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16720B: Computer Vision Homework 2
Feature Descriptors, Homographies & RANSAC

1. KeyPoint Detector:

1.2 The DoG Pyramid:

The image above is the Difference of Gaussian Pyramid.

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1.3 Edge Suppression

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1.4 Detecting Extrema

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1.5 Putting it together:

The above mentioned image shows the plot of Key points over the **'Model_Chickenbroth'** image from the data.

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2 BRIEF Descriptor

2.1 Creating a Set of BRIEF Tests

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2.2 Compute the BRIEF Descriptor

2.3 Putting it all Together

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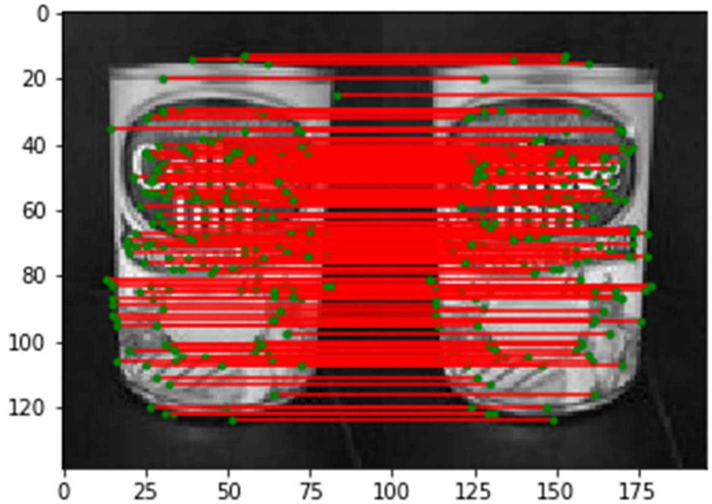
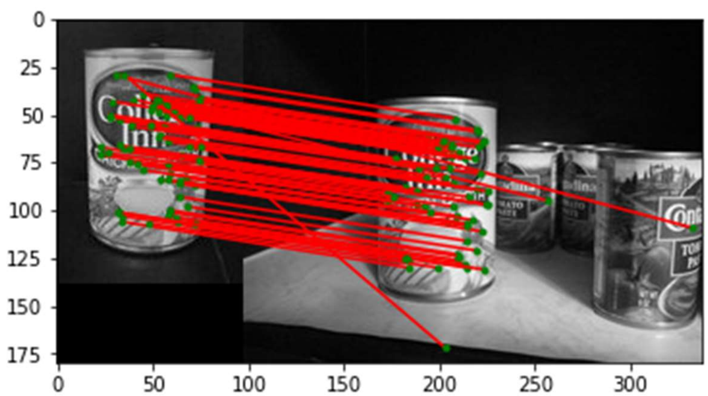
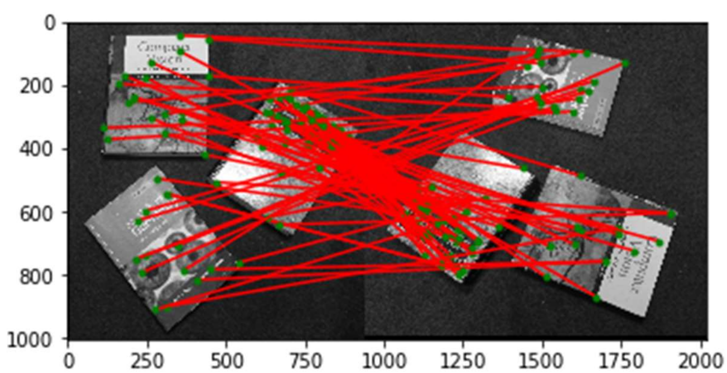
2.4 Check Point: Descriptor Matching

From the below images, it is seen that a lot of good matches is basically when the image is not rotated. The matches become drastically poor when there is an orientation change involved. Thus, proving the fact that BRIEF is not a rotation invariant descriptor.







