INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Colour Vision Based Drivable Road Area Estimation

Sabu Kamini
ME Student, Department of Electronics and Telecommunication, Government College of Engineering, Jalgaon, India
Dr. M. H. Nerkar
Professor, Department of Electronics and Telecommunication, Government College of Engineering, Jalgaon, India

Abstract:
Autonomous navigation of robot for on-road driving has gained importance in automobile research area. Image based path tracking has obtained growing attention for future driving assistance for it's inexpensive and effective. Image from a monocular camera, directing in front side is used for tracking the drivable road area. Use of colour based drivable road area estimation technique is common in such problems. Different colour parameters have been considered for image segmentation till the date. This paper considers the use of intensity and hue for better segmentation results. The segmented results prove to be more efficient in real-time road scenario.

Keywords: *Road region segmentation, Colour vision, Hue histogram, Intensity k-means clustering, Autonomous robot*

1. Introduction

Autonomous navigation of robot for on-road driving has gained large importance in automobile research area. The system is being developed first for driving assistance. The image based path tracking has obtained growing attention since it is inexpensive and effective tool. Here, a camera is fixed on the robot such that it captures the front side images. The camera is placed exactly at the center of the robot. The images so obtained are then processed to decide the robot movement.

Automated road lane detection is the crucial part of such vision-based driver assistance system of intelligent vehicles. This driver assistance system reduces the road accidents, enhances safety and improves the traffic conditions.

Different techniques are used for road lane detection. These include different edge detection based methods and segmentation methods. Edge detection and Hough transform based methods provide us with the road boundaries. The region within these boundaries may be treated as the road area.

The segmentation may be performed on grayscale image by considering a specific range of intensities. Different algorithms are also available for image segmentation. These include histogram thresholding, contrast based background subtraction, k-means clustering, etc.

When we are dealing with road area estimation, we find that roads involve large intensity variations. The presence of tree shadows, pedestrians and other vehicles too cast their shadows. The environmental conditions also tend to vary time-to-time. Use of colour based drivable road area estimation technique is needed in such problems. Different colour parameters like RGB components, hue, intensity, saturation, luminance, brightness and contrast have been considered for image segmentation till the date.

This paper gives a brief overview of different techniques used for road area estimation in section 2. The importance of including hue is included in section 3. Section 4 then introduces a novel algorithm which combines the two different techniques (one intensity based and other hue based) to get better segmentation results. The segmented results prove to be more efficient in real-time road scenario.

1.1. Road Area Estimation

Road area estimation involves separating road region from background non-road region in the image. Different region based features are used to achieve this. Different methods used for road area estimation involve edge detection based and image segmentation based.

Very simple methods were applied initially. They involved the use of edge detection approach to determine road boundaries. The area between the boundaries would then be considered as the road area. Reference [1] used the property of contrasting background colour for edge detection, Belgian section being near-white and non-Belgian section being dark black. In real-time on-road driving scenarios, however, such completely contrasting backgrounds don't occur. Therefore, some different method is required.

If lane markings are present on the road, the lane markings are detected using edge detection [2]. Line extraction based on Hough transform is used by [3] to get best linear fit to the lane markers. Colour based lane markings extraction is also used. In such case, colour intensity values are used to determine markings in the black and white images.

Reference [4] uses three different features viz, starting position, direction (or orientation), and its gray-level intensity, to determine lane boundary. The three features with different weights comprise a distance metric. Best boundary candidate is chosen as the one having minimum distance metric. Area enclosed by the boundary is nothing but the road area.

If lane markings are not present on the road and road is not well structured, edge or line based methods don't work. In such cases, only intensity may not serve better. Colour feature is then used for segmentation. In such cases, the contrast in road colour and background colour is used for separating road and non-road regions. Colour saturation may also be used for determining the road area [5].

In [6, 7], the intelligent vehicle region detection system uses colour extraction for road region recognition. At first, one dimensional colour histogram feature is set up and thresholding is applied for grouping similar pixels for the classification process.

For operation on unmarked roads under highly varying weather and light conditions, some illumination invariant schemes of colour image segmentation are required. In order to deal with such conditions, [8] used colour information for extraction, but first RGB colour properties of the image are converted into shadow-invariant feature space. Reference [9] uses colour information in HSI format for region of interest determination. Predefined threshold may be used as in [10] or the threshold may be updated with the robot navigation.

