CS180 Project 4 -- Ryan Nader -- Part A + B

github: https://github.com/berkeleybear22ryan/CS180_Project4

website: https://berkeleybear22ryan.github.io/CS180_Project4/

also look at `README.md` on codebase for more images and in other output directories for all the images and videos

for `PART 1` ...

you can call `a1.py` or `a1.py -add` to add more points

then `a2.py`

then `a3.py`

then `a5.py` it want the images cleaned and blended better

also can call `a4.py` to rectify the image

ONE --> Part 1: Shoot and Digitize Pictures

ONE --> Part 2: Recover Homographies

ONE --> Part 3: Warp the Images

ONE --> Part 4: Image Rectification

ONE --> Part 5: Blend the Images into a Mosaic

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for `PART 2` ...

`b1.py` is linked with `step1` folder

`b2.py` is linked with `step2` folder

`b3.py` is linked with `step3` folder

`b4.py` is linked with `step4` folder

`b5_1.py` is linked with `step5` folder

then use can use part 1 stuff to link all images with the auto created points

this process now can skip calling `a1.py` and just call `a2.py` then `a3.py` or `a5.py` or both

I also have 3 bash files titled `runall.sh`, `runall_shark.sh`, and `runall_shark_p.sh` so you can get a fell for how the pipeline works

main one is: `runall.sh`, which allows you to just put in images and then get the output for that group

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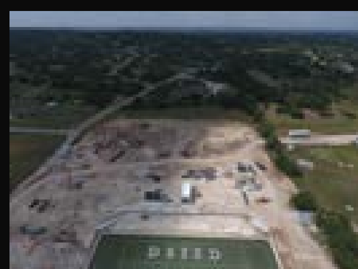
in the next few sections I will walk through a sample image for each part of the project and then at the end include my final images so it does not get to cluttered

specifically, I will walk through image set `9_0_P2`

IMPORTANT: please also right-click and open image in new tab if too small to see as all images are high resolution and pdf of website is low resolution to fit on gradescope submission

TWO --> Part 1: Detecting corner features (10pts)

so we first start with the following two images + converted to black and white so that we have a single channel ...



This is the part for detecting corner features in an image (10 pts)

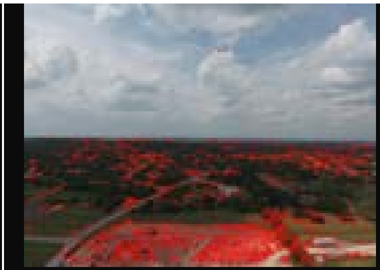
First use `b1.py` to reading and prepare images for processing for all the other files then

this section corresponds to `b2.py` where I follow the paper shared which wanted ...

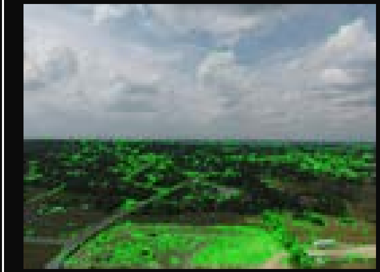
Harris Interest Point Detector (Section 2 of the paper)

Adaptive Non-Maximal Suppression (ANMS) (Section 3)

in my code `b1.py` gives step1, all the harris corners images which for this look like:

then from here step 2 from `b2.py` gives all the anms corner images which look like:

also all of the metadata for each section is saved in its appropiate section

TWO --> Part 2: Extracting a Feature Descriptor (10pts)

This section is for ... Extracting a Feature Descriptor for each feature point (10 pts)

the guidelines for this that I followed also stem from the paper in which there are the following condition ...

