REMOTE CONTROLLED HUMAN NAVIGATIONAL ASSISTANCE FOR THE BLIND USING INTELLIGENT COMPUTING

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ABSTRACT
The smart walking stick helps visually challenged people to reach their destination with the help of humans, guiding them remotely. A lot of work and research is being done to find ways to improve life for visually challenged people. There are multiple walking sticks and devices which help the user to move around- indoor and outdoor locations, but none of them provide run time autonomous navigation with direct human assistance. Blind Assistance through Remote Control (*BARC*) is a device which provides aid to the visually challenged, by humans, through a web platform from anywhere. An image sensor mounted on the *BARC* transmits live video to the volunteer's phone which helps the volunteer to control the stick remotely and navigate the blind to the destination. A web platform is an intermediary between the visually challenged and the volunteers. It is used by the blind to send requests and find volunteers willing to help them navigate to their destination. *BARC* is a passive intelligent stick which combines mobile computing along with hardware support such as micro controller, image sensor, and ultrasonic sensors to navigate the visually challenged to their destination.

Keywords
BARC; Blind; Navigation; Autonomous; Human Guidance.

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1. INTRODUCTION
Blindness means the inability of visual perception due to physiological or neurological factors that cannot be fixable by usual means, such as glasses. The term blindness is used for complete loss of vision or nearly complete loss of vision. In both cases it causes people difficulties to perform their day-to-day activities such as driving, reading, socializing etc.

Navigation from one place to another is one of the most fundamental functions. There are various natural solutions to this, like using a cane stick, using the help of a dog to walk, a human assisting you to the destination. Among the various solutions the best is the human directly navigating them to the destination. But the availability of a volunteer at all places is difficult, so in this paper we put forward a system, where the blind is guided to the destination through remote human aid.

The BARC is passive type intelligent stick, which aids the blind to reach their destination through remote human aid. The blind uses a custom app to register a request for aid in a web platform; this is broadcasted to all registered volunteers. The BARC has an image sensor which transmit live video feed from BARC to the volunteers app. Using this live video feed the volunteer can navigate the BARC using controls in his app. The BARC also has ultrasonic sensors to avoid obstacles. The Web platform in addition provides additional features such as security mechanism, path guidance and weather forecast.

2. LITERATURE SURVEY
There are a lot of devices which assist the visually challenged for navigation indoor and outdoor. All these devices rely mainly on Global Positioning System (GPS) alone, to navigate around. These solutions based on GPS are not always reliable because of their low accuracy. All these navigational devices give instruction to the blind on how to navigate, in which case the user still has to think and move around i.e. it is not autonomous. None of these devices physically help to the blind move around. The basic properties and limitations of existing devices are discussed.

Indoor/Outdoor Blind Navigation System and Service [7]: The system known as drishti uses precise position measurement system, wearable computer, and vocal communication interface to guide the blind. In outdoor the system uses DGPS as its location system to keep the user as close as possible to the central line of side-walks of campus and down-town areas also it provides the user with an optimal route by means of its dynamic routing and re-routing ability. In indoor OEM ultrasonic positioning system is used to provide precise indoor location measurements thus conveying the layout of the indoor facility. The user is given vocal step by step walking guidance to avoid obstacles in indoor environment.

Mobile-Cloud Pedestrian crossing guide [4]: The system is based on mobile cloud computing providing real time guidance for the blind at pedestrian crossings. The computational power of resources made available by the cloud computing providers is used for real time image processing. The two main components are the mobile device with GPS and Cloud Server. The mobile device is used for location, obstacle detection and avoidance as well as interacting with the users. An external camera is used to capture the image of the pedestrian crossing which is sent across to the cloud server by the mobile device to process the image and give details about the crossing to the blind.

Smart Assistive Device for Visually Impaired People [10]: The model consists of two modules- cane and shoe units, both are integrated together through Bluetooth connectivity and offers solution for orientation through digital compass. The IR ranging sensors used in the shoe and cane together provide information to the user. It also incorporates a pressure switch to alert the user if the blind person loses hold of the cane. LED lighting system on the cane helps to alert the crowd about the presence of the blind person. All of these together reduce the risk of injury to the blind person.

