A Mini-Project Report on

Road Lane Line Detection

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Semester VI

in

Information Technology

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CERTIFICATE

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has completed all the specified work for submission in Mini-Project (ITM605) of Semester VI, as laid down by University of Mumbai in satisfactory manner within the premises of Institute during the academic year 2020-21.

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Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic with honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

Managing the lane system on the road for the vehicles is very important. We plan to provide safety by using the lane detection system and also guide people on the correct ways and time for shifting from a lane to another lane and avoid accidents. Driverless technology has developed rapidly in recent years. Unmanned vehicles need to learn to observe the road from the visual point of view if they want to achieve automatic driving, which specifically is the detection of lane lines. This includes identifying the positional relationship between the lane line and the car, whether it is a solid line or a dotted line. The detection of lanes is an important part of the system we are trying to create here for the safety of the drivers and other vehicles. Given this feature, this paper proposes the use of improved Hough-transform to achieve straight-track detection of lane detection. We also tend to create a centralized web server where we capture the data from the cameras present on the vehicles which report unnecessary lane cuttings and also provide their latest geographical location along with the car details to an administrative authority, to put a curb on the excessive and unimportant lane cuttings that happen on daily basis and result in accidents and loss of lives.

Introduction

Advanced driver assistance systems (ADAS) are being developed to assist the driver in their driving processes to reduce road accidents. Car safety and road safety are thereby nowadays a most important issue. Human errors are prone to occur in the majority of road accidents on highways. Not being Patient or attentive is one of the main factors for road accidents. ADAS provides the automated system to automate, enhance and adapt to the environment to reduce road fatalities and avoid collisions.

The system either alerts the driver or takes necessary actions of driving tasks providing necessary information like lane departure warning (LDW), the position of vehicles, road boundary. One of the scientific fields involved in these tasks includes computer vision that performs tasks automatically compared with human visual system tasks. Computer vision senses the environment and can be applied in many applications supported by intelligent vehicle systems (ITS). Autonomous vehicles are a newer arena of computer vision ranging its level from fully autonomous vehicles to vehicles where a driver is supported by computer vision-based systems. Road boundaries and lane markings are the most perceptual cues for human driving.

The Lane Line detection is a critical component for self-driving and cars in general and also for computer vision. Through this project, we will build a machine learning project to detect lane lines in real-time. We will do this using the concepts of computer vision using the OpenCV library and also use the programming language Python. To detect the lane, we have to detect the white markings that are present on both sides of the lane. Using computer vision techniques in Python, we will identify road lane lines in which autonomous cars must run. This will be a critical part of autonomous cars, as self-driving cars should not cross their lane and should not go in the opposite or adjacent lanes to avoid accidents.

Literature Review

Paper 1: "Real-Time Lane Detection for Autonomous Vehicles"

Authors: Abdulhakam.AM.Assidiq, Othman O. Khalifa, Md. Rafiqul Islam, Sheroz Khan.

Methodology:

- Image Capturing: The input data is a colour image sequence taken from a moving vehicle. A colour camera is mounted inside the vehicle at the front-view mirror along the central line. It takes the images of the environment in front of the vehicle, including the road, vehicles on the road, roadside, and sometimes incident objects on the road.

- Conversion to Gray Scale: To retain the colour information and segment the road from the lane boundaries using the colour information. The road surface can be made up of many different colours due to shadows, different pavement styles, or age, which causes the colour of the road surface and lane markings to change from one image region to another. Therefore, colour images are converted into grayscale.

- Edge Detection

- Line Detection

- Hyperbola Fitting

- Hough Transform

- OpenCV

Findings:

In this paper, a real-time lane detection algorithm based on video sequences taken from a vehicle driving on a highway was proposed. the system uses a series of images. some of the different frames used are shown in the lane detection algorithm which conducts image segmentation and removes the shadow of the road. The lanes were detected using Hough transformation with a restricted search area. The proposed lane detection algorithm can be applied in painted roads, as well as slightly curved and straight roads.

Paper 2: "An Efficient Method of Lane Detection and Tracking for Highway Safety"

Authors: Bubly Barua, Shuva Biswas, Kaushik Deb

Methodology:

- Capturing Image: The first step involves capturing an image. The input data is a colour image sequence captured by a CCD camera. The camera is mounted just at the front view mirror along the central line of the road inside the vehicle. Camera calibration may be required to calibrate the captured image due to its distortion. Geometric camera calibration also referred to as camera re-sectioning, measures the parameters of the camera lens and image sensor of the captured image.

