# Obstacle Detection System for Automobiles using Contour Analysis

**Girdhari Lal, Rohit Maheshwari**

***Abstract*— As one of the most promising applications of computer vision, vision-based vehicle detection for driver assistance has received considerable attention over the last 15 years. There are at least three reasons for the blooming research in this field: first, the startling losses both in human lives and finance caused by vehicle accidents; second, the availability of feasible technologies accumulated within the last 30 years of computer vision research; and third, the exponential growth of processor speed has paved the way for running computation-intensive video-processing algorithms even on a low-end PC in real-time. This project deals with the problem of obstacle detection from a single camera mounted on a vehicle. We define an obstacle as any object that obstructs the vehicle's driving path. The perception of the environment is performed through a fast processing of image sequence.**

***Index Terms*— contour analysis, contour detection, Gaussian blurring, , image processing, Obstacle detection.**

## I. INTRODUCTION

Obstacle detection is defined as "the determination of whether a given space is free of obstacles for safe travel by an autonomous vehicle" by Singh [1]. Obstacle detection is one of the most renowned problems within the subfield of computer vision in terms of the amount of research it has attracted and the number of uses it has. Together with research into other subfields of artificial intelligence, obstacle detection is crucial in order to perform many basic operations for mobile robots such as avoidance and navigation. In these systems, robust and reliable vehicle detection is the first step — a successful vehicle detection algorithm will pave the way for vehicle recognition, vehicle tracking, and collision avoidance. A good obstacle detection system must be capable of the following[1]:

- To detect obstacles on a given space in good time
- To detect and identify correct obstacles
- To identify and ignore ground features that may appear as obstacles.

Optical flow based approaches [2] and correlation based stereo systems [3] have also been used. Several difficulties arise from the planar assumption. First high-speed operation requires a strict real time performance and also a large range of distances. These requirements imply that the use of a strictly planar model of the road is inadequate. Second many roads in urban environments are not completely planar in a small range of distances, often with hills and valleys [4], and even with a slight curvature across the road. The existence of texture and/or patterns is essential for the dynamic estimation of the plane parameters. Small errors in the plane parameters severely affect obstacle detection. Various sensors can be used in this purpose. Radar or sonar constitute one possibility but present some drawbacks: they are expensive and delicate devices, and send electromagnetic waves into the environment. For night vision, infrared cameras can be used but remain expensive.

We know that the safe driving is heavily depends on the vision of the driver. The vision of the driver can be improved by systems that give information about the environment around the vehicle that cannot or hardly seen by driver. Therefore, a vision based obstacle detection system is the current research focus and mainstream in intelligent vehicle technology.

## II. LITERATURE REVIEW

There exists a large body of research from the last two decades on driving assistance system (DAS). With the goal of creating autonomous vehicles, many research groups have launched several projects in different aspects of DAS [5]. With the ultimate goal of building autonomous vehicles, many government institutions have lunched various projects worldwide, involving a large number of research units working cooperatively. These efforts have produced several prototypes and solutions, based on rather different approaches [6].

Although the first research efforts on developing intelligent vehicles were seen in Japan in the 70's, significant research activities were triggered in Europe in the late 80s and early 90s. MITI, Nissan and Fujitsu pioneered the research in this area by joining forces in the project "Personal Vehicle System" [7]. In 1996, the Advanced Cruise-Assist Highway System Research Association (AHSRA) was established among automobile industries and a large number of research centers [8].

The current obstacle detection system can be categorized in to three categories[9]:

- The first method uses a monocular static camera. This method detects obstacles based on optical flows which are inconsistent with the main movement direction of vehicle[10]. This method use huge calculation and sensitive to the vehicle motion. It can't detect the object which are stationary or slow in speed. It can only be used with objects in motion.
- The second method uses a moving monocular camera. This method detect obstacle based on searching for such features as shape [11] or symmetry [12]. This method can

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only be used with some specific type of objects such as pedestrian or vehicle.

- The last method is based on stereo vision[13]. Scene images are captured using two or more cameras at different angles simultaneously and then the obstacles are detected through matching. This method requires a great deal of time in calculations and sensitive to the vehicle motion.
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In Europe, the PROMETHEUS program (Program for European Traffic with Highest Efficiency and Unprecedented Safety) pioneered this exploration. More than 13 vehicle manufactures and several research institutes from 19 European countries were involved. Several prototype vehicles and systems were designed as a result of this project.

Although the first research efforts on developing intelligent vehicles were seen in Japan in the 70's, significant research activities were triggered in Europe in the late 80s and early 90s. MITI, Nissan and Fujitsu pioneered the research in this area by joining forces in the project "Personal Vehicle System" [14]. In 1996, the Advanced Cruise-Assist Highway System Research Association (AHSRA) was established among automobile industries and a large number of research centers [15].

