# Vanet Introduction And Real-Time Authenticated Detection of Road Lane-Lines Using LaneRTD Algorithm

*End Sem Thesis Report*


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# 1 Introduction

This section covers a brief introduction to Real-time lane detection algorithm , a concept of VANET and the problem statement.This concept is introduced in the proposal.

## 1.1 Introduction to Automatic Lane Detection

The main objectives for installing ADAS which stands for Adavnced Driving Assistance systems in newer cars are protection, reliability and convenience, minimizing road Mishaps, and improve convenience and a good riding experience. It's not difficult to deduce from this how important it is to accurately find and locate road lane in present world scenario when using VANETs as authentication.

Integrating Road-Lane Detection in modern cars with ADAS can lead to the resolution of a number of challenging issues, including:
1. Highway Driving that is Automated
2. Automated Parking
3. Collision Avoidance
4. Manoeuvring in a Collaborative Environment [3]

and much more, all in real time, which is one of the most difficult and difficult tasks. [1] Localization of the road, determination of the relative position between vehicle and road, and analysis of the vehicle's heading direction are all required for Road Lane – Detection.

Figure 1: Lane Detection in ADAS

[5]The technology uses a camera installed on the car to capture the front image, which is then processed to recognise the lanes. The following are the major parameters that a lane detecting algorithms must have for robustness:

1. Shadows cast by trees, buildings, and other objects should not influence the quality of lane recognition.
2. It must have the ability to process both painted and unpainted roadways.
3. Instead of presuming that the roads are straight, it should manage curved roads.
4. It should derive a concise output for the input images.

## 1.2 Introduction to Vanet

A car network (VANET) is a wireless network with vehicles (e.g., cars, buses, trucks) and neighbouring roadside infrastructure . Each vehicle has a transmission device that lets it to communicate with the other vehicles and infrastructure nearby. The on-board unit (OBU) on vehicles, the roadside unit (RSU), and a trusted authority compensate a VANET (TA). With the help of RSUs, the TA is a third-party device that registers RSUs, authenticates vehicles, and monitors the entire network.

The RSU is a roadside wireless device (e.g., WiFi, WiMAX) that serves as a facilitator between the TA and the vehicle's OBU, delivering safety instructions to vehicles within range. The OBU is a storage device placed on a vehicle that gathers and distributes critical messages to other cars nearby.[6]

## 1.3 The Problem Statement

Design and implement an authenticated road lane line detection mechanism for automated driving using the following mechanisms:
In lane detection, there are three main approaches:

A. The feature-based technique identifies lane segments in road photos by combining low-level characteristics such as painted lines or lane borders, which are discovered using standard image segmentation.[9]

B. The model-based technique, on the other hand, just utilizes a few parameters to represent the lanes. The process of detecting lanes is approached as the process of calculating those model parameters, assuming that lane shapes can be described by one of the following : a linear curve euqation or a hyperbolic curve equation[9]

C. A Hybrid Approach: This is a mix of the previous ways.

Both techniques have their own set of drawbacks:

A. Feature-based technique: In order for this technique to work, the road being analysed must have well-painted lines or strong lane borders. This approach may suffer from occlusion or noise because it does not impose any global limits on the lane edge forms.

B. Because most lane models are solely focused on certain road designs, they lack the flexibility to simulate any road shape.

Motivated by the challenges above, I used LaneRTD algorithm for automatic lane detection and VANET for authentication of vehicles.

## 2 Literature Review

Lane detection is a key element of a vision-based driver assistance system, and it can be utilised for vehicle tracking, horizontal management, obstacle detection, or lane departure warning.

### 2.1 Lane Detection based on Computer Vision Technique

The capabilities of sensing the surrounding environment for the detection, identification, and tracking of road lane lines are provided by vision techniques. A lane detection method called LaneRTD (Lane Real-Time Detection) is presented as a further step towards the prospects of autonomous driving for this approach, cheap processing cost, and real-time vehicle-based solution. The algorithm's key novelty is the careful balance between speed, compact footprint, and dependability and resilience that meets at least the standards of ADAS applications. One of the benefits of the LaneRTD algorithm is that it just requires a single CCD camera to operate.[3]. The following is how this algorithm works:

1. Taking a picture with the camera.
2. Grayscale the image.
3. Gaussian Filtering is the third step.
4. Canny Detector for Edge Detection.
5. Identifying the Area of Interest.
6. The Hough Transform is used to detect straight line segments.

