Ultrasonic Blind Stick with GPS Tracking System

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Abstract - This paper proposes an efficient electronic system for guidance of a blind person. It is based on the design and developments of a smart stick for visually impaired people to provide them with ease, confidence and to gain independence in an efficient and cost-effective way. This report presents the concept of the system, its theoretical and practical model for providing an electronic aid to visually impaired people. The system covers obstacle detection, light sensing, water detection, location detection and emergency messaging. The device is based on a small circuit mounted on the white cane and a small circuit serving as a control unit. A microcontroller-based circuit is used to handle the entire system functioning. The detection of obstacles is based on ultrasonic sensors giving a beeping sound, light sensing system detects the darkness and light in the surrounding to alert the user, the water sensor detects ground water to alert the user. In addition, a GPS with GSM connection sends the approximate location of the stick to the caretaker phone. The system aims to provide visually impaired people with artificial vision by giving them information on the surrounding environment.

Keywords: blind stick, GPS, ultrasonic, infrared.

1. Introduction

Sense of vision is a gift to human beings and is an important aspect of life. Visually impaired people (partially or fully) lack this ability and face difficulties in their routine life. Technology is improving day by day to provide safe and secure movement of these people.

According to World Health Organisation, the estimated number of people with sight loss in the world is 285 million out of which 39 million are visually impaired. Among many other challenges, one of the challenges for a visually impaired person is to navigate independently. Most of the time a visually impaired person relies on a sighted person for his assistance that means a lot of people with visual disability cannot find their way in an unknown area. People with visual impairment have limited ability to perform their daily task hence the possibility to interact with people and surrounding becomes limited. Blindness is another form of visual impairment where a person cannot see at all. Mostly a visually impaired person uses a white cane. Quality rehabilitation allows the blind people to achieve their goals and become productive in the society. A lot of efforts have been made to innovate and improve the technologies for blind people. Most of the devices developed can detect the obstacles on the floor but still, there is a lot of concern over the detection of objects in depth and above the waist. These restrictions are a motivated to develop a smart cane to overcome all these limitations. Technology using ultrasonic sensors can be used to assist users. Different beeping and vibration sequence can be used to indicate the intensity of distance from obstacle to cane [1].

The goal of detecting obstacles above the waist and in-depth can be achieved by moving and placing the ultrasonic sensors on the white cane at various positions. The main objective of this project is aiding blind people. If an obstacle comes close to the stick, the buzzer turns on, alerting the user to walk in a different direction. The main component of this project is RF module [2]. There is a use of RF module serving as a remote control to find the misplaced stick. In addition to that, there is water and light detector that detects the presence of light and water in front of the user. Moreover, the cane is linked with a smartphone to make use of Google maps. GPS and GSM module take the approximate location of the person and send the coordinates to caretaker by sending SMS.

2. Literature Review

Different types of electronic travel aids (ETA) are developed to assist the visually impaired people with navigation. These ETA devices are consisting of infrared or Ultrasonic sensors that sense the information of user's surrounding and transmit to the user by transmitter present in this electronic system. Some of these aids are called obstacle detectors. These detectors only detect the direction and general area of an obstacle and do not give any information about the obstacle nature. For example, Russell Path sounder developed a detector using the chest level ultrasonic sensors. That only detects the obstacle if it is in 6-feet distant to the person. Across the Globe, a huge amount of research has been done to develop an efficient and cost-effective navigation aid for visually impaired people. This section is review on the ETA devices developed so far.

According to research, the biggest difficulty faced by a visually impaired person is finding the way while walking on the road. A lot of devices have been developed to help the visually impaired people in navigation assistance and mobility. These aids are known as "blind mobility aids" or "travel aids [3]. The most commonly used travel aid is the long cane, known as the white and red cane. This cane is white in colour and its tip is red which is known as the symbol of blindness. This cane is the simplest of all the devices developed for blind people. This cane is used to detect steps, uneven surfaces, obstacles, and holes. Blind people tap their cane on the ground and this cane detects the type of surface and results in vibration. In the case of obstacles, the tapping produces sound [4].

