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A Technique for Bump Detection in Indian Road Images Using Color Segmentation and Knowledge Base Object Detection

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Abstract—Sudden variation in the surface of the road makes it very difficult for safe driving and causes lot of accidents. The situation is more critical especially for vehicles moving with high speed. Sudden bumps pose a very difficult situation and applying sudden break at those juncture leads to many accidents. So, any techniques which can avoid such accidents need to be invented on urgent basis. With this background in view we have proposed to undertake a study by which it will be possible to suggest a novel, efficient technique for detecting the bumps. Bumps are detected by extracting the horizontal profile of the roads and by estimating the volume of horizontal profile. System is tested against the images of the roads taken across different parts of India using digital camera from a moving SUV running at a speed of 30km/h. Experiments show promising results in the detection of bumps.

Keywords - Bump Detection, Color Segmentation, Road Image Analysis, Threshold Segmentation, Texture Segmentation, Classification, Knowledge Base.

1 INTRODUCTION

Many works have been already carried out in respect of automated driver guidance system. There are various major techniques for classifying road images, such as., i) techniques for detection of road profile ii) irregularity in the road profile like bump or zebra crossing detection iii) traffic pattern of the road detection.

The preliminary steps followed in respect of classification of road images are; i) segmentation ii) voting for the candidate problem iii) classification.

There are various segmentation techniques which are primarily categorized into i) color based segmentation ii) texture based segmentation iii) threshold based segmentation iv) contour tracking and active contour based segmentation. The technique takes the help of either local or global properties of the road to determine the road part. For the classification problem a voting technique is used. Here the road part pixels are scanned and are voted either as 1 or as 0 belonging to a particular zone. This approach is quite helpful in detecting zebra crossing and other road candidates. One of the significant drawbacks of this technique is that they are applied on the independent road images. We consider here that the road image analysis is the part of automated driver guidance system and that the images are the frames from a video sequence of the roads.

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2. METHODOLOGY

The entire work is divided mainly into three major parts.

1. Segmentation of the Road part from the rest of the image
2. Bump Detection

A. Segmentation of the road part from the rest of the image

Fig 1: Sample Road Images

Color based segmentation is fast but suffer from mis-segmentation problem. Despite this, it is the best suited method for the proposed application due to its speed of detection. The immediate front part of the vehicle is bound to be road part and there could be a variation of about 10% in the color profile of the color values of the road. Hence, the color information obtained from this part of the image should be a good descriptor for the image segmentation for road part extraction. But some of the background may also share the same color

information like that of the road images. Therefore segmentation process must not only segment the road scene based on the color information but at the same time must also remove those pixels which are mis-segmented due to color similarity.

There are various image segmentation techniques available for segmenting the color objects. Most of the algorithm works with clustering and finding out the occurrence of major objects are repeated. Image in figure 1 reveals that if a cluster based segmentation is applied on these images, the objects like the pedestrians or the vehicles or the sky in the background, may all get segmented. Hence, threshold based segmentation is required to separate the road image from the rest of the objects. Color based thresholding is difficult to adopt as the color and the texture of the road varies from scene to scene and from place to place. Therefore, first 100 images are read from the image database and a small road part is cropped from these images. R, G and B components of the cropped images are tabulated. It is observed that R, G and B values in the road part are defined by a color bound of 50 to 220. Further, the pixels in the road part have very small deviation in R, G and B values. Therefore, the following algorithm is developed for separating the road part.

Read the image pixel by pixel.

Extract R, G and B components from each pixel

Define distance between the color components of each pixel.
D1=|R-G |/255
D2=|G-B|/255
D3=|R-B|/255
If D1, D2, D3<10% and 50<=R, G, B<=220
Mark the pixel as road pixel

From the current pixel take a block size of 50x50 pixel and move the block in current pixels neighborhood (Up, Down, Right, Left, Diagonal UP Left and Right ,Diagonal Down Left and Right.)

Classify the pixels in the blocks

If a block has more than 50% pixels being classified as road pixels and there exists atleast two such blocks
Then mark the current pixel as final_road_pixel

Else

Don't consider the current pixel as road pixel.

Repeat the steps till the entire image is marked.

Extract the marked image as the mask image and segment the road part from the original image using this mask.

