ENPM 673 MidTerm

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I. Problem 1

In the problem we have to seperate the circles which are stiched together. One way is to first perform morphological erosion using a elliptical kernal (9,9) ,perform a morphological closing operation using a (5,5) square kernel. After than convert the image to gray scale and threshold it. After than using cv2.findContours, we could detect the number of contours. Calculation the number of contours we could find the number of circles. Finally performing the dilation operation using the elliptical kernal (9,9), we could get the original circles back.The final output is shown in figure 1. The images after every major operation is shown in figure 2.The pipeline for the problem is shown in figure 3.

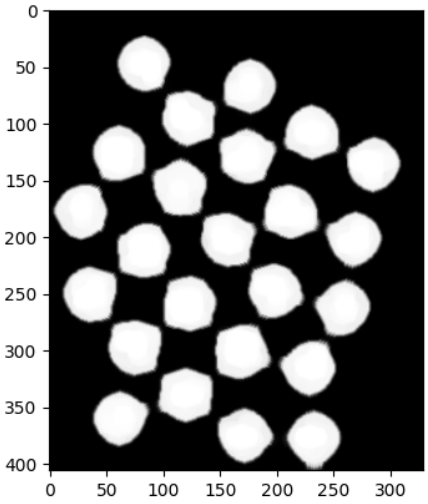

Fig. 1. Dilated Image

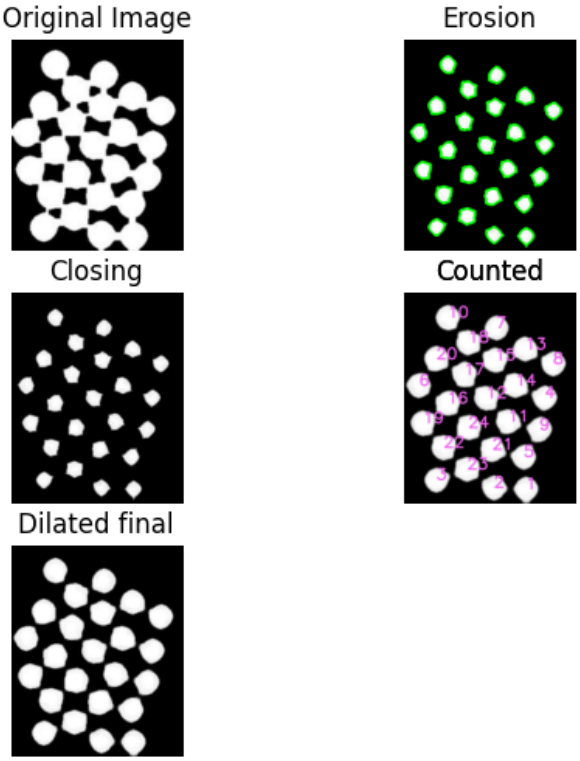

Fig. 2. Pipeline Images

II. Problem 2

The problem of stitching image involves converting the images to grayscale. After that we need to find common feature which can be matched to compute homography.To compute the common features we can use sift,surf or orb feature detection algorithm.As sift and surf are not supported in current version of opencv and are patented we use orb feature detector. After detecting features we use Brute Force method to calculate the likely hood of feature to be common in two sets. After getting the common feature we compute homography using cv2.getHomography which uses common features and ransac tofilter out the outlier homograhies. After computing homography we use cv2.warpPerspective to warp one image into another and stich the images. We crop the final output image to get a nice output image.

III. Problem 3

A. Part 1

The minimum number of points required to compute the calibration matrix is 6. We have 11 unknowns so 6 points i.e 12 points are enough to compute the P matrix.

