Automatic Panorama Stitching

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Objective

Automated tool for creating multiple panoramas through images without human assistance.

Problem

Given a set of images from multiple scenes in jumbled unordered way, construct all possible panoramas of the different scenes.

The input images can vary in orientation, scale or illumination.

Motivation

Clicking panoramas through mobile phones and cameras have number of constraints:

1. Cameras should move in a fixed direction.
2. There should exist a minimum level of overlap.
3. Camera should be steady while being moved across the scene.
4. Scene should be static.

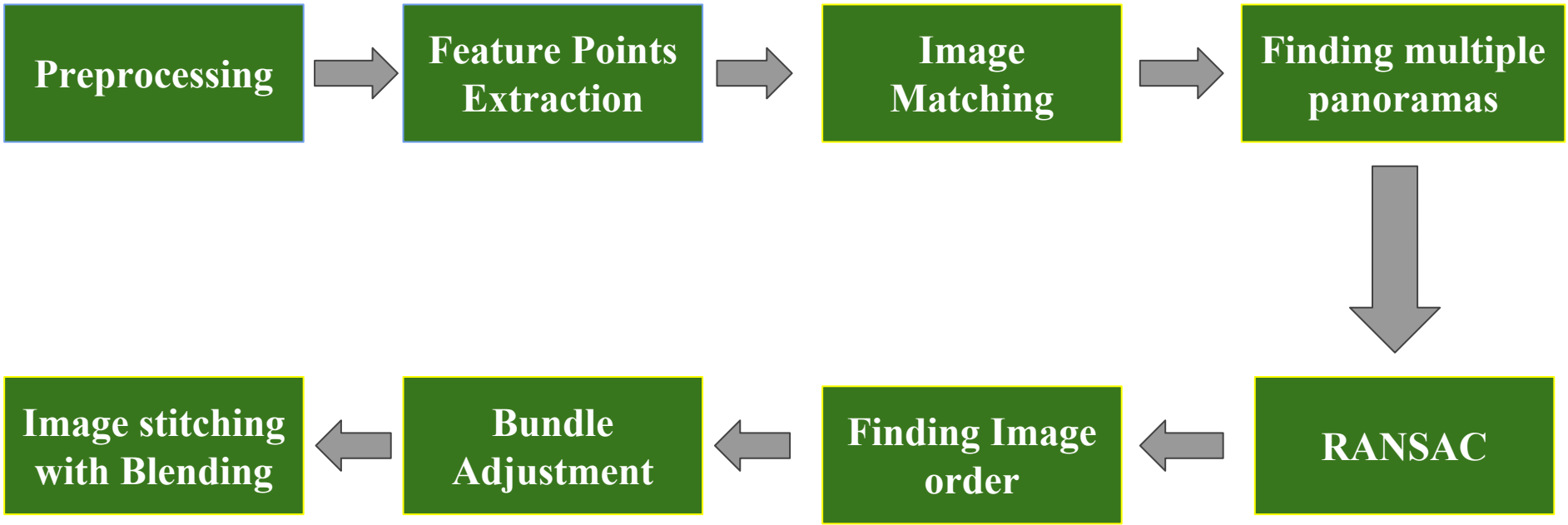
Motivation

These constraints make the process of taking panoramas challenging and a difficult task. However clicking multiple images of the same scene with small overlap still remains very easy. So an offline tool for creating panoramas is very important in today's world. Creating offline panoramas has number of perks also:

1. Higher Resolution Images
2. Wider angle photos in both x and y direction.
3. Lesser Noise.

Overview

Pipeline


Preprocessing
Feature Points Extraction
Image Matching
Finding multiple panoramas
RANSAC
Finding Image order
Bundle Adjustment
Image stitching with Blending

Action Plan

Preprocessing

Images are resized such that maximum length is 800px, while maintaining the aspect ratio. We specifically chose this dimension because it was a balance between the number of feature points and time taken to run the algorithm.

SURF Descriptor

SURF is a local feature descriptor inspired by SIFT. It uses integer approximation of determinant of Hessian Blob detector to find feature points and then Haar Wavelet response around the interest point to find descriptor.

Feature Points

Why SURF?

