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Image Processing-based Driver Assist and Monitoring System using OpenCV

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Abstract: ***The primary concern when it comes to the point of AI cars or vehicles is how it is going tackle the obstructions Infront of it. Secondary problem is about maintaining its position in a particular lane without deviating into another. This project helps AI cars achieve that ultimately resulting in a safe travelling or accident-free travelling from one place to another. This has been achieved using image processing techniques and with the help of OpenCV.***

Keywords: Canny, Sobel, Laplacian, ROI-Region of Interest, Dilation, erosion, Hough Transform, speed-breaker, lane lines

1. Introduction

At an average, 4% of the deaths worldwide are related to road related accidents. There is a high demand for road safety to prevent such casualties. There are hundreds of active projects to decrease this number and provide safety. Vehicles that won't start without putting on the helmet, speed limit warning are a few ideas that are being implemented into projects. Overall, every aspect of a vehicle is being made into something more to enhance safety during driving. One of the things that would provide safety and saves cost at the same time is an Artificially driven intelligence car. The major concern about an AI car or vehicle is how the vehicle would know, when to decrease or increase its speed. There wouldn't be much problem if all cars go in a steady speed straight from the starting to ending point. This is not a possible task cause the speed of the vehicles traveling in the same line or the lane near to the AI vehicle is not predictable. The obstructions on the road whether it may be a speed-breaker or a vehicle or a road damage are the things that should determine the speed of a vehicle. Based on this fact, the speed of the vehicle can be decreased or increased in real time. If a speed-breaker or an obstruction is detected, the vehicle should be suggested to decrease its speed. Similarly, if the road is bent and due to that the vehicle is deviating from lane then it should be suggested to stay in its lane.

2. Literature Survey

There are papers like accident prevention using sensors, image processing techniques previously published by different authors. The ones that have been useful are described here:

2.1 Edge Detection Methods: "Dr. Ahmed Mohamed Abushaala*"*

Edge detection is a fundamental tool used in most image processing applications to obtain information from the frames as a precursor step to feature extraction and an object segmentation. This process detects outlines of an object and boundaries between objects and the background in the image. In this project a few of the methods like Sobel and Canny technique are being used to detect the speed breakers on the road.

2.2 Vision based speed breaker detection for autonomous vehicle:

"Arvind C.S., Ritesh Mishra, Kumar Vishal, Venugopal Gundimeda"

In this paper, a robust and real-time, vision-based approach is used to detect speed breaker in urban environments for autonomous vehicle. The method used detects the speed breaker using visual inputs from a camera which is mounted on top of a vehicle. The method performed is inverse perspective mapping that is used to generate top view of the road and it segments out the region of interest based on difference of Gaussian and median filter images.

3. Methodology

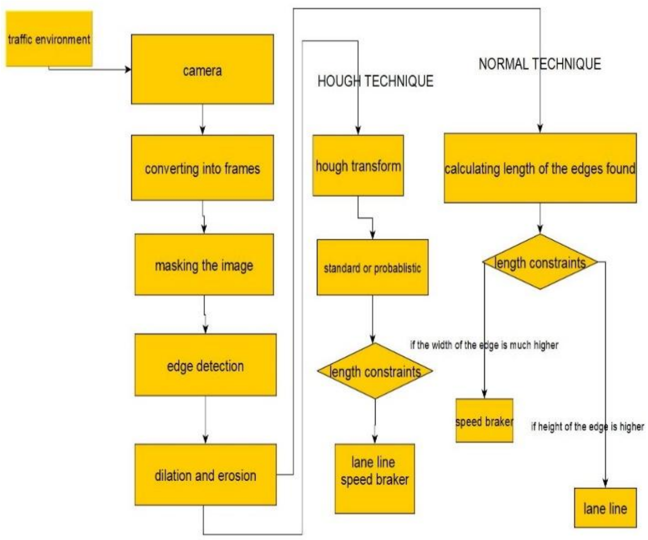

Figure 1: Flowchart of the system

Starting from a video as an input and detecting the speed-breakers, lane lines, obstructions etc.… A particular procedure has been followed as shown in the above figure. Firstly, an input video is converted into frames. This input video will be from the camera fixed onto an Auto-driving vehicle. Since a video is nothing but certain number of frames per second, working on a video is nothing but working on an image, i.e. operating and finalizing a frame before going onto another frame.