These existing methods have some inadequacies. In the first place, although the third method uses two or more cameras, it is generally accepted that the method which uses a monocular camera is much better because of economic aspects and of processing time. Actually the method using a monocular camera is easier to achieve real time processing. In the second place, unlike the first method which detects only moving obstacles, a method which can detect both moving and static method is necessary. It is because static objects which are general on Indian roads are also very dangerous for drivers.

Most obstacle detection systems uses infrared, laser, etc to detect obstacles and the system which are vision based uses, binocular cameras, stereo vision and optical flow algorithm. Laser based systems have environmental issues. Binocular camera cost more and stereo vision and optical flow computationally complex.

## III. PROPOSED SYSTEM

The proposed system is very useful for driver assistance system. The system uses simple image processing algorithms so it is computationally efficient and will work in real time. These existing methods have some inadequacies. In the first place, although the some method uses two or more cameras, it is generally accepted that the method which uses a monocular camera is much better because of economic aspects and of processing time. Actually the method using a monocular camera is easier to achieve real time processing.

- **Area Of Interest-** Digital cameras have a wide photo angle. The image clicked with camera present the triangle view of the environment. But we need opposite triangle view of that environment. So for our purpose we don't need the whole picture. We only need a specific region of the image. For that we need to specify a area of interest in our images. And we process only that specific region.

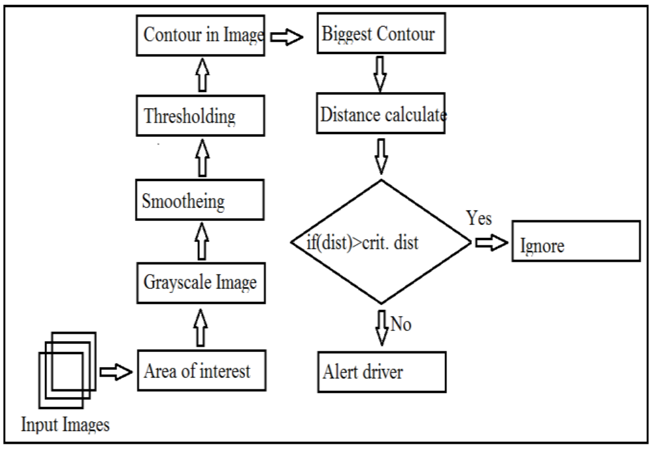


Fig. 1 Work Flow Diagram of the proposed system

The following is a brief description of the purpose and planned implementation of the solution to each sub-problem or "module".

- **RGB To Gray** – The color image is converted to the grayscale image because color image is heavy and hard to process. In RGB model, each color appears in its primary spectral components of red, green and blue. This model is based on Cartesian coordinate system. Images represented in RGB color model consist of three component images.
- **Smoothening -** Smoothing, also called blurring, is a simple and frequently used image processing operation. There are many reasons for smoothing. Here we will focus on smoothing in order to reduce noise. To perform a smoothing operation we will apply a filter to our image. To blur the images here, we used Gaussian blurring because it's the most efficient blurring technique.
- **Threshold-** These methods rely on the ability to distinguish objects from the background only if the intensity of the pixels on it falls outside a certain threshold which is a characteristic of the background. This method too is very susceptible to blurring since only local rather than spatial information on pixels is taken into account. Moreover a prior knowledge of the background itself is required to preset the allowable range of intensities on it, unless some other methods are used to first identify the round itself or to first train the system on each particular background.

- **Euclidean Distance-** In mathematics, the Euclidean distance or Euclidean metric is the "ordinary" (i.e. straight-line) distance between two points in Euclidean space. With this distance, Euclidean space becomes a metric space. The associated norm is called the Euclidean norm.

The Euclidean distance between point p and q is the length of the line segment connecting them (pq). In Cartesian coordinates, if p = $(p_1, p_2)$ and q = $(q_1, q_2)$ are two points in Euclidean *n*-space, then the distance (d) from p to q, or from q to p is given by the Pythagorean formula:

$$dist. = \sqrt{(p_1 - p_2)^2 + (q_1 - q_2)^2}$$

Where (p1 , q1) is the first pixel's coordinate and (p2 , q2) is the coordinate of second pixel. The coordinate of the first pixel are known and fixed and the pixel coordinate of second pixel can be calculated from the biggest contour of the image. The vector array which holds the pixel values of contours can be used to find the lowest pixel of contour, which is also the nearest pixel from the vehicle.

