Project 2: Panorama Stitching

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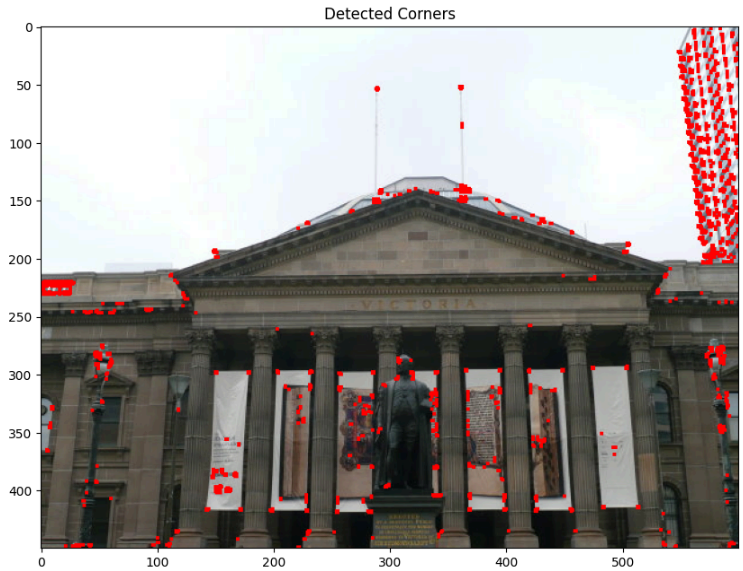
Introduction

The goal of this project was to stitch multiple overlapping images into seamless panoramas using a variety of image processing techniques. At the heart of our approach was the identification of image features, linking these common features across different images, calculating geometric transformations (known as homographies), and blending the images smoothly. This document presents the techniques used, the challenges encountered, and the strategies employed to overcome these challenges throughout the project.

Pipeline Overview

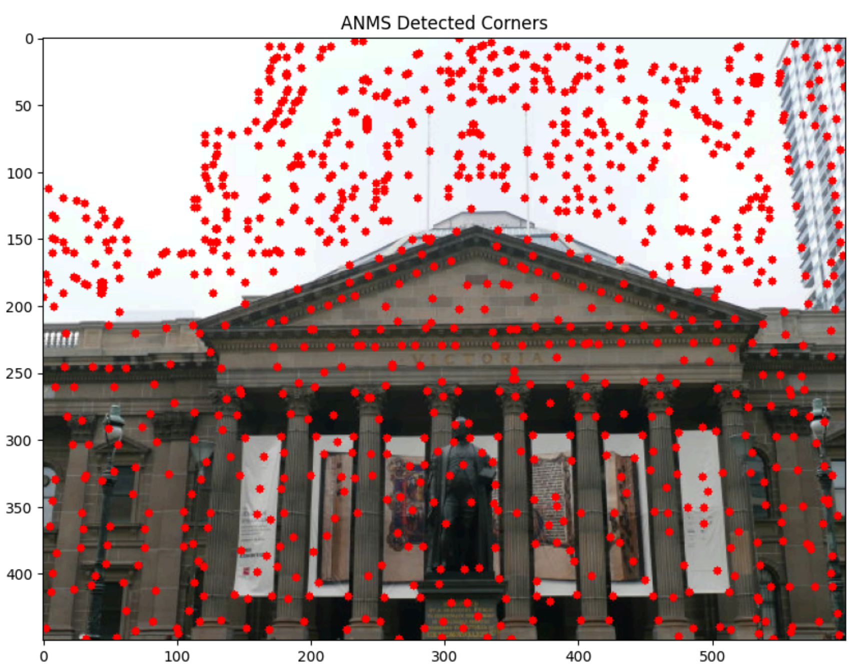
Our methodology was organized into several crucial steps: Corner Detection, Adaptive Non-Maximal Suppression (ANMS), Generating Feature Descriptors, Matching Features, RANSAC for Homography Calculation, and Blending and Warping Images. Essentially, we are trying to identify key points that are common in the overlapping images and refine them, before aligning them and blending them to form a nice, smooth panorama.

Detect Corners



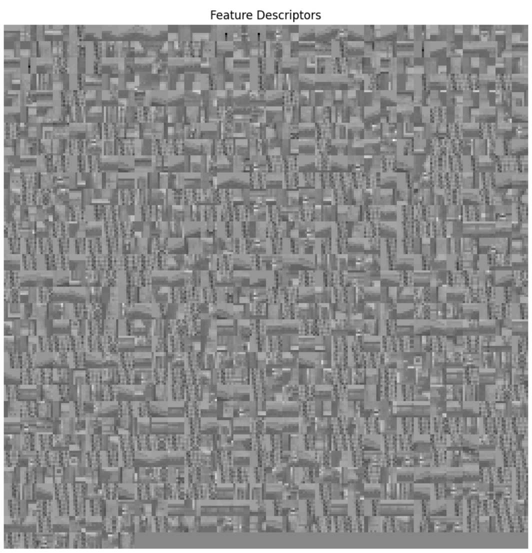
Using the **cv2.cornerHarris** function provided by OpenCV, we identified image corners as preliminary points of interest. The obstacle here was to sift through many irrelevant corners, achieved by applying an intensity cutoff that effectively diminished extraneous data.

ANMS



ANMS focuses on corners that are equally distributed across the image to prevent weird artifacts in warping. It takes the best corners which have the largest suppression radius, which means that they are most likely to be the local maxima in their neighborhood. The challenge here was to increase the efficiency by vectorising the code and reducing the number of nested loops. This was done through boolean indexing to find out which points are suppressing the current point, and then using broadcasting to calculate the minimum distance from the suppressing point.

Feature Descriptors



We crafted a distinctive feature descriptor for every corner selected. This involved isolating a patch around the corner, applying a Gaussian filter for blurring, followed by resizing and standardizing the patch. The challenge of maintaining rotational invariance was met by orienting patches according to their leading gradient direction prior to calculating the descriptor.

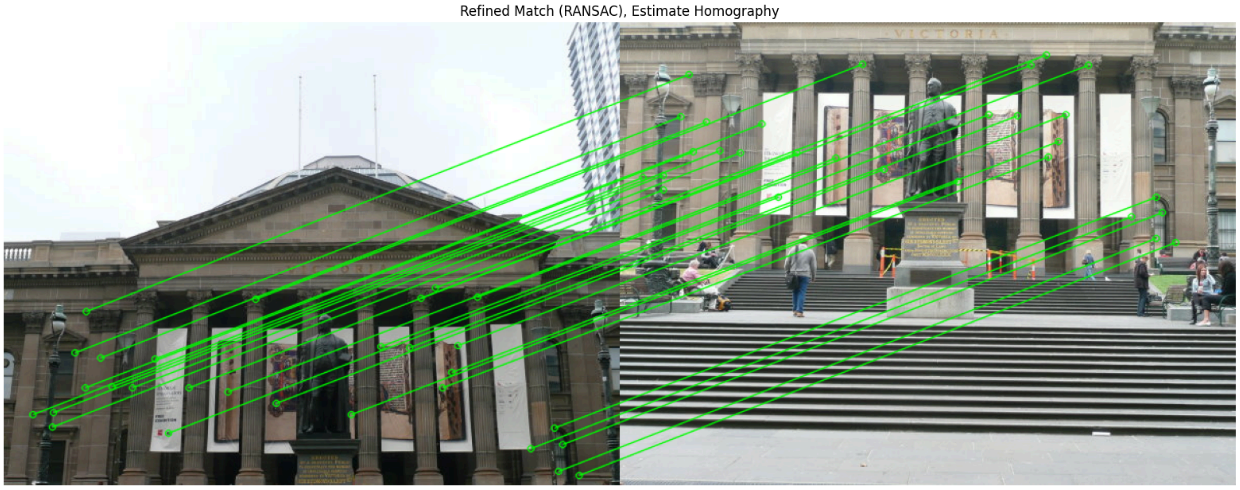
Feature Matching

Feature Matching

We matched feature descriptors from various images to identify correspondences. Utilizing a k-NN approach along with a distance ratio test helped eliminate weak matches. A cross-check process was subsequently applied to ensure only reciprocal best matches were kept, crucial for precise homography estimations.

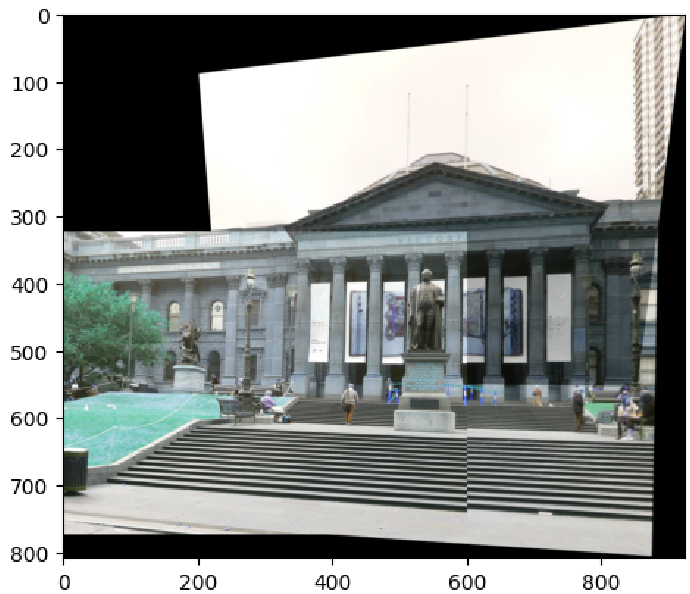
RANSAC and Homography Estimation

Refined Match (RANSAC), Estimate Homography



For the features matched, we applied the RANSAC algorithm to accurately determine homographies while filtering out outliers. A challenge was to find a suitable threshold for selecting inliers. Through experimentation, we found a balance that effectively minimized outliers while retaining a sufficient number of points for accurate homography determination.