As there was no advanced equipment available to help the blinds, researchers were encouraged to use the advanced technology like microcontrollers and sensors to create such an electronic aid that is compatible with the people [5]. In 2009 the central Michigan university developed an electronic cane for visually impaired people that can be used to provide the information about the external environment around the user. RFID chips were implanted into storefronts and street signs. The cane developed, was used to read and provide the user with the information. In this cane, they used an ultrasonic sensor for detection of the obstacles. They also developed a bag along with the stick, that bag had a speaker on the strap to vibrate and alert the user on detection of an object and directs them to a different direction [3].

In 2011, Gangwar [6] developed a white cane for visually impaired people for obstacle detection using infrared sensors. At the detection, the stick used to alert the user by vibration signal. But the drawback of this stick was that it only detected the obstacle and didn't cover any other emergency aspects that can be encountered by a blind person. Furthermore, the infrared sensor used in this stick was not that efficient in detecting the obstacles [3]. Furthermore, in 2011 another smart stick for blind people was developed by Benjamin et al. He used the laser sensors to detect the down curbs and obstacles. A microphone was used to give the signal of beep on the detection of an obstacle. The design of this cane was very innovative and simple but the problem with the stick was that it could not give psychological and cognitive support. this stick only used to give beep sound on detection of obstacle and there was no assistance in directing the users [3].

Table 1 shows a comparison of different developed devices for visually impaired people. It is clear that there are some areas that need enhancement to have an efficient and reliable blind stick for blind people to have better safety precaution during their movement.

Table 1: Detection technologies used for blind people navigation [3].

Technology	description	Advantages/disadvantages
Infrared	Transmission of electromagnetic waves	Easily shielded, not accurate
RFID	Transmission of electromagnetic waves which reads form RFID tag.	Requires RFID tags, not efficient specially in outdoor environment
Ultrasonic	Transmission and reception of ultrasonic waves	Cover reasonable range, cost effective, provides 60 degrees field of view.
Laser	Transmission and reception of light waves	Not efficient in broad daylight, easily shielded, very high price.

3. System Design

The system consists of setting the system specifications, then system simulation and finally hardware design.

3.1. System Specifications

The general system's design in form of the block diagram is shown in Figure 1. The system includes light sensing, water sensing, obstacle sensing, RF remote control and GPS tracking works.
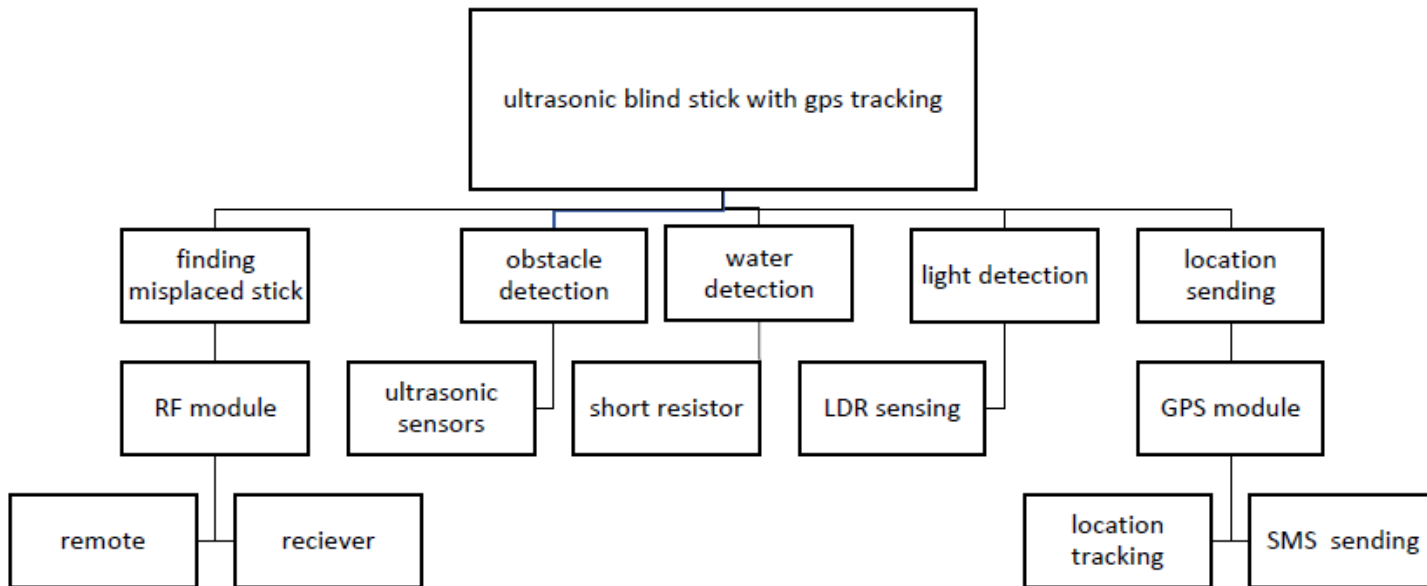

