Depth Camera Based Navigation System for Blind People Assistance

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Abstract— Blind humans are confronted with numerous difficulties on the subject of spending their regular lives. This research study investigates the efficacy of the diverse systems developed for the navigational assistance of the blind and visually impaired humans and proposes a new system. While traditional systems rely on the development of assisting hardware such as canes, suits and sticks, our proposed system explores the utilization of depth cameras. In contrast to the general cameras, the depth cameras can provide the distance of the object from the camera, in the field of view. This information in conjunction with image processing has been utilized in the current research work for efficient identification of obstacles and provision of accurate navigational directives. Currently, the proposed system can inform the user of any object(s) appearing in their frontal path and suggest directions to bypass the object. Validation of the system was performed in real time and it suggests the system having high potential for practical use.

Keywords— Blind, Navigation, 3-D Camera, Depth, Object Detection and Obstacles.

I. INTRODUCTION

In today era the number visually impaired people is increasing day by day. A lot of assistance is provided to them in various forms. Nonetheless, the detection of obstacles is a great challenge for researcher and primary focus is on the utilization of various forms of sensors for object detection in the close vicinity and then providing feedback to the user in the form of directives to help them navigate.

Many sensors are available for detection purpose in the literature. Some of those sensors are extensively utilized in domestic protection structures and are supposed to stumble on simplest heat bodies, including human beings and animals. Others are utilized in robots to keep away from boundaries and become aware of matters and impediments. Finally, positive sensors, including methane fuel line detection sensors, are utilized for a particular purpose. Infrared sensors, for example, are not suitable for each situation. It does now no longer provide top results in a darkish environment. These are discussed in detail in Section 2.

Various systems have been developed for the navigational assistance. Section 2 critically reviews and summarizes the existing techniques and methods mainly focusing on object detection. Section 3 presents the proposed scheme based on a depth camera while Section 4 demonstrates the experimental setup and results.

Concluding remarks are presented in Section 5 including future directions. Section 2 below presents the current techniques and methods.

II. TECHNIQUES AND METHODS

This section briefly reviews and summarizes approach and strategies of those sensors but especially focused may be on strategies and methods for object detection. Systems and techniques which were critical in terms of efficiency, robustness, cost and practicality were selected for analysis. This included selection based on sensor type as well. Many sensors are available for sensing motive in literature. Some of those are used detect simple warm bodies like human and animals. A few detectors are not appropriate for each sort of environment like an infrared radiation sensor. It does not work desirably in a dark environment.

A detecting component could be a gadget/module that identifies and answer a type of contribution from the physical setting. That information could likewise be sound waves, IR waves, light and so on. There are 2 verities of sensors, active and passive. The first are active sensors that require energy to operate, such as infrared and ultrasonic sensors [1].

An emitting source and a collecting source are combined in the IR sensing component. After striking an item in front of the sensor, the transmitting source transmits IR signals, which are likewise received by the receiving source. To create and transmit IR signals, the IR detecting device requires electricity. Passive sensors, such as the PIR sensing element [2], which detects heat radiation generated by hot bodies such as humans and animals, are the second class of sensors.

For intelligent structures such as intelligent car parking systems, industrial intelligent robots, and blind aid systems, a variety of sensors are commonly employed. In [1,] Meppurath et al. demonstrated a sensitive stick for visually impaired people that relies on ultrasonic sensors. By sensing the impediment in front of it, this stick may direct you to a safe path. This smart stick has a 4 m range and vibrates to alert the user to any obstacles detected.

In [2,] Sekar et al. established a facility to assist visually impaired persons in walking. In this ultrasonic, humidity, and temperature sensor company, three sensors are employed. The ultrasonic sensor is utilised in this installation to detect impediments ahead of vision impaired persons.

This help system for the blind is dubbed "Navigation aid for the visually impaired (NAVI)" by Saiarayan et al. in [1].

