Project 2 Report

ENPM 673: Perception for Autonomous Robots

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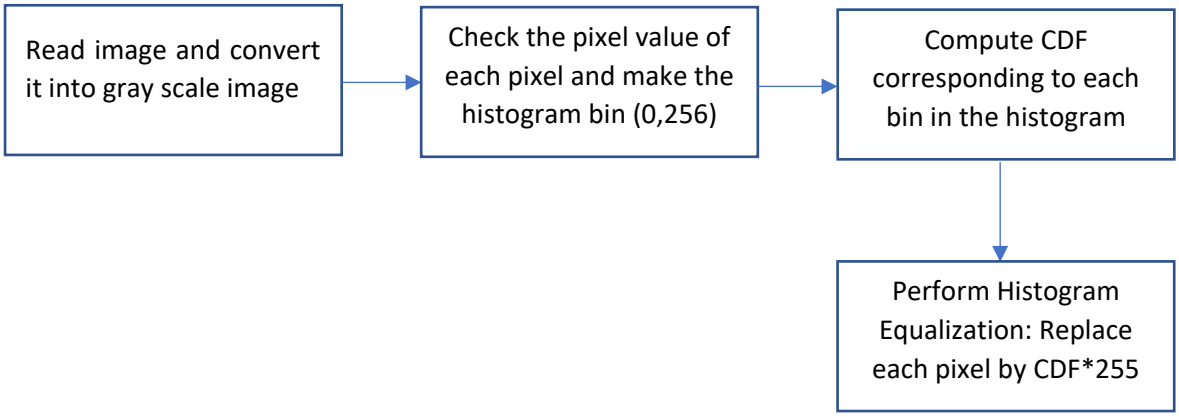
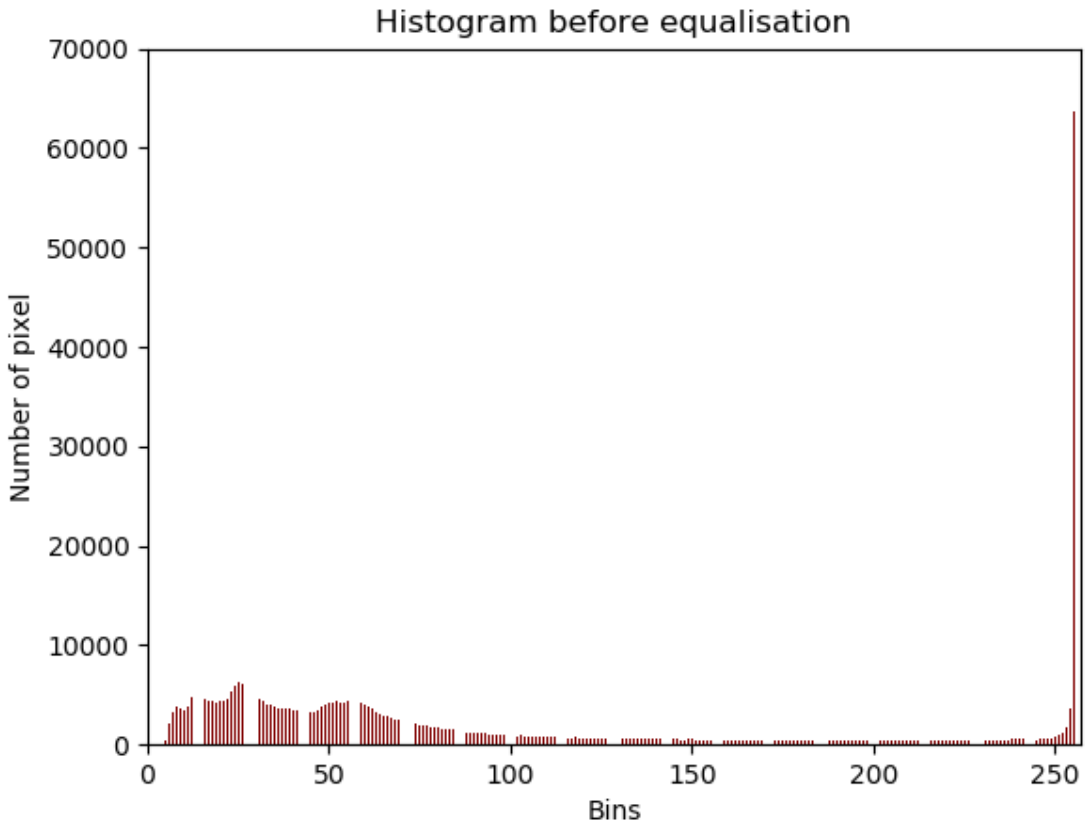
Question 1a:

Block Diagram:

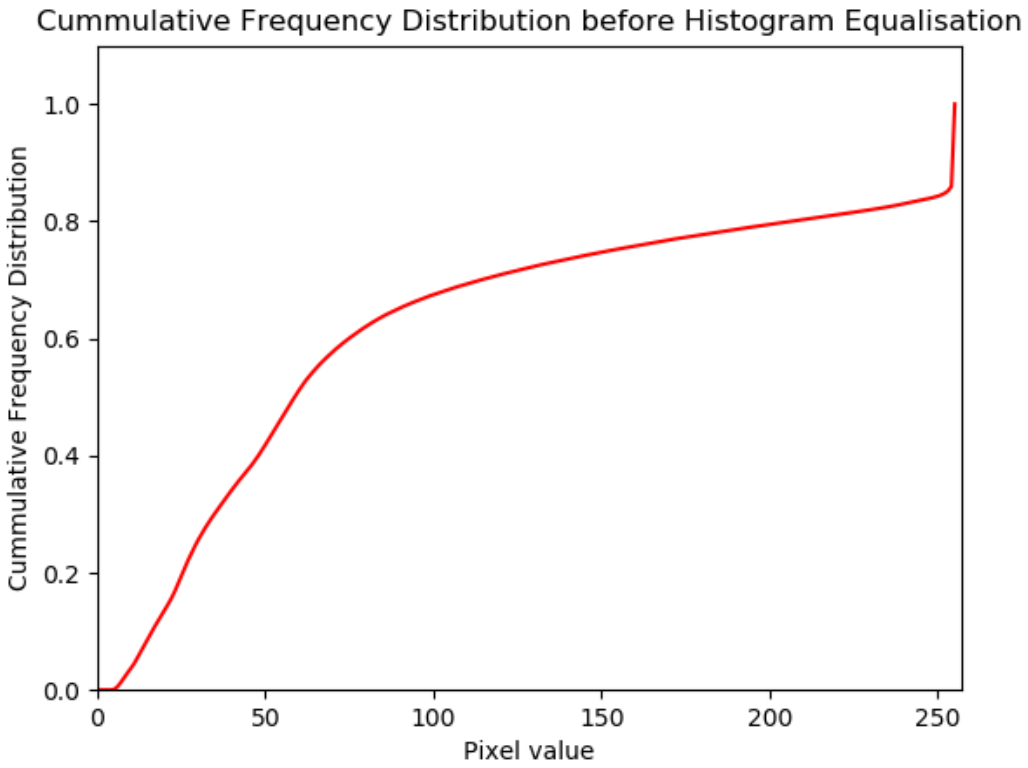


Result:

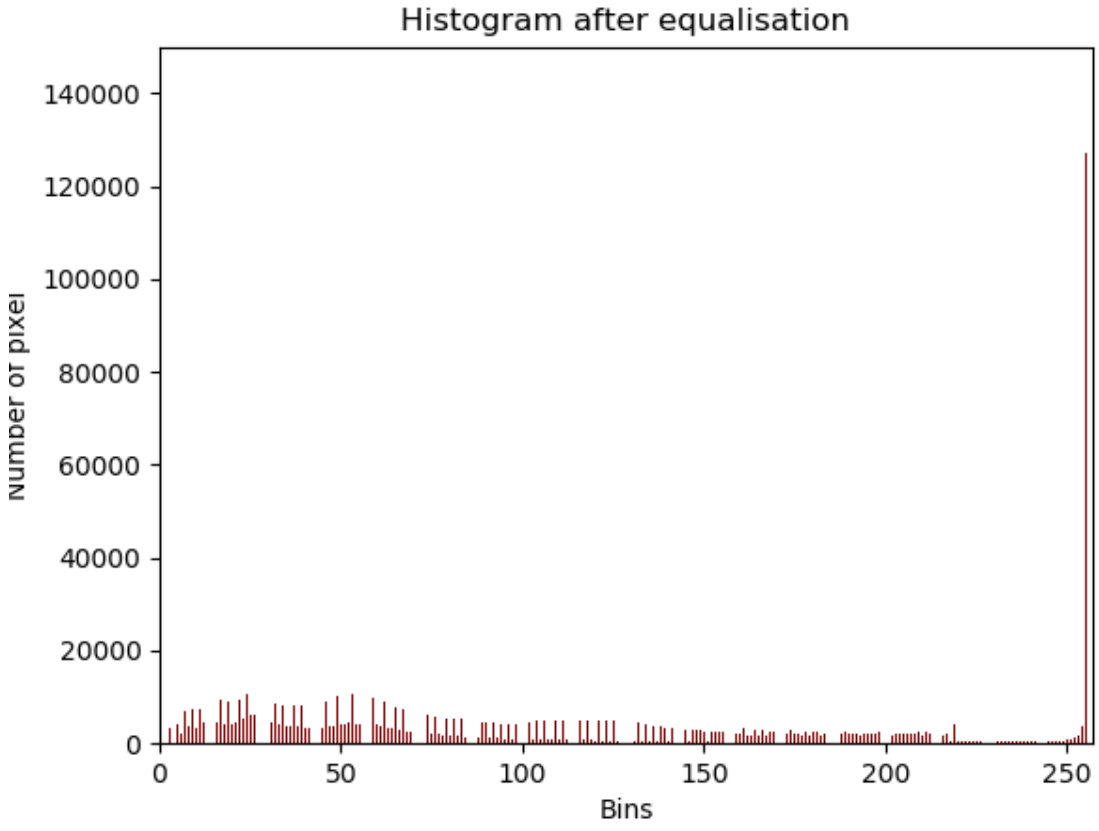
1. Histogram before Equalization:



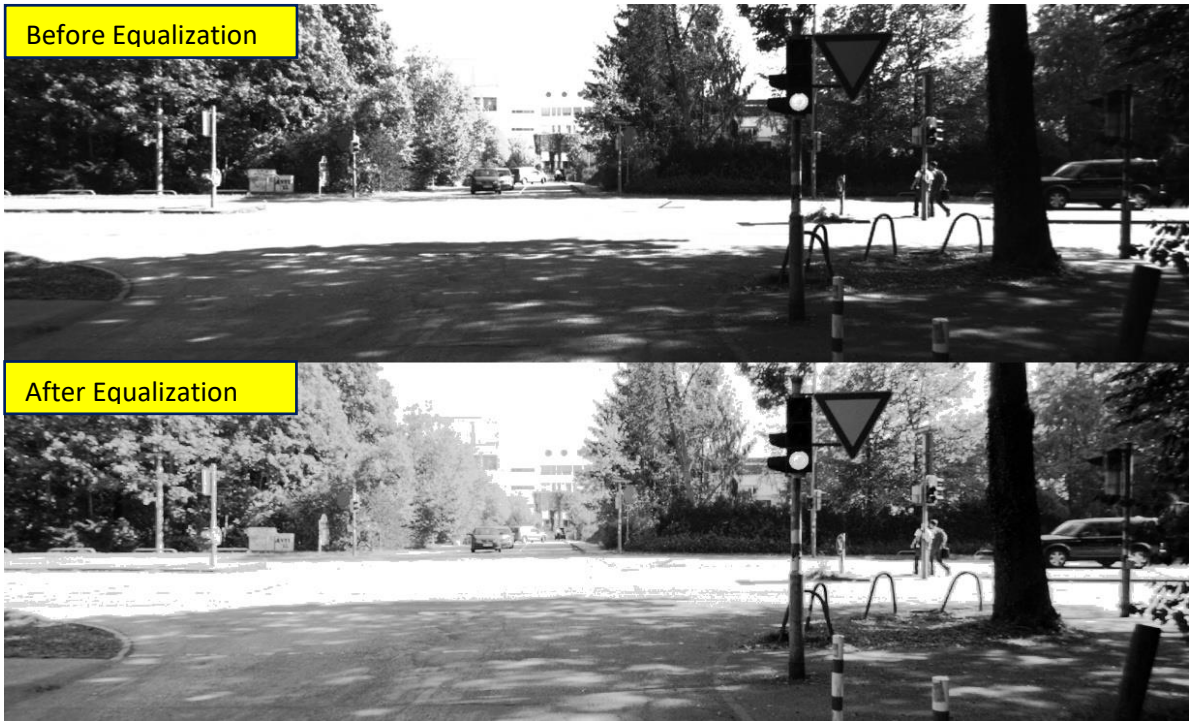
2. Cumulative Distribution Function:



3. Histogram After Equalization:



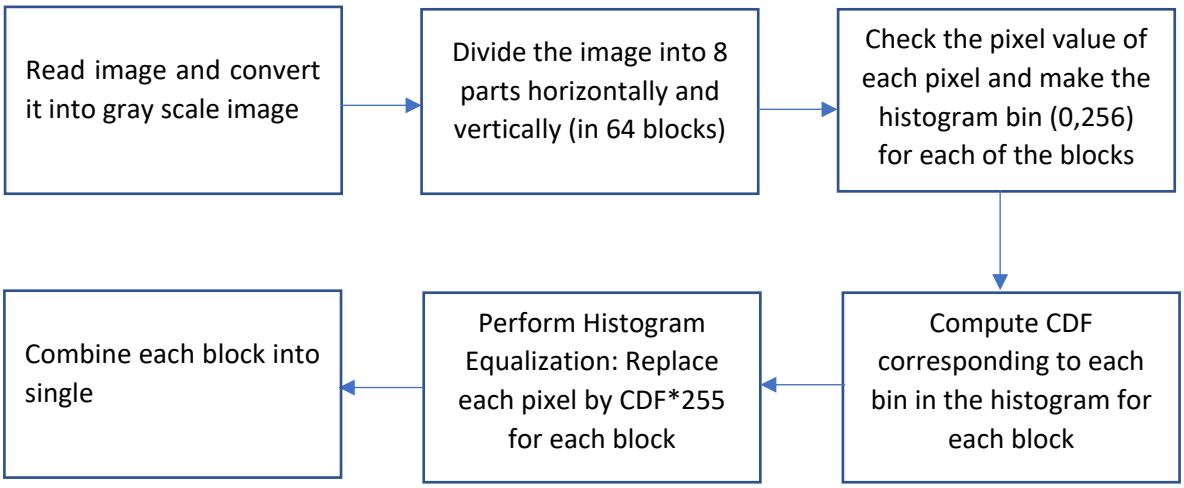
4. Output image:



5. Video Link: https://youtu.be/h418o2JIkBY

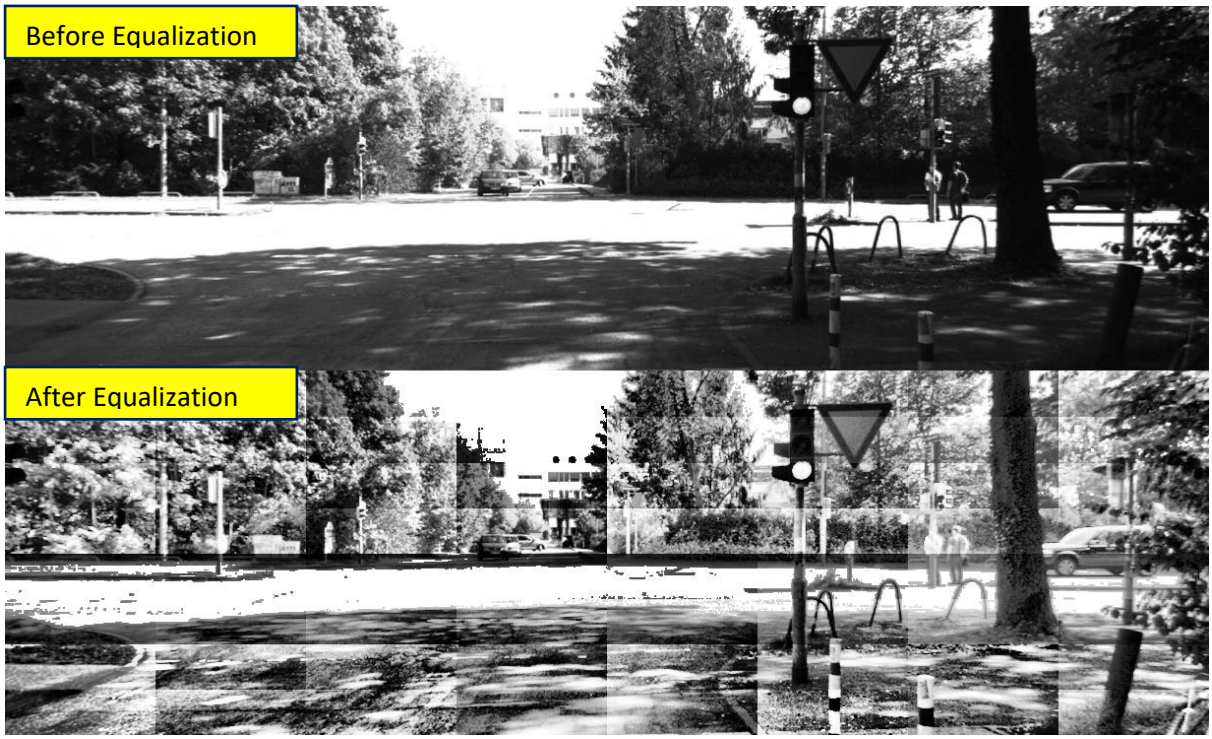
Question 1b:

Block Diagram:



Result:

1. Output Image



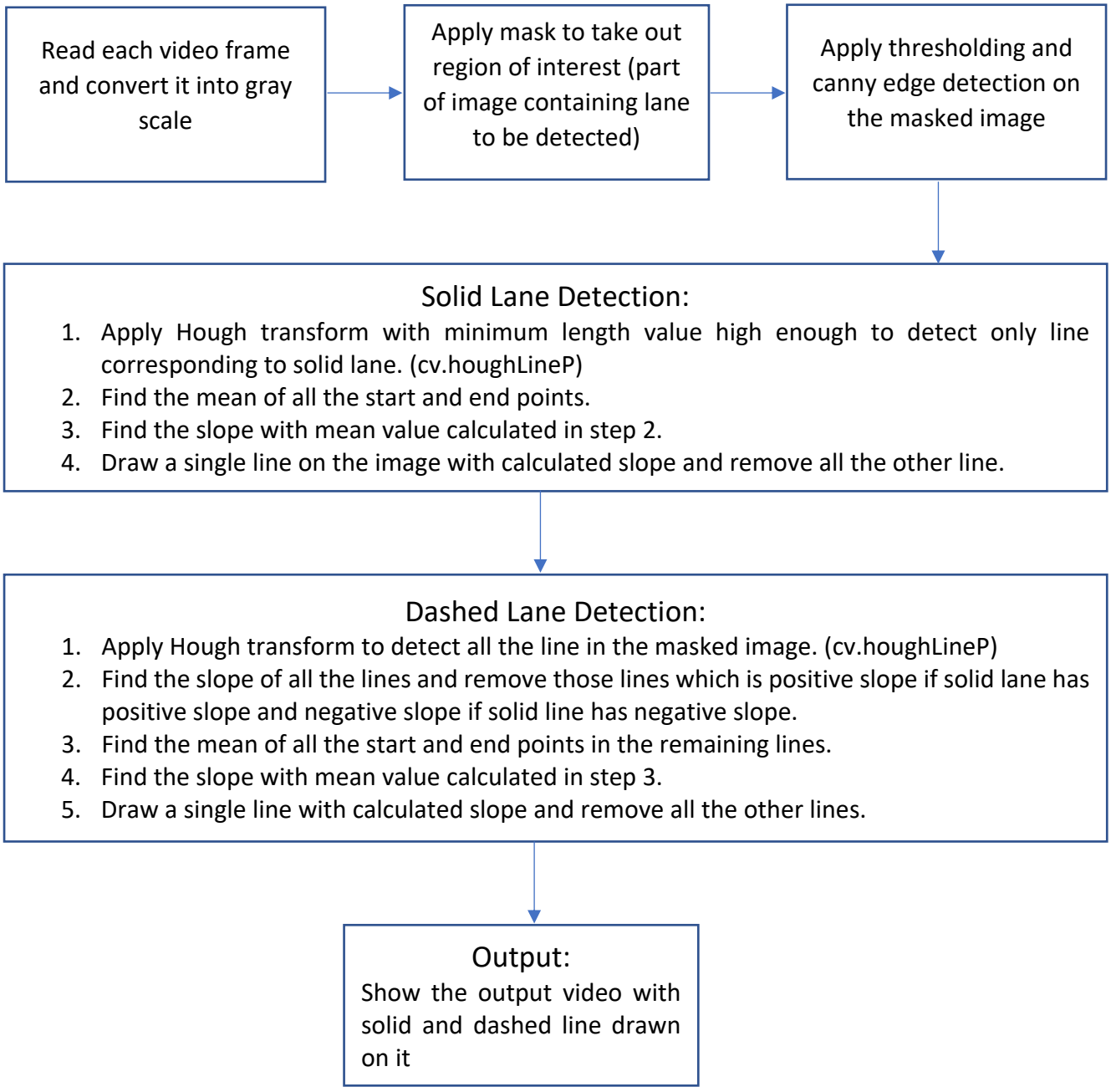
2. Video Link: https://youtu.be/QuaeNFejO6Y

Comparison of Histogram and adaptive histogram:

Histogram considered overall brightness of the image for equalization while adaptive histogram considered brightness of a window surrounding the pixel. Hence, adaptive histogram performed better than normal histogram if it is followed by subsequent image processing such as image blending or pixel intensity interpolation at the boundary of the window.

Question 2:

Block Diagram:



How Generalize the Solution is?:

The solution will work in the image that satisfies the following scenario:

1. One line should be solid, and another should be dashed irrespective of the left or right position.

2. The shade of the color of the road should not be significantly different than the given shade.
3. Field of view and direction of view of the video should not be significantly different from the given video.

Result:

1. Output

2. Video Link: https://youtu.be/-cTdaXYeGYA

Hough Transform:

One of the problems with boundary detection is knowing which edge corresponds to the boundary. If we know that, then half the problem would be solved. Hough Transform gives were powerful and elegant ways to solve this problem when the boundary can be described using a small number of parameters.

Problem with boundary detection:

1. Extraneous data: Which points to fits to?
2. Incomplete data: Only part of the model is visible
3. Noise

Hough Transform is an algorithmic approach to solve the above issue for simple shapes.

Consider the following equation of line:

$$y = mx + c$$

The same equation can be written as:

$$c = -mx + y$$

This is a straight-line equation in x and y.

This allows us to see the problem in two spaces: Image space and parameter space.