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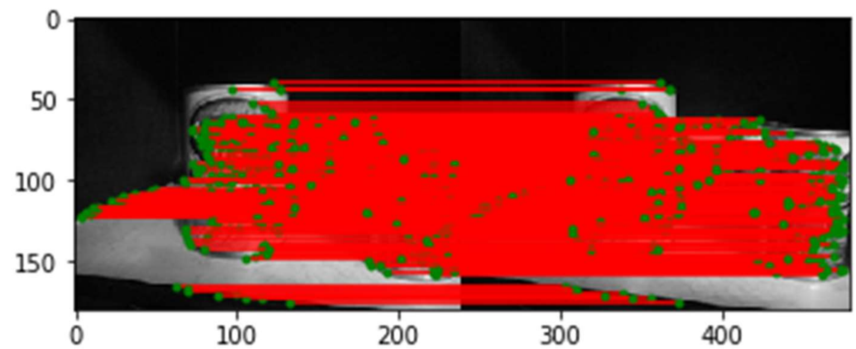

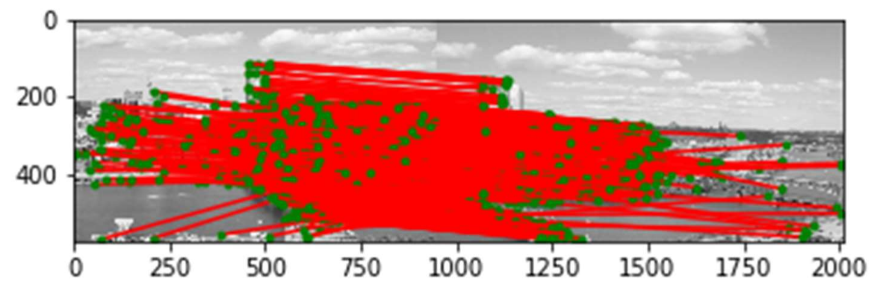

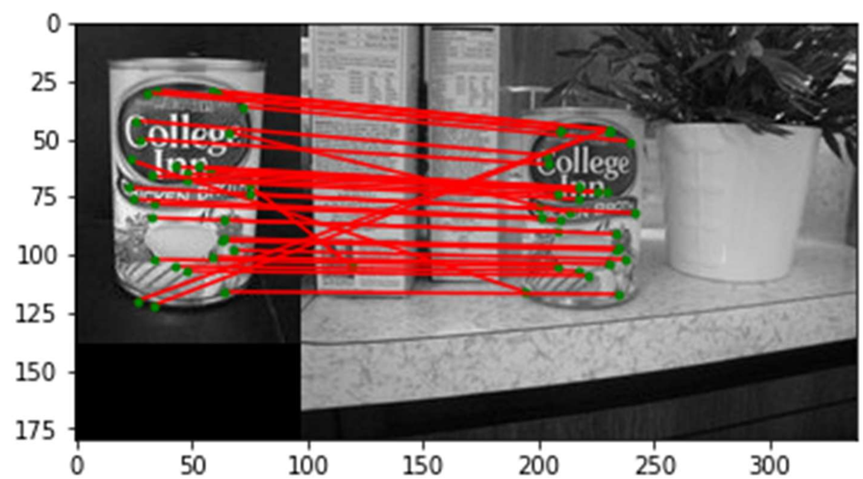

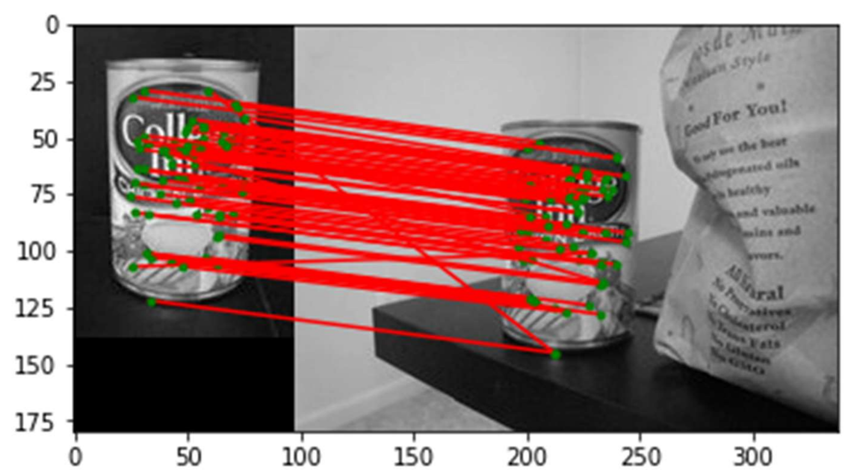

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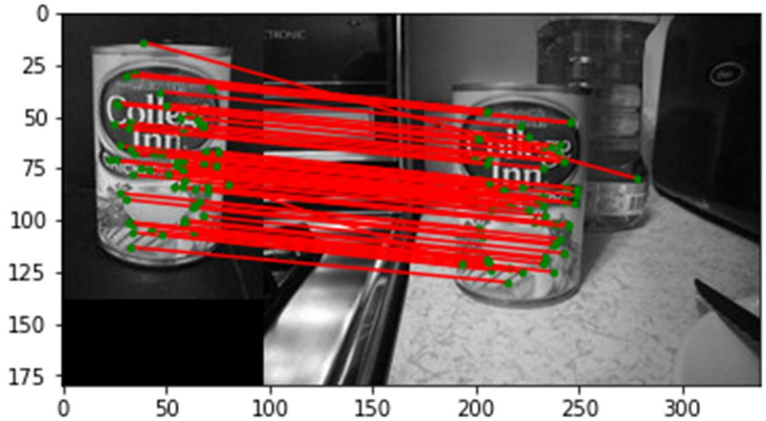

