

# Obstacle Detection Based on Color and Range Estimation Using Triangulation for Autonomous Vehicles

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**Abstract** - Obstacle detection is a main key of autonomous vehicles. When communicating with huge robots in unstructured background, resilient obstacle detection is required. Few of the existing methods are mainly suited for the backgrounds in which the ground is comparatively flat and with roughly the same color throughout the terrain. A novel procedure proposed in the work presented here uses a monocular camera, for real-time performance. We compute the homography between two successive frames by computing the fundamental matrix between the two frames. Estimation of fundamental matrix is followed by triangulation so as to estimate the distance of the object from the camera. We examine a difficulty intrinsic to any fundamental matrix-based outlook to the provided task, and show how the discussed way can resolve this difficulty by a huge level. An obstacle detection and distance estimation system based on visual particular attribute and stereo vision is hence discussed in the presented work.

**Keywords** - Face recognition, Preprocessing, characteristics match, Image Processing etc.

## I. INTRODUCTION

With increase in road hazards day by day, technology is required to be improved with respect to safety measures to avoid obstacle in the path traversed by the vehicle. An obstacle is a object or thing which creates barrier that stops the movement of the vehicle or robot. It can be natural obstacle or it may be manmade or combination of both. Obstacle detection is the methodology that refers to the ability to detect the obstacle that appears in that hinders the path of the object. If there is any obstacle in their way then obstacle detection technique helps to take decision to avoid collision. Already existing methods which are used for obstacle detection faced different issues, because hardware uses sensors like Ultrasonic range detector, LiDAR etc. To detect obstacles which are either economically expensive or possess low range. There are further issues that most of the sensors work in line of sight. This reduces the field of view of the sensors. Therefore camera based technique can be a probable solution to above issues. Now-a-days, use of automotive vehicle, air vehicle and mechanism system are increasing noticeably. So, thereby a number of problems are also increasing in their path. Accident with an object is one of the major problems and this object is outlined as an obstacle. Obstacle detection could be a way for safety from such obstacles from any type of autonomous vehicles, human being or any other object. An obstacle is nothing but only an object that makes some obstruction. For various surroundings, obstacles are often outlined in several types, which are as following

- For visually impaired people obstacle is often known as “something that can stop blind people or change the movement of his current direction”. In this case obstacle can be anything like glass, door etc. For safety purpose blind peoples use white cane however, it is not always very helpful while travelling as it cannot differentiate between color.

For an autonomous navigation vehicle “obstacle is something that can cause some hazard or accident, once it meets with host vehicle”. Therefore, obstacle is something that forestalls or delays some action in any environment. In many vehicles there are some buzzers that get activated and generate warning, if it detects some obstacle in its path.

The main objective of this work is to detect the obstacle on the basis of color cue. Any obstacle is detected by its color from the monocular or binocular camera. Position can be calculated by finding the distance which in the computer vision fraternity known as triangulation. The method of triangulation makes use of the relative orientation of the two frames of same object so that distance can be detected. In computer vision, triangulation refers to the process of determining a point in 3D space given its projections onto two, or more, images. This point is an interest point of two frames of same image. Triangulation of a set of points in 2D image computes any other operation in the form of sparse matrix on triangulations of order 3. This model typically calculates the position of obstacles according to a monocular camera by using color information. The two frames which capture the colored object are processed in order to obtain the centroid of the imaged object. This work describes an obstacle detection algorithm for use in for all types of terrain but provided the obstacles are differentiated by color. If the obstacle is in the range then unnamed vehicle or human-being can take decision accordingly so as to avoid collision. Therefore we prefer vision based techniques. The advantages of these techniques are as follows:

1. Vision based techniques are comparatively less expensive as compared to others because these system require only camera for obstacle detection whereas other rely on sensors although they have cameras mounted on the vehicle.
2. It has low power consumption because it requires less computation as compare to laser.

- The method performs relatively better in terms accuracy as compared to existing techniques

## II. LITERATURE REVIEW

**Iwan Ulrich and Illah Nourbakhsh**, This paper presented vision-based impediment speech act methodology for the compact robots. Each single image has element is called having a spot which is either to associate degree obstacle or bottom considering its shading look. The framework used a separate unapproachable performs unceasingly, shading camera, and gives a matched hindrance image at large determination. The arrangement is prepared by simply driving mechanism through its situation. Within versatile mode, the structure may keep taking within neck of woods of bottom within the interior of operation. The system has tested with success in a very kind of environments, inside further as outdoors .This paper given a replacement technique for obstacle detection with one color camera. The strategy performs in the real- time and offers a binary obstacle image at high resolution. The system will be trained and has performed well in very kind of environments, inside further as outdoors. [1].