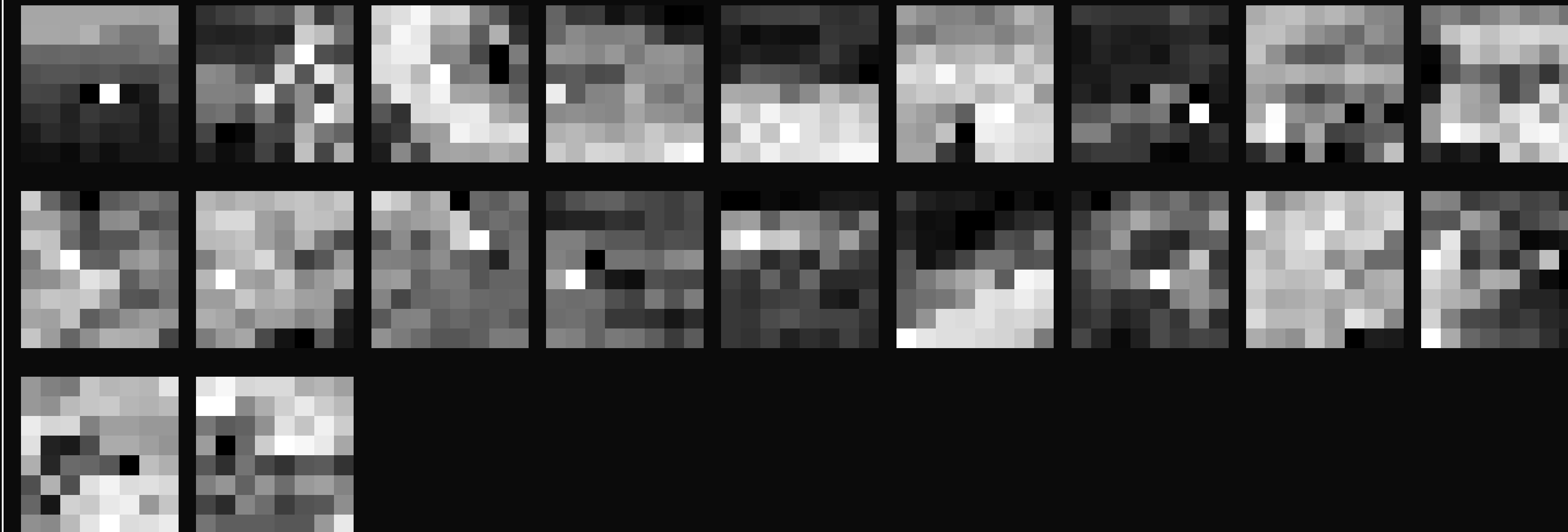
Implement Feature Descriptor extraction (Section 4 of the paper).

Extract axis-aligned 8x8 patches from a larger 40x40 window.

Bias/gain-normalize the descriptors.

Ignore rotation invariance and wavelet transform.

this section corresponds to `b3.py` and for reference here are what some of the feature descriptors for each point look like:



TWO --> Part 3: Matching feature descriptors (20pts)

This section is for ... Matching these feature descriptors between two images (20 pts)

the code for this is in `b4.py`

in the paper this corresponds Implement Feature Matching (Section 5 of the paper).

here we use Lowe's ratio test for thresholding based on the ratio between the first and second nearest neighbors.

please consult Figure 6b in the paper for picking the threshold.

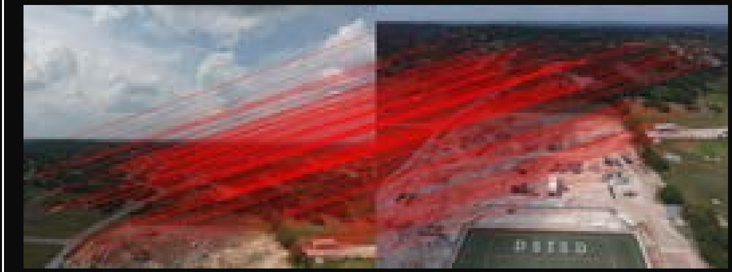
and what `b4.py` specifically does is perform feature matching between pairs of images by ...

Loads descriptors from `b3.py` for each image.

Computes distances between descriptors from different images.

Applies Lowe's ratio test to retain good matches.

And it returns matched keypoint indices between image pairs which you can see for the image below



TWO --> Part 4: Robust method (RANSAC) to compute a homography (30 pts)

This section is for ... Use a robust method (RANSAC) to compute a homography (30 pts)

the code for this is in `b5_1.py`

`b5.py` uses the 4-point RANSAC as described in class to compute a robust homography estimate

so that we can handle outliers effectively

the process is as follows ...