Fig. 1: Block diagram of the system functionality.

The system features the following sensors:
- **Obstacle Detection**: This circuit block contains an ultrasonic sensor, will be used to avoid and detect any obstacle in the range set by the user. Beeping sequence of buzzer gives the information on the detection.
- **Water detection**: The water sensor detects a puddle or water in a user's way to avoid it by short-circuiting and alerting the user with a beeping sound.
- **Light detection**: This block detects light mode condition in surrounding giving beeping sound on detection of darkness.
- **RF module**: This block is used in finding the misplaced stick using remote control. Pressing the ON button of remote control gives the beeping sequence after finding the stick OFF button is pressed to stop the beep.
- **Location tracking**: In case of emergency, pressing the button activates the GPS which identifies the location of the person and sends it to the GSM module that sends a text message containing the exact location of the stick and google map link to the caretaker phone to alert him/her.

A block diagram of the system architecture is shown in Figure 2. Four different buzzer types were used to distinguish the alert type to the user. The system is powered by Li-Ion battery which is sufficient to supply the electronics and the GSM connections for a prolonged time period.

3.2. System Simulation

The system was simulated using Proteus Professional 8 Software. It incorporates an Arduino microcontroller, ultrasonic sensor and RF module, GPS module, moisture sensor, light sensor, voltage regulator, and power source (battery). Figure 3a shows an individual simulation block of the sensors (light, ultrasonic, and moisture), and the RF module connection, while Figure 3b shows a simulation of the GPS module that is connected to the mobile App.
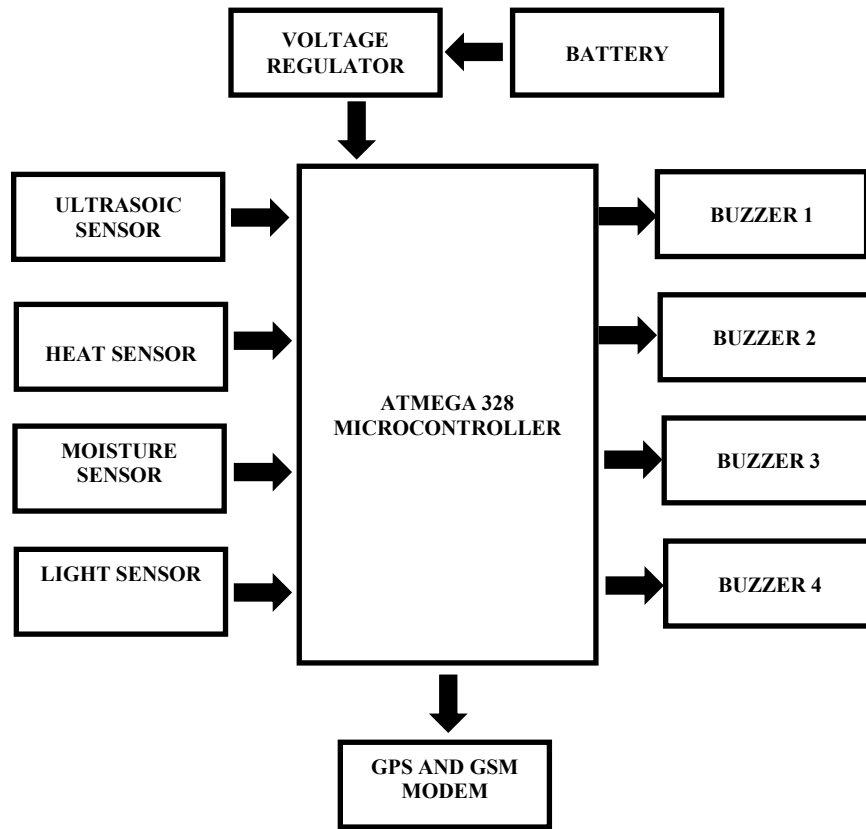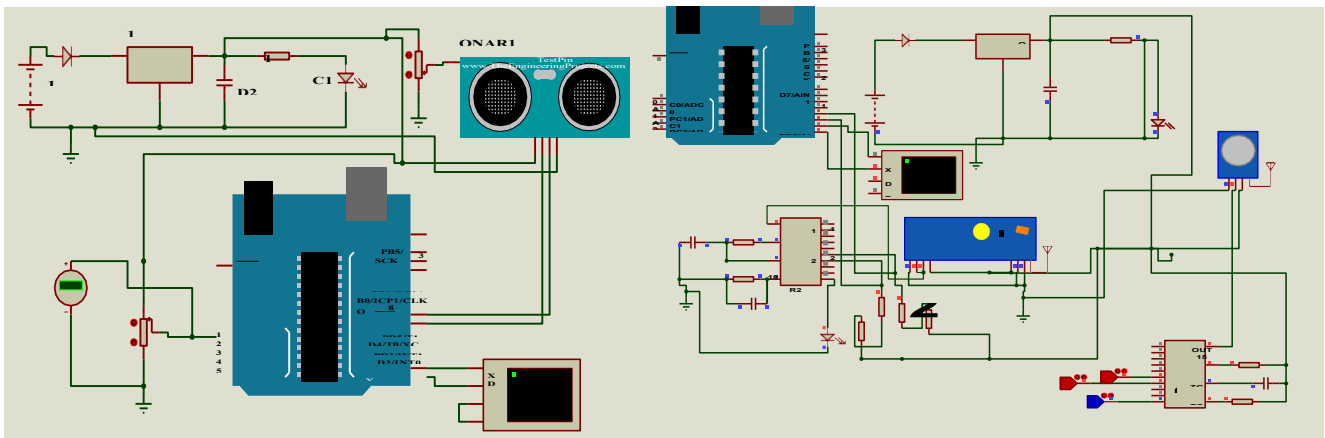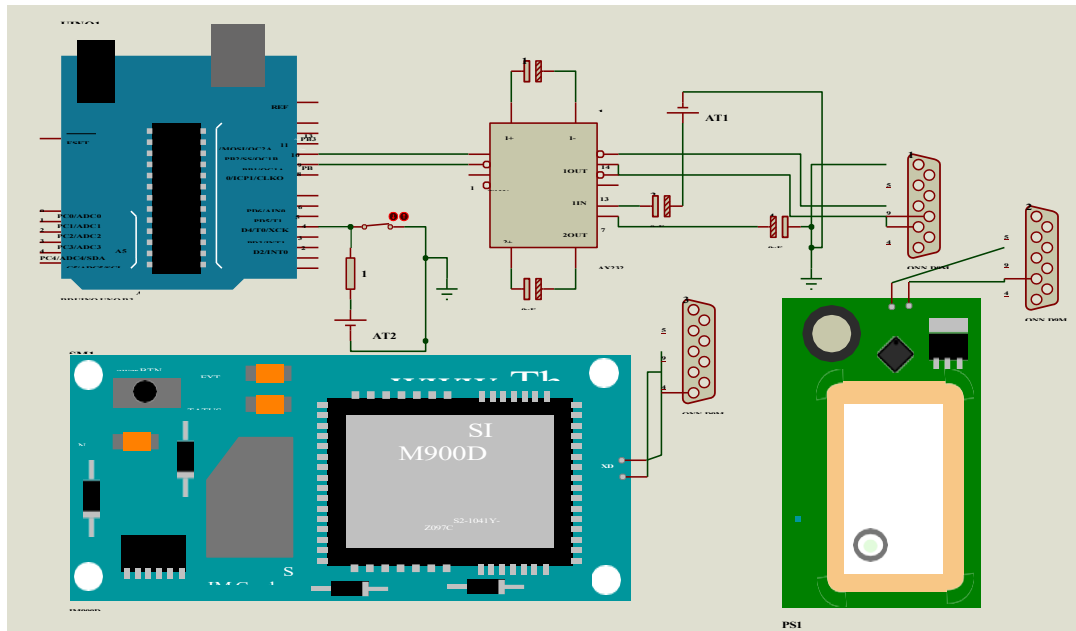
Fig. 2: Block diagram of the system architecture.