- RGB to Grayscale conversion

- Edge Detection

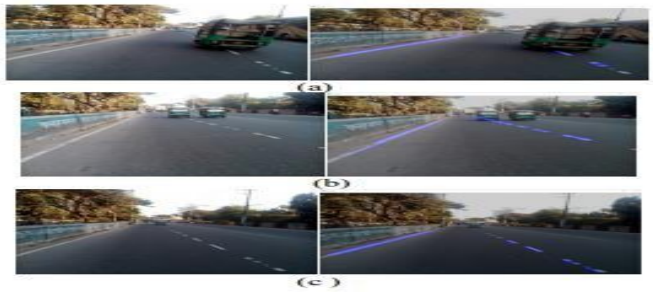
- Line Finding Using Standard Hough Transform

- Finding Lane Line

- Curve Fitting

Findings:

The experiment is performed on moving vehicles shooting in highway roads under various illuminations with different distances ranging from 10-60 meters. The camera height from the ground should be a certain value that is not more than two meters. .The captured images from different distances and the detected resultant images are shown in 'Figure 1'. The blue lines in the images show the result of the final processing of lane detection. As observed from the figures that the lanes can be easily detected in different distances and different illuminations. The results reveal that the proposed system is not affected by the environment of the streets; have the ROI selected suitable for any set frames recorded by the camera.



Paper 3: "Lane Detection and Tracking for Intelligent Vehicles: A Survey"

Authors: Mehdi FENICHE, Tomader MAZRI

Methodology:

- Image Cleaning
- Features Detection
- Model Application
- Tracking integration
- Coordinates Translation
- Adaptive bilateral filter

Findings:

Several advancements were made in these detection fields. Most of the strategies are based on the Vision or Lidar (Light Detection and Ranging) approach and are very simple for detecting. Despite all the progress made concerning the lane detection and tracking area, there are still opportunities for improvement because of the wide range of variability on the vehicle environments, as the dynamic motion of obstacles, parked and moving vehicles, bad quality lines, sharper curves, irregular and strange lane shapes or emerging and merging lanes.

Generic Model for Lane Detection.

Paper 4: "A Study Of Lane Detection Techniques And Lane Departure System"

Authors: Suvarna Shirke **,** Dr.C.Rajabhushanam.

Methodology:

- **None**

Findings:

In this paper, we have studied the different approaches to lane detection and lane departure system. We have also studied the various challenges faced by the lane detection system. We have also seen the datasets available for lane detection. As compare to the feature-based approach the model-based approach requires too many computations, but as compared to the feature-based approach the model-based approach gives good accuracy.

Paper 5: "Research on Lane Detection and Tracking Algorithm Based on Improved Hough Transform"

Authors: Xianwen Wei1, Zongjun Chai 2, Wei Feng3, Zhaojin Zhang1

Methodology:

- Image Pre-processing
- Extraction Lane Line
- Lane Line Detection Based on Hough Transform Improved by ROI Region

Findings:

The Hough line detection method is accurate and simple, and the curve detection can be performed after adding the tracking algorithm. The fitting method is unstable but has the advantage of being able to detect curves. The advantage of the affine transformation method is that multi-lane detection can be performed. The disadvantage is that in a complex situation, the vehicle or other object in front can be easily obstructed and suffer severe interference. Therefore, the detection of lane lines needs to adapt to various conditions. Compared with the above two algorithms, the algorithms designed in this paper have good robustness and hold many advantages. When the direction of travel of the vehicle deviates from its vanishing point, the driver is reminded to take corresponding measures to realize the lane departure warning, which can effectively suppress the occurrence of the accident.

Existing System Architecture

Real-time lane detection in an autonomous car is a system that provides a means of warning the driver to the danger has the potential to save a considerable number of lives. One of the main technologies involves in these takes computer vision which becomes a powerful tool for sensing the environment and has been widely used in many applications by intelligent transportation systems (ITS) In many proposed systems, lane detection consists of the localization of specific primitives such as the road markings of the surface of painted roads. This restriction simplifies the process of detection, nevertheless, two situations can disturb the process: the presence of other vehicles on the same lane occluded partially the road markings ahead of the vehicle are the presence of shadows caused by trees, buildings.

