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Robotic Walking Aid for Visually Impaired

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ABSTRACT : *In this fast developing world, it is hard for the people to help the physically challenged people in all aspects, since those people are totally dependent on others for their routine activities including their basic requirements. This project aims to provide a solution for the above problem by using the modern technology by developing a robot to assist the visually impaired people to fulfill their basic needs. This novel device helps visually impaired people to walk safely and quickly among obstacles and other hazards. The robotic model consists of compatible sensors for detecting the obstacles within the specified range and sends input as digital signals to microcontroller board which then calculates the distance of the obstacle and guides the user. The user feels the steering command as a very noticeable physical force through the handle and he/she is able to follow the system's path easily without any conscious effort. The proposed device overcomes the fundamental shortcomings of conventional electronic walking aids for the visually impaired people that relieves the user from making complex decisions. This device boosts the visually impaired people morally.*
Keywords –*Arduino processor, Chassis Fabrication, Distance Measurement, Motor Speed Control, Obstacle Detection.*

I. INTRODUCTION

According to World Health Organization (WHO) 285 million people are blind all over the world. Among them 39 million are blind and 246 million people have low vision. According to the Times Of India(TOI), India is now home to the world's largest number of blind people, out of 39 million over 15 million people are only from India and 30,000 new cases are being added every year.

About 65% of total visually impaired people are aged 50 and older. Hence, in this fast developing world, it is hard for the people to help the physically challenged in all aspects, because today's generation are engaged in their busy life. But on the other side visually impaired people are totally dependent on others for their routine activities including their basic requirements.

II.PRE-EXISTING MODELS

2.1 Nav-Belt:

The first electronic aid is the Nav-belt, which is worn by the user like a belt and is equipped with an array of ultrasonic sensors. It provides, via a set of stereo earphones, acoustic signals that guide the user around obstacles, or "displays" a virtual acoustic panoramic image of the traveller's surroundings.

2.1.1 Advantages:

- Nav-Belt can detect objects as narrow as 10mm.
- Nav-Belt can reliably detect objects with a diameter of 10cm or more, regardless of the travel speed.
- The current detection range of the Nav-Belt is set for 3m.

2.1.2 Disadvantages:

- For object with diameter of 10mm, the detection is possible if the objects are stationary or the subject is walking slowly.
- Nav-Belt lacked the ability to detect overhanging objects, steps, sidewalks, edges etc. This can be removed by addition of Sonars pointing up and down to detect these types of obstacles.
- The Nav-Belt uses a 2-D representation of the environment. The representation of this type becomes unsafe when travelling near overhanging object or approaching bumps and holes.
- It is extremely difficult to recognize and react to signals at walking speed

2.2Guide cane:

Uses the same mobile robotics technology as the Nav-Belt.It is a wheeled device pushed ahead of the user via an attached cane. When it detects an obstacle it steers around it and user immediately feels this steering action and can follow its new path easily and without any conscious effort.

2.2.1Advantages:

- It allows fast walking, up to 1m/s while completing complexmaneuvers through cluttered environments.
- It can be used to travel or detect staircases.
- Easy to handle, and no extensive training needed.
- It rolls on wheels that are in contact with the ground, thus allowing position estimation by odometry.

2.2.2Disadvantages:

- It uses ultrasonic sensor-based obstacle avoidance system, which is not sufficiently reliable at detecting all obstacles under all conditions.
- It cannot detect overhanging objects like tabletops.

2.3 Whitecane:

It's a older device widely used for indoor movement of visually impaired. It notifies the user about the presence of obstacles. Hence the user is forced to perform additional scanning once the obstacle is detected the user must evaluate all the obstacle information such as size, velocity and position of the obstacle. Therefore the user must take complex decisions such as deciding whether to move or to stop.

2.4 Nav-Chair:

It is a powered semi-autonomous powered chair equipped with sensors and obstacle avoidance technology. The disadvantages are, the user unnecessarily be burdened with additional handicap of limited mobility.

III. SYSTEM DESIGN

3.1 Objectives

To model a robotic walk assistant ,

- Detects obstacles in the path.
- Find alternate path in case of obstacle.
- User is guided along the new path .
- Pause and resume the system as required by the user

3.2 Hardware Components

3.2.1 Arduino Processor

The Arduino Leonardo is a microcontroller board based on the ATmega32u4 (datasheet). It has 20 digital input/output pins (of which 7 can be used as PWM outputs and 12 as analog inputs), a 16 MHz crystal oscillator, a micro USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Leonardo differs from all preceding boards in that the ATmega32u4 has built-in USB communication, eliminating the need for a secondary processor. This allows the Leonardo to appear to a connected computer as a mouse and keyboard, in addition to a virtual (CDC) serial / COM port. It also has other implications for the behavior of the board these are detailed on the getting started page.

3.2.1.1 Arduino IDE

The Arduino Leonardo comes pre-burned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the AVR109 protocol.We can also bypass the boot loader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header.The Arduino language is based on C/C++. It links against AVR Lib and allows the use of any of its functions.