Loads matched keypoint indices from `b4.py`

Loads keypoint coordinates from `b2.py`

then do RANSAC Homography Estimation which includes ...

Randomly sample subsets of matches to compute candidate homographies

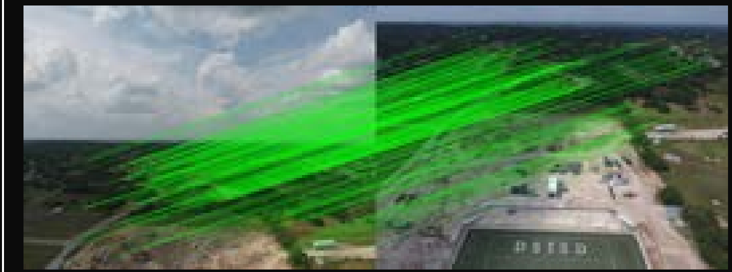
Computes the homography using the Direct Linear Transformation (DLT) method

Identifies inliers based on reprojection error and a specified threshold

Repeats for a number of iterations to find the best homography

then from here all the info and points are stored so they can then be used to produce the mosaic

this is the result from step5 data inliers ...



and as you can see it cleans up a lot of the issues as I also set it to prioritize accuracy over point totals

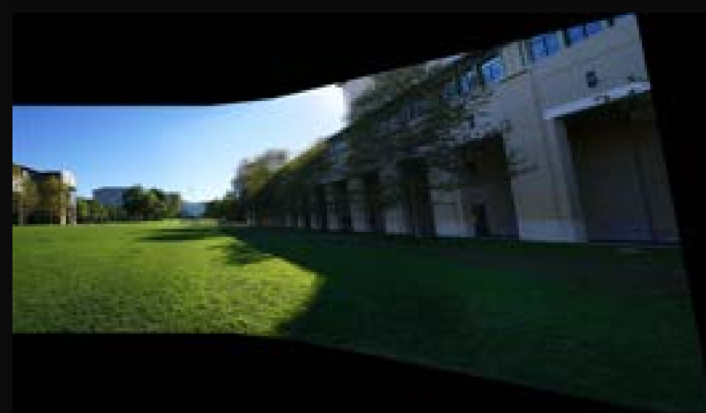
TWO --> Part 5: Producing a Mosaic (30 pts)

below I have more details plus extra images beyond the 3 but here are the three so you can see them quickly and not miss them ...

manual on left, auto on right


DSISD


DSISD



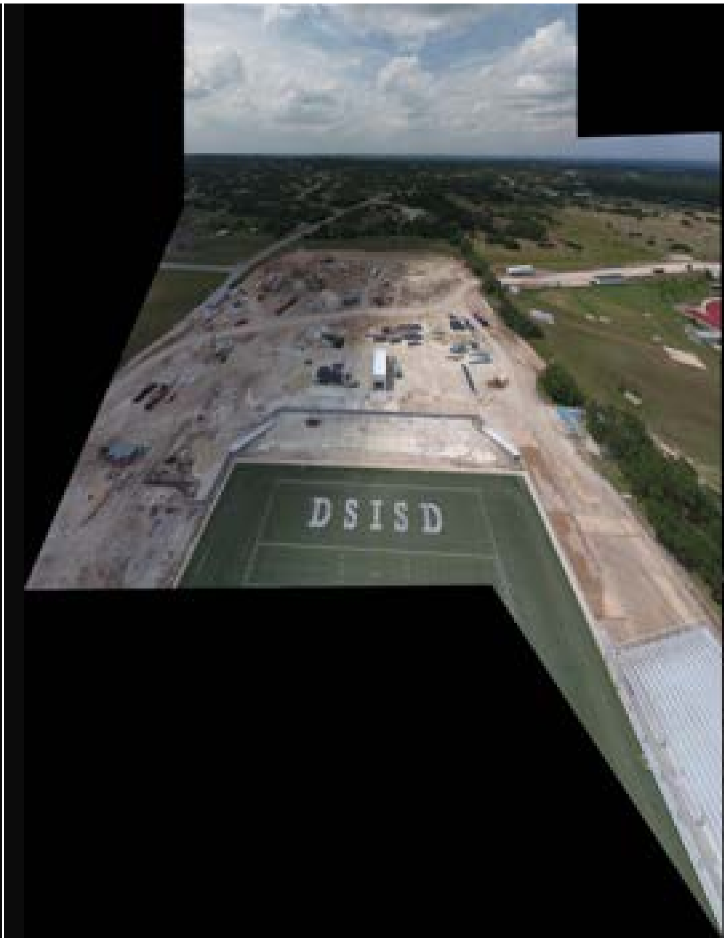
please continue reading below if more info is needed ...