Considering the fact that each and every operation on a frame has only certain amount of time to operate and to provide results of the operation, computational load should be decreased. In order, to decrease computational load, the image should be operated only on the region of interest. For a vehicle travelling on the road, the ROI of the image would be road, lane in which the vehicle is travelling.

Edge detection techniques like Canny, Laplacian, Sobel are used to detect all the edges in the ROI. Morphological operations like Dilation, Erosion are used to enhance the edges. These processes are used to fill in the gaps between broken edges. Contours of the image are then detected i.e. the boundaries of the edges are detected to check with the length constraints.

Techniques like Hough transform are used further to find lane line or speed-breaker depending on different length and width constraints to classify them. The message are displayed on the video itself whenever a speed-breaker, lane-line deviation is occurred. This message should be on the top of the image i.e. outside the ROI for the better understanding of video.

If at least one of the obstructions like speed-breaker is not detected then this may lead to damage or accidents on the vehicle. Even if one speed-beaker is not detected it is a big problem but even if a speed-breaker is detected without an obstruction present on road is fine, because it just results in a warning message to decrease the speed. So, all True positive are acceptable and a significant amount of False negative too, but all True negative results are dangerous.

4. Working

4.1 Reading Input Video

Input video will be read from a camera present on the vehicle. The orientation of the camera should be in such a position that the road in which it is travelling should be in the lower half of the video.

Figure 2: A frame from the video recorded.

4.2 Masking the image

Obtain the region of the interest part of the image which in this case is the road the vehicle is travelling in. The region of interest would be a pentagon starting from the point (0, height) i.e. left bottom corner, (0, height*4/5), middle point of the image (width/2, height/2), (width, height*4/5) and ending at bottom right corner of the image.

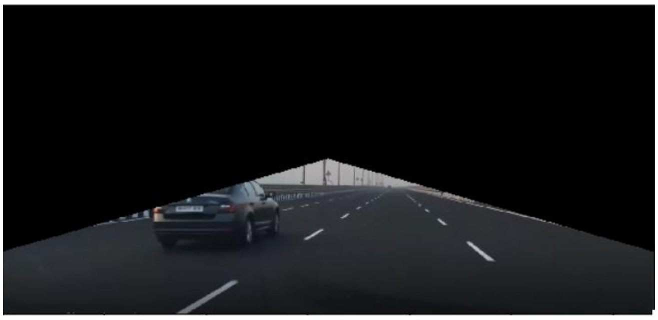

Figure 3: The ROI of the image

4.3 Edge detection

Using edge detection techniques canny, Laplacian, Sobel all the edges in an image are found. All results from each technique are combined with co-efficients of particular technique ranging from 0 to 1.

4.4 Morphological operations

Morphological operations are important in filling the gaps between broken edges and removing thin strands of the images. Therefore, it is quite important to perform this operation because of the breakage in edges due to ups and downs or obstructions present on the road

Figure 4: After edge detection and morphological operations on ROI

4.5 Hough Transform

Using Hough transform broken lines can be further filled. With the help of Hough transform it is easy to match the lines with same slope and same y-intercept. This is possible by converting lines in XY plane to Hough plane. By matching lines with same slopes and same y-intercept with minimum amount of gap and length, all broken lines can be manufactured. The edge belongs to the boundary of the ROI should be neglected.

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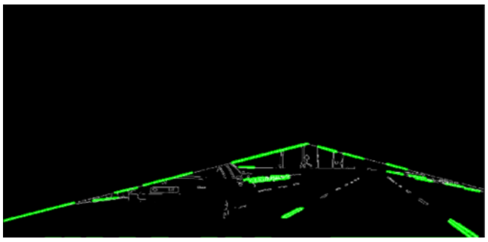

Figure 5: After detection of Hough Transform

4.6 Image finalization

Drawing the lines on edge detected on the initial frame would make things clear and provides better understanding of the image. Length constraints are added to detect only speed-breaker and lane-lines.