Stereo headphones, a single board computing system, and a vision sensor mounted on the helmet make up this system. The image is captured using a vision sensor, and then analysed using their algorithm to locate an impediment in the image.

In [2,] Ismail et al. developed a robot that identifies obstructions in its route and continues along it without them. The infrared sensor and the passive infrared sensor are both used by this robot.

These sensors keep an eye on the robot's front end and train it to follow an obstacle-free path. The programme is written in C++, and the Arduino microcontroller is programmed using the Arduino IDE 1.6.5 software.

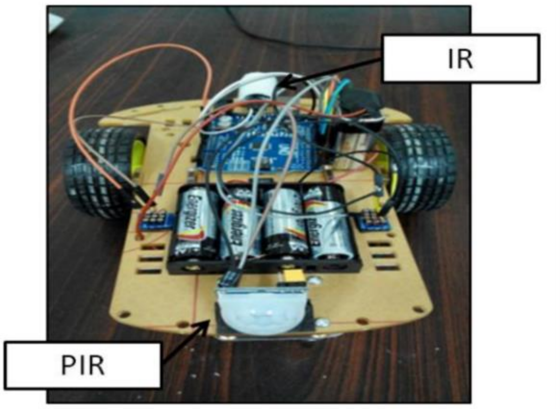


Figure 1: *Obstacle Avoiding Robot [1]*

As shown in Figure 2, Bagwan M et al. created a robot for the purpose of picking up, positioning and monitoring industrial personnel.

Infrared and passive infrared sensors are used to detect possible thieves. IR sensors work during the day, while PIR sensors work at night.

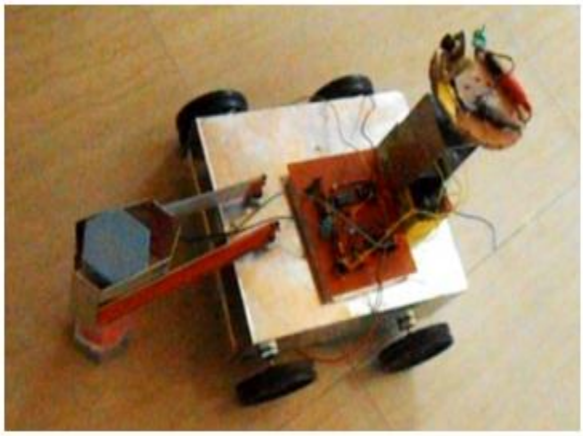


Figure 2: *Industrial Robot [2]*

Praveen and Roy in their research work focused on the estimation of depth from a single image for blind navigation system [3]. For obstacle extraction from the foreground, they worked on firstly detecting object edges in the image, joining the edges which were followed by noise removal. Ankit et al. mainly focused on the navigation system for the visually impaired people using a portable stick having GPS, Camera, and an ultrasonic sensor. The ultrasonic sensor can detect the obstacles within a range of 180 degrees. After detection, it alerts the person by the help of a buzzer or vibrator [4].

Wahab et al. in their research work discussed developed a smart cane by the help of a number of ultrasonic sensors and servo motors [5]. The ultrasonic sensor helps out to detect the barrier in front of visually impaired person by warning him through voice or buzzer, as shown in Figure 3. They also achieved the target of sensing the water at 0.5 cm deep. It has some limitations like smart cane can't be folded and also it is expensive to buy for a low income person.

Figure 3: *The Smart Cane [5]*

Furthermore, another paper shows the methodology of navigation system using infrared ways develop by Amjed et al. [6]. They developed the system using infrared microcontroller to detect the obstacle as well as the shape and material of obstacle, shown in Figure 4.

The person can instruct by using speaker which are mounted on the hat of person as shown below.

