

Towards Developing Walking Assistants for the Visually Impaired People

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Abstract— Blindness is the condition of lacking discernment because of physiological or neurological components. Different techniques have been established to define the degree of vision misfortune and visual deficiency. The problems that visually impaired people are facing are that they cannot avoid the objects around them while moving, so accident may occur. Various researches have been conducted to minimize the sufferings of the visually impaired people. But it does not reach to the optimized level. The contribution of this paper is to investigate a solution for the visually impaired people. This paper targets to provide a solution that helps blind to avoid obstacles around them without holding any sticks or other heavy things. The system calculated the smoothness of the surface both for the daylight and dark using RGB data through microcontroller and smartphone. The highest smoothness of the surface is achieved by the system is 96.341% and 98.683% for the day-night and dark respectively. It designs and develops a system which is consisting of small, wearable, lightweight, low-cost spectacle for the blind by which they can get assistance to walk easily and detect obstacles around them.

Keywords- *Blindness; Visually Impaired People; Walking Assistants; Object Detection; Surface Smoothness Detection.*

I. INTRODUCTION

A recent statistics from WHO shows that about 285 million people in the world are approximated to be visually impaired. Among them 39 million are blind and 246 million have a slight vision [1].

Blindness is an interruption to some day-to-day events and there is a lack of new assisting tools [2]. It is a standout amongst the most extreme sorts of handicaps a man must persevere through and, in spite of various progressions in innovation, it remains a significant issue till now [3]. Most of the blind rely on the conventional white cane that has been utilized for navigation by blind for periods. The white cane is exceptionally restricted in its capability to deliver navigational freedom to its clients. Furthermore, the visually impaired people still require the help of sighted people to lead them towards the destinations. These deficiencies drive the requirement for research on evolving inventive navigational frameworks for the visually impaired people. Many innovative explanations usually known as electronic travel aids (ETA) [4] have hence been proposed and executed; yet none have been broadly effective in enhancing the flexibility and lives of the blinds. Many systems exist that use this revolution, for

example, the Guide Cane [5], a device which utilizes echolocation to perceive objects straight in front of the cane and direct the user far from them. While numerous previous tools have been evolved to include components for example echolocation, integration with GPS [6], and recognition of Radio Frequency Identification (RFID) [7] tags, no framework that have been used are well acknowledged by the visually impaired community as a reasonable navigational explanation.

This paper proposes the outline and execution issues of developing walking assistants for the blinds. The device accepts any reflected waves and creates vibration reply to any closer objects. The strength of the sound is proportional to the proximity of the identified object. It also measures the smoothness of the surface by image processing. A line laser splatter device is placed to the surface of the user. When the user desires, the device will inform the user about the smoothness of the surface by voice instruction.

The rest of this paper are organized as follows: Section II discusses related work which has been done in this field by other researchers. The background information about the system is described in Section III. The proposed methodology to develop the assisting tools is outlined shortly in Section IV. Section V represents the experimental results analysis of the proposed methodology. The conclusions of the paper are drawn in Section VI.

II. RELATED WORK

Many devices are designed to guide visually impaired people. Several institutions have been working for a long time to make cost effective and efficient devices for them. The work related to this area is outlined shortly as follows.

Assistive frameworks are already proposed to enhance the life quality and safety for those with uncommon necessities including indoor navigation and way discovering [8]. Some researches have been done where Microsoft Kinect is the main hardware component to help the visually impaired people in navigation since it has depth information as well as RGB data [9]. Kulyukin et al. [10] proposed a system named as RoboCart where the authors used a RFID based system and in here everything is tagged using RFID. However, this system is not applicable in real life since it is practically impossible to tag everything with RFID. Helal et al. [11] proposed a system, named as Drishti, which is another aided framework for the visually impaired people. Here, the authors proposed a

location based system using GPS where location information and maps can be provided but this system cannot be used in a closed area like a living room, conference room, hall room, classroom etc. The speed of GPS's data transferring is also a major problem in this approach.

Sonic-Guide [12], Sonic Pathfinder [13], and Guide-Cane [5] are some developed systems that can only detect an obstacle in front of the user which is truly insufficient. However, these systems can not detect other obstacles on the surface. The white cane [14], and the smart cane [15] are some other tools for the visually impaired people. These also have some limitations like large in size, uncomfortable use, difficulties in using in public places and also have the limitation of detecting few objects only. An idea of a smart wheel chair named 'HARUNOBU-6' is also a blind navigation system developed by Mori et al. [16]. Differential GPS mechanism is used as its basic principle in here. Some sensors are equipped with the wheelchair which helps the visually impaired people to move to a general area. Unfortunately, this system suffers problem similar to GPS. Large physical size, high cost also make the system vulnerable.

