Obstacle Detection Based on Color cue: Review and Proposed Techniques

Shailesh Mehra
Student
PEC University of Technology
Chandigarh

Ajay Mittal
Assistant Professor
PEC University of Technology
Chandigarh

Shubham Vijayvargiya
Student
PEC University of Technology
Chandigarh

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. An obstacle detection and distance estimation system based on visual particular attribute and stereo vision is hence discussed in the presented work.

Keywords

Image Segmentation, Centroid, Thresholding, Fundamental Matrix, Triangulation.

1. 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. Obstacle detection is the methodology that refers to the ability to detect the obstacle that appears in that hinders the path of the object. It helps the vehicles; robots etc. to take decision so that they avoid collision when there is any obstacle in their path. Generally an obstacle is a situation or object that creates barrier or any impediment which stops or halts the movement of the vehicle. An obstacle can be natural or man-made or it may be that it is combination of both. Earlier methods for obstacle detection faced issues, because hardware uses sensors like Ultrasonic range detector, LiDAR etc. to detect obstacles which are either economically expensive or possess low range. Apart from this, the sensors require high computational power. 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, as now-a-days all the autonomous vehicles possess camera and hence an extra sensor is not a requirement now. 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 (stereo) 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 (either two consecutive frames for monocular scheme or two corresponding frames of two cameras in binocular scheme) 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. Then the centroids in both the frames are triangulated so as to estimate the position of the object in space with respect to the camera or in-turns the vehicle. 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.
3. The method performs relatively better in terms accuracy as compared to existing techniques.

In this paper, Section 2 describes related work or Literature study. Section 3 describes motivation. Section 4 describes problem statement. Section 5 describes innovative content. Section 6 describes assumption of obstacle detection. Section 7 describes methodology.

2. RELATED WORK

This section gives an overview of the related research that has been done in respect of obstacle detection based on color cue till now. Following are the existing work done by the researchers in context of obstacle:-

Bruce, Balch and Veloso [1] tell about the fast color image segmentation for robots. It describes vision systems employing region segmentation by color are crucial in real-time mobile robot applications. Generally systems involving priority wise color-based segmentation are either executed in hardware, or extremely important software systems that retrieve the gain of domain information to achieve the better efficiency. However; we have found that with careful achieve to algorithm efficiency, obstacle detection can be done using image capture and CPU hardware [1].

The important step in [1] used approach is to classify each pixel in an image into one of an individual number of color classes. This approach to complete the obstacle detection includes four tasks. These tasks are linear color thresholding, nearest neighbor classification, color space thresholding and probabilistic method [1].

The technology in this system is as following:

1. An implementation of a threshold identifier.
2. Grouping system to form regions through connected components.
3. Segregation and sorting system that collects many region features, and a top down merging heuristic to approximate perceptual grouping.

The authors showed results about image segmentation that first execution was rules which are set of autonomous robots on the behalf of Probotics Cye platform. And it depends on Uclass [11], Vclass [11] and Yclass[11].In its present model the system can process 320x240 images at 30 Hz with 25% utilization of the 375 MHz CPU.

This Approach includes the use of thresholds in a three dimensional color space. Various color spaces are in mostly use, including Hue Saturation Intensity (HSI), YUV and Red Green Blue (RGB).

The authors showed with the use of figures 1 a 3-D region of the color space for classification is represented as a grouping of three binary functions. These three functions are

Pixel-in-class = YClass[Y]
AND UClass[U]
AND VClass[V];

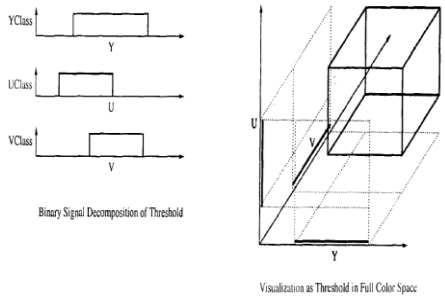

Figure 1: 3-D region of color as grouping of 3 binary functions.

