Homework 2

16-720A Computer Vision

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Q 1.5

Figure 1: Using the difference of gaussians local extrema with intensity and principal curvature thresholding to determine points of interest.

Q 2.4

Using a randomly distributed test pattern, my `testMatch` function produces the following results:

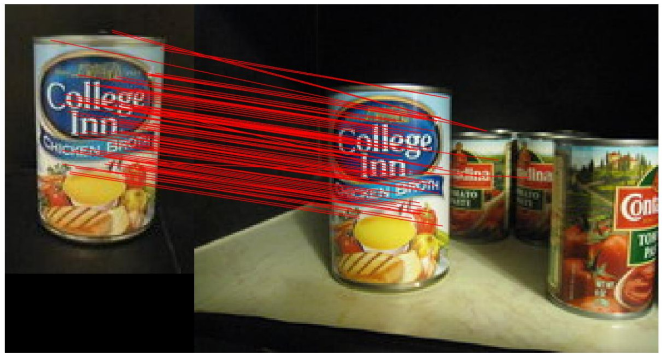


Figure 2: Comparison of model_chickbroth.jpg and chickenbroth_01.jpg

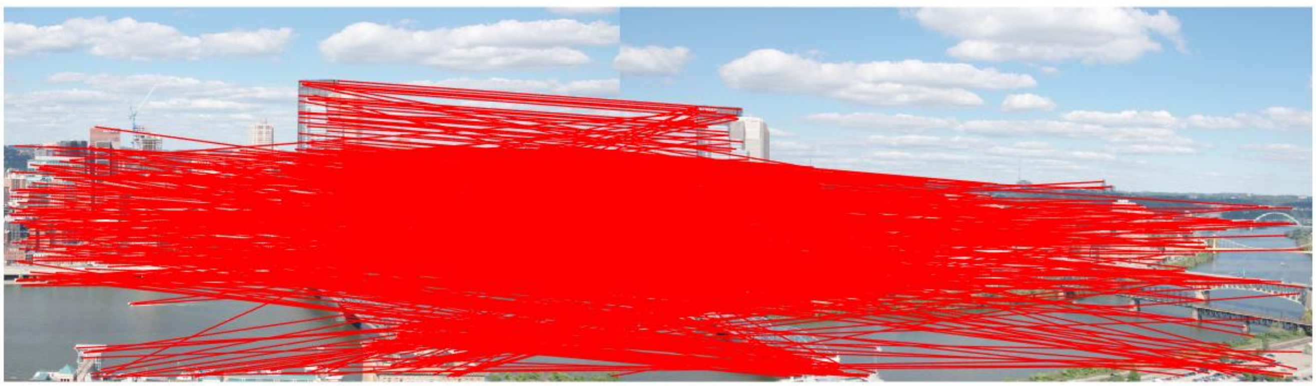
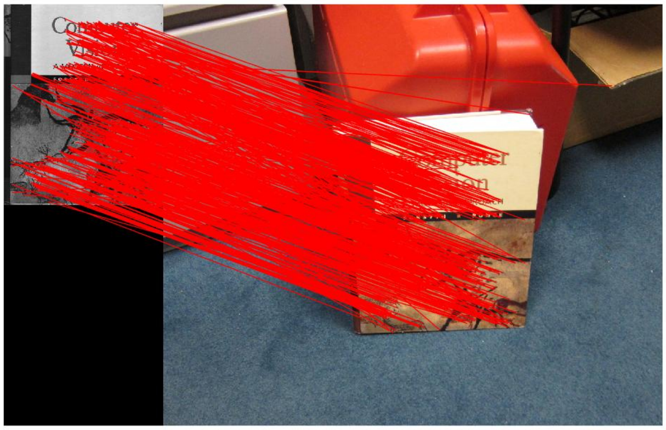


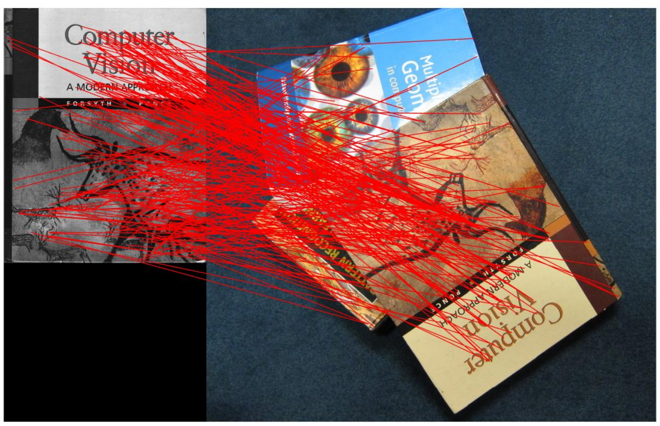
Figure 3: Comparison of the two incline images. There are over a thousand matches, which generally obscures the photo.