Figure 4: *Infrared microcontroller based navigation assistance system.*

Ayat et al. they develop the cheap navigation system for visually impaired people. Assistive infrared sensors are used into smart stick to detect the object coming in front of a person with in arrange of 2m [7].in their research work they produced six different voices when stick detect the obstacle. Bagwan et al. in [8] designed a robot with the purpose of select and vicinity and surveillance of enterprise employees as appeared in parent 2. IR and PIR sensor right here are applied to become aware of any thief. IR sensor work at day time while PIR sensors work during the night time.

Ali Khan et al. in their research work utilized ultrasonic sensors for detecting objects in close proximity [9]. Figure 5 shows their developed system. The sensors were placed on the arms and around the knees and one on top of the head. This way objects to the right and left, below belt level and in the front could be detected and buzzer would be activated when the ultrasonic sensor would detect any object.

Figure 5: *Ultrasonic sensors placed on various parts of the body for object detection [9].*

Section 3 presents the proposed system based on depth camera.

III. PROPOSED DEPTH BASED NAVIGATION SYSTEM

The proposed scheme is based on depth camera. An overview of the proposed scheme is shown in Figure 6.

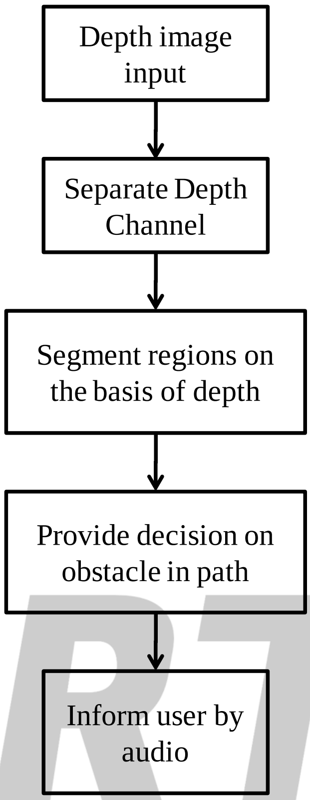


Figure 6: *Overview of the proposed method.*

The steps are laid out as follows:

- First the depth camera captures the image.
- The depth channel is separated and input to the segmentation algorithm.
- The segmentation stage segments the depth for obstacle distances.
- Number of objects and their relevant distances are informed to the user through audio messages for their decision making.

IV. EXPERIMENTAL SETUP AND RESULTS

The Intel Real Sense D415 camera was used to capture images. Figure 8 shows the depth camera D415 [10].

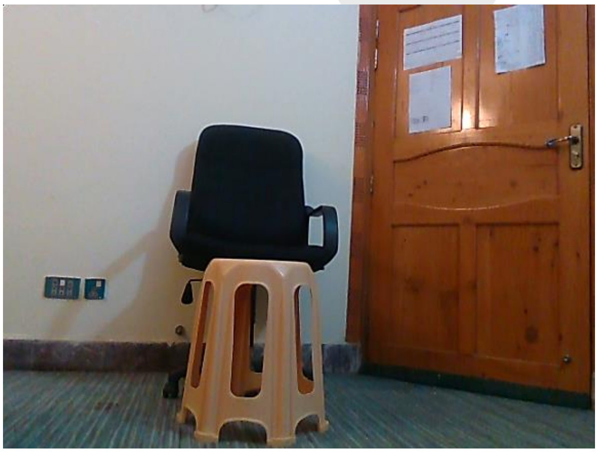
Figure 7: *The Intel Real Sense D415 camera with infrared module for depth sensing.*

The camera takes the RGB image along with the depth information. The depth information was used to gauge the distance of the object from the frontal area of the user. So the direction in which they user is moving is constantly updated at a frame rate of 30 fps for a 680x480 image resolution. In order to reduce high computations at real-time user feedback, 1080p resolution was used with 6 fps.

