HW2: Automatic Feature Matching Across Images

Himanshu Jhawar (hj2713)
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 → 8×8×3 (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)

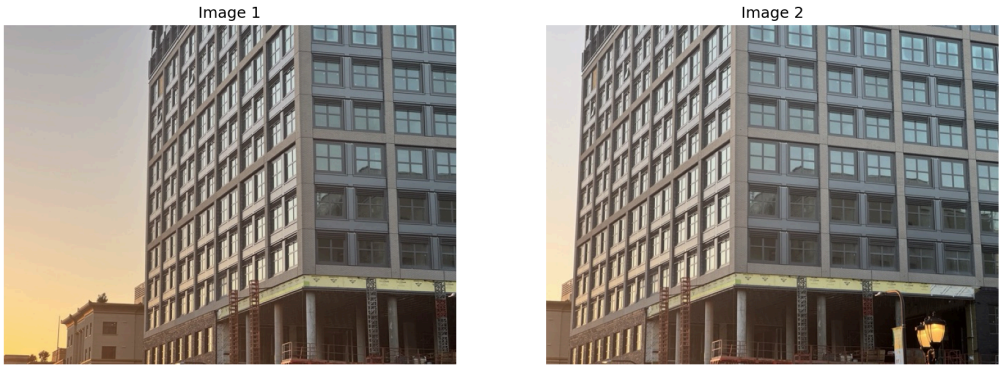
> **Extra Credit Libraries:** scikit-image (`ransac`, `ProjectiveTransform`, `warp`)

Hyperparameters

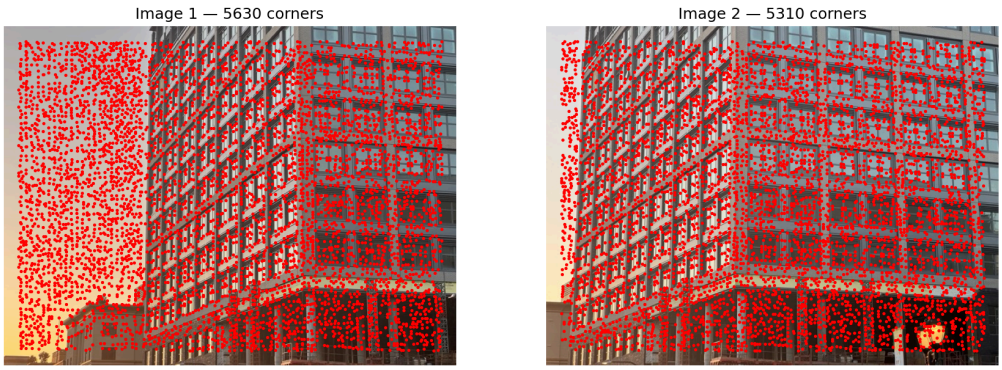
Parameter	Value
Harris edge_discard	20 px
NMS window size	20 px
Descriptor	40×40 → 8×8×3 RGB (192-dim)
Similarity metric	L2 (Euclidean distance)
NNDR threshold	0.5

▼ Scene 1 — HW Staff Example Images

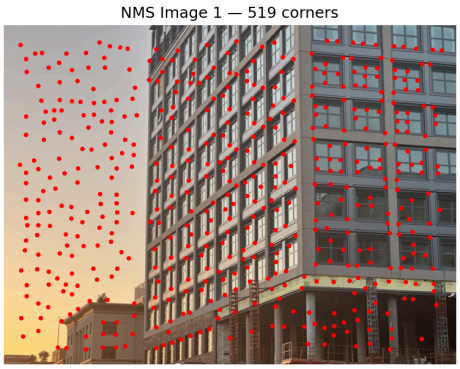
▼ Step 0: Original Images — Two staff-provided input images displayed side-by-side

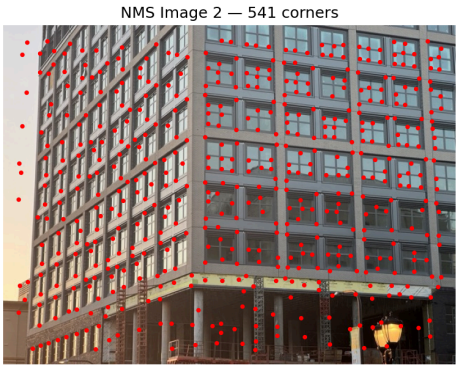


▼ Step 1: Harris Corner Detection — Detected corners overlaid on both images (red dots)

