Problem 1 Link : https://drive.google.com/file/d/1rsJ9K79hTj63KE5RhqdHYWUIXj59j6jN/view?usp=sharing
Problem 2 Link : https://drive.google.com/file/d/1eve-Hbd8eqjwKqRfBOJ3NEe8DpY0Q5Qv/view?usp=sharing

Problem 1 : https://youtu.be/Nu34pACOJnA
Problem 2 : https://youtu.be/2j9vNFaDJGE
Problem 3 : https://youtu.be/nHTj2jjW5tg

ENPM673 Project 2

A. Your understanding of homography and how it is used
Homography gives the relation between two different sets of points.It is used to transform one set of points to another using the Homography matrix.Any two perspectives of the same image are related to each other and can be transformed to either perspective by using the calculated Homography. Thus, we can say that we can transform an image from one point of view to another by using the concept of Homography.

To use homography, we need at least four corresponding points from both perspectives. We then calculate the Homography matrix, which is a 3x3 matrix, using these points. Now, we can transform the second image with respect to the first image by simply multiplying the coordinates from the first image with the Homography matrix. Here, we take the coordinates in [X,Y,Z] format where Z is always equal to 1.

The homography is used in third problem to get the bird view of the lane.For homography we need 4 points which are selected as 4 corner points of the lane image which are warped to get the bird's view image using Homography.

B. Your understanding of how HoughLines work
Hough Line Transform is a transform used to detect straight lines.The Hough Transform is a popular technique to detect any shape, if you can represent that shape in a mathematical form. It can detect the shape even if it is broken or distorted a little bit.A line can be represented as $y=mx+c$ or in a parametric form, as $\rho=x\cos\theta+y\sin\theta$ where ρ is the perpendicular distance from the origin to the line, and θ is the angle formed by this perpendicular line and the horizontal axis measured in counter-clockwise.So if the line is passing below the origin, it will have a positive rho and an angle less than 180. If it is going above the origin, instead of taking an angle greater than 180, the angle is taken less than 180, and rho is taken negative. Any vertical line will have 0 degree and horizontal lines will have 90 degree.Any line can be represented in these two terms, (ρ,θ). So first it creates a 2D array or accumulator (to hold the values of the two parameters) and it is set to 0 initially. Let rows denote the ρ and columns denote the θ. Size of the array depends on the accuracy you need. Suppose you want the accuracy of angles to be 1 degree, you will need 180 columns. For ρ, the maximum distance possible is the diagonal length of the image. So taking one pixel accuracy, the number of rows can be the diagonal length of the image.

Consider a 100x100 image with a horizontal line in the middle. Take the first point of the line. You know it's (x,y) values. Now in the line equation, put the values $\theta=0,1,2,....,180$ and check the ρ you get. For every (ρ,θ) pair, you increment the value by one in our accumulator in its corresponding (ρ,θ) cells. So now in the accumulator, the cell (50,90) = 1 along with some other cells.

In the second problem to detect straight lines Hough line transform is used.By applying Hough line transform we get all the lines in the image and the start and end points of each line. These lines are used to differentiate between solid and dashed lines.

C. How likely you think your pipeline will generalize to other similar videos.
The pipeline that is explained below will work for other videos as well to detect the turn and classify the lanes.For getting the lanes and classifying them Hough line transform is used and the length of the lines is used to differentiate these lines.For turn prediction the left and right lane points are found out and the lane center points are calculated to compare them with image center points to detect the turn.They are certain difficulties that I faced for example in third problem there is issue when there is shadow the lanes are detected hence I tried to use prediction from previous frames of the lane using the slope of the line since the lane is same the slope of the line remains almost constant.

Problem 1
Steps to solve the problem

A. Histogram Equalization

1. Split the image into Red, Green and Blue color channels.
2. Create 256 histogram bins and get the number of pixels for respective intensity value and assign them the corresponding them that bin of the histogram.
3. Calculate the Cumulative frequency Distribution(CDF) for each bin of the histogram.
4. Calculate the new intensity of each pixel of the image by checking to which bin of the histogram it belongs.The new intensity value of that pixel is 256 x CFD.
5. The same process is followed on the rest of the color channels and all the results are merged to get the final output which is histogram equalized image.