**Ashish R. Derhgawen and D. Ghose**, This paper suggested the fast obstruction recognition algorithm for the transportable robots . it uses a solitary shading camera because main device to the spot obscure snags in a very state of affairs. The calculation can used shading HSV histograms to order an each individual constituent that having an area either to snag, or bottom in the lightweight of its look. The framework is supplied for the playing quick impediment discovery on every uniform territories. The robot's solely goal to date in experiments has to maneuver around safely in the unstructured environments by avoiding obstacles. This technique with navigation and path designing algorithms to permit it to plan towards targets, or perhaps for exploration and mapping of remote locations. [2].

**James Bruce Tucker Balch and Manuela veloso**,This paper describes a system capable of pursuit many hundred regions of up to thirty two colors at thirty Hertz on general purpose goods hardware. Vision frameworks utilizing different division by the shading square compute pressing an continuously transportable mechanism application, for example, RoboCup. Usually, systems utilizing continue shading primarily based division square measure either the dead in instrumentality, or specific programming frameworks that take advantage of the space data to realize the basic efficiency. However, careful attention to formula efficiency finds quick color image segmentation which will be accomplished mistreatment goods image capture and mainframe hardware. [3].

**Richard I. Hartley and Peter Sturm** this paper presents a technique which requires intersection of two acknowledged rays in house and which is known as triangulation. There is tendency to consider the matter of finding the position of a degree in house given its position in 2 pictures gaga cameras with acknowledged standardization and cause. triangular method requires intersection of the 2 acknowledged rays in house. All strategies are performed comparatively for the geometrician re-construction, as measured in the terms of 3D error. Within the case of 2Derror, only the methods Poly–Abs iterative–LS, Polynomial, and Iterative–Eigen perform acceptably[4].

**Ricardo Neves and Anibal C Matos**, presents an approach to the stereovision applied to the tiny water vehicles. By using a tiny cheap pc and cheap off-the-peg elements, a tendency to develop an autonomous driving system which is capable of following distinct vehicle and moves on ways delimited by colored buoys. With assistance of stereoscopic system, there has a tendency to position the objects that function references to ASV steerage. The final system has capable of distinguishing and following targets in very distance of over five meters. The system is ready to accomplish operate it's designed for below USD seventy. With this work, it's been tested that it there's likelihood of playing stereoscopic image process mistreatment low price procedure units. Though mistreatment a lot of dense matching algorithms continues to difficult task to those tiny units, mistreatment less complicated techniques involving binary imaging and criterions chosen 3D information could be a great way of surpassing those limitations[5].

**Peter Lindstrom**,in this paper,an easy and efficient formula for two- read triangulation of the 3D points from second matches supported the L2 reprojection error has been presented . Within the case wherever the 2 cameras square measure pointed within same direction, the strategy incontrovertibly converges to associate degree optimum answer in the 2 iterations. For general camera poses, 2 iterations square measure sufficient to realize the convergence to machine exactitude , that exploit to plan a quick, non-iterative technique. There has a tendency to give a quick unvaried technique for uncalibrated two-view triangulation that takes optimum sizes therefore on enforce the epipolar constraint in every iteration[6].

## III. PROBLEM FORMULATION

The existing methods assume that the obstacles contrast in appearance from the ground. The ground is assumed to be relatively flat. Also, there are no overhanging objects. The first assumption distinguishes obstacles from the ground, while the other two assumptions estimate the distances between obstacles and the camera. If the ground is flat and there are no overhanging obstacles, then the distance is a monotonically increasing function of the pixel height in the image. If the ground is not flat or if there are overhanging obstacles, then the distance estimate would be erroneous. Hence a system is required to estimate the distance non-erroneously.

## IV. METHODOLOGY

The algorithm uses the area immediately in front of the as a reference region and computes its RGB channels. The histogram of this region is compared to other parts of the image to find objects that are likely to be obstacles. The depth of this reference region

can be manually adjusted depending on the terrain. A deep reference region will provide more information, but it could also contain obstacles. The reference region is manually adjusted to be deep enough to provide sufficient information of the terrain without including any obstacles.

