# Assignment 1 Report
# Image Processing - EEL715
# Group No 15

Piyush Kaul
Entry No. 2015EEY7544
EE Dept. IITD

Shiva Azimi
Entry No. 2015EEZ8458
EE Dept. IITD

Shailendra Singh Kathait
Entry No 2015EEY7537
EE Dept IITD

***Abstract*—This report covers the ELL715 Image Processing Assignment solution for panorama stitching of images using Harris Corner Detector and SIFT Algorithm for Keypoint identification and Matching.**

## I. Introduction

The Harris Corner Detector has been implemented in Matlab to detect Corners in images. Also SIFT algorithm from (VL_FEAT) has been used for key-point feature extraction which are then matched to identify matching features between two images. Projective transformations were identified between the images with respect to the middle images. All the images were then warped based on this transformation and added together to obtain the Panorama Image

### A. Harris Corner Detector

We first convert the image to grayscale find the gradient in x and y direction. The following sobel filters are used Once

$$\mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A} \quad \text{and} \quad \mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A}$$

Fig. 1. Sobel Filters.

we the Gradients, we obtain the gradients

$$X = I \otimes G_x$$
$$Y = I \otimes G_y$$

Next step is forming the followng 2nd order forms

$$I_x x = X^2 I_y y \qquad = Y^2 I_x y = XY \tag{1}$$

These are convolved with Gaussian kernel to obtain A, B and C respectively. Next we form the Matrix M such that

$$M = \begin{pmatrix} A & C \\ C & D \end{pmatrix}$$

At every pixel of the picture we find the following

$$det(M) - k * Tr(M) \tag{2}$$

We use k=0.5 and obtain the following 2d values.

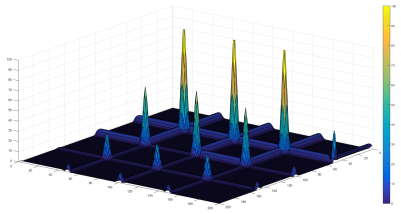

Fig. 2. Output of Harris Corner Detector before thresholding.

We normalize the image such that minimum is 0 and maximum 100. We then threshold the image with value 10. We find the regions, by applying the max filter and then selecting only single maximum value from the filter. This five the following detected corners.

$$det(M) - k * Tr(M) \tag{3}$$

We use k=0.5 and obtain the following 2d values.

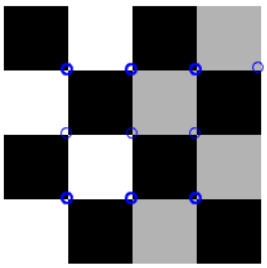

Fig. 3. Final Output of Harris Corner Detector.

*1) Panorama Stiching with Keypoint Generation:* For Keypoint Feature Generation we use VL_Feat Toolbox SIFT implementation. Original Image of Bharti Building have overlap between them.

We calculate the SIFT features for each of the overlapped images and match for keypoints for two pairs : First and Second Picture, and Second and Third Picture.

Fig. 4. First Input Image of Bharti Building.

Fig. 5. Second Input Image of Bharti Building.

## II. Conclusion

The quality of point correspondence with SIFT is fairly exact and we get smooth matching after stitching the images for panorama. All corner co-ordinates can be detected with from harris corner detector with appropriate setting of thresholds.

Fig. 6. Third Input Image of Bharti Building.

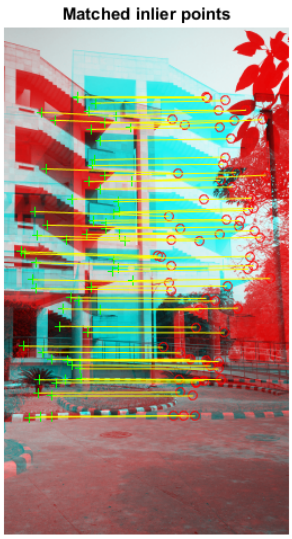


Fig. 7. Keypoint Feature Matching between First and Second Images.

## References

[1] http://www.vlfeat.org/
[2] http://www.mathworks.com/

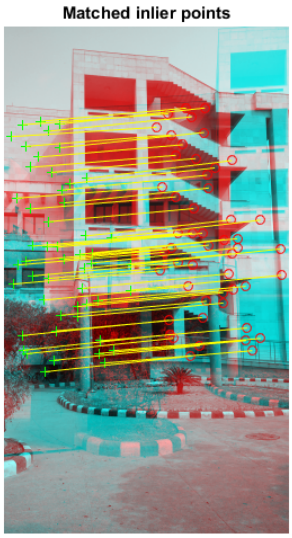


Fig. 8. Keypoint Feature Matching between Second and Third Images.


Fig. 9. Final Panorama.