B. Adaptive Histogram Equalization.

1. Divide the image into 8x8 tiles(64 in total)
2. Apply contrast limiting by applying clipping on the histogram so that all the values remain below a certain threshold(40).Evenly distribute the pixel count to all the bins of the histogram.
3. Apply histogram equalization on the tile.
4. Same procedure is applied on all the tiles and after combining all the outputs we get the final output of histogram equalized image.

Normal Video Frame

Histogram Equalization frame output

Adaptive Histogram Equalization frame output

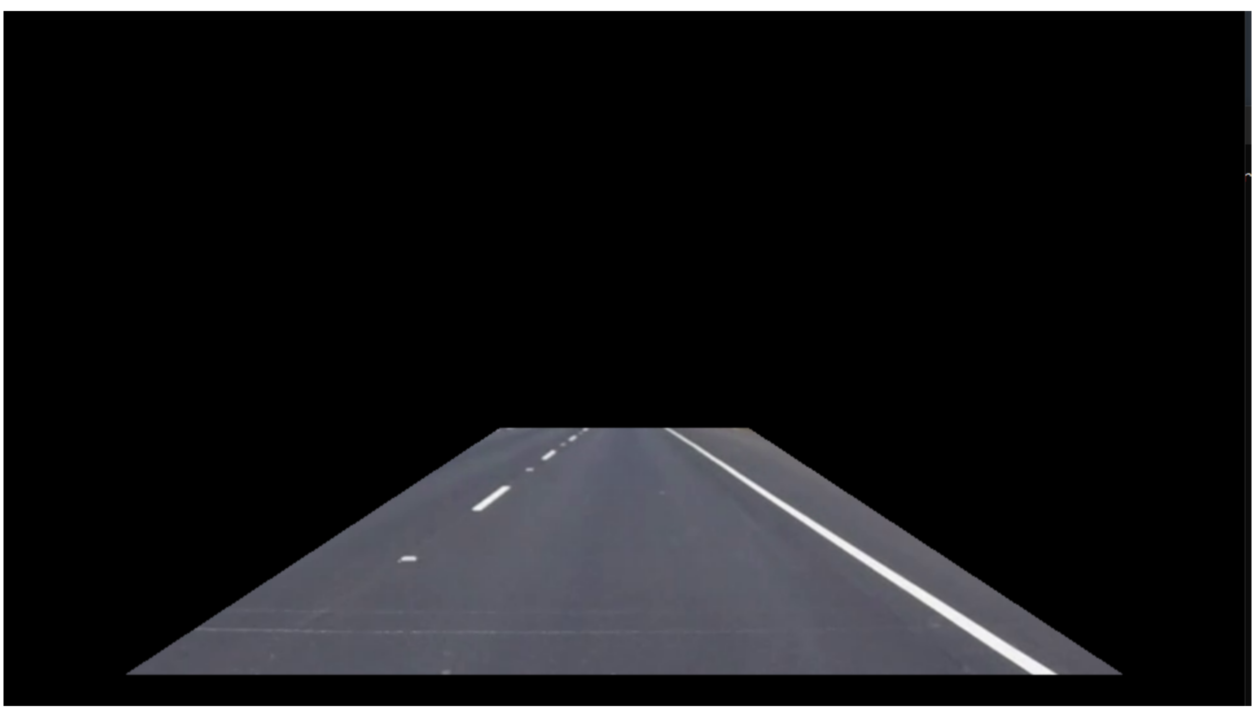
Problem 2 :

Steps to solve the problem :

1. Read the video frame by frame.
2. Extract the region of interest to cover the lanes in it.
3. Preprocess the image by thresholding the image
4. Apply cv2.HoughLinesP to get the detect the lines in the image.

5. The line points are divided into left points and right points depending on their x coordinates.
6. Average length of each line in the left and right half is calculated.If the average length is larger then it is a continuous(solid) line otherwise it is a dashed line.
7. Highlight the dashed and solid line with red and green color.

