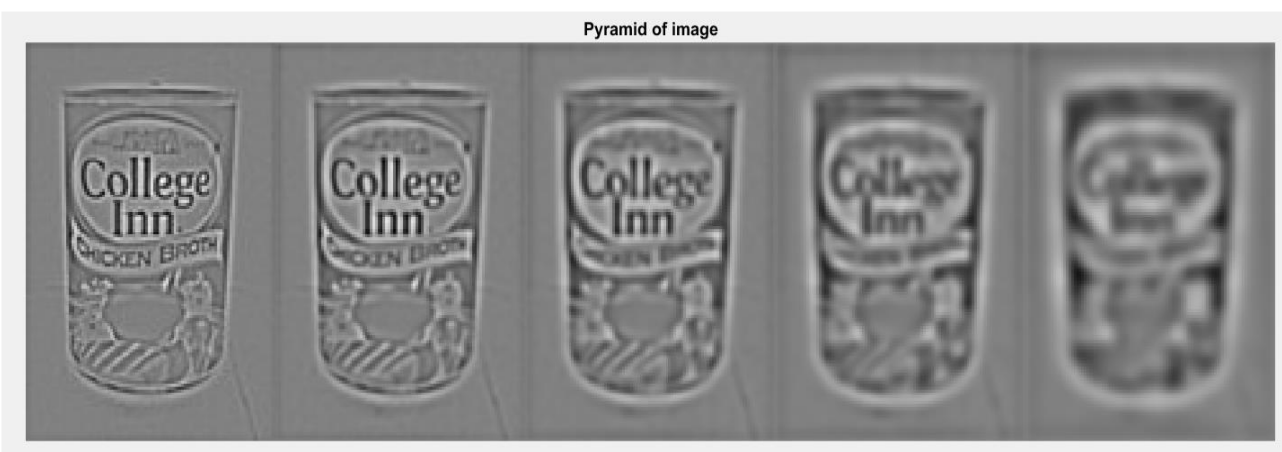
Computer Vision Home Work 2

vgramasw@andrew.cmu.edu

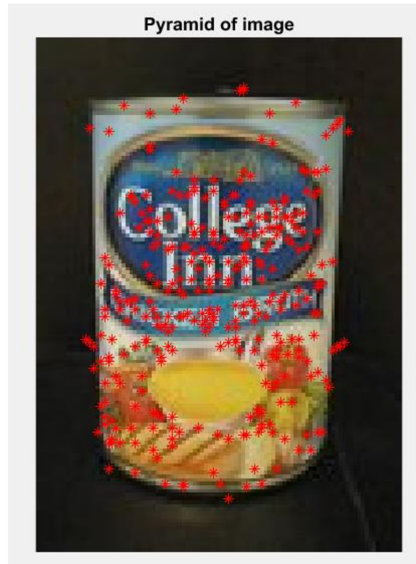
Question 1.1 Gaussian Pyramid

Question 1.2 DOG Pyramid



Question 1.3 Edge Suppression

Without Edge Suppression

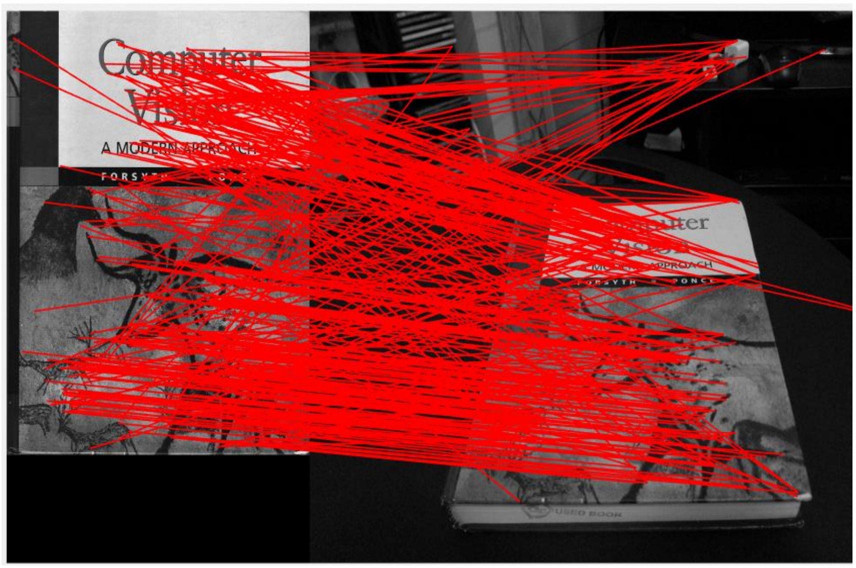


With Edge Suppression

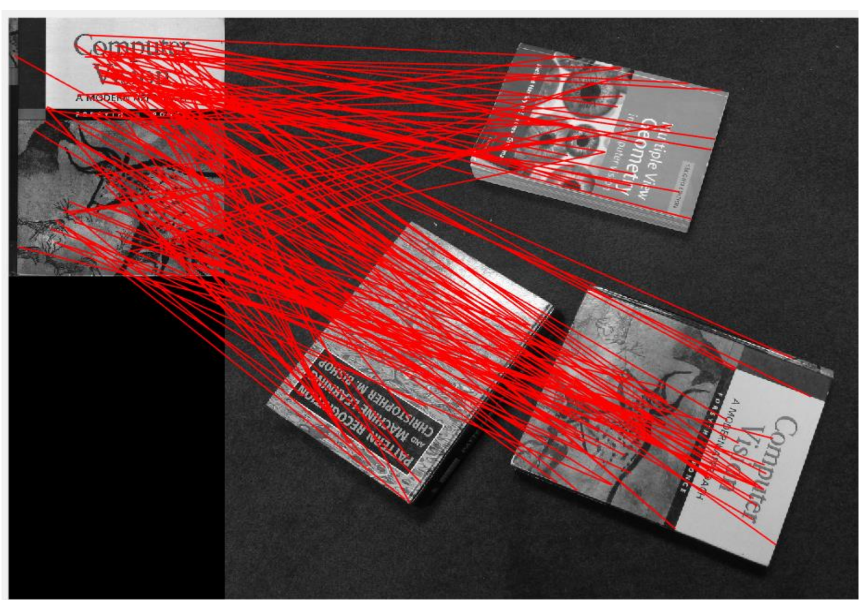
Question 2.4 Descriptor Matching

Picture 1: Scanned Image with Pile