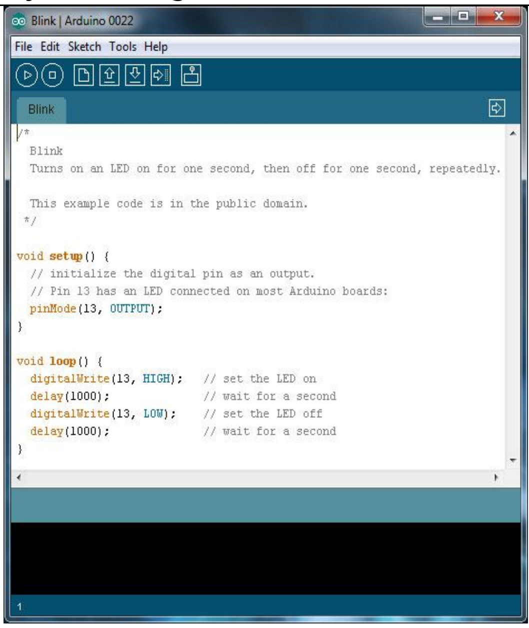


Fig.1: Sample Ardiuino Code

3.2.2Sensors

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit.
There are 4 pins out of the module , VCC , Trig, Echo, GND . So it's a very easy interface for controller to use it ranging. A short ultrasonic pulse is transmitted at the time 0, reflected by an object. The senor receives this signal and converts it to an electric signal. The next pulse can be transmitted when the echo is faded away. This time period is called cycle period. The recommend cycle period should be no less than 50ms. If a 10μs width trigger pulse is sent to the signal pin, the Ultrasonic module will output eight 40kHz ultrasonic signal and detect the echo back. The measured distance is proportional to the echo pulse width and can be calculated by the formula below. If no obstacle is detected, the output pin will give a 38ms high level signal.

3.2.2.1 Working

Pull the Trig pin to high level for more than 10us impulse, so the module starts ranging.If you find an object in front ,Echo pin will be high level, and based on the different distance, it will take the different duration of high level.

Compute the distance: Distance = ((Duration of high level)*(Sonic :340m/s))/2 ……(1)

3.2.3 Servo Motors

Servo motors are used in closed loop control systems in which work is the control variable. The digital servo motor controller directs operation of the servo motor by sending velocity command signals to the amplifier, which drives the servo motor.

An integral feedback device (resolver) or devices (encoder and tachometer) are either incorporated within the servo motor or remotely mounted, often on the load itself. These provide the servo motor's position and velocity feedback that the controller compares to its programmed motion profile and uses to alter its velocity signal. Servo motors feature a motion profile, which is a set of instructions programmed into the controller that defines the servo motor operation in terms of time, position, and velocity. The ability of the servo motor to adjust to differences between the motion profile and feedback signals depends greatly upon the type of controls and servo motors used.

Three basic types of servo motors are used in modern servo systems:

- Ac Servo Motors, based on induction motor designs.
- Dc Servo Motors, based on dc motor designs

- Ac Brushless Servo Motors, based on synchronous motor designs.

3.2.3.1 Advantages

- High Stall torque
- High torque to inertia ratio
- Speed control
- High efficiency
- No need for driver circuit

3.3 Block Diagram

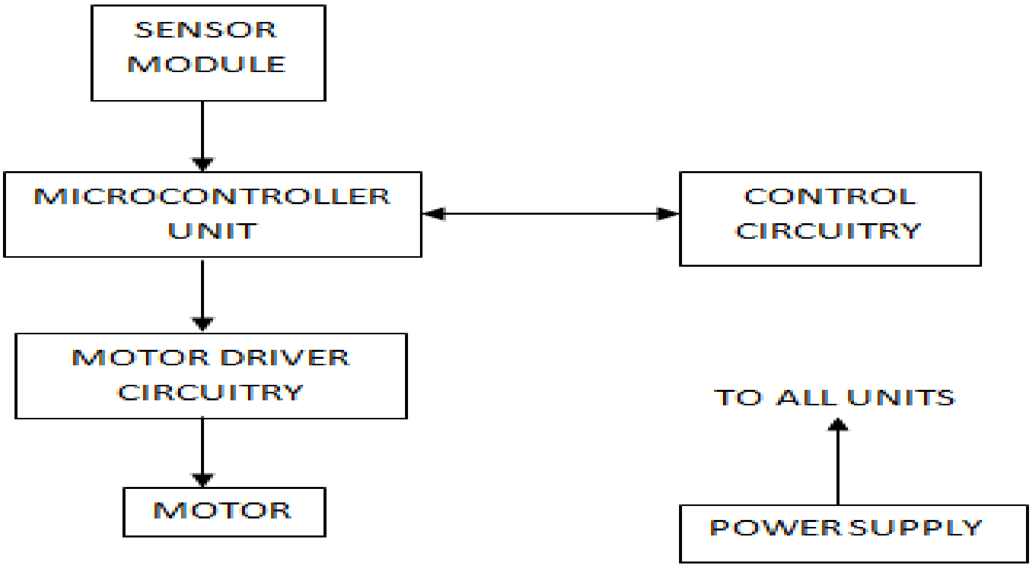


Fig.2: Overall System Description.