Normal video frame



Region of Interest

Thresholded Image of Region of interest

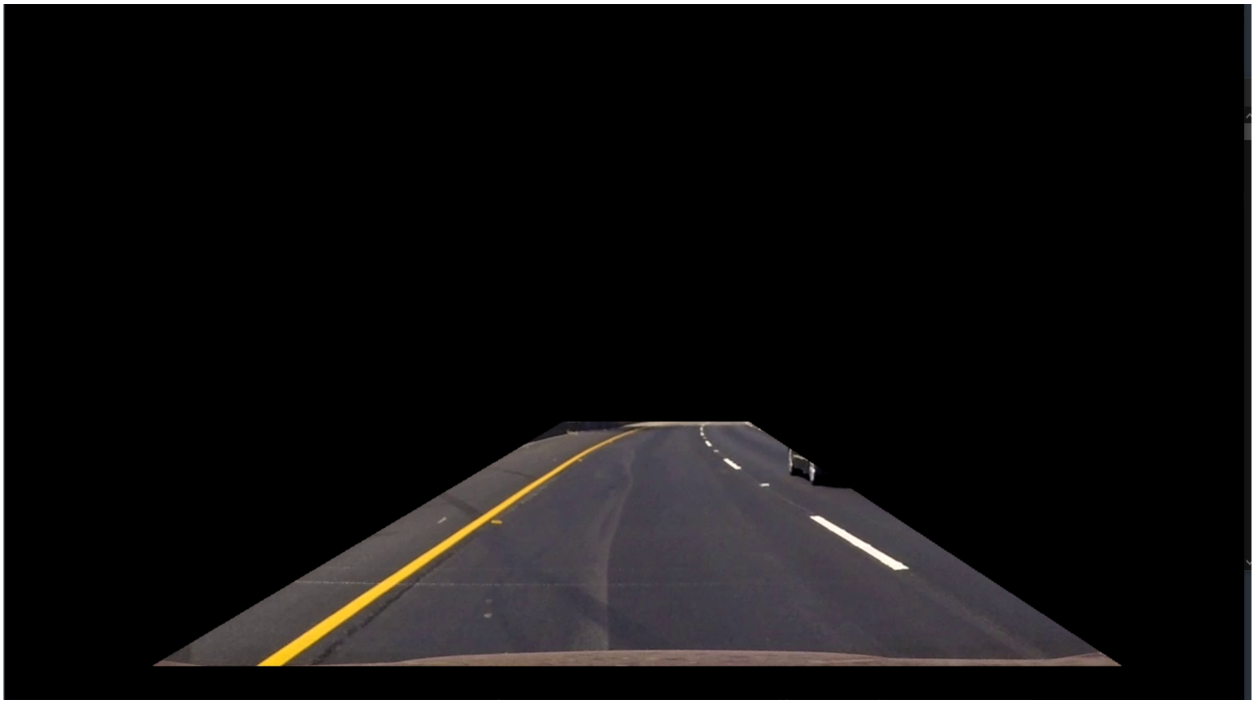
Output showing the lane detection

Problem 3

Steps to solve the problem :

1. Read the video frame by frame
2. Extract the region of interest (ROI) such that we can cover both the lanes in our ROI.
3. Preprocess the image by applying the threshold and by applying the histogram equalization on it.
4. Get the bird's view of the ROI by selecting the 4 corner points and finding out the homography.The homography matrix is used to warp the image of ROI and bird's view image output of the lane is created.
5. Preprocess the bird's view image (warped image) of the lane.Find out the corner points of the warped image of the lanes.Divide the points into left half and right half according to their x coordinate.
6. Fit these points to get the equation of the curve of the lanes.Fit the y coordinates of the image into these equations to get the points which lie on the lanes in the image.
7. Calculate the radius of curvature of the left, right lane and the center points.
8. Lane center was calculated using the points of the right and left lane.The difference between the lane center and image center was calculated.Depending on whether the difference is less than or greater than zero the turn of car is decided.
9. The warped image is retrieved back into its original form by applying inverse of the homography that we calculated in the previous step.
10. The retrieved image is blended back with the original image by stitching it onto the original image.
11. Create an interface to show different outputs.