The following are images of the black and white vertically oriented textbook cover matched with the textbook in various situations and orientations. In general, the matching performed worse when the textbook being matched was at a different rotation from the black and white image.

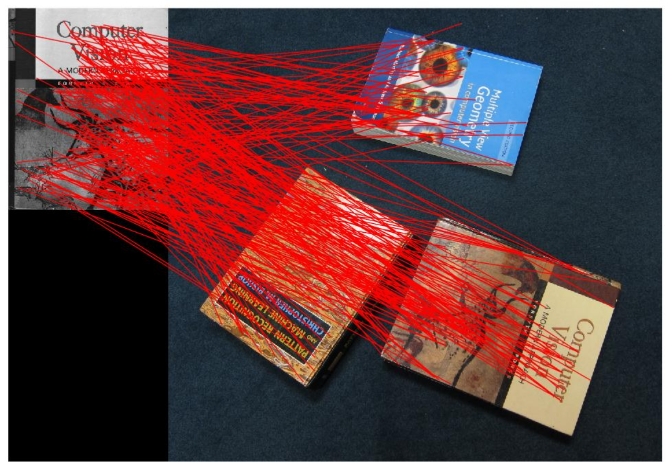


(a)

(b)



(c)



(d)

Q 2.5

As noted above, BRIEF performs notably worse when forced to match rotated images. I believe this is because the BRIEF descriptors are comparisons of pixels in a given area at a fixed orientation. If the area underneath the test pattern is rotated, the resulting descriptor changes, often drastically.

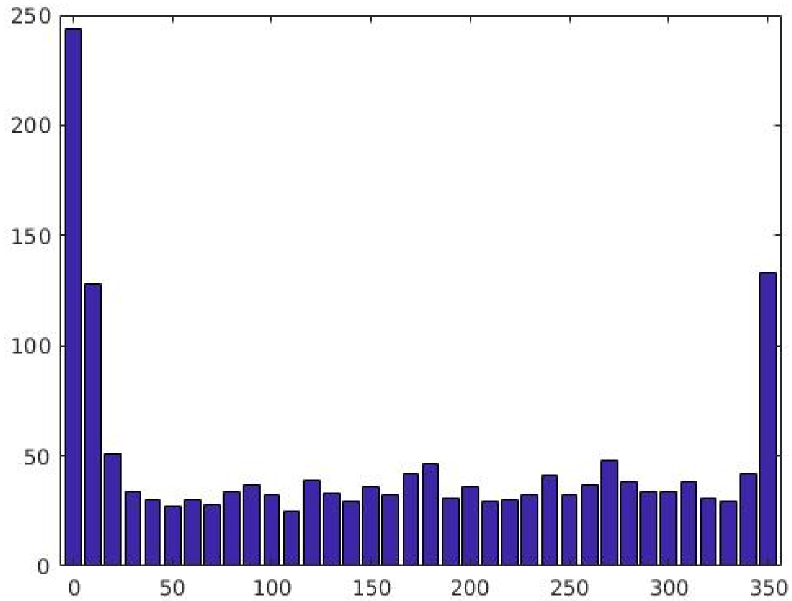


Figure 4: Bar graph showing count of correct matches between `model_chickenbroth.jpg` and itself at 10 degree increments.

Q 3

Q 3.a

$$\lambda_n \tilde{x}_n$$

$$\begin{bmatrix} u_i \\ v_i \\ 1 \end{bmatrix} = \begin{bmatrix} H_{11} & H_{12} & H_{13} \\ H_{21} & H_{22} & H_{23} \\ H_{31} & H_{32} & H_{33} \end{bmatrix} \begin{bmatrix} x_i \\ y_i \\ 1 \end{bmatrix} \tag{1}$$

$$\begin{bmatrix} u_i \\ v_i \\ 1 \end{bmatrix} = \begin{bmatrix} H_{11}x_i & H_{12}y_i & H_{13} \\ H_{21}x_i & H_{22}y_i & H_{23} \\ H_{31}x_i & H_{32}y_i & H_{33} \end{bmatrix} \tag{2}$$

