VISUALLY IMPAIRED PEOPLE NAVIGATION AND OBSTACLE DETECTION USING KINECT SENSOR

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Abstract - *People with visual impairment find it really difficult to navigate themselves without the help of others and the previous technologies developed to solve this issue is less effective. This project provides a solution to enable people with visual impairment to navigate in their environment effortlessly. The proposed project presents a novel approach for detecting and classifying 3 dimensional objects by using the KINECT sensor. Once the object is identified, it is communicated to the person via voice output and the obstacle can be avoided. The algorithm also differentiates human obstacles from non-human obstacles with the help of skeleton creation and face recognition techniques. In addition to this, 2 motors are placed on both sides of the hips of the person which rotates based on the side where the obstacle is detected (i.e. either on the right side or the left side of the hip). Python is used in the Kinect sensor for human segmentation process. The Arduino IDE is used as an interface to the Arduino board which is programmed in embedded C for the functioning of the ultrasonic sensors and DC motors. The system is capable of performing with an accuracy of 80 percent and it can identify objects at a faster rate compared to other existing devices. In future, the system can be made even smaller for easy portability. The frames per second can be decreased for faster image processing and the detection range can be further increased to help navigate in highly crowded environment.*

Key words: Visual, Impairment, KINECT, Sensor, Navigation, Arduino, Obstacle.

1. INTRODUCTION:

Blindness is defined as loss of useful sight. Blindness can be temporary or permanent. Damage to any portion of the eye, the optic nerve, or the area of the brain responsible for vision can lead to blindness. There are many problems for visually impaired and blind people in our society. They face many type of hurdles in performing every day routine works, as the barrier of low vision do not let them to become part of this society. Several technologies contribute a lot to fill this gap between society and visually impaired people.

1.1 Navigation:

Navigation refers to any skill or study that involves the determination of position and direction. Normal people can easily navigate themselves in their environment with the help of their vision. However it is not the same in case of visually impaired people. They also find it difficult to identify the obstacles that are present in their path.

1.2 Obstacle detection:

It refers to the technique of identifying objects that are present along a pathway with the help of sensors and other technologies. This is also important to facilitate the navigation of visually impaired people. Considering the lack of efficiency in the existing systems to provide a solution for the navigation of blind people, there is a need for new improved systems.

The purpose of the proposed system is to make the navigation of the visually impaired people more effective than before and enable them to identify obstacles more clearly.

2. REVIEW OF LITERATURE:

The system proposed by Enyang Xu et al., (Jan 2013) studies the problem of tracking signal-emitting mobile targets using navigated mobile sensors based on signal reception. The mobile sensor controller acquires the time-of-arrival (TOA) measurement information from both the mobile target and the mobile sensor for estimating their locations before directing the mobile sensor's movement to follow the target. However this technique takes more time to estimate the location of the target and enable tracking of the located target.

It is followed by the system proposed by Po-Hsuan Tseng et al., (Feb 2014) which investigates the problem of cooperative self-navigation (CSN) for multiple mobile sensors in the mixed line-of-sight (LOS) and non line of sight (NLOS) environment. It is based on measuring TOA from the cooperative sensing. An ego-motion tracking method is proposed, that utilizes visual-inertial sensors for wearable blind navigation. This system focuses mainly on simple navigating environments and does not provide enough details regarding obstacle detection techniques.

The Mercury device given by Zhenyu Liu et al., (2017) is used for obtaining the location of an individual which enables a variety of emerging applications on mobile devices. . However, the mercury system can be used only with the help of smartphones and cannot be interfaced with any other hardware devices for future improvements.

The system designed by Bing Li et al., (2018) detects obstacles and adjusts path planning in real-time to improve navigation safety. It develops an indoor map editor to obtain geometric information from architectural models. This system using the on-board RGB-D camera develops an efficient obstacle detection and avoidance approach. However, this device takes more time to detect the obstacles, hence it is only suitable for indoor navigation. In addition to this, the device realizes obstacles in a two dimensional form which in turn reduces the efficiency in detecting the obstacles.

