Autonomous Walking Stick For The Blind Using Echolocation And Image Processing

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***Abstract*—The smart walking stick, the *Assistor*, helps visually challenged people to identify obstacles and provide assistance to reach their destination. The *Assistor* works based on the technology of echolocation, image processing and a navigation system. The *Assistor* may serve as a potential aid for people with visual disabilities and hence improves their quality of life. There is a lot of work and research being done to find ways to improve life for visually challenged people. There are multiple walking sticks and systems which help the user to move around, indoor and outdoor locations but none of them provide runtime autonomous navigation along with object detection and identification alerts. The Assistor uses ultrasonic sensors to echo sound waves and detect objects. An image sensor is used to identify the objects in front of the user and for navigation by capturing runtime images and a Smartphone app is used to navigate the user to the destination using GPS (Global Positioning System) and maps.**

Keywords—Autonomous walking stick; Blind; Assistor; GPS Application; Image Processing; Echolocation

I. INTRODUCTION

Blindness means the inability of visual perception due to physiological or neurological factors. Many blind people have trouble maintaining a proper circadian rhythm due to the lack of visual input to their brains. In one's life navigating from one place to another is one of the most important and fundamental functions. Visually challenged people face this problem on a day to day basis. Many blind people are dependent on others for navigation.

To be categorized as blind, there is a total loss of vision. Blindness cannot be corrected by simple visual aids such as glasses. For the indigents blindness is a drawback. So this paper puts forward a system to aid the visually challenged. The *Assistor* is a device which is a passive type intelligent stick that focuses on aiding the visually challenged people to move around from one place to another without having to worry about anything.

The *Assistor* is a smart walking stick that has two types of input sensors: ultrasonic sensors and image sensors, which continuously feeds information to the smart phone. The ultrasonic sensors are used to detect how far the objects are from the person and the image sensor finds what those objects are with precision. The data from the sensors are transmitted to the Smartphone through Bluetooth communication. A servo motor is used for the mobility of the stick. A microcontroller is used to interface the hardware components with the smart phone.

The entire project is dependent on the Smartphone App and its reliability. It performs all the computation and calculations. A separate database is designed, where the definition of the objects are found. In the system level we could say that the novelty lies in the real-time application working on the Smartphone.

II. 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.

- Ultrasonic blind walking stick [1]: The system is intended to provide artificial vision and obstacle detection around the blind person. The system uses ultrasonic sensor to detect the presence of object. It also has a moisture sensor to detect the presence of water. The microcontroller used is a small computer on a single integrated circuit. When the system detects an object the signal is transferred to the micro controller which notifies the user through a buzzer.
- Advanced cane for visually impaired [2]: The guide cane is used to assist the blind person both indoors and outdoors. It has an obstacle detection system along with a GPS navigation system. The GPS navigation system is pre programmed to help the user navigate to their desired location. A raspberry pi is used to store the obstacle detection programs and GPS navigation programs. The user is given audio feedbacks for navigation and obstacle detection.
- Smart Ultrasonic stick for blind [3]: A study was made in the system to help blind people use the pulse echo technique in order to provide a warning sound when detecting the obstacles. By means of calculating the

difference between the signal's transmit time and signal's receiving time we can predict the distance between the user and the obstacles. This system is very useful in detecting the obstacles with a detection range up to 3 meters and a detection angle 0 to 45 degree. However, this system consumes more power to operate because of the transmitter and receiver circuits. So, this system needs to be re-designed to operate with less power consumption and thereby increase its efficiency.

- Voice aided electronic stick [4]: Alejandro R. Garcia Ramirez and Renato Fonseca Livramento da Silvaetal (2012) together have designed an electronic long cane to serve as an aid to the blind and visually impaired. They have implemented the cane by an ergonomic design and an embedded electronic system. The system was designed using haptic sensors that are used to detect obstacles above the waistline. So every time it detects an obstacle, the electronic stick vibrates or makes a sound. But this system is held back as it can detect obstacles only above the waistline

- Walking system with image matching [5]: 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 - the *Assistor*.

III. SYSTEM ARCHITECTURE

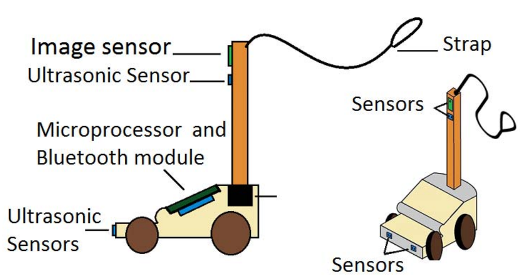

Fig.1. Prototype of the Assistor

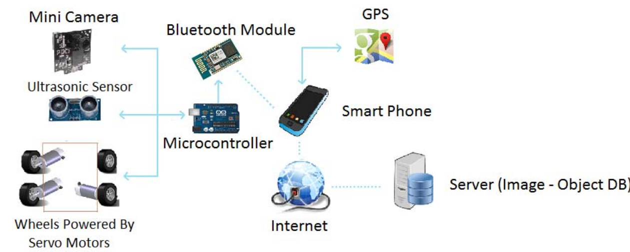

Fig.2. Architecture diagram of the Assistor

Fig 1 shows a detailed drawing of the *Assistor's prototype*- first or preliminary version of the *Assistor*. Fig 2 shows a detailed architecture diagram of the *Assistor* and how its components are interconnected.