Reference [10] also utilizes the connected component based feature extraction and background subtraction for road area estimation.

If the road to be followed is typical for the robot, online learning approaches are used for road area detection. In such conditions, road models are built initially. These models are then referred and updated time-to-time during actual execution. Statistical road modelling of road edges and boundaries in [11] and probabilistic generative modelling of road geometry in [1] are examples of this approach. They provide improved performance at the cost of increased memory database for prior information storage.

2. Theory

2.1. Methods Used

The novel approach discussed in this paper uses following two algorithms for segmentation of image.

2.1.1. Histogram Based Thresholding

In this method, histogram is plotted for the intensity values. Histogram is a function indicating number of image pixels belonging to a particular intensity. The function, when plotted against the intensity values, forms a bar graph called an intensity histogram. Similarly, histogram may be plotted for other parameters also. This paper uses hue parameter.

From the histogram, one comes to know the range of intensity values present in the region of interest. By specifying proper threshold, the region of interest can then be separated out. This type of segmentation is very common and easier one. However, it requires the intensity be same throughout the area of interest.

2.1.2. K-Means Clustering

K-means is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. It is the most popular algorithm so far in intensity based image segmentation due to its success rate.

The procedure follows a simple and easy way to classify a given data set into K clusters. K is positive integer number. Each cluster has a centroid associated with it. The grouping is done by minimizing the sum of squares of distances between data and the corresponding cluster centroid. While grouping, centroids need to be placed approximately. The better choice is to place them as much as possible far away from each other. The centroid positions can then be updated based on grouping.

K-means is a nice method to quickly sort data into clusters given the number of clusters a priori.

2.2. Hue for Segmentation

Intensity images or grayscale images are used to detect road boundaries. The region between the edges that lies exactly in front of the camera can be treated as the road area. However, it is quite difficult to get good results with no clearly visible road markings painted on road surfaces and in conditions of heavy traffic. This is clearly so since the edges of shadows; some random road markings painted on the middle of road (which often exists in urban environments); and edges of vehicles, pedestrians, etc. appear as edges. This can clutter the true road boundaries. Furthermore, road areas with different colors from the surroundings may appear quite similar in intensity in the gray level images. Therefore, in order to cope with some of these problems, it is wise to heavily rely on the full-color image in order to robustly and efficiently detect the roads from their surroundings [12].

Many of the techniques used so far include vision based techniques for the extraction of color, because color has a distinctive characteristic that can be used for classification. The assumption that road region has similar color different from non-road region can be used for the recognition of road area [13]. While some focus on using color technique for the extraction of edges. Edges extraction has been used for boundary detection, which is used for classification of image into road region and non-road region [14].

Color based segmentation has been successfully used for road detection on well structured Highways and Expressways. To avoid the effect of illumination changes due to shadows, etc. on the segmentation, HSI or HSV color space is used. This helps eliminate the falsity arising due to shadows and bright sunny environments.

HSI stands for Hue, Saturation and Intensity space. Hue represents the impression related to the predominant wavelength in the perceived color stimulus. Saturation corresponds to the color relative purity, and thus, non saturated colors are gray scale colors. Intensity is the amount of light in a color. The maximum intensity is perceived as pure white, while the minimum intensity is pure black.

Some of the most relevant advantages related to the use of the HSI color space include the close relation to human perception of colors, having a high power to discriminate colors, specially the hue component. The difference between colors can be directly quantified by using a distance measure.

2.3. Novel Combined Approach

Road region is an important feature that is necessary for an autonomous driving system to detect for navigation. Various techniques have been used by previous researchers to detect road region but recently vision based system is preferred to be used because of the ability to acquire data in a non-intrusive way [4].

The approach discussed in this paper uses the segmentation on grayscale version of the captured image followed by hue based checking and improvement. K-means clustering is applied on grayscale image to get three clusters. The cluster of interest is checked for hue. The algorithm proceeds as follows --

i. First of all the captured image is transformed from RGB color space to HSI color space.
ii. Intensity component is divided into 3 clusters using K-means clustering algorithm.
iii. The bottom central part of the image is assumed to be the road area. Accordingly, the cluster corresponding to this region is considered as the road cluster.
iv. The hue histogram is plotted for this road cluster.
v. The histogram is used to determine the maximum count with the same hue. Threshold is calculated as 10% of maximum count.
vi. Hue values are selected from the histogram for which the threshold is reached.
vii. The complete image is searched for these hue values. Resulting area is considered as the road area.
viii. Morphological opening is performed to fill up the small holes in the area.