3. METHODOLOGY:

The proposed system uses KINECT sensor which is a motion sensing input device that can identify the obstacles and map them in a 3D fashion. It has inbuilt infrared projectors and RGB cameras that allows gesture recognition and speech recognition. The RGB and depth images are detected by the KINECT sensor and then it performs either one of the two operations. The KINECT produces the 3d image of the detected obstacle and it either identifies it as a Human or Non- human obstacle. If the detected obstacle is much smaller in size, then it is classified under non- human obstacle and the object is identified. The identified obstacle is then communicated to the user via Ear phone speakers.

If the detected image is tall and has the possibility of being a human, then the sensor performs creating the skeleton of that obstacle. If the obstacle is a human, then his/her face is identified and the information is communicated to the user via voice output saying that the obstacle is a human.

Suppose if the face recognition cannot be done then the user is informed about a larger non-human obstacle via voice output. These processed information is communicated to the Arduino board via NVIDIA processor or PC. Based on the information received by the Arduino the respective motor is rotated which vibrates in the hip of the user indicating the presence of an obstacle. By this process, a visually impaired person will be able to navigate themselves without the help of others.

Advantages:

- Human sensing is enabled in order to identify moving obstacles.
- Less time for processing the detected image which enables faster navigation.
- Navigation is feasible even in a less crowded outdoor environment with the help of KINECT sensor.
- Obstacles are identified in a 3D fashion which improves the efficiency in navigation.