IV. SYSTEM DESIGN

The System is divided into two parts

- Hardware
- Software

A. Hardware

- The *Assistor* is a walking stick with two- 80 mm diameter and two- 60 mm diameter wheels in the bottom powered by three- 12v , 360 degree continuous rotation servo motors. Two motors in the front used to control the direction and one in the back for power. Servo motors do not rotate freely like a standard DC motor. Instead the angle of rotation is limited to 189 degrees back and forth. 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 *Assistor* has a mini camera, the Pixy CMUCam5 which is an image sensor with 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. The Pixy CMUCam exports information in a variety of useful ways- UART (Universal Asynchronous Receiver/Transmitter) serial, SPI, I2C, digital out, or analog out. The Pixy CMUCam5 also uses hue and saturation as its primary means of image detection rather than normal RGB.

- Echolocation is the use of sound waves to determine where objects are in space. In order to apply this concept we use an ultrasonic sensor which produces sound waves to detect objects. A special transducer is used in an ultrasonic sensor which allows it to alternate between transmission and reception of sound waves. The transducer emits the sound waves and switches to receive mode to receive the waves. The time elapsed between emitting and receiving is proportional to the distance between the object and the sensor. The *Assistor* is attached with three ultrasonic sensors, two at the bottom and two on top. This is to cover larger angles for object detection.

- A Bluetooth module is used to achieve communication between the microcontroller and the Smartphone through serial port communication. Code for handling different hardwares is hardcoded in the flash memory of the microcontroller. After pairing the mobile phone with the Bluetooth module, data can be exchanged between the two. The time required to transfer image over 115200 bps baud rate with different resolution and format is specified below

TABLE 1 IMAGE DATA TRANSFER RATES IN BLUETOOTH

Resolution	Image data size	Time required to transfer with 115.2 kbps
BMP 320×240	150KByte	13s
JPEG 320×240	3~6KByte	0.3~0.5s
JPEG 640×480	20~30KByte	1.7~2.6s
JPEG 1600×1200	~130KByte	~11s

- The *Assistor* 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.
- The image sensor captures image regularly at an interval of 2 seconds. This image is processed and all the objects in the image are identified.

B. *Software*

- *Smartphone App:* A user friendly mobile app is developed for the blind. All the facilities in the app have voice assistance. The application is used to perform all computation and calculations for the hardware components. The app acts as the brain for the *Assistor*. All operations are controlled by it. It also controls the data flow between different components.
- *Image – Object-Database:* This is a database used by the mobile app to identify various objects in an image. This database is queried based on key value pair. To identify an image, the image's description has to be stored in advance. Building the database is a tedious and a time consuming process.

V. PROPOSED APPROACH

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

- The first step is to get the destination address from the user. Input is given to the Smartphone app.
- The app uses Google map web services to get directions.
- These directions are obtained as fragment directions. The motors are adjusted based on these directions.
- Image sensor takes photos every two seconds and these images are processed by the app.
- The images are used to identify static and dynamic objects based on relative motion and to identify a suitable path for the *Assistor* to take.
- GPS enabled assisting devices does not have very high accuracy and so dynamic image processing is used to determine the path in short range.
- Ultrasonic sensor produces sound waves regularly to detect objects. When an object is detected the distance is calculated. If this distance is within close proximity, the *Assistor* has to stop and maneuver around the object. This maneuvering of *Assistor* around objects uses an Iterative Deepening depth first search.
- Iterative Deepening Depth First Search
  - I. The goal state is to reach the path formulated initially, by processing images.
  - II. Each obstacle is considered as a node.
  - III. A depth of 2 is chosen for each iteration
  - IV. When the first obstacle is detected, it is considered as the root node and the *Assistor* moves left by default. If another obstacle is detected immediately it is considered as a child of the previous node and the *Assistor* again chooses left.
  - V. Once depth of 2 is reached it traces back to its previous node and explores the other direction
  - VI. Step iv and v is continued until the goal state is reached
- Runtime object detection is used to identify the objects and maneuver around them. If no proper path is formulated based on image processing, the *Assistor* uses the rough values of the GPS to continue around the obstacles.

- The user is informed once the destination is reached. The user needs to use a bond induction headphone which enables them to hear both from the Smartphone and from the environment

VI. Future Scope

Our future work will focus on enhancement of object recognition system so that it can detect and identify objects better in challenging environmental conditions. It will also include improving the charge capacity of the device. The object identification can be improved by enhancing the image-object database. Better algorithms could be formulated for the device to navigate using dynamic image recognition.

VII. Conclusion

Blind people face lot of difficulties while travelling from one place to another. With the intention to help the blind, their difficulties, we proposed a new system— an autonomous navigation and obstacle detection and identification stick. The proposed system takes the blind person to the destination by direction identification, obstacle detection and identification, path recognition and navigation. Navigation is performed with the help of GPS and maps, obstacles are detected using sensors and obstacles are identified using an image-object database. This database contains images stored along with its unique key points, identified using SURF algorithms, and it is used for object identification.

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