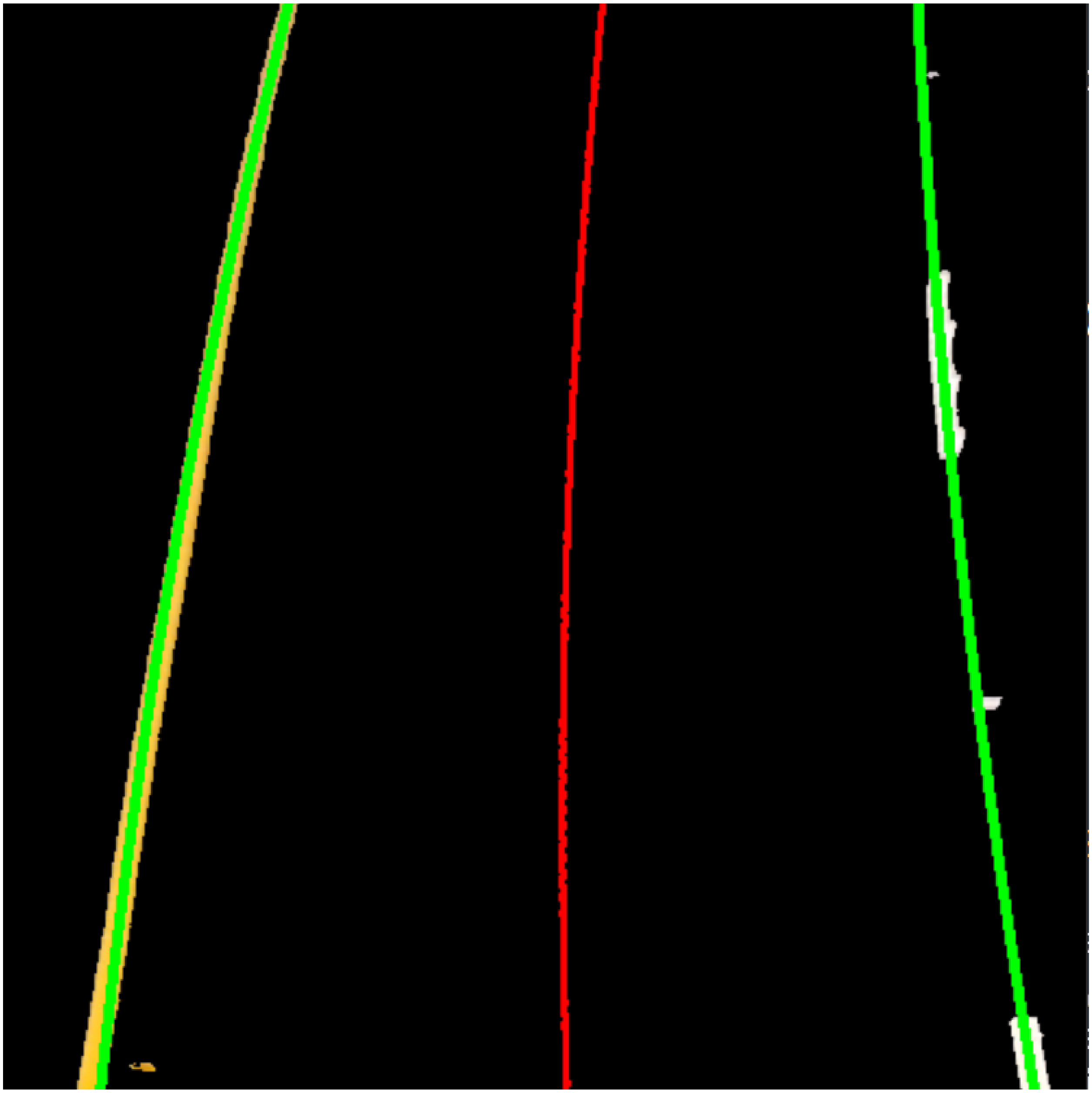
Frame of Video 3



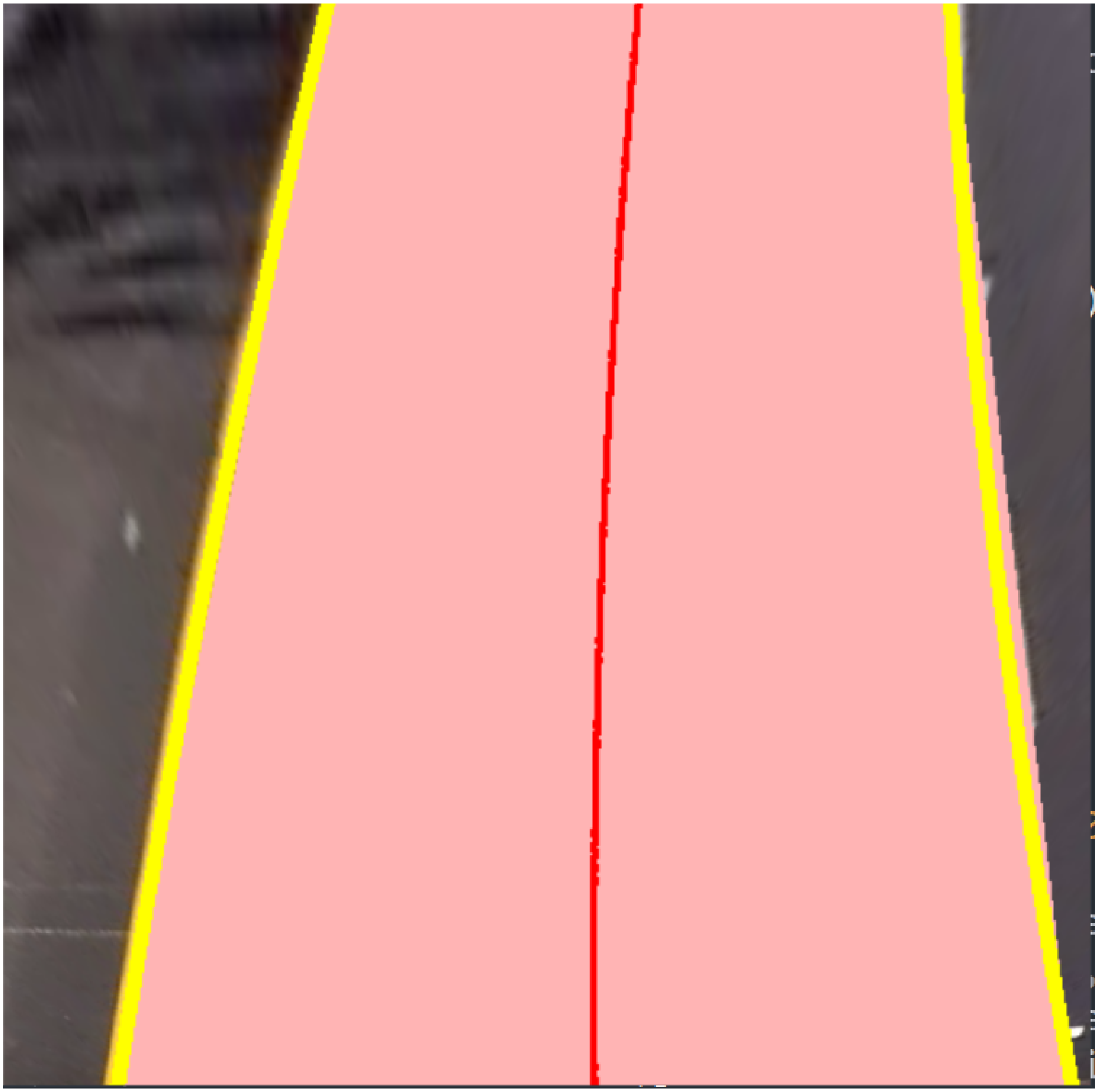
