EFFICIENT IMAGE PROCESSING TECHNIQUE FOR LANE DETECTION IN AUTONOMOUS VEHICLE

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Abstract: Autonomous vehicle is a driverless car which can guide itself without the help of human contact. This advanced technology is finding its relevant place in today's international market. Lane detection, lane marker tracking, advanced image processing, GPS tracking are few research areas in this domain. This paper concentrates on Lane detection and lane marking. Multiple images are captured and processed periodically using an advanced camera placed on top of the vehicle. Each of these photos are processed and data is simulated. First, ROI (Region of Interest) is calculated in order to increase the processing speed and to reduce complexity in its procedure. Proper filtering techniques are carried out to reduce the noise that can superimpose with image quality. This is followed by binary conversion and relevant edge detection technique. Hough Transform is used to extract lines from image. Increase in the threshold value of Hough transform increases the possibility to map lanes accurately. A proper colouring method is used to improve the visibility of lane and thus helps the autonomous vehicle to follow its path through mapped lanes. The analysis shows that this algorithm produces effective results as compared to that of the existing algorithms.

1. INTRODUCTION:

Nowadays, with an increase in the population, there is an exponential growth in the demands for vehicles. But this demand has often been a headache for most of the traffic control rooms. Moreover, the world is witnessing approximately 35,000 accidents on a daily basis. This is a big tread for upcoming future generation. The introduction of a self-driving car which can simulate and act efficiently with improved decision-making skills and strategies can be a proper solution for this raising traffic issues.

An autonomous vehicle is a self-driving robot that uses a variety of sensors and image processing techniques to make decisions according to a predefined database. Multiple sensors are incorporated together using an ECU which controls both the electrical and mechanical parts of the vehicle. Hundreds of research topics are carried out related to this modern technology. Sensor technology, image processing, object detection, collision avoidance, lane detection, battery management are different fields in this domain. This paper concentrates on lane detection. Most of the roads including highways and service roads have a proper lane marking system. An autonomous vehicle is programmed to follow these lanes. This is followed by a proper GPS system to navigate its destination.

The introduction of ADAS (Advanced driver assistance system) has led to an additional safety measure while driving. ADAS helps in assisting driver under various circumstances. Lane centering and departure, cruise control, motion detection are various applications performed by ADAS. Advanced image processing algorithms are used in order to actively map lane under different circumstances. Advanced driver assistance system is not just dealing with the lane departure warning and collision avoidance. It is more of an integrated work performed by different parts of the vehicle. It deals with advanced image processing techniques which are combined with different sensors and GPS modules. Adaptive cruise control, adaptive light control, automatic braking system, blind spot detection, automatic parking system and, driver drowsiness detection gets add up to the list. Most advanced ADAS applications seem a little more esoteric.

A high definition camera is placed on top of the car which captures images (often a live video) of the road. These camera is capable of capturing multiple number of images in few second. The idea is to process and simulate results individually to each of these images. Processing speed has to be high in order to reduce the delay between this operations.

A number of papers have already been published which actually maps lane from a captured image. But most of the techniques are finding difficulties in order to remove the superimposed noise which reduces image quality. Many techniques are used to properly mark lanes, but these techniques often fail during different weather conditions. Researchers have found that different algorithms are required for proper lane mapping under different weather conditions. This has led to the discovery of a variety of algorithms which helps to provide driver with proper lane departure guidelines.

This paper concentrates on a well-defined algorithm for lane detection and mapping during a sunny day. This algorithm helps in reducing the noise interference that can superimpose with the image quality. Noise can be any sort of error or a pixel that can cause practical problems for mapping lanes from a real image. Noise gets multiplied during each step of any algorithm and hence it is very important to completely remove the noise before performing any advanced transform on to the image.

2. Algorithm description

This algorithm is directly applied on to the captured image. The image captured from the camera is processed by various image processing techniques which improve the image quality.

Figure 1 shows the proposed algorithm flow chart.

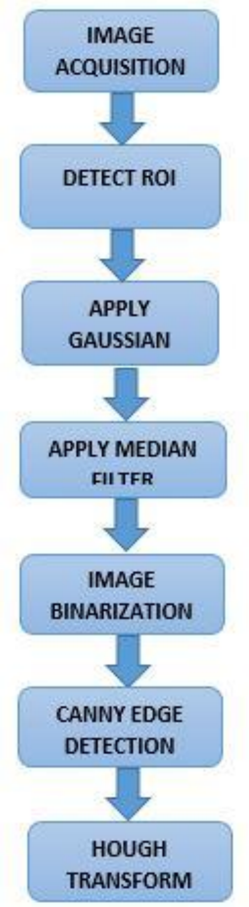

Fig1: Flow chart of the algorithm

2.1 Image Acquisition:

Image acquisition deals with capturing image of road lanes from the camera. The camera is the eye of an autonomous vehicle. The captured image can have high level of pixel errors and noise. This Image acquisition deals with capturing an image of road lanes from the camera. The camera is the eye of an autonomous vehicle. The captured image can have a high level of pixel errors and noise. These noises can adversely affect the system. Therefore, advanced image processing techniques are applied on to this image for further noise cancellation.