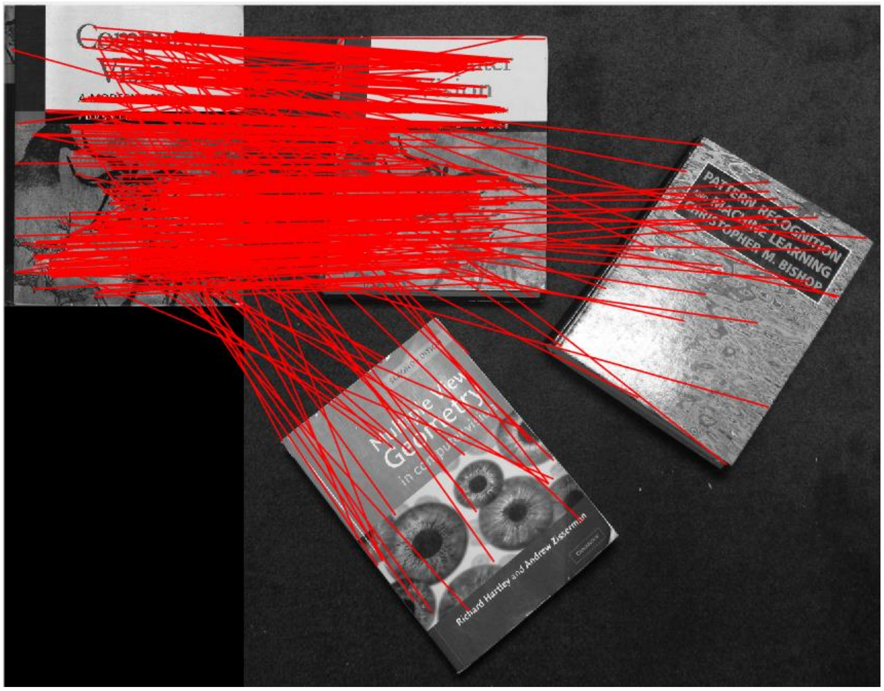
Picture 2: Scanned Image with desk



Picture 3: Scanned Image with Floor_Rotated

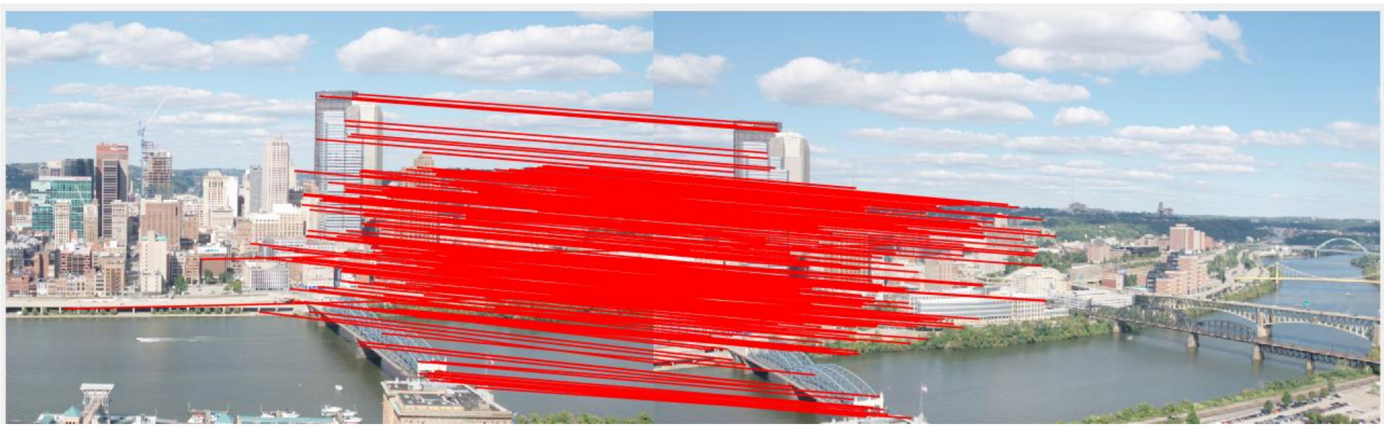


Picture 4: Scanned Image with Floor



Picture 5: Scanned Image with Stand

Picture 6: Incline Images L and R with ratio value as 0.5



The best matches are achieved between the original scanned image and the image lying on the floor which is not rotated as shown in the **picture 4**.

The matches gets degraded when the original scanned image is matched with the rotated image lying on the pile as shown in **picture 1,** because while computing the BRIEF descriptors we take in the location and intensities of nearby pixels centered around a patch and this makes the BRIEF,rotation variant.

Question 2.5 BRIEF and Rotations

Note: Since the it was taking a lot of time for computing for 360 rotations, I did it for 4 rotations.

