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A Review on an Obstacle Detection in Navigation of Visually Impaired

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Abstract : Vision is a beautiful gift to human beings by GOD. Vision allows people to perceive and understand the surrounding world. However a World Health Organisation survey made in 2010, estimated 285.389 million people with visual impairment across the globe. These visually impaired people face the problems of orientation and mobility in an unknown environment. Many efforts have been made to improve their mobility by use of technology. For doing so, a virtual vision is offered using digital image processing.

Keywords - *algorithm, camera, image processing, obstacle detection, visually impaired*

I. INTRODUCTION

The human vision is a complicated vision system based on information collected by a very large number of receptors - the rods and cones - cells of the eyes. Visual acuity is a measure of the spatial resolution of the visual processing system. A decreased level of visual acuity is currently improved by different approaches based on methods and devices that enhance the diminished vision or, else, the option is to substitute for the diminished or lost vision by using other senses. Thus, when vision loss is total (blindness), a “sensorial substitution” is performed. This solution entails using an alternative human sense to collect information that is normally captured by other sense [1]. Blindness is the inability to see [2]. There are four levels of visual function, according to the International Classification of Diseases -10 (Update and Revision 2006):

- normal vision
- moderate visual impairment
- severe visual impairment
- blindness

Moderate visual impairment combined with severe visual impairment is grouped under the term *“low vision”*: low vision taken together with blindness represents all visual impairment.

1.1 Global estimates of visual impairment and blindness

Global estimate of the number of visually impaired people according to World Health Organisation survey made in 2010 [2] as indicated in Table1.1:

Population (million)	Blind (million) A	Low Vision (million) B	Visually Impaired (million) A+B
6737.50	39.365	246.024	285.389

Table 1.1 Global estimate of visually impaired

Key facts
1. 285 million people are visually impaired worldwide: 39 million are blind and 246 have low vision.
2. About 90% of the world's visually impaired live in developing countries.
3. The causes of visual impairment: Globally the major causes of visual impairment are:
-uncorrected refractive errors (myopia,
hyperopia or astigmatism), 43 %
-cataract, 33%
-glaucoma, 2%

Poverty is the cause for ill health, including eye health. Blindness remains a key barrier to development.

1.2 Estimates of visual impairment and blindness in India

The main causes of blindness in india as shown in Fig. 1 are as follows: - cataract (62.60%) refractive error (19.70%) corneal blindness (0.90%), glaucoma (5.80%), surgical complications (1.20%) posterior capsular opacification (0.90%) posterior segment disorder (4.70%) and others (4.19%). The estimated national prevalence of childhood blindness /low vision is 0.80 per thousand [3].