SURF Descriptor

It was our preferred choice of descriptor over SIFT and Harris because of the following reasons:

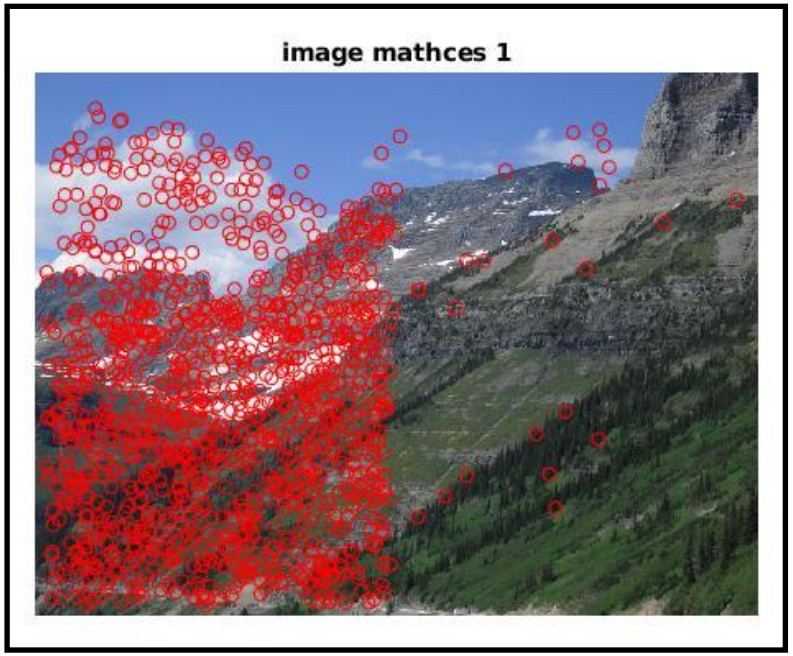
- Faster than SIFT while maintaining similar results.
- Scale invariant.

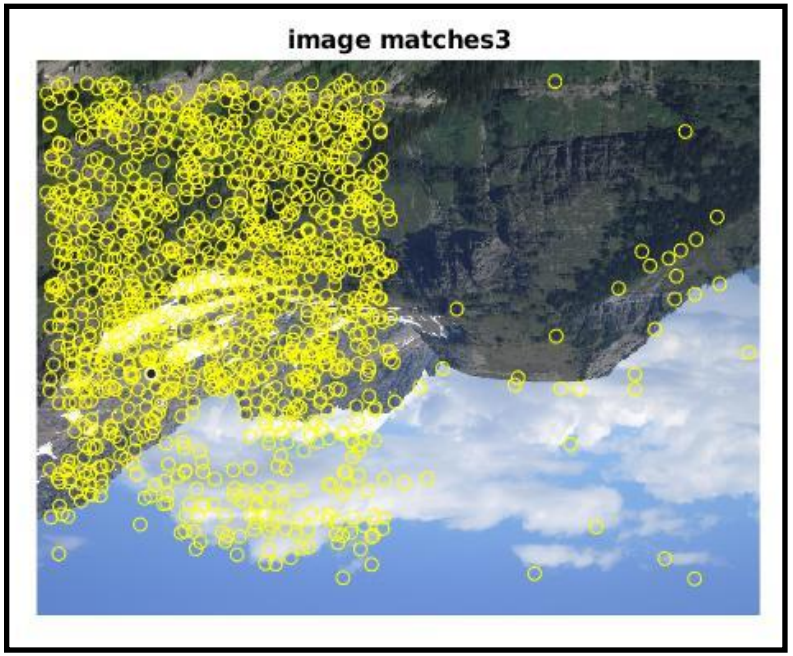
After getting the SURF feature points and descriptors, all the images are compared with each other. A pair of images is set to be matched if they have a minimum number of 300 matched points with 0.9 threshold.

Finding Image Matches

Image Matches

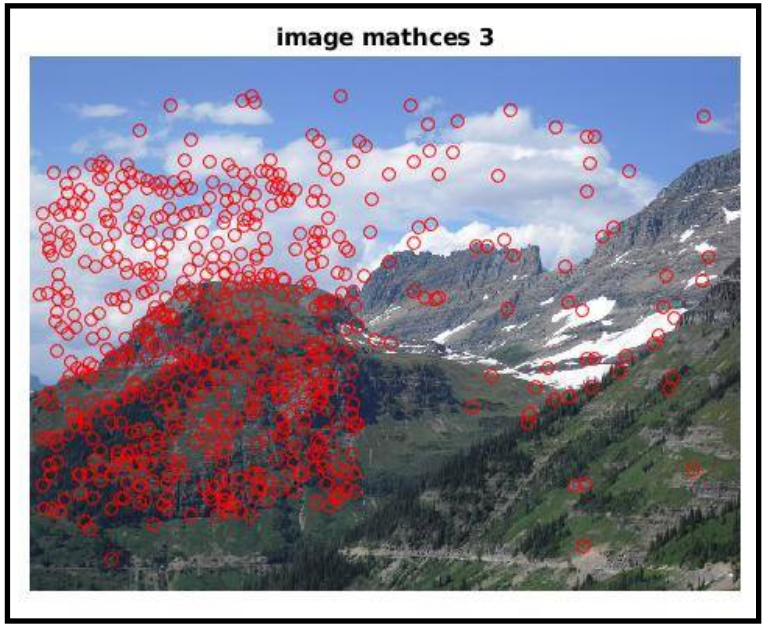
SURF Output

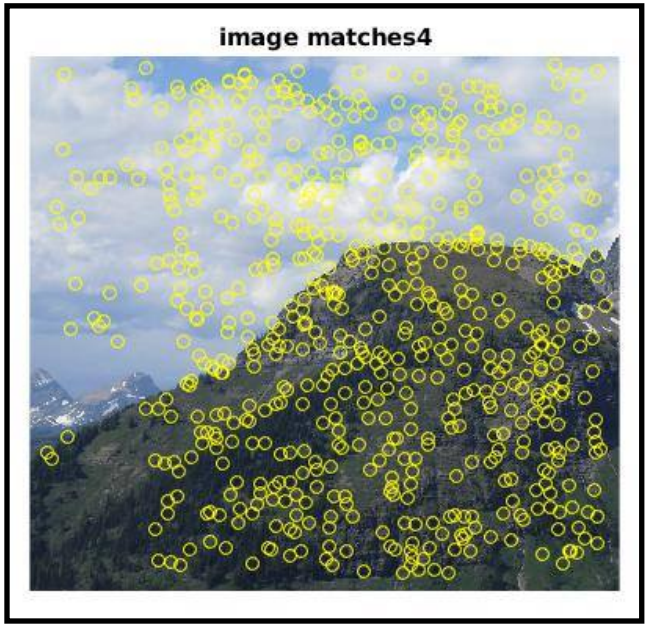




Rotation Invariant

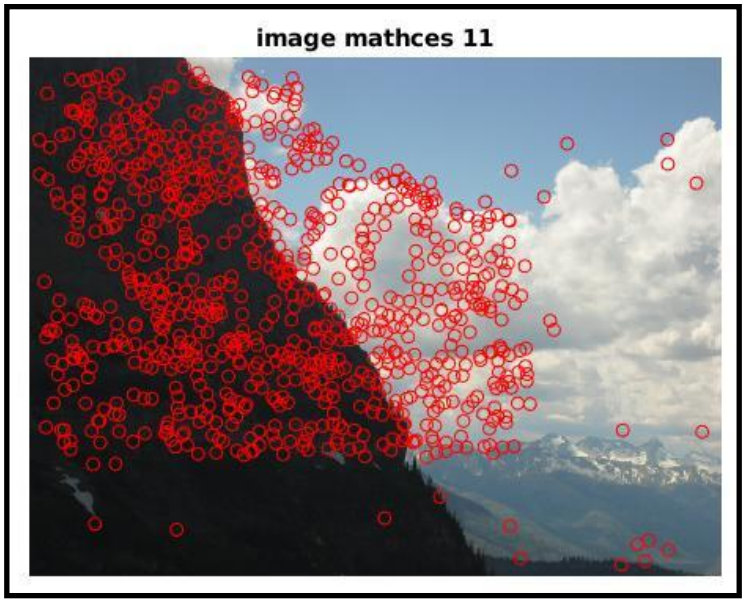
SURF Output

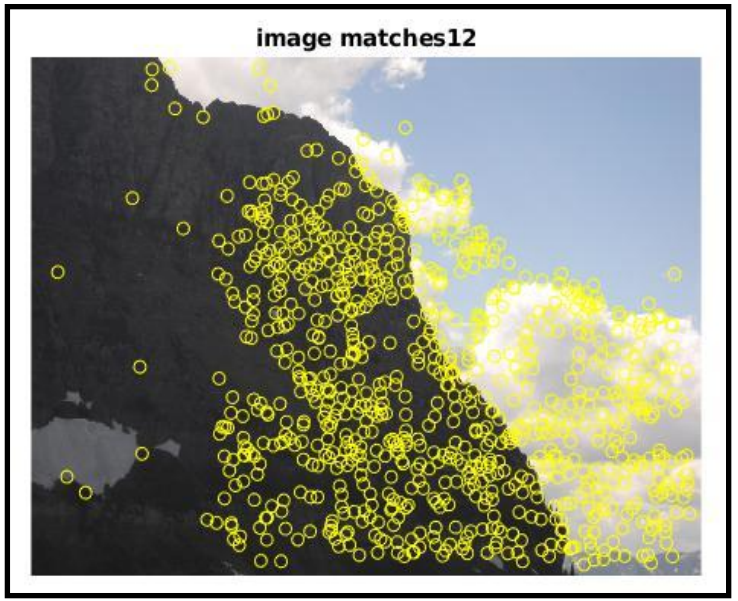




Scale Invariant

SURF Output





Illumination Invariant

Multiple Panoramas

With multiple scenes, we need to segment out the different images of one scene from the other. In order to do so we find the connected components of the images and then label them as belonging to one scene. We repeat this process till we label all the images in the folder.

Input Dataset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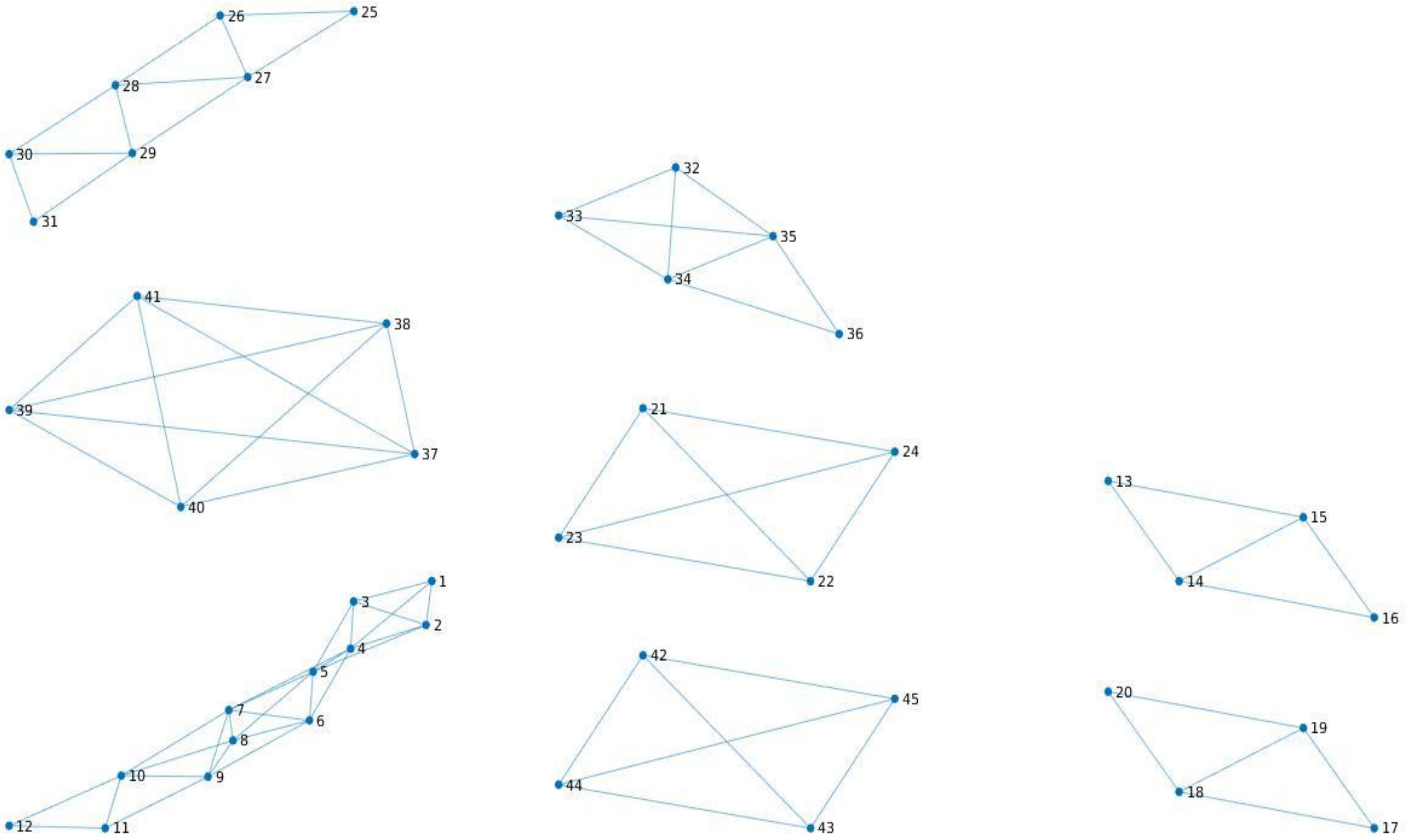
Connected Components Graph



RANSAC

- The SURF feature matches between two images consist of outliers which are removed using RANSAC.
- We detected the inliers though fundamental matrix estimation method.
- Feature points of the image matches would satisfy the constraint:

$$X1 * F * X2' = 0$$

X1, X2 are feature points

F is the Fundamental matrix

RANSAC Inliers

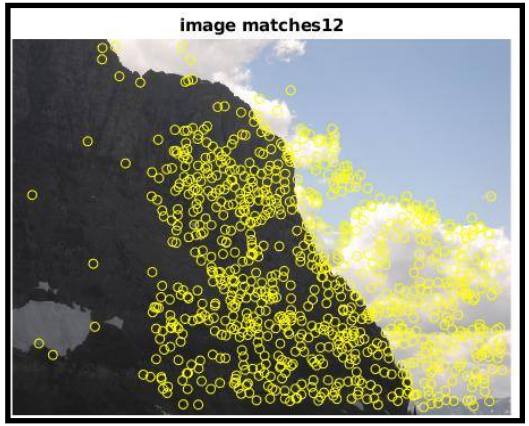


image matches12

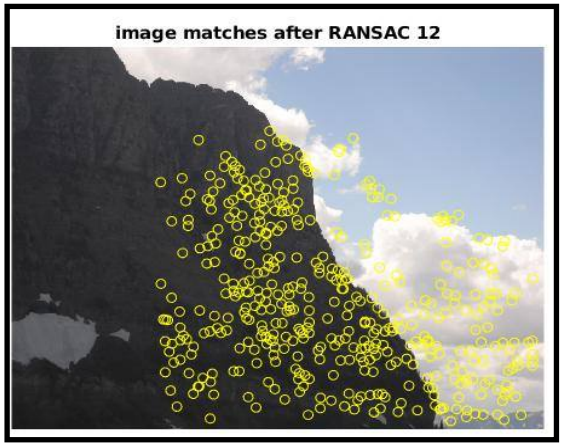
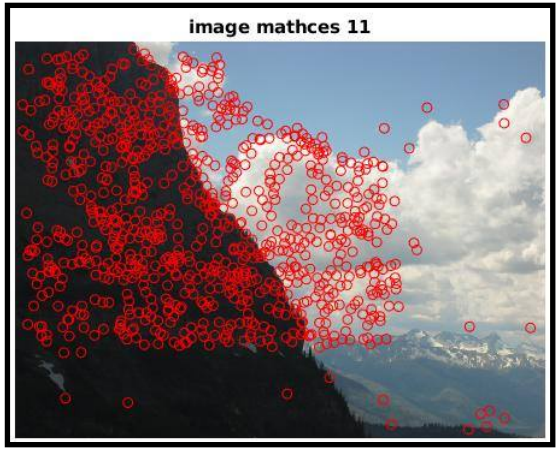


image matches after RANSAC 12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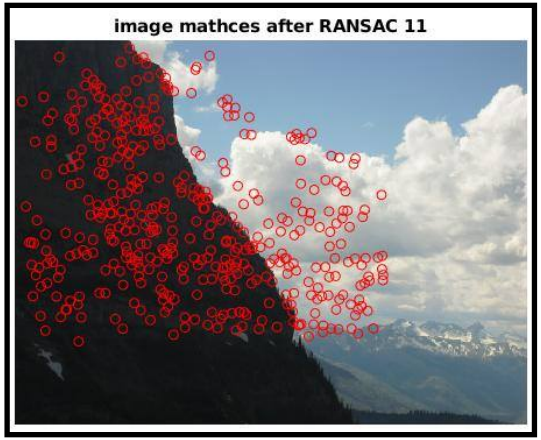
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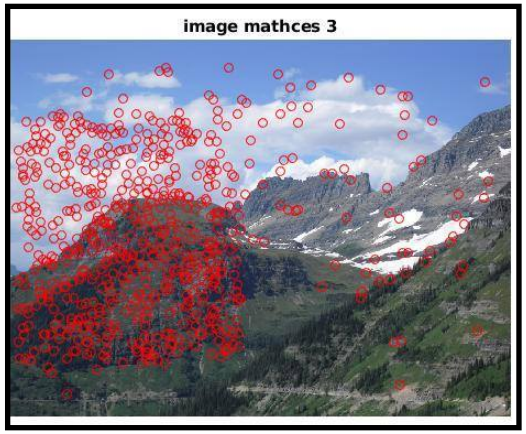
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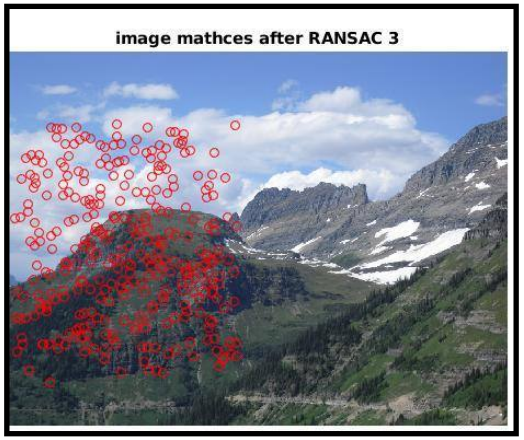
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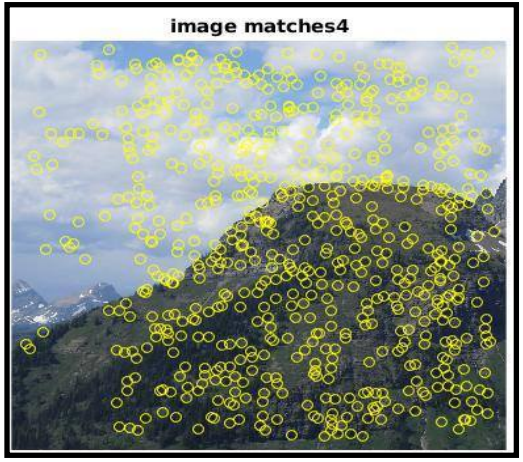
image matches4

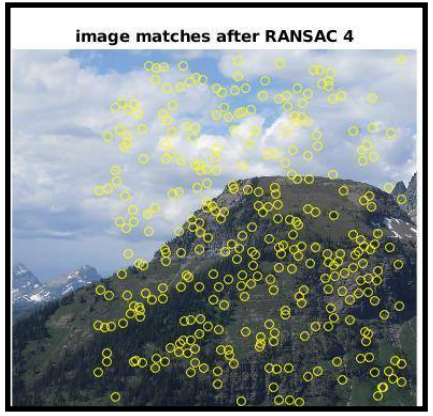
image matches after RANSAC 4

Image Ordering

After receiving inlier points from the RANSAC algorithm we find the order in which the images should be stitched.

For each image I in sequence, I’ is selected such that it is the best matched image i.e. maximum number of RANSAC inliers. At every point it is ensured that a cycle is not formed in the sequence.

- Bundle Adjustment is used to the estimate the homography matrix between the image matches.
- It reduces the error in the estimated parameters using the Levenberg Marquardt algorithm.
- LM algorithm uses a nonlinear least square error objective function for its update rule.

Bundle Adjustment

The error function used in the algorithm.

$$e = \sum_{i=1}^{n} \sum_{j \epsilon \mathcal{I}(i)} \sum_{k \epsilon \mathcal{F}(i,j)} h(\mathbf{r}_{ij}^{k})$$

Where the residual is : $\mathbf{r}_{ij}^{k} = \mathbf{u}_{i}^{k} - \mathbf{p}_{ij}^{k}$

u^{i}_{k} is the k^{th} feature in the i^{th} image.

