

HW2: Automatic Feature Matching Across Images

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COMS4732W Computer Vision 2

Overview

This project implements an automatic feature matching pipeline:

- **Step 0:** Capture & display 2 images
- **Step 1:** Harris Corner Detection (provided `harris.py`, single scale)
- **Step 2:** Non-Maximal Suppression (NMS) via `scipy.ndimage.maximum_filter`
- **Step 3:** Feature Descriptor Extraction — 40×40 RGB $\rightarrow 8 \times 8 \times 3$ (192-dim), bias/gain normalized
- **Step 4:** Feature Matching — Lowe's NNDR with **L2 (Euclidean)** distance
- **Extra Credit:** 3-image panorama stitching with RANSAC homography

HW Libraries: numpy, matplotlib, scikit-image (`resize`, `corner_harris`), scipy (`maximum_filter`, `cdist`), Pillow (EXIF orientation fix)

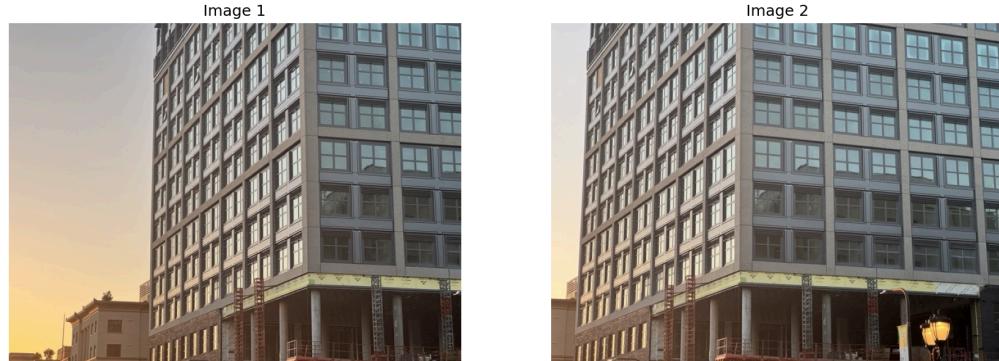
Extra Credit Libraries: scikit-image (`ransac`, `ProjectiveTransform`, `warp`)

Hyperparameters

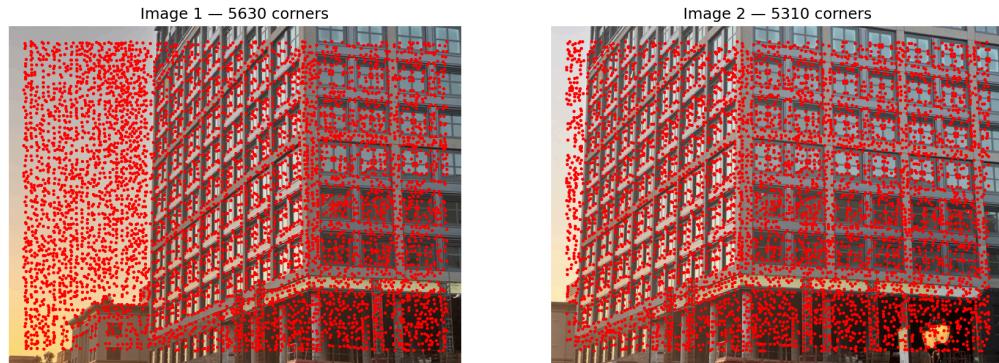
Parameter	Value
Harris edge_discard	20 px
NMS window size	20 px
Descriptor	$40 \times 40 \rightarrow 8 \times 8 \times 3$ RGB (192-dim)
Similarity metric	L2 (Euclidean distance)
NNDR threshold	0.5