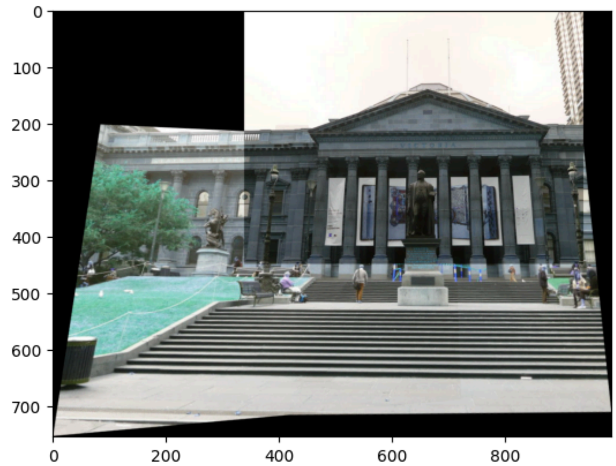
Image Warping and Blending



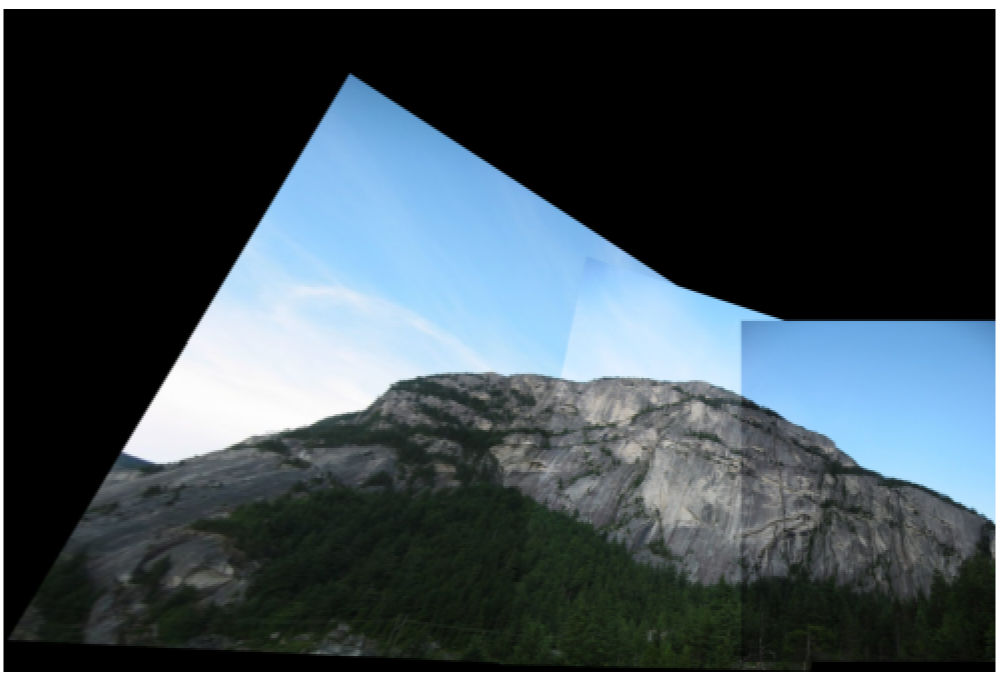
After calculating the homographies, we transformed the images onto a shared plane and merged them. We tested several blending techniques, ultimately selecting a method that averages the pixel values in overlapping sections to avoid visible seams. A noteworthy challenge was minimizing distortions at the panorama edges, which was addressed by fine-tuning the warping adjustments and cropping the final composition to exclude areas with severe distortion.

Results and Discussion

Set 1



Set 2



Set 3

The resulting panoramas, for both the training and validation sets, confirmed the success of our approach. The integrations were seamless, with precise geometric alignments across various sets of images. The staged visualizations underscored the methodical conversion of initial images into a cohesive panorama, marking the effective resolution of issues like feature discrepancies and blending anomalies.

Conclusion

This project not only solidified our grasp of critical image processing and computer vision principles but also offered practical experience in addressing the challenges of panorama creation. Through the iterative enhancement of each stage within our process, we managed to create high-quality panoramas that elegantly fused multiple images together.