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ECTE 401: IMAGE PROCESSING

pROJECT 1: LANE ANALYSER

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# Introduction:

One of the most pressing concerns of human beings is their safety. In this regard, one of the minor expectations of the public is to arrive at their destination safely without any accident. In most traffic-congested countries, such as the United Kingdom, the United States, and Asia, vehicle crashes continue to be the leading cause of accidental death and injury, claiming tens of thousands of lives and injuring millions of people each year **[1]**. The majority of these transportation-related deaths and injuries happen on highways. By taking advantage of improved driving support technologies, the risk of a road accident can be significantly reduced.

Graphical user interface

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Lane detection is one of the methods that employs the vision-based lane detection principle. As the name implies, it is a method of detecting and recognizing the lanes in which ground traffic circulates. This useful technology has gotten a lot of attention from researchers in the field all over the world in the last few decades.

# Objectives:

A lane-position detection system primarily employs image processing techniques to extract lane markings from video captured by a single camera mounted on the vehicle's dashboard. For our project we will be looking forward to using these image processing techniques to:

* Detect the lane in which the car is currently traveling.
* Highlight the lane section ahead of the car.
* Predict the car's direction movement on the lane ahead.
* Predict the angle at which the steering wheel must be turned.

The autonomous driving system project was developed with the help of MATLAB.

# Scope:

Our project has some constraints that are outside of its scope, such as:

* Only a pre-recorded video can be used by the program to be capable of running its functions.
* If the lane markings are faded or missing, the program may encounter difficulties.
* If a curve has a very high curvature, the program may have trouble detecting it.
* There may be complications for the software if the lane is changed while the application is running.

# Design and Testing:

Detecting the lanes in a video first requires the frames of the image to be extracted. The extracted frame is then processed to identify the lane edges and the steering/turn prediction.

Text

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Figure 1. Flowchart of Image Processing.

*To have a better perspective of the procedural steps required a reference was made from the GitHub link provided under References* ***[2]****. The procedures to determine the Hough Lines and plotting them were taken from the referred GitHub code. Note this project uses a different approach when compared to the referred code to complete the integral procedures which include extracting the desired lines, determining the turn prediction, and steering angle.*

The Image processing involves 5 major steps:

## Image preprocessing:

The frame has to be preprocessed in order to remove unwanted objects that would otherwise interfere with detecting the lines. The image is first convoluted with a gaussian kernel in order to remove noise.

Graphical user interface

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Description automatically generated with low confidence

Figure 2. First frame of the Video (left) is processed to the Gaussian filtered frame (right)

The RGB threshold values of the yellow and while lines are determined and used to get two binarized images, one isolating the yellow thresholds while the other isolating the white thresholds. The threshold values were determined using the color picker tool on paint.

A screenshot of a computer

Description automatically generated with medium confidence A screenshot of a video game

Description automatically generated with medium confidence

Figure 3.Binarizing for yellow (left) and white (right) RGB thresholds

The edges were determined at pixels with a high gradient using Canny edge detection.

Graphical user interface

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Figure 4. Edges for yellow (left) and white (right) binarized image.

Two masks were created to isolate the region of interest. The projects region of interest comprises of the yellow and white lane edge. The masks were extracted using the roipoly function. The edge images are then multiplied (dot multiplication) with the mask image resulting in two edge images of the yellow and white lane edge thereby isolating the lanes.

Shape, icon, rectangle

Description automatically generated A picture containing shape

Description automatically generated

Figure 5. Region of interest masks, to extract yellow (left) and white (right) lane. The ROI is determined from the first frame (Figure 1)

The edge images are then multiplied with the mask image resulting in two edge images of the yellow and white lane edge thereby isolating the lanes.

A picture containing graphical user interface

Description automatically generated A picture containing text, screenshot, monitor, electronics

Description automatically generated

Figure 6. Isolated edges of the lanes. yellow (left) white (right)

## Finding Hough Lines:

The Hough lines is used to extract the edges of the lane edge by determining the equation of a line in polar coordinates.

The hough function plots the ‘r’ (rho) and theta values in the Hough transform (x-axis represents theta and y-axis rho). For each coordinate in the x – y plane its rho value is plotted for different values of theta.