Fig2: Captured image

2.2 ROI (Region of interest)

Region of interest highly determines the processing speed of the system. A captured image can be a combination of both useful and junk data. For lane detection and tracking, the part of the image which has the got the pixel combination indicating lanes of a road are the useful data. The rest has to be cropped out from the original image. A properly selected region of interest increases the processing speed. Processing speed is a crucial parameter which highly determines the efficiency of the system. These areas are not permanently cropped out. They can vary with application to application.

Fig3: ROI image

2.3 Greyscale conversion:

Greyscale image is a combination of grey shades that define the whole intensity of an image. Colour changes from black to white depending upon the intensity level, where black represents the lowest intensity and white represents the highest intensity level. Grey scale image conversion is necessary before applying any sort of image filtering mask on the image. A series of image processing techniques are used on the greyscale image in order to improve the visibility of the lane.

Equation 1 represents the formula that has to be applied on to an RGB image to convert it to a greyscale image.

$P(x,y) = 0.21R(x,y) + 0.72G(x,y) + 0.07B(x,y)$

Where,

R = Red component of the image

G = Green component of the image

B = Blue component of the image

Fig4: Greyscale image

2.4 Gaussian Filter:

After converting an RGB image into a greyscale image, certain filters can be applied in order to improve image quality. A Gaussian filter is a filter whose impulse response is a Gaussian function. It reduces the image sharpening, which is very important for specific noise filtering application. A Gaussian filter increases the smoothness of an image depending upon the given threshold value. Fourier transform of a Gaussian filter is another Gaussian and thus it helps in reducing an image's higher frequency component. This makes Gaussian filter a low pass filter.

High-frequency components in the captured image can often interfere in the edge detection process. Therefore selective filtering is required in order to blur the unwanted region of the image. Basic blurring operations are carried out by this filter within the range of given threshold value.

Equation 2 represents the function for a Gaussian blur filter.

$$g(x,y) = \frac{1}{2\pi\sigma^2} \cdot e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (1)$$

Where, σ is the standard deviation of the distribution.

Fig5: Gaussian filter

2.5 Median filter

A median filter is used to remove noise within the image. This is a widely used filter which is used before a particular image processing operation. This helps in reducing noise but the same time preserves the edges of the image. Thus, this filtering mask is used before any of the edge detection techniques.

Median filter calculated the median value from the neighbouring pixels and replaces itself with the calculated result. This helps in reducing the pixel complexity. Passing on the calculated median values of neighbouring pixels helps in deleting the unwanted pixels from an image. This filter is a frequently used processing mask due to its less complexity and relatively high processing speed.

Fig6: Median filter

2.6 Image Binarization

A two-dimensional image can have a number of different pixels values. Applying an edge detection technique on such a two-dimensional image can create simulation errors and often reduces output efficiency. Therefore, converting all the pixel values in to ones and zeros depending upon a minimum and maximum threshold value often helps in reducing the output errors. Such an operation is carried out with the help of image binarization.

Binary images are often called are two level image. A grey scale image can be converted into a binary image by specifying the desired threshold value. Often histogram equalization is carried out to determine the threshold value. But here we don't use the histogram equalization method to calculate the threshold value. A common threshold value of 0.8 is used for further procedures. For most of the cases, this threshold value has proven to be efficient. Figure (a) and (b) represents the binary image above and below the given threshold value.

(a) Binary image with threshold less than 0.8

(b) Binary image with threshold greater than 0.8

(c) Binary image with threshold 0.8

Fig7: Binary image at different threshold value.

2.6 Edge detection

Edge detection is an advanced image processing technique which locates the edges of a given image. Edge detection frames the most important concept in lane detection and tracking. Initial filtering of images helps in increasing the image quality by reducing noise interference while Edge detection uses this filtered image to obtain the output.

There are a number of edge detection techniques available. Most of the techniques are simple and effective. Use of a particular detection technique can vary according to the climatic conditions of a day. Here, I have used Canny edge detection technique.

