CS 4476/6476 Project 3

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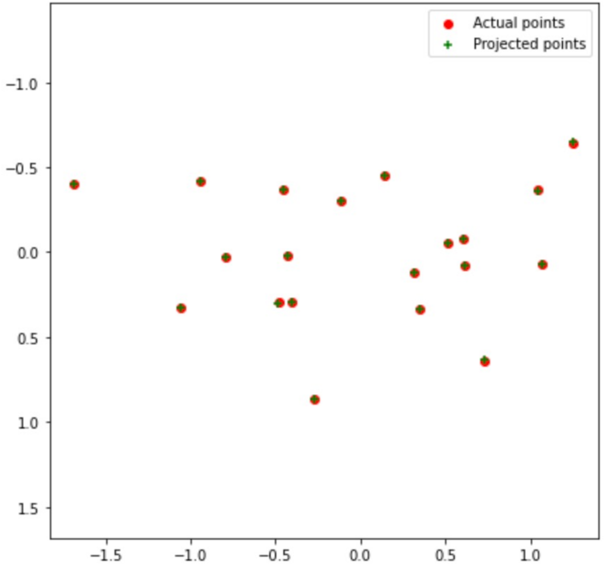
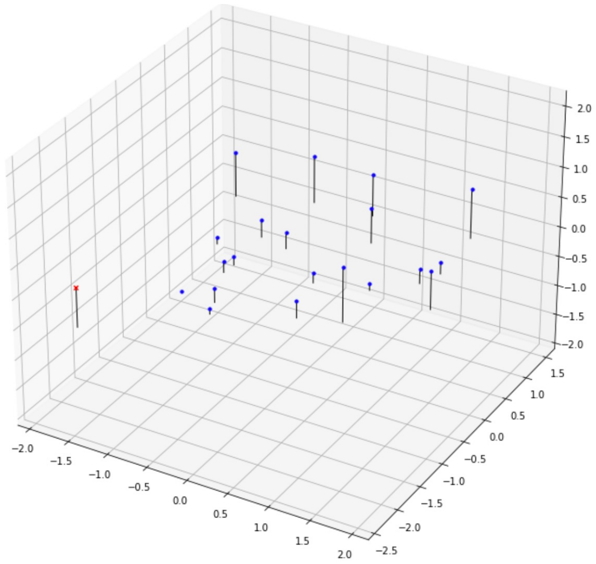
Part 1: Projection matrix

[insert visualization of projected 3D points and actual 2D points for the CCB image we provided here]

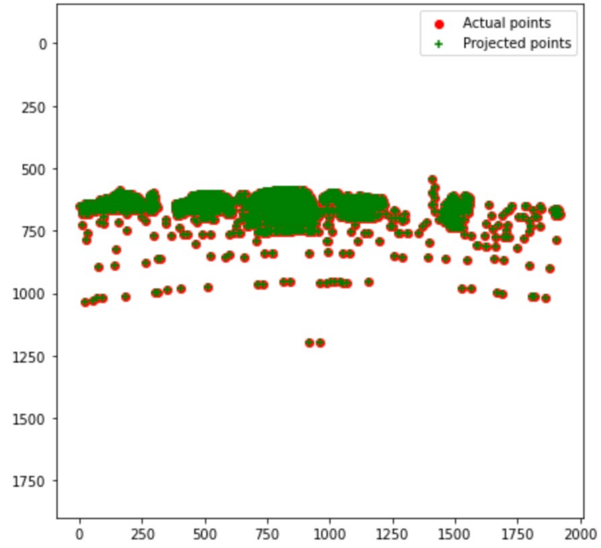


[insert visualization of camera center for the CCB image here]

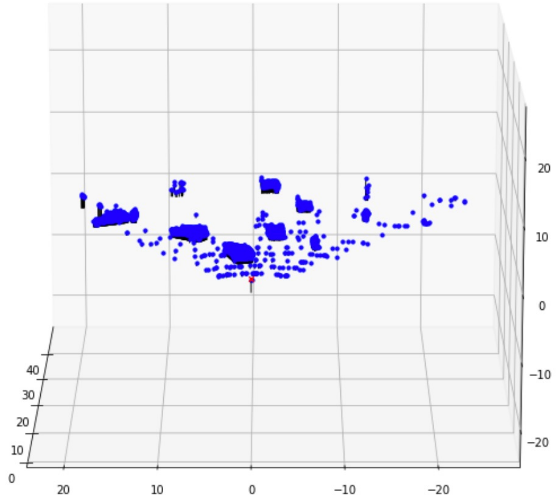


Part 1: Projection matrix

[insert visualization of projected 3D points and actual 2D points for the Argoverse image we provided here]



[insert visualization of camera center for the Argoverse image here]



Part 1: Projection matrix

[What two quantities does the camera matrix relate?]

Multiplying 3D points to camera matrix can give projected 2D points.

[What quantities can the camera matrix be decomposed into?]

Extrinsic matrix and intrinsic matrix

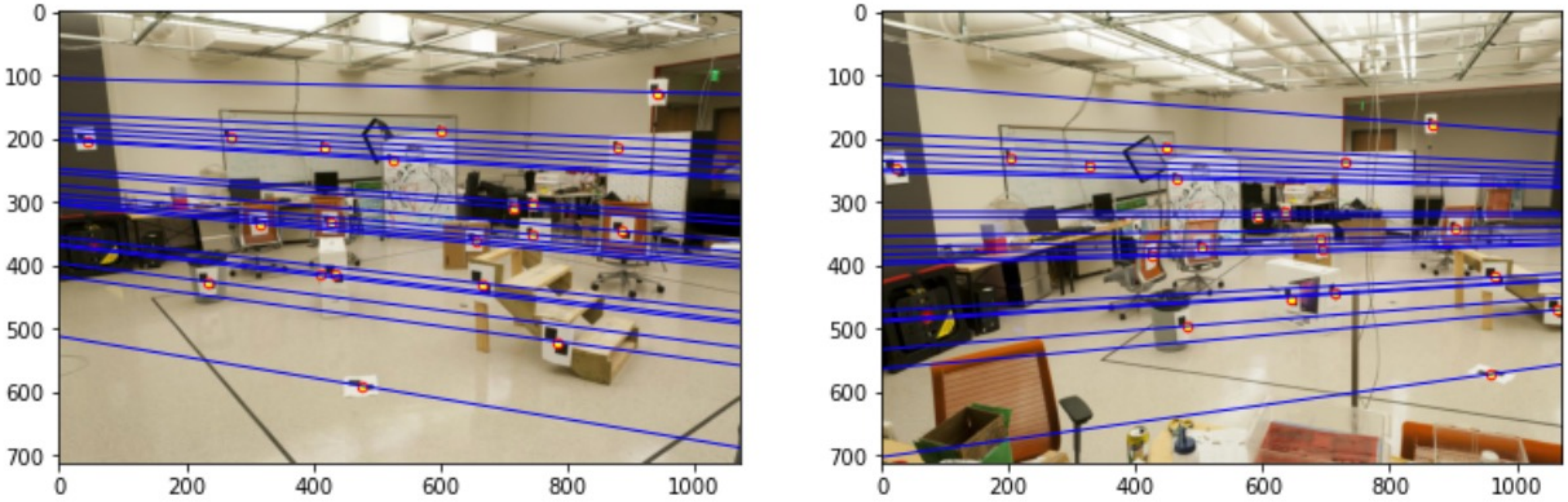
Rotation matrix, translation vector, focal length, pixel sizes, image center point, radial distortion parameters.

[List any 3 factors that affect the camera projection matrix.]

Focal length, camera rotation, pixel sizes.

Part 2: Fundamental matrix

[insert visualization of epipolar lines on the CCB image pair]



Part 2: Fundamental matrix

[Why is it that points in one image are projected by the fundamental matrix onto epipolar lines in the other image?]

Because fundamental matrix is rank two, so the dimension of vector space is two.

Fundamental matrix converts every point in image A to the epipolar line on image B.

[What happens to the epipoles and epipolar lines when you take two images where the camera centers are within the images? Why?]

The epipolar line will become only a dot (the epipole) on each image plane overlapping with the camera center. Because the line between the optical center and the real-world point and the baseline will both only intersect with the camera plane at the camera center (a dot).

Part 2: Fundamental matrix

[What does it mean when your epipolar lines are all horizontal across the two images?]

It means the epipolar plane is horizontal.

[Why is the fundamental matrix defined up to a scale?

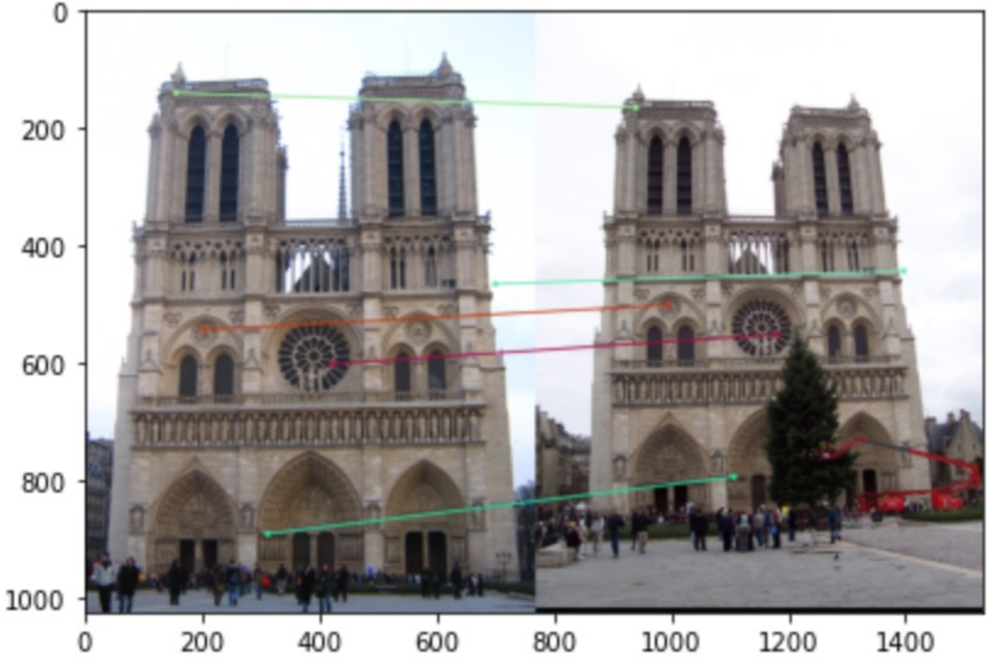
So that the fundamental matrix is not all zeros. Also, if we multiply the 2D coordinates with a scalar, the result of apply fundamental matrix would still be 0.

[Why is the fundamental matrix rank 2?]

Because it represents a mapping from a **2**-dimensional projective space onto a 1-dimensional projective space(epipolar line).

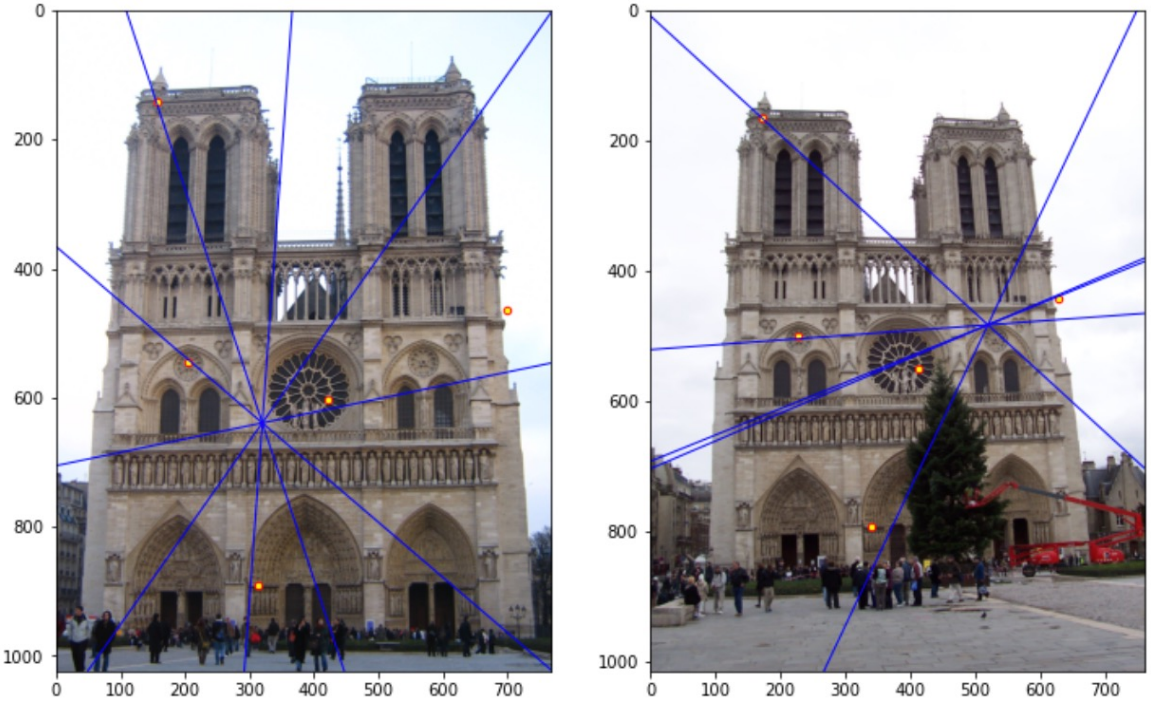
Part 3: RANSAC

[insert visualization of correspondences on Notre Dame after RANSAC]



Part 3: RANSAC

[insert visualization of epipolar lines on the Notre Dame image pair]



Part 3: RANSAC

[How many RANSAC iterations would we need to find the fundamental matrix with 99.9% certainty from your Mt. Rushmore and Notre Dame SIFT results assuming that they had a 90% point correspondence accuracy?]

13 iterations.

[One might imagine that if we had more than 9 point correspondences, it would be better to use more of them to solve for the fundamental matrix. Investigate this by finding the # of RANSAC iterations you would need to run with 18 points.]

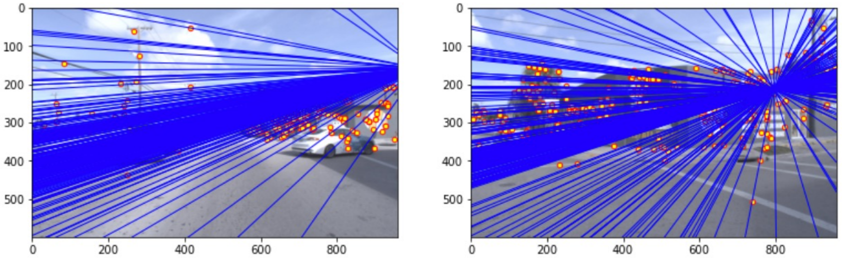
43 iterations.

[If our dataset had a lower point correspondence accuracy, say 70%, what is the minimum # of iterations needed to find the fundamental matrix with 99.9% certainty?]

