OJUS:A guidance system for the blind

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***Abstract*—Traditionally, visually challenged individuals employ the white cane to aid their mobility outdoors, which provides very limited utility.Moving with the help of a white cane is an elusive task for the visually challenged unless they create a mental route map with recognisable reference elements. In order to improve the safety of visually challenged users and enhance their awareness of their surroundings while navigating in outdoor environments, a smart device is needed.The proposed device can detect obstacles as well as terrain changes in the user's path. A conventional walking cane forms the main frame of the device, upon which ultrasonic sensors are mounted at appropriate locations to detect obstacles, steps and pits in the path of the user. A water sensor is used to detect the presence and level of water on the terrain.The presence of these obstacles is notified to the user by the means of voice recordings played via earphones or through haptic feedback, provided using vibration motors placed on the hand support of the stick. Adding to these features an LDR technology is used to create a beacon for others even while night movements.The smart walking cane further employs GPS and GSM modules which can be used to send a distress call to the user's kin along with the user's location upon being activated by a simple press of a button. The device is lightweight and is powered by a rechargeable battery. The overall design of the device ensures accuracy, energy efficiency and easy portability.**

Keywords—GPS; GSM; Obstacle detection; Terrain detection; Ultrasonic sensor; Visually challenged; Walking Cane

I. INTRODUCTION

According to the World Health Organization, as of 2010, over 285 million people in the world are visually challenged, of whom 39 million are blind and 246 million have moderate to severe visual impairment [1]. India accounts for 21.5% of the total number of visually impaired, with 53 million citizens suffering from some form of vision loss.

Visually challenged individuals largely use white canes to aid their mobility. The white cane is a very rudimentary device which provides information about ground-level obstacles to the user. However, it is ineffective at detecting obstacles that are above waist height but do not touch the ground, such as tree branches or fences sticking out in the path. In addition, the white cane can typically detect obstacles within a distance of 1m, making it less effective in outdoor areas where fast-moving vehicles and other obstacles may be present. With increasing rates of road accidents and pedestrian casualties, it is necessary to help increase the spatial awareness of the visually challenged. One of the simplest ways to do this is to replace the conventionally used white canes with smart walking canes.

Although there have been other projects developed in the past to aid in this mission [2-6], these prototypes still face several drawbacks and limitations. The models reported in

2. and [3] are cost-effective, but employ only a single ultrasonic sensor to detect obstacles present in front of the user, and cannot detect changes in terrain or send SOS messages. Devices that can indicate the distance of the obstacles present in the path of the user have been proposed in [4] and [5]. In [4], the distance of the obstacle is indicated by different vibrational patterns, which would be time consuming for the user to analyse and understand. The model in [5] uses voice commands as feedback and also employs a water sensor, though other terrain detection methods and SOS features are not available. The smart cane proposed in
6. employs multiple sensors for a wide angle of coverage, and contains a GPS and GSM system to send distress messages, but does not provide methods to detect changes in terrain.

In this paper, an accurate, energy efficient and portable smart walking cane has been proposed for visually challenged individuals to aid with their navigation in outdoor environments. The proposed device addresses the limitations of the existing prototypes and aims to provide a better walking aid to the user. The obstacle detection module covers a wide field of vision by employing three ultrasonic sensors, thus making navigation easier. When an obstacle is detected, the information is conveyed to the user through tactile feedback by means of vibration motors. The smart cane can also detect changes in terrain, such as steps or elevations in front of the user, presence of water, and potholes and other depressions in the ground, and sends the information to the user through voice feedback. In addition, the user will be able to send distress messages along with the current location by the simple push of a button when needed. Through the use of the proposed device, the effort and risk taken by visually challenged people during navigation can be greatly minimized.

The following section of this paper explains the design and working of the smart walking cane. Quantitative evaluations of the proposed device have been described in Section III. Section IV highlights the overall reported work and explores the possibilities for further developments in the smart walking cane design.