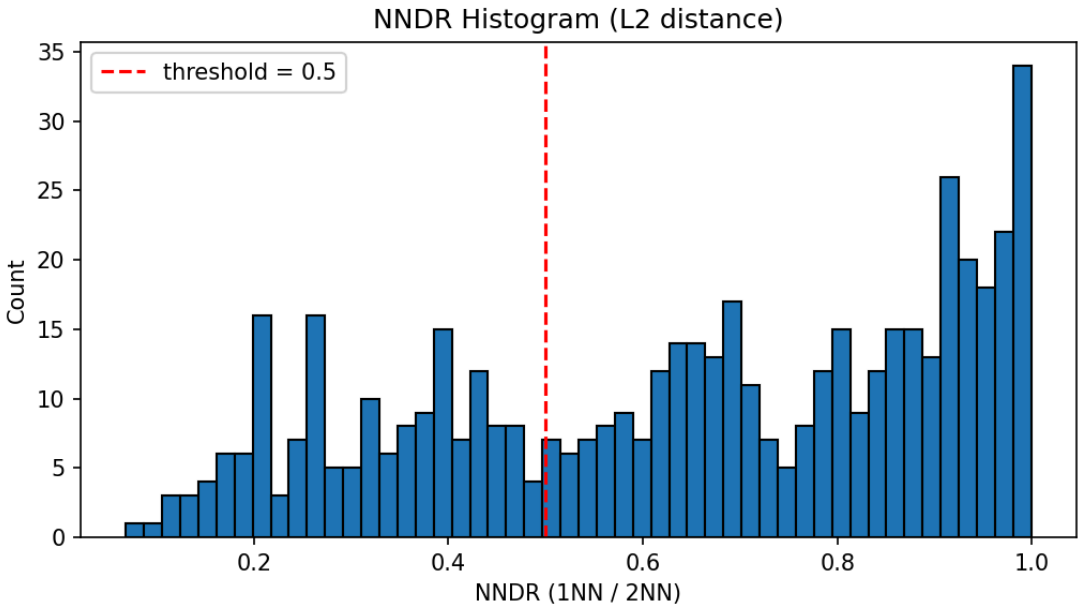


▼ Step 2: Non-Maximal Suppression — Corners after NMS (window size = 20), only local maxima retained

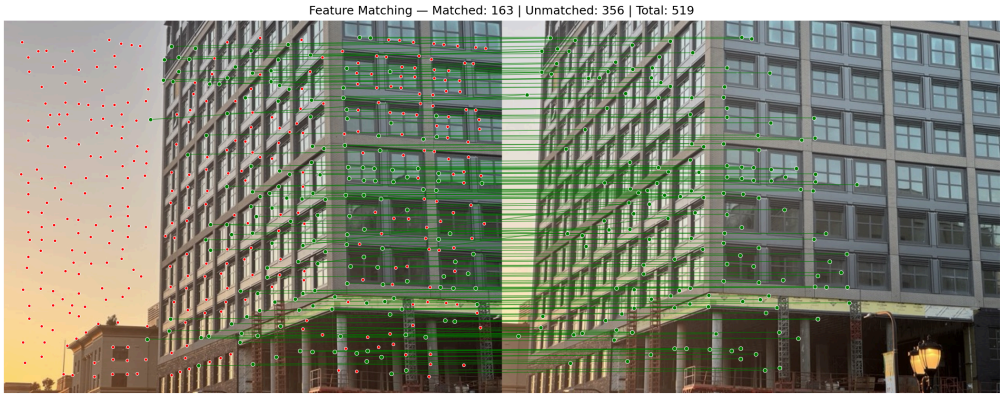




▼ Step 4.1: NNDR Histogram — Distribution of nearest-neighbor distance ratios with threshold (L2 metric)

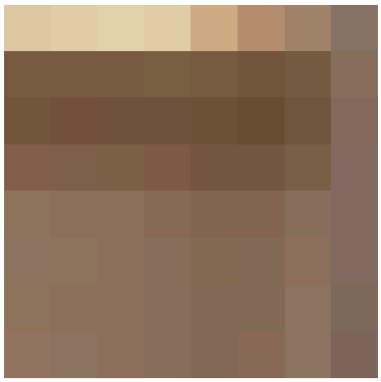


▼ Step 4.2: Feature Matches (Option 2) — Green lines = matches, red dots = unmatched



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)

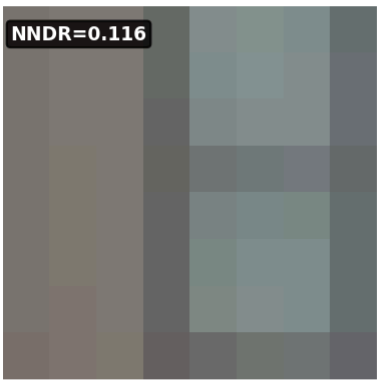
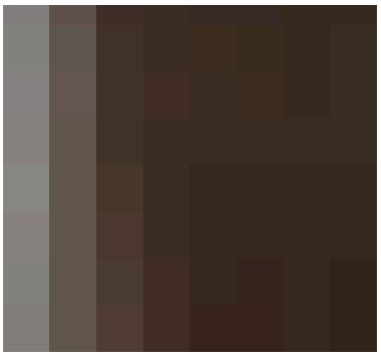
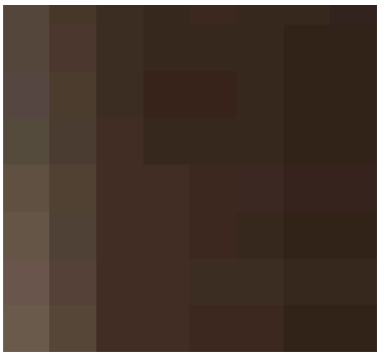