Image Rotated by 0 deg

Image Rotated by 10 deg

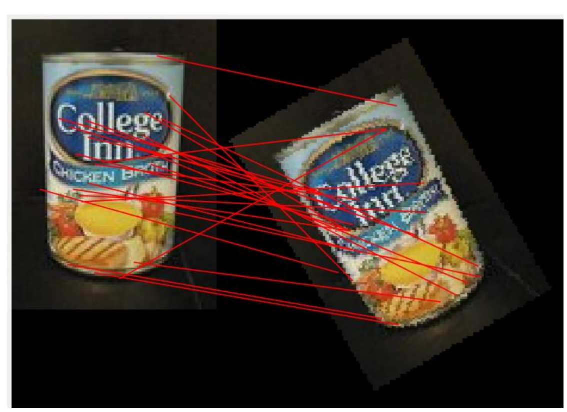


Image Rotated by 20 deg

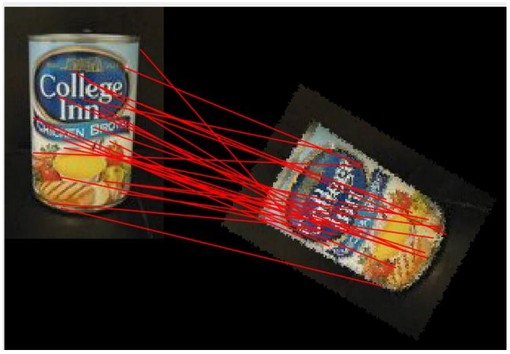


Image Rotated by 30 deg

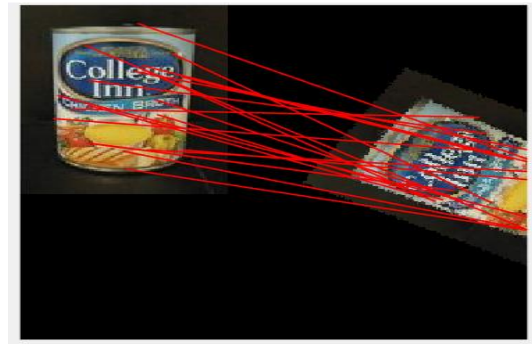
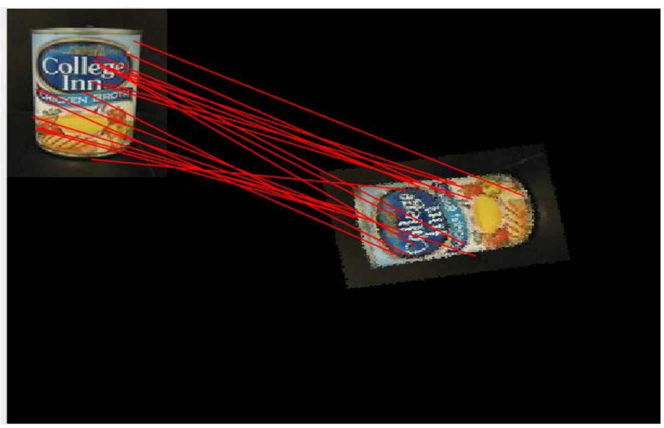
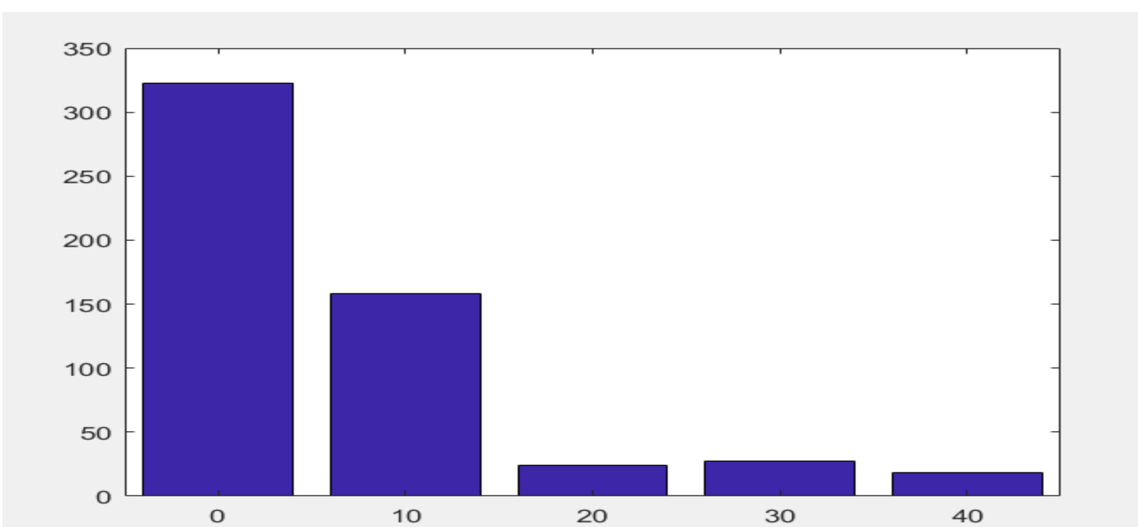


