Haptic Navigation For Blind

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***Abstract*— Vision impairments or visual impairments are a broad term to refer to any degree of vision loss. Visually impaired people face difficulty in walking and have a constant fear of falling. But among all these losses blindness counts as the most significant part. It can be caused due to infections, genetic conditions, and other diseases. Blindness increases the risk of falls by affecting the quality of life. Hence we propose a system that helps them to easily accommodate. In our proposed system cameras is used to record the video. With the help of real-time video processing, the output delivers to the person by activating the actuators to make the person stop or suggest he take a turn. Different tools like sobel operators and other edge detector operators have been used for processing. The proposed system uses the spatial configuration and edge detection as the primary differentiator.The device helps people to easily accommodate and shows a good accuracy rate.**

Keywords: Vision Impairments, Genetic, Sobel operator, Spatial Configuration

I. Introduction

According to WHO at least 2.2 people around the world suffer from visual impairments among these the blind suffer the most. There are many surgeries available worldwide but not all can afford that.Visual Impairment can categorized into different categories.
Category 0: Visual acuity is better than 6/18. It is also referred as mild or no visual impairment.
Category 1: Visual acuity is worse than 6/18 but better than 6/60. It is referred as moderate visual impairment.
Category 2: Visual acuity worse than 6/60 and better than 3/60.It is referred as severe visual impairment.
Category 3:Visual activity worse than 3/60 and better than 1/60. This category lies under blindness.
Category 4:Visual activity worse than 1/60 with light perception. This category falls under blindness.
Category 5:Irreversible blindness with no perception of light.

Among all these different categories last three categories falls under blindness and affect the life of people. Blindness not only affects the quality of life but also the mental health of a person. The person feels isolated and weak, and he becomes dependent on others and that dependency can lead to anxiety, self-doubt and anger issues and causes depression in many cases.Navigation aid can be also very useful in such cases it has been perceived that through the last decades, many attempts at creating a navigation aid for the visually impaired have been done. These come in numerous different forms and functions, and are alternatively known as electronic travel aids (ETAs) or orientation and mobility (ORM) aids, but all these innovations can also not help as there is a minor impact on visually impaired people.Hence, there is a major demand for a system or device that can help these people to overcome this fear and can help them to lead a normal life in a small way. The device must not only help such person but it must also be affordable.Hence, the device which is being designed has all these features, it is helpful in navigation. Cameras and different techniques of video processing is been used. The camera associated with the device is ZED 2 AI Stereo camera, which combines 3D sensing with AI to create spatial intelligence. It consists of different features such as:
Wide Angle 3D AI camera: Large range depth perception with AI which helps it to understand the surroundings, it also has 120 degree wide-angle of field view. This feature makes this camera equivalent to human eye.
Multiple lens Selection with Polarizer: With the multiple usage of lens it makes sure the camera captures every detail around the surroundings it selects the lens depending on our surrounding. It is equivalent to cones and rods cells present in our human eye.
Built-in IMU, Barometer and Magnetometer: Sensors are used for better awareness for spatial and positional awareness.
IP66-rated Enclosure: As the camera is used for outdoor application and different medical applications,it is made sure that it is protected from water, dust and humidity. This feature is equivalent to eyelids and eyelashes as well as different liquids present in eye. The camera can be seen as equivalent to human eye,but there are some more attributes which make it special.
Natural depth sensing: Uses a neural network that produces a visual field that is similar to human vision and enables depth perception from 0.2m to 20m.
Spatial object detection: Objects are easily detectable by combining AI with 3D localizations that help to characteristics but the major attributes are to create a better awareness of the surroundings.
Improved positional tracking: Positional tracking becomes accurate with help of sensor stack and characteristics but the major attributes are thermal calibration.

All these attributes combined give better accuracy and a result that helps the blind people to accommodate. Human eye works with the help of optic nerve and motor neurons. For that we use actuators that are equivalent to motor

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neurons. The actuators are installed in the shoes, as they can easily give signals to the person by getting activated by the response given after processing the data captured from cameras while walking in real-time.For processing we can use different operators but we have used Sobel operator,a great filter for computer vision and processing particularly for edge detection. The major work is to detect and emphasize the edges.The edge detector operator is technically discrete differentiation operator that computes the gradient of image intensity function. Sobel operator performs 2-D spatial gradient measurement and gives output with a high spatial frequency that correlates with edges. The utmost advantage of using this operator is it finds out the absolute gradient magnitude at every point in a gray scale image. Using the features of ZED 2 AI cameras and tools of image processing together gives us a device that can be useful and affordable for the person.