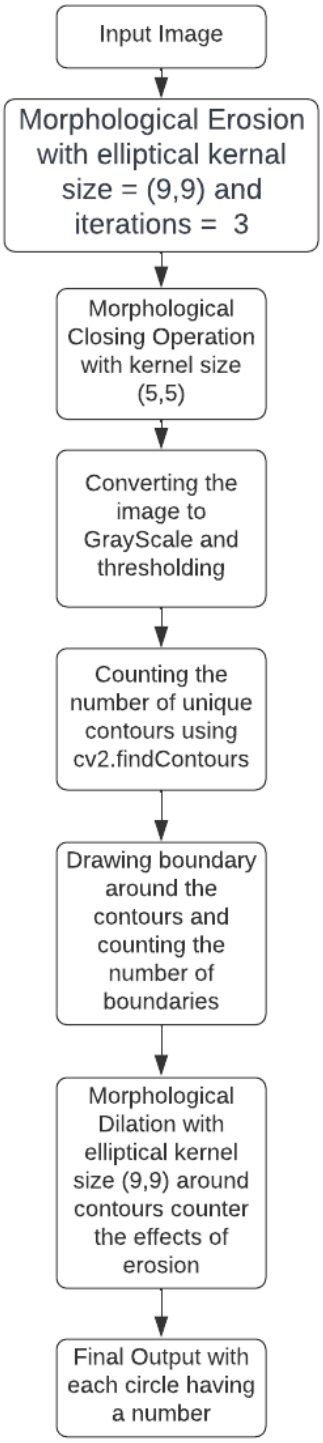

Fig. 3. Flowchart of Problem1

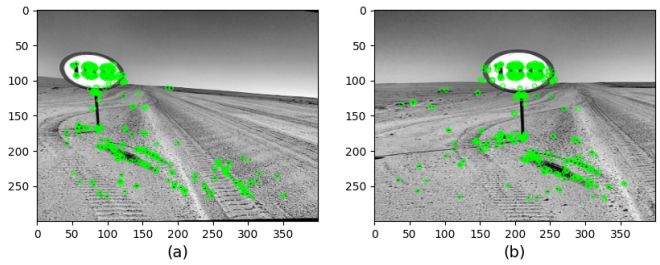

Fig. 4. Feature Detection using ORB Feature detector

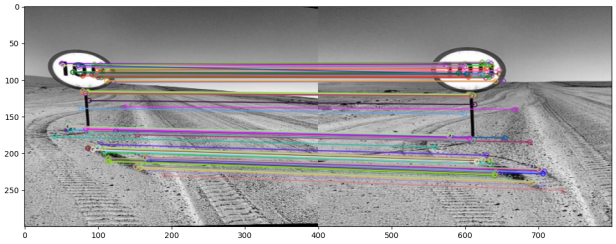

Fig. 5. Matching Features in images

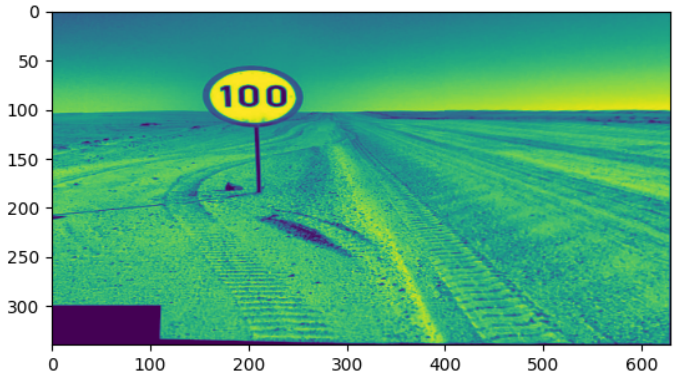

Fig. 6. Final Stiched image

B. Part 2

The flow chart in figure 8 summarized the pipeline to find camera parameters.