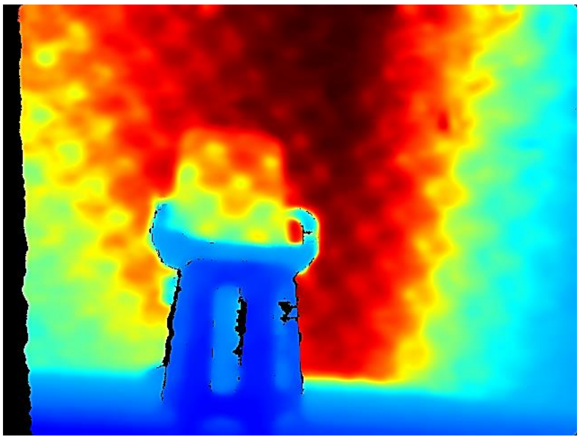
The camera was embedded in a cap and placed on the head of a user. Figure 9 depicts the setup on top of the user's head. Nylon straps were used to hold the cap in place and keep it stable.

Figure 9: *The depth camera implanted in a cap and placed on the head.*

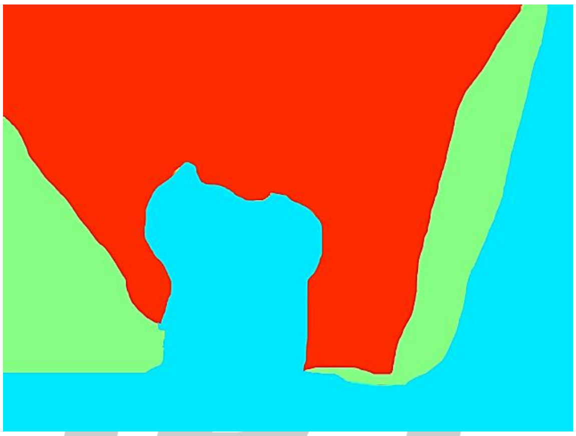
Figure 8 shows a sample image and the associated depth information. Objects that are relatively near to the camera are depicted in bluer color while farther objects are shaded as red.



(a)



(b)



(c)

Figure 8: *Sample 3-D depth image (a) RGB data (b) associated depth data depicted as an image (c) depth image after segmentation.*

Using the K-means algorithm [11], the depth channel is separated in 3 regions i.e. the near objects (blue colour), middle areas and objects (green colour) and far objects (red colour). The three regions were selected so as to inform the user if there are any spaces among the nearest and the farthest objects.

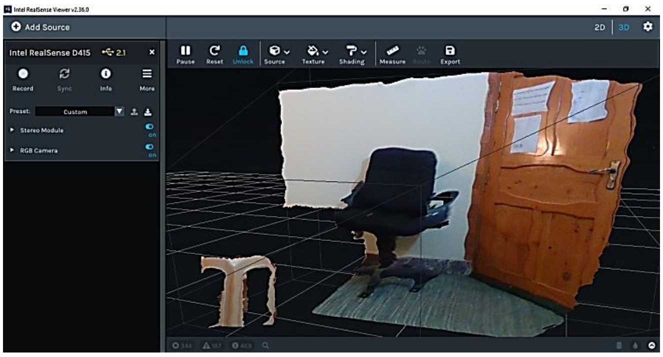


Figure 9: *The Intel Real Sense Viewer presenting the RGB image as a 3-D object.*

Figure 10 shows some case scenarios where the object (stool) was moved in various directions to present to the system different scenarios. It was noted that while the camera documentation suggests a nearest object detection at around 1cm and a farthest object at 10 feet, the practical usage differed. The nearest object was detectable at 10cm and the farthest at 6 feet respectively.