a)   Simulation of detection sensors and RF module.

b)   Simulation of GPS module

Fig. 3: Block diagram of the system Proteus simulation.

3.3. Software Developments and Implementation

The Arduino microcontroller is coded in C/C++ programming languages. The different systems were developed and assembled. The main two systems are the obstacle detection and the GPS tracking system. Table 2 shows the features of the two systems.

Table 2: Obstacle and GPS codes' features.

Obstacle detection pseudocode	GPS tracking pseudocode
• Define pins &declare variables	• Add serial library for communication
• Set the pin modes Trigger= input, Echo=output	• Define pins 9,10 for GSM to communicate & declare variables
• Clear trig pin, set trig pin high to generate wave (20us delay), Set it low	• Set the pin modes pin track button=input
• Set echo pin high and declare Duration=echo pin	• Initialise GSM
• Reads potentiometer value	• Buzzing sequence while wait for call
• Convert the analogue value to digital	• Configuration of phone number done on receiving call
• Calculate the distance	• Buzzing sequence stops
• distance = duration/58.2;	• Check if track button is pressed
• Compare distance value with pot value	• Get GPS location
• If Distance <=pot value	• Tell GPS and GSM to act is data present
• Turn on LED and buzzer	• Check GPS working or not
	• No: GPS not working message
	• Yes: send location to number

3.4. Hardware Implementation

After testing the simulated breadboard circuit. The final circuit was built on the PCB. The first step of this process was to design the PCB layout and then printing this layout on the PCB board. Two PCB layout were designed. One for the remote control and other for the main circuit. The designed layout was printed on the PCB using the printing machine. All the components were soldered on the board. After the simulations are complete. The