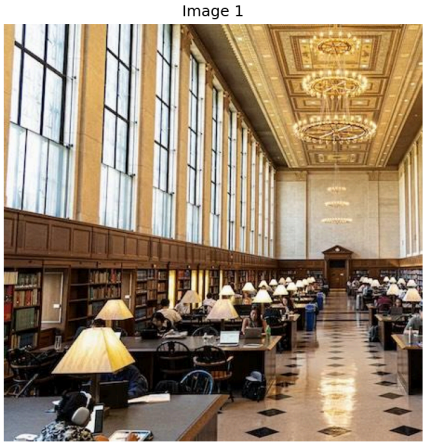
Image 1 Feature #4	Image 2 NN (1st)	Image 2 2NN (2nd)
		
Image 1 Feature #5	Image 2 NN (1st)	Image 2 2NN (2nd)
		

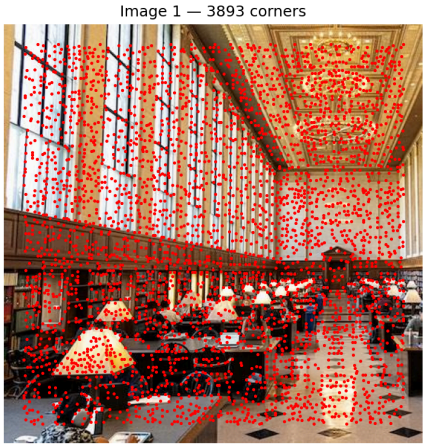
▼ Scene 2 — Custom Scene

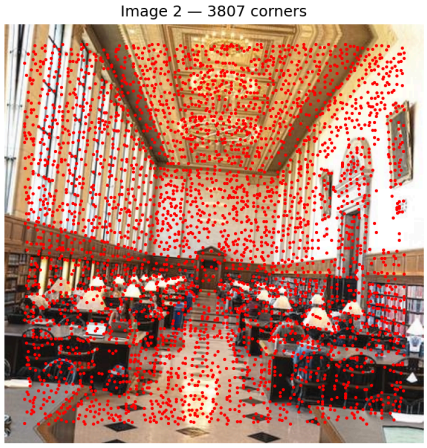
▼ Image Pair 1

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

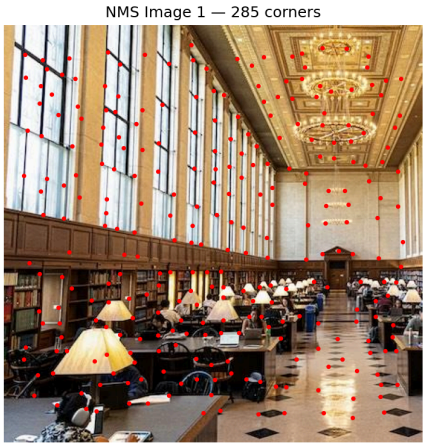


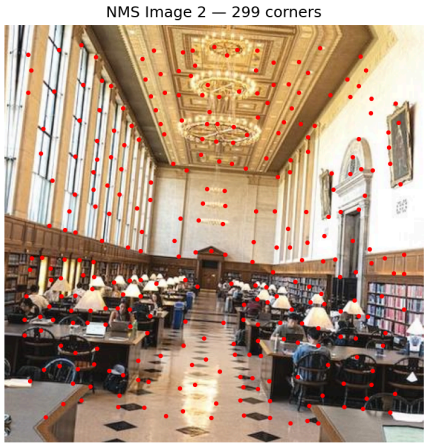
▼ Step 1: Harris Corner Detection — Detected corners overlaid on both images (red dots)