Architecture:

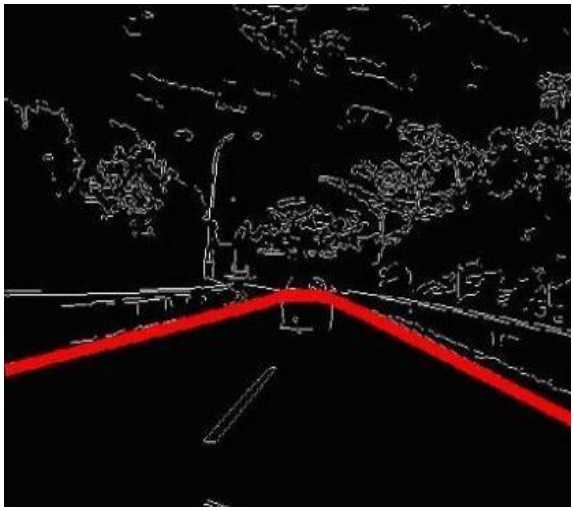
It uses a vision-based approach capable of reaching a real-time performance in detection and tracking of structured road boundaries (painted or unpainted lane markings) with a slight curvature, which is robust enough in presence of shadow conditions. Road boundaries are detected by fitting parallel hyperbola pairs to the edges of the lane after applying the edge detection and Hough transform. The vehicle moves on a flat and straight road or with slow curvature.

The road surface can be comprised of light or dark pavements or combinations. Depending upon the surrounding a variety of road conditions can be seen, some roads have relatively simple conditions with both solid and dashed line lane markings. Lane position in such cases can be considered relatively easy because of the clearly defined markings and uniform road texture. But in other complex cases in which the road surface varies and markings consist of circular reflectors as well as solid lines the lane detection will not be an easy task. Furthermore, shadowing obscuring road markings makes the edge detection phase more complex. Along with the various types of markings and shadowing, weather conditions, and time of day can have a great impact on the visibility of the road surface.

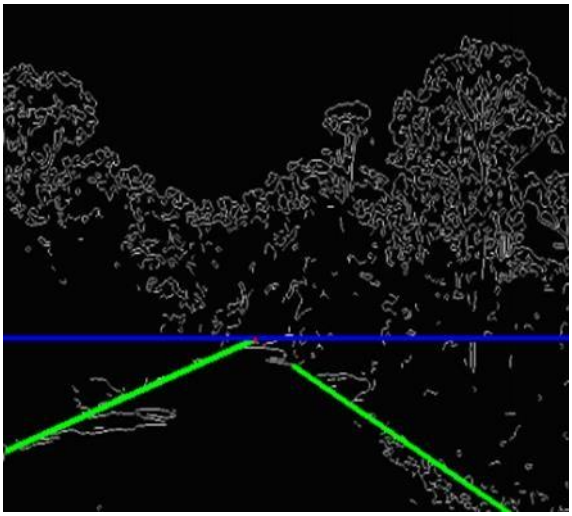
A CCD camera is fixed on the front-view mirror to capture the road scene. Each lane boundary marking, usually, a rectangle (or approximate) forms a pair of edge lines. In this paper, it was assumed that the input to the algorithm was a 620x480 RGB colour image. Therefore, the first thing the algorithm does is to convert the image to a grayscale image to minimize the processing time. Secondly, the presence of noise in the image will hinder the correct edge detection. Therefore,

they apply the (F.H.D.) algorithm to make the edge detection more accurate. Then the edge detector is used to produce an edge image by using the canny filter with automatic thresholding to obtain the edges, it will reduce the amount of learning data required by simplifying the image edges considerably. Then edged image is sent to the line detector after detecting the edges which will produce a right and left lane boundary segment. The projected intersection of these two-line segments is determined and is referred to as the horizon. The lane boundary-scan uses the information in the edge image detected by the Hough transform to perform the scan. The scan returns a series of points on the right and left sides. Finally, pair of hyperbolas is fitted to these data points to represent the lane boundaries. For visualization purposes, the hyperbolas are displayed on the original colour image.

