ENPM673 - Perception for Autonomous Robots

Project 2

Submitted by:

Raj Shinde (raj0407)	116852104
Shubham Sonawane (shubhams)	116808996
Prasheel Renkuntla (prasheel)	116925570

Contents

1 Problem 1 - Video Enhancement

The task of this problem is to improve the quality of Video sequence of the Night Drive for a car. The lighting conditions are poor and the lanes, sign boards are not visible for a normal RGB camera.

The pipeline used here in this part of the project is as follows-

- Read individual frames
- Convert to LAB color space
- Apply Contrast limited Adaptive Histogram Equalisation
- Convert back to BGR color space
- Get the median blur of the current frame
- Apply a sharpness filter

The night drive video has very dark frames when read individually which does not give any significant information. A way to overcome this problem is by increasing the contrast of the image which is achieved by the use of Contrast Limited Adaptive Histogram Equalisation (CLAHE) [1]. We apply this technique on the lightness L channel of the LAB color space. The usual Histogram equalisation too, does not work very well for this case. Hence, we chose an advance version of it, called CLAHE which is a variant of adaptive histogram equalisation. Here, there is a limitation to the contrast amplification. It is better than an ordinary AHE that will amplify even in the presence of noise.

Figure 1: Original Frame

Figure 2: CLAHE Output

Figure 3: Final output after sharpening

Figure 4: Final output after sharpening

2 Problem 2

2.1 Problem 2(a) - Data 1

For this part, we have been provided with frames of a video. The objective is to develop a lane detection system. We combined the frames to generate a video, which is being used further in the pipeline. Since the camera remains in the same position throughout the video, with little or no movement, one particular frame is selected from the given frames. This frame acts as the basis frame for calculating the homography.

Using the camera parameters, the video frame is undistorted. The points for homography were selected such that at least 2 white lanes on the left side are included. The points circled in red are selected for the homography estimation, shown below:

Figure 5: Homography estimation points

The image is then warped, thereby giving us an image where the lanes are parallel. With this image, we apply the further pipeline. The warped image is then converted to grayscale. In order to improve the contrast of the white lane lines, the gray image is darkened using gamma correction. This method works well for images having white lines. In case of yellow lines, the thresholding needs to be done in the HLS image.

Canny edge detection is then applied on the darkened image, thereby giving edges where the lanes are present.

Using the canny edge detection image, hough lines are detected for the frame. Initially, we were printing all the hough lines that were being detected. This however was not an efficient approach as the small lines were being drawn, which were unnecessary.

Figure 6: Warped image

Figure 7: Darkened Grayscale

To solve this problem, we averaged the lines on the left and right (seperately) to develop just one line on the right and one on the left.

Another advantage of first warping and then applying hough lines was that we were able to eliminate the lines that did not belong to the lanes.

While calculating the average lines, we also removed the outliers that were being detected by the hough transform. We removed the points that were beyond 2 standard deviations of the mean of the data. This improved the resulting average lines.

All these processing was being done on the warped image, where we are looking at the lanes from the birds-eye view. In order to project this image on the actual video frames, we perform inverse warping on to the frames. After the inverse warping, the

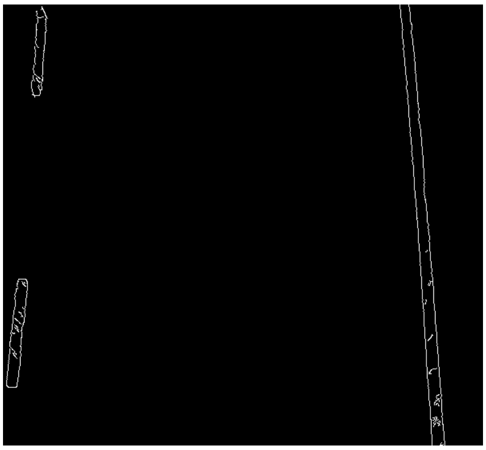

Figure 8: Canny edge detection

lanes are detected in the actual video frames.