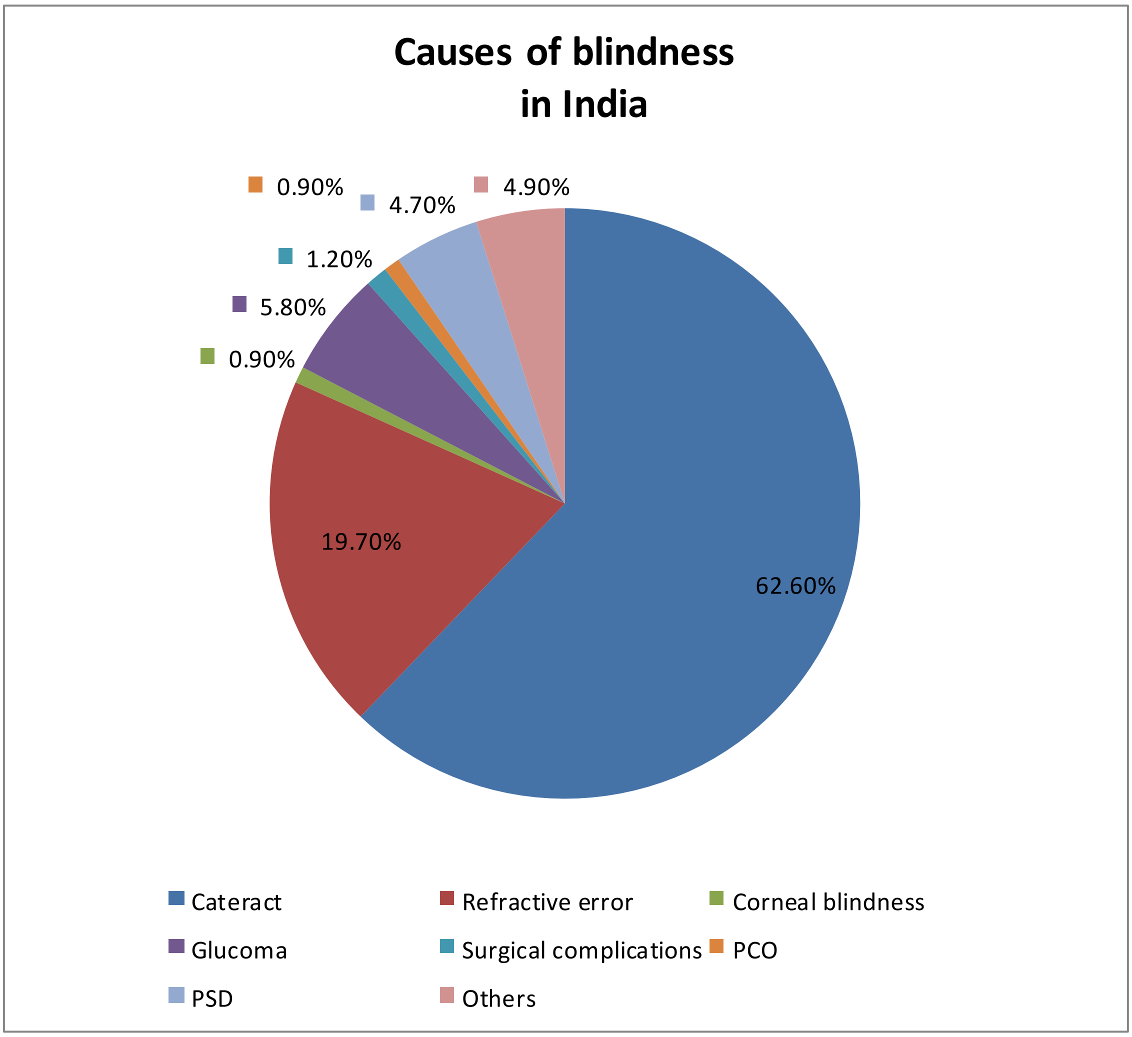

Figure 1: Main causes of blindness in India
Source: Community Eye Health J Indian Supplement 2008, NPCB

India shoulders the largest burden of global blindness, about 3.5 million across the country with 30000 new cases being added each year [4]. One out of every three blind people in the world lives in India - an estimated 15 million blind people live in India [5]

The National Sample Survey of India: The NSSO conducted the 47th round of a nation-wide comprehensive survey of disabled persons during July-December 1991. The survey revealed that population of the visually impaired in India at 850 million level of population is 4 million as per the following distribution as shown in Table 1.2 [6]:

Sex	Rural (%)	Urban (%)	Total (%)
Male	1539 (38.42)	308 (7.69)	1847 (46.11)
Female	1796 (44.84)	362 (9.03)	2158 (53.88)
Total	**3335 (83.27)**	**670 (16.72)**	**4005 (100.00)**

Table 1.2: Estimated population of the visually impaired (1991)(Thousands)
Source: Survey of Disabled Persons, NSSO, 1991

Thus the population of the visually impaired according to above estimate is 0.47 % to population.

II. MOTIVATION AND SCOPE

Millions of visually impaired people are facing the problems like mobility and orientation in an unknown environment [7]. Currently majority of them rely on the white cane for local navigation, constantly swaying it in front for negotiating walking paths and obstacles in the immediate surround. Technologically it is possible to develop a vision aid which complements the white cane, for alerting the user to looming obstacles beyond the reach of the cane, but also for providing assistance in global navigation when going to a certain destination. However, since more than 80% of potential users of such an aid are from so-called developing countries with low economic level, most are very poor and cannot afford expensive solutions. Even guide-dogs cannot be afforded by most because of their expensive training. What better can be the use of technology than using it for the visually impaired, who cannot make the use of these otherwise? A virtual vision should replace a big part of the functionality of a normal visual system: centring automatically on paths, detecting static and moving obstacles on the fly, and guiding to a destiny. The research aims towards solving the major problems of mobility and orientation faced by the blinds. Utilization of technology to improve the mobility will be of tremendous help to visually impaired in acquiring the independence.

