Journal of Artificial Intelligence, Machine Learning and Neural Network
ISSN:2799-1172
Vol: 02, No. 04, June-July 2022
http://journal.hmjournals.com/index.php/JAIMLNN
DOI: https://doi.org/10.55529/jaimlnn.24.33.42

A Literature Survey on Vision Assistance System Based on Binocular Sensors for Visually Impaired Users

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Received: 20 February 2022 **Accepted:** 09 May 2022 **Published:** 29 July 2022

Abstract: According to research, in 2015, there were an estimated 253 million people with visual impairment worldwide. Of these, 36 million were completely blind and a further 217 million had moderate to severe visual impairment (MSVI). This forms a considerable part of the population if you look at it. But the visually impaired still face a lot of difficulties in just going about their daily life. Most have to rely on the people around, on a basic walking cane or on a guide dog. This takes away a good part of their independence as they have to rely on someone for their basic needs. Many wearable technologies have been proposed to assist the visually impaired in their daily routines in order to solve this problem. This paper is an attempt to comprehend all of the past research done on the subject.

Keywords: Binocular Vision Sensors, Object Detection, Object Identification, Disparity, Convolutional Neural Network.

1. INTRODUCTION

When discussing the challenges that the world's population faces, we frequently overlook those who are the most affected by the current situation: the blind and visually impaired. According to surveys, in 2015, there were an estimated 253 million people with visual impairment worldwide. Of these, 36 million were completely blind and afurther 217 million had moderate to severe visual impairment (MSVI). Blind people are not automatically entitled to basic care needs in most nations since they are not defined as clinically extremely vulnerable.
With breakthroughs in Artificial Intelligence and Technology, we are better positioned to improve this group's quality of life. This technology, also known as assistive or adaptive technology, is constantly growing and has helped people with vision loss overcome many barriers to access.

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The goal is to create a blind aid equipment that includes two cameras mounted on a walking stick that is commonly used by blind people. One camera alone cannot accurately imitate the human vision system, but two cameras can be used to sense depth and interactions between objects. Following the acquisition of the binocular image, we run it through a CNN-based object detection model to help us identify the classes to which they belong and therefore lead the visually impaired along their journey. Each camera captures slightly different spatial information and sends it to the model. The model then uses the differences between the two cameras to calculate the parallax of the pictures and evaluate distance and depth. A communication device linked to the person's body is used to convey to the user the obstacle ahead.

Through the research conducted in this paper, we hope to address such socio- economic issues. With the dependence on technology, we may help these individuals find independence for themselves.

Background and Motivation

Without vision, it is difficult for a visually impaired person to maneuver around any environment without colliding with various impediments. They are unable to carry out their everyday duties, such as strolling down the street, visiting friends or relatives, or performing any other daily tasks. Even a standard walking stick can be inconvenient and inaccurate when it comes to detecting and avoiding obstacles.

The goal of this paper is to conduct a literature survey on the topic that helps us summarize and analyze previous theories and research conducted with respect to the topic.

Literature Survey

Jiang et al. [1] suggests that visually impaired people have a difficult time navigating in general. This solution aims to assist these users using computer vision, and a wearable vision assistance system. The issue with many similar systems is that the quality of images is not up to the mark, due to noise and distortions being added during the data transfer process. To solve this, binocular vision sensors are used to capture environment images and the highest quality images arechosen using stereo image quality assessment (SIQA). After this, the images are sent to a cloud for further processing. A convolution neural network (CNN) is used to detect and identify objects in the images and this is then relayed back to the user, based on which they can then make a calculated decision.

Liu et al. [2] work with the calculation of the distance of an object from the camera using binocular vision. Using two cameras, an object's position from both the cameras would be slightly different from the other. This difference in position is called disparity. Using the principles of disparity, the 3-D positional information of the object can be obtained. MATLAB is used to stereo calibrate the camera, or determine the position and orientation of the camera with respect to a world reference system, and OpenCV is used for stereo rectification and stereo matching, which gives the disparity value, from which the position of the object from the camera is calculated.

