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A Walking Aid for Blind Navigation

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Abstract: The goal of the project "A Walking aid for Blind Navigation" is to develop a small and reliable system for assisting the blind and visually impair people, so that they could navigate in a known area. In this paper we present an overview of the prototype, design issues, and its different modules which integrate some computer vision algorithms with slight modifications at some places. The prototype addresses local navigation by analyzing known landmarks, depth detection of the closest object in the scene(so that visually disabled person could get rough idea about how far the closest hindrance is present), obstacle avoidance and object recognition.

I. INTRODUCTION

People with visual impairment face enormous limitations in terms of their mobility and in today's world; there is a lack of infrastructures to make it easier. The task of moving from one place to another is a difficult challenge that involves obstacle avoidance, finding doors and knowing the current location.

Visually impair people depend on other human beings for various daily routine works even inside their locality. It would be great if we can make an aid which will help them navigate in their locality without other human's help and give them feedback, say voice in this case, saying the type of the object which is present in the image clicked by the visually impair person, wall is present in image or not, how far is the nearest object to the person and it is present on which side of the image taken.

Over the years, various researchers have discussed navigation issues using RFID technology. An advantage of passive RFID technology is that, it doesn't require a power supply because it depends upon the power of probe signal itself for data transformation but the disadvantage of passive RFID approach is that it requires a very short distance to communicate [1]. Another approach was to use active RFID which makes use of GPS technology along with it but the disadvantage of this approach is that when GPS is unavailable, such as in between skyscrapers or inside buildings, system is disabled or may provide inaccurate positioning information because GPS accuracy is about 10-12 meters (for non-military applications) [1].

Our proposed solution is to provide a self dependent system to visually impair persons such that it is capable of capturing the images and give corresponding feedback to user with good amount of accuracy and which will solely help them to navigate inside a known area. The aim of this project is to develop a system containing features like image detection, color detection, wall detection (if present) and closest object depth detection. These features will be discussed in section II , III and IV below.

The basic block diagram of our system is shown below:

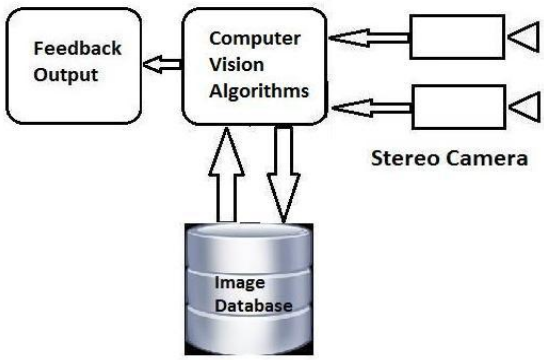

Fig. 1. Block Diagram of Blind Navigation System

And the software architecture of the project is shown below:

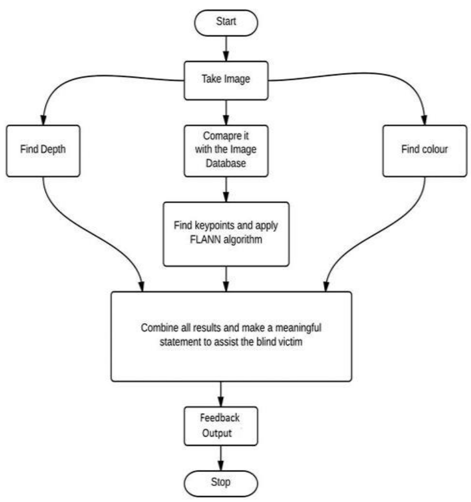

Fig. 2. Software Architecture

The hardware components required for the project are:

1. Two cameras(C270 Logitech), left & right camera, for stereo vision algorithm.

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2. A laptop with 4 Gb RAM (where our software is installed).

II. IMAGE DETECTION

Matching features across different images in a common problem in computer vision. When all images are similar in nature (same scale, orientation, etc) simple corner detector can work. But when you have images of different scales and rotations, you need to use SIFT algorithm. Image Detection is based on a computer vision algorithm known as SIFT(Scale Invariant Feature Transform) algorithm.