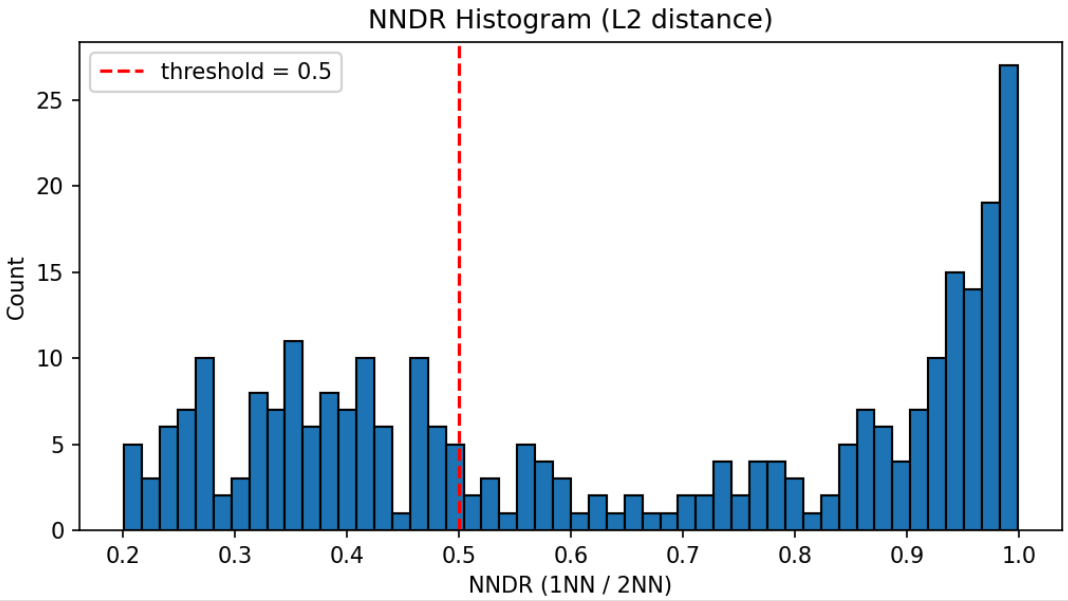


▼ Step 2: Non-Maximal Suppression — Corners after NMS (window size = 20), only local maxima retained





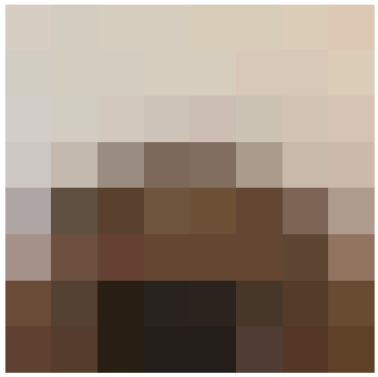
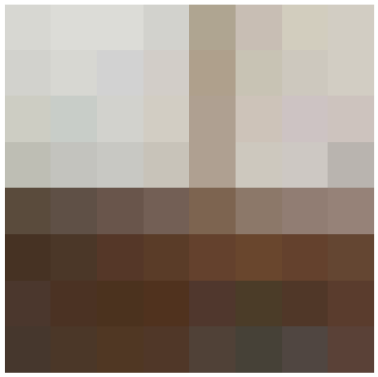
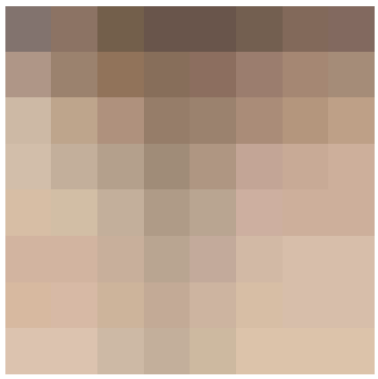
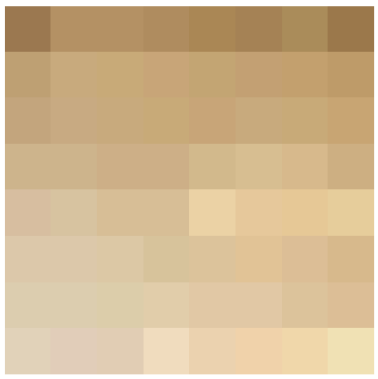
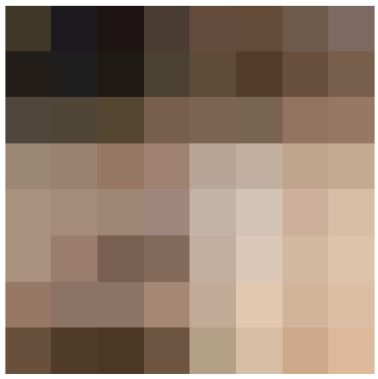
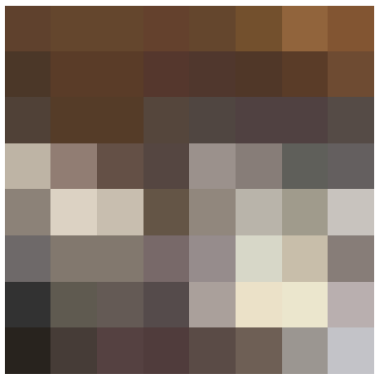
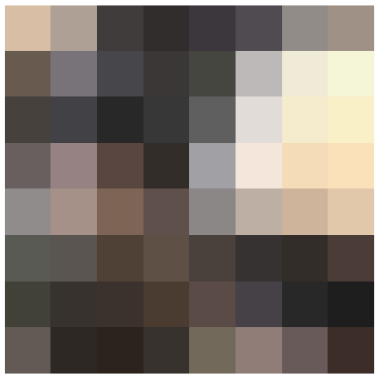
▼ Step 4.1: NNDR Histogram — Distribution of NNDR with threshold (L2 metric)