IV. SYSTEM IMPLEMENTATION

4.1Chassis

Chassis material is fabricated using LASER CUT for the required dimensions. The corners were made blunt for safety precautions.

4.2 Distance Measurement

Sensors continuously senses for the presence of obstacles around their operating angle. If the ultrasonic sensors ,detects any obstacles within their range and sends back responses as digital signals. A short 10μs pulse to the trigger input to start ranging is given and the module will send out an 8 cycle burst of ultrasound at 40kHz and raise its echo.Echo is a distance objects that is pulse width and the range in proportion.We can calculate the range through the time interval between sending trigger signal and receiving echo signals. The responses are sent to Arduino board for processing the signals. The board upon receiving the signals from the sensor calculates the distance.

4.3Obstacle Detection

When the system finds the obstacle in front of it within the range, it halts the motion by sending signal to the microcontroller. Then the motor head rotates carrying the ultrasonic sensor placed at the front ,searches for an alternative path .The motor sweeps through an every 10 degree and the sensor searches for a path without obstacle. Then the sensor sends signal for back to board so that the motion of the robot resumes and moves forward .The side sensors placed on either sides of the robot keeps track of obstacles and sends the signals. If in case of any obstacle then the bot is made to move in opposite direction away from the object.Once if the object is not in range then the bot moves back to the straight path and moves forward

4.4Circuit Board Design

Power to all modules are centralized and taken out from PCB. ON and OFF switch is provided to initiate and halt the robot.All signals to the servo motors from the Arduino are supplied through the PCB board by means of a single 3-pin RMC connector. The echo pulses to the sensor are supplied from Arduino are supplied through PCB board by means of single 3-pin RMC connector.Common Trigger is supplied from the Arduino to all the sensors.Sensors are connected to PCB board by 4-pin RMC connector.Motor are connected to PCB board by 3-pin RMC connector.

V. EXPERIMENTAL RESULTS

5.1Case 1

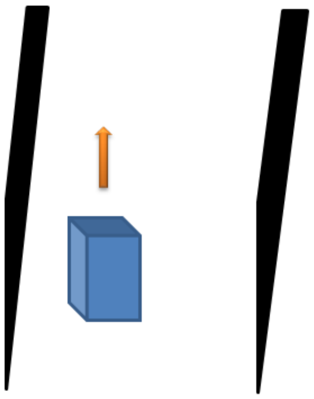
When there is no obstacle the robot takes a straight path.The front and the side sensors continuously checks for the presence of obstacles along the path as shown in Fig.2.

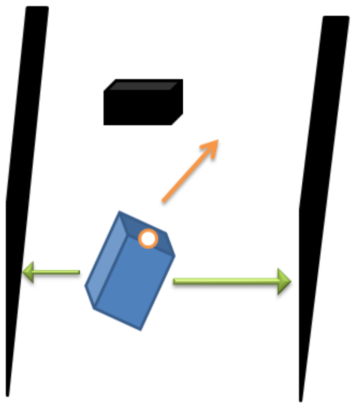
5.2Case 2

If the sensor finds any obstacle in front, the robot slows down and the front sensor continuously sweeps every 10 degree to find an alternative path to guide the user.Once the path is found then the robot automatically turns its direction and proceeds in that path as shown in Fig.3

5.3Case 3

If the sensor doesn't find any alternative path (if entire front side is surrounded by obstacles) then the system halts down but the sensor keeps on tracking for an alternative path as shown in Fig.4.





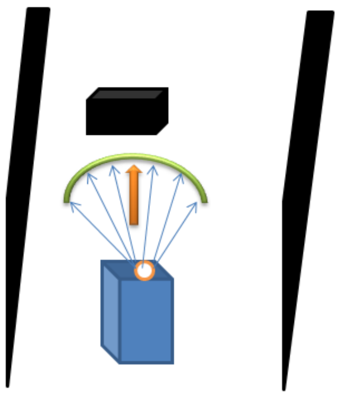


Fig.3:Case 1 Fig.4:Case 2 Fig.5:Case 3

VI.CONCLUSION

In this project, We proposed a robotic based walking aid , which continuously looks for detecting obstacles which comes along the user way. On detecting any obstacles the front sensor mounted on the mini-servo motor searches for the alternate path, hence the bot steers through the corresponding angle guiding the user along that path. The driving servo motors movementare controlled by the microprocessor signals.The proposed device overcomes the fundamental shortcomings of conventional electronic travel aids for the blind. Because,it is easy to use and requires little training time. Also since the sensors are fixed, there are no fluctuations from the sensor input, as occurs in the sensors mounted on the body. This bot also frees the user from making complex decisions about the obstacle free path since the bot makes all the decisions. Hence the bot is more user-friendly compared to other devices. Therefore it may be used without any stress. But the bot doesn't handle irregular surfaces, staircases etc. Also head-level obstacles are difficult to detect, but it can be achieved by optimal placement of sensors. The bot can be further extended by using GPS/Google Maps to find the current location of the user. It can also include additional sensors to keep the bot aligned with side walls. This project aims in developing a robust robot that provides a great service for visually impaired people and boost them morally.

VII. Acknowledgement

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