Extrapolation of lane-line segments is number seven.

8. Draw lane lines on the left and right.

### 2.2 Lane Detection based on Directional Random Walks

This method uses morphology to identify all feasible lane segments. Let Sm,n signify a m*n-sized structural element, where m,n¿=1. To start, a smoothing operation with a structural element of 5,5 is used to eliminate noise. The smoothed picture is then subjected to the closure and opening procedures with a structure element, yielding the images Ic and Io, respectively. A differencing operation is conducted to the pictures Ic and Io in order to find vertical edges. Following thresholding, these adjacent edges are further joined by a closing operation to form a connected segment. Then, to extract all of the lane-analogue segments from roadways, a connected component analysis is used. After that, a congested environment can be used to generate a list of prospective lane markings.[8]The following is how this algorithm works:

1. The Markov process
2. Markov Probability Matrix Calculation
3. Creating a link between different lane segments

### 2.3 Lane Detection based on Vehicular Sensor Network

Vehicle-to-vehicle (V2V) communications are used in an infrastructure-less cooperative lane positioning (ICLP) architecture. Vehicle sensor networks (VSNs) are used in the ICLP architecture to locate vehicle lane positions on roads. Without using global positioning system (GPS) locations or roadside infrastructures, ICLP allows vehicles equipped with image sensors to recognise the current positioned

lane. ICLP can continue to recognise a vehicle's lane position. ICLP enables novel applications of intelligent transportation systems that rely on precise positioning.[2]
The following is how the algorithm works:

1) Lane line recognition: vi continues to recognise lane stripes on the road segment and calculates the current lane location.
2) LPR: Vi continues to recognise lane stripes and the licence plate number of the vehicle in front of it in the same lane.
3) Cooperative LREQ (CLR): vi detects lane stripes and transmits LREQ messages to the vehicle in front of it in the same lane.

### 2.4 Lane Detection based on B-Snake and tracking

For generic lane borders, a novel B-Snake based lane model that describes the perspective effect of parallel lines has been constructed. Other lane models, such as straight and parabolic models, are unable to capture a larger range of lane layouts. The issues of identifying lane markers on both sides are combined here as the problem of detecting the lane's mid-line. For the BSnake lane model, a robust approach named CHEVP is described for delivering a decent initial position. This algorithm is resistant to noise, shadows, and fluctuations in illumination in acquired road photos.[10]The following is how the algorithm works:

1.A novel B-Snake based lane model is created with dual external forces for generic lane boundary or marking, and it is able to explain a wider range of lane structures than conventional lane models such as straight and parabolic models.
2. A robust technique known as Canny/Hough Estimation of Vanishing Points (CHEVP) is resistant to disturbances, shadows, and lighting fluctuations in collected road photos and may be used on both marked and unmarked, dash and solid paint line roads.
3. A minimum error method called Minimum Mean Square Error (MMSE) that finds the correspondence between B-Snake and the real edge image is presented to iteratively determine the parameters of the road model using Gradient Vector Flow (GVF) to construct the B-Snake external force field for lane detection.

### 2.5 Lane Detection based on Catmull - Rom spline

The Catmull-Rom spline, commonly known as the Overhauster spline, is a local interpolating spline that was created for computer graphics. From the series of points P0 to Pm, the Catmull- Rom spline can be used to interpolate the points P1 to Pm. Furthermore, the tangent vector at Pi is parallel to the line connecting Pl and P2. Ferguson's parametric cubic curve was used to create the Catmull-Rom spline. After estimating the left-hand side of the lane model with PL0; PL1; PL2, the parallel-line property in the ground plane can be used to reduce the searching area of the associated control point PR1 in the right-hand side of the lane model.[9] The following is how the algorithm works:

1) Ferguson's cubic parametric curves
2) Describe lane markings or borders using the Catmull-Rom spline.
3) Search area with control points
4) Detection of vanishing points (lines)
5) Detection of edges

6) Image processing of a probable edge field
7) Looking for lane model control points in the edge image
8) Using a multi-resolution technique to speed up the control point search

### 2.6 Lane Detection based on Lane Marking Detection

1) [4]It employs a more advanced lane-marking-detection algorithm to deal with difficult scenarios including worn lane markings and distracting objects/markings, such as at an intersection or on a road surface.
2) Unlike most earlier work, it detects the left- and right-lane borders separately, whereas most previous work employs a fixed-width lane model. As a result, it can efficiently handle difficult conditions such as merging or dividing lanes, as well as on- and offramps.
3) It incorporates lane detection and tracking into a single probabilistic architecture that can handle lane changes, emerging, ending, merging, and dividing lanes effectively.

### 2.7 Review of Lane Detection Methods Based on Deep Learning

The first comprehensive review of recent deep learning-based lane detection algorithms is presented in this study. It includes a detailed definition of representive methods from the perspective of computer vision and pattern recognition, as well as a detailed analysis of the structures and loss functions of convolution neural networks, which are employed in lane detection. Deep learning-based methods have several advantages over standard heuristic recognition-based methods. Also discussed are the current challenges of existing deep learning-based methods, as well as some potential solutions.[7]

### 2.8 Survey on authentication and privacy-preserving schemes in VANETs

Through the interchange of traffic and infotainment information with automobiles, vehicular ad hoc networks (VANETs) promise to improve transportation efficiency, passenger safety, and comfort. Acceptance of VANET is dependent on transmission exactness, as well as assurance of an individual's safety via privacy protection. Vehicle authentication is required for message accuracy. This necessitates the use of an efficient privacy-preserving authentication system, as well as the need for message secrecy and timely delivery. The security and privacy issues must be addressed first and foremost in the design of the communication protocol. To secure the correctness of messages during vehicular communications, many privacy-preserving authentication techniques have been developed. However, the majority of systems fall short of fully resolving difficulties like as security and privacy, risks and vulnerabilities, communication, and computing costs.[6]

## 3 Table of Literature Review

| Year | Author | Method Used | Remark | Limitations |
|---|---|---|---|---|
| Jan 15, 2019 | Wael Farag | Computer Vision,LaneRTD Algorithm, CannyEdge Detector, Hough Transform, Draw$_Lines()Fn$ | [3] The measurements are taken for three sample testing video streams using an Intel Core i5 with 1.6 GHz and 8 GB RAM—a relatively moderate processing environment. | 1) The results could be better, particularly on light-colored roadways with intricate shade patterns. 2) The algorithm created only detects straight lane lines. Curved lanes must still be handled. 3) The approach is incapable of handling both uphill and downhill routes.[3] |
| June 4 , 2008 | Luo-Wei Tsai | Markov process,Computing the Markov Probability Matrix, Linking Different Lane Segments , Lane Segment Linking Algorithm | [8] Several video clips (MPEG) having a dimension of 320*240 were utilised to test the lane detection technique. On a PC with a 3.0 GHz Intel Pentium CPU and 1GB of memory, the average frame rate is around 1520 fps. | 1) The input frames that were taken at night do not work. 2) In such circumstances, distracting road markers cause the system to fail. 3) The algorithm is influenced by varied lighting conditions such as cloudy, night, sunny, occlusions, and shadows.[8] |
| December 7,2015 | Lien-Wu Chen | Lane Line Recognition License Plate Recognition Cooperative Lane Requesting | [2] Panel localization, panel orientation and sizing, normalizing and edge detection, character segmentation, and optical character recognition are all included in the ICLP programme. | 1) The trial results suggest that CLR can optimize lane positioning success ratios for on-the-road automobiles. 2) The sensors must still be deployed in each and every automobile, which might be substantial.[2] |

