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Obstacle Detection For Visually Impaired

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***Abstract*— This thesis aims to present the system that helps the visually impaired person to detect obstacles in the outdoor environment. This method uses MATLAB which is used to perform image processing and is synced with a Bluetooth connector such that it consolidates object avoidance. The additional components used are Raspberry pi and microphone which provides more clarified location and orientation information. A command is issued by the visually impaired person and the direction response is sent to him using audio signals. Multi-view relations are used as the fundamental principles upon which the solution is based that involve image processing and audio processing particularly. It includes the usage of a digital camera to capture the image frames directly in front of the user. The processor then implements image processing to determine the obstacle as well as the lateral distance between the visually impaired person and the obstacle, thereby providing audio response to the visually impaired. Being a real time system, it accounts for real time changes by processing on current frames and provides instant responses.**

***Index Terms*— Computation of heights, Corner detection, Edge detection, Image segmentation, Image warping.**

I. Introduction

Recently an important amount of time and resources spent in the field of computing has been directed into computer vision. What has drawn so much interest into the subfield is perhaps the inexplicable ease and immaculate accuracy with which the human brain accomplishes certain tasks related to vision. Much like the modern computer, the human brain is essentially considered as an information processing device. The computer scientists have based much of their ideas and motivations on this concept when researching into computer vision.

For a considerable amount of time, biologists have rummaged into and untangled a proportion of the enigmas of human brain. But, we are yet incapable of mimicking its functionality with the help of a device. This project aims to explore one of the human brain's most important image processing operations to be accomplished by a computer – obstacle detection. It helps in providing some insight into several basic techniques that are used in fields of computing such as image processing, pattern recognition and computer vision. These methods can be integrated with a few prominent and a few innovative approaches for performing basic obstacle detection for a machine.

Obstacle detection can be defined as "the determination of whether a given space is free of obstacles for secure travel by a human or an autonomous vehicle". One of the most renowned problems within the subfield of computer vision is obstacle detection.

It is based on the amount of research computer vision has attracted and the number of uses it has. Research is being made into different subfields of artificial intelligence for the mobility of robots. Obstacle detection is one of the crucial building blocks in process of performing various basic operations like avoidance and navigation.

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II. Proposed Model

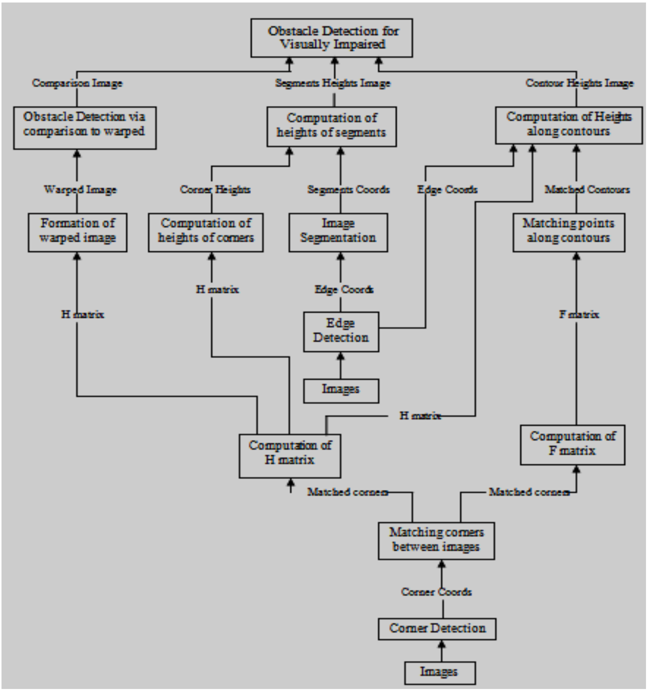

Fig. 1 Basic Block Diagram

A detailed block diagram of the system is shown in Fig.1

III. Detections

A. Edge detection

Edge Detection is a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The image brightness changes sharply at some points which are typically organized into a set of curved line segments termed edges. In 1D signals, the same problem of finding discontinuities is called as step detection and change detection is the problem of finding signal discontinuities over time. Edge detection is a fundamental tool in machine vision, image processing and computer vision particularly in areas of feature detection and feature extraction.

Fig. 2 Edges with the intensity

The edges extracted from a two-dimensional digital image of a three-dimensional scene can be classified as either viewpoint dependent or viewpoint independent. The inherent properties of the three-dimensional objects, such as surface markings and surface shapes are reflected typically by a viewpoint independent edge. The geometry of the scene, such as objects occluding one another is reflected typically by a viewpoint dependent edge and it may change as the viewpoint changes.

For instance, a typical edge might be the border between a block of red colour and a block of yellow. In contrast a line (as can be extracted by a ridge detector) can be a small number of pixels of a different colour on an otherwise unchanging background. For a line, there may therefore usually be one edge on each side of the line.

John Canny had derived the mathematical problem of deriving an optimal smoothing filter given the criteria of detection, localization and minimizing multiple responses to a single edge. He also showed that by using the first order derivatives of Gaussians this filter can be well approximated. Canny also introduced the notion of non-maximum suppression, which means that given the presmoothing filters, edge points are defined as points where the gradient magnitude assumes a local maximum in the gradient direction. Haralick first proposed to look for the zero crossing of the second derivative along the gradient direction.