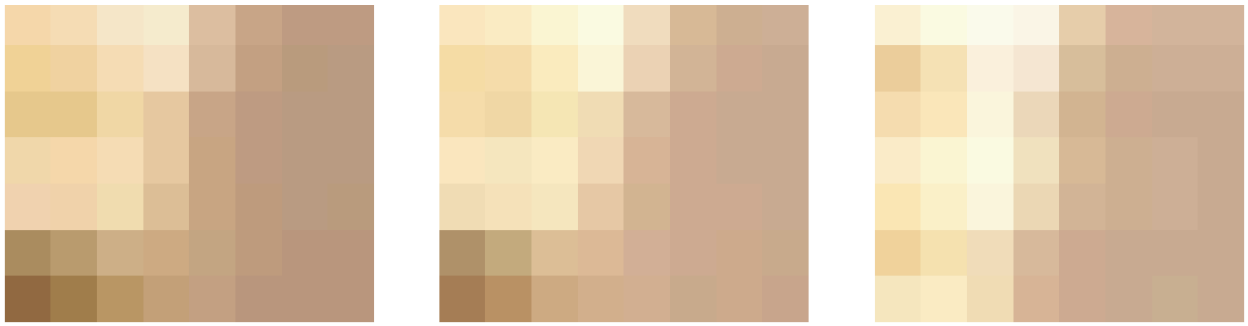


▼ Step 4.2: Feature Matches (Option 2) — Green lines = matches, red dots = unmatched

▼ 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

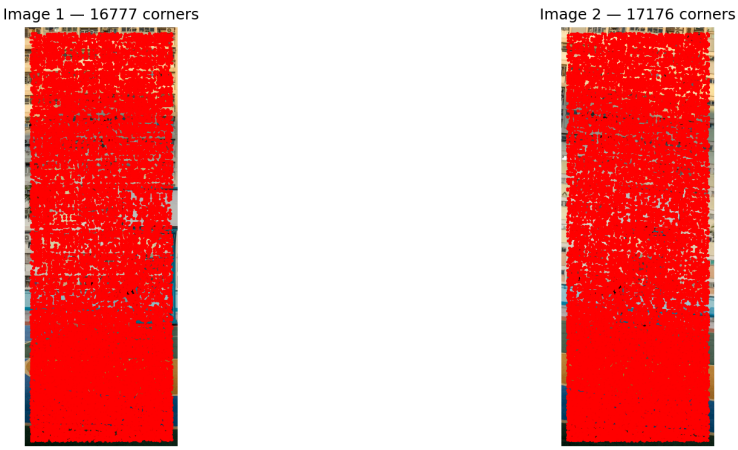
Image 1 Feature	Nearest Neighbor (1st)	Second Nearest (2nd)
Image 1 Feature #1	Image 2 NN (1st)	Image 2 2NN (2nd)
		
Image 1 Feature #2	Image 2 NN (1st)	Image 2 2NN (2nd)
		
Image 1 Feature #3	Image 2 NN (1st)	Image 2 2NN (2nd)
		
Image 1 Feature #4	Image 2 NN (1st)	Image 2 2NN (2nd)
		
Image 1 Feature #5	Image 2 NN (1st)	Image 2 2NN (2nd)
		