However, still, some problems did not solve yet such as sharp curves in the foreground of the image and the accurate detection of the lanes under heavy rain also the captured frames are not that stabile due to the vehicle movement and therefore, we need to improve the algorithm to overcome these problems. In the lane detection due to shadowing and the Hough line and horizon overlaid then in the lower-left edge with the lane boundary points overlaid and, in few cases, lane scan fails to track the correct lane.



Hyperbola Fitting



Lane Boundary Detection

Problem Definition:

- Increase in numbers of accidents of vehicles caused by rash and undisciplined drivers: many of the times people are tend to creash the lanes inorder to reach their destination faster, this leads to fatal accidents.

- Environment Damage: Often the accidents leads to crashing of the vehicles on the road side trees or stary/wild animals, causing them a great harm.

- Human Errors: According to the statistics, 40% of road accidents of road accidents are caused due the drowsiness of drivers, thus they need an alarming system.

- Excessive and unnecessary lane cuttings: when stuck in traffic people are tend to find the fastest way out, thus breaking all the traffic rules and leading to mass congestion.

- Coloured Markings: at some scenarios the colour of lane markings differ i.e they are either with of yellow

- Roads: Many times, it is observed that writing on the road and other markings also create problem to detect the lane. Strange street materials and different slopes create problems in lane detection.

- Unwanted lane shiftings: Most of the time, people are tend to cross the lanes for unnecessary reasons.

- Reduce unwanted Overtaking of vehicles: Many of the times on Highways, it is seen that if people are stuck behind a car, they try to overtake that car to find a free-way

- Road and traffic environment is difficult to predict: It is difficult predict the road designs and architecture according the environment.

- Climate: Environmental condition like rain, fog, reflecting roads due to overheating or wetness, etc affects the image clarity.

Objectives

- To capture the images in frames, remove the unnecessary pixels, converting the images from RGB image to Gray-scale to remove unwanted shadows.

- To detect the line and determine the approximate position and shape of the lane by using lane detection, edge detection and region of interest.

- To obtain secure environment and improved traffic surroundings.

- To detect lane markings on the road by capturing the video of the road as an input to the system.

- To prevent the occurrence of accidents due to reckless and undisciplined driving.

- To developed a safety system for avoiding lane departure for a large and complex set of traffic scenarios.

Project Scope

- Lane and road understanding as unsupervised data in large quantities of supervised data can be gathered with some effort by driving with additional sensors.

- Seeing the future development in the infrastructure of the world, Road Lane line detection could be adapted in cars to avoid traffics.

- Making Road Lane detection a mandatory feature for all cars will help to reduce accidents and it will also help to discipline rash drivers.

- Improved accuracy and consistency in machine learning and real-time systems can help overcome some current problems faced in Road lane line detection.

- Creating a web server where all the unnecessary and unwanted lane cuttings are reported with the owner and drive details and their latest geographical location to the concerned government authorities.

- It can be installed in all the cars for lane departure warning, as well as for obstacle detection in driver assistance.

Proposed Technology Stack

Hardware (Minimum)

- Processor type: Intel Pentium 3/ Pentium 4
- Processor speed: 2.1Ghz or more
- Hardware: 5GB
- Memory: 1GB RAM
- Digital Camera: 12-20MP

Software

- Operating System: Windows XP/2000/Vista or Linux
- Language used: Python
- Tools and Libraries: OpenCV, NumPy, Haversine
- Algorithms: Hough Transformation
  Frame masking

Proposed System/Architecture

Lane Line detection is a critical component for self-driving cars and also for computer vision in general. This concept is used to describe the path for self-driving cars and to avoid the risk of getting in another lane.

In this system, we will build a machine learning project to detect lane lines in real-time. We will do this using the concepts of computer vision using OpenCV library. To detect the lane, we have to detect the white markings on both sides on the lane. Using computer vision techniques in Python, we will identify road lane lines in which autonomous cars must run. This will be a critical part of autonomous cars, as the self-driving cars should not cross its lane and should not go in opposite lane to avoid accidents.

We would be using,

- **Frame Masking:** to detect white markings in the lane, first, we need to mask the rest part of the frame. We do this using frame masking. The frame is nothing but a NumPy array of image pixel values. To mask the unnecessary pixel of the frame, we simply update those pixel values to 0 in the NumPy array. Here applies a mask to an image, we simply change the pixel values of the desired region in that image to 0, or 255, or any other number. It is a pretty simple but effective method of removing unwanted regions and objects from the images.