The RGB data of this region is then back projected onto the rest of the image to find out the presence of obstacles or hindrance. The result of back projection is a single channel probability image that shows the pixels that are most likely to be an obstacle. This probability image is then thresholded to obtain a binary obstacle image. By adjusting the probability threshold, it is possible to make the system work on multicolored surfaces. The basic steps of the algorithm are:

1. Perform noise removal on input image
2. Calculate RGB channels of reference region
3. Back projection
4. Find pixels that are most likely to be part of an obstacle
5. Find connected components (blobs) in the image

In the first step, a mean filter is applied to the color input image. This reduces the noise from the image. This has the effect of removing pixel values which are unrepresentative of their surroundings. Next, a rectangular region immediately in front of the robot is used as a reference region, and its HSV histogram is calculated. If the value of a pixel is below this critical value, it is classified as black. Similarly, hue is calculated only if the saturation of a pixel is above the saturation threshold value (which is approximately 20% of maximum saturation). If the value is below the saturation threshold, it is termed as white. If both brightness and saturation values are above their respective threshold values, only then the hue of the pixel is calculated. It is not important in our case to represent every shade of luminance and saturation as these two parameters are only used to differentiate between colorful pixels (pixels with valid hue values), and dark/white pixels. Histograms consume little memory, and can be calculated very quickly. This makes them well suited for this application.

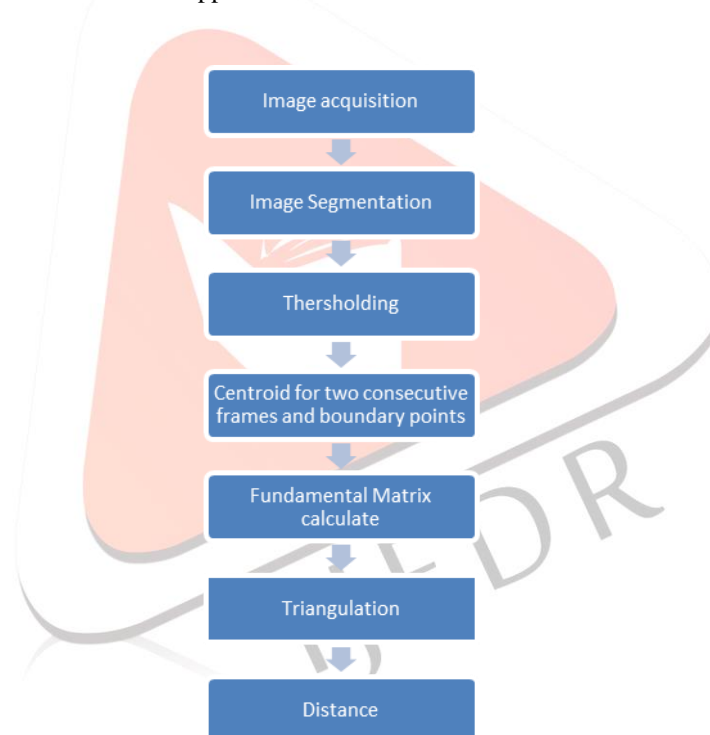


Fig: 1

#### **Facilities required and Proposed Methodology**

The facilities required for the proposed work are:

1. Set of image frames with the obstacle.
2. The obstacle should be identifiable because of its color
3. Base method implementation for further improvement

The block diagram of proposed method is shown in fig 1.

1. Image acquisition is a process to take image from camera. So that applies further operation on those images to detect obstacle.
2. Image Segmentation technique is then used to divide images into parts to correlate between interested objects and rest of objects. This operation will be done on the pixels of images based on RGB values.
3. Thresholding is then applied because it helps to differentiate between obstacle and ground. It means for instance we say if value of the Red pixel is 220 and the threshold value is 128. And if the value is greater than threshold then it is obstacle else it is free space. Finally, fundamental matrix calculation is done in order to facilitate the triangulation process. The triangulation process requires the fundamental matrix between the two frames to estimate the distance of the camera from the objects.

4. Center Detection: It is necessary to detect the center point of image so that we can apply triangulation method to calculate distance. Here we required to detect center of two frames of same image.
5. Fundamental Matrix calculate: Sometimes camera parameter for example focal length occurs some reflection in image if this parameters are known then fundamental matrix does not require else it requires.
6. Triangulation: This is most important because when the two rays projected on the camera then it gives a point where two rays of frames are intersected. So distance can be calculated from any one of the frame to camera.