Table 1: Literature Review Table

| Year | Author | Method Used | Remark | Limitations |
|---|---|---|---|---|
| October 1 , 2003 | Yue Wang | A novel B-Snake based lane model, Canny/Hough Estimation of Vanishing Points (CHEVP) ,Gradient Vector Flow (GVF) | , [10]As can be seen, the B-Snake lane model performs admirably when approaching lane lines on both sides of the road. | 1) it's startup isn't completely right. 2) Due to poor lane edge pixels, the outcome does not match very well. 3) It focuses on a two-dimensional lane model.[10] |
| February 8, 2000 | Dinggang Shen | a Catmull-Rom spline-based lane model with generic lane boundary alongwith Ferguson's parametric cubic curves | [9]The analysis indicate that a rated execution speed of 4 to 5 frames per second was achieved. A Pentium II 300 MHz computer with 32 MB of RAM and a frame grabber card make up the system. Visual C++ programming software is used by the programming. | Because this road image lacks well-painted lanes and clearly defined boundaries, not enough edge information can be used to effectively generate a lane model.[9] |
| March 2008 | ZuWhan Kim | Uses lane detection algorithm that includes Intensity-Bump Detection,Artificial Neural Networks ,Naive Bayesian Classifiers,Support Vector Machine | [4]RANSAC-based laneboundary identification and probabilistic categorization based solely on current frame data were applied. Both algorithms were put to the test on a 352 *240 picture resolution video clip (total of 923 frames). Over 80 percent of the frames were correctly identified by our detection technique. | 1) Fast lane changes cause unexpected misdetection. 2) Strong shadows cast by overpasses caused misdetection. 3) Lane markers inside the shade have a very low contrast due to the great contrast between the shadow and nonshadow sections. |

Table 2: Literature Review Table

| Year | Author | Method Used | Remark | Limitations |
|---|---|---|---|---|
| June 1 , 2021 | Pravin Mundhe Shekhar Verma S.Venkatesan | Various Methods are being interpreted and their limitations are being mentioned | [6]This paper present a detailed analysis of schemes, including classifications, strengths, and shortcomings. According to the findings, most existing authentication techniques require trusted authorities that are ambiguous in their operation, and certificate revocation necessitates a lot of computation and storage, as well as a lot of lookup time. | This s a review paper.[6] |
| September 15 , 2020 | Jigang Tang ,Songbin Li ,Peng Liu | Various Methods are being interpreted and their limitations are being mentioned | [7]The following two views are presented in this paper: (1) network designs, these include classification and object detection-based strategies, end-to-end image segmentation-based methods, and certain optimization strategies; and (2) related loss functions. The benefits and drawbacks of each strategy are discussed. Then there's a quick comparison of several representative methods. | This s a review paper.[7] |

Table 3: Literature Review Table

# 4 The Proposed Protocol

The proposed algorithm combines the VANET concept with the LANERTD algorithm, allowing for the detection of road lane lines, vehicle authentication, registration, and fraud detection. Vehicle detection is also a joint effort. The idea provides LANERTD with a secure perspective by introducing VANET. The plan is separated into three parts, with the goal of lane detection and to verify the vehicle using the VANET concept with Road-Side Units (RSU), OBU, and AU. After that, the authorised photo/video is sent to Lane-Detection. The following are the phases and their descriptions:

## 4.1 PHASE 1 : SETUP PHASE

This phase contains all of the algorithm's inputs, including the Car ID and its related attributes, as well as the participants in the proposed protocol. Automated vehicles travelling on straight or curved roads must first authenticate and register with their local RSU and then getting authenticated by Traffic Authority before submitting their dashcam video to have their lane recognised in real-time using the LANERTD Algorithm.

## 4.2 PHASE 2 : AUTHENTICATION USING VANET's PHASE

The VANET is used on the road, with vehicles acting as mobile nodes. VANET applications such as active security and intelligent transportation require appropriate vehicle-to-vehicle communication technology, particularly routing technology.