The performance of this custom segmentation technique for the road image is observed to segment the roads with nearly 100% efficiency interms of road marking. Though some extra objects are also observed to have segmented along with the road based on the color composition of the objects, these objects are further filtered using a morphological technique.
Extracted road image is first converted into binary image. Most the objects falsely segmented are seen as smaller objects with span less than 100 pixels. Hence, erosion is applied over the entire image with a square structuring element with 3x3 kernel. This process erodes the smaller noisy segmented objects from the image. But at the same time it also lightens the road part of the image. Now, a dilation process is applied to fill the gaps in the road image with the same structuring element. It results in a smooth binary road image. This is superimposed over the original image to extract the road part.

This assumption may be considered as wrong for those road images where there are parallel roads as in case of multilane highways. In such roads morphological technique can not remove the detection of parallel roads and may lead to misdetection. Hence we adopt a unique method for extracting the current road part.

Extract the segmented binarized images.

Draw a bounding box across the connected components.

Draw vertical straight lines for marking the area where maximum bounding boxes are observed.

Mark those zones which are in 25% of the either side of image boundary.

Separate these segments from the original image.

B. Bump Detection

Bumps are horizontal abstraction laid over the road signaling the vehicles to slow down their speed. According to Road Rules, bumps must be properly marked like zebra crossing and there must be appropriate road signs prior to the occurrence of the bumps. Such rules are not always strictly followed specially in the village areas. Unscientific bumps are laid at places which will be difficult to distinguish. Such bumps may cause a great deal of discomfort for driving and may cause severe accidents.

Bump images has a particular property. Even if a bump is not marked with white cross lines and posses the same color as that of the road, a sharpened road image with bumps presents sharp edges across the bump. The profile of the road is generally vertical to the image where as the bump profile is horizontal. Another interesting fact observed in cases of bumps is that, at bump points there is a vast difference in the texture structure of the image. If a plain edge of an image is considered then in such image there are many edges and dead

ends which can never be detected conclusively. As such, bump detection is based on two methods:

1) Bump detection based on texture variation and hough transform in the road part.

2) Bump detection based on local neighborhood information.

The bump is further cross verified to obtain the actual bumps in the road. The following algorithm is developed for detecting the bump in the road.

Method A: Bump detection using horizontal information variation in the road image

1. Convert the segmented road image to gray scale image.
2. Using intensity transform sharpen the image
3. Convert the image to binary image
4. Invert the image such that the road part is depicted with white pixels and the background in black.
5. Extract the edges from the images.
6. Generate contours from the edges.
7. Find the horizontal contours.
8. Link them to the actual road image.
9. If the horizontal profile has more than one profile and the appearance of the profile appears in the region of the road image, then it can be considered as a bump part.
10. The horizontal change can be observed due to several other factors like, there may be another vehicle ahead and exactly at the front of the vehicles. The back of the front vehicle specially the lower part may give a bump like appearance in a binary image.
11. Therefore, once the "bump" part is detected from the horizontal profile of the contour, it is checked if the area within this closed part resembles that of road texture. Hence, the color segmented road image is extracted and the bump part is segmented. Pixels in this part are compared with the rest of the roads. If the similarity is more than 30% then the part is marked as the bump part.

Though, this technique detects bumps with high efficiency, there is a problem of detecting perfect horizontal contours across the bumps. This strategy depends upon the efficiency of the edge detection technique and the uniformity in the image color information. Such edges may even be detected due to shadows and other objects in the roads like other vehicles.

Therefore, another technique is developed for detecting the bumps in the roads.

Method B. Bump detection based on local neighborhood information of the pixels.

1. Convert the segmented image to gray scale image. Let us call it Image I .
2. Apply median filtering with 5x5 neighborhood in I to obtain a detail less image with blurring at the edges. Let us call the image as D .
3. Let S_i^I be the standard deviation of N x N neighborhood in pixel i of image I .
4. Let S_i^D be the standard deviation of N x N neighborhood in pixel i of image D .
5. The contrast difference at pixel i for both Detailed and Detail less image I and D is given by

$$C_{ID} = \frac{\left(S_i^I - S_i^D\right)^2}{C + \left(S_i^I\right)^2 - \left(S_i^D\right)^2}$$

where C is a constant used in order to avoid divide by zero exception.