The keypoints of image taken from left camera is matched with the image database present on the laptop using FLANN matcher and the best matched image (if it is valid) is taken into consideration and if the best matched image is valid (based on threshold as 'number of keypoints matched') then its corresponding information is conveyed to the user. SIFT algorithm is explained below.

The first step is to create scale space. The image is taken and blurred using Gaussians (different σ), and then the image is resized to half and blurred again. The process is repeated. Amount of blur in a particular image is σ. Then, the amount of blur in the next image will be k*σ. Here k is an arbitrary constant.

Next the Laplacian of Gaussian (LoG) operation is found. The blurred image is taken and its second order derivative (laplacian) is calculated. Thus edges and corners in the image are detected. These edges and corners are good for finding keypoints. But the second order derivative is extremely sensitive to noise. The blur smoothes it out the noise and stabilizes the second order derivative. These Difference of Gaussian images are approximately equivalent to the Laplacian of Gaussian are also "scale invariant" (Laplacian doesn't depend on the blurr σ).

Next the maxima and minima are located. Each pixel is compared to its neighbours. The check is done within the current image, and also the one above and below it. These extremum points are key feature points. These points are subject to thresholding to reject bad matches. The outputs of SIFT algorithm is shown in figure 3 and figure 4.

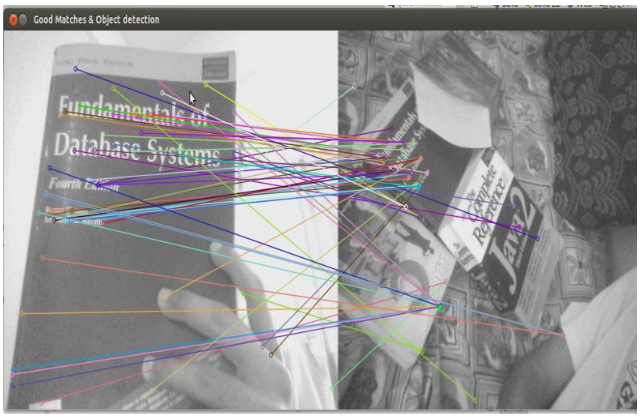

Fig. 3. OpenCV Output

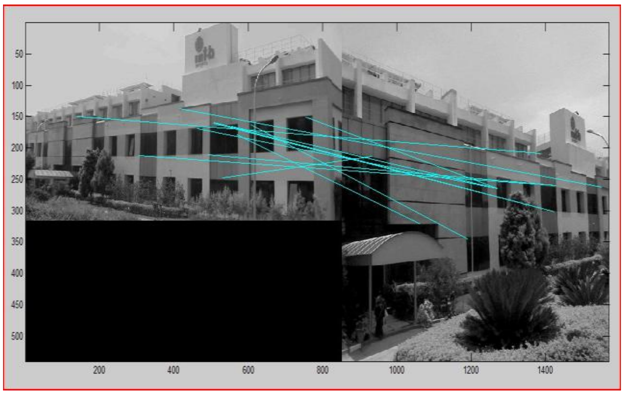

Fig. 4. MATLAB output

Hence, by using this, we can detect the object present in the image (as shown in Figure 3) and the location at which the visually impair person present (as shown in Figure 4).

III. COLOR AND WALL DETECTION

SIFT and other image keypoints matching algorithms works well when at least we have edges present in the image. If an image don't have any edge (like in the case of Wall's which is logically always expected to be of almost same color throughout) then SIFT algorithm fails to detect any keypoints and hence it fails. So, there is a need of wall detection algorithm. This algorithm has an additional feature of color detection as well. In this module, given a colored image from the left camera, the algorithm first applies a Gaussian blur on the image so as to maintain homogeneity throughout the wall image (as walls may contains some dirt on it in practical cases). Then we will visit each of the pixels and will check if almost the same value of RBG(Red-Blue-Green) is maintained throughout or not. If it is maintained and the number of keypoints matched from SIFT is below some threshold value then there is very high chance that a wall or a large obstacle is present in the image taken. Also, on the basis of the various combinations of R B and G values, we can detect the color of the wall.

