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A Review: Obstacle Tracking Using Image Segmentation

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ABSTRACT: Unmanned ground vehicle (UGV) are being deployed for many mission critical applications to operate primarily in hazardous environments. In order for unmanned ground vehicles operating at high speeds in rough changing terrain, Rapid hazard avoidance machination will be required. Image segmentation is the technique which is used for UGV Video processing. This process plays important role in object recognition and detection. This process of image segmentation is crucial in many areas such as object detection, recognition task, video surveillance & medical imaging. This paper provides a review of various image segmentation, obstacle detection and avoidance techniques in unmanned ground vehicle.

KEYWORDS: image segmentation, obstacle, steering angle, computed speed, flat ground, intensity matching, coordinate frame, filter noise, normalization and inconsistency calculation.

I. INTRODUCTION

The UGV (Unmanned Ground Vehicle) as suggested by the name is an autonomous board vehicle that takes a destination as input from the user, maps its current position on a predefined map and finds the simplest and least time-consuming path between the two points. It then follows this path to reach the destination while detecting the obstacles in its path. If the obstacle is big enough to block the entire path then it takes an alternative path to the destination.

A few projects under development in many parts of the world are: the Auto Drive project that is to be completed in the US by 2030, Google driverless car project at Stanford, driverless Audi, etc.

Obstacle detection systems are functioned to compute the position of obstacles. Obstacle detection systems typically compute the position of obstacles relative to a mobile agent by using range information. Range information may be obtained from ladar (laser ranging) [1, 2], sonar (sound ranging) [3, 4] or vision based techniques [5, 6, 7, 8].

Visual technology has the benefits of poor cost, low power reduction and a high point of mechanical accuracy. The speed and accuracy of vision algorithms are commonly extent with faster computing platforms. In addition, the passive nature of the camera implies that it has no detectable signature and is relatively free of signal interference in the present working of other sensors. However, the relatively slow speed of stereo based obstacle detection has limited its application in real-world problems. Existing implementations of correspondence based algorithms either fail to meet real time requirements or run at coarse resolutions.

The obstacle detection algorithm trades accuracy and image resolution for speed, effectively limiting the accuracy of obstacle position estimation to within a small area. Further, since the MPL is a large vehicle, the observable area is navigable only if it has few obstacles. We believe that for sparsely distributed obstacles, a reflexive approach, without resort to detailed path planning, is sufficient for avoidance. Our approach is reflexive in the sense that the steering and speed are modulated by a fast greedy algorithm based purely on the instantaneous local perception of obstacle positions.

In this paper, section II describes the application of unmanned ground vehicle, section III describes the related work section IV describes about the image segmentation and its technique, section V describes obstacle detection and

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assumption, section VI describes obstacle detection algorithm, section VII describes obstacle avoidance, and section VIII describes the computation of steering and speed.

II. APPLICATION OF UNMANNED GROUND VEHICLE

UGVs can be used for many applications where it may be inconvenient, dangerous, or impossible to have a human operator present. Generally, the vehicle will have a set of sensors to observe the environment, and will either autonomously make decisions about its behaviour or pass the information to a human operator at a different location who will control the vehicle through teleportation. Numerous potential applications of unmanned ground vehicles (UGV) have been identified both in military and civilian areas such as reconnaissance, surveillance, target acquisition, search and rescue, and exploration. UGV technology used in different field:

1) *Agriculture:* - In agriculture, UGV are used for automatic monitoring and protection of crops .UGV are an important aspect in future of automated agriculture activities.

2) *Security purpose*: - Collect information about the environment, such as building maps of elements in the surrounding. Trace objects of interest such as people and vehicles.

3) *Military war:* -In Department of Defence, Unmanned Ground Vehicles save lives and improve national defence capabilities with the control system architectures, advanced sensor systems, research services, and standards to achieve autonomous mobility for unmanned ground vehicles. These vehicles could also serve as automated petrol vehicle for police and military reducing life threat.

4) *General transport:* - In this modern world, the need of automation in every possible field of human interference. Driving road vehicle is also an area of concern where human errors cause major fatal loss of life and property. With rise in mental stress and hard work factors some situations might occur with mind diversion form the road may result in fatal accident but with the machines trained and capable to do automated driving cannot go under stress and can make such major mistakes unless human error persists.