Image Rotated by 40 deg



Bar Graph:



Bar graph with angles in X direction and number of matches in Y direction

The number of matches degrades drastically, as the images are rotated because the BRIEF uses the intensities of the nearby pixels centered around a patch to generate descriptors. When the image is rotated, the intensities of the pixels are no longer a match with respect to the patch and thus the matches reduces.

Question 3.0 Planar Homography

a)

Planar Homography

$$\lambda \tilde{x} = H \tilde{u}$$

$$\lambda \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \\ 1 \end{bmatrix}$$

$$\lambda x = h_{11} u_1 + h_{12} v_1 + h_{13}$$

$$\lambda y = h_{21} u_1 + h_{22} v_1 + h_{23}$$

$$\lambda = h_{31} u_1 + h_{32} v_1 + h_{33}$$

To get x & y, we divide it by λ

$$\frac{\lambda x_1}{\lambda} = \frac{h_{11} u_1 + h_{12} v_1 + h_{13}}{h_{31} u_1 + h_{32} v_1 + h_{33}}$$

$$\frac{\lambda y_1}{\lambda} = \frac{h_{21} u_1 + h_{22} v_1 + h_{23}}{h_{31} u_1 + h_{32} v_1 + h_{33}}$$

$$\frac{\lambda}{\lambda} = \frac{h_{31} u_1 + h_{32} v_1 + h_{33}}{h_{31} u_1 + h_{32} v_1 + h_{33}}$$

$$x_1 (h_{31} u_1 + h_{32} v_1 + h_{33}) = h_{11} u_1 + h_{12} v_1 + h_{13}$$

$$x_1 (h_{31} u_1 + h_{32} v_1 + h_{33}) - (h_{11} u_1 + h_{12} v_1 + h_{13}) = 0$$

$$y_1 (h_{31} u_1 + h_{32} v_1 + h_{33}) = h_{21} u_1 + h_{22} v_1 + h_{23}$$

$$y_1 (h_{31} u_1 + h_{32} v_1 + h_{33}) - (h_{21} u_1 + h_{22} v_1 + h_{23}) = 0$$

Taking coefficients of h

$$
\begin{bmatrix}
-u_1 & -v_1 & -1 & 0 & 0 & 0 & u_1x_1 & v_1x_1 & x_1 \\
0 & 0 & 0 & -u_1 & -v_1 & -1 & u_1y_1 & v_1y_1 & y_1 \\
-u_2 & -v_2 & -1 & 0 & 0 & 0 & u_2x_2 & v_2x_2 & x_2 \\
0 & 0 & 0 & -u_2 & -v_2 & -1 & u_2y_2 & v_2y_2 & y_2 \\
- & - & - & - & - & - & - & & \\
- & - & - & - & - & - & - & - & -
\end{bmatrix}
\begin{bmatrix}
h_{11} \\ h_{12} \\ h_{13} \\ h_{21} \\ h_{22} \\ h_{23} \\ \vdots \\ m
\end{bmatrix}
$$

$$Ah = 0$$

Here with A matrix has a dimension of $2N \times 9$ and H is a 9×1 Matrix

b) There are in total 9 elements in h. But the degree of freedom is only 8, as the elements of **H matrix** are independent of the scale factor and thus reduces the DOF from 9 to 8.

c) Each new correspondence gives two independent equations(information's). We need 4 pair of points, with 8 independent equations for planar homography.

