Design Document Image Processing

Aim: Given multiple photographic images with overlapping fields of view, develop an automated tool that perform stitching followed by blending to produce a segmented panorama or high-resolution image.

Algorithm / Design of the code:

The algorithm used in the project to stitch multiple images together into a single panorama image has essentially 4 components-

1. Harris Corner Detector
2. RANSAC Algorithm (RANdom Sample Consensus)
3. Warping the two images.
4. Blending of the joined images.

Harris Corner Detector:

Commonly, Harris corner detector algorithm can be divided into five steps.

1. Colour to grayscale

2. Spatial derivative calculation

3. Structure tensor setup

4. Harris response calculation

5. Non-maximum suppression

Colour to grayscale

If we use Harris corner detector in a colour image, the first step is to convert it into a grayscale image, which will enhance the processing speed.

Spatial derivative calculation

Next, we are going to compute $I_x(x,y)$ and $I_y(x,y)$

Structure tensor setup

With $I_x(x,y)$, $I_y(x,y)$, we can construct the structure tensor .

Harris response calculation

In this step, we will compute the smallest eigenvalue of the structure tensor with following approximation equation.

$\Lambda_{min} \sim \Lambda_1\Lambda_2/(\Lambda_1+\Lambda_2) = det(M)/trace(M)$

$$M = \sum_{(x,y)\in W} \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = \begin{bmatrix} \sum_{(x,y)\in W} I_x^2 & \sum_{(x,y)\in W} I_x I_y \\ \sum_{(x,y)\in W} I_x I_y & \sum_{(x,y)\in W} I_y^2 \end{bmatrix}$$

Non-maximum suppression

In order to pick up the optimal values to indicate corners, we find the local maxima as corners within the window which is a 3 by 3 filter.

RANSAC Algorithm and Warping:

The RANSAC algorithm is used to calculate the homography matrix that can be used to orient one image with respect to the other so that the two can be joined by translation. The RANSAC Algorithm does this job by scaling +rotation followed by affine transformations for linear translation.

Generic RANSAC algorithm:

```
Given:
    data – a set of observations
    model – a model to explain observed data points
```

```
    n - minimum number of data points required to estimate model parameters
    k - maximum number of iterations allowed in the algorithm
    t - threshold value to determine data points that are fit well by model
    d - number of close data points required to assert that a model fits well to
data

Return:
    bestfit - model parameters which best fit the data (or nul if no good model is
found)

iterations = 0
bestfit = nul
besterr = something really large
while iterations < k {
    maybeinliers = n randomly selected values from data
    maybemodel = model parameters fitted to maybeinliers
    alsoinliers = empty set
    for every point in data not in maybeinliers {
        if point fits maybemodel with an error smaller than t
             add point to alsoinliers
    }
    if the number of elements in alsoinliers is > d {
        % this implies that we may have found a good model
        % now test how good it is
        bettermodel = model parameters fitted to all points in maybeinliers and
alsoinliers
        thiserr = a measure of how well bettermodel fits these points
        if thiserr < besterr {
            bestfit = bettermodel
            besterr = thiserr
        }
    }
    increment iterations
}
return bestfit
```

The Homography matrix calculated is then used on the second image and it is translated to marge/stitch the two images. This is Homography Warping.

Blending:

The two images are then blended using a linear blending pattern so that the edges and the discontinuities after warping are visible to the smallest extent. Blending uses a weighted average of the intensity value of both the images at overlapping pixels. The weights used in the blending transform vary linearly with the distance of the pixel from the image edge.

$$N(x, y) = \alpha I(x, y) + (1- \alpha) C(x, y)$$

(Where N is final image, I is the original image, C is the image to be warped and α is the weight that is calculated as the distance from the image edge and normalized.)

Libraries Used: numpy, matplotlib, opencv, sys, os , math