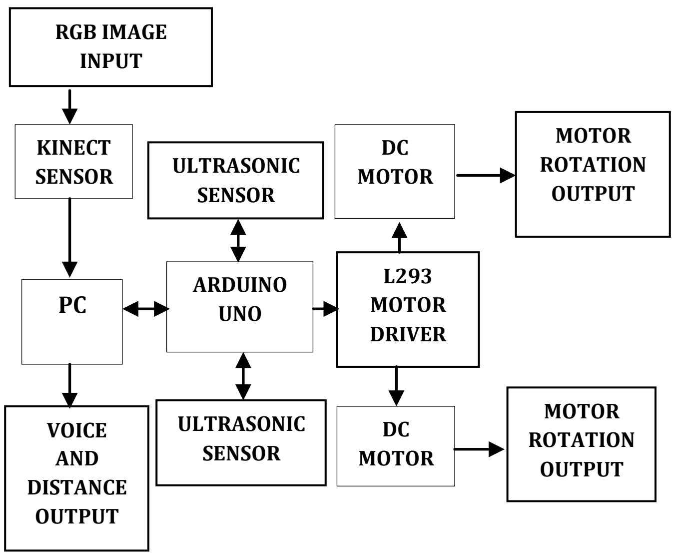

Fig -1: Block diagram of the proposed system

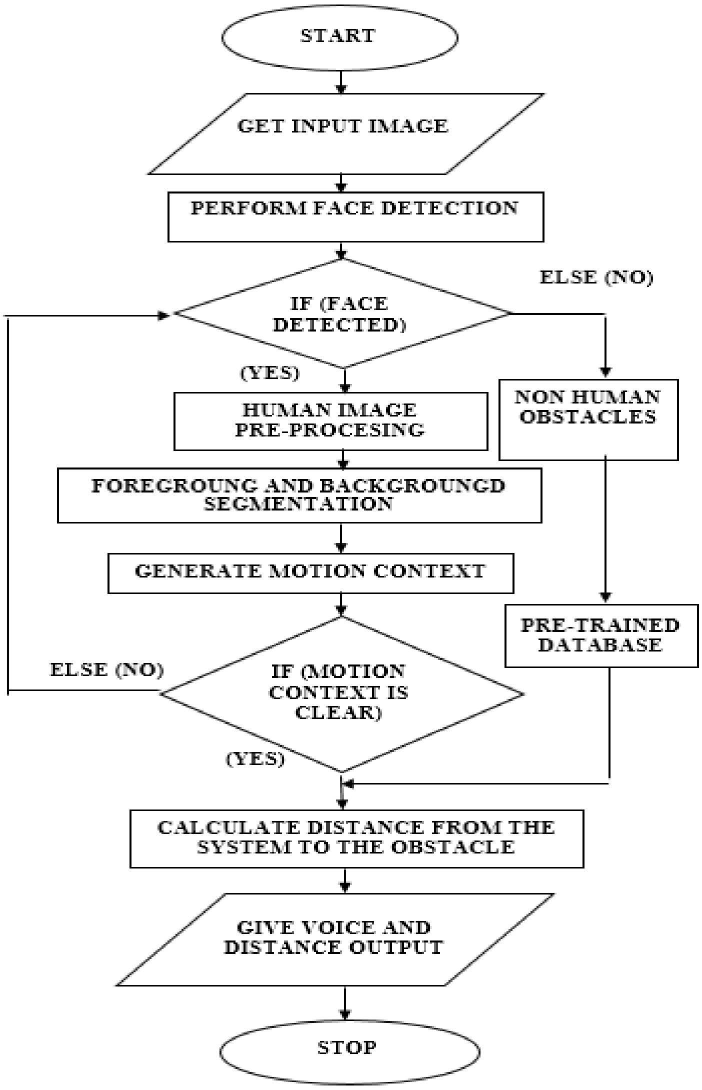

Fig -2: System software flowchart

3.1 Assembled module:

The assembled module consists of a KINECT sensor interfaced with a laptop along with the obstacle detection module. The obstacle detecting module contains the necessary hardware devices that are integrated together in a single board (Fig-3). The entire assembled model with KINECT sensor is shown in Fig-4. The following are the operations performed by the entire module:

The KINECT sensor will enable the person to identify an obstacle and navigate themselves by producing a voice output as soon as it encounters with any nearby object that can act as an obstacle to the user. If the obstacle is a human, then the KINECT sensor will perform skeletal creation operation via face detection technique at a high processing rate and it will produce the voice output saying that the obstacle is a person.

The obstacle detection module that consists of two DC motors will tell the user at which side (i.e either to their left side or to their right side) the obstacle is located. This is possible via the ultrasonic sensors which rotates the respective DC motor when an obstacle comes nearby.

Fig -3: Obstacle detection module

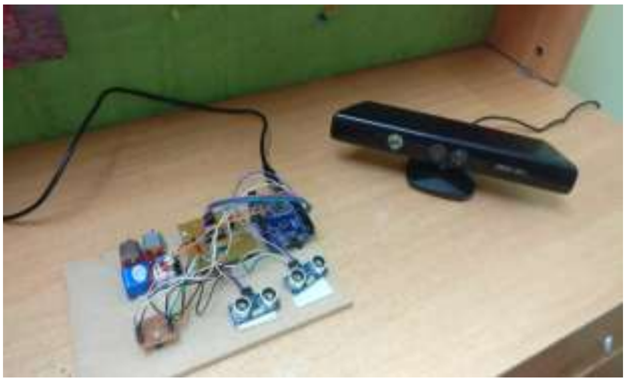

Fig -4: Assembled module with KINECT sensor

The obstacle detection module also has 2 ultrasonic sensors (used to calculate the distance between user and obstacle), L293 motor driver, Arduino board along with a couple of DC motors. They are powered with the help of a battery.

4. RESULTS AND DISCUSSION:

Globally about 285 million people are visually impaired due to various cases. Among them 39 million of them are blind. The main challenge faced by them is to navigate themselves. However, with practice visually impaired people can roam easily around their house without any help because they know the position of everything in the house. But this is not the case everywhere.

Thus the proposed system focuses to make their lives easier by enabling visually impaired people to navigate themselves even in outdoor environments.

4.1 System output:

The output of the system comprises of a voice output corresponding to the image detected by the KINECT sensor along with the intimation of the distance between the user and obstacle by the obstacle detection module.

- Image Detection:

The image is detected by the Kinect sensor using the RGB camera. The KINECT sensor is trained to detect several objects. The main focus is to enable human detection, thus human skeleton along with 3 other non-human obstacles are pre-trained in this module. Depending upon the pre-trained model of the objects, if the object is small without any motion then the object identified is non-skeletal and if the object size is big then the skeleton of the body is scanned.