Ulrich and Nourbaksh [2] proposed a technique for appearance based obstacle detection. We have developed a new *appearance-based* obstacle detection system that is based on passive monocular color vision. The main point of this technique is to segregate from the ground on the basis of appearance and then denoting them as obstacles. Range sensors are also unable to differentiate between various forms of ground surfaces. This is a problem with sensors so they gave solution hence obstacle detection system is purely based on the appearance of individual pixels.

The approach used in [2] has number of assumption so that it can handle the problem with indoor and outdoor environments as well.

Obstacles differ in appearance from the ground.

There should not be any over-hanging obstacle.

The ground must be flat.

The simplified technology of appearance-based obstacle detection method [2] consists of the following four steps:

1. Filter the given input binary image.
2. Transform the color input image into HIS color space.
3. Histogram the reference area.
4. Compare this histogram with other reference histogram.

Batavia and Singh [3] purposed Obstacle Detection Using Adaptive Color Segmentation and Color Stereo homography. The view of author behind color segmentation for obstacle detection is that pixels in an image are notified as obstacle or free space on the basis of color.

The idea of homography is that general stereo cameras are used to find range to images and It requires high computationally cost. So there is another way to find obstacle i.e. homography. It is linear in the number of pixel because it does not require any computationally cost.

The authors discussed an approach for obstacle detection using color segmentation. Each pixel in image is denoted by 3-tuples i.e. Red, Green, Blue. In this model, several protocols would be used to classify pixels, for instance "If blue is between 125 and 170 and red is less than 20 and blue is more than 75, then termed as ground i.e. it is not obstacle.

Batavia and Singh has discussed training set which is represented by 2-D histogram. The bins in histogram are located on the basis of H and S values in the pixels of image. The values of the bin show the number of occurrences of that specific H and S pair in the training set. For each pixel in the training image, the value of that histogram bin is increased. After training; the system is ready to recognize pixels as obstacle or free space. For each pixel, p, in a test image. We look up the bin value of the respectively color of p. It gives a probabilistic measure, P, of that image. If P is larger than threshold then it is assumed as free space else it is considered as an obstacle.

- Another way is to use nearest neighbor classification. To classify a new pixel, a list of the *K* nearest essence is found, and then the pixel is

classified according to the largest ratio of categorizing of the neighbors [4].

- Another approach shown in [5] is to use a set of constant thresholds defining a color class as a rectangular block in the color space. This technique provides well performance, but is not able to retrieve gain of prospects dependencies between the color space dimensions.

- H.R. Everett [6] purposed a technique in which it can be detect the position of autonomous system and sensor. While a huge part of work exists for range-based obstacle detection, little work has been done in appearance based obstacle detection.

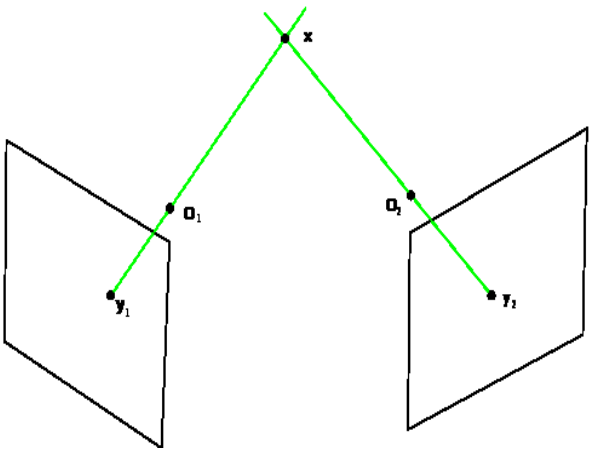

Figure 2: Triangulation

- Active vision for the visually impaired, financed by the Portuguese Foundation for Science and Technology, combines several technologies, such as GPS, GIS, Wi-Fi and computer vision, to creat asystem which helps the visually impaired to move in- and outdoor [9].