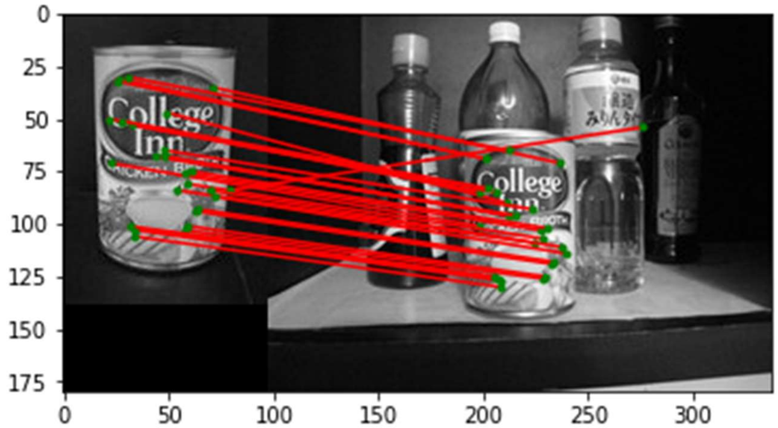

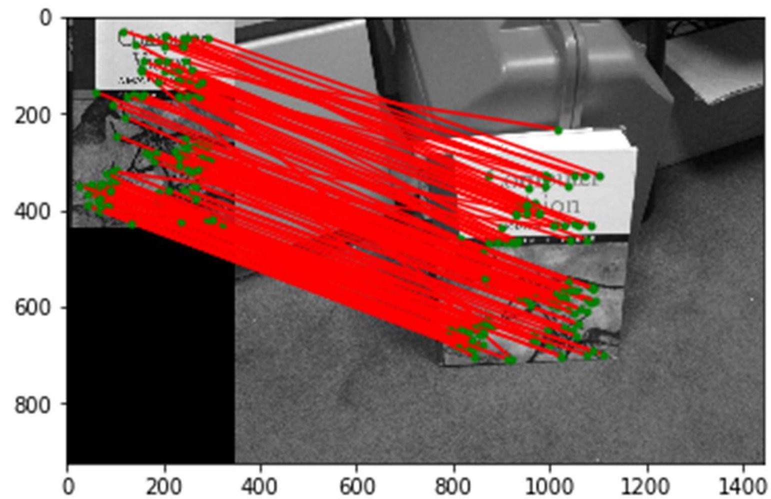

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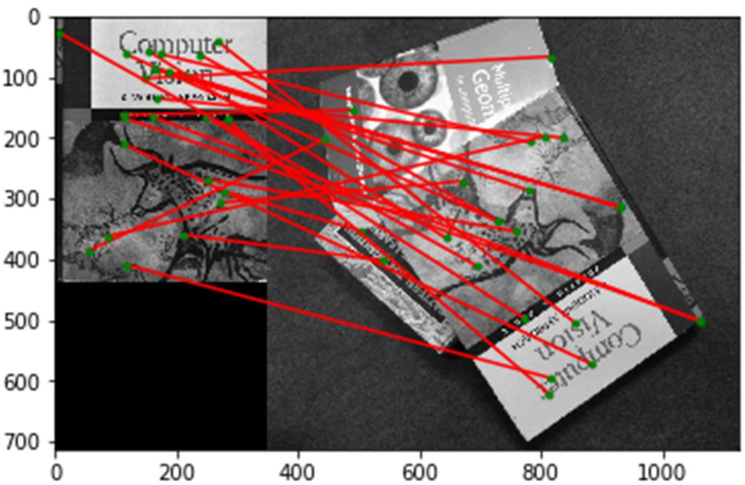