3. Result and Discussion

The algorithms were implemented in MATLAB R2012a and tested on different sizes of different resolutions. The results obtained from this combined algorithm are compared with the results obtained by applying the two algorithms independently. Results have been summarized in Figure.1.

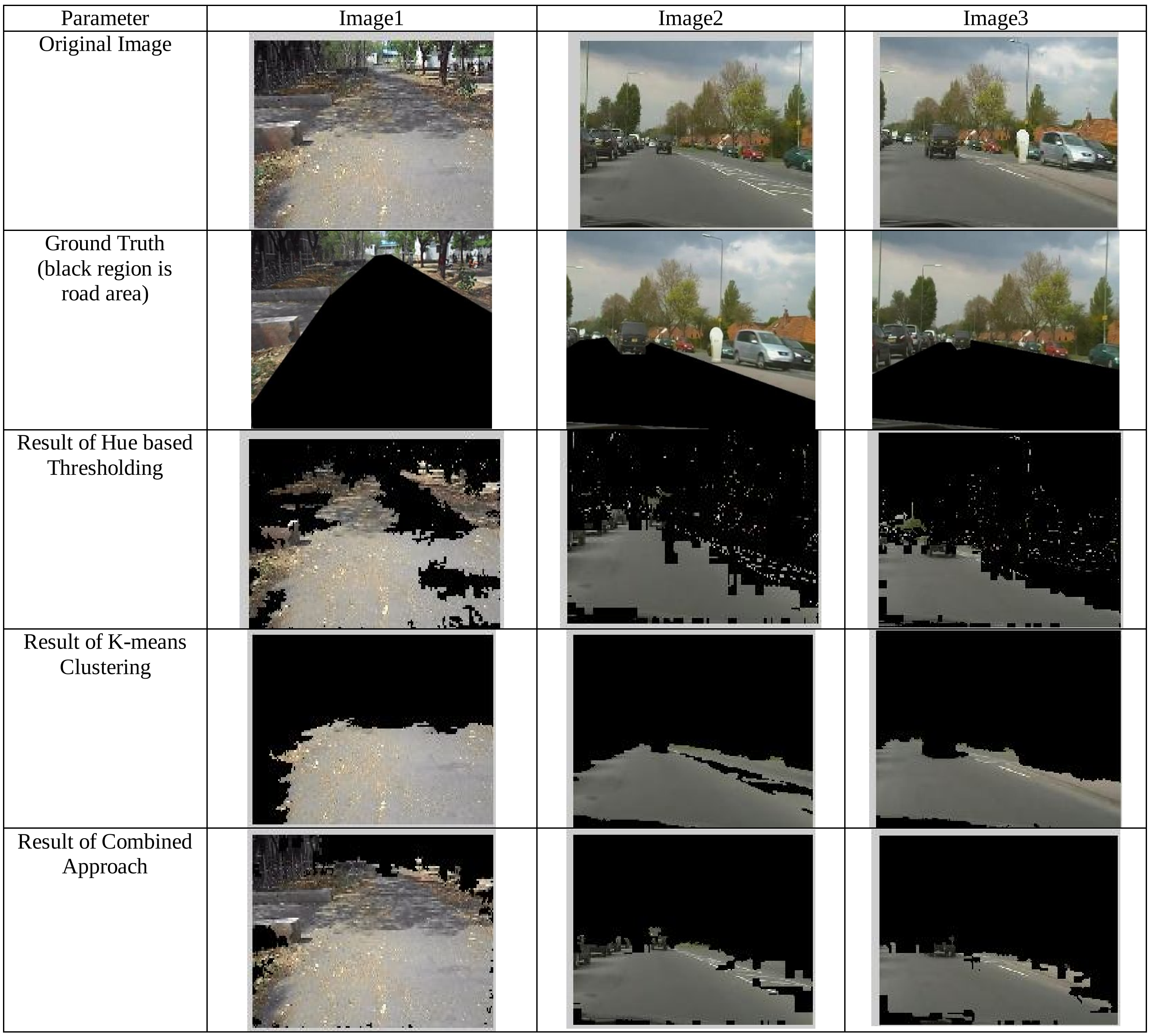

Figure 1: Results for Hue based, Intensity based and Combined Approach of Segmentation