### Triangulation

The motion estimation from 3D correspondences and from 3D and 2D features correspondences requires image points to be transformed back into 3D point. Over the last few decades, development of computer vision techniques for estimating the position of a point in space, has been the goal of many research programs for the applications ranging from guidance and control to 3D structure reconstruction. This process of estimating the location of a point in space, using its projection in two views, is known as triangulation. The basic method of triangulation is by the back-projecting rays corresponding to the 2D image points, from the two images, and find

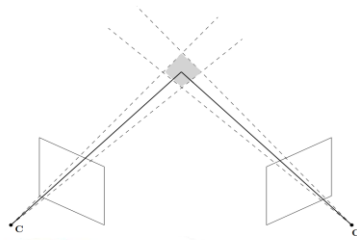


Fig.2: Error due to quantization

Quantization error introduces uncertainty in the estimated 3D point. This is shown here with the gray region.

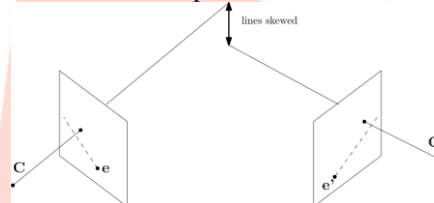


Fig.3: Triangulation error

Due to triangular error, the measured points may deviate from the epipolar line.

This is popularly known as Direct Linear Transform. Direct linear transform helps to minimise the algebraic distance. However, due to the noise in the estimated 2D image points, which involves quantization noise, geometric error and feature matching uncertainty, the triangulation problem has become non-trivial.

Several methods have been proposed in the past in order to obtain a better estimate of the position point in space. The midpoint method, proposed by Beardsley et al., calculates the midpoint of the shortest distance between the two rays. Although some improvements have been added to this method, but they do not provide an optimal output owing to various approximations. An optimal method to minimize the error is by considering  $L_2$  the re-projection error as the cost function

$$L = \min \sum_i d(\mathbf{x}_i, \hat{\mathbf{x}}_i)^2 + d(\mathbf{x}'_i, \hat{\mathbf{x}}'_i)^2$$

Where,  $d(*,*)$  denotes the Euclidean distance, and vectors  $\hat{\mathbf{x}}_i$  and  $\hat{\mathbf{x}}'_i$  denotes the re-projection of the point in space corresponding to the image point vectors  $\mathbf{x}$  and  $\mathbf{x}'$  in homogeneous coordinates, in the two views respectively. Usually, an optimum solution is obtained by using non-linear optimization techniques. Vite-Silva et al. have used multi-objective evolutionary algorithm whereas Wong and Ng implemented Particle Swarm Optimization for finding the optima, but these algorithms are computationally expensive and hence can be used if there are only few noisy corresponding points.

In this field Hartley and Sturm sets milestone in his work, in which the cost function is reformulated by considering the Euclidean distance between the image point and corresponding epipolar line. Henceforth the method will be referred to as *polynomial*. The focus of the method is that the dimensionality of the cost function has been reduced to only one variable, with the solution meeting the epipolar constraint. Hence finding the optima became easier, thereby finding an optimal solution to the problem.

## VI. RESULTS

The depth calculation algorithmic formula included a measurement error which is termed as epipolar error given by

$$\mathbf{x}'^T \mathbf{F} \mathbf{x} = 0.$$

It is an empirical model for error function where  $\mathbf{x}'$  is the corresponding image point in the second image,  $\mathbf{F}$  is the fundamental matrix and  $\mathbf{x}$  in the image point in 1<sup>st</sup> image. As defined in the base paper, they have used the disparity method to calculate the



depth. Hence, epipolar error is one of the important aspects to find whether the estimated value is totally correct or not. When depth values are estimated by calculating for error using error function, it has been found that the epipolar error is very large. The changed error varies with actual depth as well as the frames are coming. The effect of this error over depth measurement results in slight variations in the location of corner points. The error in localization results in inclinations of the edges that are straight with the actual object. Though it can be observed from the image frames that as the frames are coming the camera is moving closer to the obstacle, the epipolar error is increasing largely.