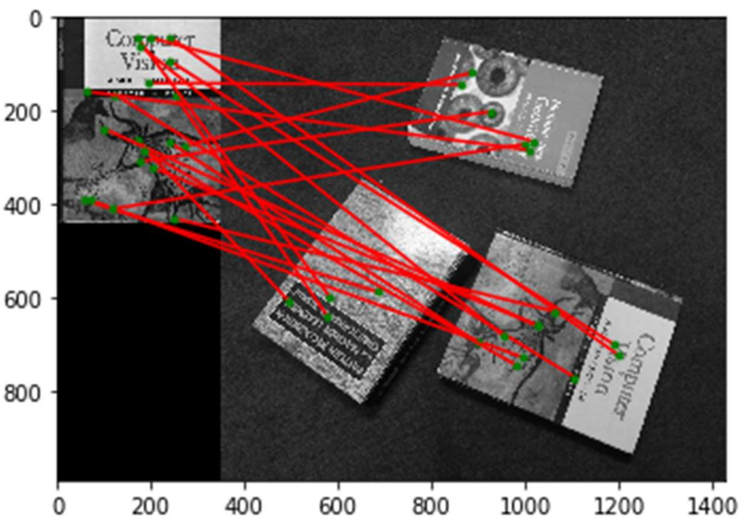

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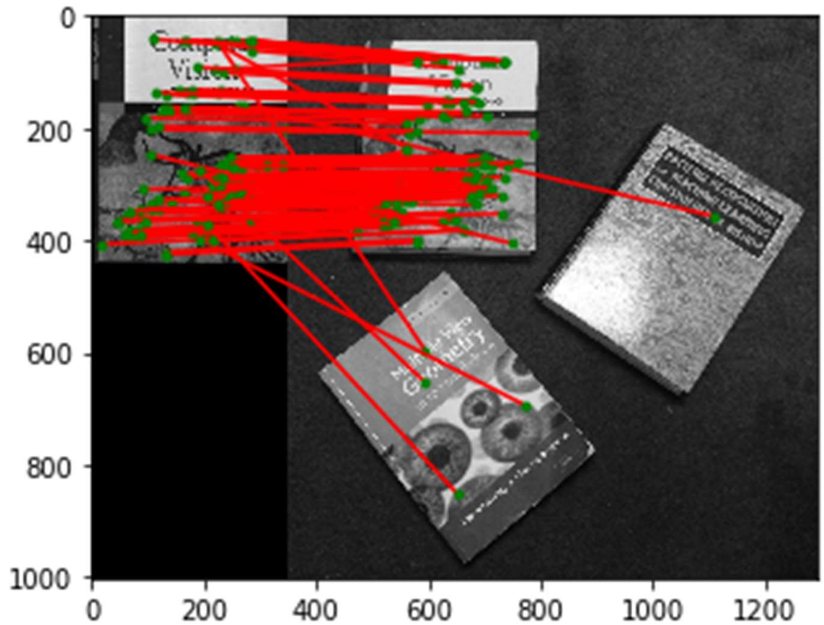