Results in the Figure. 1 clearly show that the road region is efficiently segmented from the complete image if combined approach is used. The intensity based approach gives better results normally. However, in case of shadows, the method fails to recognize the road region. Hue based

thresholding approach proves best for illumination variant conditions. However, it detects narrower region as road area. This may become barrier for the robot to move even if region is available for the robot.
Table 1 compares the algorithms on the basis of error between ground truth and segmented image and the corresponding SNR values. The values are for the above three images. The values show that results provided by hue based thresholding and combined approach are quite similar.

Parameter	Hue based Thresholding	K-means Clustering	Combined Approach
Mean Square Error	1.22, 1.82, 1.72	1.3, 1.94, 1.95	1.28, 1.89, 1.87
Peak Signal to Noise Ratio	-12.73, -4.49, -4.24	-13.01, -4.74, -4.77	-12.94, -4.63, -4.60

Table 1 Parameters of Comparison

The three algorithms compared thus show that the K-means clustering of intensity gives very smooth segmentation results. On the other hand, results of hue based thresholding are more close to ground truth. Combined approach takes a step ahead to smooth out the results, however, at the expense of some falsely detected road areas. Due to smoothness, further computational procedures for robot movement can be easily applied.

4. References

i. Arshad N., Moon K., Park S. and Kim J. (2011). Lane Detection with Moving Vehicles Using Colour Information, Proceedings of the World Congress on Engineering and Computer Science, Vol I.
ii. J. M. Alvarez, and A. M. Lopez (2010). Road Detection Based on Illuminant Invariance, IEEE Transactions on Intelligent Transport System, vol. 10.1109/TITS.2076349, pp. 1-9
iii. Charbonnier P. et.al. (1998). Road Boundaries Detection Using Colour Saturation, Eusipco : European Signal Processing Conference, 2553-2556
iv. Charbonnier P., Nicolle P., Guillard Y. et al. (2013). Road Boundaries Detection using Color Saturation, Laboratoire Regional des Ponts et Chaussees de Strasbourg
v. Ishikawa S., Kuwamoto H. And Ozawa S. (1988). Visual Navigation of an Autonomous Vehicle Using White Line Recognition, IEEE Transactions on Pattern Analysis and Machine Intelligence, 10(5), 743-749
vi. Isa K. and Jantan A. (2005). An Autonomous Vehicle Driving Control System, International Journal of Engg., 21(5), 855-866
vii. D. Kuan, G. Phipps, and A. C. Hsuen (1988). Autonomous land Vehicle road following, IEEE Trans. Pattern Anal. Machine Intel, vol. 10, no. 3, pp. 648-658
viii. Lee et.al. (1996). Development of Autonomous Test Vehicle Using Image Processing, Proceedings of the IEEE Intelligent Vehicles Symposium, 409-414
ix. Lee J., Cho J. (2010). Effective Lane Detection and Tracking Method Using Statistical Modeling of Colour and Lane Edge-Orientation, Advanced In Information Sciences and Service Sciences, 2(3)
x. W. Y. Minghao Hu, Mingu Ren and Jingyu Yang (2004). A Vision Based Road Detection System, Conference on Robotics, Autonomous and Mechatronics, vol. Proceeding of the 2004 IEEE, 846-850
xi. Sotelo M. et.al. (2004). A Colour Vision-Based Lane Tracking System for Autonomous Driving on Unmarked Roads, Autonomous Robots 16, 95–116
xii. M. A. Turk, D. G. Morganthalar, K. D. Grembian et al. (1988). VITA-a vision system for autonomous land vehicle navigation, IEEE Trans. Pattern Anal. Machine Intel, vol. 10, no. 3, pp. 648-658
xiii. Yim Y. and Oh S. (2003). Three-Feature Based Automatic Lane Detection Algorithm (TFALDA) for Autonomous Driving, IEEE Transactions on Intelligent Transportation Systems, 4(4), 219-225
xiv. Yinghua He, Hong Wang, and Bo Zhang (2004). Color-based Road Detection in Urban Traffic Scenes, IEEE Transactions on Intelligent Transportation Systems, Vol. 5, No. 4