and update the location coordinates during navigation. Therefore, we have added an extra feature as an emergency solution. In case if the user is lost, he/she can supply “help” voice command which will initiate a phone call and at the same time send SMS that contains the current location to a predefined phone number.

C. Multi Language Support

One of the cultural constraints is to support Arabic language. In addition, the voice recognition results are not consistent due to the errors occurring in the voice recognition process. Therefore, there is a need for an extra feature to solve this issue. Our solution is to add a dynamic dictionary that maps the original command with other possibilities from voice recognition and also match the original command to other language words. A commands translated from English to Arabic. The user can issue a voice command from any language he/she prefers.

D. Cane Implementation

The Cane is a central module in Naviah. In order to implement the cane module, we must have general information about the components to be used and the connections. In this section, more details are shown on how the cane module was implemented. We designed the circuit and simulated its operation using Proteus simulation software and we observed the circuit’s behaviour. Figure 3 shows the circuit layout and the connection between different components in the cane.

The system contains sub modules that will be discussed below:

- Atmel Atmega8 Microcontroller : Processing unit
- 3 Voltage Regulator :Voltage Divider
- DC motor: Vibration generator.

The ultrasonic sensor “HC-SR04” is connected to the microcontroller through serial port. The microcontroller triggers the sensor to send a pulse and run a timer at the same time. When an echo is received “signal reflected by an object” the timer will stop and time interval is obtained. The Distance is calculated by knowing the time interval and using special formula to calculate the distance.

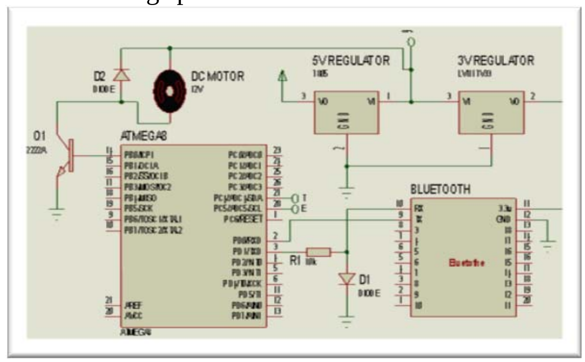

FIGURE 3
CANE MODULE

The microcontroller is programmed to decide whether there is an object in front of the user or not and if an object exists in a range below 1 meter the microcontroller will send continues pulses to trigger the motor to rotate. When the user deviates to the left or to the right, the smart handheld device sends a character “Either R or L” to the microcontroller. The microcontroller decides whether user should deviate to left or right.

E. System Testing

Several tests have been conducted to check the functionality of the proposed system. Testing was conducted on different levels starting with unit testing followed by integration testing and finally acceptance testing. Unit tests checks the functionality of each unit individually. Examples of such tests include testing the voice to text module, RFID to text module, testing sensors and motors. Acceptance testing is used to verify that the system meets design requirements listed in section I.B

V. CONCLUSION

Blind people are facing difficulties every day; they need assistance to help them move from one place to another.There are many traditional methods to help a blind person to navigate. Today, technological methods are being used to guide blind people. The objective of this project is to design and prototype a navigation system to help blind student navigate from and to all places. Different design alternatives exist; however, an application on a handheld device was the design choice that met our pre-defined requirements and existing engineering constraints. The system communicates with the user through voice command and it can read RFID tag to identify the current location. A cane was developed to help the blind student avoid obstacles and stay in the prescribed path. "Naviah" can be extended in the future to permit synchronizing the application with the student study timetable. We anticipate that "Naviah" will have a positive impact on the society and will help blind students navigate safely.

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