In figure 5 and 6, the output is 'a wall of green color'. And in figure 7, the output is 'a wall of white color'.

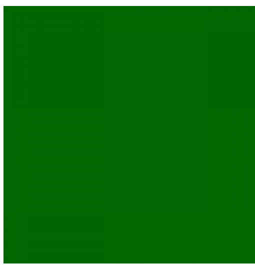

Fig. 5. Dark green wall

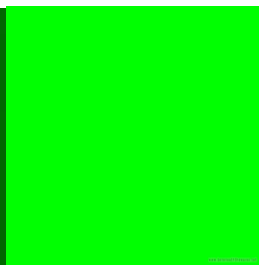

Fig. 6. Faint green wall

Fig. 7 White Wall

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IV. DEPTH DETECTION

A. Stereo Vision

Stereo vision is a widespread technique for inferring the three dimensional position of objects from two or more simultaneous views of a scene. Stereo vision systems do not need complex hardware two coupled video cameras such as

that in figure 8 are the minimal requirement. The main objective is to find out depth of the object in the scene .A stereo system is not straight forward , it involves number of steps such as camera calibration, image rectification, correspondence estimation, reconstruction. In our work we have used technique described in [2]. It requires at least two different views of a planar pattern. Next important step in stereo system is image rectification. Rectification simplifies task of finding correspondences. For rectification we have used algorithm defined in [3],[4]. After the rectification we need to find the correspondences between two views. [5] gives a good review of various correspondence estimation techniques. In our work we have used algorithm explained in [6].

B. Concept of Stereo Depth Estimation

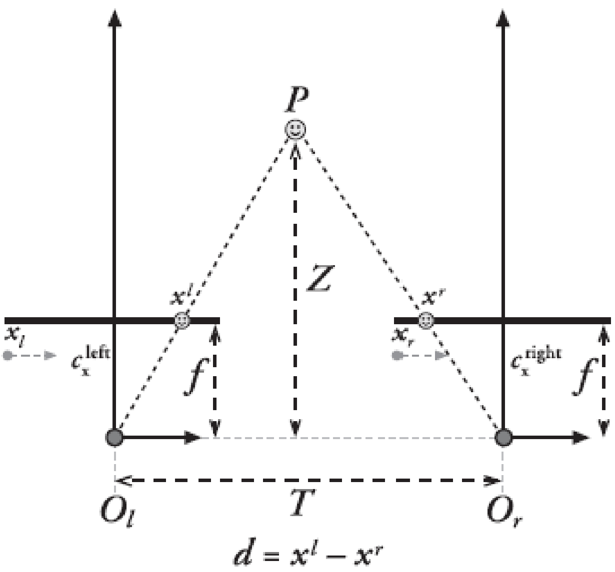

Fig. 8 Concept of stereo depth estimation

Here, P is a world point Ol and Or are origins of left and right camera coordinate system respectively. xl and xr are the pixel coordinates of point P in left and right images respectively. C^{left}_x and C^{right}_x are the centres of the left and right imagers . T is the separation between Ol and Or also known as baseline f is the focal length of left and right cameras. Z is the depth of the point in space from the camera. Then using the concept of similar triangles.

$$\frac{T-(x^l-x^r)}{(Z-f)}=\frac{T}{Z} \qquad (4.1)$$

On simplifying,

$$Z=\frac{fT}{(x^l-x^r)} \qquad (4.2)$$

Here, the term $(x^l - x^r)$ is also known as disparity and the separation between the camera i.e. T is called the Baseline. In the expression 4.2 ,f ,c^{left}_x ,c_x^{right} and T are found by stereo calibration and disparity $(x^l - x^r)$ is found by correspondence estimation.