II. Methodology

This project aims to build a comprehensive real-time navigation for vision-impaired people. So, the Project focuses mainly on obstacle recognition edge and slope detection of terrains. The whole Project methodology can be divided primarily into two parts.

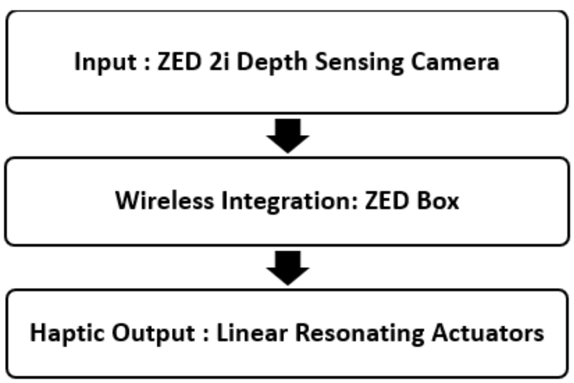

Fig. 1. Block Diagram

A. Obstacle recognition and Edge detection

Here ZED-2i camera and a ZED box are used, which include most of the sensors which can be crucial in-depth sensing features like an Accelerometer, Gyroscope, Magnetometer, Barometer, and Temperature sensor.

For 3D Object detection, it uses AI and a neural network that determines the objects that are present on the left and right of the image. It detects all the objects in the image and computes their 3D position and velocity. The distance of the object from the camera is expressed in metric units and calculated from the back of the left eye of the camera to scene the object. Then a 2D mask is computed, indicating the image's pixel belongs to the object. From there, the ZED can output the 2D bounding boxes of the objects and accurately compute the 3D bounding boxes. For Edge and slope detection in terrains, Sobel Edge operator is used, which processes the image in the x and y direction first; this results in the formation of the new image which has information on the X and Y edges of the image. And then for kernel calculation, the Gradient of image intensity at every pixel is calculated using the convolution between the Gaussian filter and derivatives of X and Y edges. Now with obtained kernels in the X and Y directions convolution is performed with the image matrix. X -direction kernel will move from left to right in each column, and the Y-direction kernel will move from top to bottom in each row. With the help of the above mathematical the operation, two Gradient is obtained, from which net Gradient is calculated using the formula:

$$G_{net} = \sqrt{(G_x^2 + G_y^2)}$$

where, Gnet = Total Gradient
Gx = Gradient of the kernel in X direction
Gy = Gradient of the kernel in y direction

Now Gnet is compared with Gthreshold to check the presence of edges. Hence as per the obtained Gnet value object/edge will be classified as obstruction, depression, or elevation, and accordingly, a decision is made to avoid collision with it like moving left moving right, or stopping. Finally, this obtained output send to the ZED box which is connected to Linear resonating Actuators.

B. Working of Linear resonant actuator

Once the Obstacle and Edge detection is done and the signal is transmitted to the ZED box, the corresponding Linear resonant actuator connected to it gets activated. These outputs are in haptics form (vibration or sensation), which helped users navigate easily in a terrain or a room. These actuators are actuated as per the signal obtained from the ZED box and hence according to that user is moving Left, Right or Straight. Each actuator is assigned to a particular part of the divided visual field which makes the working of the model more efficient. These actuators are positioned on both feet of the user as shown in figure.2.

The actuators labeled 1 correspond to the obstructions or edges present in the straight path of the user and vibrate to indicate that obstruction. The actuators labeled 2 correspond to the obstructions or edges present on the right and left side of the user and vibrate to indicate that obstruction. Actuator 3 corresponds to the depressions and elevations in the terrain. (This includes ramps, steps, and other platforms that can be climbed up or down). The actuators can be tuned to different vibrations to indicate various terrain complications.

C. Haptic Feedback Technology

Haptic is derived from a Greek word which means to 'grasp something'.Haptic feedback technology integrated products are not a new thing, but it has very limited applications like conveying external forces through springs and masses to aircraft pilots or remotely operating a robotic arm handling hazardous materials in a nuclear plant.

Fig. 2.

Nowadays people give attention to their mobile phones whenever it vibrates, which is the most common example of haptic feedback. There has been advanced use of haptic technology for visually impaired communities one such example is a user moves a handle around in a certain workspace volume, with the interface able to exert forces on that grip depending on its position. While using haptic feedback in navigation aid we observed that the biggest advantage is it does not interfere with environment audio signals, but it has been also seen that it requires user training to convey complex information.