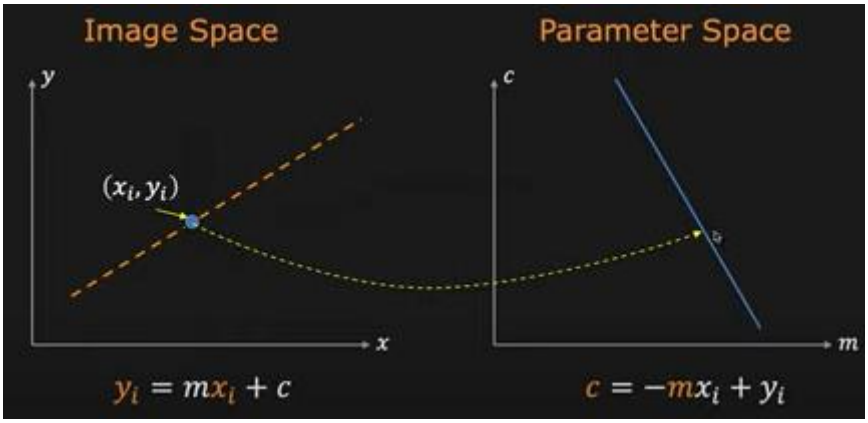


Fig 1

As shown in the figure, points in the image space are corresponding to the line in the parameter space and vice versa. All the points lie on line in parameter space represent different lines passing though the points (x_i, y_i) in the image space.

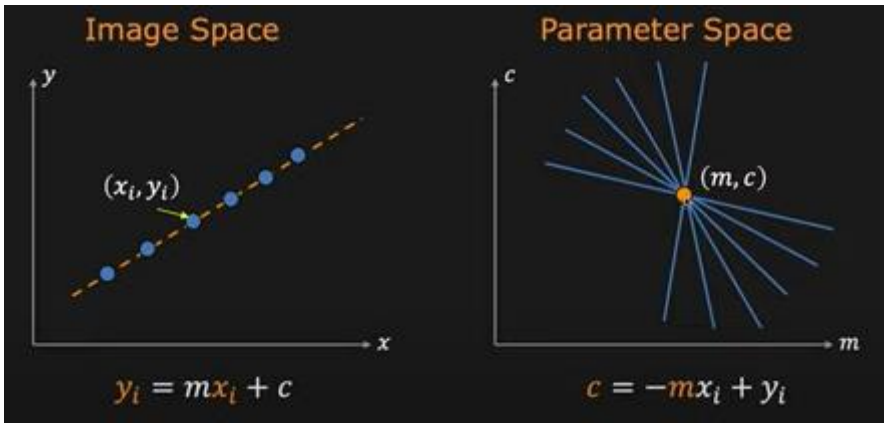


Fig 2

Now, if you take more points on image space as shown fig 2, it represents a different line in the parameter space. However, all the lines in parameter space are passing through the common points (m,c) which represent the line passing through all the points in image space.

We can decide the voting scheme for each points in the parameter space to decide whether it represent the line or not. In this way, it is possible to find all the lines in the image space.