▼ Scene 1 — HW Staff Example Images

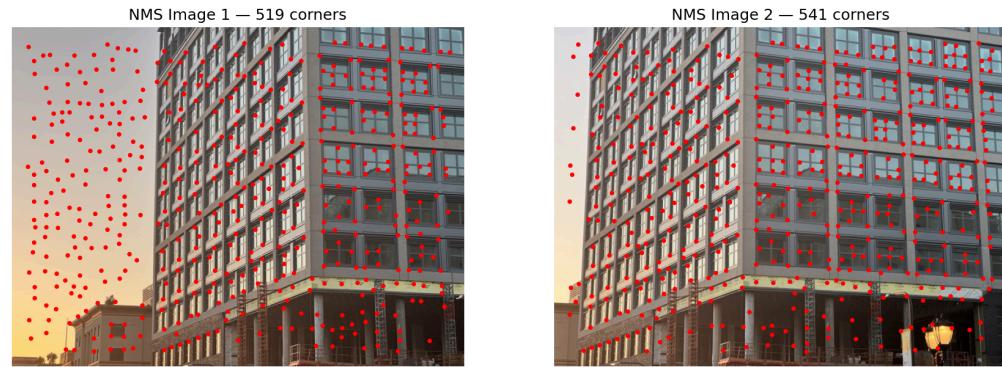
▼ Step 0: Original Images — Two staff-provided input images displayed side-by-side



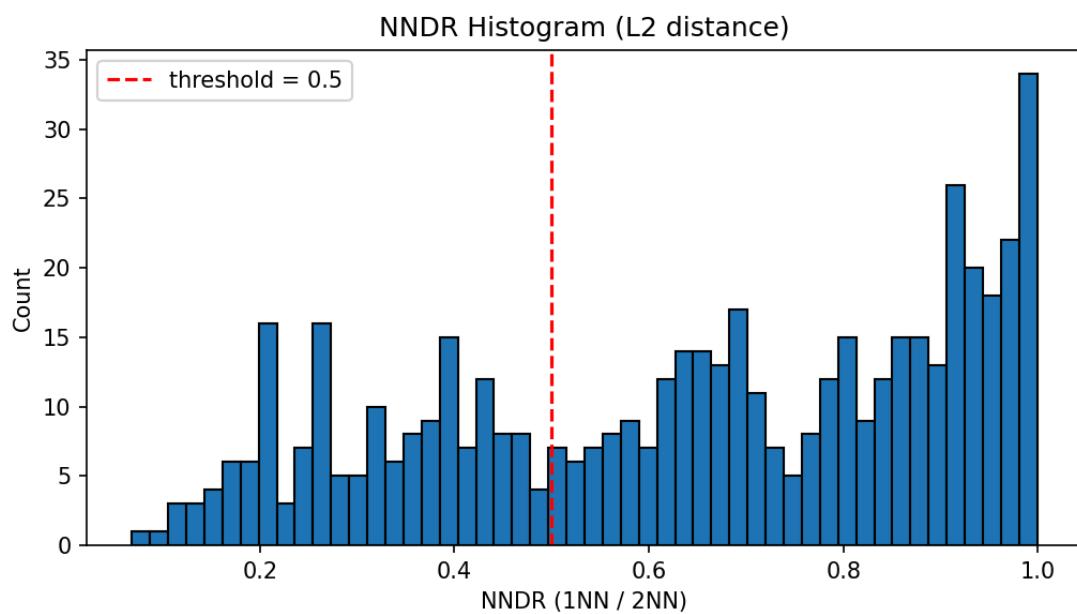
▼ Step 1: Harris Corner Detection — Detected corners overlaid on both images (red dots)



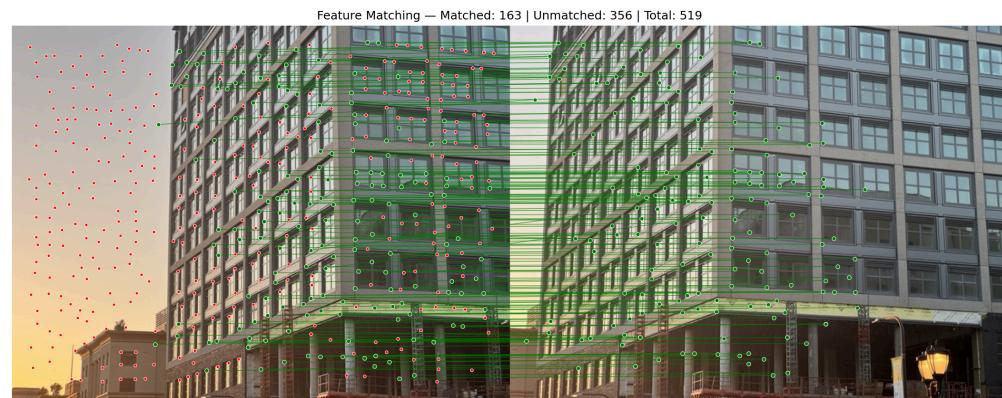
▼ Step 2: Non-Maximal Suppression — Corners after NMS (window size = 20), only local maxima retained