- **Contour Analysis-** Contour detection in real images is a fundamental problem in many computer vision tasks. Contours are distinguished from edges as follows. Edges are variations in intensity level in a gray level image whereas contours are salient coarse edges that belong to objects and region boundaries in the image. Contour tracing is one of many preprocessing techniques performed on digital images in order to extract information about their general shape. Once the contour of a given pattern is extracted, it's different characteristics will be examined and used as features which will later on be used in pattern classification. Therefore, correct extraction of the contour will produce more accurate features which will increase the chances of correctly classifying a given pattern. Contour analysis is the most important part of the project. First of all we find all contours in the image. Contour finding is a part of image segmentation. After finding all contours in the image, we draw them. By analyzing the size of all contour we decide which is the largest contour of the image. And the largest contour is our obstacle. Now our job is to decide whether that contour is in the path of the vehicle or not. And when we decided which is our obstacle we calculate the distance of the obstacle from the vehicle, if the distance is more than critical distance we ignore that obstacle and if its less than critical distance we alert the driver with a horn. Chain code tracking process is as follows:

1. Adopt the line scan technology to get the outline of starting point, record the point coordinates of the Start-X and Start-Y, and take this starting point as the current point, turn to step (2), if cannot get contour points after scan, turn to step (4);
2. Sequential scan the 8 neighborhood adjacent with current point according to the direction of the chain code, if encountering contour points, immediately stop tracking contour and recording the track to the direction of the chain code value, turn to step (3); If not, set the sign of end of contour tracking "-", set up the scan starting place as Start - and Start X - Y, and turn to step (1);
3. Filled with ground color to fill contour points that are scanned, set up and the current point as the tracked contour points, turn to step (2);
4. Use "-" to sign all end of contour tracking.

## IV. ALGORITHM

The algorithm of the proposed system is very easy to implement. We just used simple image processing techniques to implement the proposed system. The algorithm is given as follows:

- Start
- Input the live video feed
- For (image = 0 to last image)
- Set the area of interest (crop that part)
- Convert the image from color to grayscale
- Blur the image to reduce noise
- Threshold the image to get binary image of grayscale
- Find the contours in that binary image
- Draw the contour
- For (contour = 0 to last contour )
- Calculate the size of contour
- Compare the size with previous contour
- If (size > previous one )
- It's the new biggest contour
- Draw this contour
- End if
- Calculate the distance of the contour from the car
- If (distance < critical distance)
- Blow horn (alert the driver)
- End if
- End for

The methodology used in this paper is based on the fact that contour of any image provide a lot of information about the environment of the image. If we process and analyze the contour of the image, we can get almost every object in that image. And the size of contours in the image can be used to define the object as an obstacle or non obstacle. Figure 2 and 3 shows the process of the proposed system.

Fig.2 Original input image from the live video feed.

The fig. 2 shows the input image from the live video feed. But for the purpose of obstacle detection we don't need the whole image, we only need a part of that image. We call it the area of interest.


Fig. 3 processing of the input image

Fig. 3 (a) shows that area of interest from the input image. This area of interest covers enough area in which objects can act as obstacle. The area of interest is a RGB image we need to convert that RGB image to grayscale so that it becomes easy to process. Fig. 3 (b) shows that grayscale output of the RGB input image. The grayscale image is noisy so we need to remove the noise and we perform a blurring operation to remove noise. Fig. 3 (c) shows the blurred image of the grayscale image. Then we need to separate the background and foreground of the blurred image. We used thresholding for that purpose. In blurred grayscale image there are a lot of intensity values. By thresholding we can convert that image to a binary image. Binary image is an image which has only two values: zero for background and one for foreground. Fig. 3 (d) shows that binary image of the blurred image. We use that binary image to extract contours. And we compare that contour based on their size. And find out the biggest contour which acts as an obstacle.

## V. EXPERIMENTAL RESULTS

The system was tested with a live video feed and the results were satisfactory. Although it's not an navigation system but it's very helpful for drivers. The experimental results are like shown in fig. 4 and fig. 5.


Fig. 4 detecting the obstacle in driving lane and avoiding in the right lane

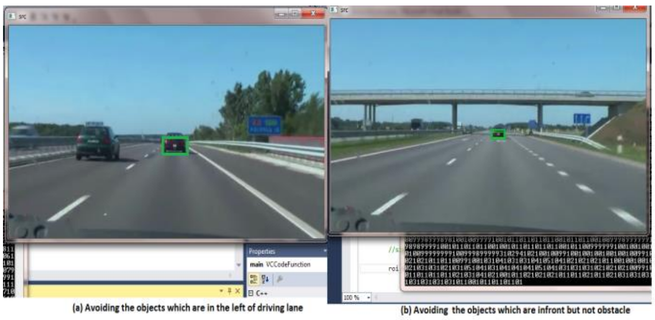


Fig. 5 detecting the objects which act as obstacle and avoiding others

## VI. CONCLUSION

Each method seems to have its limitations despite how theoretically sound they may be. As sound as the theories of computer vision are, they have not yielded the best results under a wide range of scenes. However, given certain restrictions on the scene such as the presence of distinct corners on the ground, sufficient camera movement, minimum texture on ground, so on the results have proven the theories very sound. Under these conditions, obstacle detection using computer vision can be considered quite reliable.

## VII. FUTURE WORK

Several optimizations could be made to enhance the reliability of the methods. For example, if an obstacle and the ground get segmented together, epipolar geometry and contour height estimates could be used to detect where the ground ends and where the object starts.

A horizontal line can be drawn separating the obstacle and the ground marking them with their appropriate heights. At the moment, the obstacle detection system is simply a digital camera on a tripod being moved around manually between images for experiments.

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