HW1

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1 Problem 1

Given a video sequence taken in low light conditions, we look to improve its quality. We achieve this by performing Gamma Correction in the following steps:

- Images (I) are first extracted frame by frame from a video.
- Each pixel is then scaled from a range of [0, 255] to [0,1].
- Gamma-corrected image is then given by:

$$O = I^{1/G}, \tag{1}$$

  where, $G = 2$ is the gamma value we choose.
- The resultant image O is scaled back to range [0,255].
- We note that if $G > 1$, the image is brightened and when $G < 1$, the image is darkened. While testing, we found $G = 2$ to be optimal.

A sample output at a particular timestep is shown in figure 1.

(a) Before Correction

(b) After Correction

Figure 1: Enhancing the output of the low light video using Gamma Correction. Observe the significant improvement in the visibility of the road.

2 Problem 2

2.0.1 Finding the Lanes of the Road

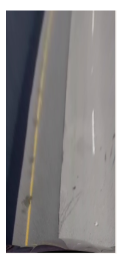
For this problem, given a video of a car driving on a freeway, we want to extract its lanes, and use that information for determining the curvature of the upcoming road.

In order to do this, we first undistort the image using the camera calibration matrix K and the undistortion coefficients provided. Then, we project images of the road extracted from the video to obtain a bird's eye view of the road. This is done using homography, by taking advantage of the fact that the lane markings of the road appear to be parallel when seen from the top view.

To perform homography, we select 4 points on the lane markings, which are chosen in accordance with the center line of the lane. These points are the corner points of the projected image. The original image, the distorted image, and the projected image are shown in figure 2a, 2b and 2c.

(a) Image of the lane

(b) After Undistortion



(c) After homography

(d) Applying Canny

Figure 2: Obtaining the bird's eye view of the lane by projecting (computing homography) the lane of the road onto a predefined image window. The red marking in (b) shows the region of the road (ROI) selected for performing homography. (d) is the result of applying a Canny Edge detector on the top view obtained.

We use the *cv2.findHomography* and *cv2.warpPerspective* functions to perform this. This type of homography computed from a single view works well in this case, since we have information regarding how the final outcome should look like, i.e., we know that the lines of the lane look parallel from the top.

After finding the projection, we use a Canny edge detector to find the edges on the road. The output of this is shown in figure 2d.

We use the edge image to find lines in the image using a Hough Transform (using *cv2.HoughLines*). This gives us a lot of lines, which are then finetuned using the angle they make with the X axis. We look to obtain only almost parallel lines on the road.

The outcome of applying the Hough Transform and extrapolating selected lines is shown in figure 3a. We then take the average of all the selected Hough Lines to obtain lines representing the lanes. This is shown in figure 3b.

(a) Outcome of the Hough Transform

(b) After Averaging the Lines

Figure 3: We compute a Hough Transform on the edge image. After computing the transform, we are left with several irrelevant lines from different angles. We finetune these lines according to a constraint obtained by the fact that they should be almost parallel to each other. After this, we take the average of the pixel coordinates of each of the lines to obtain two solid lines representing the left and right lane.

2.0.2 Obtaining the Direction of the Turn

Once the left and right lines are obtained, we find the average of their slopes to obtain the direction of turning. A positive slope value indicates that the road is curving towards the right, while a negative slope value indicates that the road curves towards the left. This outcome can be seen in figure 4.

3 Conclusion and Lessons Learnt

In this project, we analyse road videos and use various computer vision techniques to extract useful information from them.
For the first part, we improve the illumination of a video taken during night time using Gamma Correction. This makes the video brighter, making objects on the road and its environment a lot more clear, which can greatly help during autonomous navigation.
For the second part, we try to detect the lane lines on the road, and use this information to predict if the road is curving towards the left or right. We do this by performing a projective transform to obtain a bird's eye view of the road in front of the car. This transform helps us identify the lane lies and using the

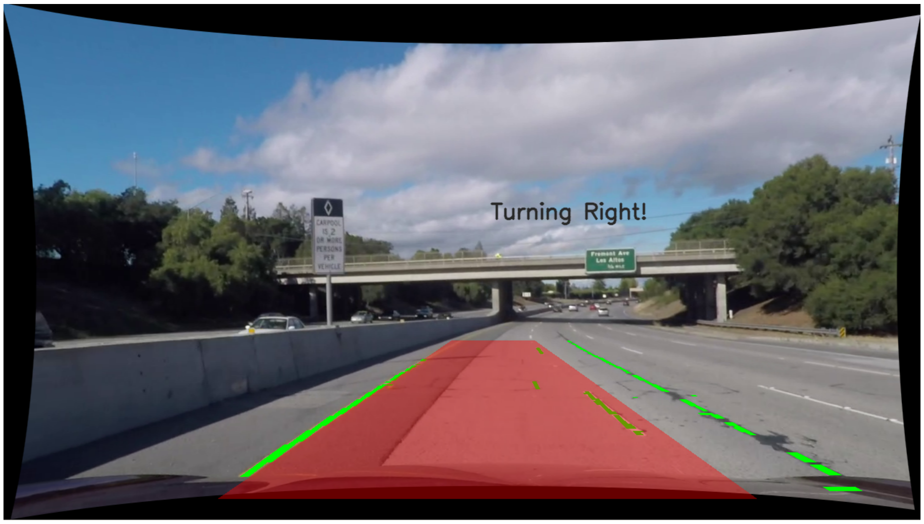


Figure 4: By taking the average of the slope of two lane lines obtained, we predict if the road is turning towards the left or the right. In this image, observe that the road turns towards the right.

slope of these lines we find the curvature of the road.
Throughout the course of this project, we learnt the following lessons:

- Hough Transforms require a lot of tuning for them to work as expected.
- It was interesting to see the application of homography on a single image, which is counter intuitive, as generally we require two frames of reference. Transforming the frame to obtain a top view of the road helped us extract edges and lines a lot easier as opposed to taking them from the front facing image.

4 Links

Problem 1:
https://youtu.be/79OiSbJDZuc

Problem 2, Image set:
https://youtu.be/jDEunWuHEAw
https://youtu.be/qZhw8iesYVw

Problem 2 challenge video:
https://youtu.be/ay9dWjfrlfc
https://youtu.be/s6dbk6HA-1Q