Canny edge detection is used to detect a wide range of edges in an image. This detection technique has proven to be the most appropriate technique for this research topic. Among the different edge detection techniques, Canny edge detection has shown its reliability for accurate output. The threshold setting is properly assigned in order to get proper output.

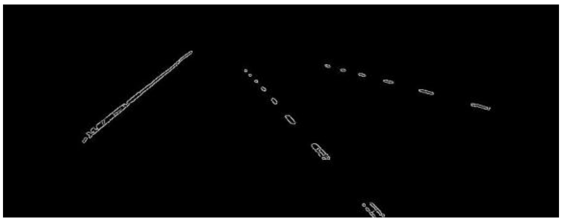

Fig8: Canny edge detection

The algorithm tracks the edges of the binary image and hence results in a proper boundary tracking. This algorithm has proven to be more precise and accurate than any of the other edge detection techniques. Increase in the threshold value of canny edge detection can often result in reduced operating speed. A proper GPU with sufficient technology will solve the problem. Processing speed is of less concern for this algorithm since the simulated result can be obtained less than a few seconds. Canny edge detection has an improved processing capability than any other techniques. The processor should be able to segregate the pixel values properly from a binary image so as to obtain the desired output. Edge detection can work properly only if an understandable binary image is obtained.

2.7 Lane tracking by Hough Transform

After obtaining the edge detected image, we have to map and mark the lanes. This can be done with the help of Hough transform. A traditional Hough transform method is used to analyze the lanes as a straight line.
Hough transform works on a basic principle that defines a straight line cross point (x, y) as,

$$y = px + q \qquad (2)$$

The parameters p and q stands for slope and intercept respectively. That is, if the values of the parameters are known, then the coordinates can be determined.
Equation 2 represents the basis for performing Hough Transform.

$$r = x \cos \theta + y \sin \theta \qquad (3)$$

Where r is the length of a normal from the origin to the line and theta is the orientation of r with respect to the X-axis.
From lane detection algorithm we consider a few points which are part of lane markings. Using Hough transform we generate line through these points. It connects points in the 2-dimensional polar coordinates of r and theta. From this, it generates multiple lines from each point. After this it finds out that particular value of r and theta for which the two points intersects each other and these points becomes a common interest to all the lines generated. This results in the generation of a straight line.

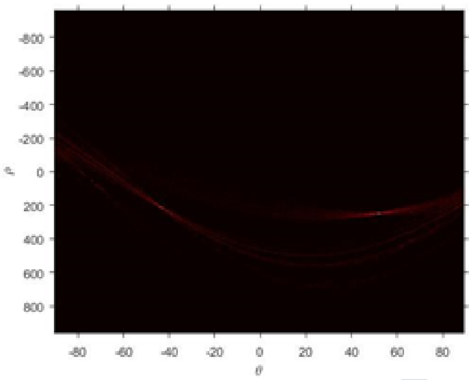

Fig9: Hough matrix of the image

Hough transform is further modified under certain conditions in order to obtain proper results. Horizontal lines cannot represent lanes and hence they are not considered. Algorithm stresses on vertical lines so as to reduce unnecessary processing which results in improved operational speed.

Fig10: Hough Transform output.

9. Result and analysis

In order to prove the algorithm, simulations were conducted in Matlab. Images of different roads were captured and simulations were carried out for the same. Experimental results show that the algorithm is capable of withstanding a minimum possible noise interference of the images.

Figure shows the simulation results. View of the lanes from different angles are considered for the simulation. This also includes the bird's eye view.

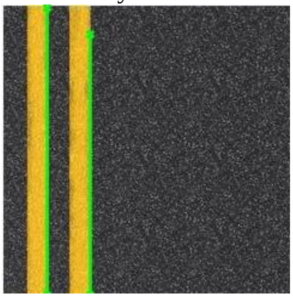

Fig10: Result during day time

Quality of the output image depends upon the input captured image. Therefore, detecting lanes at night can be a great challenge as the captured image may contain a lot of noise from the headlight of the opposite vehicle. This can often become a big issue where the roads may not be processed properly. But this algorithm even stands good for night images.

(a)

(b)

(c)

Fig11: Output at night

10. Conclusion:

Presented in this paper is an effective algorithm for lane detection. This algorithm consists of detecting ROI which helps in increasing the processing speed of the system. Greyscale conversion of the image followed by Gaussian and Median filtering helps in reducing the noise in the image. Binary conversion along with Canny Edge Detection helps in detecting lane boundaries. Finally, Hough transform helps in detecting and mapping lines in an image which represents lanes of the road.
Therefore, it is concluded that the algorithm is able to provide a fast and efficient procedures in order to provide a proper lane mapping system.

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