III. REVIEW OF RELATED LITERATURE

J. Nascimento, J.S. Marques [8] have addressed the evaluation process for checking the performance of object detection algorithms like background subtraction BBS algorithm, W4 algorithm, Single Gaussian Model SGM, Multiple Gaussian model MGM, Lehigh Omnidirectional tracking system LOTS algorithms. They have proposed framework which selects the set sequences for testing, and moving objects are detected using automatic detector by comparing with ground truth. Experimentation is done using user friendly interface, with which user can select the foreground regions in test sequence. The user can edit the image by adding, removing, checking the operation to get correct segmentation. Different types of errors like splits of foreground regions, merges of foreground regions, simultaneous spilt and merge of foreground regions, false alarms and detection failures are considered. Also computational complexity is calculated for every algorithm. The advantage of the proposed method is that it can provide a statistical characterization of the object detection algorithm by measuring the percentage of each type of error. It is only applicable for fixed/static camera with frame rate of 1 frame/s. Camera specification, its interface, image properties are not elaborated.

D. Lee, J.D. Anderson, J.K. Archid [9] have addressed the correspondence problem for an embedded stereo vision sensor to provide real time visual guidance to visually impaired. They have used 1D signal matching method based on spline representation. Genetic algorithm is used to find dense disparity map. The hardware requirement is Virtex-4FX60 FPGA core, CMOS imagers, SDRAM image storage, SRAM, Vision processing engine, Compass, GPS receiver. The algorithm is tested for indoor as well as outdoor scenes. The advantage of this approach is that the algorithm is suitable for implementation in hardware and can be easily extended to solve image registration and motion detection problems. It is well suited for the situations where there is a large variation in illumination. Hardware simulation shows that, it works satisfactory for 640*480 images, 9-11frames/sec for normal walking speed of 4feet/sec, update the information approximately every 12cm. Areas of glare and shadows are not considered as obstacles. Staircase drop-offs, Ariel objects need to be detected.

ZiadHunaiti, V.Garaj, W. Balachandran [10] have tested the performance of 2G, 2.5G, 3G mobile networks to serve as telecommunication platform for the navigation of visually impaired people in real time. In prototype, Mobile terminal unit (camera + GPS) carried by the user sends the images and user's position to Stationary Navigation Service Centre. The computer matches GPS data with the GIS database and identifies user location on digital map. The received video image and digital map is referred by the guide. The guide uses the system's GIS module to plan optimal travel route and verbally communicates the navigational instruction to the user. The communication between MTU and SNC is done through mobile communication link. The performance assessment is done based on link characteristics: latency, link outages, bandwidth and packet losses for 2G, 2.5G, 3G mobile networks. 2G gives low bit data rate transmission, it has low bandwidth, and it is not suitable for video transmission. For 2.5 G mobile network latency is carried out by performing roundtrip time test. Latency (delay) increases as number of users increases. Link outage is more. Uplink data transmission is with 12kb/s rate and downlink data transmission is done with 48kb/s rate. Also packet loss is high in 2.5G mobile link. As compared to 2.5G, latency in 3G mobile link is less, no congestion and no loss of information is there. Uplink and downlink data transmission rate is 64 kb/s and 384 kb/s in 3G. It is more robust than 2.5G mobile link.

Y.H. Lee, G. Medioni [11] have implemented the technique to overcome the limitation of stereo vision based system (inaccuracy in depth map) for navigation of visually impaired. Experimentation is done for 350 frames. It is proven that 3D depth map from stereo camera is inaccurate & results in inconsistency of the traversability map in the experimentation area and hence navigation algorithm fails to find an appropriate way point and safe path whereas dense traversability map built using RGB-D camera showed more accurate map, also it takes care of low textured environment. The performance and reliability of the system is improved. Experimentation is done using RGB-D camera 320*240 QVGA@60 frames/sec, USB interface, CPU: Intel(R)Xeon Quad Core @ 3.72GHz, RAM 3 GB, OS: Windows XP- 32 bit. The advantage of this approach is that dense 3D information is provided at faster rate. The system is wearable, having low cost and consumes less power. Depth maps extracted from stereo camera in low textured environments are not accurate for successful navigation as compared to RGB-D camera. Quantitative performance analysis is not given.

