

Q1. $E = [t_x] R$

$$= \begin{bmatrix} 0 & -t_z & t_y \\ t_z & 0 & -t_x \\ -t_y & t_x & 0 \end{bmatrix} \begin{bmatrix} r_1 & r_2 & r_3 \\ r_4 & r_5 & r_6 \\ r_7 & r_8 & r_9 \end{bmatrix}$$

We know

$$E \mathbf{e}_0 = 0$$

$$\& \underbrace{\mathbf{e}_r^T E = 0 = E^T \mathbf{e}_r}$$

$$E = \begin{bmatrix} t_y r_7 - t_z r_4 & t_y r_8 - t_z r_5 & t_y r_9 - t_z r_6 \\ t_z r_1 - t_x r_4 & t_z r_2 - t_x r_5 & t_z r_3 - t_x r_6 \\ t_x r_1 - t_y r_4 & t_x r_2 - t_y r_5 & t_x r_3 - t_y r_6 \end{bmatrix}$$

\therefore A line of the form $[x \ y \ 1]$ satisfies E 's system of equations

ⓑ

Analogously a line of the form $[x' \ y' \ 1]$ satisfies the system of equations by E^T

Q₂

$$E = [t_x] R = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_x \\ 0 & t_x & 0 \end{bmatrix} \quad T = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_x \\ 0 & t_x & 0 \end{bmatrix}$$

$$\Rightarrow [x \ y \ 1] \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_x \\ 0 & t_x & 0 \end{bmatrix} \begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = 0$$

$$= [x \ y \ 1] \begin{bmatrix} 0 \\ -t_x \\ t_x y' \end{bmatrix} = 0$$

$$\therefore -t_x y + t_x y' = 0$$

$$\therefore \underbrace{y = y'}$$

Part 2

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1. Extract the keypoints and descriptors from the first two images using the SIFT algorithm and draw them overlaid on the original images to visualize and verify their correctness.
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Image 1 with Keypoints

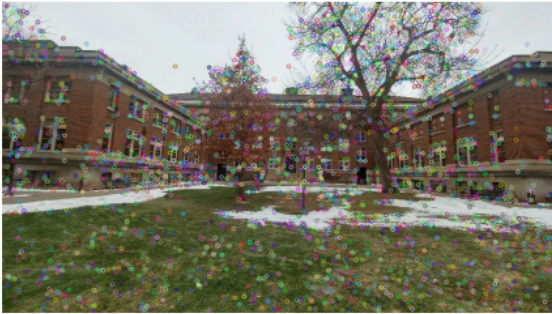
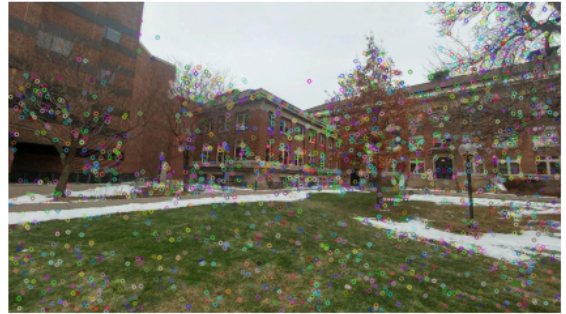
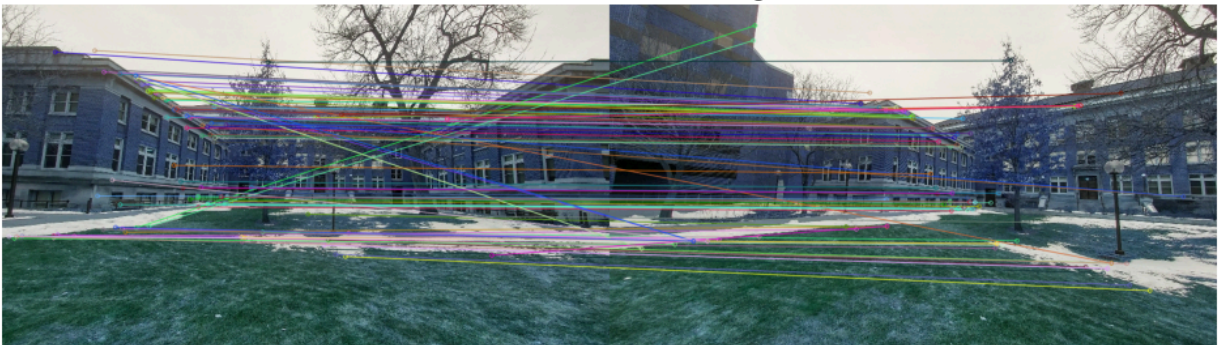