II. PROPOSED SMART WALKING CANE

A. Construction

The basic frame of the device has been formed by a steel walking cane. A rigid structure made of plastic at a height of 45 cm from the ground level to accommodate the ultrasonic sensor for obstacle detection. The sensors were placed thus to ensure obstacle detection above the knee level. The unit consists of LEDs to be activated when the light goes low through LDR technology.The water sensor was placed at the bottom of the walking cane.

Three vibration motors have been placed within the handle of the cane to provide tactile feedback to the users from the obstacle detectors. The microcontroller module has been placed above the obstacle detection sensors. The system has been wired using jumper cables and ribbon wires.

The GSM module, rechargeable battery and have been accommodated to provide distress signals through calls and messages keeping the device charged up even during the utility. This ensures that the portability of the conventional walking cane is retained.

B. Module Description and Working

The electronic system of the device consists of two major units: The obstacle detection unit,light detector to create beacon for others and the GPS and GSM unit for sending distress signals. The complete design of the device and the GPS and GSM units have been shown in Fig. 3.

The micro-controllers used in this device is the Arduino Mega for the obstacle detection unit and the GPS and GSM units respectively. They have been chosen for their fast access and availability of varied types of input and output pins [7-8]. The micro-controllers are programmed using Arduino software, which enables the use of several code libraries.

The flow of operations in the device is shown in Fig. 4. The values from the various electronic sensors are read and upon being processed, the signals for the corresponding audio and tactile feedback are sent. The device has been programmed to notify the user of the presence of multiple obstacles simultaneously. However, the possible obstacles and terrain variations are assigned priorities contingent upon their danger level. The description and working of the individual modules are given below.

Fig. 1. The Smart Walking Cane Prototype

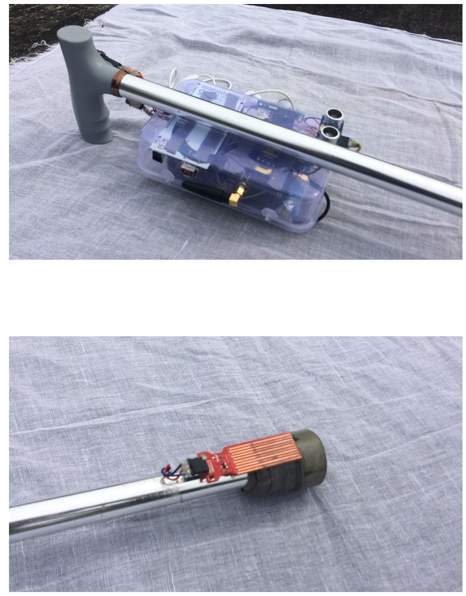


Fig. 2. View of the individual modules – (a) Obstacle detection Unit consisting of LED (b)Water sensor

1) Obstacle Detection Unit

The three sensors used for obstacle detection, the step sensor and the depth sensor are ultrasonic sensors. Ultrasonic sensors have been used due to their high precision within a shorter distance and resistance to external disturbances such as vibration and electromagnetic interference [4].

In this device, the HC-SR04 ultrasonic sensor has been used, which has a detection range of 2-400 cm and a viewing angle of 15°. It can determine the distance of obstacles with an accuracy of 3mm, making it perfectly suited for outdoor environments. It is energy efficient, having an operating voltage of 5V and drawing a maximum current of 15mA. The time taken by the ultrasonic wave to return to the detector after reflection can be determined using the time duration for which the Echo signal from the sensor remains high. The distance of the obstacle from the user is calculated using the formula:

$$D.= v \times t$$

Where D is the distance of the obstacle in m, v is 330m/s, which is the speed of the ultrasonic wave in air, and t is the time duration in seconds for which the Echo signal from the sensor remains high. The distance of the obstacle from the user is then converted to centimetres.