The dashcam video/pictures are saved at the RSUs in the area. Data goes from the RSUs to the private cloud/Internet via a gateway. During this step, server-side authentication is performed, as well as security and implementation analysis. If authentication is successful, the algorithm for lane detection is fed real-time videos/pictures.The simulation of VANET can be done using 3 simulation Techniques:
1. Using Ns2 and Ns3 simulation
2. Using Python(.py files)
3. Using Google veins simulator , omnetpp and veins

## 4.3 PHASE 3 : LANERTD ALGORITHM IMPLEMENTATION PHASE

This approach is a generalised vehicle-based solution with a low computing cost. The true innovation is in striking a careful balance between speed, compact footprints, and dependability and robustness that meets the needs of at least ADAS applications.
This programme makes use of a single CCD camera, which captures RGB colour images with a resolution of 960*540 pixels.

The steps of the algorithm are as follows:
1. Examine the images
2. Grayscale picture conversion: to reduce processing or execution time.
3. Gaussian Blur: A technique for reducing noise in grayscale images.
4. Canny algorithm: To create an edged image, a simplified algorithm is used.
5. A trapezoid area is retrieved as the region of interest.
6. Line detection function: An edged picture is added to the region of interest, and the plain boundaries

on the right and left are segmented.

The suggested protocol is represented in the diagram below, which shows VANET introduction and real-time authenticated detection of road Lane lines using the LANERTD method.

