Project 2

Problem 1

- Approach: The first step to detect the corners was to detect the edges of the paper. For this we first convert the frames into gray scale and then use canny edge detection to get the edges. A Gaussian blur filter was added to suppress some unwanted edges like the edges generated by the keys in the frame.

  After getting the edges of the paper a accumulator was created. Then for every pixel that is not zero (i.e. the edges) in the canny frame the respective element of the accumulator is incremented.

  The accumulator is of size $((2*framediagonal), rangeof\theta)$ where ρ ranges from $-framediagonal$ to $framediagonal$ and the values of ρ and θ is calculated as follows:

  $$\rho = x \cdot cos(\theta) + y \cdot sin(\theta)$$

  Next we find the peaks in this updated accumulator matrix to get the Hough lines. The edges of the paper should produce the highest number of votes. We can then sort these peaks in reverse order to get edges of the papers. But this may return the same line with a slight offset due to the line thickness in canny edge detection. Hence we suppress the values around the peak to get one single line per edge. We get the 4 strongest peaks and their ρ and θ values to calculate their respective x and y co-ordinates in the image using the formula:

  $$x_1 = \rho \cdot cos(\theta) + \alpha \cdot (-sin(\theta))$$
  $$y_1 = \rho \cdot sin(\theta) + \alpha \cdot cos(\theta)$$
  $$x_2 = \rho \cdot cos(\theta) - \alpha \cdot (-sin(\theta))$$
  $$y_2 = \rho \cdot sin(\theta) - \alpha \cdot cos(\theta)$$

  where α is a scaling factor

  Once we have the Hough lines we can find the corner by finding the intersection points between 2 lines. We do this by the following calculations:

  $$A = \begin{bmatrix} cos(\theta_j) & sin(\theta_j) \\ cos(\theta_k) & sin(\theta_k) \end{bmatrix}$$
  $$B = \begin{bmatrix} \rho_j \\ \rho_k \end{bmatrix}$$
  $$mat = A^{-1} * B$$

  where $mat[0] and mat[1]$ are the x and y co-ordinates of the corners.

Project 2

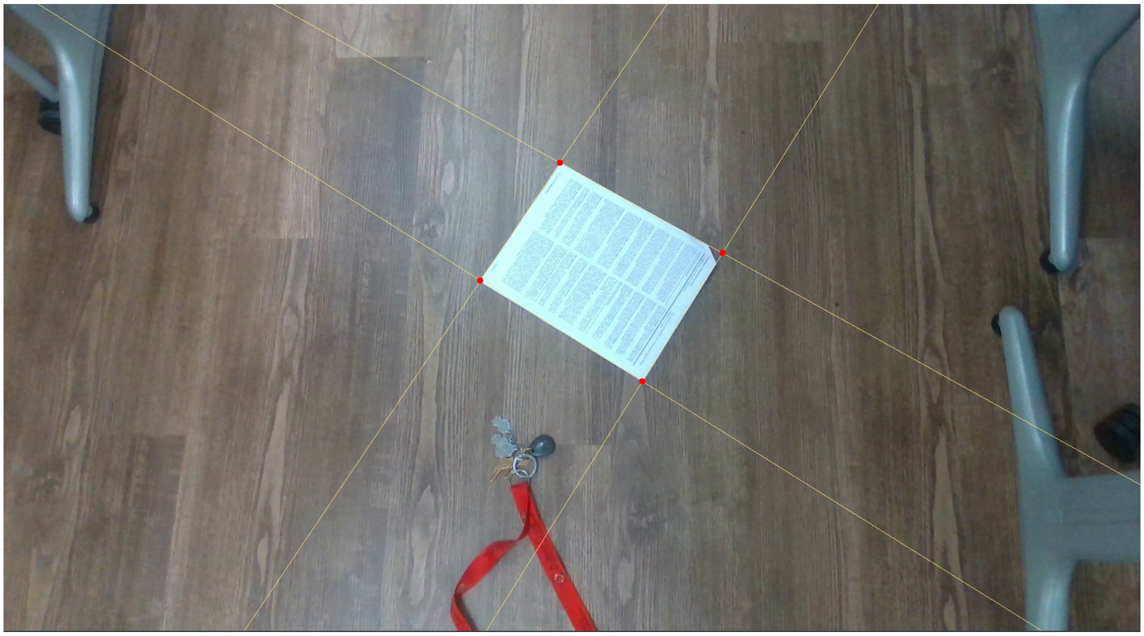

Figure 1: Hough Lines and Corner Detection

We then transform these corners with the size of the paper using homography as follows:

$$A = \begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & (-x_2 \cdot x_2) & (-x_2 \cdot y_1) & x_2 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & (-y_2 \cdot x_2) & (-y_2 \cdot y_1) & y_2 \end{bmatrix}$$

where x_1, y_1 are the corners of the paper and x_2, y_2 are the corners that we detected
We then minimize $||A \cdot h||^2$

$$||A \cdot h||^2 = (A \cdot h)^T \cdot A \cdot h = h^t \cdot A^t \cdot A \cdot h$$

$h =$ the eigen vector of $A^T \cdot A$ with the smallest eigen value

we the estimate the pose of the camera as follows:

$$x = K[r_1 r_2 r_3 t] \cdot \begin{bmatrix} X \\ Y \\ 0 \\ 1 \end{bmatrix}$$

here the first row of the transformed matrix is r_1 the second row is r_2, the cross product of the first and second rows is r_3 and the third row is t

- Results: We then plot the x, y, z and ϕ, θ, ψ for each frame.