Pascolini et al. [3] proposed that based on reviews from published and unpublished surveys, it is estimated that there are 285 million visually impaired people around the world. Around

65% of this population are above the age of 65. The major causes of visual impairment are uncorrected refractive errors (43%) followed by cataract (33%). There isn't a lot of research being put into this particular field, even though there is a significant number of people facing difficulties with respect to their vision. This paper tries to bring about the statistics behind this and concludes by saying that considering this data, the magnitude of visual impairment should be regularly monitored and eye care systems should be set up, including human resources and infrastructures.

Cardin et al. [4] postulates a mechanism that uses sonar sensors to detect the presence of an object and send vibrotactile feedback to the user regarding the position of closest objects around them. Since many visually impaired are not open to new technologies, this system tries to complement the already existing cane. It will focus on objects that are at the shoulder lever of the user. The user will be informed of the presence of an object with the help of a vibration device.

Terven et. al. explained that instead of ultrasound, infrared, or laser sensors, this paper looks at the improvements in the field of Jupiter vision and how it can be used to help the visually impaired [5]. It lists different computer vision based visually imparied assisting devices, along with their advantages and disadvantages. For example, the virtual white cane that uses vibrations from a smartphone to inform the user of an obstacle/s ahead, and the vibratory belt, that uses vibrations from a belt worn around the user's waist to warn them of obstacles ahead. It concludes by saying that although computer vision-based systems for the visually impaired look promising, it is still in the intermediate stages of invention and development. One important factor that these systems should consider is the ease of use of the user, which generally takes a back seat as developers don't pay much heed to it.

Melmoth et. al. suggested that theoretically, binocular information should provide advantages in the planning and execution of natural reaching and grasping activities when compared to monocular sight. These predictions were tested using a simple prehension task in which normal people reached, gripped, and lifted solitary cylindrical household objects in a well-lit environment with binocular vision or one eye blocked. According to the findings, binocular vision has a distinct advantage when it comes to controlling the terminal reach and grab. Subjects' monocular post-contact durations were significantly longer, implying that they were relying more on non-visual feedback when manipulating the objects before attempting to lift them [6].

Flores et. al. put forward that for guiding blind walkers, their research suggests a vibrotactile interface in the form of a belt [7]. This interface allows blind walkers to get haptic directional guidance along complex courses while maintaining their capacity to listen and perceive their surroundings. The belt interface was tested and compared to audio guidance in a controlled trial with ten blind people. The belt, according to quantitative and qualitative data, led in a closer path following at the sacrifice of speed. Participants were enthusiastic about the usage of a vibrotactile belt to offer directional guidance, according to the study.

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Fang et. al. mentioned in their paper, a deep convolutional neural network is used to offer a no-reference quality assessment approach for stereoscopic images (DCNN). The Internal Generative Mechanism in the Human Brain inspired this, as it is shown that the brain first analyzes perceptual information before extracting effective visual information. Experiments reveal that the proposed method can effectively measure the visual quality of stereoscopic images, demonstrating the usefulness of the proposed solution in imitating the human visual system's perception mechanism [8].

Thakurdesai et al. [9], proposed a system that employs the YOLO algorithm, which divides the image into a SxS grid. If an object's center falls inside a grid cell, that grid cell is responsible for detecting that object. The bounding box with which an identified object has the greatest IoU will be connected with it (Intersection over Union). On the same image, a comparison is made between YOLO and a few different object detection systems. Regardless of the item, YOLO provides the best accuracy. Stereo vision perceives the three-dimensional structure of the world and generates a depth map using two camera-calibrated pictures. The two cameras are calibrated to determine their intrinsic and extrinsic properties, such as focal length, skew, distortion, picture center, and so on. The system produces a text-to-speech output to communicate the results to the user.

According to B. Montrucchio et al. [10], they suggested the development of a model that can characterize and quantify the response of human eyes to stimuli of various sizes, contrasts, and colours, as well as to assess dark adaptation over time in both binocular and monocular vision. The difference between monocular and binocular vision has been shown to be relatively minimal in this investigation. This fact gives weight to the argument that stereoscopic vision has no effect on vision threshold.