- ▼ Step 4.1: NNDR Histogram — Distribution of nearest-neighbor distance ratios with threshold (L2 metric)



- ▼ Step 4.2: Feature Matches (Option 2) — Green lines = matches, red dots = unmatched



▼ Step 4.3: Top 5 Best Matches — img1 feature | 1NN from img2 | 2NN from img2 (RGB patches)

Top 5 Best Feature Matches by NNDR (L2) - RGB**Image 1 Feature****Nearest Neighbor (1st)****Second Nearest (2nd)**

Image 1 Feature #1



Image 2 NN (1st)

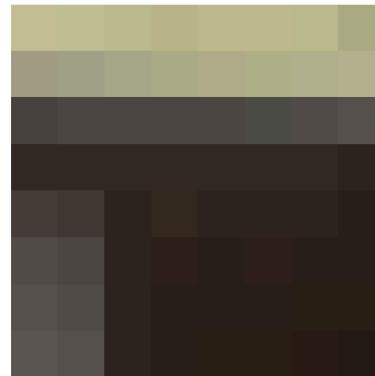


Image 2 2NN (2nd)



Image 1 Feature #2



Image 2 NN (1st)

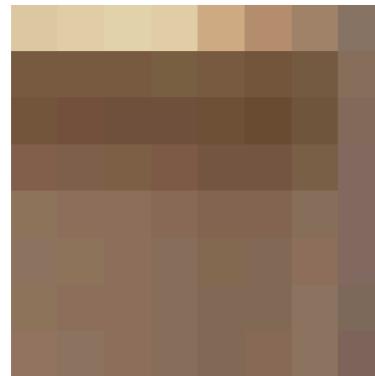


Image 2 2NN (2nd)



Image 1 Feature #3



Image 2 NN (1st)

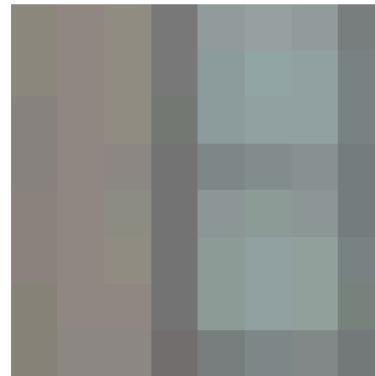


Image 2 2NN (2nd)

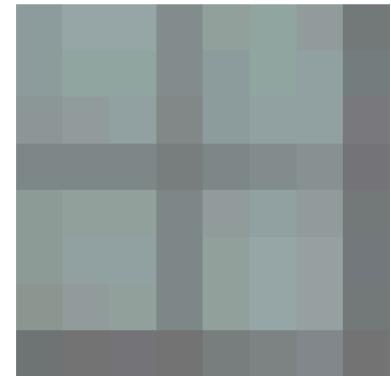


Image 1 Feature #4



Image 2 NN (1st)

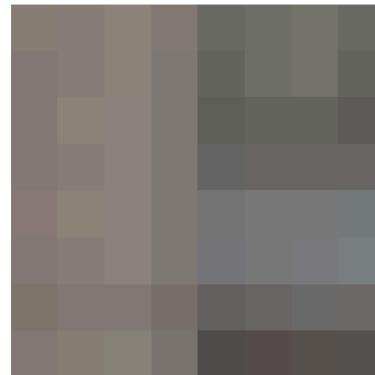


Image 2 2NN (2nd)