This section is for ... Proceed as in the first part to produce a mosaic (30 pts; you may use the same images from part A, but show both manually and automatically stitched results side by side) [produce at least three mosaics]

the code for this is reuse of part1 as I saved the auto generated points in `./points` directory and then call `a2.py` and `a3.py` and `a5.py`

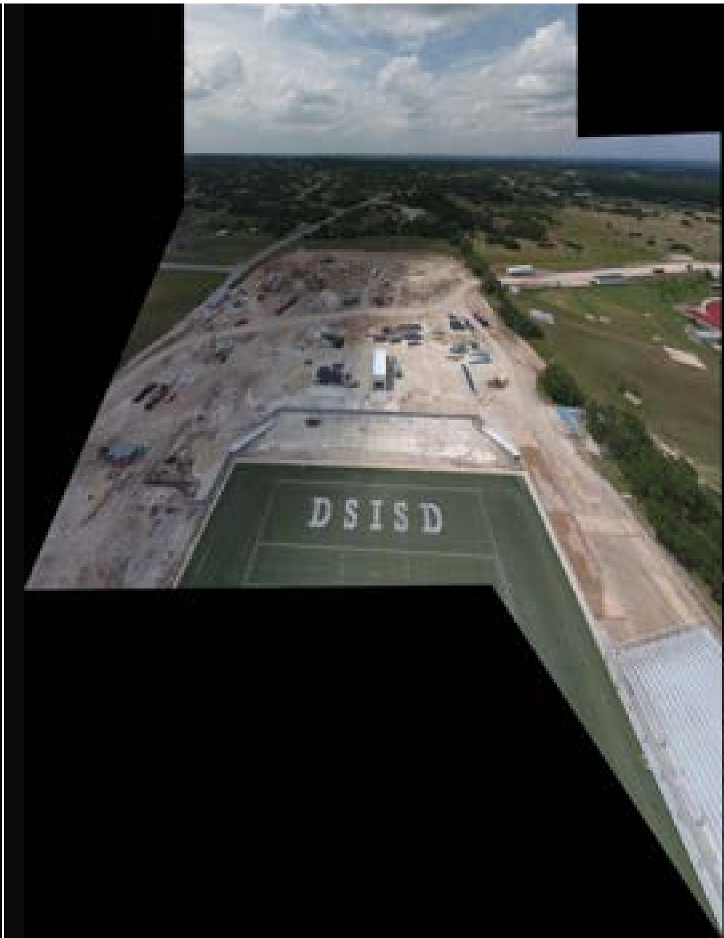
which then gives ...

this can be compared to the manual selected points one which gave ...



as you can see because I selected a lot of points for this one and am blending and sharpening very strongly both look good but they are some where one might look worse then another

when comparing handpicked `\9` which looks like



to autopicked `9_1_P2` with to strict parameters and thus too little points we can see that the auto picked one is slightly blurrier then handpicked

it looks like ...

another image I worked on was in which the auto generated point looked better was when comparing handpicked `\10` with auto generated `10_0_P2`

handpicked `\10` looks like ...

