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Implementation of Obstacle Detection and Navigation system for Visually Impaired using Smart Shoes

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Abstract – *The Highly over sighted field of application for the visually challenged people has put it in a despair. Current solutions prove to be insufficient or end up being highly expensive. Today's technological advancements must benefit, above all, the most disabled. In this paper we have surveyed the existing solutions meant for autonomous mobility for the visually impaired people as well as proposed a novel design, Smart Shoes with embedded sensors to guide a visually impaired person while navigating and to alert him or her of the obstacles that lay ahead in his path. The design is aimed to develop an easy to use Android application to cater to the special needs, used to guide the person coextending the features of the Smart Shoes.*

Key Words: **Embedded system, Arduino , Android Visually impaired, sensors.**

1. INTRODUCTION

Embedded systems are the systems with a major mechanical or electrical dedicated function often integrated with real-time computing systems. They have a control access to all the real-time operating systems in our day-to-day life.

Android is an operating system developed by Google for mobile systems. It is based on the Linux kernel and designed for touch-screen mobile devices such as smart-phones and tablets. Andriod phone's UI is direct manipulation based and by using touch gestures with features such as swiping, tapping and pinching for changing the on-screen objects with a feature of virtual keyboard for inputs.

Our primary objective here is to make the best use of the sensors which are available at hand for real time obstacle detection and navigation. The sensors to be used need to of minimum size and cost providing maximum functionality in order to help a visually impaired person navigate and move around autonomously.

The usage of Android is restricted to its features which are not visual but will still help a visually impaired person. The user needs to be able to launch his application without having to view anything on the device with the sole help of the hardcoded keys on the Android device. All the features of the sensors, Arduino microcontroller and Android are to be combined to design a new device for autonomous mobility of a visually impaired person.

2. RELATED WORK

A complete and reliable sensing system for obstacle detection can value a lot from the collective usage of numerous types of sensors, especially from the active - passive combination. Any precise type of technology may have hitches to meet all necessary necessities in order to detect an obstacle in various lighting or weather conditions. The muddle background and intricate moving patterns of all objects which may appear on a road scene in urban streets demand erudite processing of sensor inputs. In order to overcome this problem, a sensor - fusion and segmentation approach can be used. From the technology's point view, different sensing technologies such as ultrasonic sensor, laser scanner, microwaves and computer vision can be used for obstacle detection task. The main problem is to design algorithms that are robust enough to reliably detect and warn for any obstacles that can appear in front of the user on the road area.

In [1]A.Discant et al. speaks about the different types of sensors such as active and passive sensors. It also throws light on various sensing systems designed using the combinations of these sensors.

[2] This paper presented the use of ultrasonic and infrared sensors for distance dimension in the enlargement of an obstacle detection system for senior and people with vision impairment. Investigational results show that ultrasonic and infrared sensors have diverse characteristics in terms of output voltage measurements. It is clearly designated that ultrasonic sensor gives a linear output representative whereas infrared sensor shows a nonlinear output representative. Both sensors are able to detect an obstacle at the distances within their usable range with percentage of precision between 95% and 99%. The experimental result indicates that the US and IR sensors are able to provide reliable distance measurements even with different colours and materials of obstacles. Another thing that has been shown is that IR sensor has slightly advanced resolution than that of the US sensor, particularly for slight distance measurement within their usable ranges. The system is designed to determine the sensor location only when the user is touching his foot completely on the ground with the sensors pointing forward.

[3] A motion supporting device is proposed which can be used to help navigate in the surroundings and avoiding from collisions with obstacles. This could help decrease health costs incurred and improve the quality of care and independence of the elderly. Conventionally, mobility-assisting devices have been electromechanical devices, in which the main function is to provide physical support for the elderly whilst moving around using canes and wheelchairs. Microcontroller and wireless network applications and usages have increased the functionality of these devices in terms of obstacle detection and information processing. They have also brought in stirring new concepts, which make these devices to be hands free and small. The system here proposes use of ultrasonic sensors which are able to detect a wide range of obstacles including from walkway to the tall buildings, as well as stairs and uneven surfaces making the user aware of the objects before making a contact with the objects few yards away depending on footstep of the impaired person.

[4] It provides a comprehensive summary for convention of navigation systems for visually impaired people as a technique designed for art. Achievement of usability for the navigation systems for large-scale lacks due to unaffordable costs, accuracy and user efficient needs as concluded by this. Further, in the future, navigation systems need to firstly reduce the installation expenditure by curtailing the infrastructure disagreements that is required for confining the consumer. Usability can to be enhanced by curtailing the amount of sensors users have to carry and also providing usable directions in a vigorous modality of feedback. Systems need to take into account the user's special necessities, minimize intellectual load, cost effective, user friendliness and minimize any meddling from the surroundings.

[5] An ultrasonic sensor based navigation system for blind people, where the system consists of microcontrollers having the feature of synthetic speech output and portability to guide the user for the obstacles to think and update the next move. This device uses the principle of echo of high frequency ultrasonic beam to detect hindrances in the path. This mobility support instructions are given by vibro-tactile form r to reduce navigation complications. A shortcoming of ultrasound is that walls may reflect or block ultra sound signals, which result in less accurate localization.

[6] Vibration and voice operated navigation system developed using ultrasonic sensors to detect obstacles. Since visually impaired people are more sensitive in hearing and possesses strong perception than ordinary people. So this system gives alert through vibration and voice feedback. System works in indoor as well as outdoor navigation and focus on continuously sensing surround obstacles and alerting through vibration and voice feedback. Depending upon the distance between obstacle and user different intensity levels are provided to vibration motor to alert user's mobility.

3. PROPOSED SYSTEM

The scope of this product covers its usage by visually impaired and blind people who cannot find their way without use of an explicit tool or some other persons help. The idea is to use a daily use apparel that is our shoes to guide the user to his/her destination with description of obstacles in his/her path. The product does not deal with guiding about how to avoid the obstacle but it defines a way to notify the user about the presence of that obstacle so that the next step from the user will be taken accordingly with-respect-to the position of the obstacle.

This product is an innovation designed for helping the visually impaired people to be able to navigate without using any external tool other than their smart phones and shoes. It works as an audio guidance system which takes inputs from the sensors attached to the shoes of the user and gives the output in form of audio instructions. The application designed for the same shall also have an interface with Google Maps in order to have the real time navigation.

This product initiates and performs following major functionalities:

- For navigation internally call the Google API
- Voice commands for reading and directing the path from the source to the destination.
- Detection and categorization of the objects near the user's environment.
- Intuit the user through voice commands for the existing position of the user and the obstacle which is in its vicinity along with its type.

Recognizable hardcoded keys on a smartphone device, such as volume up or volume down key for starting up the application for a visually impaired person. Google maps running in the background as well as on the screen whenever the app gives a call to the Google maps internally.

Software's usually available and are usable are the components for Google maps to run in dynamic conditions which are an internet connection and a location tracker, inbuilt in the smartphone, for location tracking.

Real time processing may be the most critical implementation of the proposed system. The software should have a capability to do real-time processing of the obstacles detected by the sensors. The necessary detection, processing and transfer of these details to the Android via Bluetooth in minimum required time, is imperative. For effective use of battery life of the batteries present in the shoes, it is necessary that the computations be kept to a minimum.

The text to speech conversion, to inform the user of any possible obstacles, has to be done in least possible time.No delay can be tolerated in this as the entire processing time saved will be rendered useless if the text to speech is done ineffectively.

All the equipment for the obstacle detection, i.e., sensors and Arduino Nano will be placed in each of the shoe with

batteries attached and thus the chances of losing equipment strength is more if not wore properly and due to worst wear and tear of the SmartShoes. Percolation of water has to be avoided as far as possible to keep an efficient functioning system.

It is also expected that the user be accustomed to all the conventions of the app before actually putting it to use in real life scenarios such as roads and crossings. It'll be safe to first use it in a safe inside space before taking it to a hostile environment. The user should also confirm the battery levels before usage so that nothing stops working in the middle of a hostile scenario.