Image 2 with Keypoints

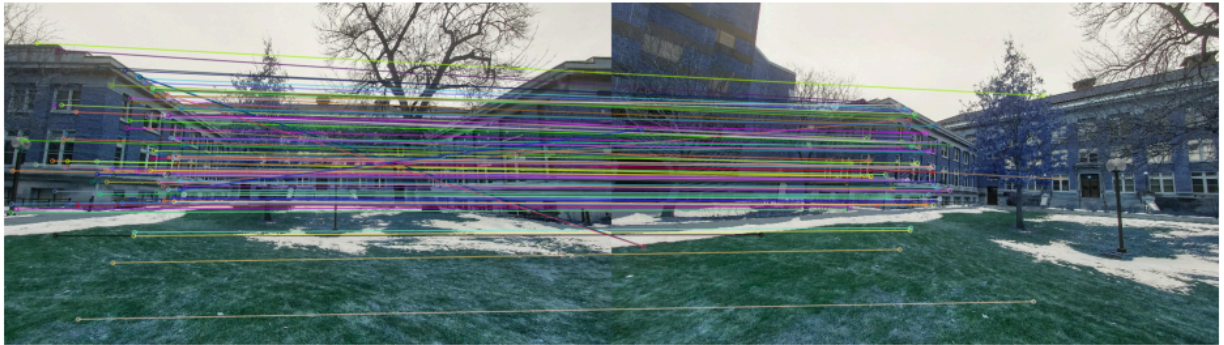


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2. Match the extracted features using two different algorithms: BruteForce and FlannBased. After performing the matching, display the matched features by drawing lines between them. Good matches, i.e. with less Lowe's ratio are taken for matching purposes. The ratio is kept at 0.75.
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BruteForce Feature Matching



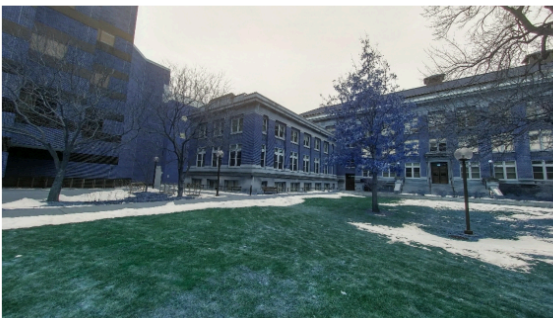
FlannBased Feature Matching



Homography matrix (to transform coordinates in right_image in left_image's frame)

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[[-1.63891433e-02 -3.52143971e-02 3.65833825e+02]
 [-3.04538936e-01 5.51932558e-01 1.28653772e+02]
 [-1.01375766e-03 -1.20285389e-04 1.00000000e+00]]
```

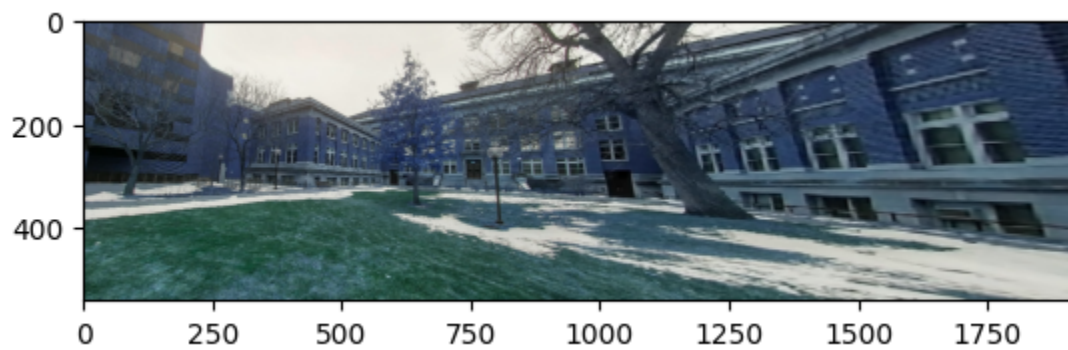
Left Side of Panorama



Right Side of Panorama



Final Panaroma



Stitching

Panorama