- **Image Capturing:** The input data is a colour image sequence captured by a CCD camera. The camera is mounted just at the front view mirror along the central line of the road inside the vehicle. It captures image from the front view of vehicle including road curvature, trees, buildings, shadows, vehicles and so many objects which do not come under consideration. The real time computer system attached with image capturing card read the images in real time and store them in memory.

- **Gray Scale conversion:** The gradient of the road surface and lane markings change invariantly due to its shadows, buildings, trees and invariant illumination. Images are made of pixels and each pixel in the image is a combination of three intensities. Therefore, images are converted into grayscale meaning that three channel colour images consisting of red,

green and blue channel-24 bit are now converted to one channel gray 8 bit. The basic form of the conversion is defined in Equation,

$$Y = 0.299R + 0.587G + 0.114B$$

Y, the gray scale representation of the colour image is the weighted sum for the red, blue and green component value.

- **Noise Removal:** Noise removal is a prerequisite step for edge detection and thus smoothens the image. When detecting edges it is important to accurately catch as many edges in the image as possible. Image noise must be filtered out as it creates false edges and ultimately it affects edge detection. As the presence of noise in our system will hinder the correct edge detection so that noise removal is a prerequisite for efficient edge detection with the help of the (F.H.D.) algorithm that removes strong shadows from a single image. The basic idea is that a shadow has a distinguished boundary. Removing the shadow boundary from the image derivatives and reconstructing the image should remove the. A shadow edge image can be created by applying edge-detection on the invariant image and the original image and selecting the edges that exist in the original image

- **Edge Detection:** Edges are the points where the grayscale values change sharply. Edge detection is a very important step in determining the location of lane boundaries as the edge is one of the major information contributors to the lane. The edge detector was implemented for this algorithm and the one that produced the best edge images from all the edge detectors evaluated was the ‘canny’ edge detector.

- **The Canny edge detector:** it works in a multi-stage process. The method is based on the characteristics of intensity values of the considered pixel. A signal to noise ratio (SNR) on the edge detector may be applied so that edges could be found even the data quality is poor. A gradient is a change in brightness or discontinuity over a series of pixels. So, the Canny function computes the gradient in all directions of the blurred image and then traces the strongest gradients as a series of white pixels.

- **Line Detection:** To detect the line we use Hough transformation. It can detect shapes like rectangles, circles, triangles, and lines. The Hough Transform technique is used to detect