III. Experimental results

The Proposed system was tested on ZED box (Stereo labs) device. The Processor used was Quad-Core ARM Cortex-A57 MPCore with 256-core NVIDIA Pascal™ GPU. The image-capturing System used ZED 2i depth-sensing camera. The project was implemented in C++ programming language using Open-Source Computer Vision Library (OpenCV).

During experimentation, when the object and edge detection module were activated camera captured different objects for processing. The figure shows the the frame which is captured at any instant. In the the proposed system, Obstacles were created and simulated in the space using a combination of chairs. Then an input video was taken and processed using OpenCV and the Sobel operator. It created a the framework that divided the visual field of space into three parts. Now comparing the middle segment with left and right an output of MOVE LEFT! or MOVE RIGHT! is actuated such that the pathway for the user does not have any obstacles. In case the user encounters a close obstacle and there is the possibility of collision, it gives STOPPPP! Signal Figure.4.

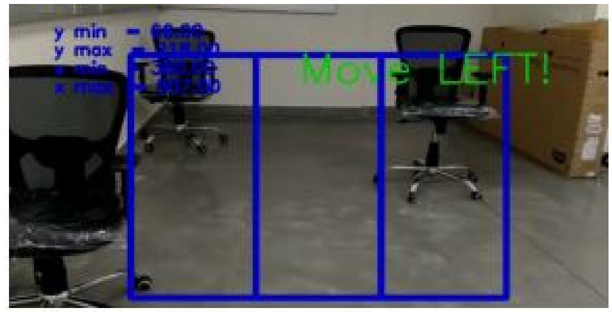

Fig. 3.

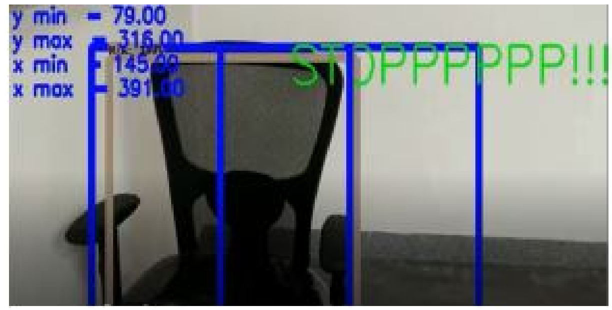

Fig. 4.

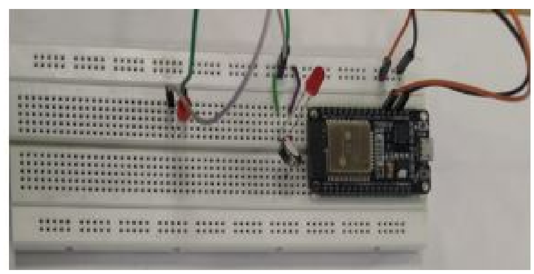

Fig. 5.

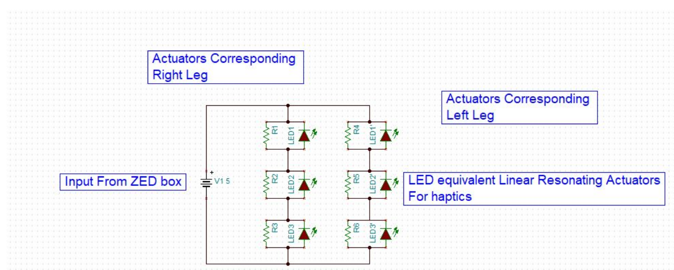

Fig. 6.

Now this output is transmitted to the server, and from there it will be fetched in the ZED Box module. The ZED box module is programmed in such a manner that it activates the corresponding linear resonant actuator as per the input signal Figure.5. An equivalent simulation circuit for the actuators is also represented in Figure.6.

IV. Conclusions

This Project Proposed an efficient device that can be assistive for the blind and visually impaired. The device includes modules for obstacle and Edge or slope detection in various terrains along with its real-time output signal in form of haptics that can be helpful for the person to navigate.The system is implemented using the stereo lab's depth-sensing camera and ZED box using integration like OpenCV, TensorFlow, and Sobel operator. For processing and understanding the surrounding we have used ZED box and ZED 2i camera, it can be further changed and new operators can also be used for better accuracy and edge detection. The use of actuators has also made this device handy as people get the signals as soon as the data is processed. Further research will be done to improve and also include smart mobility features like GPS tracking in order to make the device more user-friendly.

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