Nada et al. [11], presented a smart stick that is essentially an embedded system with the following components: a pair of ultrasonic sensors to identify obstructions in front of the blind from ground level to head level height in the range of 400 cm a head, and an infrared sensor to detect upward and descending stairs. Real-time data is collected by ultrasonic and infrared sensors and sent to the 18F46K80 microprocessor. The microcontroller activates the motor to vibrate and sends the right speech warning message over the headphones after processing this data. This system lacks stereovision, which is required to discern depth in objects.

Narayani et al. [12] have recommended a system that considers objects at different heights. For the completeness of varied obstacles, the objects below knee level and hanging objects ahead of the chest level have been addressed in this method. It alerts the user to the existence of obstructions by emitting an alarm signal using vibrators. A dedicated camera module with a PIR sensor is used in the design to detect moving objects or people before the cane is activated. It explains the distance computed using the theoretically proposed equation, as well as the obstacle's response at various distances. When the vibration passes a threshold point, the sensor employs a comparator to detect it. It generates a digital signal in response to the vibration.

Elmannai et. al. hinted that there are a few systems out there to assist the visually impaired. They also come with their flaws. This paper takes a look at the current state of blind assisting wearable and portable devices, their advantages and disadvantages, and future improvements possible. Even at present, the most common assisting mechanisms used by the visually imparied are the cane and/or a guide dog. However, they do not provide a lot of features and are limited in their capacity. Assistive technologies fall under three main categories- visual enhancement, visual substitution, and visual replacement. The most common technologically enhanced systems currently in use are the smart cane, that detects and alerts the user of an object ahead using sensors, and the eye substitution device, that uses ultrasonic sensors to detect the presence of an object ahead. However, none of the systems mentioned were 100% satisfactory in terms of the essential features. This goes to show that there is a major need for more research and development to be done in this particular field [13].

Chen et al. [14] found that visually challenged people frequently face action and identification difficulties in their daily lives. This study presents a smart wearable device with image recognition capabilities. The project uses image processing on a cloud server, with the local unit just uploading images and providing feedback. The algorithm ensures recognition speed and accuracy. The standard video continuous scanning technique is replaced with a power-saving strategy of recording points of interest. The system ensures real-time output thanks to the numerous priority feedbacks and arbitration mechanism.

Mahammed et. al. recommended that a three-dimensional camera is used to create two stereoscopic images of a single object [15]. The distance between the cameras and the object may be calculated using the distance between the positions of the objects in both photos, both cameras' focal lengths, and the distance. Triangulation is a technique for connecting the dimensions described above. Through the technique of template matching, image processing is employed to discover relationships between the photos of the item in the images created by the left and right cameras. A 3D webcam was utilized throughout this project, and a MATLAB code was built to calculate the object distance.

Praveen et al. [16] proposed that object detection is accomplished in three steps in this system: edge detection and conversion to grayscale, edge linking, and noise removal. The technique for depth perception was devoid of any user participation and was based on a single image determining the vanishing point for the depth using a local depth hypothesis. Multiple pictures and stereo vision make depth perception easier. No method has been included in this system to alert the user to the impediment in front of them.

2. CONCLUSION

From the survey of existing methodologies and the techniques used to design an effective system to assist the visually impaired in their daily lives, it seems clear that the implementation of stereovision over monocular vision has been more successful in this endeavor. While most designs for this type of system uses auditory signals in order to convey to the user of any impending danger, the use of a pressure device or vibration would be able to aid those with both visual and auditory impairment. Basic canes are not able to detect items that are far away from them, nor can they detect objects that are suspended in the air, such as tree branches. We will attempt to detect majority of objects in the vicinity. Most devices already present in the market use object detection and identification, which takes a while to get an accurate output, by using real-time object detection we will be able to accelerate this process and help the user to evade obstacles. This survey has aided us in our quest to discover the most effective way to assist people with physical disabilities. The analysis of theories and research with regard to this topic has shown us a clear path towards implementing the blind aid system.

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Journal of Artificial Intelligence, Machine Learning and Neural Network
ISSN:2799-1172
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