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REAL-TIME DETECTION OF UNMARKEDSPEED BUMP FOR INDIAN ROADS

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Abstract:

One of the important roles of Driver Assistance System (DAS)is to assiststhe driver by alertingthe road anomalies. Detection of the speed bumps/breakers, potholes, and maintenance holes will fall under the road anomalies category.In India, generally there are two type of speed bump i) marking type speed bump ii) unmarking or non-marking speed bump. Among the two, using image processing technique identification of speed bump in earlier is comparatively easily than the later. Still, it is very challenging to detect the unmarked speed bump sincethere is a noyellow or white stripe to indicatetheir presence. During driving, the human visual system recognises the marking type speed bump in long-distance, but it is very tough in the case unmarked speed bump. So, a new method is proposed to identify the Real-time speed bump.The detection of such type of speed bump is essential for the driver to avoid accidents/inconvenience in driving. In the proposed method, after converting the RGB image into a grayscale image,a Gaussian filter is used to remove the noisy environment in the road image. Followed by canny edge detection to identify the edges of the image. This helps to locate the edges of speed bump though the colour of road and speed bump remains the same;there is a minute transition between them. Commonly the speed bump is constructed horizontally in the form of the linethat can be identified easy using Hough transform. On average, the accuracy ratio of corrected detected speed bump is 95.5%. In addition to driver assistance, the system can also be implemented in self-driving cars.

Introduction:

The dream of an Intelligent Transportation System (ITS) gets fulfilled when the critical component Driver Assistance System gets developed. The objective is to alert or warn the driver when the speed bump is recognised. Sometimes it can work ahead to act directly on the Engine control unit to reduce the vehicle speed automatically for safedriving. The DAS subsystem includes warning system for running away from lane, warning downside-updriving, Traffic sign recognition,Speed bump Detection, Adaptive cruise control (ACC), Driver drowsiness detection, Zebra or predestines crossing, and an automotive navigation system. Obstacledetection in roadside like a speed bump, potholes is also one of the vitalresearch areas for self-driving cars.The speed bump plays the role of sleeping police on roadways to decrease the speed of the vehicle in a restricted area.The restricted area can be a danger zone, accident-prone zone, school zone, hospital and residential space. Detection of marking speed bump is quite easy using Image processing concept. However,detecting the unmarked speed bump is a challenging task not only for the system but also to humanity. Compare to marking speed bump, accident due to unmarked speed bump are very common due to the absence of highlighter on a speed bump. Thus, the prime focus of this paper is to develop a system for detecting unmarkedspeed bump using powerful concepts like Gaussian and Hough Transform methodology.

Literature Survey:

Most of the earlier research detects speed bump using hardware like sensors,accelerator, software Application or a combination of both.

Hardware: Speed Bump Detection (SBD) using a sensor is a straightforward method, but the efficiency is not appreciated due to the misclassification of obstacles in the road. In an earlier paper [1][2][3]using sensors at medium and high-cost LIDAR sensor,real-time SBDwasemployed. Using anangular rate sensor and Global Position System the SBD is achieved in paper[4][5]. These types of speed bump detecting systems perform better for speed bump that is constructed with appropriate height. The less heightened speed bump is not recognised using sensors method. In the paper[6][7][8], they used accelerometer and magnetometer to detect the speed bump since the axis component varies when they cross over the speed bump. When there is a speed bump, the z-axis various according to the speed bump height, but this method needs to collect the information about the speed bump and update it in GPS for further benefit similar to google maps. The tricky part is to collect the data for all possible route and update the same in a cloud server.

Software: In paper[9][10][11] with the help of smartphone and accelerometer the variation caused due to speed bump are stored earlier in database and informed to thedriver when the car is getting closer.Using the inbuilt sensor in a smartphone,Wolverine[12] monitor the traffic and detect the bumps without any restriction to the orientation of the mobile phone. Their erroneous rate is 10% concerning bump detection. Nericell[13]to monitor road condition uses mobile smartphone uses the embedded hardware and software application like microphone, accelerometer, GSM radio and GPS sensors. Thedownsides of using smartphone system arethe need for networking and the reduced accuracy ration because it is challenging to differentiate the vibration patterns ofa speed bump and normal road. Collecting information about speed bump and update same in GPS. GPS sometimes fail or send some garbage, benign events, overloading the network for the whole running time and running out battery due to frequent usage of the smartphone.

Embedded: An image processing approach using a monocular IR camera to detect obstacles in the road was proposed [14]. Shadows Cancellation is the dominant motive of this work and worked on Open Source Computer Vision (OpenCV).Bahena,projected a procedureusing discrepancy, structural operation, Border and edge detection to detect the presence of speed bump in the work [15]. All this image processing methodology consider only the marking speed bump. Theresearch area left open is detection of unmarked speed bump detectionwhich is a very common in Indian roads.

Speed Bump Detection:

The flow of the proposed method is sectioned into**i)** Preprocessing **ii)** Gaussian filtering **iii)** Canny edge Detection **iv)** Hough Transform, as shown in Figure 1.