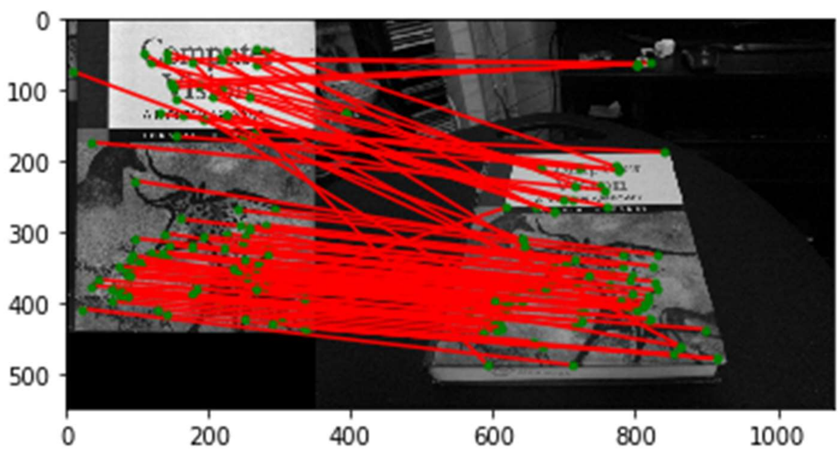

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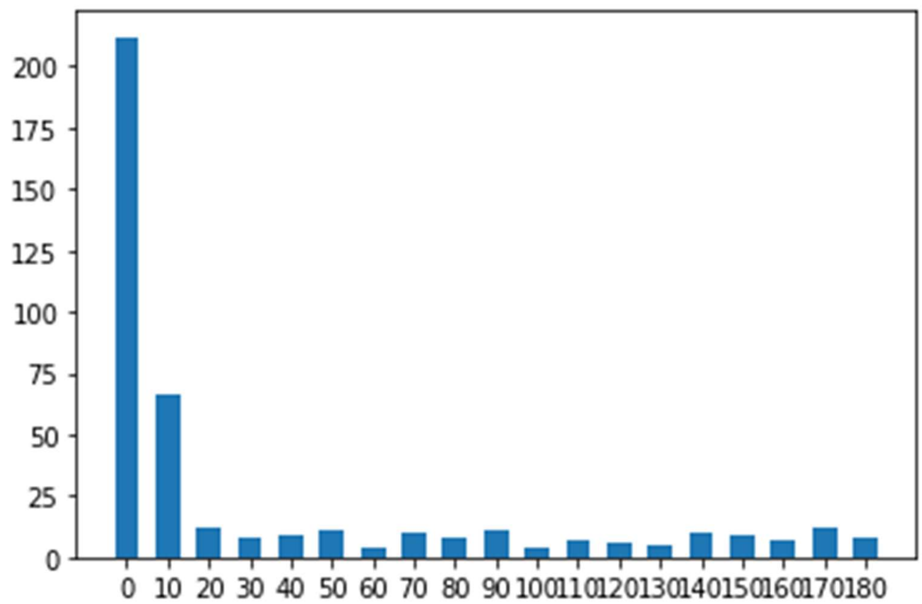
2.5 BRIEF and rotations:



The graph shows that rotation causes the accuracy and efficiency of BRIEF to hit rock bottom when there is significant rotation involved. It might be due to the fact that the patches won't match since the image Is not oriented In the same way causing the descriptor to fail the pattern match, thus reducing the number of matches.