1. Calibration Process :

In order to apply stereo ranging techniques with a reasonable level of accuracy, it is important to calibrate the camera system. The aim of camera calibration is to estimate how world coordinates are related to the pixel coordinates as shown

In the figure 9 i.e. estimate various camera parameters such as focal length, and extrinsic parameters such as camera orientation.

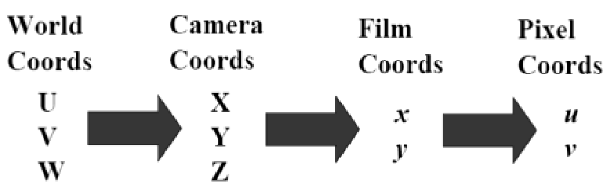

Fig. 9

Steps involved in the process are
1. Capture number of images (around 20 or more) of a planar checkerboard in different orientations
2. Detect corners in the image
3. Feed the image coordinates and world coordinates of the corners (assuming Z=0)
4. Run the Camera calibration algorithm
5. Save the Intrinsic parameters and Distortion coefficient.

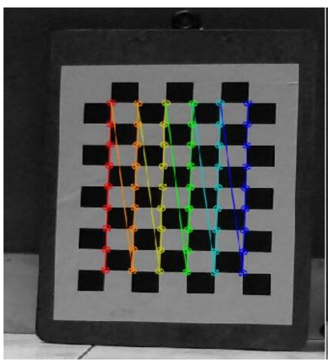

Fig. 10

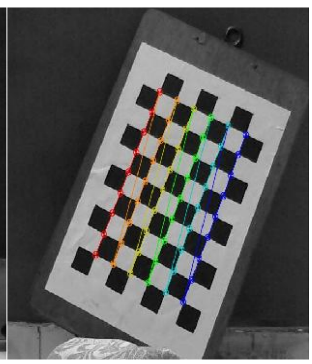

Fig. 11

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2. Image Rectification :

One of the most difficult part of a stereo algorithm is finding the correspondence i.e. for each pixel in the left image find the match in the right image. If simply brute force is applied i.e. entire right image is scanned for the match, the time required will be very significant. To improve this situation, image rectification is applied which ensures that the match for any pixel in left image lies along the same row in the right image.


Fig. 12. Left Camera Image


Fig. 13. Right Camera Image


Fig. 14. Left Rectified Image


Fig. 15. Right Rectified Image

3. Correspondence Estimation:

Estimating a Dense disparity map is a widely researched topic in computer vision. There are number of algorithms proposed in the literature for this. They are local or global in nature, they make use of techniques like graph cut, dynamic programming, belief propagation etc. We have used OpenCV [7] implementation of Semi Global Block Matching Technique proposed in [6].

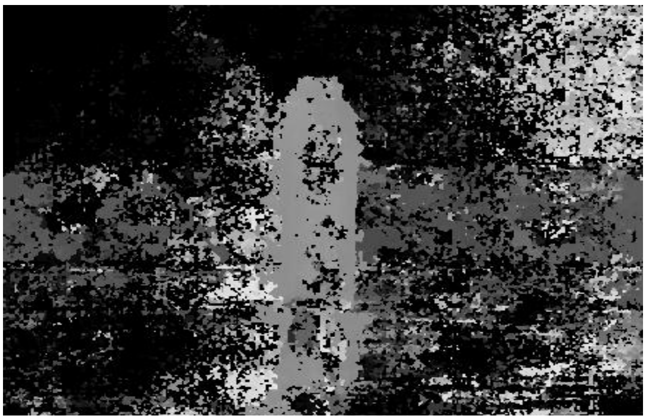
Fig. 16. Disparity Image

V. RESULTS

A. Experimental Setup

Two Logitech C270 (left camera and right camera) webcams are mounted on a wooden plank as shown below