Since the video data presented to us here does not have any turns, we detect the position of the car with respect to the center of the road.

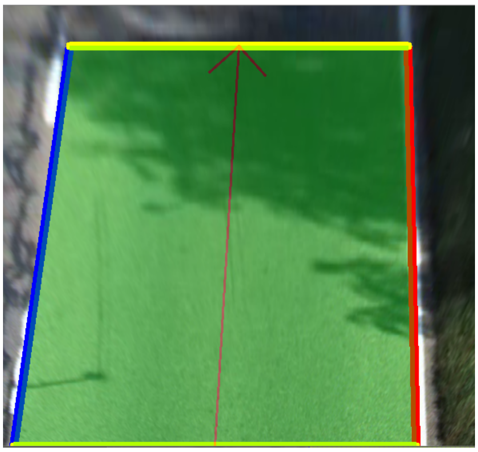

Figure 9: Lane detection on warped image

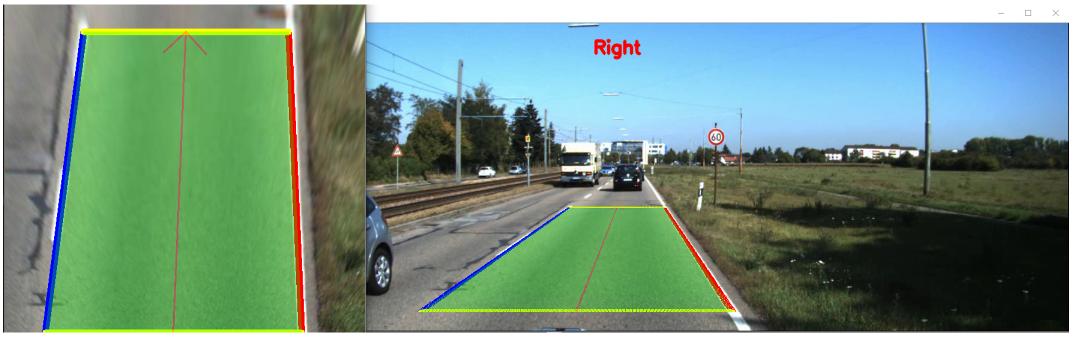

Figure 10: Lane detection on video frame

Problems faced:

1. After inverse warping on the video frame, we observed that the aliasing effect of the polygon between the lanes was noticeable. Increasing the image size of warped image solved this issue.

2.2 Problem 2(b)

In this part a video is provided with various challenges like a curved road, shadows caused by bridge and breakage in lanes-lines.
To tackle these challenges we decided to use the histogram of lanes approach instead of Hough transform approach. The reason for not using Hough transform is because it doesn't work well at turns. After deciding the approach, we started implementing our algorithm.
We started by undistorting the video with the help of the provided camera matrix and further converting the video from RGB Colour space to HLS Colour space, this made it easy to differentiate colours and select only the colours present within the lane-lines.