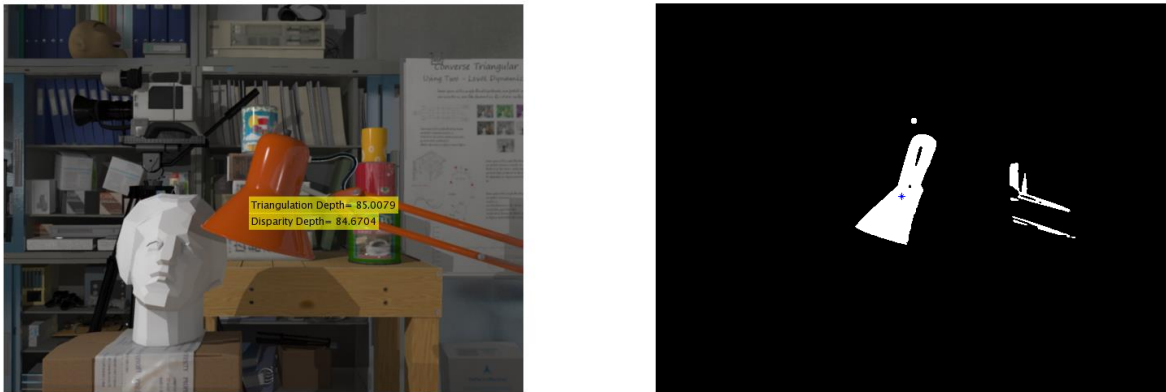


Fig 4. Depth value on video frame and detected centroid.

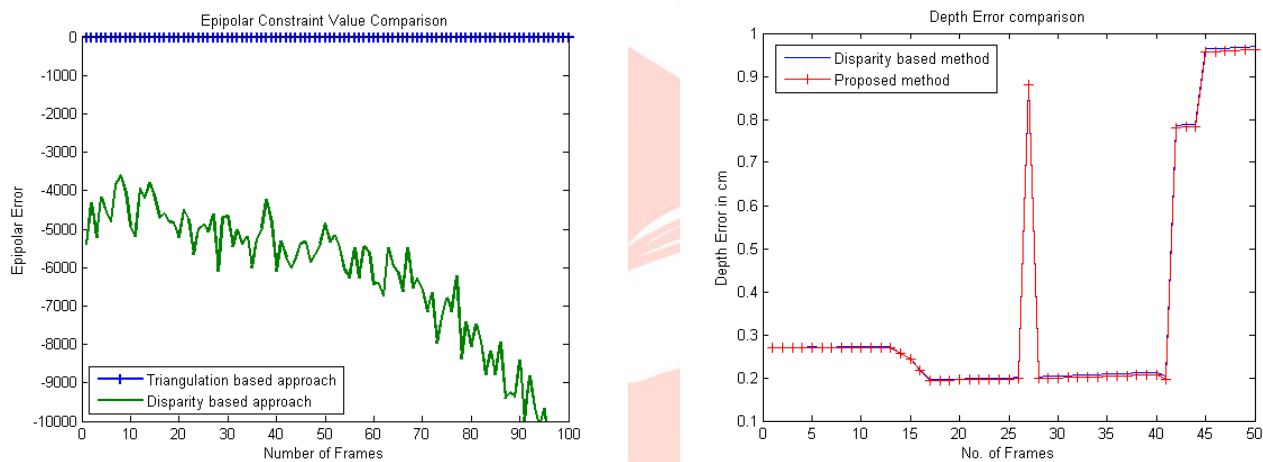


Fig. 5 Epipolar error and Depth error compared for both methods.

## V. CONCLUSION AND FUTURE SCOPE

In this thesis various techniques for detection of objects on the basis of color are discussed. Various algorithms like niter is discussed which minimize the epipolar error. A hybrid technique based on color cue and triangulation method is proposed. In Color based obstacle detection, obstacle detect based on color cue. Pixels in any image can be classified on the basis of R, G, and B. In triangulation method when the two rays projected on the camera then it gives a point where two rays of frames are intersected. So distance can be calculated from any one of the frame to camera.

The advantage of the proposed method is to estimate the distance with minimum epipolar error as compared to disparity based method. The limitation of the method is that the error keeps on increasing as we move on to the consecutive frames. This type of error is termed as drift error. Therefore, the future work may rely upon the minimization of the drift error also so as to get the correct estimate for each pair of frames.

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