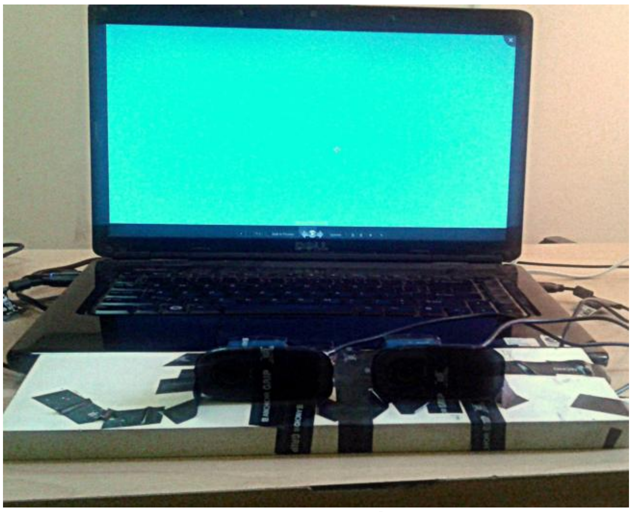
Fig. 17. Experimental Setup

B. Results

Original images: Fig. 12 and Fig. 13 shows the original images.
Rectified images: Before finding the correspondence images are needed to be rectified. The rectified images are shown in : Fig. 14 and Fig. 15.
Disparity image: After rectification we perform correspondence estimation. The disparities obtained by correspondence estimation can be shown in the form of an image (Fig. 16)
Reconstruction: From the disparity image we can find the distance of the object.

VI. FUTURE WORK

Considering the results of present work, we see that there is a immense scope for further improvement and extension of our work. Some of the possible works are

- Implement the techniques developed in this work, to work on-board as a independent unit. This is a challenging in itself because on-board implementation has stringent resource requirements and limited computing power.
- We can reduce resources i.e. reduce number of camera used and also computation complexity by measuring depth from defocus technique .In this technique by using single camera only we can find out depth of the object in the scene.
- Improve the Image recognition algorithm by storing keypoints of the database image instead of image itself.

VII. CONCLUSION

Simulated and hence built the prototype for blind navigation application using various computer vision and color/wall detection algorithms.

Within the scope of this project, three main works have been carried out

- Image Recognition

- Color/Wall Detection
- Depth Detection

In case of Image Recognition, accuracy depends on glitter on the object being captured and also on features of that object. In case of color/wall detection, accuracy depends on the homogeneity present in the image captured. In case of depth detection, accuracy depends on selection of baseline. To conclude, we can say that the image recognition part will help visually impair person recognizing the object or place. Color/wall detection will improve the detailing of the above result and tells about obstacles like wall present. In addition to that, depth detection will give estimated distance of obstacles present in the scene. Thus together this technique will make the navigation of visually impair person much easy.

REFERENCES

[1] Saleh Alghamdi, Ron van Schyndel, Ahmed Alahmadi "Indoor Navigational Aid Using Active RFID and QR-Code For sighted and Blind People ".
[2] ZhengyouZhang.A fexible new technique for camera calibration.Pattern Analysis and Machine Intelligence , IEEE Transactions on, 22(11):1330-1334,2000.
[3] Andrea Fusiello, Emanuele Trucco, and Alessandro Verri. A compact algorithm for rectification of stereo pairs. Machine Vision and Applications,12(1):16-22, 2000
[4] Emanuele Trucco and Alessandro Verri. Introductory techniques for 3-D computer vision, volume 93. Prentice Hall Englewood Cli_s, 1998.
[5] Daniel Scharstein and Richard Szeliski. A taxonomy and evaluation of dense two-frame stereo correspondence algorithms. International journal of computer vision, 47(1-3):7-42, 2002.
[6] Heiko Hirschmuller. Accurate and e_cient stereo processing by semi-global matching and mutual information. In Computer Vision and Pattern Recognition, 2005. CVPR 2005. IEEE Computer Society Conference on, volume 2, pages 807-814. IEEE, 2005.
[7] G. Bradski. The OpenCV Library. Dr. Dobb's Journal of Software Tools,2000.