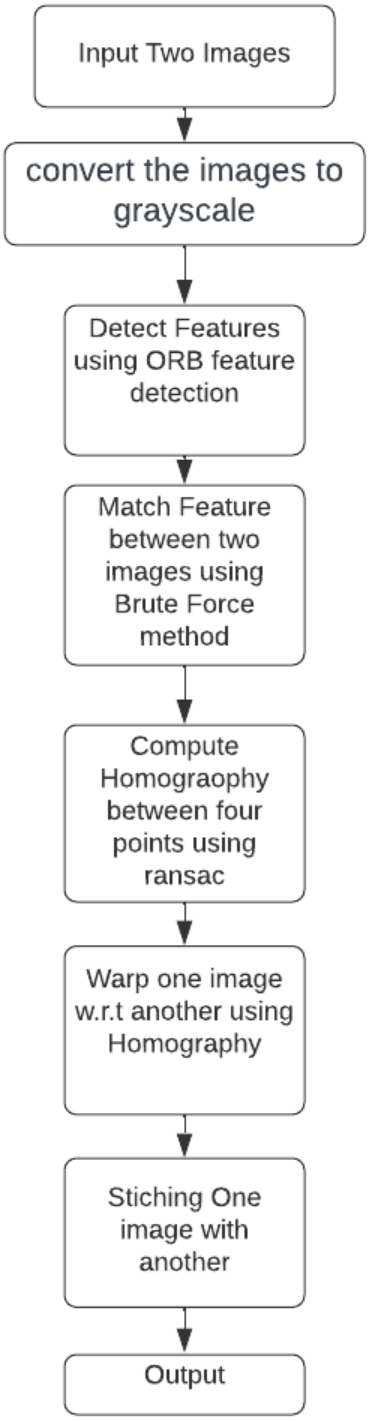

Fig. 7. flowchart of image stiching for two images

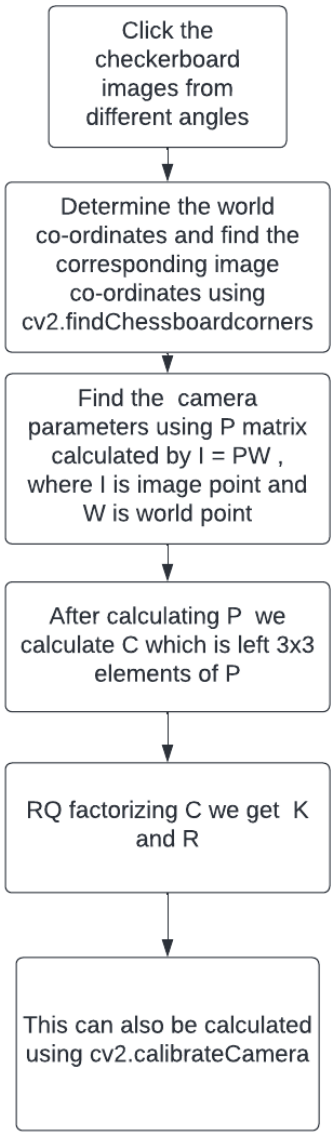

Fig. 8. Camera Calibration Pipeline

C. 3

We are given image and world co-ordinates so we calculate P using the equation 1

$$\begin{bmatrix} x_{image} \\ y_{image} \\ 1 \end{bmatrix} = \text{P} \begin{bmatrix} x_{world} \\ y_{world} \\ z_{world} \\ 1 \end{bmatrix} \tag{1}$$

Here P can be decomposed as given in equation 2.

$$P = KP \begin{bmatrix} I_3 & |\tilde{-}C \end{bmatrix} \tag{2}$$

To compute P lets assume lets assume ${P_1}^T$,${P_2}^T$, ${P_3}^T$ are three row vectors of P. We compute A as given in equation 3. Where AP = 0

$$A = \begin{bmatrix} 0_4^T & -w_i^{'}X_i^T & v_i^{'}X_i^T \\ -w_i^{'}X_i^T & 0_4^T & -u_i^{'}X_i^T \\ -v_i^{'}X_i^T & -u_i^{'}X_i^T & 0_4^T \end{bmatrix} \tag{3}$$

We solve for P by computing SVD of A. P is last row of V obtained by SVD of A reshaped to (3,4).We divide P by its last element to get 1 at last position.

C Matrix is calculated by computing SVD of P. C is the last row of V matrix obtaind by svd of P reshaped to (4,1)

A M matrix is obtaine by dot product of P and $[I_3|\tilde{-}C]^-1$. RQ factorization of M yields calibration matrix K.The following equations represent the method to calculate K

$$K = MK_xK_yK_z \tag{4}$$

$$K_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c & -s \\ 0 & s & c \end{bmatrix} \tag{5}$$

$$K_y = \begin{bmatrix} c^{'} & 0 & s^{'} \\ 0 & 1 & 0 \\ -s^{'} & 0 & c^{'} \end{bmatrix} \tag{6}$$

$$K_z = \begin{bmatrix} c^{"} & -s^{"} & 0 \\ s^{"} & c^{"} & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{7}$$

$$c = -m_33/(m_32^2 + m_33^2)^1/2 \tag{8}$$

$$s = m_32/(m_32^2 + m_33^2)^1/2 \tag{9}$$

IV. Problem 4

The problem requires to segment the image into 4 different cluster using K-means algorithm. The clustering is based on the colors. To start the algorithm first initialized 4 clusters and 4 random mean points. It then calculates the distance of each point from all four means and gets assigned to the nearest mean.The distance is the euclidean distance.After the entire image is clustered into 4 groups , new mean is calculated which if is different than the previous mean or the difference is greater than a threshold, we again compute the eucledian distance using the new means. We compute this until difference betwee the new mean and previous mean is less than a threshold.The output of the K-mean is shown in figure 9.

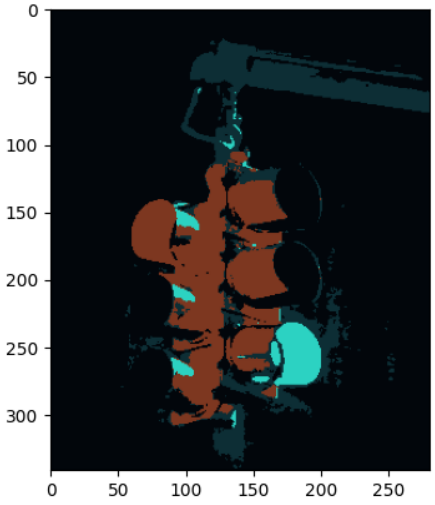

Fig. 9. K-mean output