3.1 Algorithm & Flow

Dijkstras Shortest Path Algorithm used by google Maps:

1. *function Dijkstra(Graph, source):*
2. *create vertex set Q*
3. *for each vertex v in Graph: // Initialization*
4. *dist[v] ← INFINITY // Unknown distance from source to v*
5. *prev[v] ← UNDEFINED // Previous node in optimal path from source*
6. *add v to Q // All nodes initially in Q (unvisited nodes)*
7. *dist[source] ← 0 // Distance from source to source*
8. *while Q is not empty:*
9. *u ← vertex in Q with min dist[u] // Node with the least distance will be selected first*
10. *remove u from Q*
11. *for each neighbor v of u: // where v is still in Q.*
12. *alt ← dist[u] + length(u, v)*
13. *if alt < dist[v]: // A shorter path to v has been found*
14. *dist[v] ← alt*
15. *prev[v] ← u*
16. *return dist[], prev[]*

Obstacle detection algorithm:

1. *Start*
2. *Read users destination input.*
3. *Pass the input to Google Maps api.*
4. *Start the navigation.*
5. *If ping returns true then*
6. *Calculate the distance of obstacle*
7. *Return the obstacle detection on front with distance as voice*
8. *If IR sensor returns true*
9. *Return obstacle detection on left/right as voice*
10. *Repeat 5-6 till app is running*
11. *Stop*

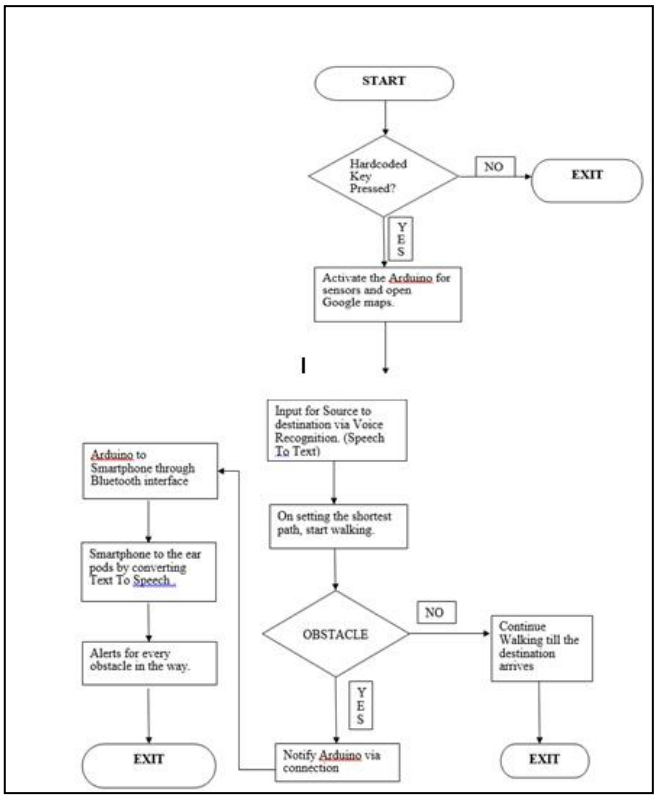

Fig -1: Flow Diagram

The primary attribute of this application will be usability given to the visually disabled user solely using voice commands, hard coded keys and text to speech conversion. The navigation system from the Google Maps will provide the destined route to the user without having to ask for any directions or help. The sophisticated obstacle detection system will be presented in a reasonable and understandable manner to the user so as to avoid any obstacles that might present themselves in the path.

4. ARCHITECTURE & WORKING

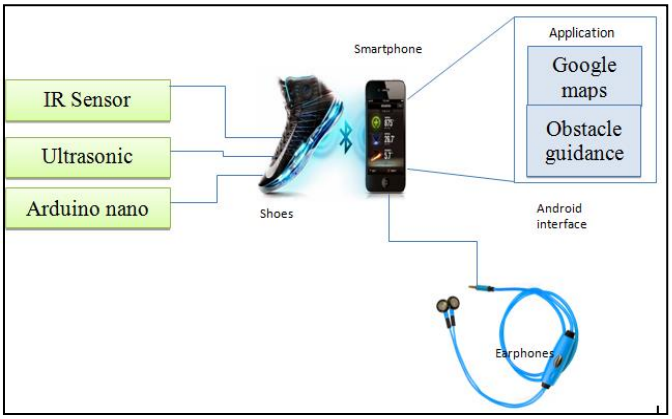

Fig -2: System Architecture

Above figure illustrates the architecture of the navigation system. The Smart-shoes are embedded with An IR sensor and a ping Ultrasonic sensor. The ping sensor is mounted on front and the IR sensor is mounted on the side of the shoe.