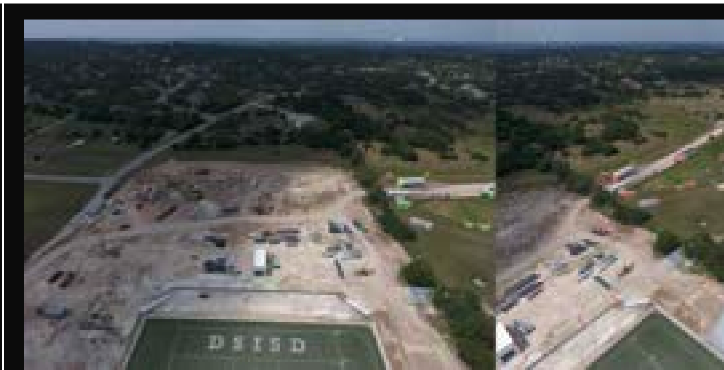
and auto generated `10_0_P2` looks like ...

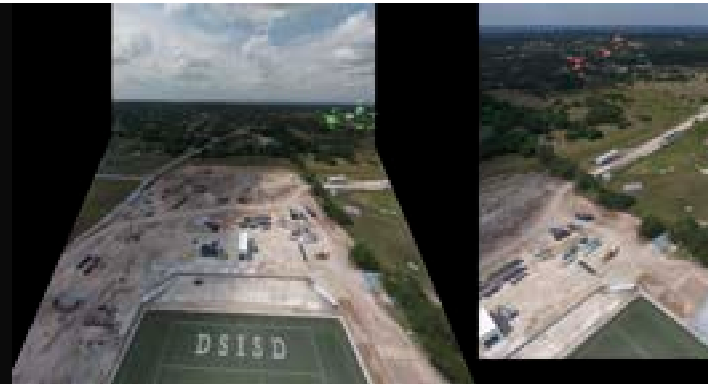
here you can see that the grass looks a lot better and if you zoom in most if not all the images looks sharper

this can be further seen when comparing the points I selected for the two and how accurately I tried to select the points here they are for context

`\9` and `\9_1_P2`

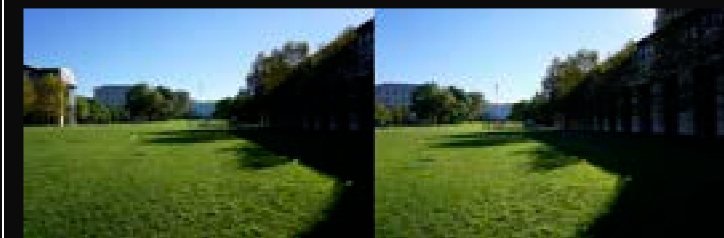
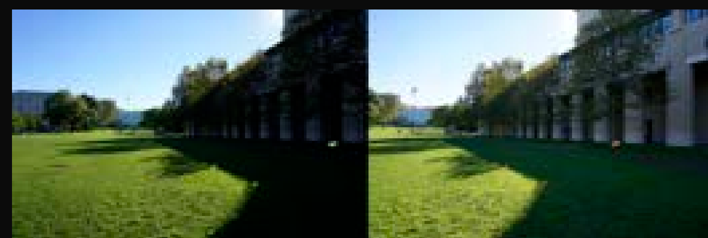
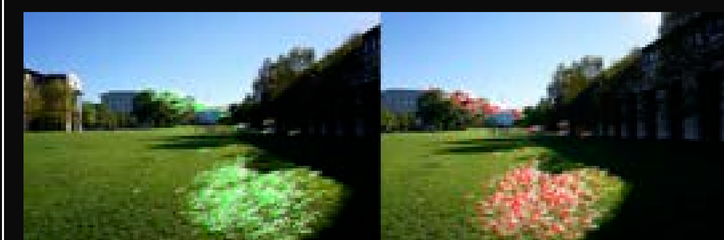
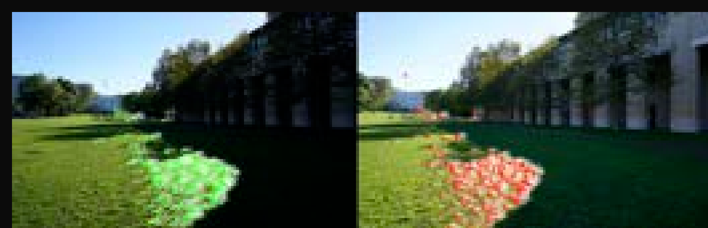
here is was not able to find as many connection as there was not as much overlap so it was less certain ...