III. THE SYSTEM DESCRIPTION

In the proposed methodology, two sonar sensors are used for object detection in front of the blind. By using these sonar sensors, the distance from the object to the user is measured and a vibration is generated which is proportional to the measured distance. The lesser the distance is the more the vibrator vibrates.

Then a camera is used to detect the smoothness of the surface. The camera takes the image of the surface where hole or obstacle can be found. Then the camera sends the image to the smartphone via Bluetooth dongle to process the image. Smartphone processes the images in real time and calculates the smoothness of the surface. According to the smoothness of the surface, the smartphone creates some intelligent voice instructions which can guide the user to move safely. The block diagram of the proposed system is illustrated in Fig. 1. The proposed system consists of two modules. These are the wearable spectacle module and smartphone module. The wearable spectacle module detects an object center and takes the image of the surface for processing. The smartphone module receives the image sent from the wearable spectacle module and then processes the image and finally calculates the smoothness of the surface.

A. Wearable Spectacle Module

The wearable spectacle module is integrated within the spectacle which the blind will wear. The components of the wearable spectacle module are (i) Embedded microcontroller LPC1768: It controls the camera, sonar sensor, and vibrator and sense the captured images and send the images to the smartphone via Bluetooth (ii) LinkSprite JPEG Color Camera: Takes the images of the surface on command from the microcontroller, (iii) Bluetooth Module RN-42-I/RM: Sends the images to the smartphone, (iv) Microcontroller PIC12F683: Controls the sonar sensors and vibrators, (v) LV

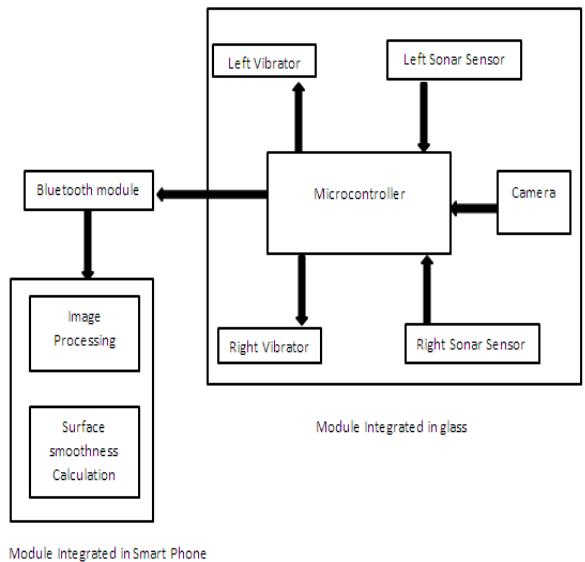


Fig. 1. Block Diagram of the Proposed System.

MaxSonar EZ0: Detect the obstacle around the user, (vi) Mini Vibration Motor: Alert the user to avoid the obstacle.

B. Smartphone Module

In the smartphone module, a smartphone is used which receives the image that is sent from the camera via Bluetooth dongle and then processes the image to give result whether the surface is smooth or not. If there is any obstacle on the surface then the mobile application will alert the user about the obstacle via voice instruction. A smartphone application is developed which possesses four units. These are the Image Processing Unit, Time Checker Unit, Temperature Checker Unit, Location checker Unit.

IV. THE PROPOSED METHODOLOGY TO DEVELOP THE ASSISTING TOOLS

The proposed methodology works with several phases. These phases are illustrated in brief as follows.

A. Object Detection

The first phase of the proposed methodology is object detection. It is composed of three sequential steps. These are (i) Interfacing the Sonar Sensors (LV MaxSonar EZ0), (ii) sending and receiving ultrasonic sounds, (iii) Calculating the distance of objects.

At first, the sonar sensors are interfaced with the microcontroller. Two ultrasonic sensors are utilized in here which assess the characteristics of a target by translating the echoes from radio or sound waves individually. Ultrasonic sensors produce high-frequency sound waves and assess the echo which is received by the sensor. Sensors compute the time interim between sending the signal and receiving the echo to decide the distance of an object. Then the distance is stored in the microcontroller and vibration is generated according to the distance. The elevation angle of the used sonar sensors is 60 degree. So, two ultrasonic sound sensors are placed with 60-degree angle so that they can detect individual objects from the left, front and right side. When there is an obstacle on the right

side then it is detected by the right sensor and the right vibrator vibrates as a result. When there is an obstacle on the left side then it is detected by the left sensor and consequently the left vibrator vibrates. When both left and right sensor detect an object in front of them then both vibrators vibrate and it means that the object is in front of the user. The two sensors are placed with 60° angles.

B. Surface Smoothness Detection

The aim of this section is to calculate the smoothness of the surface. The approaches adopted in this phase are (i) The image of the surface is captured, (ii) Then the image is sent to the smartphone from the microcontroller via Bluetooth dongle, (iii) At last, the image is processed and the smoothness of the surface is calculated.

C. Taking and Sending Images

In this part “LinkSprite JPEG color camera” starts capturing the images, processes the images and sends it to “LPC1768” microcontroller and microcontroller stores it into a file. As the JPEG image file starts with “FF D8” and ends with “FF D9”, the camera will stop capturing the images until the microcontroller receives “FF D9”. Then “LPC1768” microcontroller read the file where JPEG image is stored and sends the whole file asynchronously (each time 4 bits) to the smartphone via Bluetooth. Several functions are performed to complete these jobs.

D. Receiving and Processing Images

The images are received into smartphone. Smartphone first connects with wearable spectacle module using Bluetooth. As smartphone Bluetooth input stream receives byte (8 bit) by byte and the wearable spectacle module works with only 4 bits, thus 8-bit data needs to be converted into 4-bit data to receive original data. Next step is to construct the original image. The hex data is received and the data is converted into a byte array and write this as ASCII format in a file to construct the original image. When all the images are received then these are written into a file to construct the original JPEG image. Finally, original JPEG image is received by the smartphone application which was sent from the camera. The straight line of the laser in the images demonstrated that the surface is smooth. Fig. 2(a). demonstrates no obstacle on the surface thus the laser line is straight. But if there is any obstacle in the surface then the laser line will not be straight all along. The scenario of laser line is depicted in Fig. 2(b) where there is an obstacle on the surface. The smoothness of the surface is calculated according to the nature of the obstacle and presence of any hole in the surface. The 80% smoothness of the surface demonstrated that the obstacle or any hole in the surface is tiny and ignorable. The 50% smoothness of the surface implied that there is obstacle or hole in the surface.

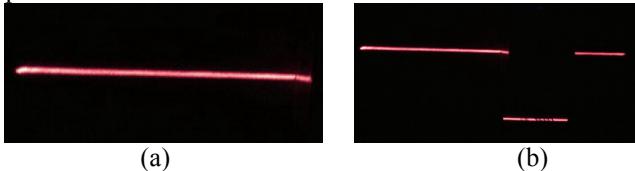


Fig. 2. (a) The laser line is straight since the surface is smooth. (b) The laser line is not straight all along since the surface is not smooth.

A challenge came up to match the color of the laser. Several images were taken and the RGB values of the laser line were analyzed. By analyzing the RGB values, a relation between RGB values for laser line and a range of RGB color to match with laser line pixels have found. The analysis was gone through the each row and counts the matched pixels of the laser line. Finally, a percentage of the smoothness is calculated by subtracting the total sum of matched pixels of rows from total columns. Then the system informed the user about the smoothness of the surface and the condition of the obstacles.

V. EXPERIMENTAL RESULTS ANALYSIS

The experimental results that were obtained to measure the performance of the proposed are detailed shortly as follows.

A. Object Detection

The performances of object detection are evaluated by calculating the errors at different areas and also by comparing the actual distance and measured distance. The errors at different areas are calculated and plotted them in a 3D-graph. Six areas or regions are considered for the experiment each area interval is 60cm. The areas are Area 1: (0-50cm), Area 2: (51-100cm), Area 3: (101-150cm), Area 4: (151-200cm), Area 5: (201-250cm), and Area 6: (251-300cm). The accuracy of the two sonar sensors is calculated in these areas individually. The different objects are placed at different regions and the sonar sensors are set to detect the objects. The errors at different regions are calculated and illustrated in Fig. 3.

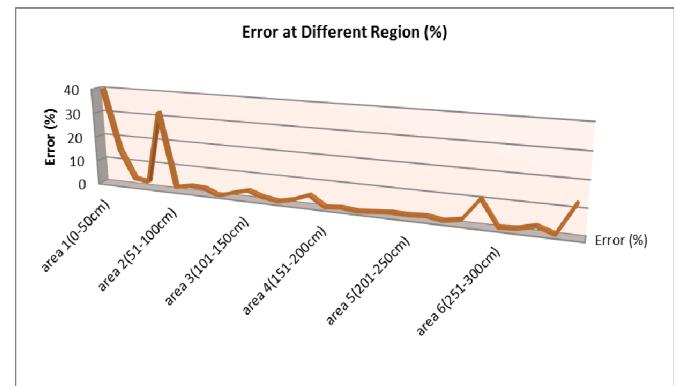


Fig. 3. Error at different regions.