- H.D.Cheng [7] purposed color image segmentation algorithm. Basically approaches are based on monochrome segmentation approaches operating in different color space. For example histogram Thresholding, edge detection, feature clustering, fuzzy technique etc.

- Richard I. Hartley [8] developed a technique for obstacle detection based on Triangulation. In this paper they consider the problem of finding the position of a point in space given its position in two images taken with cameras with known calibration and pose. This process requires the intersection of two known rays in space and is commonly known as triangulation.

Hartley demonstrated the triangulation method in which it defines a point in space which is intersection of two rays from two frames of same obstacle in following fig 2.

- Cheng-Lung Lee [10] purposed an evaluation of a simple obstacle detection device for Blind people in which questionnaire survey for mobility needs was performed at the start of this study. After the detector was succeed, five blindfolded sighted and 15 blind peoples were invited to organize test under three terms: (1) using a white cane only, (2) using the obstacle detector only and (3) using both devices.

- Long CHEN, Bao-long GUO, Wei SUN [12] discussed obstacle detection system for blind people on the basis of stereo vision method. In this discussed approach, two cameras are installed simultaneously and by making map of those images he applied segmentation for feature extraction. And he detected region of the images so that microphone can detect there is an obstacle.

Long CHEN described a system model for obstacle detection in fig 3.

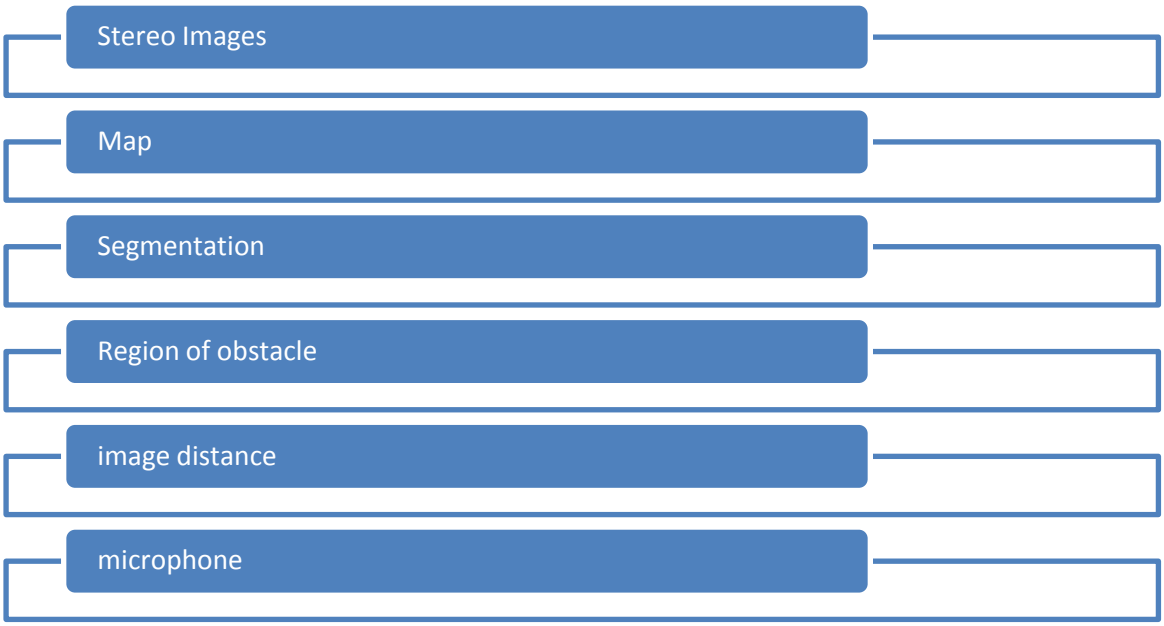

Figure 3: system model for obstacle detection

(1). Comparison of different ideas.