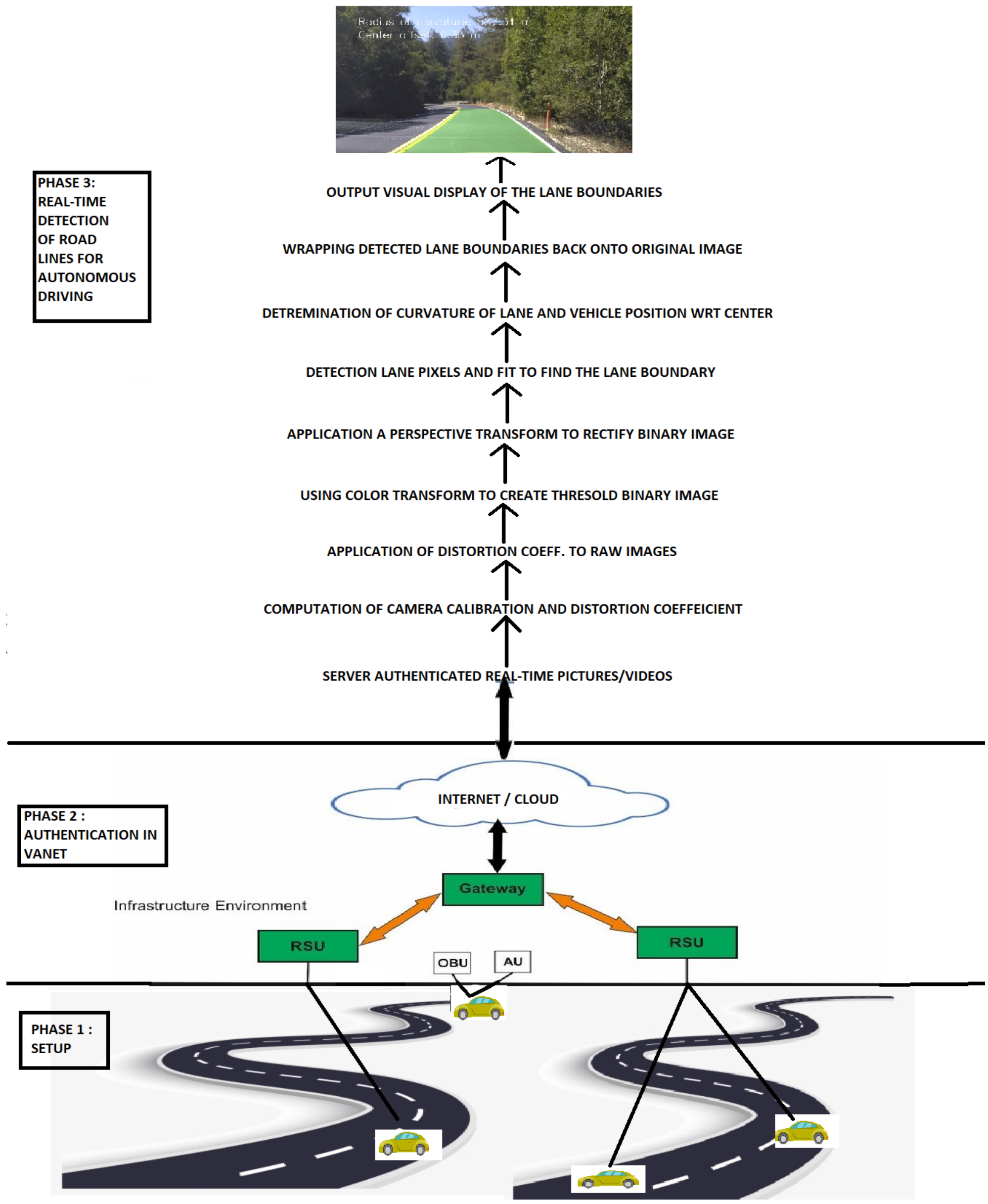


Figure 2: The proposed Protocol Block Diagram

# 5 Implementation of the Proposed Algorihtm

The implementation of the algorithm was processed over two steps:
1. Implementation of VANET using three Python files.
2. Implementation of Lane RTD algorithm using jupyter.

## 5.1 Implementation of Vanet

Three Python files are used in the simulation for the implementation of the VANET:

1. Model.py : is a Python script that creates a model. This Python file primarily contained all of the methods and classes that the other two Python files used. All of the libraries are imported, along with their base classes and static methods. We employed the SHA algorithm for authentication and privacy, and we used hash sizes of 160, 256, and 512 bits. The procedures were as follows:
a) hash: For a given input, computes a 160-bit hash value.
b) sxor: Strings that are Xored together.
c) create a nonce at random
d) generate a key: generate a random nonce and then use SHA to generate the key size.
e) create a string from the current timestamp, hex-transform, and byte.

The traffic authority class and methods are then defined, which include registered cars, RSU registration, and the generation of 1024 bit secret keys that cover all functions.
The RSU class is then created, which validates whether or not the traffic authentication ID is legitimate. If the ID is correct, it checks for communication timeliness and then compares the hash supplied to the hash calculated. If they match, the hash is returned to the vehicle, and authentication is confirmed; otherwise, the print fails.
After that, several functions such as request authentication, vehicle authentication, authentication precompute, authentication authenticate, and authentication received acknowledge are defined.

2. Auth.py: For authentication of vehicles this python script is is used. The first step is to import all the libraries, defining vehicle count as 1(which later is simulated till 1000) , rsu count as 6 and traffic auth ID as "TA-001".
The next step is to define the method simulate that takes vehicles,rsu, simulation size as 20, average count and hash size and authenticate all vehicles,RSU,OBU etc and return average time that is later plotted.
The next step is to generate user ID for each simulation size.Then for each user ID, physical registration is done. When all vehicles are registered ,the rsu is registered the plot is saved in the device with x axis as "auth iteration number" and y axis as " average authentication time". 1 random plot is shown for all 3 key sizes.

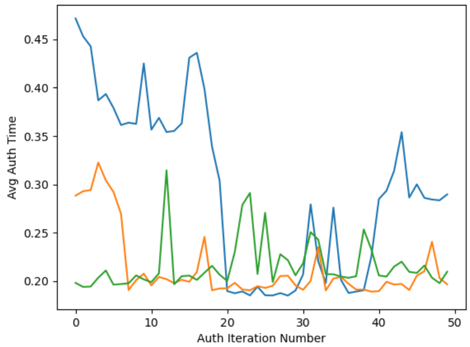


Figure 3: Authentication of Vanet Plot

3. Register.py : This Python script is for registration of RSU of the authenticated vehicle. The first step is to import all the libraries. The vehicle count is defined as 1, the rsu come as 6 and traffic authority is the same.
Then a method simulate that take iteration, skips and hash size is called for 100 for all 3 key sizes. For each iteration traffic authority is created and auth.py is called. Request authentication is called and password is matched using hash. Time required for authentication and hash computed is displayed and a plot is drawn.

