Computer Vision **Name:** _____
Prof. Bolton **Net ID:** _____
Assignment 3

This assignment contains 4 pages (including this cover page) and 1 questions. Total of points is 300.

Conditions: Work in groups of two or less.

Include your name and Net ID. Follow submission instructions as indicated herein.

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1. (300 points) For this assignment you will complete 1 of the following 3 options: A. Camera Obscura, B. Image Mosaic, or C. Morphing Video. Note: This weeks assignment is worth 300 pts (3 times more than previous assignments). Note that each option has extra (bonus) points associated with particularly challenging tasks. You will not be penalized if you do not complete the challenging tasks; instead it is simply a chance to earn extra points if you are up for the challenge.

    A. **CAMERA OBSCURA.** Construct your own camera obscura using household items – be creative! You will need a tube (like a poster tube) or box (like a shoebox) which can block out ALL light. You may need some foil, black marker, and/or black tape to help block out all light. You will also need a screen to act as an image plane, e.g. wax paper, tissue paper, etc. You will finally need a pin or needle to create a pin hole.

    Key points:

    - For pinhole camera ... the smaller the pin the better.
    - Be sure to block out all light except the light from the pinhole.
    - For lens model, you may wish to have an image plane (or lens) that is "mobile" so you can focus your image (see example 2).

    Examples:

    1. BASIC ... https://youtu.be/157pbd1MIN8
    2. MORE ADVANCED ... https://youtu.be/y00xhyWRz9A

    What to submit ...

    1. Similar to the examples above, create a video which documents the-making-of your camera obscura. Be sure to include multiple video clips or image stills which show the construction and utilization of the camera. Within the video, detail visually or via discussion, the main components of your camera. Upload your video to youtube. (Also, feel free to bring your camera into class – show off your engineering skills!)
    2. Challenge Task (+10 pts) **Use your camera.** Using your camera, estimate the height of the tallest tree in the center of Copley Lawn. (Hint: you

may wish to draw a ruler or measurement marks on your image plane.). Provide all details on how you arrived on your estimate and what key factors/measurements were required to complete your estimate. Finally, geometrically illustrate the scene: your camera, the tree, etc to support your discussion of the estimate.

3. Challenge Task (+40 pts) **Add a lens.** Rather than using a pinhole, use a lens (eg from a magnifying glass.). Create a mobile image plane (so that you can focus at different depths).

B. **IMAGE MOSAIC.** The goal of this exercise is to investigate and implement an image alignment algorithm. Your implementation should take as an input a sequence of images and should output 1 mosaicked image. Take a sequence of overlapping pictures on Georgetown campus (to be mosaicked). I suggest Copley Lawn or Dahlgren Quad. Collect a sequence of 2 (minimally) or more images overlapping vertically and/or horizontally. I suggest overlapping about 1/3 to 1/2 of the scene between sequential images. In your implementation ...

1. Determine Image Correspondences. This information can be "fixed" based on apriori knowledge, or you can implement an interactive display which allows you – the user – to click on image correspondence points when presented with an image sequence.
2. Warp and Align images: identify the mapping between image coordinates using Least Squares or other approaches.
3. Map images to a mosaicked image coordinate system and stitch / blend the images so they are "seamless". Use feathering and other approaches to assure no gaps and seamless stitch.
4. Challenge Task (+15 pts). Stitch 5 or more images covering 180+ degree field of view.
5. Challenge Task (+50 pts). Remove objects (such as people) in the mosaic. Heuristically: When stitching two images, if pixels from both input images map to the same mosaic pixel, choose the pixel that is not the object (if possible.).

In PDF format turn in the following information:

1. Methods: Brief Description of the Approach Used
2. Data: The original images
3. Result: The final mosaicked image
4. Appendix: Actual Code with comments

Grading Considerations:

- Creativity of the scene captured
- Color vs. Grayscale

- The number of images successfully stitched (the more, the better)
- Quality of alignment / warp
- Quality of blending

C. **MORPH VIDEO.** The goal of this exercise is to investigate image warping within the context of morphing. When given a two input images, Morphing is the process create an image sequence which begins with image 1 and ends with image 2, which gives the appearance that image 1 has gradually "transformed" into image 2.This effect is produced by creating "intermediate-warp" representations See examples below:

Examples:

1. Female Portraits ... https://youtu.be/nUDIoN-_Hxs
2. Politicians ... https://youtu.be/pqpS6BN0_7k

In your implementation ...

1. Determine Image Correspondences. This information can be "fixed" based on apriori knowledge, or you can implement an interactive display which allows you – the user – to click on image correspondence points when presented with an image sequence.
2. Compute a triangulation (eg Delauney Triangulation) based on the correspondences. s
3. Locally Warp and Align images: for each triangle identify the mapping between correspondences associated with 3 triangle points. Use Least Squares or other approaches. Impose this warp for all coordinates contained with the triangle.
4. Produce a sequence of intermediate representations by interpolating coordinates and image values. I recommend repeatedly halving, that is, mapping each image to a mid-way representation of each. Repeat until you have approximately 30 - 60 intermediate representations.
5. Save the image sequence as a (compressed) video file.
6. Challenge Task (+50 pts). Implement your own triangulation method. (Do not use a built-in function which performs this task, in this case.) Provide comments and clearly describe your implementation and comment each line, explaining how the triangulation is being computed.
7. Challenge Task (+30 pts). Create a morph video for 5 or more images.
8. Challenge Task (+100 pts). Create a morph video for ALL images provided.

In PDF format turn in the following information:

1. Methods: Brief Description of the Approach Used (including description of your own triangulation implementation if attempted.)
2. upload your video directly to canvas (if possible), or simply include a link to your video in the PDF (and uploaded to youtube)
3. Appendix: Actual Code with comments

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Grading Considerations:

- Creativity of the morph captured
- Color vs. Grayscale
- The number of images in the video sequence (the more, the better)
- Quality of morph

Assignment Conditions for parts B and C: For the coding based options, you cannot use any built-in functions nor functions composed by anyone other than yourself for the purposes of estimating the warp transformation (the crux of the exercise) or interpolation. You can use pre-existing functions for interactive coordinate selection (i/o), basic arithmetic, basic matrix operations, matrix inverse and pseudo-inverse, triangulation method for a point set, converting an image sequence to video format, SVD or some eigenvector decomposition. If there is any question – ASK ME.