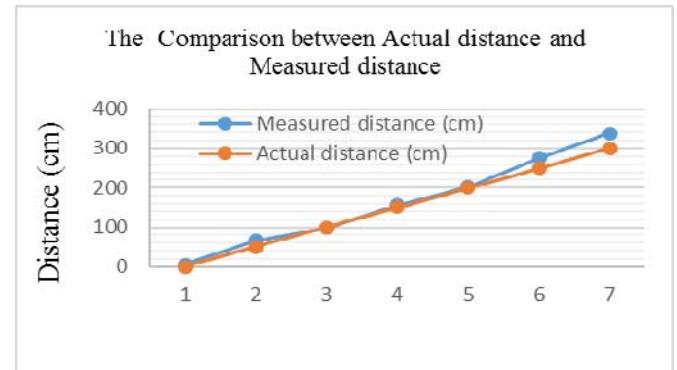


Fig. 4. The comparison between actual distance and measured distance.

The error rate at area 1 and area 2 are about 39% and 31% respectively and these are comparatively higher than the others. The error rates of the remaining areas are near about zero which depicts the higher accuracy of the proposed method.

The error rate becomes higher when the obstacles are closer (<60cm). Hence, we can conclude that the average error rate is within acceptable range. After calculating the error at different areas, the actual distance and the measured distance are compared. A significant accuracy is found. As shown in Fig. 4, the comparison between actual distance and measured distance which is found from the experiment. Fig. 4 demonstrates that the measured distance and actual distance is almost same at the beginning. Then a slight variation between the distances in area 1 and area 2 is noticeable. The distances from 100 cm - 200 cm (actual) are identical. Then the measured distance increased slightly after 250 cm (actual).

B. Surface Smoothness Detection

The smoothness of the surface is measured and evaluated for different scenarios. Fig. 5 portrays the accuracy of smoothness calculation of the proposed method for several images that were captured during daylight and dark. The Fig. 5 (a), 5 (c), 5(e) were captured during daylight and 5(b), 5(d), 5(f) were captured during dark. The corresponding smoothness of the images that were calculated by the proposed method are shown at the bottom of each figure. It is observable from this figure that the proposed system detect the smoothness of the surfaces within acceptable ranges at both dark and daylight conditions.

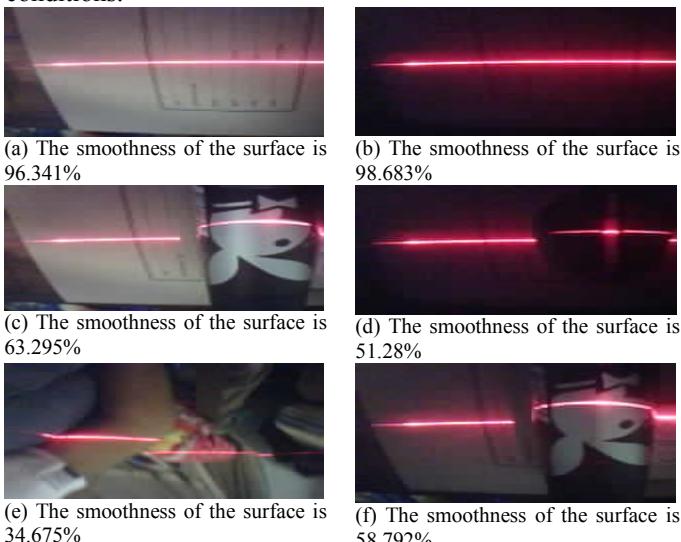


Fig. 5. The smoothness of the surface in Daylight and Dark.

VI. CONCLUSIONS

This paper proposes a new method which aids the visually impaired people to walk without any collision with obstacles. The obstacle may reside on the left, right or straight. The responses will be given on the basis of the obstacle's position and distance. It also determines the presence of the hole or small obstacle on the road which is done using image processing. Though this system has limited accuracy level in terms of distance and surface smoothness, it can assist the

visually impaired people up to the extent to walk in general scenarios. In future, this paper can be enhanced in a way such that only one single device can be developed which will be integrated into a spectacle. The visually impaired people just wear the spectacle and walk on the road with the assistance of this spectacle.

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