III. RELATED WORK

This section gives an overview of the related research that has been done regarding autonomous navigation for unmanned ground vehicles. Some of these are as following:-

Matthies, Larry, et.al [10] in this paper, authors developed a real time stereo vision system that uses Data cube MV-200 and a 68040 CPU board to sense terrain geometry and composition under night ,day and low visibility conditions. Somboon.H.et.al[11] in this paper, authors proposed an activity representation and probabilistic recognition methods which are mainly used to detected and segmented events from video data automatically by a probabilistic analysis of the shape, motion and trajectory features of moving objects. But main problem of these methods are tracking a crowd of people, necessary for many surveillance applications, is also still very difficult due to self-occlusion and the occlusion of the body parts with others.

Maria T.et.al [12] in this paper, the authors presented a dynamic visual attention method used to segment the scene into moving objects—vehicles a pedestrians—and background, without using a reference image or modelling the background.

Durst.et.al [13] in which authors proposed a new environment called Autonomous Navigation Virtual Environment Laboratory (ANVEL) .it uses video game technology and physics-based modelling techniques to provide an M&S toolkit that is intuitive, interactive, and physically meaningful for unmanned ground vehicle but it is mainly operate during off road navigation and UGV can detect and avoid obstacles in static environment.

Sumin Zhang and YuWang et.al [14], this paper, presents a novel method for trajectory planning, based on a "curvature matching" technique. This method quickly generates a path connects the end of the path generated by a hazard avoidance. Trajectory planning algorithm has been applied in intelligent driver model to control the unmanned ground vehicle in complex environment. The experimental vehicle attained speeds of 8 m/s (18 mph) on flat and sloped terrain and 7 m/s (16 mph) on rough terrain.

Saurabh Trikande.et.al [15] proposed visualization technique for UGV using 3D point cloud which give depth information, uses 3D scanner which scans environment in front in one plane and perceive the output in 3D point clouds. The Cluster extraction enables to extract the cluster in the point cloud which is mainly help to identifying the objects of interest i.e. Bomb .but it is mainly used in unmanned ground vehicle for home hand security.

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IV. IMAGE SEGMENTATION

UGV uses image segmentation technique to divide an image into parts that have a strong correlation with objects or areas of the interest contained in the image including terrain shape and Formation. In image processing, useful pixels in the image are separated from the unrequired pixel or pixel of no interest.

Real-time and physics-based simulation environment is a prerequisite for UGVs. Autonomous Navigation Virtual Environment Laboratory is also good software to test UGV virtually.

Threshold and Edge detection are the two most common image segmentation techniques:

1) Thresholding is the simplest method of image segmentation. From a grayscale image, thresholding can be used to create binary images. Colour images can also be threshold. One approach is to designate a separate threshold for each of the RGB components of the image and then combine them with an AND operation. This reflects the way the camera works and how the data is stored in the computer, but it does not correspond to the way that people recognize colour.
2) In edge detection, special algorithms are used to detect edges of objects in the image. Edges mark image locations of discontinuities in gray-level, color, texture, etc. Edges typically occur on the boundary between two different regions in an image. There are a number of algorithms for this, but these may be classified as derivative based where the algorithm takes first or second derivative on each pixel or gradient based where a gradient of consecutive pixels is taken in x and y direction. Operation called kernel operation is usually carried out. A kernel is a small matrix sliding over the image matrix containing coefficients which are multiplied to corresponding image matrix elements.

V. OBSTACLE DETECTION BASED SOME ASSUMPTIONS

There are five basic assumptions that underlie the obstacle detection algorithm:

1) Obstacles can be regarded as objects lying sufficiently high from the ground or services predefined depth in the surface. For the system we discussed, obstacles are restricted to objects that are at least k unit's height above the horizontal plane.

2) *Flat Ground:* It is assumed that the ground can be locally represented by a plane. The assumption is correct on the basis of the area where a vehicle can be driven is more or less on flat plane.