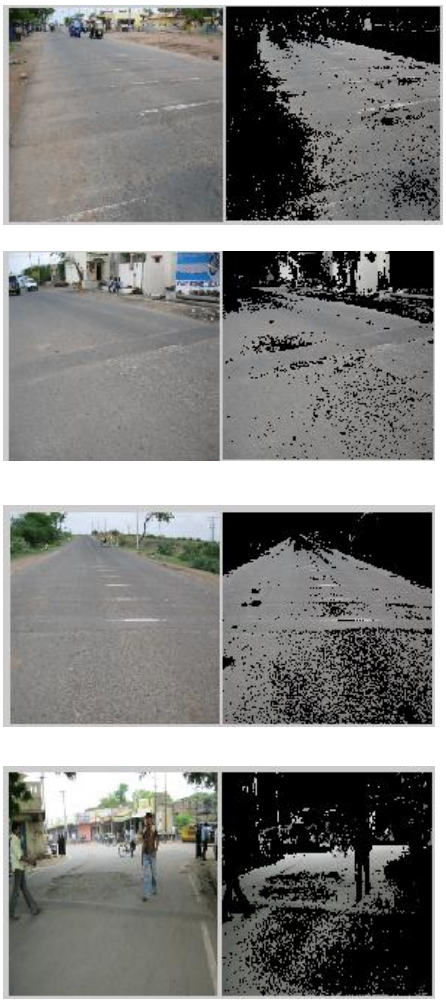
The value of C_{ID} will be lowest in most of the image but will be highest at the bumps due to intensity scale variation in the bump area from that of the other image area. Those pixels that have high values in C_{ID} are classified as the bump edges.

6. A Hough transform of Binary converted C_{ID} image will have maximum peaks at the bump edges. Hough lines are extracted and the pixels covered by those lines which are not at the bottom or at the top of the images are selected as possible bump candidate.

Pixel points thus obtained are cross referenced with the bump candidate pixel obtained through method A.

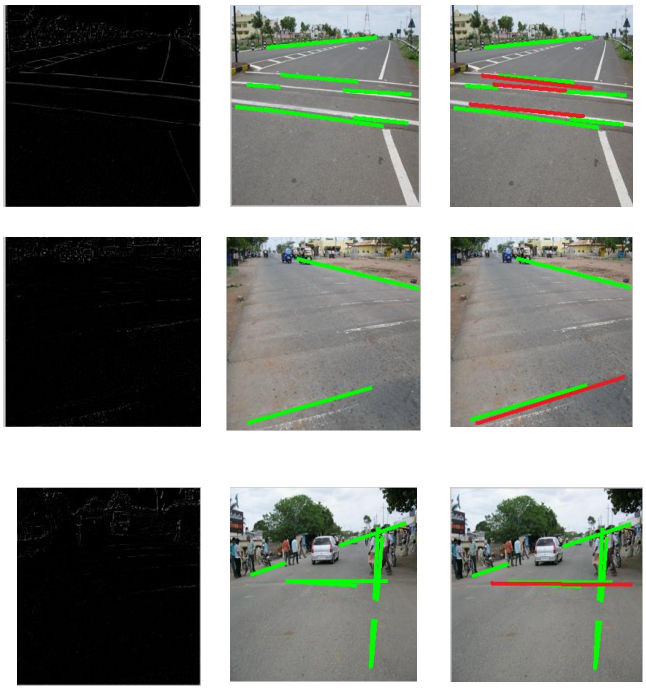
3. RESULTS

Fig. 2. Bump Database



(a) (b)

Fig.3. Result of Segmentation
(a) original Image, (b) Segmented Image



(a) (b) (c)

Fig. 4. Result of Bump Detection (a): Method B (b) Method A (c) Interpolated result of Method A and B for final Bump Detection

4. CONCLUSION

Various image processing techniques have been proposed over the years for detection and classification of various road objects like lanes, zebra crossing, pot holes, bumps, vanishing points and so on. Different techniques are used for detection of such features. The goal of the present work is to develop a fast and efficient technique for detecting the bumps of roads in Indian road images. Indian rural and sub urban roads profile in a color model is inconsistent, hence making it very challeng-

ing task to extract the road part and detect bumps. The other criteria considered are fast detection of the same. Therefore, in this paper a simplistic approach for the problem is proposed which is purely based on image processing in color domain and without any significant transformation like Fourier Transform to speed up the detection, as image is taken from moving vehicle and a certain blurring effect is usual in such image. But due to straight orientation of the camera such effects is minimized and hence does not require any specific deploring algorithm. The results in color domain image processing and gray scale processing of the images helps for detecting the bumps with utmost efficiency. The only drawback observed in the technique is that in cases of multiple bumps, not all of them are detected accurately. This problem can be overcome with multiple bump detection technique by the incorporation of recursive bump detection method.

5. ACKNOWLEDGMENTS

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