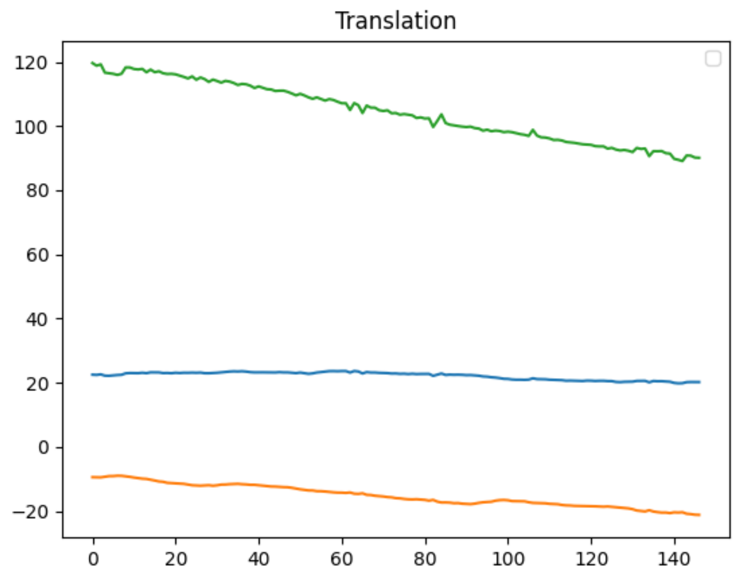

Figure 2: Trajectory of Paper

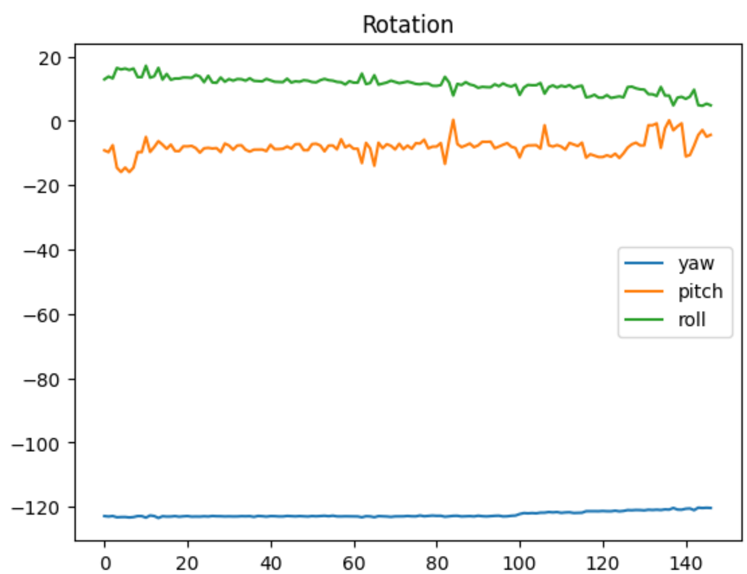

Figure 3: Trajectory of Paper

- Problems Encountered: The Hough lines did not match all the edges of the paper some lines were along the same edge. This was solved using suppression of neighbours.

Problem 2

- Approach: For image stitching we first need to get the feature of all the images. Once we have this we can select the common features and find their corresponding location (x, y). Once we get the points we calculate the homography to transform the first image with the reference of the second image. We calculate the homography as follows:

$$A = \begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & (-x_2 * x_2) & (-x_2 * y_1) & x_2 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & (-y_2 * x_2) & (-y_2 * y_1) & y_2 \end{bmatrix}$$

and

$$Ah = 0 \quad \text{such that } ||h|| = 1$$

We then find the eigen vectors of $A^T \cdot A$ and h is given by the eigen vector with the smallest eigen value.

- Results:

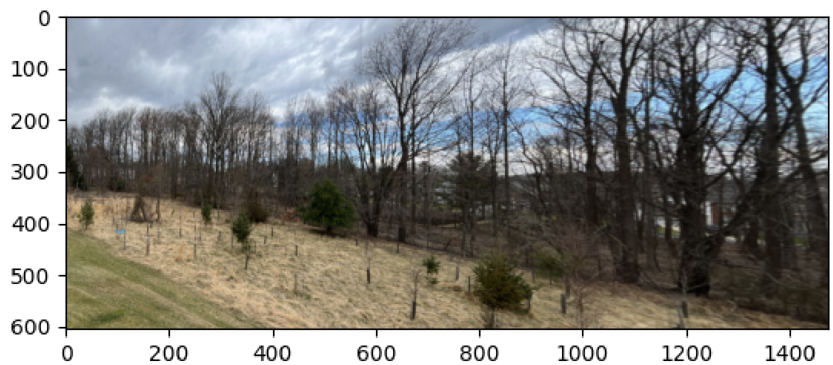

Figure 4: Stitched Image

- Problem Faced: The images did not stitch properly and the end of the warped image was seen twice. The warping of images also created issues such as radial distortion or linear distortion