S.Fazli, H.M. Dehnavi, P.Moallem [12] have focused the problems of obstacle detection in highly textured environments and detection of staircases using stereo vision.In the experimentation, calibration of camera is done. Images are captured. Adaptive thresholding, resizing, & noise removal operations are performed. After these preprocessing operations, disparity map and depth are computed. Area based algorithm for stereo matching by SHD (sum of hamming distance) is used. The method is easy to implement, fast, applicable for highly textured environments. Limitations of the system is that, for staircases the detection region must have at least 3 concave and convex edges alternately. Quantitative performance analysis is not done. Hardware requirement is not mentioned

Long Chen,Bao-long Guo, Wei Sun [13] haveimplemented obstacle detection system for visually impaired people using stereo vision. They have used HSV color model to generate saliency map. In their approach, features are extracted based on colour, intensity and direction. Obstacle is detected from its area through threshold segmentation to saliency map and 3D information is calculated using stereo vision. Obstacle information is transformed into voice to inform visually impaired. They experimented using TMS320DM642, digital media processor DM642 evaluation module board. They used CCD camera with 320*240 image size with 5 frames per second. Future scope of the work is to extract the obstacles with similar background information in real time.Only stationary objects can be detected using those saliency maps.

H. Sun, C.Wang, N. EI-Sheimy [14] have addressed an approach for detecting and tracking moving objects using stereo cameras. They used Scale Invariant Feature Transform (SIFT) based particle algorithm to detect the features of moving object by a moving observer. They illustrated through experimentation that the algorithm detect the moving object/ vehicles on road and vehicles waiting in line are not detected as they are stationary. The performance of independently moving object detection and tracking is expressed using number of correctly detected, missed and false positive independently moving objects. Future scope of the work is to improve proposed algorithm for stereo sequences with severe image clutter and dynamic occlusion and motion based recognition of independently moving object.

Won J. Kim, I Kweon [15] have explained the concept of multi moving object detection and tracking under moving camera. Moving objects are detected by homography based detection. Objects are tracked using on line boosting algorithm. For moving object detection, features are extracted from images using KLT feature Tracker. Homography H is obtained by Random sample consensus (RANSAC) scheme. From two frames, residual pixels are identified. These pixels are refined by morphological process. For object tracking online booster algorithm is used. Each detected object is used to train the classifier. The success rate of this approach for object detection is 85.6% and for detection & tracking, it is 89.6% for outdoor scene. Multiple objects can be detected and tracked.The paper does not focus on speed of moving object and time required to detect & track the same. Also it doesn’t focus on the distance between object and user.

L. Dunai, et al [16], have developed a prototype as a travel aid for blind people. They addressed a method to detect static and dynamic objects from the surrounding environment and inform user through generating acoustical sounds. Also conveys free path detection. They experimented using a pair of Firewire Flea2 stereo colour camera with 25 frames/s, Toshiba Laptop with Windows XP OS and headphones. They have used image and acoustical processing algorithm. The stereo camera records the environment information & this information is used to provide acoustic data to user. The distance to the object is represented by the signal pitch & the direction by spatial direction of signal. Images are captured & depth maps are extracted. KLT tracker is used. Segmentation algorithm is applied by using the Maximum Likelihood Sample Consensus (MELSAC). Object detection is depicted with red, yellow and blue dots. Blue colour represents moving objects; red dots are referred to near objects. The most dangerous object is marked with a frame named bounding box. he prototype can detect the object between 5m to 15m but it does not focus on tracking speed. The use of multiple & different sounds for multiple objects cause interferences. The system is unable to detect objects at ground level such as stones/steps.