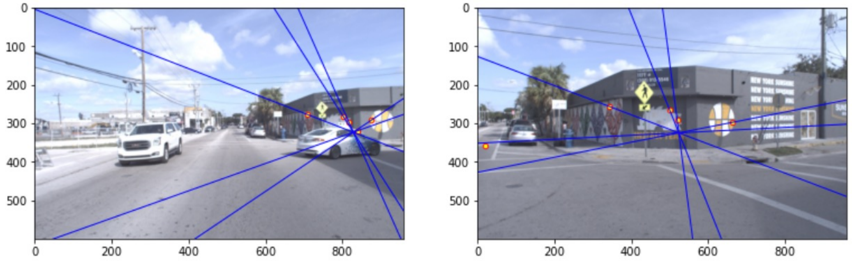
117 iterations.

Part 4: Performance comparison

[insert visualization of epipolar lines on the Argoverse image pair using the linear method]



[insert visualization of epipolar lines on the Argoverse image pair using RANSAC]



Part 4: Performance comparison

[Describe the different performance of the two methods.]

The linear method generates more epipolar lines, and the epipolar lines from those two methods have different intersection points(epipoles).

[Why do these differences appear?]

Because RANSAC only calculates with a subset of points and linear method utilizes all the point pairs. Thus, more epipolar lines are calculated by linear method. The epipoles are different because essentially the dataset used for those results are different.

[Which one should be more robust in real applications? Why?]

In real applications RANSAC will be more robust it does not utilize outliers which can make the result inaccurate.

Part 5: Visual odometry

[How can we use our code from part 2 and part 3 to determine the “ego-motion” of a camera attached to a robot (i.e., motion of the robot)?]

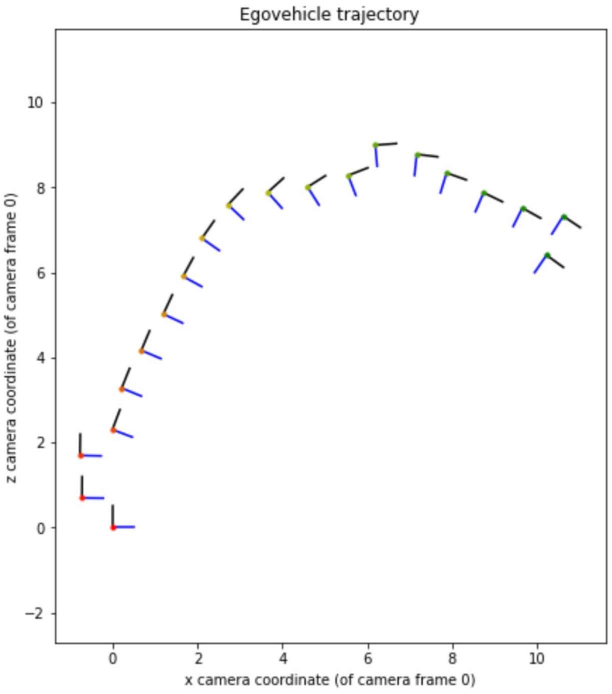
We utilize RANSAC to exclude outliers. After getting the best fundamental matrix and inliers from both images, we can use the intersection of epipolar lines as the epipole. Collecting data and calculate in real-time gives us the real-time motion of the robot.

[In addition to the fundamental matrix, what additional camera information is required to recover the ego-motion?]

Intrisic matrix

Part 5: Visual odometry

[Attach a plot of the camera's trajectory through time]



Part 6: Panorama Stitching

1. Load images to numpy arrays
2. Find interest points
3. Find inliers using ransac in part3
4. Use inliers as inputs and calculates homography matrix using findHomography() in cv2.
5. Apply homography matrix to each point of image B and find its corresponding position in panaroma.
6. stitch image A to the left side of the panaroma

Part 6: Panorama Stitching

[Insert visualizations of your stitched panorama here along with the 2 images you used to stitch this panorama (**there should be 3 images in this slide**)].