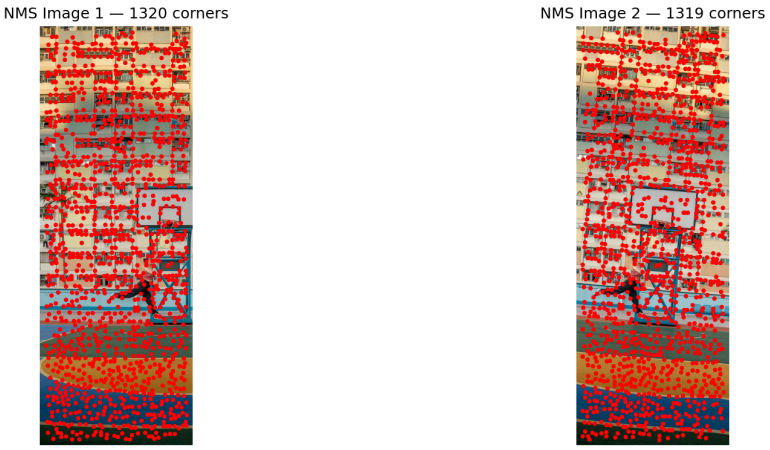
▼ Image Pair 2

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

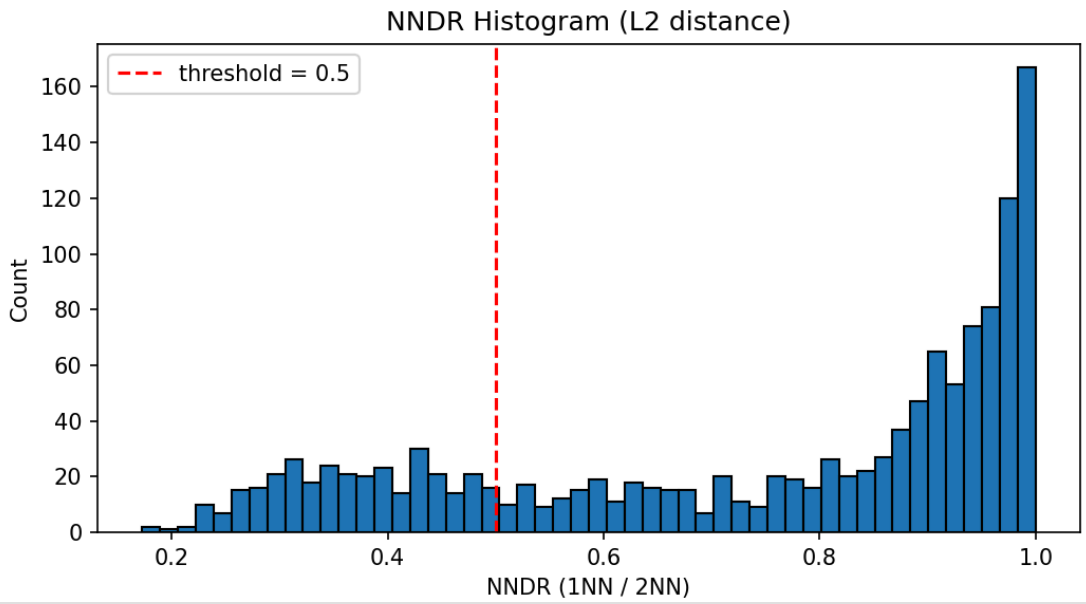
▼ Step 1: Harris Corner Detection — Detected corners overlaid on both images (red dots)



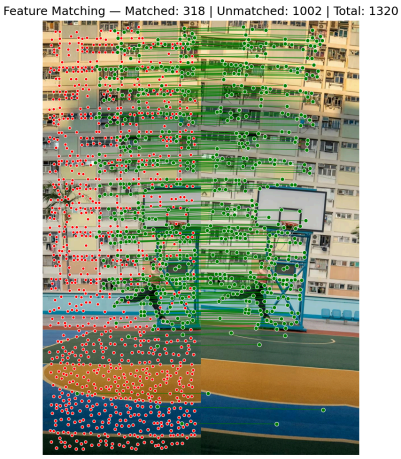
▼ Step 2: Non-Maximal Suppression — Corners after NMS (window size = 20), only local maxima retained



▼ Step 4.1: NNDR Histogram — Distribution of NNDR 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)

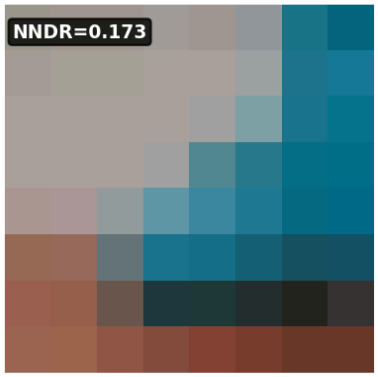



Image 1 Feature #2	Image 2 NN (1st)	Image 2 2NN (2nd)

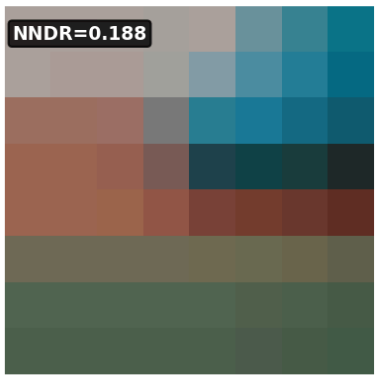



Image 1 Feature #3	Image 2 NN (1st)	Image 2 2NN (2nd)
		
Image 1 Feature #4	Image 2 NN (1st)	Image 2 2NN (2nd)

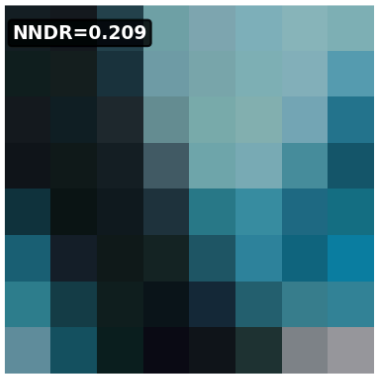
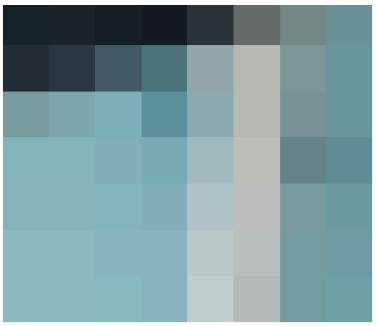



Image 1 Feature #5	Image 2 NN (1st)	Image 2 2NN (2nd)
		