Region of interest for video 3

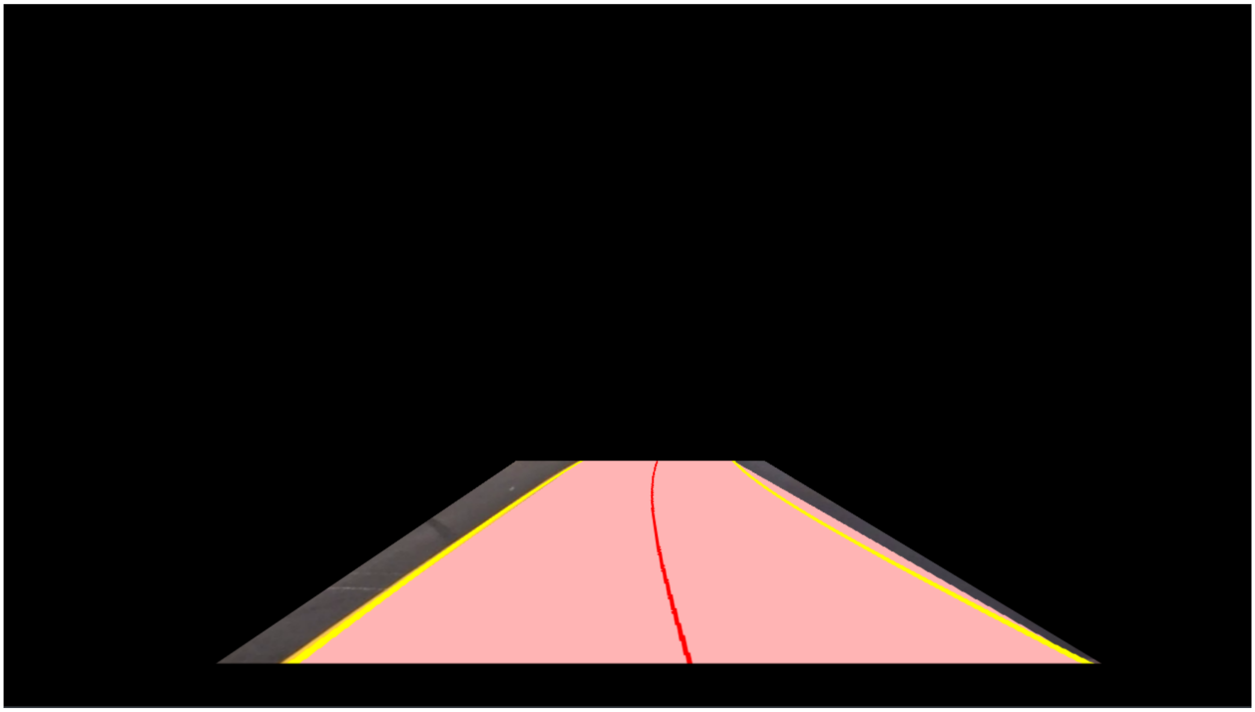
Thresholded image of region of interest of video 3