No.	Algorithm proposed by	Idea	Limitation
1.	James Bruce ,Tucker Balch and Manuela Veloso [1]	This paper describes a system which is able of following various number of regions of up to 32 color at 32 Hertz on common commodity hardware	This system operates on images only in color space and each pixel has been defined up to only 32 colors.
2.	Iwan Ulrich and IllahNourbakhsh [2]	The idea of this paper is to detect the obstacle based on appearance so that obstacle can be differing from free space.	This paper defines algorithm which is not relay on combination of all color space.
3.	Parag H. Batavia and Sanjiv [3]	The purpose of this paper is obstacle detection using color homography because it requires linear computational cost.	Homography approach is not limited to flat grounds. And it allows navigation system for small area only.
4.	J. Borenstein1, H.R. Everett2, L. Feng3, and D. Wehe[6]	This paper describes the location of objects i.e. monocular camera, robot, and sensor. So that can be detecting the movement of these objects.	This paper has limitation that effective range of the landmark navigation and model matching is limited.
5.	H.D.Chang , X.H. ziang and Jingli Wang [7]	In this paper, color segmentation depends on histogram and merges the regions. This histogram contains the occurrence of grey levels.	The proposed approach used in HIS color space to compare images, value of hue makes some unreliable

			for segmentation.
6.	Cheng-Lung Lee, Chih-Yung Chen, Peng-Cheng Sung [10]	Authors discussed in this paper in which a survey questionnaire was conducted before test. And this test had done under some condition.	White cane algorithm generally applied to detect only static obstacle on the ground. And some electronic travel aids (ETA) require manual operation.

3. MOTIVATION

The motivation of our purposed technique is to overcome the problem of other existing technique so that robot, visually impaired people, vehicles etc. can detect an obstacle in their way. And easily they can change their way. This motivation solves following problem:

A. When there any two obstacle having same color then there will be conflict so we will propose an algorithm to solve this problem on the basis of distance calculation.

B. Other existed technique does not provide any way to handle overhanging obstacle.

4. PROBLEM STATEMENT

Obstacle creates hindrance, in order to move freely obstacle detection algorithm plays a vital role. The present work intends to develop an obstacle detection algorithm that can detect obstacle based upon color cue.

5. INNOVATIVE CONTENT

To solve the problem of other referred technique, this paper will discuss idea. And the idea of this paper Take two Images from the camera and segment it into two categories 0 or 1.and calculate the centroid of two that frames and with the help of triangulation method calculate distance.

6. ASSUMPTION OF OBSTACLE DETECTION

There are following assumption that assumed under the algorithm:

1) For the system we assumed obstacles are limited to objects that are at minimum constant unit's height above the horizontal plane.

2) It is assumed that ground must be relatively flat so that obstacle can be detected.

3) Obstacles are assumed to be differentiable from the framework intensity in the image.

7. METHODOLOGY

The block diagram of proposed method is shown in fig 4.