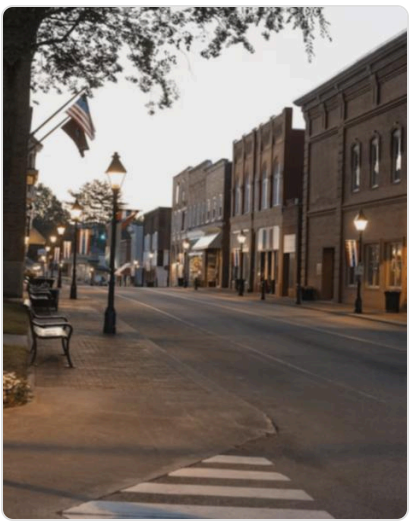




▼ Extra Credit — 3-Image Panorama Stitching

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

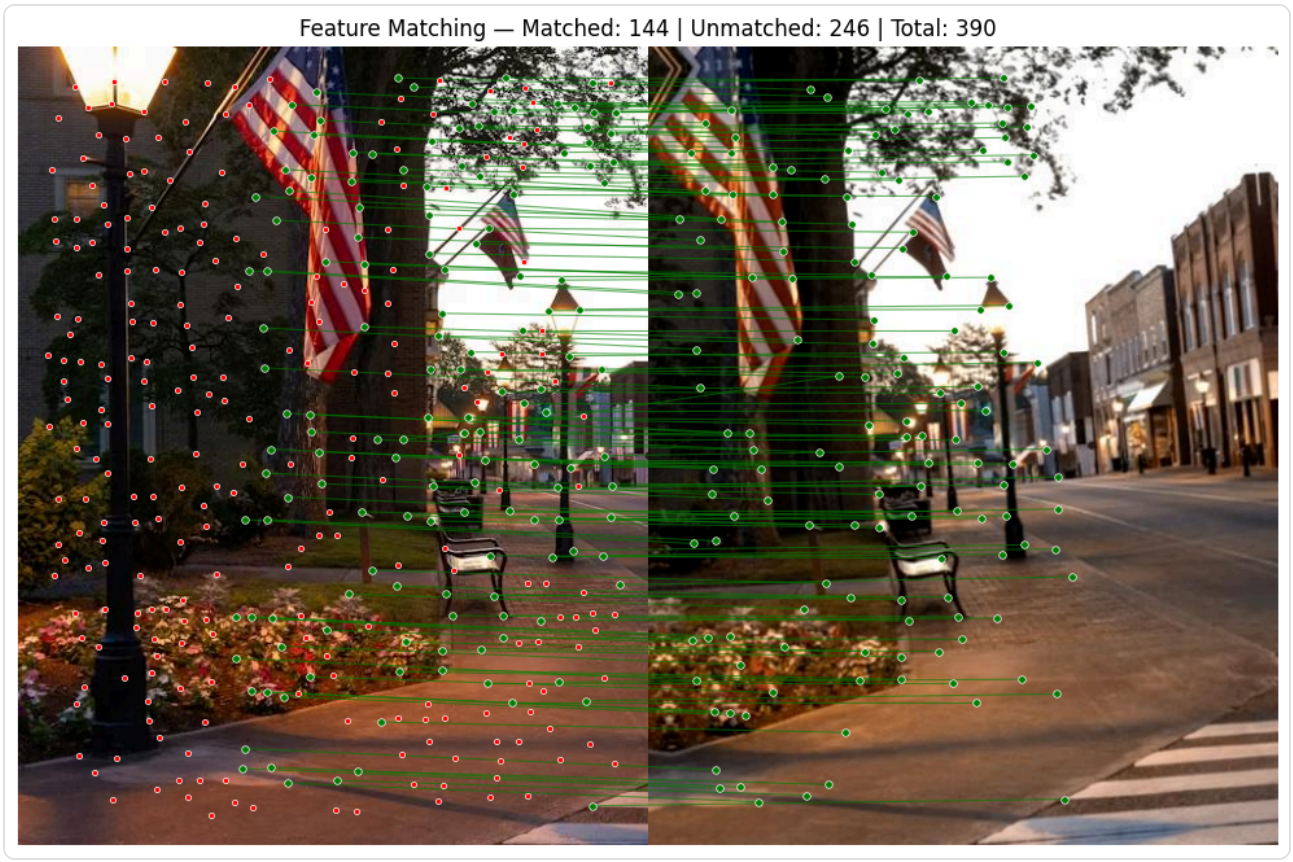




imgC1 imgC2 imgC3

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

C1 ↔ C2


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

C2 ↔ C3

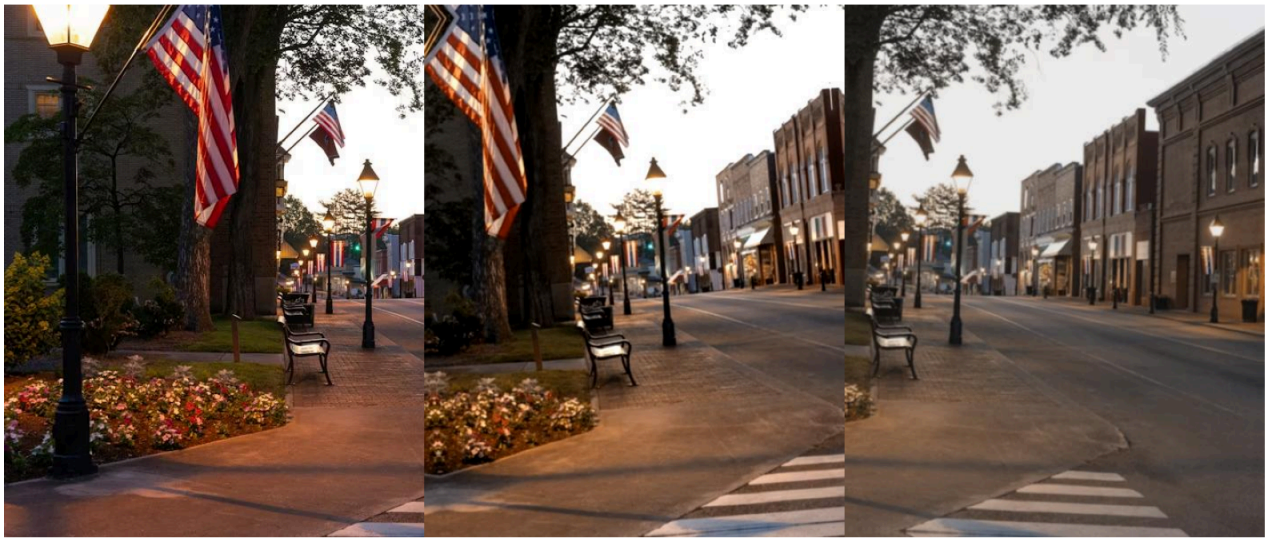

Feature Matching — Matched: 158 | Unmatched: 204 | Total: 362

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