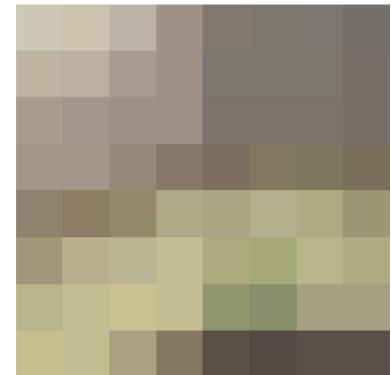


Image 1 Feature #5

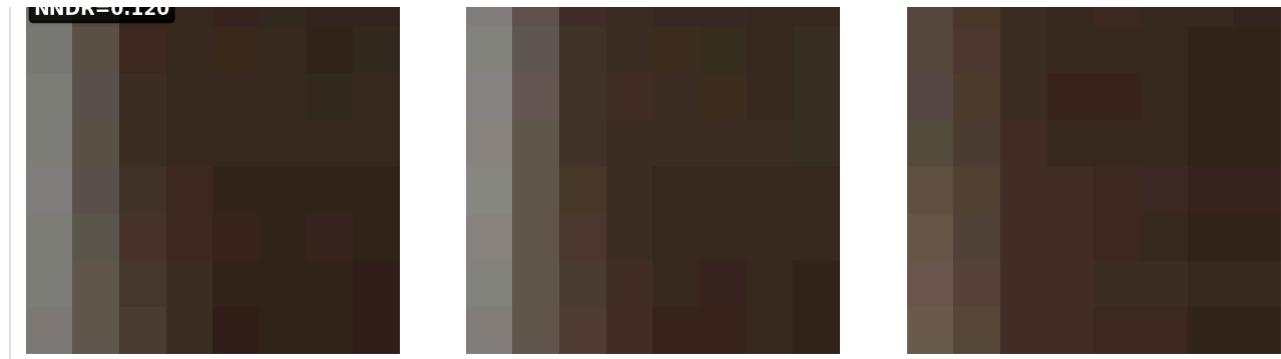


Image 2 NN (1st)



Image 2 2NN (2nd)





▼ Scene 2 — Custom Scene

▼ Step 0: Original Images — Two personal photos displayed side-by-side



▼ Step 1: Harris Corner Detection — Detected corners overlaid on both images (red dots)

Image 1 — 16777 corners



Image 2 — 17176 corners



- ▼ Step 2: Non-Maximal Suppression — Corners after NMS (window size = 20), only local maxima retained