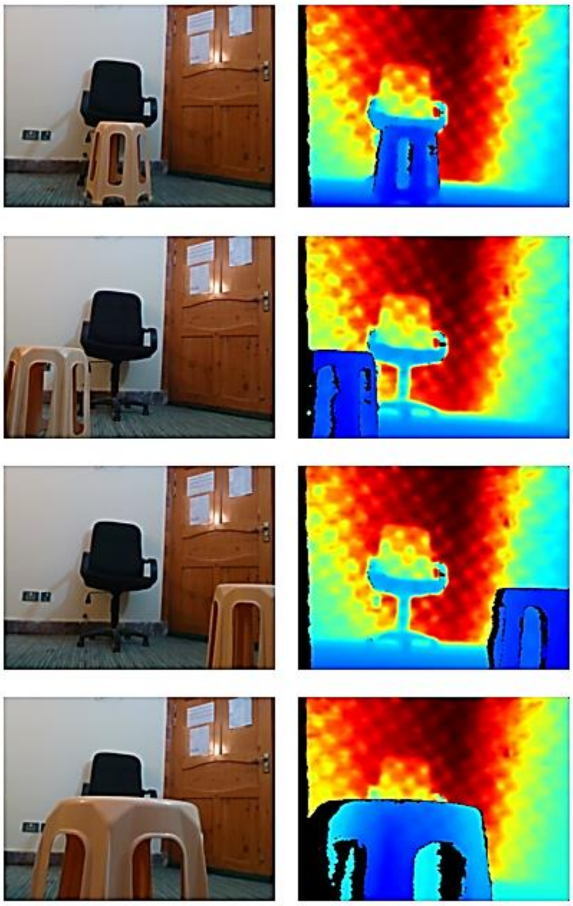


Figure 10: *Effect on the depth image when object is brought near.*

V. CONCLUSIONS

In this research work, the existing methods and systems developed for blind people assistance were discussed in detail. This included the analysis of various sensors used, complexity of each technique and its usability. A system based on depth camera in conjunction with image processing has been proposed. It utilized the depth information to inform the user about obstacles. In the future, it is aimed to include deep learning based object recognition so the user can be informed what object is present in the path. Further, the system can be embedded with AI to propose a path when obstacles appear.

REFERENCES

[1] Ismail, R., Z. Omar, and S. Suaibun. Obstacle-avoiding robot with IR and PIR motion sensors. in IOP Conference Series: Materials Science and Engineering. 2016. IOP Publishing.

[2] Musa, B.M.F.S., et al., Multifunctional Robotic Vehicle for Industrial and Security Applications. 2015.

[3] Praveen, R.G. and R.P. Paily, Blind navigation assistance for visually impaired based on local depth hypothesis from a single image. Procedia Engineering, 2013. 64: p. 351-360.

[4] Agarwal, A., D. Kumar, and A. Bhardwaj, Ultrasonic stick for blind. International journal of engineering and computer science, 2015. 4(4): p. 11375-11378.

[5] Wahab, M.H.A., et al., Smart cane: Assistive cane for visually-impaired people. arXiv preprint arXiv:1110.5156, 2011.

[6] Al-Fahoum, A.S., H.B. Al-Hmoud, and A.A. Al-Fraihat, A smart infrared microcontroller-based blind guidance system. Active and Passive Electronic Components, 2013. 2013.

[7] Nada, A.A., M.A. Fakhr, and A.F. Seddik. Assistive infrared sensor based smart stick for blind people. in 2015 Science and Information Conference (SAI). 2015. IEEE.

[8] Bagwan, S.M.R. and L. Sankpal. VisualPal: A mobile app for object recognition for the visually impaired. in 2015 International Conference on Computer, Communication and Control (IC4). 2015. IEEE.

[9] Khan, A., A. Khan, and M. Waleed, Wearable Navigation Assistance System for the Blind and Visually Impaired. 2018 International Conference on Innovation and Intelligence for Informatics, Computing, and Technologies (3ICT), 2018: p. 1-6.

[10] Intel, Intel® RealSense™ Depth Camera D415.

[11] Arthur, D. and S. Vassilvitskii, k-means++: the advantages of careful seeding, in Proceedings of the eighteenth annual ACM-SIAM symposium on Discrete algorithms. 2007, Society for Industrial and Applied Mathematics: New Orleans, Louisiana. p. 1027–1035.