2) Water detection

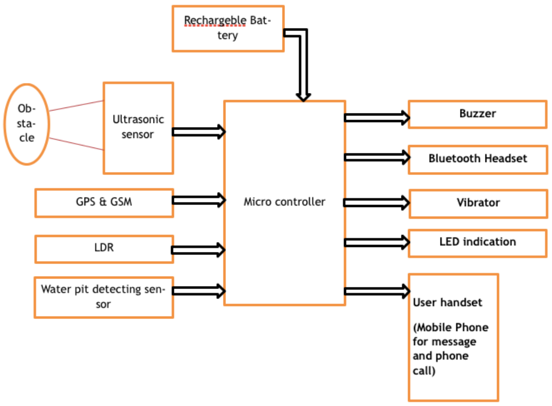
A water level sensor has been used to detect puddles in **the user's path.** The sensor occupies a compact surface area of 60mm×20mm and has a detection area of 40mm×16mm. The device has been programmed to trigger a response when the water level reaches 1cm, so that false triggers are not given in the case of water droplets falling on it due to light rain. Feedback for the water detector has been given through audio commands.

3) Vibration Motors

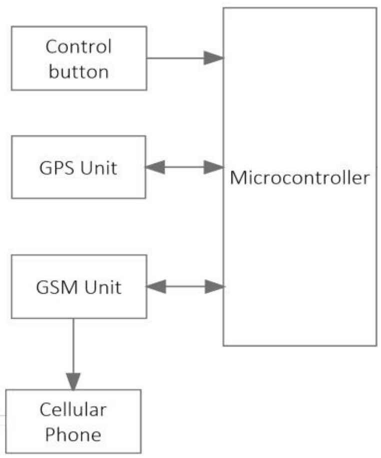
The vibration motors have been attached within the hand rest of the walking cane to provide tactile feedback to the user when an obstacle is detected by the ultrasonic sensors.

When an obstacle is detected by any one of the sensors, the vibration motor is activated. Thus, the device not only indicates the presence of obstacles, but also the relative level of the water present in front of the user. When obstacles are present at multiple locations, the corresponding motors vibrate simultaneously.

The vibration motors used in this device are of the eccentric rotating mass vibration motor (ERM) type. ERMs use a small unbalanced mass on a DC motor, which creates a force that translates to vibrations when it rotates.



(a)



(b)

Fig. 3. Block diagram of the device: (a) Ojus structure (b) GPS and GSM unit

4) Audio Module

The audio module of the device consists of a set of recorded audio segments to be played while detecting elevations, depressions, and presence of water in the path of the user. For efficient playback, the audio is converted to 8-bit, 16KHz mono-channel audio. The audio recordings are then encoded as arrays of PCM data, which are played when changes in terrain are detected. The output signal from the microcontroller is given to an audio amplifier circuit.

The audio amplifier circuit is constructed using the LM386 Audio amplifier, which can provide a gain between 20 and 200. The amplified audio is then given to a 3.5mm audio jack to be played via earphones.

5) GPS and GSM Unit

The GPS and GSM unit is used to send distress messages to stored contacts in the case of emergencies. The working of the GPS and GSM unit is based on the activation of SOS button which helps to integrate the device to the obstacle due to its high priority.

The GSM GPS SIM 808 module is used to obtain the location of the user along with other useful information such as the altitude. This module runs on a 5V supply and draws an average maximum current of 500mA., thus consuming low power. The user can send their location as an SMS to a previously specified contact when they are under duress. The GSM module is used to send the distress call.

Once the distress button on the stick has been pressed, the GPS module starts searching for a satellite fix. When it acquires a fix, the GPS module sends the data that it receives to the controller, which in turn sends it to the GSM module. The GSM module then sends this information as an SMS to the stored contact number. In case the GPS module is unable to get a fix within a period of 5 seconds after pressing the button, a default message indicating that the user is in distress is sent. Algorithm 1 describes the process of sending the distress message using the GPS and GSM module.