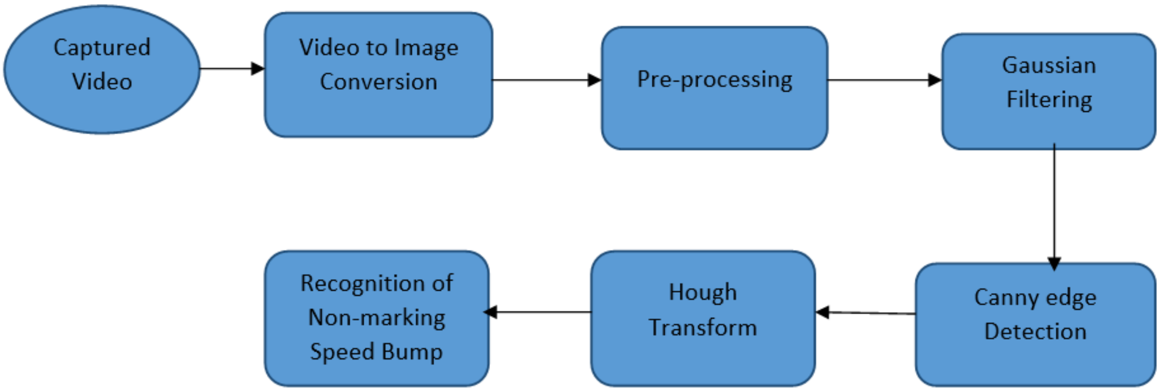


Figure1. Flowchart of the Unmarked speed bump

Video to Image Conversion: The captured videos in the aviform are converted to a jpeg image file. The counts of frames are varied from the size from 10 to 50 with a step of 5.Among them, frame count at 25 givesa better result. The images are resizing to a standard size for secure computation and analysis[16].

Figure 2. a) Input RGB Image **b) Grayscale Image**

(i) Preprocessing:

It includes two stagesresizing the input image and converting RGB to a grayscale image. Themotto of resizing is to reduce the computational burden. Here we resize various Image size to common size of 140* 320. After resizing the acquired image in RGB format, is converted into a grayscale image. It can be straightforwardly converted by using the following Equation 1 to find the intensity value instead of RGBas shown in equation 1,

$$I = 0.29\times R1 + 0.58\times G1 + 0.11\times B1 \qquad (1)$$

I is an image intensity values ranging from 0-255, where R1, G1 and B1 are the Redcomponent, Greencomponent,Blue component, respectively. The result of Preprocessing is shown in Figure 2.

(ii) Gaussian Low pass filtering:

Gaussian filter is a low pass filter that smooth or blur the image. The Gaussian filtering method is the most efficient and widely used filtering algorithms in image processing[17]as given in Equation 2. The speciality of Gauss function is it never reach value zero, and also it is an asymmetric function.

$$G(a,b) = \frac{1}{2\pi\sigma^2} e^{-\left(\frac{a^2+b^2}{2\sigma^2}\right)} \qquad (2)$$

Where G is the Gaussian function at the coordinate's location a and b, σ is the parameter which defines the standard deviation of the Gaussian. Figure 3 showcase the output image after Gaussian filtering. The performance of the system gives a better result forstandard deviation 2. The amount of standard deviation and kernel matrix is assumed larger, that result in better image smoothing.

iii) Canny Edge Detection: The world-famous and efficient edge detection algorithmsarecanny edge detection[18].The algorithm for canny edge detectionincludes four steps.

1. Though we applied Gaussian filter earlier still some of the noise is present in the image so once again apply a Gaussian filter with different kernel matrix for better noise removal.

2. Using FDA (Finite-Difference Approximations) calculate the partial derivatives of magnitude and direction,as shown in Equation (3).

3. Gradient magnitude is then applied to non-maxima suppression.

4. Hysteresis Edge tracking: Finally, the edges are shaped by keeping all sharp edges and removing all edges that are not associated with a solid edge. To detect and link edges in a better way, we use double thresholding. Figure 4. shows the output of canny edge detection. In general, for all applications, canny edge detection results better than any other methods like Sobel, Prewitt and Robert. Perfect edge detection, well localisation and low spurious response are the characteristics of Canny edge detection

$$G = \sqrt{G_x^2 + G_y^2} \qquad \Theta = a\,tan\,2\,(G_y, G_x) \qquad (3)$$

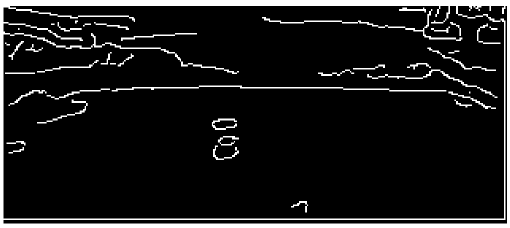


Figure 3. Gaussian filtering output Figure 4. Canny Edge Output

(iv) Hough Transform:

Hough transform is a simple and power method to detect the line, circle and ellipse for automated analysis of digital images.In image analysis, missing of pixels online or edges leads to noisy edge point that result in failures. Hough transform algorithm is one of the solutions to the problem stated. To fix the missing pixel, performedge points grouping and definite procedure over a set of parameterised image object.The image in the spatial domain(x,y) is transformed into another field related to $(\rho\ ,\theta)$.

