Applied Image and Video Processing
Project 1, Fall 2019
Preliminary Code Due: Sunday, October 13
Everything Due Sunday, October 20

The Goal of this project is to investigate and learn about Image Enhancement, Smoothing, Edge Detection, Keypoint Detection, and Histograms of Gradients, in the context of using the Scale Invariant Feature Transform (SIFT) algorithm on 3 sets of images:

Fish Images: FishIm0.jpg, FishIm1.jpg, FishIm2.jpg, FishIm3.jpg

4 color images: 4 frames of an underwater video captured every $\Delta t << 1$ secs. Video camera not moving.

Grass Images: GrassIm0.jpg, GrassIm1.jpg, GrassIm2.jpg, GrassIm3.jpg

4 color images: 4 frames of an underwater video captured every $\Delta t << 1$ secs. Video camera moving.

Stereo Image Pairs:

Pair 1:	Forest0.png	Forest1.png
Pair 2:	LeavesInForest0.png	LeavesInForest1.png
Pair 3:	TreeInForest0.png	TreeInForest1.png

6 grayscale images consisting of 3 stereo pairs. A stereo pair of images consists of 2 images that were captured simultaneously by 2 cameras at slightly different locations. These images were taken in a forest.

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(1) First **learn** the major steps in the **SIFT algorithm**. You can *read the paper* I uploaded, *look at YouTube videos* and you can *ask me questions*. I recommend university sources, such as websites that end in .edu or papers by professors. Here are 2 YouTube videos that look reasonable:

Professor William Hoff at the Colorado School of Mines.
https://www.youtube.com/watch?v=U0wqePj4Mx0

Professor Mubarek Shah at UCF. A recorded class lecture. It is long but has more details.
https://www.youtube.com/watch?v=NPcMS49V5hg

You should understand the algorithm well enough to know what the parameter choices are and have ideas about how different parameter values should change the behavior of an implementation of the algorithm.

(2) Then learn to **run the OpenCV implementation of SIFT** and what arguments (parameters) you can choose and what they mean. You can do this with any image, but you will have to think about how to run SIFT on color images.

(3) Then conduct a **qualitative evaluation of SIFT on single images**. For example, choose 1 image of each type (Fish, Grass, Forest) and evaluate the output qualitatively. Determine if the program detects reasonable keypoints and investigate the effect of changing parameters on performance. Record your observations.

(4) Then, write code to **match keypoints** in 2 video frames (a video pair) or in a stereo pair. Use the gradient histograms to do the matching. Qualitatively evaluate algorithm keypoint matching performance on pairs. Investigate the effect of changing parameters on matching performance. Consider using image enhancement algorithm(s) to improve the matching. Record your observations.[1]

[1] Note that I am not expecting you to run on all possible combinations of data and values of parameters. You should run on at least one pair for each image type.

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Submit a report, a presentation, and your code. The report and presentation should be .pdf files unless you have powerpoint animations. In the latter case, you can submit a powerpoint. Submit 3 separate files named

`<UFName>Project1Report.pdf,`
`<UFName>Project1Present.{pdf or pptx},` and
`<UFName>Project1.py.`

Report Format.
Your report should be ≤ 4 pages and have the following format:

<Title>
APIVIP Project 1 Report
SIFT Keypoint Detection and Matching
<Student Names:> {Student1Name} and {Student2Name}
<Student UF Names:> {Student1UFName} and {Student2UFName}

Section 1. <1 page>. **Overview.**

<Overview of SIFT algorithm in your own words.>

Section 2. <1 page>. **Experiments.**

<Description of your investigations including, the images you used the range of parameter choices for each image type, and any other variations.>

Section 3. <1-1.5 page> **Results and Observations.**

<Make a table with qualitative scores (Good, Medium, Bad) for the 3 single images and 3 pairs you choose.>

Images or Image Pairs	GOOD	MED	BAD

The observations should be written in text. You can expand on them in your presentation.

Section 4. (0.5 page) **References** (if you use any sources beyond the uploadedpaper and 2 YouTube sites)**.**

Presentation Format.
The presentation should follow the report but have images. Prepare to present for 10 minutes and 5 minutes to answer questions. Each team member should present for 5 minutes in a way that shows understanding.

The presentation should have
1 slide describing the SIFT concept,
1 slide describing the experiments that includes at least part of your Results Table, and
3 slides on your observations that include images.

No questions should be asked until after the presentation but after exactly 10 minutes, your presentation will be finished. The order of the presentations will be picked using a random permutation.

Code Format.
The code you submit should all be in one file named `Team{TeamNumber}Project1.py`. The main function in the file should be called `FindSomeKeypoints`. The inputs should be the following:

```
Inputs:
          FName1    An image file of the form {Name1}.{ext}
          FName2    An image file that is an optional argument
          Params    A Dictionary of keyword-value pairs to be used in
                    SIFT.  Params can have from 0 to the total number
                    of SIFT parameters elements.

Outputs:
     If the input consists of 1 image:

          + the image with the keypoints overlaid on it should be
          written to a file with the name
          Keypoints{Name1}.{ext}

          + the Params should be written to a text file called
          ParamsKeypoints{Name1}.txt

     If the input consists of 2 images:

          + the image with the keypoints overlaid on it should be
          written to 2 files with the name
          Keypoints{Name1}.{ext} and Keypoints{Name2}.{ext}

          + an image that somehow depicts the (best) matches between
          the images should be written to a file with the name
          Keypoints{Name1Name2}Match.{ext}

          + the Params should be written to a text file called
          ParamsKeypoints{Name1Name2}.txt
```

The function should display the input and output images. The displays should use subplots with titles in a way that is easy to understand. An initial version of your code should be delivered:

On Sunday, Oct 13, submit code that runs SIFT on single images as described above.

Remark 1: You may want to run batches that loop over different parameter values to help understand the best parameters. If you do this, you can change the output names formats so you don't overwrite files. For example, you could append "Run1", "Run2", etc. to the file names to keep them distinct. Just make sure that the program you submit follows the conventions above.

Remark 2: You may want to have intermediate displays the aid your understanding. For example, if you are using histograms at keypoints and you want to see why keypoints aren't matching, you may want to display bar plots of the histograms at a particular pair of keypoints. Just make sure that the program you submit follows the conventions above.

Remark 3: Please do not submit any data. I have it all. Thank you.