`\10` and `10_0_P2`

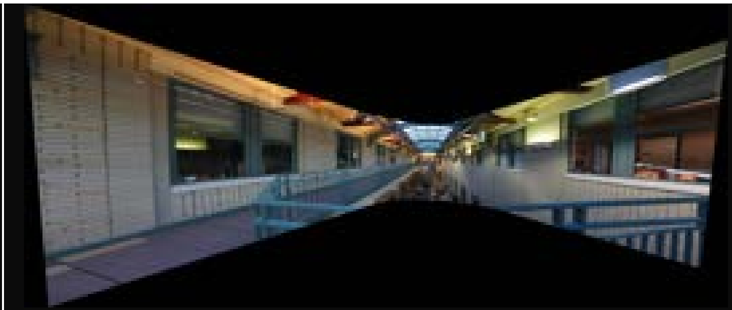
here there was a ton of overlap plus I also was lazy when selecting points ...

some other combos I made with the auto one are ones that would have taken too long to do by hand, like ...

manual on left, auto on right

`\11_2_P2`



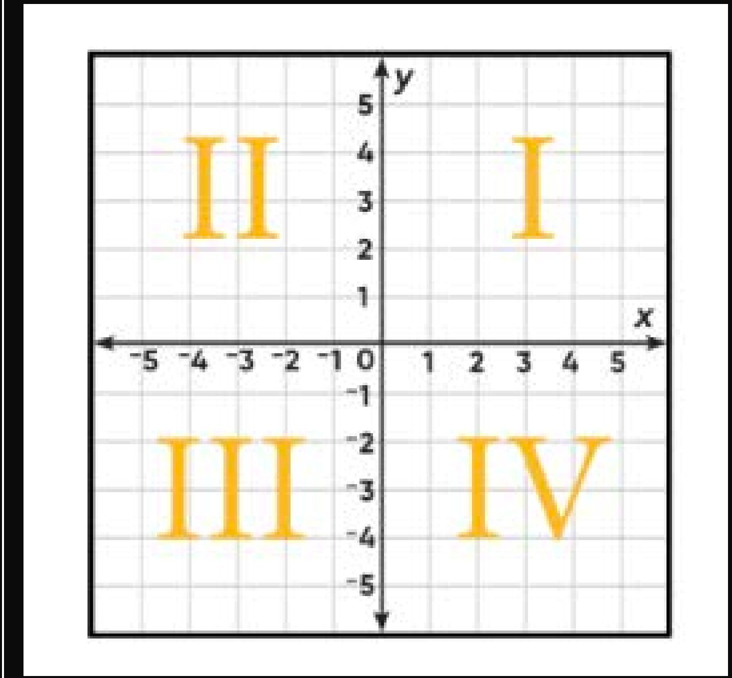
\12

\frame_0001

TWO --> Part 6: Video mosaic (??? pts)

combined 4 seperate 4k shots of geese from different overlapping camera angles and locked the orientation of the top left frames and warped everything around that

i.e. locked the orientation of quadrant 2



video frames are in 2 by 2 grid and combined them with quadrant 2 then 3 then 4 then 1 based on diagram above and then flattened and got ...

for context the 4 images for a single frame are in format ...

TWO --> Part 7: What have you learned?

The coolest thing I have learned from this project is the incredible power of computer vision techniques to automate complex tasks like image stitching. By delving deep into feature detection, description, matching, and robust homography estimation with RANSAC, I was able to create a system that seamlessly stitches images without any manual intervention. It was really cool to see how the mathematical algorithms come together to solve real-world problems. Moreover, implementing research papers and translating theoretical ideas into practical code has significantly enhanced my understanding and appreciation of the topic.