6) Power Supply

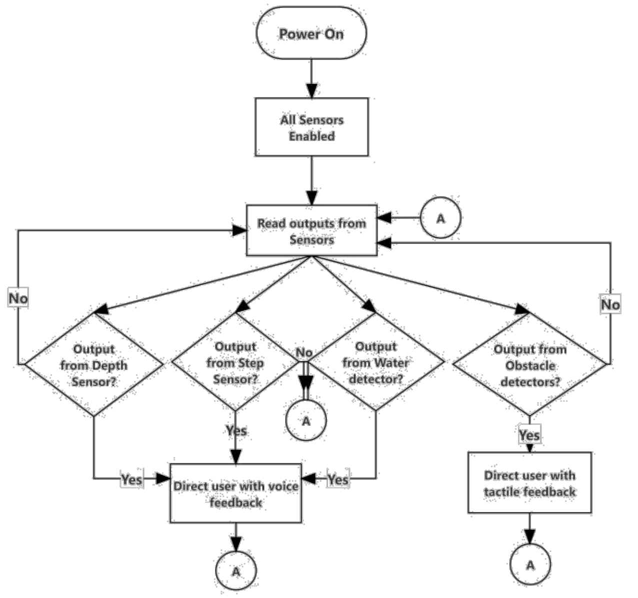
The proposed device uses a 5V, 2200mAh power bank with an output current of 950mA. One of the main advantages of this device is that the battery is rechargeable **and can be replaced with a bigger battery at the user's** convenience. The charging port of the battery is a mini-USB, compatible with a conventional mobile phone charger. The power bank is placed inside the box along with GSM module. The box is designed such that the charging port is accessible from outside. This power supply is capable of supplying the current required for all the devices on the cane.

III. EVALUATION OF THE SMART WALKING CANE

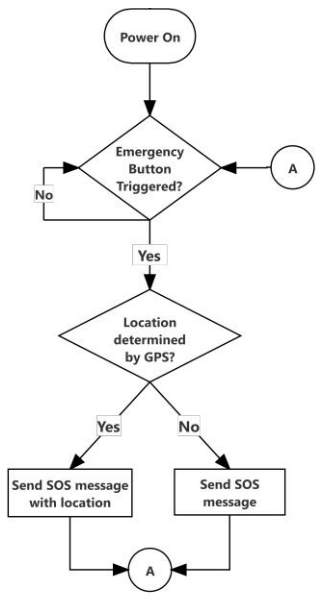
The energy efficiency of the proposed smart walking cane has been evaluated by measuring the current drawn by the various modules present in the device. The peak currents measured for each of the modules have been given in Table

Algorithm 1 Algorithm to send distress signal

```
if (Button pressed)
    Turn GPS on
    Start the Timer
    if (Timer value ≤ 5 seconds)
        if(GPS has a fix)
            Send SMS with coordinates
            Wait for the next button press
        end if
    end if
else
    Send default SMS
    Wait for the next button press
end if
```



(a)



(b)

Fig. 4. Flowchart for the operation of: (a) Obstacle and terrain detection unit (b) GPS and GSM unit

I. The GSM module draws a peak current of 97.7mA when sending the distress message to a contact. However, the quiescent current drawn by the module is only 17.7mA. The GPS module draws a peak current of 59.8mA. Each vibration motor draws a peak current of 21.3mA while vibrating and an idle current of 0.2mA. Thus, they can be **easily powered by the Arduino board's digital I/O pins** which can source a maximum current of 40mA. The GPS and GSM units which are responsible for the highest current consumptions are active only for short durations, thus limiting their impact on the overall power consumption.

IV. CONCLUSION

Ojus can detect obstacles as well as changes in terrain in the **user's path** was presented.Ultrasonic sensors were used for obstacle detection in the path of the user, providing a wide field of vision. Feedback for obstacle detection is haptic in nature, given through vibration motors, while terrain information is conveyed through audio recordings that can be heard through earphones. The GPS and GSM module in the device can be used to send emergency messages to a set of numbers when in distress by the simple press of a button. The modules have been programmed in such a way that the user can be notified of multiple obstacles present simultaneously. From Section I and III, it can be inferred that the proposed device is energy efficient and offers significant improvements over the existing devices. However, there is considerable scope for improvement and addition of features to this device. The ability to distinguish between moving and stationary objects can be added. The smart walking cane can **also be interfaced with the user's smartphone** to integrate the distress signal feature and to introduce navigation from one location to another, which can be enhanced using online resources.

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