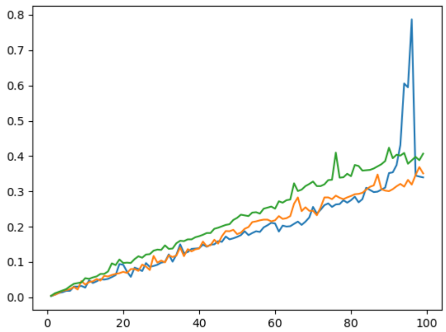


Figure 4: Registration of vanet plot

### 5.2 Implementation of LANERTD Algorithm

1) Collecting test photos: It just reads all of the images in the zip archive "testimages" one after another in randomized order by using imread (python package).

Figure 5: Reading test images

2) Using the python function "convert," integrate the colour test image to greyscale, to lower the processing time.

Figure 6: Image converted to grayscale

3) Noise screening: this is performed with the help of python method "scipy.signal" present in the scipy library.

Figure 7: Filtered Image

4) Curve Recognition and Retrieval: this is done with the "scipy" python library, which runs the Canny algorithm and displays the edges identified.

```
from scipy import ndimage
Ix = ndimage.filters.convolve(img, Kx)
```

Iy = ndimage.filters.convolve(img, Ky)

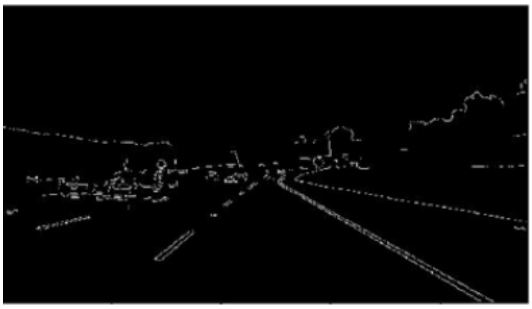

Figure 8: Edge Detected using Canny

5) The field of view is identified by obscuring a trapezoidal area in an image with edges recognized to produce an image only with lines matching to roadway lane lines.
6) Identifying Linear Arcs : Linear Arcs are found using the Hough technique in equation using "cv2.HoughLines" in the python library in polar cartesian co-ordinates.

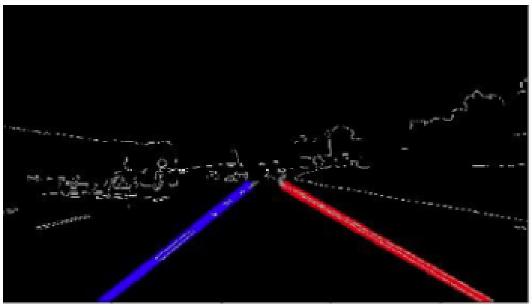

Figure 9: Detecting Straight Lines using Hough Tranform

7) Monitoring Lane Lines: After successfully detecting lane lines in immobile photos, the next step is to track them. For the transition from one frame to the next, various smoothing techniques are used.
.

## 6 Conclusion and FutureWork

Different lane detection techniques have been reviewed. As the existing approaches have their own limitations regarding the accuracy or computational cost, this lays a path for the LaneRTD algorithm that possesses both good accuracy and low computational cost. However iI the existing approaches have laid the foundation on which further development can be done to achieve better performance. Most of the algorithms fail with curved roads and little light or when the dashcam is tilted . The performance is hindered due to shadows for other cars which should be reviewed.

Figure 10: Final Output Image

The future work includes addition of camera calibration, software pipeline to identify the road Lane boundary in a video instead of pictures, camera calibration using chessboard images, using gradient thresholds, and colour thresholds. Using hard code perspective transform and histogram approach with sliding window protocol can elevate the algorithm to detect curved lines and the addition of of computing radius of curvature and centre of that will lead to to help in ADAS in systems. Figuring out bad frames will lead to to following the brute force approach and can help further.

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