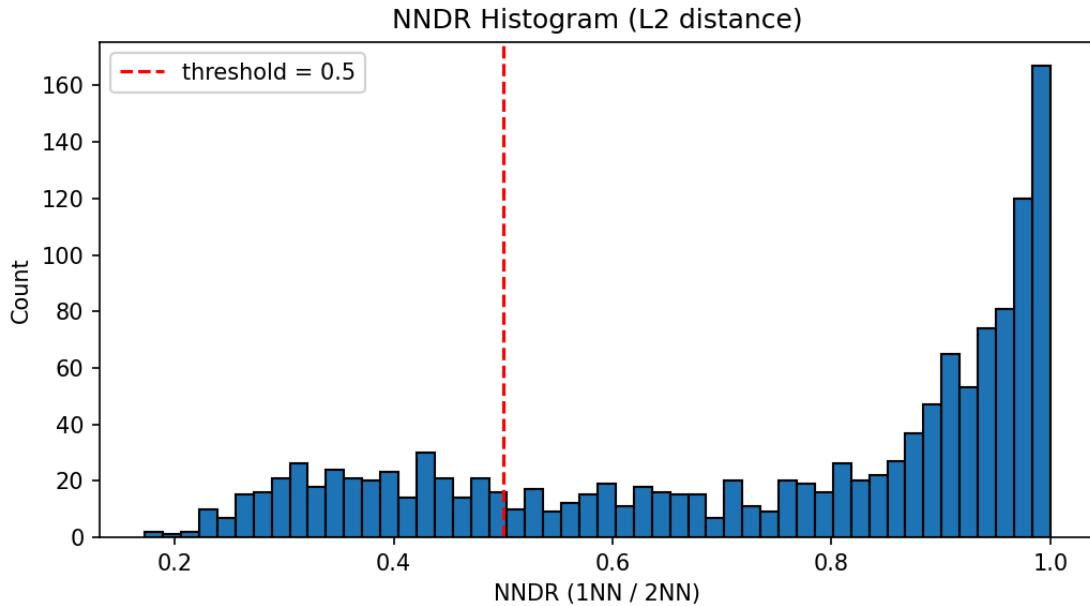
NMS Image 1 — 1320 corners



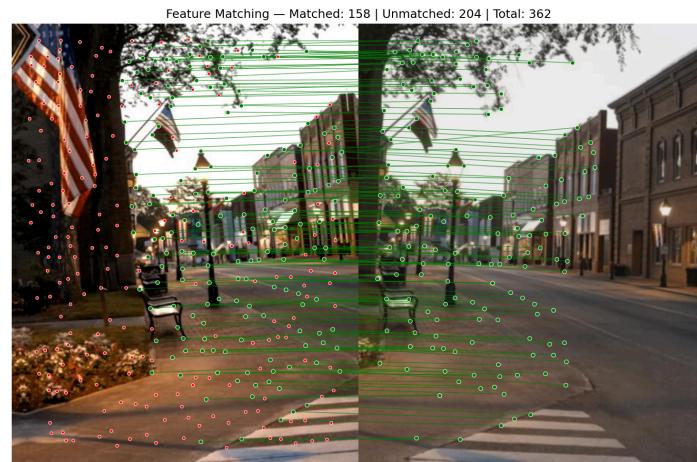
NMS Image 2 — 1319 corners



- ▼ Step 4.1: NNDR Histogram — Distribution of nearest-neighbor distance ratios with threshold (L2 metric)



▼ Step 4.2: Feature Matches (Option 2) — Green lines = matches, red dots = unmatched



▼ Step 4.3: Top 5 Best Matches — img1 feature | 1NN from img2 | 2NN from img2 (RGB patches)

Top 5 Best Feature Matches by NNDR (L2) - RGB**Image 1 Feature****Nearest Neighbor (1st)****Second Nearest (2nd)**

Image 1 Feature #1

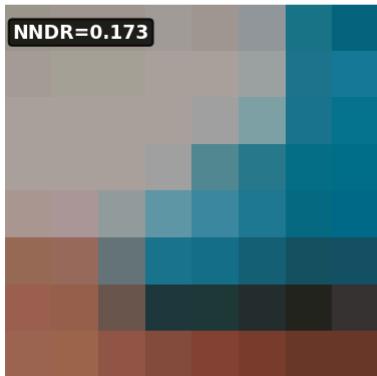


Image 2 NN (1st)

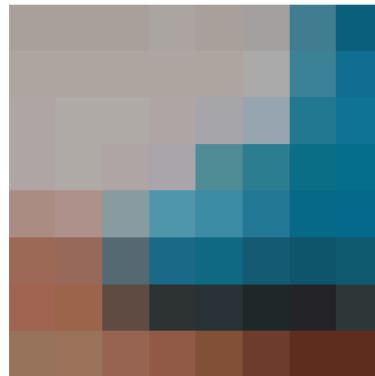


Image 2 2NN (2nd)

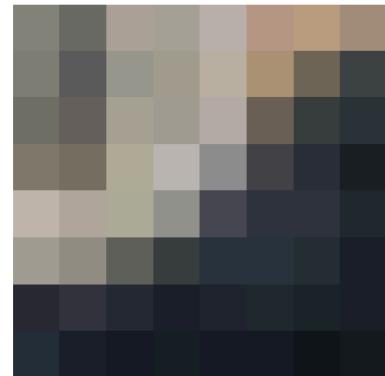


Image 1 Feature #2

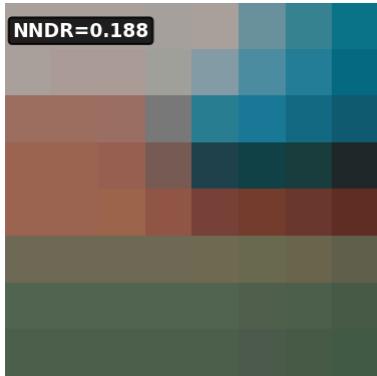


Image 2 NN (1st)

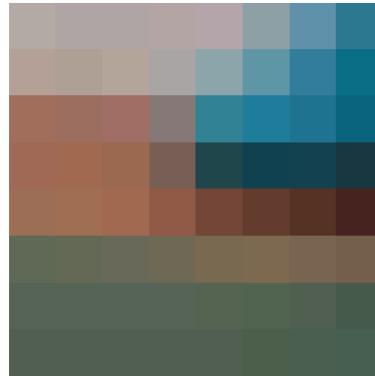


Image 2 2NN (2nd)