Voice Enabled Smart Walking Stick [3]: It consists of a simple walking stick equipped with ultrasonic sensors to give information about the environment, like object detection, pit sensing and water sensing. GPS technology is integrated with pre-programmed locations to determine the optimal route to be taken. The user can choose the location from the set of destinations stored in the memory. Also consists of voice enabled equipment which would be used in private domain.

Walking system with image matching [6]: Kenta Yamamoto, Katsuya Suganuma, Daisuke Sugimori, Masaki Murotani have come up with a system which is a walking support system for the visually challenged. It has 3 components, the first is used to find the best path to reach the destination making use of algorithms, the second component is to aid the user to navigate to the destination, and the third component is route maintenance and route recovery making use of camera based solutions to prevent route deviation. While the system proposes an optimal navigation method, it is not autonomous. All these systems mentioned above are used for object detection and identification but they are not autonomous. In order to overcome these disadvantages we propose a following system – Remote Controlled Human Navigational Assistance for the Blind.

3. SYSTEM ARCHITECTURE

Figure 1. This figure shows the system architecture for the proposed system.

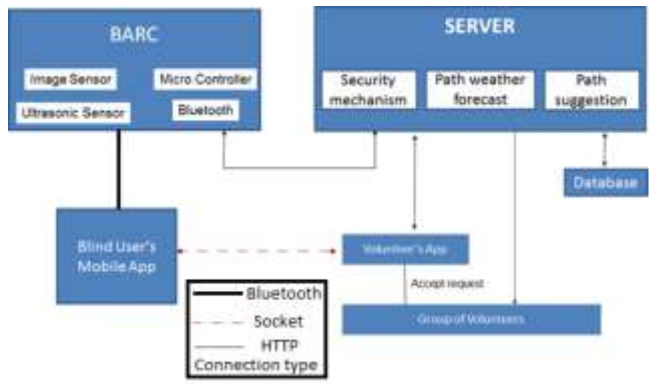

Figure 2. This figure shows the functional architecture for the proposed system.

Fig.1 is conceptual model that defines the behavior and structure of the system. It shows the various components in the system and their behavior and how they are interconnected. Fig.2 shows us the different functions in the system and how they interact. It defines how they operate together to perform the system's missions.

4. SYSTEM DESIGN

Our proposed system consists of a walking stick powered why servo motors, ultrasonic sensors, micro controller, a web platform, the blind user's app and the volunteer's app. We shall see in detail how these components interact with each other to provide a system that aids the visually challenged to reach their destination autonomously. We divide our system into two parts

- Hardware
- Software

4.1 Hardware

The BARC is a walking stick with 4 wheels in the bottom powered by two- 12v, 360 degree continuous rotation servo motors. The two motors are controlled accordingly to move the stick in all directions. Servo motors receive a control signal that represents an output position and applies power to the DC motor until the shaft turns to the correct position, determined by the position sensor. Pulse Width Modulation technique is used for the control signals of servo motors. The BARC is powered by lithium batteries

There are three ultrasonic sensors placed suitably on the BARC. The Ultrasonic Sensor sends out a high-frequency sound pulse and then times how long it takes for the echo of the sound to reflect back. The sensor has 2 openings on its front. One opening transmits ultrasonic waves, the other receives them. This time is then used to compute the distance of the object from the device using the formula

$$\text{Distance} = (\text{time} * \text{speed of sound}) / 2$$

Equation 1. This equation is used to calculation distance

A threshold distance is set in the BARC, below which if an object is detected, the user and the volunteer is warned about the object.

A Bluetooth module is used to achieve communication between BARC and the visually challenged person’s mobile phone. This communication medium is used by the ultrasonic sensor, image sensor and the motors to transmit their data to the phone and vice versa.

An image sensor is mounted to top of the BARC. This image sensor is used to continuously relay video feed to the blind person's app through the Bluetooth module which is then forwarded to the volunteer's app. This visual feed is used by the volunteer to see what is in front of the blind person and to navigate him around obstacles to the destination. Pixy CMUCam5 is used as a image sensor. It is a powerful processor that you can program to send only the information you are looking for, so that your microcontroller isn't overwhelmed by data. Images are viewed at a very rapid pace which makes it look like a video.

The BARC has one microcontroller. It is used to interface the hardware components with the smart phone. All the data from various sensors are sent serially to the microcontroller and is transmitted to the Smartphone through the Bluetooth module and vice versa.