5. Equations and theory Involved

The Hough transform technique plays an important role in matching all edges with same slope and Y-intercept. A line in a cartesian plane can be represented as a point in Hough Plane or M-C plane cause x and y variables in Hough plane are slope and Y-intercept. In XY plane a line is represented as $Y=m*X+c$ (1)
where m is slope and c is Y-intercept

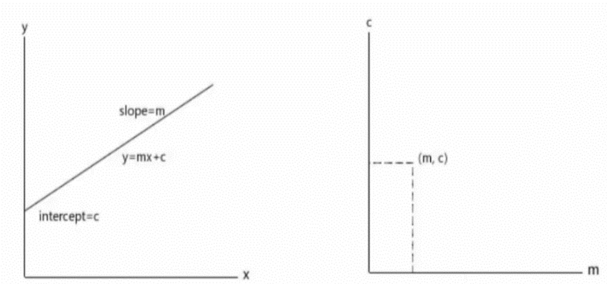

Figure 6: Representing a line in cartesian plane and a point in Hough Plane

Conversely, a point in an XY-plane can be represented as a line in Hough plane. Equation (1) can also be represented as

$$c=-X*m+Y \quad (2)$$

Therefore, a point (Xa, Ya) in XY-plane corresponds to a line can be represented as (3) in Hough Plane.

$$c=-Xa*m+Ya \quad (3)$$

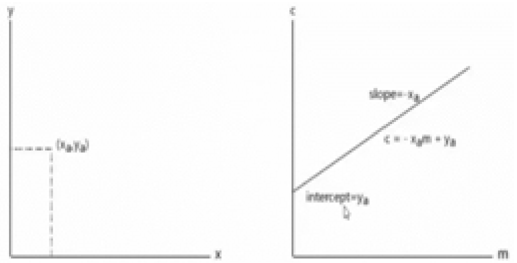

Figure 7: Representing a point in cartesian plane and line in Hough Plane

When each and every point of an edge is Hough Transformed then all lines with same slope and y-intercept can be found.

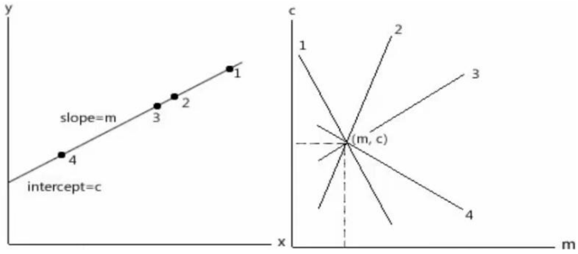

Figure 8: Representing points in an XY-plane contributing to an equivalent line affter Hough Transform

6. Algorithm

6.1 Classification of edges

I. Read the frames from the video
II. Perform edge detection technique on the ROI
III. Apply Hough transform on the image allowing a min gap between broken lines
IV. Check the length and width of the result after applying Hough Transform.
V. If difference between the end x-co-ordinates of an edge is almost equal to half of the image width and difference between Y-co-ordinates is negligible, then that particular edge is a Speed-Breaker
VI. If difference between the end y-co-ordinates of an edge is equal or greater than one tenth of the image height and difference between X-co-ordinates is negligible, then that particular edge is a Speed-Breaker
VII. If the difference between both end X-co-ordinates and Y-co-ordinates is less and doesn't meet the above criteria, then it is a normal obstruction.
VIII. Go to step I

6.2 Lane Deviation

I. Read the frame
II. Perform edge detection technique on the ROI
III. Apply Hough transform on the image allowing a min gap between broken lines
IV. Check the length and width of the result after applying Hough Transform.
V. If the difference between the end y-co-ordinates of an edge is equal or greater than one tenth of the image height and difference between X-co-ordinates is negligible, then that particular edge is a Speed-Breaker
VI. If the lane is detected at the halfway of the road, i.e. there is a deviation from one line to another
VII. Print the lane deviation message
VIII. Go to step I

7. Result and Discussion

Results after following the provided methodology assured zero cases of True Negative. This is one of the main goals to reduce the amount of True Negative because if any kind of obstruction is not detected even though it is present on the road will lead to accidents. Following are the result at some particular instances detecting speed-breaker and lane lines.

Figure 9: Showing the speed breakers getting detected

Figure 10: Showing the speed breakers getting detected

Figure 11: Showing the monitoring of lane-lines

Lane deviation message is also delivered whenever the vehicle is deviating from the line. This can be said from the fact that the lane lines are at the middle of the image. Hence, if the lane is at the middle then there can be a possible lane deviation.

Figure 11: Depicting lane deviation

8. Other recommendations

With the help of this paper, the basic needs of an AI-driven car can be fulfilled. Detection of speed-breaker, monitoring of lanes and detection of possible lane deviation is achieved. There are lot more that can be attached to this project to turn this into a full-fledged AI car like detection of sign-boards will also become a key factor. If a sign-board can be detected in real-time parameters then it is possible for the vehicle to follow traffic rules, conditions, traffic environments, nearest petrol stations etc...

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