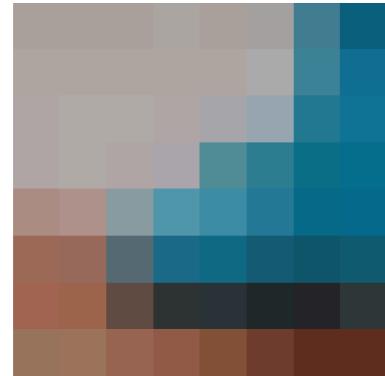


Image 1 Feature #3



Image 2 NN (1st)

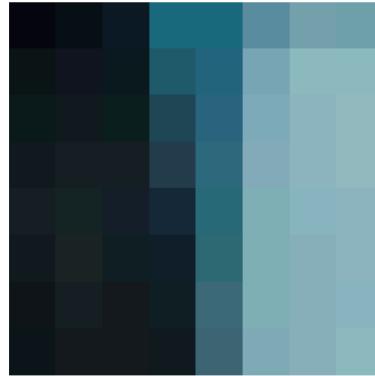


Image 2 2NN (2nd)

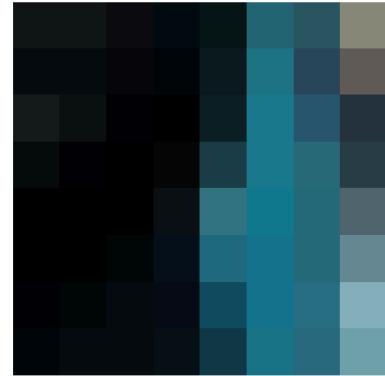


Image 1 Feature #4

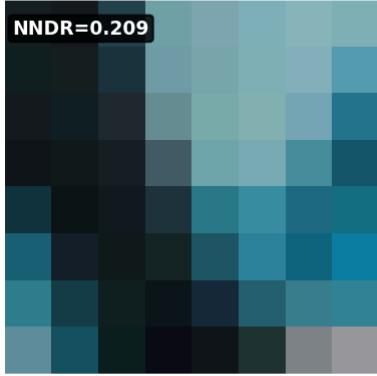


Image 2 NN (1st)

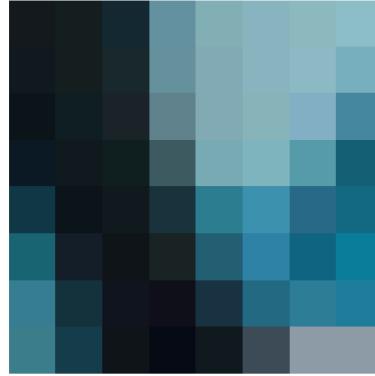


Image 2 2NN (2nd)

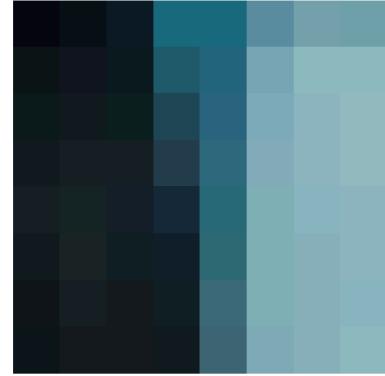


Image 1 Feature #5

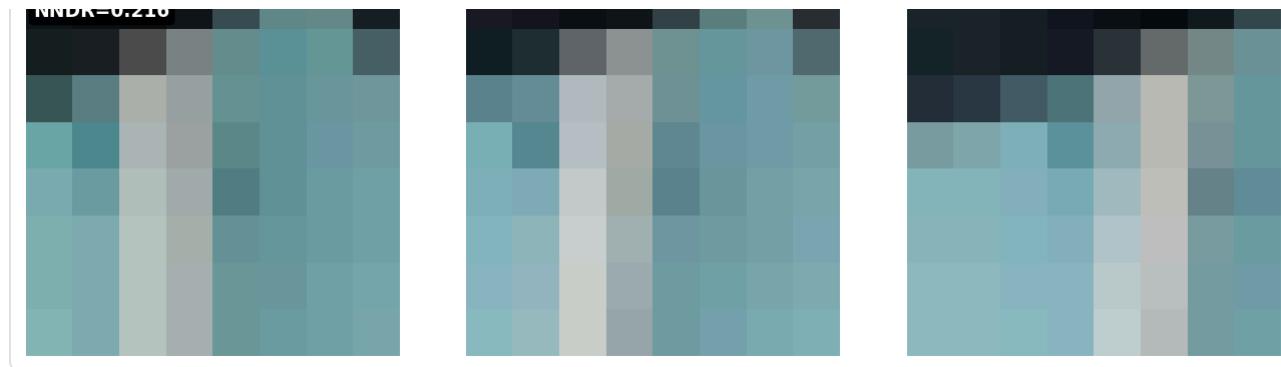


Image 2 NN (1st)