V. Pradeep, et al [17] have represented light weight, cheap, low power wearable system for assisting the visually impaired to perform routine mobility tasks. They have developed a head mounted two camera system that performs obstacle detection, route planning and uses tactile vest for cuing. They have used bumblebee stereo camera to get 3D map for obstacle detection. The users’ motion is continuously tracked (localization) on global frame of reference and new obstacles are registered into this frame (mapping). Camera motion is computed using three point algorithm in a RANSAC setting. The feature tracking is done using KLT tracking algorithm for estimating optic flow. For path planning, a shortest path is computed using D-star Lite algorithm. The advantage of this approach is that camera motion can be predicted. SLAM is used. Memory stores obstacles, so even if camera is not pointing towards obstacle, it is already stored in memory. Object recognition is not done. It doesn't address ground level or hanging objects, multiple objects and speed of object. GPS can be used for location identification. Wireless cameras can be used so that images will be streamed over wireless network to a remote server which will perform all the processing and then transmits the cues to the tactile interface.

N. Ortigosa, et al [18] have presented an algorithm for the detection of obstacle free pathway in real time. It interprets and manages real world information from different sources to support mobility to visually impaired. Depth map extraction is done by two CCD firewire cameras using dynamic programming. For normal walking speed of 1.39m/s, they analyzed 2.5m of the scene. They have detected obstacle free area by processing 25% last rows of the depth map. Obstacle free pathway detection is based on the fact that the depth map gray levels in obstacle free areas decrease slightly and linearly from bottom to top of images. Obstacles for which depth is constant, is represented by flat zones. Through experimentation authors have proved that the proposed system takes 80ms to obtain the depth map and 40ms to perform obstacle free pathway detection for 8frames/sec frame rate. The detection algorithm performance is evaluated on the basis of true positive, true negative, false positive and false negative. The performance is measured by calculating accuracy and precision. The drawback of this work is that the quality of depth map used for detection depends on the illumination conditions of the scene. Bad illumination condition reduces the algorithm performance. Also parameter optimization is done using 15 images from training set. Authors have proved computationally that the algorithm is efficient and can be used in real time.

V. DhilipKanna, et al [19] have addressed a virtual eye for blinds which communicates to the surroundings through a camera. The LADAR (Laser Detection and Ranging) is used for locating objects distance from visually impaired. PID (Passive Infrared Detector) is used for motion detection. It measures IR light radiation from objects in its field of view. Virtual object detector (VOD) is used for recognizing the object viewed by camera using online database. Location identification is done by GPS. They have experimented on FPGA with Zigbee transmitter. The entire computation is main processing unit is done within few ms. System can be used in noisy environment. But it only works for still images. Image transmission delay using ZIGBEE is not specified.

IV. CONCLUSION

In general the research work carried out so far can be classified on the basis of

1. Algorithm used detection of static and dynamic obstacle detection
2. Static and moving camera
3. Number of cameras used
4. Type of hardware used
5. Type of image transmission
6. Measures used for performance evaluation

The percentage of segmentation errors and computational complexity is calculated for evaluating the performance of BBS, W4, LOTS, SGM and MGM algorithms for moving objects using static camera[8]. Genetic algorithm is implemented on FPGA hardware for moving obstacle detection[9]. Different mobile networks are tested to determine optimal travel route [10]. A real time simultaneous localisation and mapping (SLAM) algorithm and path planning algorithms for low textured area is used [11]. A Area based algorithm for highly textured environments is used for static objects like staircase and hanging objects [12]. DSP processor based hardware is used to generate saliency map for detecting static obstacles [13]. Scale Invarient Feature Transform based particle algorithm is used to detect moving object by moving cameras [14]. Background subtraction algorithm and homography based motion detection is used to detect moving object by static camera [15]. A static or dynamic object is detected using KLT tracking algorithm [16]. A real time simultaneous localisation and mapping (SLAM) algorithm and D star algorithm is used to detect obstacles [17]. Depth map is extracted using dynamic programming to detect obstacle [18]. Hardware based virtual eye, LADAR is used to detect the object distance and PIR is used to detect motion of object [19].

Different algorithms are used for detection of static or moving obstacles using camera. Moving objects are detected using background subtraction method using static camera. Homography based detection using online boosting algorithm, KLT feature tracker and Scale invariant feature transform based particle algorithm are used for moving object detection using moving camera. Static obstacles are detected by area based algorithm. Genetic algorithm and saliency map (color, direction and intensity) are used for dynamic obstacle detection.

There is a need to focus the research on static and moving obstacle detection using camera. The objective of research should be to develop specific algorithm to serve the need of visually impaired.

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