Followed by this, the houghpeaks function returns the intersection points of the Hough lines. Two intersections/ Hough peaks were chosen. This is to ensure that the innermost edge of the lane is always detected. The houghlines function is then used to determine the starting and ending points of the line and their corresponding rho and theta values.

Graphical user interface

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Figure 7. Hough lines for yellow and white lane edges.

## Extracted lines:

After getting the lines for each lane edge, a single line needs to be chosen for each lane edge out of the two lines.

* The lines are extended to the bottom of the frame (values of the coordinate are not being changed) and the coordinate closest to the inner lane edge determines which of the lower coordinates of the lines need to select.
* The top coordinates are compared and the coordinate which represents the longer line is chosen.

From the above two points the two coordinates chosen to form the line of that lane edge. Using the coordinates, the equation of the line is determined. The equation the line is then used to find the coordinates at the bottom of the frame.

The top y coordinates of the two new lines are compared. The y coordinate that represents the furthest, is chosen to be the y coordinate for both points. The corresponding x value of the lower point of the two is calculated.

Thus, the desired line for each lane edge has its lower coordinate at the bottom of the frame and the upper coordinates of the line are at the same height.

Graphical user interface

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Figure 8. New lines after extrapolation

## Plotting and determination of direction and steering angle:

The turn prediction determines the steering direction of the car. The point of intersection of the lines and the center coordinate between the bottom coordinates is used to determine the steering direction.

If the point of intersection closely aligns with the center coordinate, the turn predicted is straight. If the point of intersection deviates to the left or right of the center coordinate the direction determined is left if it deviates to the left or right if the deviation is to the right. Another way of looking at it is the ratio of the x coordinates of the intersection point and the central coordinate at the bottom of the frame (the coordinates are plotted in red).

The steering ratio (ratio of the angle of the car to the steering angle) assumed is 12:1 **[3]**. The turning angle of the car is calculated using trigonometric ratios. The steering angle is then determined using the steering ratio applied on the turning angle.

Analyzing all frames, the straight thresh hold is between 0.9 and 1.1. Anything grater or less than the threshold limits correspond to a right or left turn. Furthermore, the coordinates extrapolated in the third step is used to plot a polygon. This is archived by using the patch function. The plotted frame is then written to the output file object.

Graphical user interface

Description automatically generated

Figure 9. Plotted frame. This frame will be written to the output file

# Conclusion:

Though the ultimate goal is to create a program that will one day allow an automobile to drive itself, this project is a minor step in that direction. The project is focused on lane detection, which is one of the first features in the field of autonomous driving. Hough transform was employed and is an integral step to achieve all of the objectives. The average time taken to process each frame is about 0.1639 seconds. The video consists of 790 frames hence the time taken to process the frames is 790 x 0.1639 which is about 129.5 seconds. A formal analysis of the effectiveness of the algorithm should be done as part of future work. The algorithm's reliability will also be assessed by applying it to various different video sequences. We feel the identification system is sufficiently robust in the automobile study, but future work could benefit from some of the more advanced tracking methodologies.

# References:

1. Transportation Cost and Benefit Analysis II -Safety and Health Costs. (2021). [online] Available at: https://www.vtpi.org/tca/tca0503.pdf [Accessed 31 Oct. 2021].
2. Shah, Y., 2021. *GitHub - ysshah95/Lane-Detection-using-MATLAB: Detection of lanes on a road and prediction of turns based on vanishing point.*. [online] GitHub. Available at: <https://github.com/ysshah95/Lane-Detection-using-MATLAB> [Accessed 1 November 2021].
3. Wikipedia. (2019). *Steering ratio*. [online] Available at: https://en.wikipedia.org/wiki/Steering\_ratio.

Video courtesy of UAE ROAD TRIPS:

[Al Garhoud Bridge | DUBAI ROAD TRIPS | DUBAI ROAD VIDEO | DUBAI CAR DRIVING - YouTube](https://www.youtube.com/watch?v=QSoZTYy-gBk&ab_channel=UAEROADTRIPS)