Bird view (Warped Image)

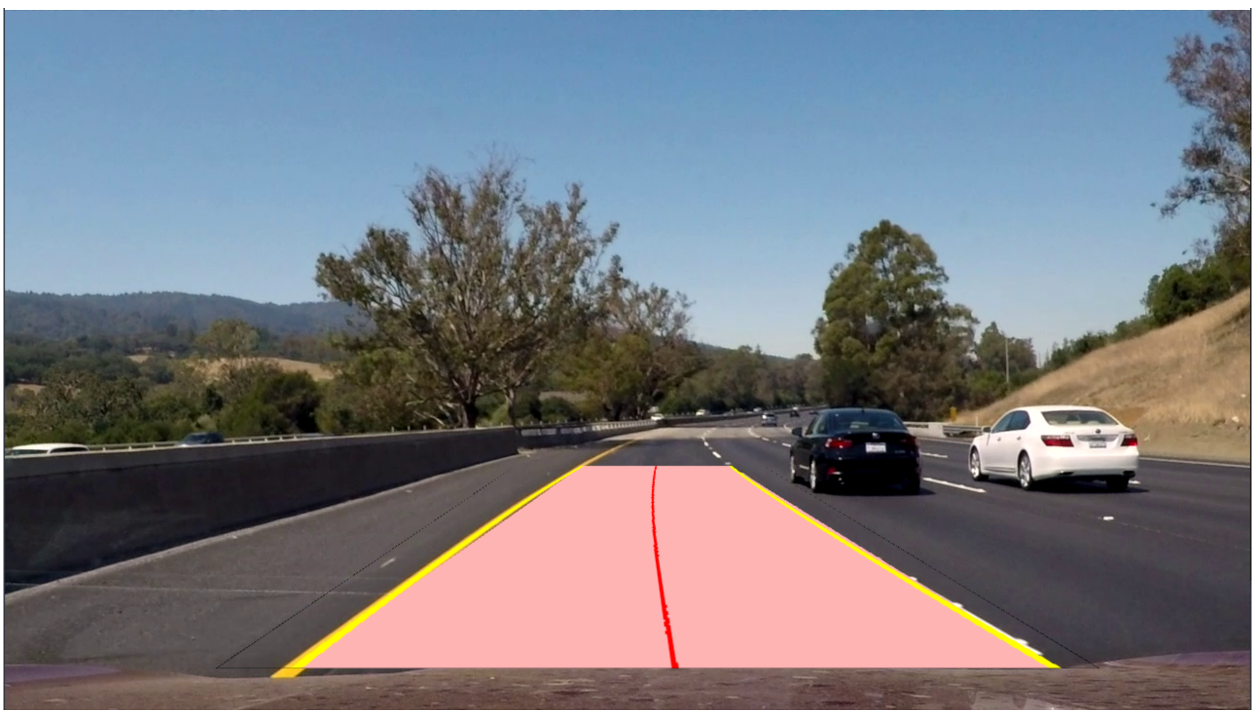


Detected lanes in the warped image


Points between lane filled in a warped image.



Retrieved Image from bird view of lane



Blended image of lane with original image

Output of turn detection