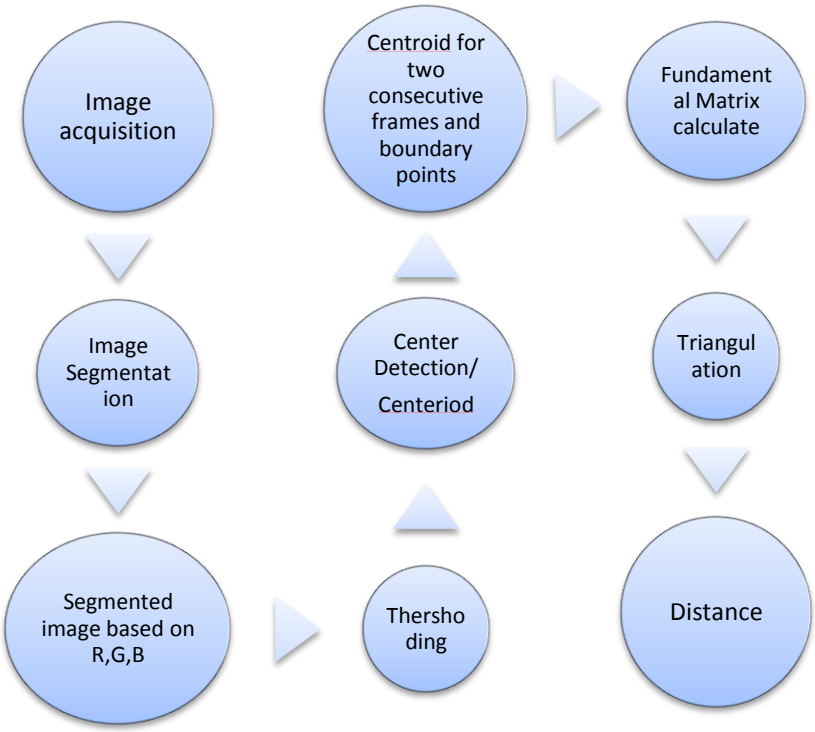

Figure 4: Block diagram of purposed work

1) Image acquisition: It is process to take image from camera. So that applies further operation on those images to detect obstacle.

2) Image Segmentation: This technique is to use 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: It used 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.

4) Center Detection: It is compulsory 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. It collects the information of each pixel of input image in the form of two- dimensional.

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.

8. CONCLUSION:

We have presented a new system for real-time segmentation of color images. It can classify each pixel in a full resolution captured color image. Thresholding is the simplest method of image segmentation for a gray scale image; Thresholding can be used to create binary images. Obstacle can be detected by using color and distance based. Triangulation helps in estimating the distance of the object and hence the distance is found.

9. REFERENCES

[1] James Bruce, Tucker Balch and Manuela Veloso, "Fast and Inexpensive Color Image Segmentation for Interactive Robots" *Proceedings of the 2000 IEEE International Conference on intelligent Robots and Systems.*

[2] Iwan Ulrich and IllahNourbakhsh, "Appearance-Based Obstacle Detection with Monocular Color Vision" *Proceedings of the AAAI National Conference on Artificial Intelligence, Austin, TX, July/August 2000*.

[3] Parag H. Batavia and SanjivSingh, "Obstacle Detection Using Adaptive Color Segmentation and Color Stereo Homography" *Carnegie Mellon University Robotics Institute Pittsburgh 2004.*

[4] T. A. Brown and J. Koplowitz., "The weighted nearest neighbor rule for class dependent s sample sizes" *IEEE Transactions on Information Theory, 2003.*

[5] CARLA E. BRODLEY, PAUL E. UTGOFF, "Multivariate Decision Trees" *Kluwer Academic*

Publishers, Boston. Manufactured in The Netherlands 1998.

[6] J. Borenstein1, H.R. Everett2, L. Feng3, and D. Wehe, "Mobile Robot Positioning & Sensors and Techniques" *2000*.

[7] H.D.Chang, X.H. ziangand JingliWang,"Color image Segmentation" *Dept of computer science Utah State of university 2003.*

[8] Richard I Hartley, "A High-Performance Stereo System for Obstacle Detection," *Carnegie Mellon University Doctoral Dissertation, CMU-RI-TR-98-24, September, 1998.*

[9] Dakopoulos, D., Bourbakis, N.G., "Wearable obstacle avoidance electronic travel aids from blind" *IEEE Trans 2010.*

[10] Cheng-Lung Lee a,*, Chih-Yung Chen a, Peng-Cheng Sung a, Shih-Yi Lu, "Assessment of a simple obstacle detection device for the visually impaired" *2013 Elsevier Ltd and The Ergonomics Society.*

[11] M. Veloso, E. Winner, S. Lenser, J. Bruce, and T. Balch., "Vision-Servoed Localization and Behaviors for an Autonomous Quadruped Legged Robot" *Artificia1 Intelligence Planning Systems, 2000*

[12] Long CHEN, Bao-long GUO, Wei SUN., "Obstacle detection system for visually impaired people based on stereo vision" Fourth *International Conference on Genetic and Evolutionary Computing 2010.*