The sensors send their data to an arduino nano chip mounted at the back of the shoe. This sensed data is then sent to an android smartphone using a Bluetooth module HC05. The specially designed android app that is running on the user's smartphone establishes a connection with this Bluetooth module and sensor data is received by the android device.

This received data is processed at the android system and necessary guidelines are provided to the user through voice commands. This complete processing occurs between the navigation systems running in the background based on users destination input. The voice instructions include the navigation guidelines along with the details of presence of an obstacle in the users path.

The constitution of both the shoes is almost similar with an exception of one of them having a transmitter and another one having a receiver for inter communication between the shoes.

Following figure shows the interaction of various components of the system:

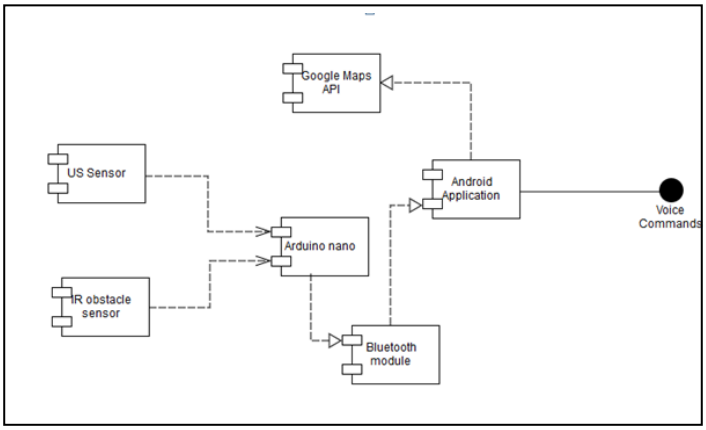

Fig -3: Component Diagram

Above component diagram shows the various components used in our project and their dependencies on each other.

1. **US and IR Sensors:** Role of these components is to detect oncoming obstacles.
2. **Arduino nano:** This component is used to embed the sensors and Bluetooth module on it.
3. **Bluetooth module:** It is used to communicate the data received at arduino to the smartphone.
4. **Android Application:** This component aggregates all th incoming data and generates necessary output
5. **Google Maps:** This API is called by the android app to run in the background.

5. CONCLUSIONS

After studying the results of various approaches described in this paper, we propose smart shoes for obstacle detection and navigation by visually impaired people. The smart shoes are acquired with Arduino, which is a type of embedded system. Rather than having a complex system which is non-portable, embedded system deals with all the functions which a user wants to perform at that instance. The processing of data will be done dynamically as the user walks with the sensors activated. The processing of the values will be communicated from the sensors to the Arduino board and the through the interfacing hub to the smartphone. This, the complexity and the time will be low and the obstacle and be detected in fraction of seconds.

The proposed system will automate according to the real time pathways and the obstacles coming in between. Obstacles will be processed by the given algorithm programmed into Arduino as well as the communication will be initiated as per the Android interfacing Algorithm. The sensors will sense the obstacle and will give out the values, thus measuring the distance of the obstacle from the sensors. Depending on the values given by the sensors the arduino will process the values for simplicity and through interfacing device will be passed to the Android smart phone. Once the values are received, with the text-to-speech algorithm, user would be able to hear the distance from the current position. However, this process works with no internet connection for better usability of the user. For navigation purposes an API is used to run a Google maps application in the background at the same time when the shoes detect the obstacles.

Hence, a visually impaired person can sense, feel, listen and walk with the ease of use and faster response time with the environment around him with the help of these Smart Shoes.

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