Assignment - 3
CSE344 : Computer Vision

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1 Theory:

(a) We know that for right and left epipoles respectively -

$$E^T e' = 0 \text{ and } Ee = 0$$

where E is the essential matrix can be represented in terms of rotation matrix and translation vector as $E = [t_x]R$

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

Now since the cross product is equal to 0, the epipoles must be parallel

(b) As $t = \begin{bmatrix} t_x & 0 & 0 \end{bmatrix}$ and $R = I$,

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

Now let the points be $a^T = \begin{bmatrix} x & y & z \end{bmatrix}$ and $a'^T = \begin{bmatrix} x' & y' & z' \end{bmatrix}$, then,

$$a^T E a' = \begin{bmatrix} x & y & z \end{bmatrix} \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & -t_x \\ 0 & t_x & 0 \end{bmatrix} \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix}$$
$$= t_x y' z - t_x y z' = 0$$

Thus, $y'z = yz' \rightarrow \frac{y}{z} = \frac{y'}{z'}$

But since this is a homogenous coordinate system, in the camera frame, the above simply means that the y-coordinate remains the same.

(c) As per the slide 42 of the shared slide deck, by using the algorithm outlined, we map the epipole to infinity in the resulting image, which implies that the epipoles coincide with the translation vector t before transformation.

Then following the outlined steps,

$r_1 = \frac{t}{||T||} = \frac{\begin{bmatrix} t_x & t_y & t_z \end{bmatrix}^T}{\sqrt{t_x^2+t_y^2+t_z^2}}$

$r_2 = \frac{\begin{bmatrix} -t_y & t_x & 0 \end{bmatrix}^T}{\sqrt{t_x^2+t_y^2}}$

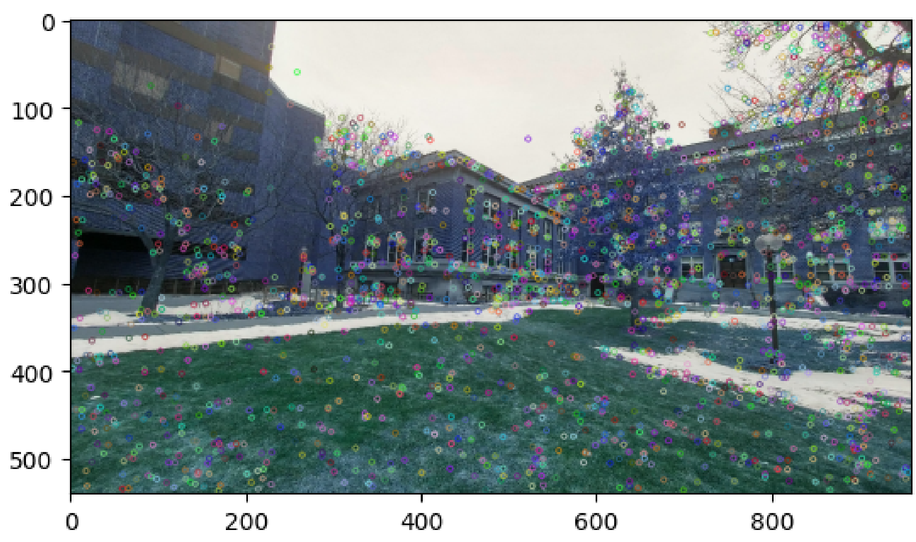
$r_3 = r_1 \times r_2 = \frac{\begin{bmatrix} -t_z t_x & -t_z t_y & t_x^2 + t_y^2 \end{bmatrix}^T}{\sqrt{t_x^2+t_y^2}\sqrt{t_x^2+t_y^2+t_z^2}}$

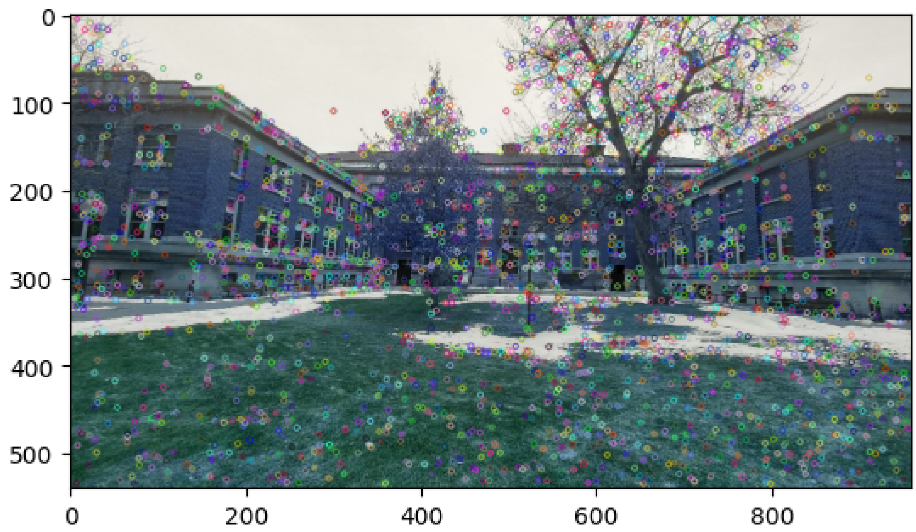
Thus,

$$R_{rect} = \frac{1}{(t_x^2 + t_y^2)(t_x^2 + t_y^2 + t_z^2)} \begin{bmatrix} t_x & t_y & t_z \\ -t_y & t_x & 0 \\ -t_z t_x & -t_z t_y & t_x^2 + t_y^2 \end{bmatrix}$$

2 Panorama Generation

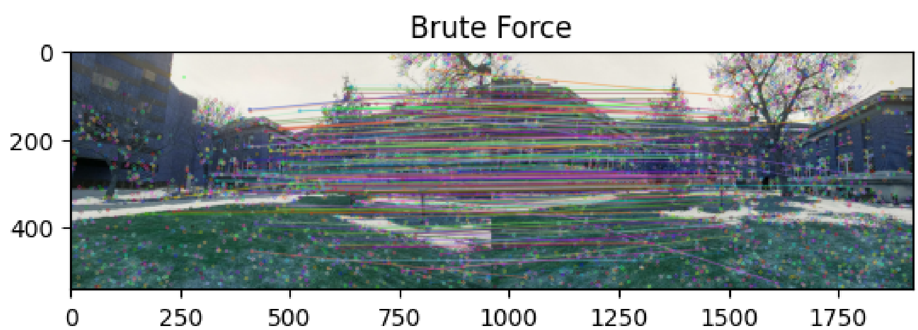
(a) **Keypoint Detection**



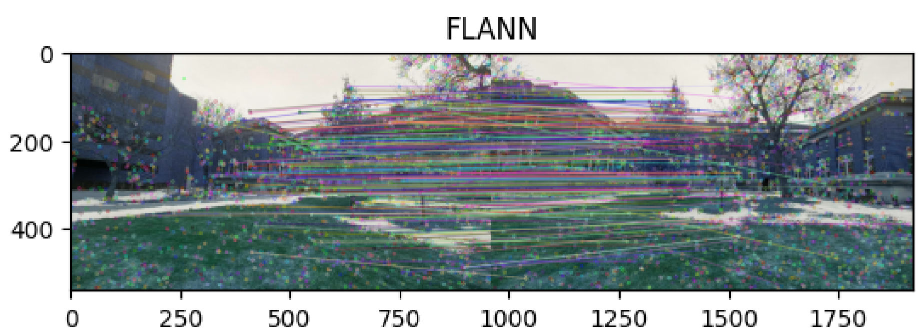


(b) **Feature Mapping**

With bruteforce -



With FLANN -

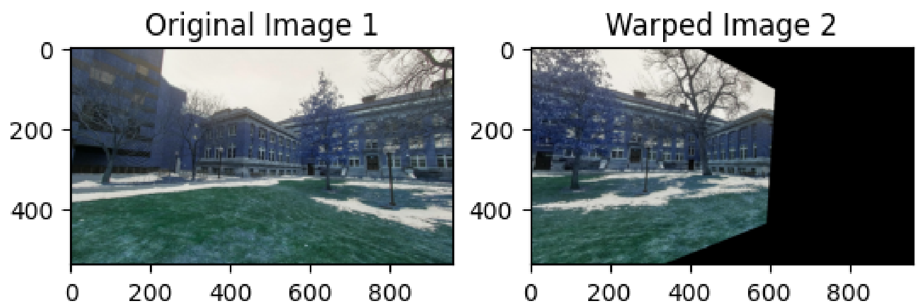


(c) **Homography estimation**

Following is the Homography Matrix -

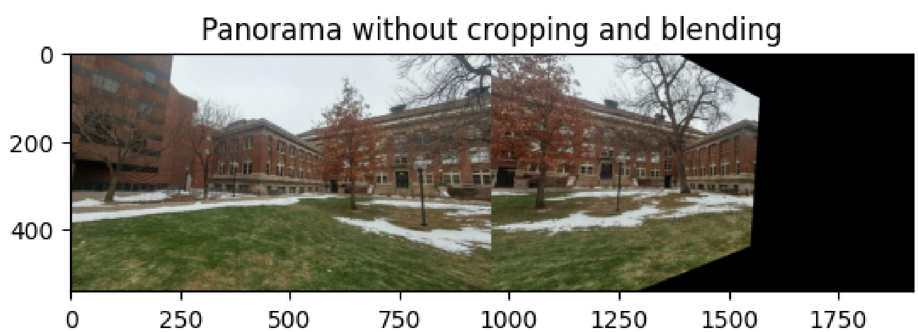
$$\begin{bmatrix} -53.4171260 & 1.33010093 & 1928.86325 \\ -16.2199190 & -32.9071626e & 10075.5356 \\ -0.0555509115 & -0.00122547678 & 1 \end{bmatrix}$$

(d) **Perspective warping**

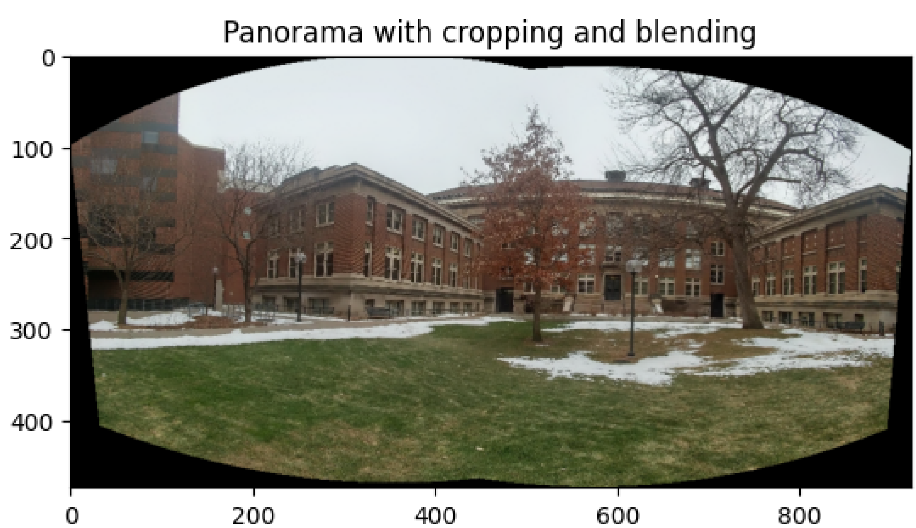


(e) **Stitching**

Without Cropping and blending -



With Cropping and blending -



(f) **Multi-Stitching**