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Lane Detection for a Vehicle Using Computer Vision

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Abstract: ***Lane detection is a key feature of autonomous and intelligent driving systems. It is one which helps position the vehicle and gives it an idea regarding its movement in real time. A robust lane detection system is extremely necessary given how sensitive environment conditions such as sudden changes in illumination or absence of lane markings etc. on the road can lead to failure of the software. Furthermore, advancements in lane detection systems can help diminish long standing problems such as driver fatigue, distractions during driving, unsafe lane changing etc. and make road traveling by vehicles considerably safer with the intervention of computers onboard vehicles. Lane detection is a key hurdle which is delaying the progress from semi-autonomous vehicles to completely autonomous vehicles since flawed detection by software brings up severe safety concerns. To increase processing speed the software uses Canny Edge detection, selective oriented Gaussian filters and Hough Transform along with Matplotlib to process and accurately analyze the captured real time images of the top view of the road. Apart from images we have further made use of moving pictures (videos) as input to analyze the working and accuracy of the software in order to test its robustness for use in the real world, which is our final goal.***

Keywords: Autonomous Vehicle, Deep Learning, Canny Edge Detection, Hough Transform, Computer Vision

1. Introduction

In recent years, lane detection systems have aroused great interest from both academia and industry where A machine vision-based system is used for lane detection. Primarily due to its safety aspect where it can assist drivers in the perception of any dangerous situations before, to avoid accidents. Traffic accidents often occur due to negligence of the driver, such accidents can be avoided if detected early and warned to other drivers. A lane detection system is a machine vision-based system that plays an important role in capturing the surroundings, including the road surface and object. The markings on a lane are used to keep the vehicles in a particular lane. A lane is a white marking which is composed of left and right lane markings, these white markings are captured using a camera which is mounted in front of the car. The representation of these white markings is dependent on many factors including luminance, weather, and traffic conditions. To reduce the dependency on such factors various preprocessing and feature extraction methods have been used, the characteristics of lane markings like color, edge and geometry is pre-processed using a specific road surface. This paper talks about how computer vision and canny edge detection is used to accurately detect the lane demarcations on a specific road surface.

1.1 Description

Our lane detection method is to extract straight lines on the road using the Hough transform. Then use the constraint information to extract the trajectory. Finally, the frame-to-frame information is used for lane tracking to achieve real-time and stable lane detection.

Sky and road area awareness is a key component of lane awareness. For this concept, there is a lot of scene information that can be used to narrow the range of possible targets. Among them, identification of airspace and street area are two important aspects. To identify the road area, we use the lane information and extract the edges using the canny operator. Region growing is then done from the bottom of the image. The basic idea of sky detection is to distinguish between sky and non-sky areas with different gray values (in general, sky areas have higher gray values)

1.2 Problem Formulation

Drivers, as well as pedestrians, can receive support and specific information from lane detection systems. By giving some sort of indicators, such systems can enable drivers to travel securely and assist them with staying in their specific lane. During scenarios which involve sudden change in the structure of the markings on the road such as distortion or change in illumination, the cameras and sensors used will still be able to identify the designated lane for the vehicle. Lane detection efficiently helps in reducing the traffic congestion as the system completely works according to the road traffic sense. According to a study published by WHO, 1.35 million human deaths were brought on by injuries sustained in motor vehicle accidents. This number could be somewhat reduced by autonomous vehicles. The widespread use of driverless vehicles could potentially reduce traffic accidents by 90%, according to a 2015 McKinsey analysis.

1.3 Scope of the Project

Detecting lanes by only using the lane marking is a huge challenge currently faced by autonomous driving vehicles.

This challenge is one of the many challenges that plague the transition from semi-autonomous driver assistance systems to fully autonomous driving systems. The lane detection using canny edge and Hough transform intends to provide the autonomous vehicles with the required data with which they can detect the lane markings and follow lane discipline as mandated by the law. The proposed system does not need any sort of huge dataset. This system will also help the autonomous driving systems to be much safer to the vehicles and pedestrians around them. This system helps to reach one step closer to the idea of fully autonomous driving systems on the road.