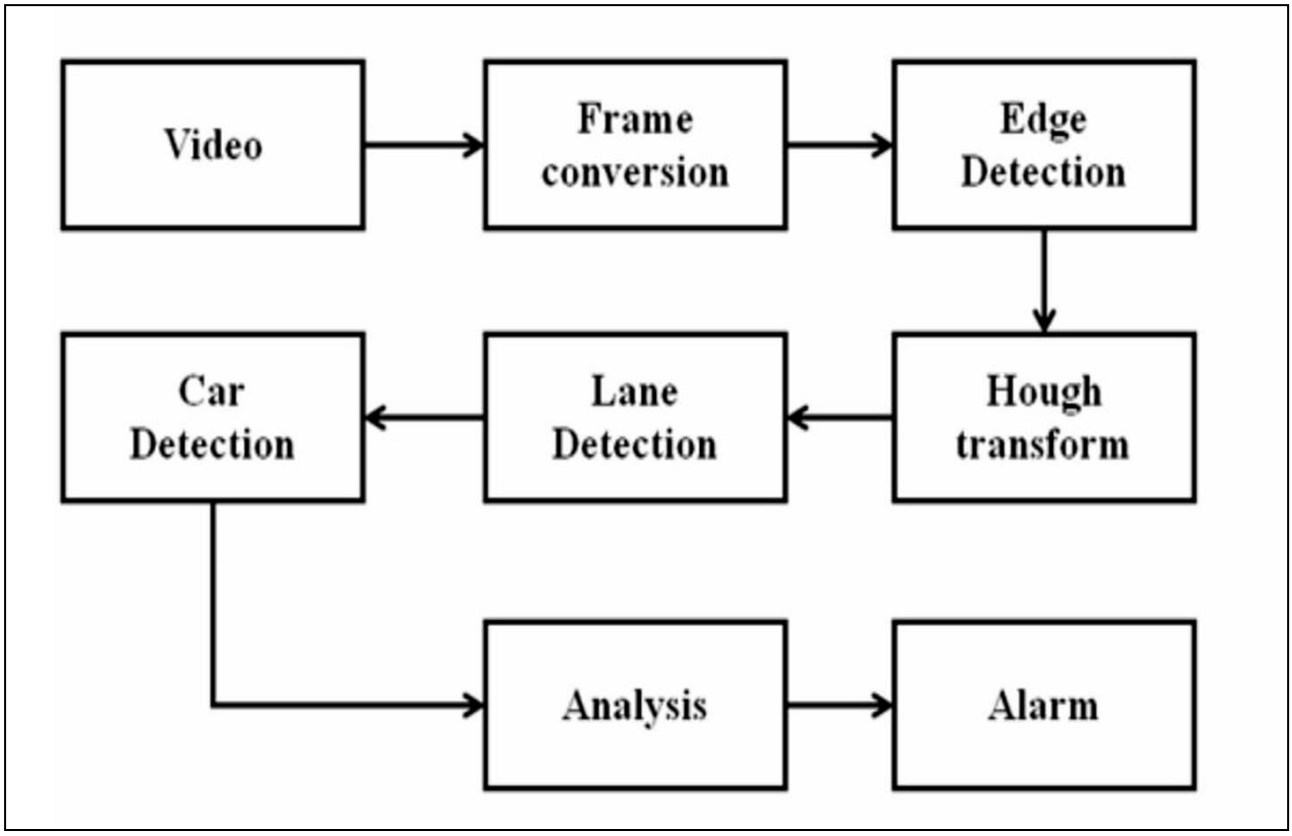
straight lines in our region of interest and thus identify the lane lines. This technique uses a parametric space called Hough space. Hough transform is a mechanism that gives more weightage to pixels that are already in line with a voting procedure. This voting procedure is carried out in a parameter space from which lines are obtained as local maxima. The lines that are outside the space are rejected.

For example, a horizontal line is probably not the lane boundary and can be rejected. The restricted Hough transform was modified to limit the search space to 45° for each side. Also, the input image is split in half yielding a right and left side of the image. Each of the right and left sides is searched separately returning the most dominant line in the half image that falls within the 45° window. The horizon is simply calculated using the left and right Hough lines and projecting them to their intersection. The horizontal line at this intersection is referred to as the horizon.

- **Lane Boundary detection:** It uses Hough lines and horizon lines as input. The scan begins where the projected Hough lines intersect the image border at the bottom of the image. Once that intersection is found, it is considered the starting point for the left or right. From the starting point, the search begins a certain number of pixels towards the centre of the lane and then proceeds to look for the first edge pixel until reaching a specified number of pixels after the maximum range. The range will be set to the location of the previously located edge pixel plus a buffer number of pixels further.

- **The hyperbola pair fitting:** this phase uses the two vectors of data points from the lane scan as input. A least-squares technique is used to fit a hyperbola to the data. One hyperbola is fit to each of the vectors of data points; however, they are solved simultaneously since they are a pair model. The parameters of the two hyperbolas are related because they must converge to the same point, due to the geometry of the roadway.

Block Diagram



Summary

In this project, we studied a real time lane detection algorithm based on video sequences taken from a vehicle driving on highway was proposed. As mentioned above the system uses a series of images. Out of these series some of the different frames used are shown in the lane detection algorithm, (F.H.D.) algorithm conduct image segmentation and remove the shadow of the road. We also have studied the different approach of lane detection and lane departure system. We have also studied the various challenges faced by the lane detection system. We have also seen the datasets available for lane detection. As compare to feature based approach the model-based approach requires too many computations, but as compare to feature based approach the model-based approach gives good accuracy.

In this review, we have presented a frame work which is robust for lane detection and tracking in highway road. This presents a detailed analysis of the use of lane position in various environments with different illuminations. This led to our presentation of the ROI based lane-tracking system operated in a wide range of environments. For safe lane systems, this approach developed a safety system for avoiding lane departure for a large and complex set of traffic scenarios.

We studied various papers, there advantages and disadvantages, for our work. We have studied the different approach of lane detection and lane departure system. We have also studied the various challenges faced by the lane detection system. We have also seen the datasets available for lane detection. Thus trying to eliminate all the possible problems appeared in the previous systems.

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