If the skeleton matches with that of the human using the trained model then the object identified is human or else the object is a non- human moving obstacle. Fig-5 illustrates the image detected by a KINECT sensor.

Fig -5: Image detected by the KINECT sensor

- Voice Output:

The trained model includes a voice output of the identified object. For example, if the object detected is a chair then the voice output will be "CHAIR IS DETECTED". If the object is identified as human then the voice output "PERSON IS DETECTED" is heard.

Fig-6 shows the screen shot of the Kinect sensor voice output corresponding to image detected in Fig-5. A voice output saying "Person is detected" is heard by the user.

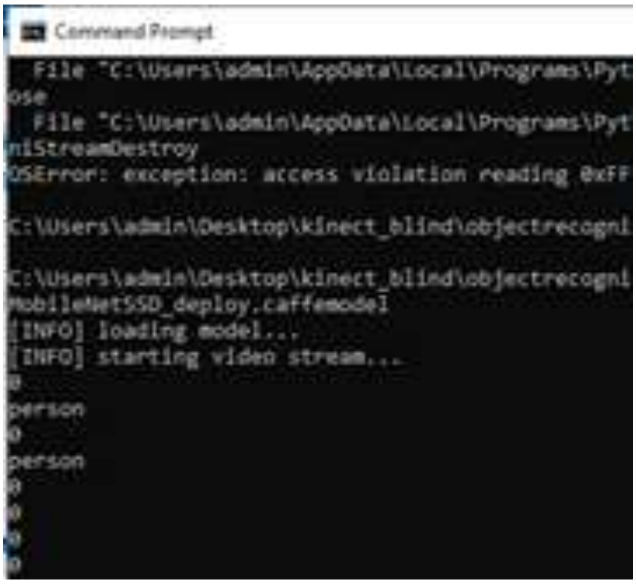

Fig -6: KINCET sensor output

- User Intimation:

The ultrasonic sensor connected to the Arduino is used to find out the distance of the object from the user. If the obstacle is detected on the right, then the DC motor on the right will start rotating which will intimate the user that the obstacle is located on his/her right side and vice-versa.

Fig-7 shows the Arduino output, that tells the distance between the user and the obstacle (in meters) depending upon the image detected by KINECT sensor.

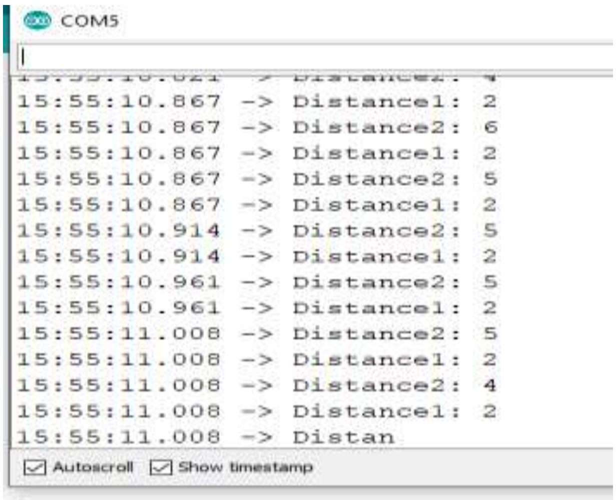

Fig -7: Arduino output

4.2 Performance Metrics:

Performance metrics are an integral component of performance measurement systems. The performance metrics of the proposed system is given in the below table:

Table -1: Performance metrics

Accuracy of object detection	80%
Object identification time	3 sec/object

5. CONCLUSION:

Under ideal conditions, the device can be efficiently utilized by the visually impaired people to navigate themselves to a greater extent. It is quite cheap and affordable compared to other existing devices. The presence of the obstacle is communicated to the user immediately compared to other devices. The obstacle avoidance system is fast and can also be improved to work even more effectively. The range of the navigation area is high, which allows the user to navigate in a safer manner.

Several additional advancements can be added to the proposed module in the near future to make it more effective. They are as follows:

- By decreasing the frames per second, the device can be made to process images at a higher rate.
- The size of the module can be reduced in order to facilitate even more comfortable navigation of the user.
- When the detection range is further increased, this device can be used in a highly crowded outdoor environment.

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