d)

$$Ah = 0$$

Sum Squared Errors

$$f(h) = \frac{1}{2}(Ah - 0)^T(Ah - 0)$$

$$f(h) = \frac{1}{2}(Ah)^T(Ah)$$

$$f(h) = \frac{1}{2}h^T A^T A h$$

To Minimize h, differentiate W.R.T x

$$\frac{df}{dh} = 0 = \frac{1}{2}(A^TA + (A^TA)^T)h$$

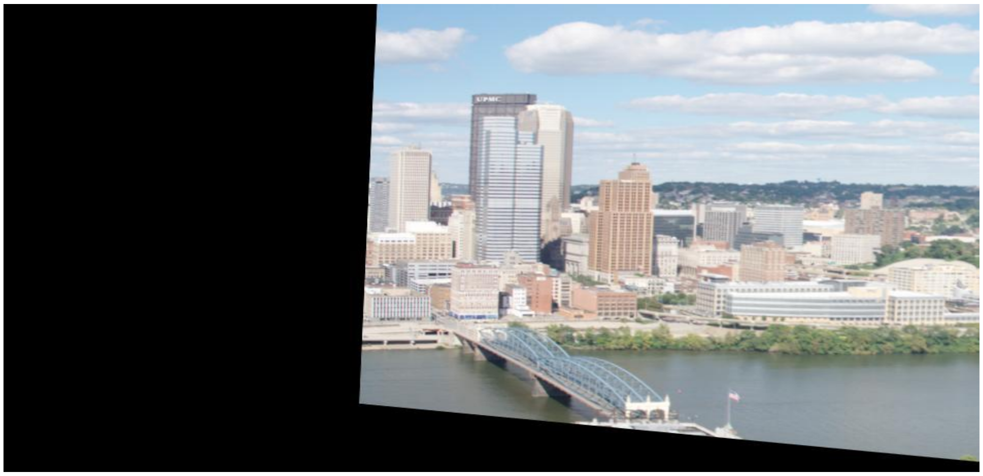
$$A^TAh = 0$$

Steps followed are:

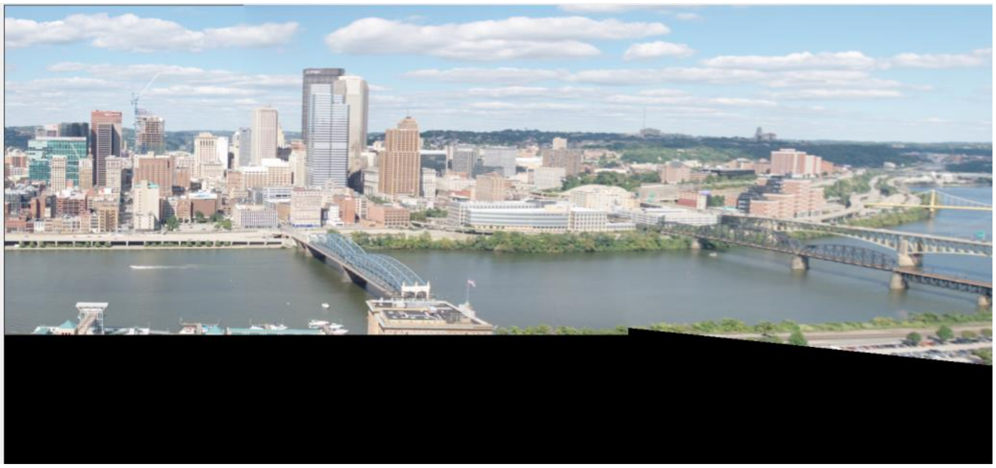
1. Derive 2N independent equations in the form Ah=0. Here we are using 4 pair of correspondences.
2. The resulting A matrix would be of size 8*9. In order to perform SVD , we make the A matrix square by multiplying it by **A'**.
3. Then we perform SVD.
4. The last column of V gives us the eigenvector corresponding to the least eigen value, which minimizes the system close to zero.
5. In ideal case **h** should be the eigenvector corresponding to zero eigenvalue, but in reality we only find eigenvalue which minimizes system close to zero.

Question 6.1 Image Stitching

Warping:



Blending:



Question 6.2 Image Stitching with no clipping with Compute H

Question 6.3 Final Panorama with Ransac: