Image-Stitching

In the project the feature points were detected and described by Scale-invariant feature transform, and each feature was matched by finding its nearest neighbor (done by k-d trees from ANN library), Finally the images were blended by alpha, and Laplacian pyramid blending. The OPENCV, ANN libraries were used in this project.

1. Feature detection

Robust feature points contain local information that can help us recognize their corresponding in multiple images. SIFT (scale-invariant feature transform) published by David Lowe is a feature detection algorithm that takes advantage of difference-of-Gaussian pyramid to acquire more stable features that is invariant to uniform scaling. The details of SIFT implementation were referenced from this matlab code.

2. Feature Matching

The aim of feature matching is to find closet features of two images for further stitching process. The nearest neighbor of each feature point was searched by minimum Euclidean distance of descriptors, and Kd-tree from ANN libraries was used to speed up the process. For a key point, if the distance of closest feature was < 0.8 * distance of second closest feature, it was considered as a match. After feature matching, the images and feature points were turned into cylindrical coordinates. To deal with some mismatches after feature matching, the RANSAC was applied to calculate the pairwise alignment. The error for computing alignments was $\mathrm{E} = \sum_{i=1}^{n}[(m_x+x_i - x_i')^2 + (m_y+y_i - y_i')^2]$, and (m_x, m_y) was the alignment of the coordinates.

3. Blending

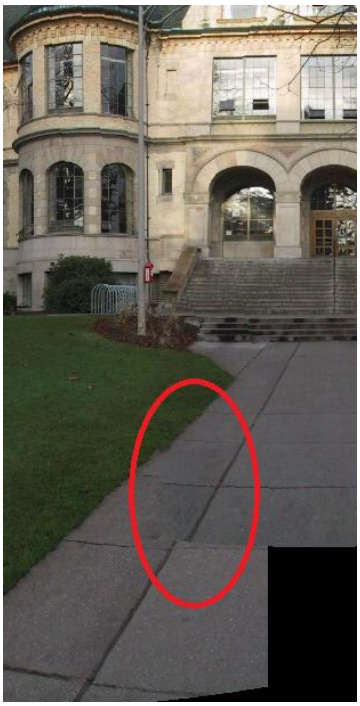
After matching and pairwise alignment, finally images were combined into a panorama. To cope with the overlapping region, the following methods were used:

The overlapping region of two images.

1. Direct connection: The overlapping region was divided vertically in half, and pasted by the overlapping region of two images which owned the half that was closer to it. The results showed that there were some visible seams due to the exposure difference between the images.

2. Alpha blending: The overlapping region was set as the windows of blending. The weight was defined as the ratio of distance to the images, and the one that was closer to the images had the larger weight. The results showed that the seams were less visible than direct blending, but the results accompanied the blurring effect due to mis-alignments in the overlapping region.

3. Laplacian pyramid blending: First, the Gaussian and Laplacian pyramid of two images were built, and then the Laplacian images were blended by a weighted mask blurred from a Gaussian filter. The results showed the seams were less invisible than the direct connection, and there were no blurring effects in the edges.

Direct connection	Alpha blending	Laplacian pyramid blending
		

Comparison of three blending methods

Reference:

- Distinctive Image Features from Scale-Invariant Keypoints, David G. Lowe, 2004
- Recognising Panoramas, M.Brown and D. G. Lowe, 2003
- Image Alignment and Stitching: A Tutorial, Richard Szeliski, 2006.