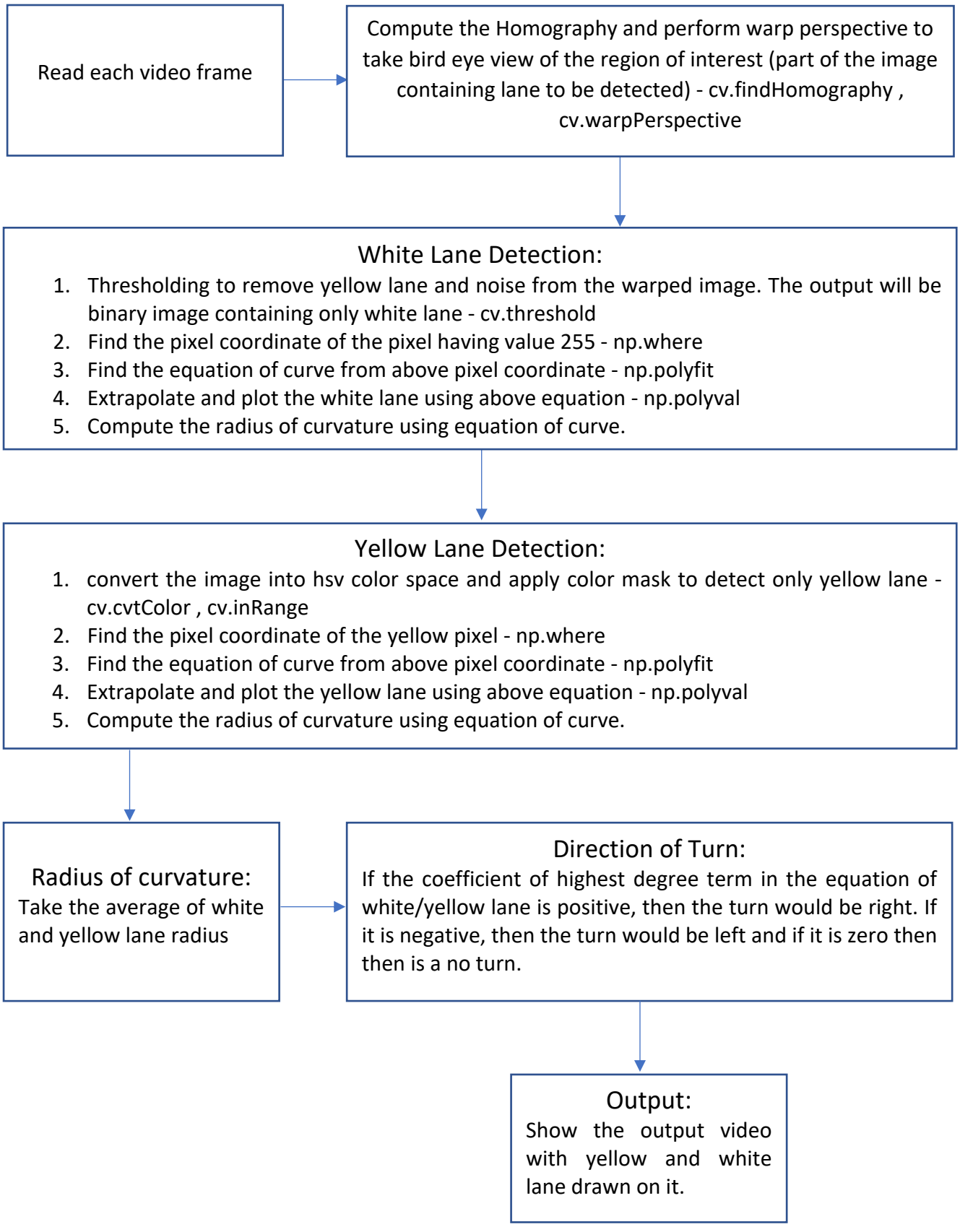
In general, it is possible to detect all the shapes that can be represented by a few numbers of parameters (i.e Line, Triangle, Rectangle, Square etc..) in image space using Hough Transform.

Use of Hough Transform in Problem 2:

Hough Transform has been used in problem 2 to detect the boundary of the lane. The boundary of the lane can be represented by a straight line. After necessary pre-processing of the image, Hough transform is applied with the necessary voting scheme to detect solid and dashed lines.

Question 3:

Block Diagram:



How Generalize the Solution is?:

The solution will work in the image that satisfy following scenario:

1. One line should be yellow, and another should be white irrespective of the left or right position or whether they are solid or dashed or whether they are curved or straight.
2. Field of view and direction of view of the video should not be significantly different than given video.

Result:

1. Output:

2. Video Link: https://youtu.be/ooSzU3RmF-c

Homography:

Homography is one of the very fundamental tools used in computer vision to achieve image transformation. It is used to transform an image from one coordinate frame to another coordinate frame. It uses the matrix to compute the transformation. From an image point of view, it produced the image as if it were taken from different viewpoints.

To compute homography between two images, it is necessary to have at least 4 matching points. Matching points can be found using SIFT transformation or any other feature detector.

Homography is valid in the following scenario:

1. All the images are captured from the same viewpoints.
2. If the image if a plane in the 3D space.

3. Scene is very far away from the camera

Uses of homography are as follows:

1. Image stitching to create a panorama from multiple images
2. Visual odometry
3. Change the perspective of the image

Use of Homography in Problem 3:

Homography is used to take a bird's eye view of the lane to detect the lane and to find the radius of curvature. To take a bird's eye view, a mask has been applied to the original image, and the masked image is warped into a blank image using homography. Corner points of mask and blank image are used as corresponds to compute homography matrix.