Image 2 2NN (2nd)





▼ Extra Credit — 3-Image Panorama Stitching

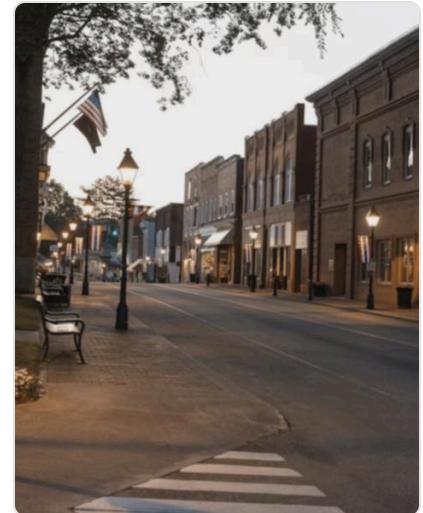
- ▼ Input Images — 3 overlapping images (imgC1, imgC2, imgC3) used for panorama



imgC1



imgC2



imgC3

- ▼ Feature Matching — Matches between pairs (C1↔C2 and C2↔C3) for homography estimation

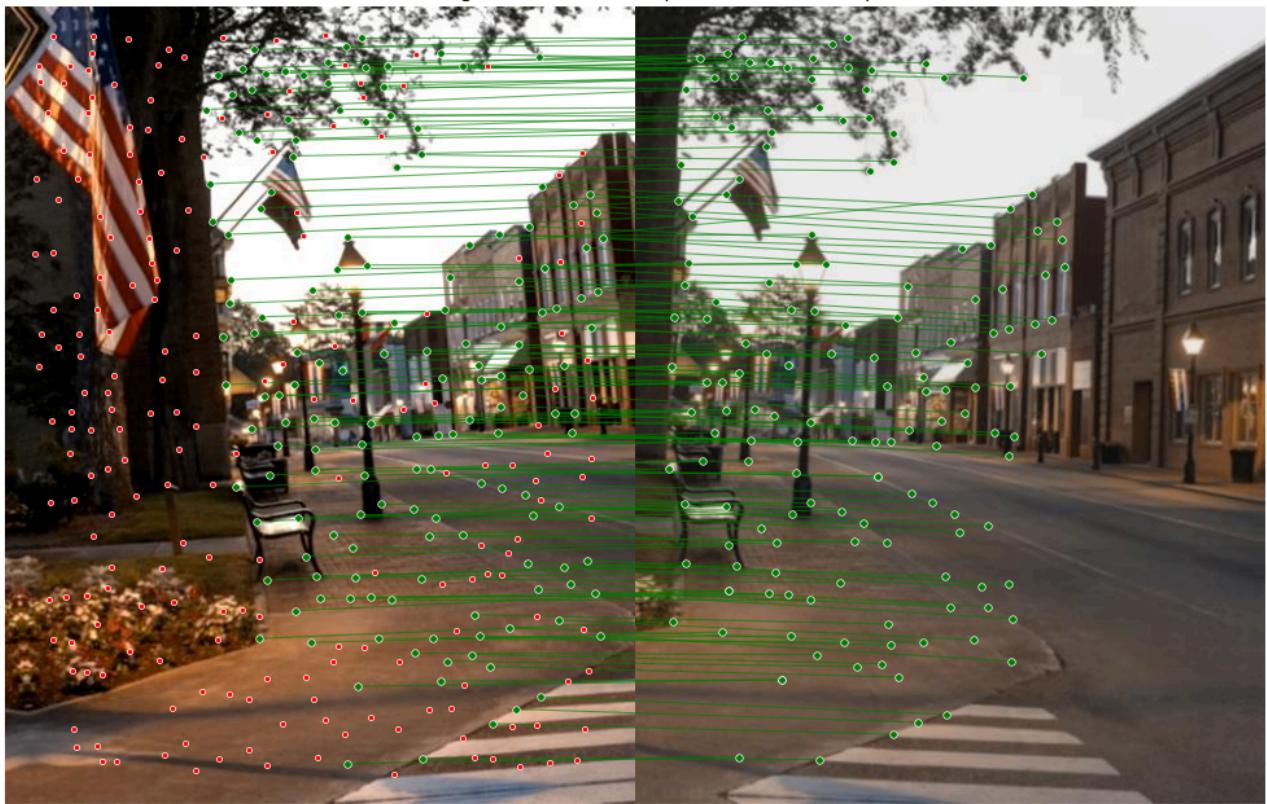
C1 ↔ C2

Feature Matching — Matched: 144 | Unmatched: 246 | Total: 390



C2 \leftrightarrow C3

Feature Matching — Matched: 158 | Unmatched: 204 | Total: 362



▼ Method — Harris → NMS → descriptors → NNDR → RANSAC → warp → blend