B. *Corner Detection*

Corner detection is an approach used within computer vision systems to extract certain kinds of features and infer the contents of an image. The intersection of two edges or a point for which there are two dominant and different edge directions in a local neighborhood of the point is called as corner.
Corners are local features on images identified by large variations in intensity in both x and y directions. At corners the motion is very distinct and moreover corners can also be used in the reconstruction of most objects even though it may be a mere approximation. For the computation of the homography and epipolar geometry of a scene, point correspondences are required. Since corners are the most distinguishable points, they are usually selected as the points used and thus are the easiest to match across images. Using a standard operation of the development environment, corners on both images are located individually once the initial and final images have been processed into data. Corners are detected using derivatives of the intensity function of pixels in both x and y directions. The corner detection algorithm, Harris, compute the "local structure matrix" of each pixel to determine whether it is a corner. Before computing the local structure matrix for each pixel, the image is often smoothed even in the presence of noise.
Note that the local structure matrix, A, is always symmetric and positive semi-definite and it has exactly two positive eigen values $\lambda 1$ and $\lambda 2$.
To distinguish between the uniform points, edges and corners on the image, these eigen values can then be used as follows:

1) For points that are on perfectly uniform parts of the image $\lambda 1= \lambda 2=0$.
2) For points that are on perfect black and white step edges $\lambda 1>0$ and $\lambda 2=0$ where the eigen vector (*vl*) corresponding to $\lambda 1$ is orthogonal to the edge.
3) For points that are on perfect black square against white background corner, $\lambda 1>0$ and $\lambda 2>0$.

The Harris corner detector uses this principle while working on grayscale images.

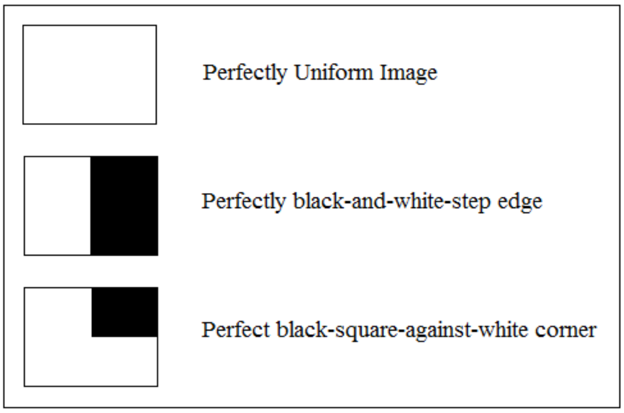

Fig. 3 Corners, Edges and other points

IV. Computation of Matrices

The algorithm, given pairs of matching points, uses RANSAC to compute the fundamental matrix which it returns along with a set of pairs of matching points that agree well with the epipolar geometry computed.

[matrix, goodmatchL, goodmatchR, residual] <-fund_RANSAC(matchL,matchR)

The function takes in 'matchL' and 'matchR' (which are 3xn matrices) as parameters which contain homogenous co-ordinates of n points on each column in 'matchL' and its match on the corresponding column is in 'matchR'. Similarly 'goodmatchL' and 'goodmatchR'are 3xn matrices containing homogenous co-ordinates of matching points given that these points agree well with the fundamental matrix computed. The returned value 'residual' is the average residual of good matching pairs. The algorithm is the 8-point normalised algorithm for the computation of F.After the normalisation of point-correspondences given as parameters, it uses RANSAC to randomly select a subset of these correspondences and computes the fundamental matrix. It then computes epipolar lines for each point on the initial (or left) image and then calculates the distance of their matches on the final (or right) image to it. Point correspondences for which this distance is below a threshold are considered as inliers. The process of random selection, matrix computation and inlier identification is repeated several times and the fundamental matrix with the most number of inliers is selected for further computation. The fundamental matrix is then recomputed using all the points that were earlier identified as inliers.

V. Computation of Heights

The computation of height is entirely dependent on the location of point correspondences between the two images of the scene. Estimation of heights of corners and points along contours are done at the same time and so these were evaluated at the same time as the computation of height. How well height has been computed can be observed by having a look at both images with each initial corner, its matched final corner and its warped position estimated from the computed value of height.