Because u_i and v_i are homogenous coordinates:

$$u_i = \frac{H_{11}x_i + H_{12}y_i + H_{13}}{H_{31}x_i + H_{32}y_i + H_{33}} \qquad v_i = \frac{H_{21}x_i + H_{22}y_i + H_{23}}{H_{31}x_i + H_{32}y_i + H_{33}} \tag{3}$$

$$H_{11}x_i + H_{12}y_i + H_{13} - u_i\big(H_{31}x_i + H_{32}y_i + H_{33}\big) - = 0 \tag{4}$$

$$H_{21}x_i + H_{22}y_i + H_{23} - v_i\big(H_{31}x_i + H_{32}y_i + H_{33}\big) - = 0 \tag{5}$$

These equations can be rewritten as a matrix equation:

$$\begin{bmatrix} x_i & y_i & 1 & \vec{0} & -u_i & x_i & -u_i & y_i & -u_i \\ \vec{0} & x_i & y_i & 1 & -v_i & x_i & -v_i & y_i & -v_i \\ & & & & \vdots & & & & \end{bmatrix} \begin{bmatrix} H_{11}x_i \\ H_{12}y_i \\ H_{13} \\ H_{21}x_i \\ H_{22}y_i \\ H_{23} \\ H_{31}x_i \\ H_{32}y_i \\ H_{33} \end{bmatrix} = \vec{0} \tag{6}$$

Q 3.b

There are nine elements in vector h.

Q 3.c

Four point pairs are required to solve this system, because each point provides two equations. Because the camera projection matrix only has eight degrees of freedom, we can choose an addiitonal bound on the matrix without specifying more points. The preferred method is to set the norm of H to 1.

Q 3.d

The matrix A is not sqaure, so it is not invertible. However, A^TA is invertible, we can find the eigenvectors of that instead. To minimize error, we want the eigenvector associated with the least eigenvalue. So the algorithm for computing the best values of h for a given A is:

1. Compute A
2. Compute A^TA
3. Compute eigenvectors and eigenvalues of A^TA
4. h is the eigenvector associated with the least eigenvalue.

Q 6.1

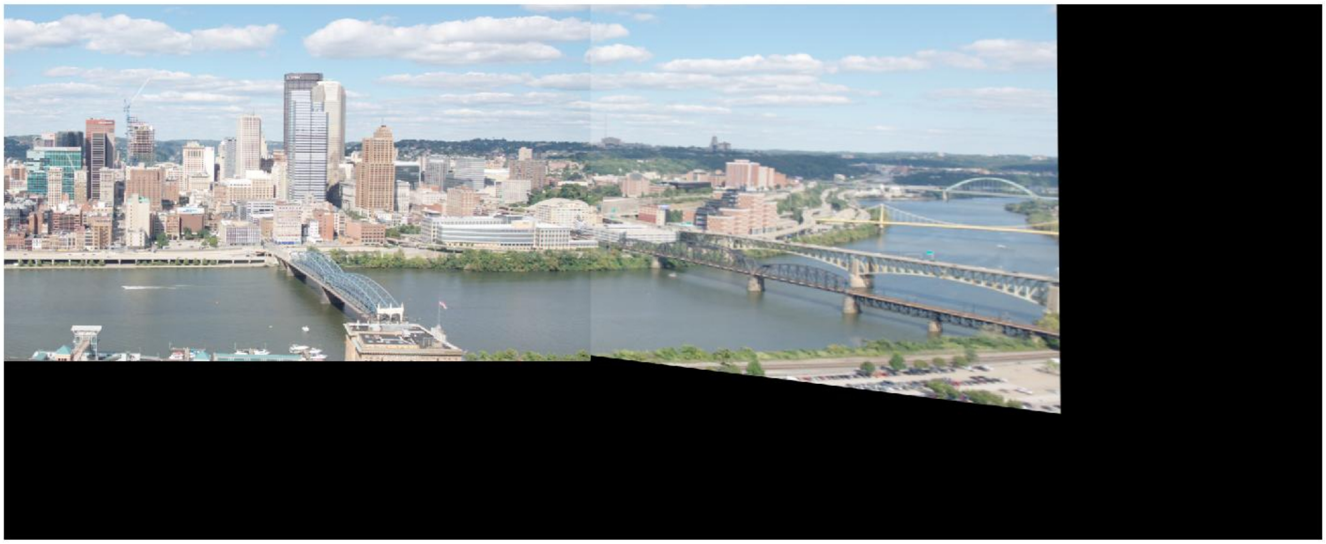


Figure 5: Initial attempt at panorama creation.

Q 6.3

Figure 6: Panorama creation after appropriately sizing output images and performing required translations. The images are already at appropriate scaling after conversion from homogenous coordinates.