4.2 Software

4.2.1 Web platform

The system has a web platform used to register volunteers and requests from the users, acts as an intermediate between the two. Any volunteer who wants to help in navigation of the blind can register in this web platform and will be notified on registration of a request from the blind. When a blind user submits a request for navigation to the destination, this request is stored in a database of the web server. This request is then broadcast to all the volunteers registered. When a volunteer accepts the request, the request information is transferred to their account and they can control the BARC from their phone to navigate the blind person to their destination. Apart from this basic navigation system, the web platform performs some additional features

- Path aid
- Security

4.2.1.1 Path Aid

The current location of the blind user is constantly fed to the server. This information is used to retrieve weather forecast information for that location using Google services. This forecast is then informed to both the volunteer and the user. The volunteer has to navigate the blind person to their destination. The volunteer's app aids the volunteer with the navigation by providing directions to the volunteer, through voice output. This is similar to the voice guidance in GPS. The ultrasonic sensor's data is constantly monitored by the server and it warns the volunteer of objects detected and their distances. This information helps the volunteer to detect and navigate around small obstacles also.

4.2.1.2 Security

One of the main concerns in terms of safety is – not to misuse the user's location. In the server, all possible routes to reach the destination is computed and warns the user if the volunteer deviates from the possible paths. The entire path along with the volunteer's profile is logged in the server, in case of any incident this information’s can be used for enquiry.

4.2.2 Prototype

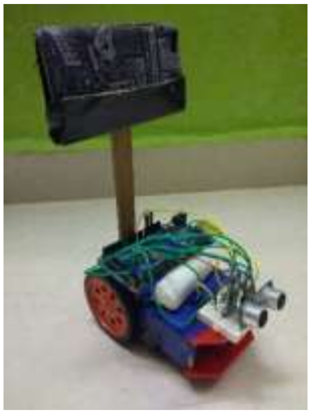

Figure. 3. Prototype designed for the proposed system.

Fig.3 is a prototype designed. Here the smart phone is used as the image sensor which feeds live video feed. It is fitted with all sensors as discussed above and can be navigated to the destination by a volunteer. The blind person has to hold on to the device using a strap and can be navigated to the destination

5. PROPOSED APPROACH

The proposed obstacle detection and navigation process is explained step by step:

1. The blind person enters the destination address in his app through voice input.
2. The blind person's request is stored in the server.
3. Request information’s are broadcasted to all the registered volunteers.
4. When a volunteer accepts the request, the corresponding information is transferred to his app.
5. Live video feed from BARC's image sensor is transferred to the volunteer's app.
6. By looking at the video being transmitted and using the direction control buttons the volunteer controls the BARC, to navigate the blind to the destination.

7. The server informs both the blind and volunteer additional information such as weather forecast, traffic details.
8. The entire navigation is logged, and the user is warned if the volunteer tries to deviate from the possible paths to reach the destination.
9. The ultrasonic sensor's data is constantly monitored by the server and it warns the volunteer of objects detected and their distances
10. In case of connection loss, the system handles it in the following ways
    i. First it immediately tries to reconnect to the same volunteer.
    ii. If connection to the same volunteer fails, automactically another request is submitted in the web platform. Meanwhile the user is navigated to the destination from the directions received from google maps webservice.
    iii. A LED in the BARC starts glowing to indicate that the blind user might need assistance
    iv. Once another volunteer accepts the request, navigation switches to the volunteer's directional guidance and continues to the destination

6. FUTURE SCOPE

Our future work will be more on concentrating on options that can be utilized in case of connection loss. When the volunteer is navigating the blind to the destination in case of any connection loss, the situation has to be handled properly without leaving the blind user stranded. Future work will also involve adding additional object detection features and improving the battery lifetime of the device.

7. CONCLUSION

Travelling from one place to another is a fundamental function. Blind people have to face many difficulties and obstacles if they want to move from one place to another. The best solution to this issue is for a volunteer to personally help the blind to reach there destination. In order to help the blind reach their destination and provide a way for volunteers to help them, we propose a system. This system provides a walking stick which aids the blind to navigate to the destination, remotely controlled by a volunteer through the web platform. In addition to basic navigation controls additional features like security and path guidance is also provided by the system.

8. ACKNOWLEDGMENTS

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