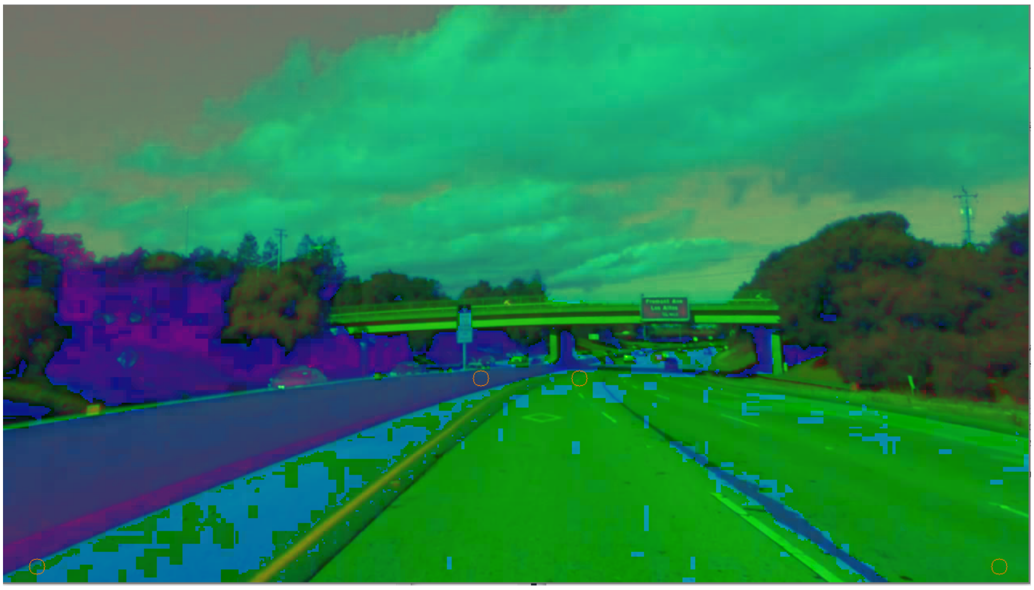

Figure 11: Video in HLS Colour space

After the video was brought into HLS Colour space, two mask were created to filter out the yellow and white lanes. Then these two masks with the lane-lines were processed using morphological operators viz. Dilation, Erosion, Opening and Closing to filter out the unwanted pixels in foreground and background and also to increase/decrease the thickness of the lanes-lines. In the end both the masks were added using bit-wise OR function, Now the image obtained was a binary image containing both the lane-lines.

Figure 12: bit-wised OR'd masks

Homography was then performed on the image obtained in the previous step, to get a two view of the binary image containing both the lanes-lines. The points for Homography Matrix were selected by doing visual inspection of the video, with frame having straight road. This matrix was then used to warp the image to a new plane.
As now we had the top view of the lanes, we then used the histogram of lanes

Figure 13: Homography on bit-wised OR'd masks

method to get the coordinates of the lanes-lines.

Histogram of Lanes:
First the histogram of lanes along the width was found, in which the peaks represented the left and the right lanes-lines. The position of these peaks were stored

as start points for left and right lane and then were used to track the lanes-lines in upward direction in each frame, using a sliding window approach. Everytime the window is slided up, the position of the peak is stored in an array. This is done for both the lane-lines in each frame. The position coordinates in the array for both lane-lines are then used to plot points as well as the region between the lanes-lines with colours.

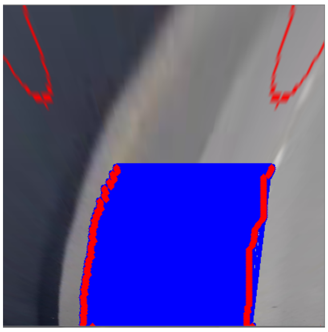

Figure 14: Lane detection on top view

The plotted points and region is then projected on the actual video frame using the same homography matrix.