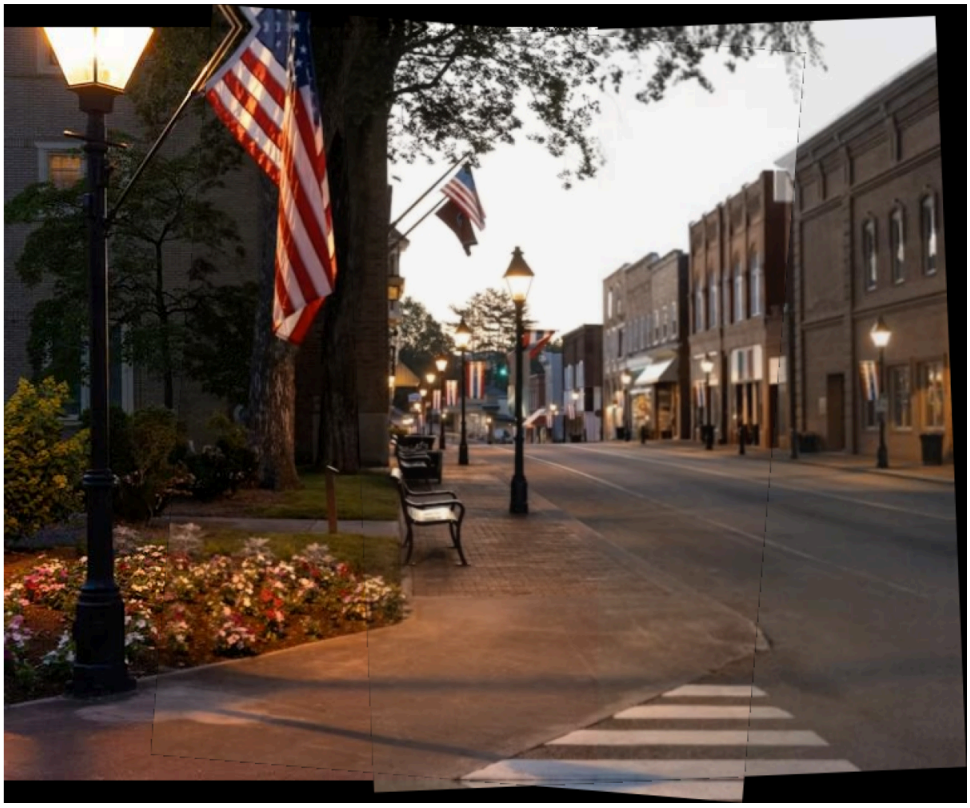
Pipeline: Harris corners → NMS → RGB descriptors → NNDR matching on pairs (C1↔C2, C2↔C3) → RANSAC homography (`skimage.measure.ransac`) → chain $H_{13} = H_{12} \times H_{23}$ → inverse warp (`skimage.transform.warp`) → average blending in overlap regions.

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

Original Images: imgC1 | imgC2 | imgC3



Stitched Panorama



COMS4732W Computer Vision 2 · HW2 · Himanshu Jhawar (hj2713)