3) Obstacles are assumed to be easily and quickly differentiable from the background intensity in the image; local color(R, G, B) intensity discontinuities form the basis for our detection process across stereo image pairs. Note that the correlation based techniques make basis of our work.

4) Image verification is a two dimensional seeking of points that can be reduced to one dimensional point if constraints are being imposed by epipolar geometry inherent in an oriented image selected. The detection algorithm exploits the epipolarity constraint by employing sensing device with identical focal lengths that are aligned till a scan line.

5) Identical sensing device are assumed to simplify the task of processing intensity images and searching points selected. A difference in focal lengths of the sensing devices introduces a 2D transformation and obtaining correspondences complications. Differences in the dynamic response of the sensors to incident light and scaling or offset of the input signal by the device require costly and time consuming intensity normalization

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VI. OBSTACLE DETECTION ALGORITHM

Detection of obstacles is based upon seven steps:

*1) Inconsistency Calculations:*The epipolarity parameters bound our work for corresponding pixels belonging to one row. We use a simple n x n correlation mask to find the pixel R(i, j) in the right corresponding image to L(i; k) in the left image.

(a) Left Image (b) Right Image (c) Computed Disparity

Figure1: Disparity Calculation……. [9]

2) *Filter Noise:*Filtering of a noise is done to insure that we have an image free undesired component that can act as barrier toward processing in this phase ,different noise like salt and pepper noise, Gaussian noise, speckle noise are being removed. The output obtain after filtering is further exposed to the upcoming operations.The matching process is kept so simple that we tend to get quite a few bad matches which result in faulty result; the popular constant-local-disparity constraint is executed to remove salt and pepper noise. These parameters enforce the errors in a small window to have resembled values. In the Marr-Poggio-Grimson approach [16], matching ambivalence is resolved so that the selected value is close to the majority of errors of non-ambiguous points in the neighbourhood. The imbalance calculated in the previous step is believed if we have at least K pixels in its m x m neighbourhood will have the same inconsistency otherwise the inconsistency is ignored.This inconsistency/consistency helping us in differentiating from obstacle point to the non-obstacle point.

(a) (b)

Figure 2: Output of a filtered noise image

3) *Setting the threshold of the inconsistency:* The inconsistency D(i; j) at a pixel R(i; j) is contrasted with the expected inconsistency of the ground plane G(i; j) and if D(i; j) > G(i; j), R(i; j) is found and will be regarded as a pixel of an obstacle.

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4) *Placing obstacles points onto the ground plane:* Every point that belongs to an obstacle is placed onto the ground plane using the pixel coordinates (i, j) and the distance out of inconsistency is computed. This step output is called the Instantaneous Obstacle Map (IOM).

5) *Transformation into steering vectors:* IOM can be easily transformed into a steering vector representing a range of desired steering directions i.e. range of the steering vector is the instantaneous turning points of the unmanned vehicle. A value entered in each time of this vector is considered as a hurdle steering in the direction of linkage. The turning direction is called as the steering angle located by a cell in the steering vector that has the lowest hurdle value, up to a threshold.

6) *Computing the steering vector:* For the computation of a steering vector from an IOM, IOM points in a 2D Cartesian coordinate frame Fc are transformed into a vehicle centered coordinate frame. In this case this frame is the intersection of the front axle and the longitudinal axis of the vehicle. The transformation is used for rotation, translation and scale. Obstacle points in Fv are represented in polar coordinates. If an obstacle is encountered that is having closer to minimum distance threshold ρ^{thrsh}_{min}(say) then the vehicle is brought to stop ; otherwise, the next step is followed.

7) *Discretization and Relaxation:* Every point of obstacle represented in a polar form is discretized to represent a location (i; j) in a discrete polar occupancy grid (POG). The POG is similar to a C-space map and encodes the possible arrangements that the vehicle can exist in. An obstacle point G (i; j) in the POG is allotted a value using the formula:

$$\mathcal{G}(i,j) = (n_\rho - i)^2$$

and all other points are assigned to 0. n + 1 and n + 1 are the number of rows and columns of G respectively.