2. Review of Literature

A literature review aids us in understanding how people before us have tackled the same problems or it helps us gauge how people assessed problems which were unique and were being solved the first time. It helps us identify a template to perform scientific inquiry in a systematic and efficient manner and ensures effective utilization of resources. While reviewing all the papers we found that most people have employed OpenCV and Canny Edge Detection to solve the problem of lane detection and edge/boundary detection, which led us to use the same tools as well.

In [1], the authors have used performance measuring parameters like Receiver Operating Characteristic Curve (ROC curve) and Detection Error Trade-off Curve (DET curve) for measuring the performance and accuracy of the computer vision methods. According to these, when the curve is plotted for two methods, the method that corresponds to a large area under the curve is more accurate. The two methods under consideration were Canny edge detection and Sobel Operator. In this method, the program is being run on a large set of input data whose correct outputs are known and counting the number of cases in which the program produces correct and incorrect results. There are four possible results, True Positive (TP), True Negative (TN), False Negative (FN), False Positive (FP)

Then they used a confusion matrix to find FP, FN, TP, TN and based on confusion matrix FP rate, FN rate, TP rate, TN rates have been found out. Then using MATLAB, the DET and ROC curves have been plotted based on a confusion matrix. The performance of both the methods was compared. Two different colors were used, the green for Canny and blue for Sobel method. It was found out that (green curve) based Canny edge detection was better than (blue curve) Sobel Operator, it's performance when plotted had a larger area under the curve as compared to for Sobel Operator.

In [2], this article introduces a reliable real-time lane detection and tracking system. Reduce your region of interest (ROI) with lane detection and road and sky area detection. The detection method is tested using real images and compared with basic object detection. The entire system is also tested using real video and compared to the base system.

In [3], a parameterized region of interest (ROI) is determined based on the distribution of road markings in the area close to the vehicle. ROI lane marking is improved by increasing pixel intensity for detection in different environmental conditions. Generally, the characteristics of lane markings include colour, edge, and geometry, and each feature is pre-processed using a specific method. The colour distribution is to identify the road surface. Transferring an image into the hue saturation intensity (HSI) colour space and using a threshold to extract the lane markings, overcoming the weakness of coloured images where the same colour varies in different luminance conditions. New colors are used to replace the RGB color space. This color space was used to analyze the distribution of lane markings and pavements, and a Gaussian distribution was used to determine the color of the lane markings. Then, the RGB weighting method was experimentally determined to increase the contrast between the lane markings and the road surface. The Edge Canny filter is used to define the display of tracks at the edges. After finding the pixels associated with the track cue, the next step is to use these extracted pixels to identify the track cue.

In [4], they have used methods such as image warping, thresholding, pixel summation and sliding window algorithm to meet the shortcomings of Lane detection, which is to give inaccurate results insituations where in the lane markings are not clearly visible or worn out. In Approach 1, they used the entire road pixels for lane detection using three methods, Thresholding which will convert the image into a binary image i.e. the area where the color of the path is detected will be white and the rest of the part of that image will be kept black, then Image warping is used to get a birds eye / top view of the path by changing the perspective of the image and then Pixel Summation which is used to find the curve of the path, summation of pixels. In Approach 2, they have used the edges of the path for lane detection, the initial steps remain same, then Gaussian Blurring is used to smoothen out the imperfections by applying a blur function to the image, thus the uneven edges get smoothened out as the pixels don't have a too sharp change in their values after blurring. The next step is to extract the lane boundaries from the thresholded binary image using Canny Edge Detection which uses a multi-stage algorithm to detect edges in images by identifying large changes in gradients of the pixels, next is to use Image Dilation which makes the edges clearer and more filled with less breaks. Dilation expands the image pixels and adds pixels to object boundaries; finally Sliding Window Algorithm is used to detect the position where the edges are present in the processed image. Approach 2 is more accurate than Approach 1 since it uses the edge geometry to give a precise value of the lane position

In [5], the author has addressed techniques to counter challenging problems in the field of lane detection using computer vision. These problems include scenarios such as a lane curvature, worn lane markings, lane changes, and emerging, ending, merging, and splitting lanes. The author used an algorithm based on RANSAC combined with a tracking algorithm to bring about their solution.