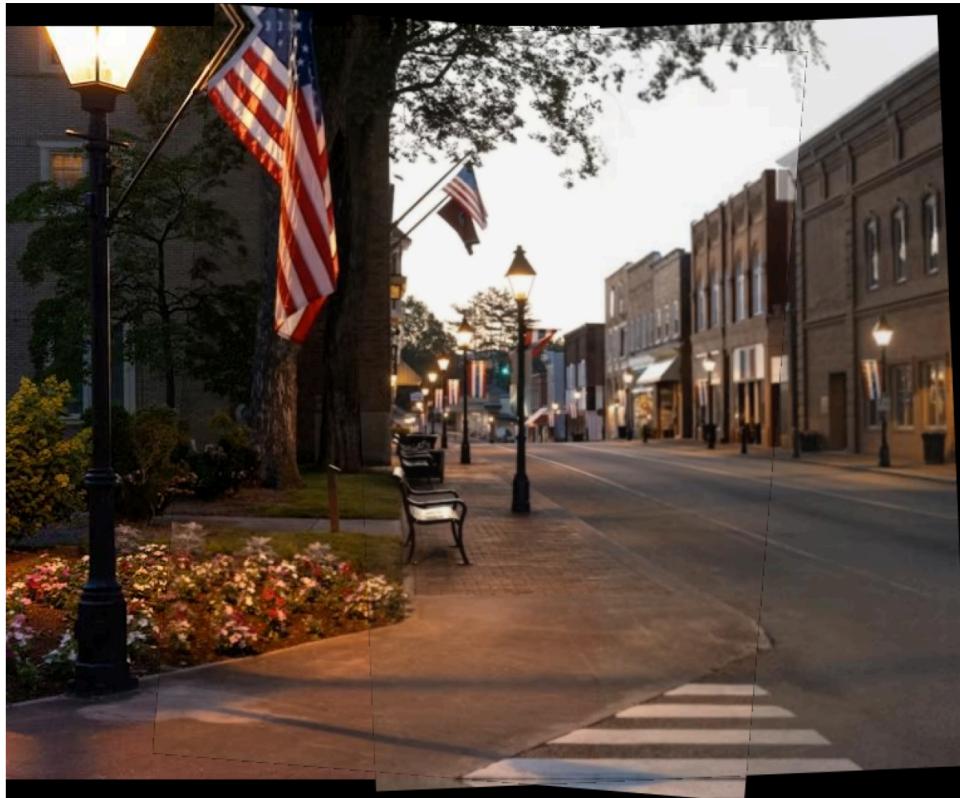
Pipeline: Harris corners → NMS → RGB descriptors → NNDR matching on pairs ($C1 \leftrightarrow C2$, $C2 \leftrightarrow C3$) → RANSAC homography (`skimage.measure.ransac`) → chain $H_{13} = H_{12} \times H_{23}$ → inverse warp (`skimage.transform.warp`) → average blending in overlap regions.

▼ Stitched Panorama — Final 3-image panorama using features from Steps 1–4

Original Images: imgC1 | imgC2 | imgC3



Stitched Panorama



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