components were sourced, RF module, MAX232 SIM808 GPS and GSM module. Each sensor circuit was built separately and tested by uploading Arduino code before any further development. After building and testing each sensor circuits separately they were assembled. The complete circuit is built with all the sensors and the codes were combined in a single application file. Only the transmitter circuit was built on a separate board that served as a remote control. Figure 4 shows the final prototype electronics system.
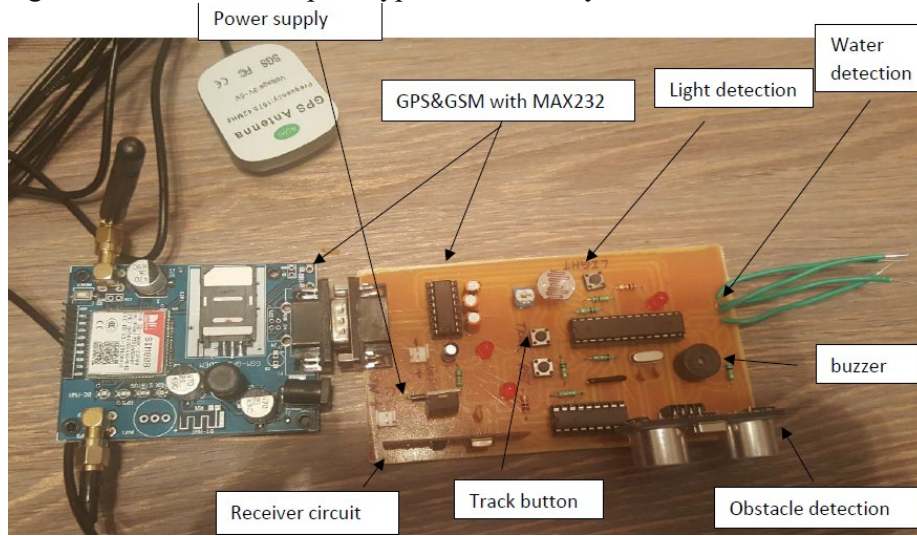

Fig. 4: PCB main sensor circuit with GPS&GSM modules.

4. System Testing

The system was tested by simulating all the sensor circuits (light, water, obstacle, RF module and GPS tracking) separately to check the working of each circuit individually on Proteus software. The circuits are built, and Arduino codes are uploaded to get the required results. Test results of all the sensors in form of artificial obstacles signals, the electronics will signal the Arduino and the algorithm recognise the obstacles and report it to the user. The simulation results are compared to the actual testing data.

The whole circuit was tested by uploading the Arduino code to check if all the sensor circuits were working the same way as they were working individually. On the successful testing, the ATMEGA328P was removed from the Arduino board and placed on the breadboard with all the connections to reduce the size of the circuit as the circuit needs to be placed on the stick afterward. Figure 5 shows the complete assembled system.
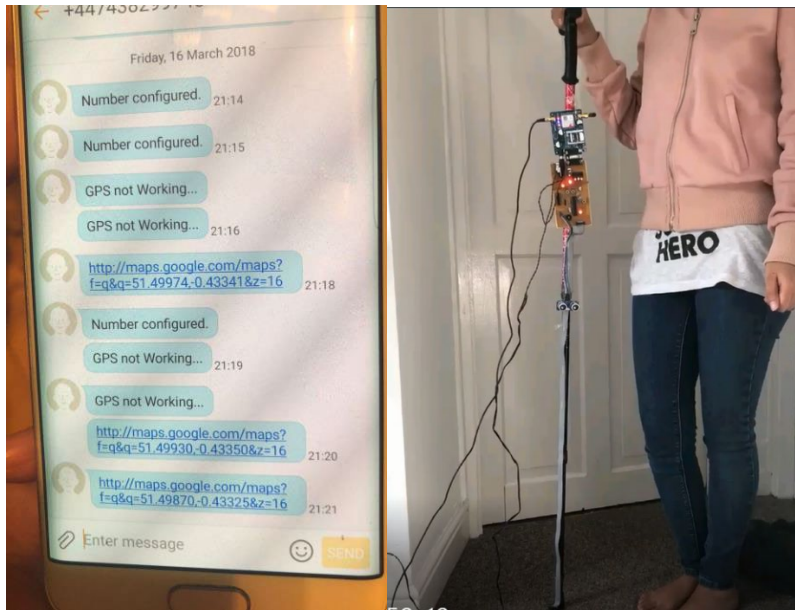
Fig. 5: System testing of the prototype.

5. Conclusion

This paper presents the process of developing an embedded system which aims to replicate the design in the real-world implications of a hardware-software system. The work presents the details of architecture and working algorithm of the blind stick. An algorithm and code based on Arduino were constructed to detect the obstacles, water in pits and puddles, the light condition in the surrounding, finding the misplaced stick and location tracking.

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