In [6], the author has used various images of urban settings to check the accuracy and robustness of their software. The computer vision model is put to test against various changing environmental factors in an urban setting such as changes in lighting, parked and moving vehicles, bad quality lines, shadows cast from trees, buildings and other vehicles, sharper curves, irregular/strange lane shapes, emerging and merging lanes, sun glare, writings, and other markings on the road. The proposed solution of using Gaussian filters was insightful and presented us with a possible solution for our problem and made us aware of factors to consider while programming the software.

3. Proposed Solution

The system proposed is a one which uses algorithms such as canny edge detection and Hough transform to detect various edges present in the input image frame. After recognition of these edges, the system concludes them to be marked lanes on the road and shows edges by highlighting them to the user. This system can be implemented to help autonomous driving systems to understand lane markings better and improve the overall safety and lane discipline of these autonomous vehicles.

3.1 Architecture

Initially the user needs to input a video sequence to the system after a video sequence is detected then the system applies the canny edge detection algorithm. In this algorithm noise reduction, intensity gradient, non-maximum suppression and hysteresis thresholding are performed. The output from this stage is sent to triangular masking and from there it is sent to the Hough transform stage. Hough transform is used to identify the left and right lane boundaries; Finally the output video sequence with detected lanes is given to the user.

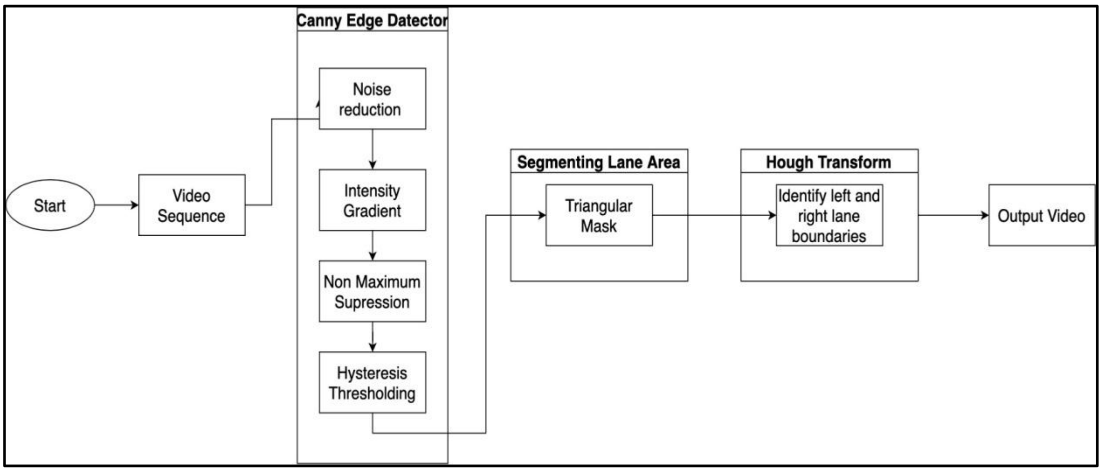

Figure 1: Architecture Diagram

3.2 Algorithm(s)

3.2.1 Canny Edge Detection: This algorithm is used to detect various edges that may be present in images. It uses a multistage algorithm approach to detect edges. Canny edge detector requires grey scale images as input to function and detect edges. Due to this reason, the input video frames must first be converted to grayscale before passing it onto the canny edge detector. The algorithm works in four stages. In stage one, a Gaussian Filter is applied to smooth the image in order to remove noise from the image. Then in stage two, the intensity gradient is computed followed by removal of spurious edge detection responses using non maximum suppression in stage three. Finally in stage four, hysteresis is used to track edges. The edges are finalized by suppressing all the weak edges that are not connected to any other stronger edges.

3.2.2 Hough Transform: It is an algorithm which is used to extract features. It has applications in analysis of images, computer vision and digital image processing fields. It uses a voting procedure to find imperfect occurrences of objects within a given class of shapes. The voting procedure is mainly performed in a parameter space out of which potential object candidates are taken a local maxima in an accumulator space which is a space constructed by the Hough transform algorithm. This algorithm is often used in tandem with an edge detecting algorithm. In this case, canny edge detection algorithm is used. The edge detecting algorithm is used for preprocessing of image after which the Hough transform algorithm is applied to detect final edges in the image frame.

4. Results and Discussion

4.1 Final Outputs Arranged Step by Step

The following sequence of figures depict a step-by-step representation of how each section of software processes the incoming data step by step, beginning from the camera until it produces the required output of successfully identifying the lane from the input image.

Figure 2 is a sample image captured by the camera mounted on the vehicle which will incorporate the autonomous technology which will be processed by the software.

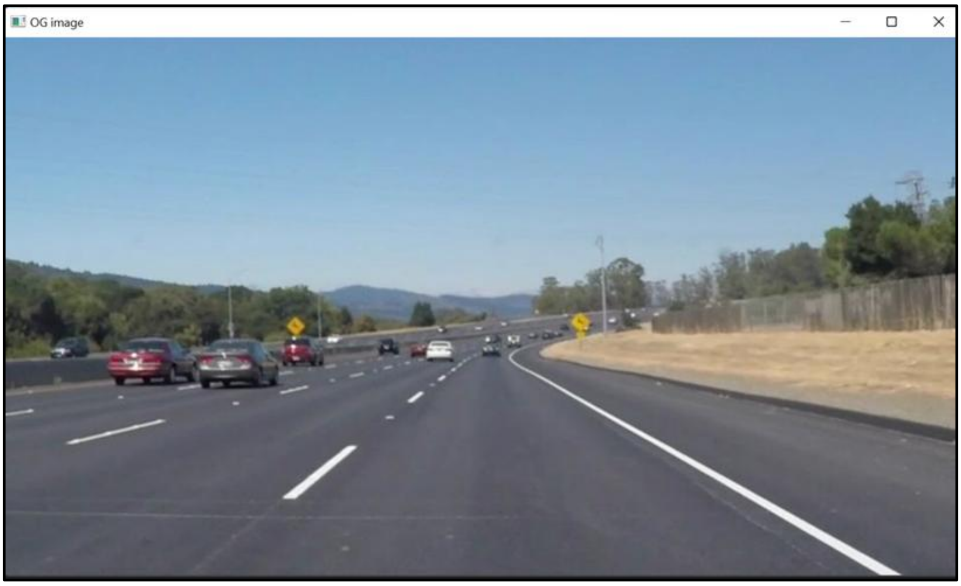

Figure 2: Input Image

Figure 3 depicts the output after the first stage of processing the image has taken place. This is the result of applying a Gaussian blur and the canny edge detector operator onto the greyscale of the input image. The desired outcome of detecting sharp shifts from white to black or vice-versa, to detect edges is achieved.

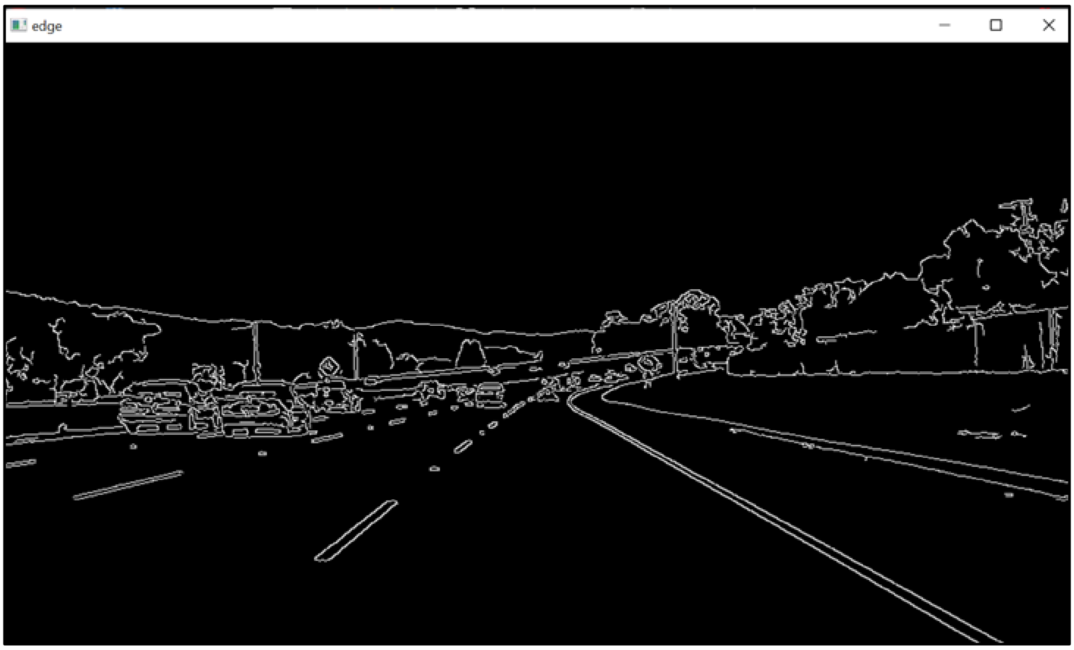

Figure 3: Creating a grayscale and applying Canny Edge Detector

Figure 4 depicts the isolated image obtained after we further process the image and extract dimensions of the lane lines using the numpy function to extract the lane lanes. This provides us with the desired region (which is triangular in geometry).

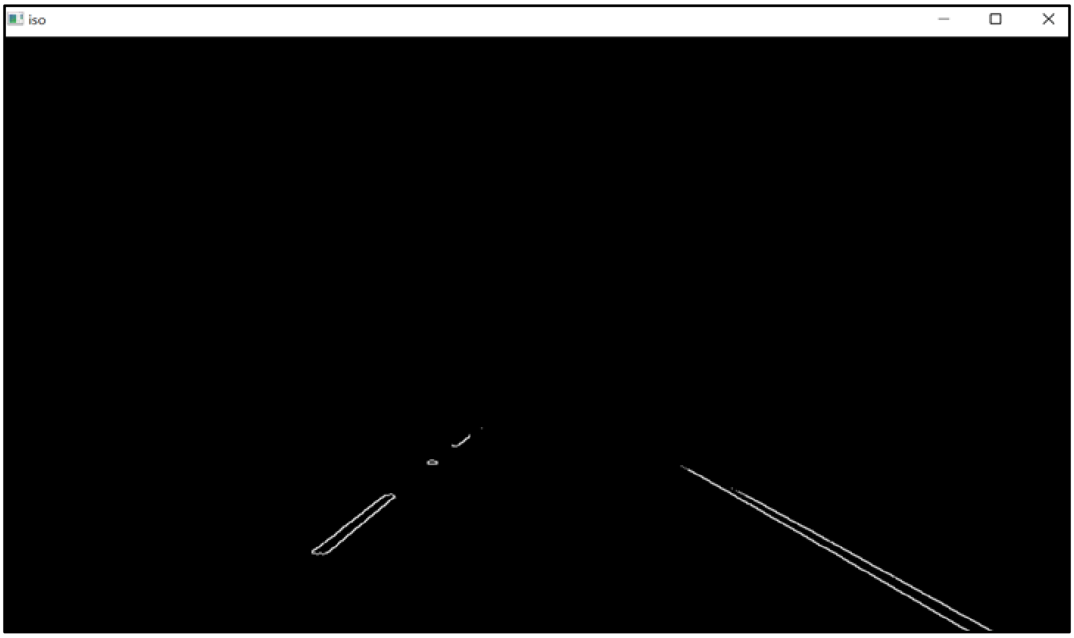

Figure 4: Output for isolated required region

Figure 5 is the final output which the software generates. It precisely identifies the lane lines and overlays them with guidelines generated by the code showing the desired result of successful lane detection.

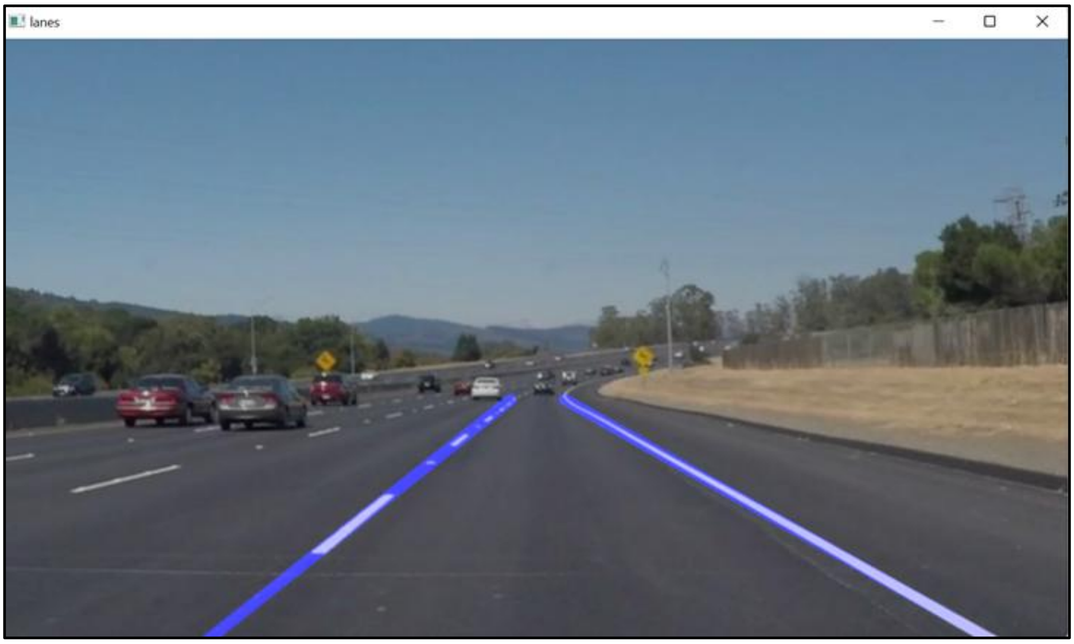

Figure 5: Final Output of Lane Detection

5. Conclusion and Future Scope

A system for detecting lanes was developed by intense research, designing and planning which can be utilized by autonomous driving systems to detect lanes and provide safer travel to the passengers in the vehicle and the pedestrians and vehicles near and around the autonomous vehicle. The system uses canny edge detection algorithm for preprocessing of image frame which is followed by the application of Hough transform algorithm to provide the user with the lanes highlighted for convenience.

The main advantage of this approach is that it requires no trained model to predict the lanes on the road. Rather it actively takes in the video frames as input and actively detects the edges in the frame which are then given back as lanes to the user. This is an advantage as no time is spent developing a dataset, training, and testing it. This system provides the user to quickly implement lane detection in their implementation of autonomous driving systems. Moreover, this system can be utilized by highway cameras to find and penalize vehicles which are not following lane discipline thereby endangering the others traveling on the same road.

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