In general, Lines can be represented uniquely by two parameters m and c as given in Equation 4.

$$y = mx + c \qquad (4)$$

Transform the spatial domain data to the polar domain to represent the lines in terms of θthe angle of the line and the length of the line from origin as ρ as given in Equation 5.

$$\rho = x.cos\theta + y.sin\theta \qquad (5)$$

1. In the image, the high frequency component (edges) are detected using Canny edge detection method.

2. Using relevant quantization level, Quantize thespace into a 2-Dimensional matrix H.

3. Setinitially the H matrix H, as zero.

4. If the point is relevant to the edges then assign it as one. Th straight line in the image are represented a as frequency component in histogram.

5. The important elements are retained by choosing an appropriate threshold value. These elements referred as lines in the original image the same is represented in Figure 5. The final speed bump detection output is shown in Figure 6.

The (ρ, θ) plane is also called as Hough space.

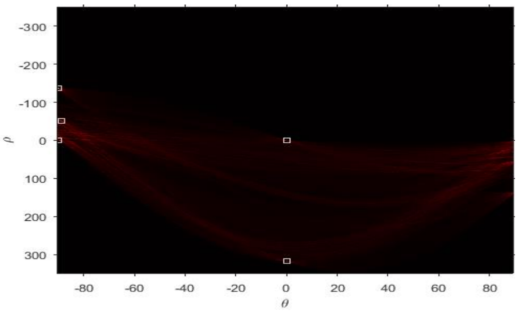


Figure 5. Hough transform output

Figure 6. Final output

Performance Evaluation

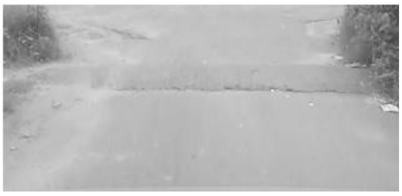
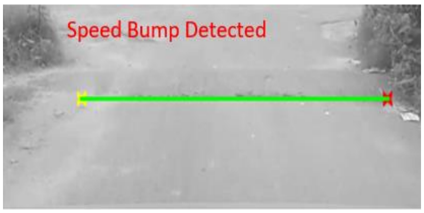
The image of unmarked Speedbump iscollected using a Raspberry pi camera across the roads of India.There is no standard database for this specific category speed bump because this type is not a legal one as per Road and Transport. In Indian, especially in a rural area, this speed bump isstandard. The database contains1385 Image.The research work is implemented in MATLAB 2018 on Intel Pentium 3 core. The images are captured at various illumination condition like early morning, at noon and in the evening. They are classified into 4type's namely i) smooth ii) medium smooth iii) sharp iv) No speed bump. Here we made the classification based on the thickness of the speed bump. The thickness range of each type is specified in Table 1. The smooth type speed bumps have a fullcurved nature compare to the medium-soft speed bump. It gives a soft feeling during driving.

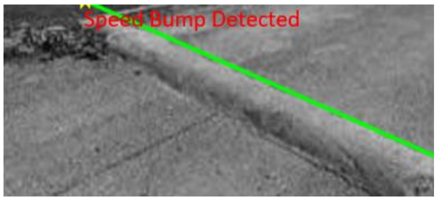
Table 1. Speed bump Vs Accuracy ratio

S.No	**Category**	**Width**	**Total Image**	**Correctly recognised**	**Accuracy**
1.	Smooth	81 to 120 cm	318	298	93.71%
2.	Medium Smooth	41 to 80 cm	267	251	94.0%
3.	Sharp	10 to 40 cm	284	275	96.83%
4.	No speed bump	0 to 9 cm	516	503	97.48%

The sharp types aremore dangerous one compare to the other two methods. Immediate notification of unmarked speed bump leads to fear the driver always. Table 2. shows the output ofthe grayscale image and correctly detected speed bumpconcerningthe different category. The speed bump is identified automatically and indicated in green line with an alert message “Speed Bump Detected”. Sometimes detection on no speed bump category fails due to the unsmooth nature and other disturbance on the road.In an average it provides 95.5% accuracy for all variety of speed bumps.

Table 2. Output for different category

Category	Grayscale Image	Output Image
Smooth		
		
		
Medium smooth		
		

Sharp		
		
No Speed Bump		
		

Conclusion:

Detection of unmarked speed bump isa quite challenging and mostessential component for DAS. The Gaussian filtering and canny edge detection are used to detect the bump transition position.Hough Transform play a vital role to remain the lines in the image. Among all line based on the location and length of the line, it is concluded as a speed bump. From the implementation,it is found that the overall accuracy rate is aroundmore than 95%. The future scope of the work is to increase the database size and implement the detection of non marking speed bump using the concepts like deep neural network.

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