VII. OBSTACLE AVOIDANCE

The constants and thresholds used in the obstacle avoidance components of the system are:
1) hmin = 0 units & hmax = 200 units
2) αmin = -20 degree & αmax=+20 degree
3) vmin < vref < vmax
This surface shows the values of vref against varying hindrance values t < Ŋ and steering (in degrees) corresponding toαmin < αref < αmax.
Note that vref = 0 for all other values of αref and t.

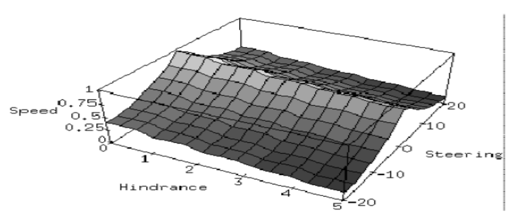

Figure3: vref is function steering angle α …………….. [9]

The image must be read in a pattern from left to right. This involves placing both cones and a human obstacle in a configuration clearly observable in the last figure. The path that will be traced out by the vehicle is considered as track on the way to destination that can also be seen in the figure below. The distortion observed in the images is an artefact of the video Sensing device.

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(a) (b) (c)

Figure 4: Obstacle Avoid Sequence…… [9]

VIII. COMPUTATION OF STEERING SPEED

The cell S(j) is said to encode the hindrance associated with steering in the direction j in the sense that, with the greater value of S(j), the chances that we would be steering the vehicle in the direction represented by j are lower[18],[19].
Then, given S, the choice of steering direction corresponds to the smallest hindrance value of cell j which should be below a predetermined threshold.
This rule is implemented as a one-dimensional search for a minimum value up to starting from the centred wheel position of the vehicle. Through threshold we set the base level distance from the vehicle up to which avoidance is selective and the current implementation incrementally lowers the selective avoidance distance. If no slot is found during this entire process the algorithm raises an exception and the vehicle is brought to an immediate halt.

$$Vref = w.Vmax \quad (1)$$

where

$$w = \left(w_1 \cdot \left(\frac{n_\rho - t}{n_\rho} \right)^2 + (1 - w_1) \cdot \left(\frac{|\theta_{ref}| - \theta_d}{\theta_d} \right)^2 \right) \quad (2)$$

And,

$$\alpha_d = \alpha max \quad \text{if } \alpha ref >= 0$$
$$\alpha_d = \alpha min \quad \text{if } \alpha ref < 0 \quad (3)$$

Above mentioned method for computing a steering direction is predatory in the sense that it settles on the steering direction as the angle ref corresponding to the rest satisfactory slot at the farthest possible avoidance horizon.

IX. CONCLUSION

An image segmentation algorithm producing rear disparity information turns out to be influential for obstacle avoidance in a common outdoor setting. The obstacle avoidance module is reflexive in the sense that it is data driven and apt in generating motor commands. The algorithm is independent of position of obstacles as well as the inaccuracies of the actuator servos. The algorithm is stable, simple, fast, robust and practical to implement. We determine that our advent may fail, but we also observe that our technique performs very well in most outdoor scenarios, especially with far obstacle sets.

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An engineered system can be made with few assumptions so that a complicated task can be turn into practicality in real world, real time using available recent technologies.

X. LIMITATION AND FUTURE WORK

Relaxation of the ground assumption would be a substantial extension of the obstacle detection system. Automatic representation of the ground plane by computing the equation of the plane would help in situations when the ground slope changes abruptly. It would also help in situations where the distance of the stereo system is not fixed i.e. relative to the ground plane but can be actively controlled by the driver. Other improvement can be expected by relaxing the epipolarity and the identical sensing device assumptions [20].
The obstacle detection system presented here can only work in real time situation considering assumption mention above. However, we have analysed in which the obstacle detection system coexists with other modules including a generator and a road follower or UV Rays based sensor deployed. Desirable behaviour has been observed to emerge from adding up of these modules (for example, move along a particular heading while avoiding obstacles or follow a road while avoiding obstacles).
Our obstacle avoidance system has a limitation in that it does not account for the non-free parameter introduced by the vehicle. It would be interesting to incorporate non-free parameter with computing the speed, distance from obstacle and steering angle.

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BIOGRAPHY

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