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3 Planar Homographies: Theory

1. **Derivation:**

Homogeneous:

$$\lambda \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & h_{33} \end{bmatrix} \begin{bmatrix} u \\ v \\ 1 \end{bmatrix}$$

$$\lambda x = h_{11}u + h_{12}v + h_{13}$$

$$\lambda y = h_{21}u + h_{22}v + h_{23}$$

$$\lambda = h_{31}u + h_{32}v + h_{33}$$

$$x = \frac{\tilde{x}}{\tilde{z}}$$

$$y = \frac{\tilde{y}}{\tilde{z}}$$

Cartesian:

$$x = \frac{h_{11}u + h_{12}v + h_{13}}{h_{31}u + h_{32}v + h_{33}}$$

$$y = \frac{h_{21}u + h_{22}v + h_{23}}{h_{31}u + h_{32}v + h_{33}}$$

$$x(h_{31}u + h_{32}v + h_{33}) = h_{11}u + h_{12}v + h_{13}$$

$$y(h_{31}u + h_{32}v + h_{33}) = h_{21}u + h_{22}v + h_{23}$$

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Form linear system $\mathbf{Ah} = \mathbf{0} \quad \text{s.t.} \; ||\mathbf{h}||_2^2 = 1$

$$\begin{bmatrix} 0 & 0 & 0 & -u_1 & -v_1 & -1 & y_1u_1 & y_1v_1 & y_1 \\ u_1 & v_1 & 1 & 0 & 0 & 0 & -x_1u_1 & -x_1v_1 & -x_1 \\ 0 & 0 & 0 & -u_2 & -v_2 & -1 & y_2u_2 & y_2v_2 & y_2 \\ u_2 & v_2 & 1 & 0 & 0 & 0 & -x_2u_2 & -x_2v_2 & -x_2 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & -u_N & -v_N & -1 & y_Nu_N & y_Nv_N & y_N \\ u_N & v_N & 1 & 0 & 0 & 0 & -x_Nu_N & -x_Nv_N & -x_N \end{bmatrix} \begin{bmatrix} h_{11} \\ h_{12} \\ h_{13} \\ h_{21} \\ h_{22} \\ h_{23} \\ h_{31} \\ h_{32} \\ h_{33} \end{bmatrix} = \mathbf{0}$$

2. How many elements are there in h?

There are 9 elements in H and consists a 3 X 3 matrix.

3. How many point pairs (correspondences) are required to solve this system?

4-point pairs are required to solve the system with 8 unknowns as the 9th element of H can be made 1 by using lambda manipulation.

4. Show how to estimate the elements in h to find a solution to minimize this homogeneous linear least square system. Step us through this procedure.
Ah = 0

known as the Homogeneous Linear Least Squares problem. It is similar in appearance to the in homogeneous linear least squares problem

Ah = b

in which case we solve for x using the pseudoinverse of A. This won't work with Ah = 0. solve it using Singular Value Decomposition (SVD).

By doing a single value decomposition of A

$USV^T = A$

since the column of V^T consists of the eigen vectors of A^TA; and given the eigen values along the diagonals of V^T are in descending order, the last column of V will give us the least singular value that corresponds to minimizing the homography matrix "h".

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4 Planar Homographies: Implementation

Q 4.1 Implement the function

5 RANSAC

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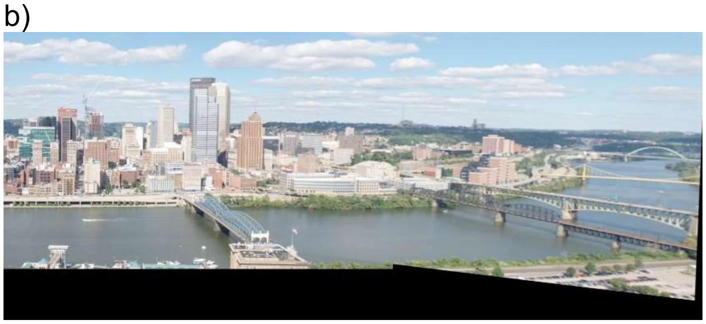
6 Stitching it together: Panoramas

6.1

a)

Img2 warped to img1's frame

b)



Panorama with clipped edges.

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6.2

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6.3

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7 . Augmented Reality

The picture shown below has a Yellow Sphere augmented onto a 2d image with the use of homography. And as per the question, it is also positioned right on the centre of the alphabet ‘O’ of Computer vision by adding some offset.