P^{k}_{ij} is the projection from image j to image i of the point u^{k}_{i}.

$$\tilde{\mathbf{p}}_{ij}^{k} = \mathbf{K}_{i}\mathbf{R}_{i}\mathbf{R}_{j}^{T}\mathbf{K}_{j}^{-1}\tilde{\mathbf{u}}_{j}^{l}.$$

Image Stitching with blending

- All the homographies are now calculated with respect to a fixed frame.
- Starting from the fixed frame, the images are projected onto the fixed frame using the homographies.
- While stitching, the overlapping pixel intensities are blended using a weighted average of the pixel intensities.

Results

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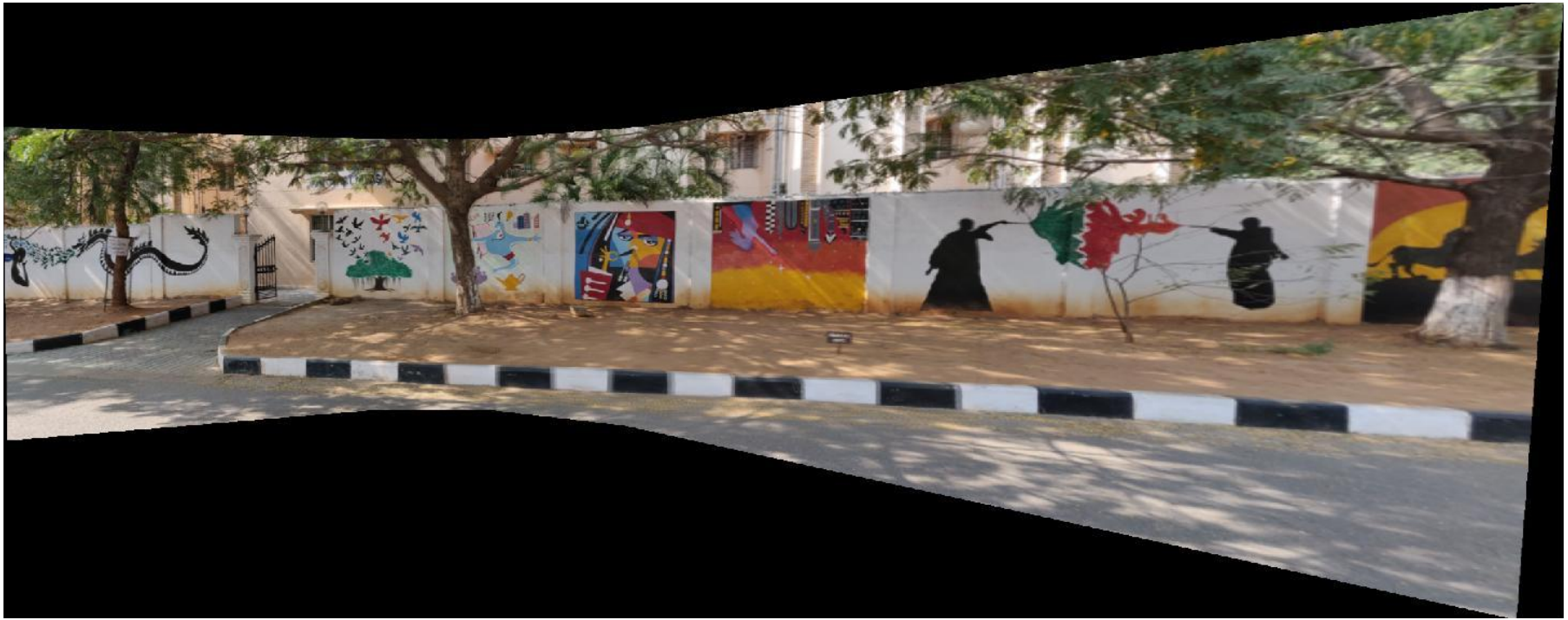

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Result Analysis

- Finding connected components for multiple scenes helped to create multiple panoramas and remove noise image.
- Although SURF uses a feature descriptor to find image matches, still there were a number of false matches which were removed by using RANSAC.
- Levenberg–Marquardt algorithm used for minimizing non-linear least square errors can be take a very long time if the initializations are very poor.

- The constructed panorama has a wavy effect which can be removed by straightening the image.
- We can extend the construction to a 360 degree panorama, where we project the images onto a cylinder.

Future Milestones

THANK YOU