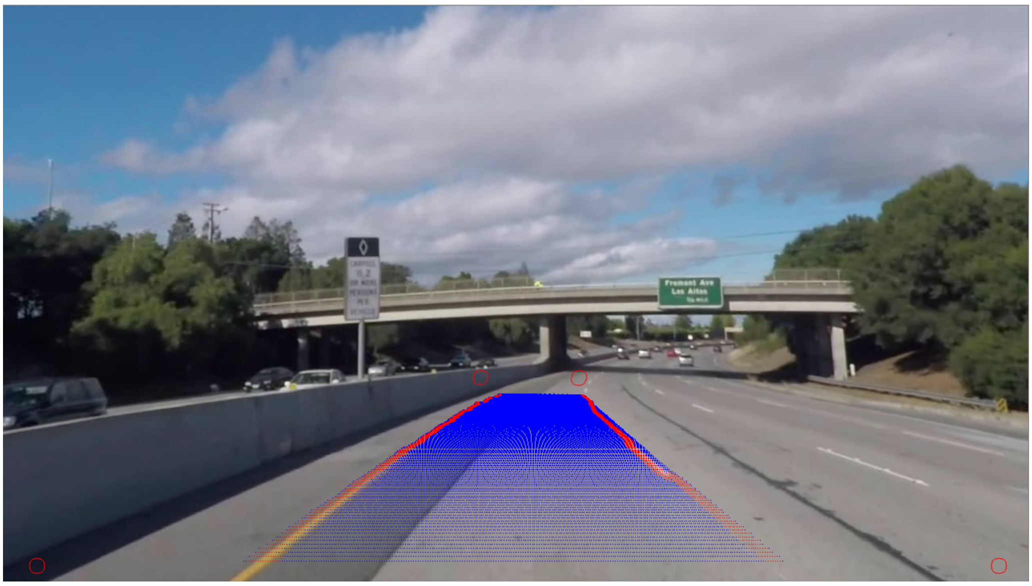

Figure 15: Projected Region between lane-lines

Turn Prediction:
The final task of this problem is to find in which the direction the car is heading. We do this by taking the points along the lane from the Histogram, using which we find the mean of first 4 points, i.e, first two points $(x_1, y_1), (x_2, y_2)$ on the left lane and the second set of points on right lane $(x_3, y_3), (x_4, y_4)$. We find the mean of these points and check with the a reference point. The reference point is at the center of the homography frame. If the mean point calculated above, lies on the right side of the center point, then the car is turning to the right and if it lies on the left side of the center point, then the car is turning to the left.

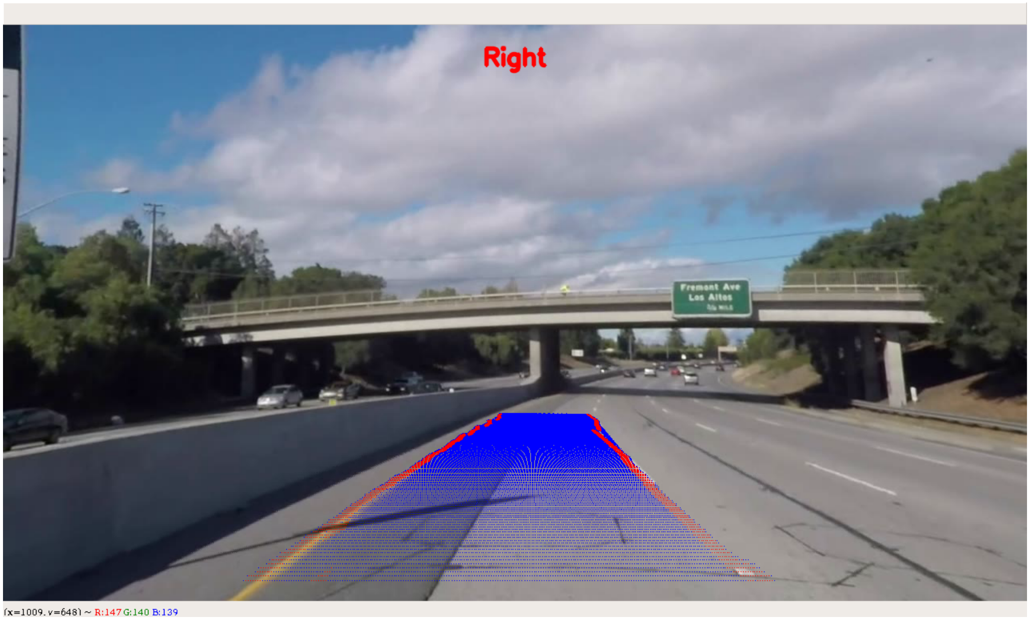

Figure 16: Final With Turn Prediction

Problems Faced:
1. It was difficult to create the masks for yellow and white lane-lines due to low saturation of colours in the video.
2. lane detection during the points where the the lane-lines break was difficult.

Bibliography

[1] Wikipedia. Contrast Limited AHE. https://en.wikipedia.org/wiki/Adaptive_histogram_equalization. Accessed: 2020 - 03 - 04.