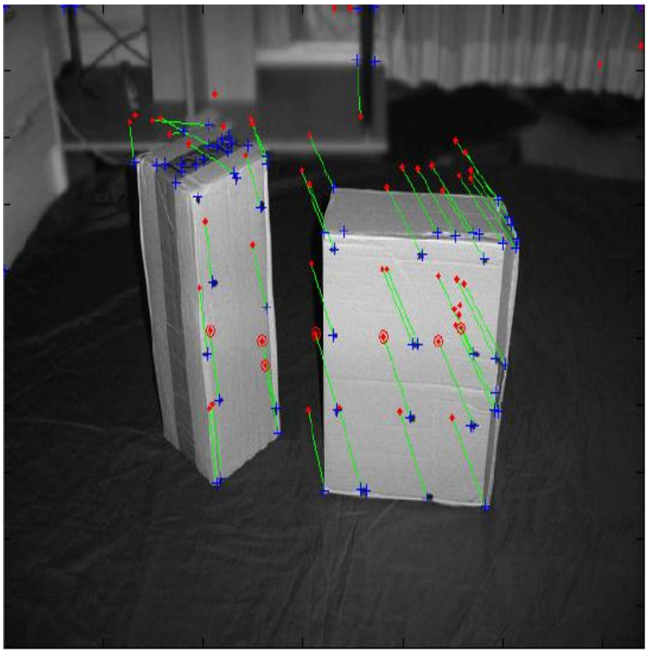

Fig. 4 Image with corners

The closer the final and warped positions of each corner on the ground are, it can be assumed that more accurate the height computation was. Moreover if the computation of height is accurate, then the computed heights of corners on the ground and obstacles would be consistent with their real heights.

Corners in the background did not have much on an effect on the computation of H, since only corners on the lower half on the image were taken into account while performing the RANSAC algorithm. Inaccurate point correspondences on the floor owing to too much texture on it may lead to degenerate computations of height. Therefore, heights estimated will not be accurate either.

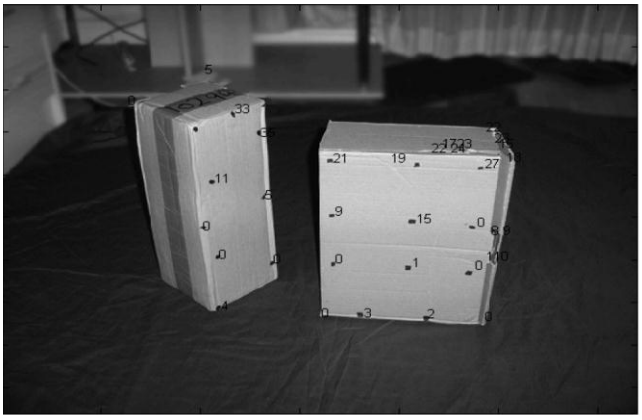

Fig. 5 Image with heights of corners

If there are no point on the ground (that there is either too much texture on it or none at all), the RANSAC algorithm attempts to compute H by using the corners on the base of the obstacle. This does not produce a very accurate estimation of height since there are very few such corners usually present. Moreover this is only possible if the base of the object lies in the lower half of the image since anything above it is disregarded during the computation of height.

It is also possible for RANSAC to choose points that are on a different plane above the ground to compute height, corners on the 10cm plane (marked with circles) are chosen by RANSAC for the final computation of height. As a result, all computed heights of corners are about 10cm less than their actual heights with 10cm being identified as 0cm.
Corners marked with circles are used for the computation of height and all these lie on the ground plane. A floor with large tiles would yield the maximum point correspondences and thus the best computation of H. The height estimations are highly inaccurate for heights close to the camera height.

VI. Image Warping

Image warping is the method of digitally handle or control an image such that any shapes portrayed in the image have been significantly distorted. While an image can be transformed in various ways, pure warping means that points are mapped to points without changing the colors. This can be based mathematically on any function from (part of) the plane to the plane. If the function is injective the original can be reconstructed. If the function is a bijection any image can be inversely transformed.

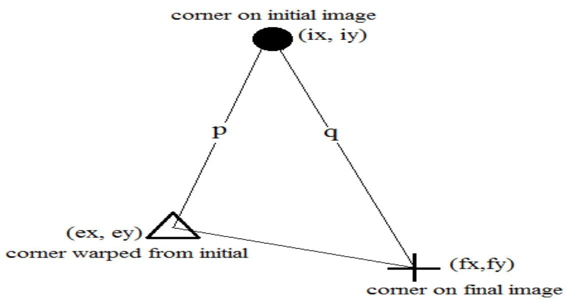

Fig. 6 Warping of images

The following list is not meant to be a partitioning of all available methods into categories.

- Images may be distorted through simulation of optical aberrations.
- Images may be viewed as if they had been projected onto a curved or mirrored surface. (This is often seen in raytraced images.)
- Images can be partitioned into polygons and each polygon distorted.
- Images can be distorted using morphing.

There are at least two ways to generate an image using whatever chosen methods to distort:

- (forward-mapping) a given mapping from sources to images is directly applied
- (reverse-mapping) for a given mapping from sources to images, the source is found from the image.

VII. Conclusion

This study presents a simple and efficient obstacle detection system. It includes the background information required in computer vision, image processing and pattern recognition. Corner and edge detection techniques were used for computing the geometry of a scene. Using several design methodologies and development methods the most appropriate one was selected. The image warping methodology detects obstacles above a certain height depending on a threshold set. The epipolar geometry uses contour heights that depend on the computation of the fundamental matrix. Image segmentation counts on the minimum texture on objects and grounds and the presence of very distinct corner points on both images. It uses multi-view relation, planar homography, epipolar geometry and segmentation for the obstacle detection. Thus, obstacle detection using computer vision can be considered quite reliable.

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