EECS 504 Computer Vision: HW4

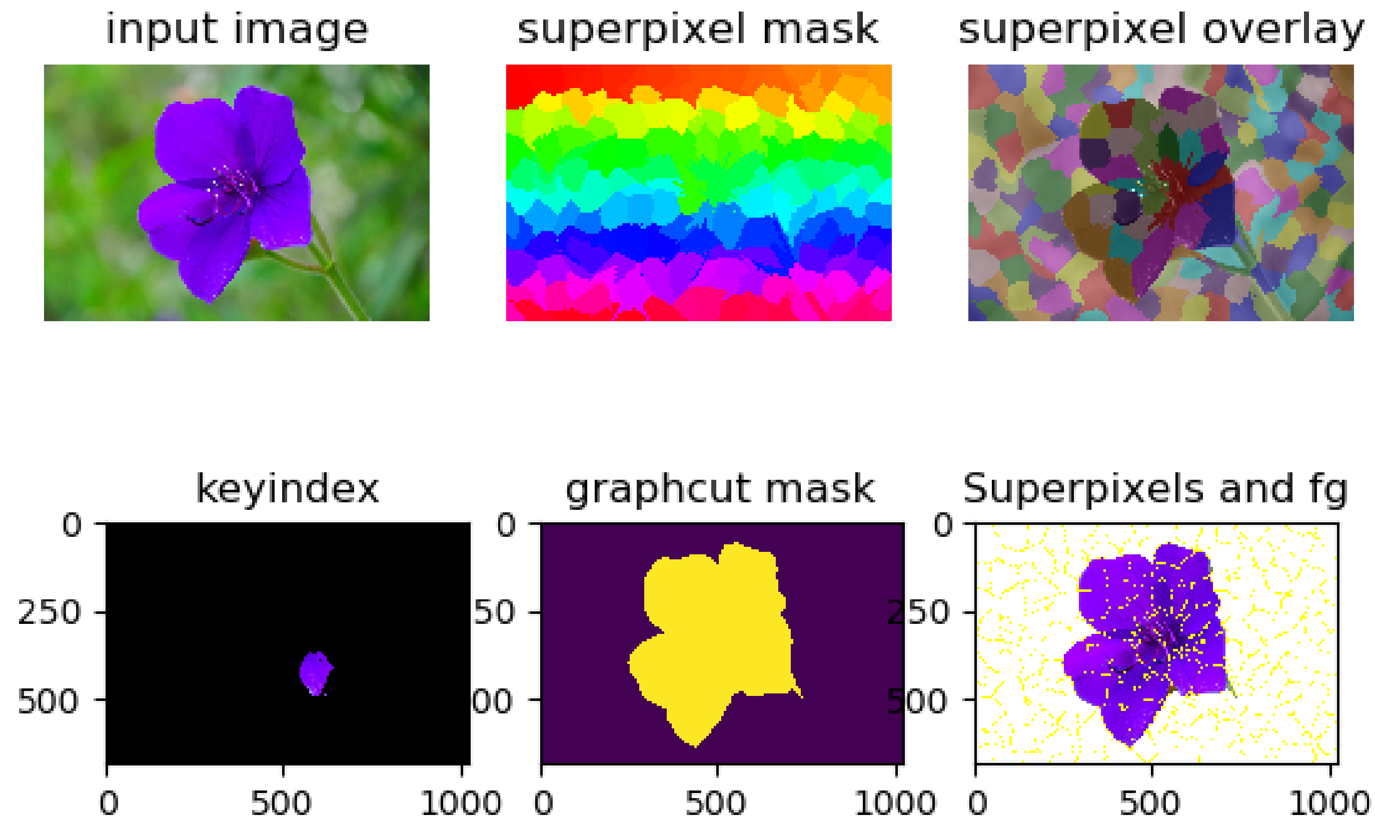
Term: Fall 2018
Instructor: Jason J. Corso, EECS, University of Michigan
Due Date: 11/16 23:59 Eastern Time

Constraints: This assignment may be discussed with other students in the course but must be written independently. Programming assignments should be written in Python using the open-source library ETA. Over-the-shoulder Python coding is strictly prohibited. **Web/Google-searching for background material is permitted. However, everything you need to solve these problems is presented in the course notes and background materials, which have been provided already.**

Data: You need to download `hw4.zip` to complete this assignment. All paths in the assignment assume the data is off the local directory. You need to run this homework inside the ETA environment you have created in Homework 0.

Problem 1 (55): Foreground-background graph-cut

We discussed the figure-ground graph-cut case study in class. You will implement this method for figure-ground extraction on color images using a superpixel graph and color histograms as the feature. A basic MRF is implemented in the graph. The figure below shows the expected results and facets of the assignment.



The provided code includes the core framework, an implementation of the SLIC superpixel method, and an implementation of the Ford-Fulkerson algorithm for computing the max-flow. You will implement the histogram feature representation and all aspects of taking the superpixel result and implementing the graph on top of it as well as reading out the results of the graph cut as a two-class segmentation.

The function `example()` provides a full run through the whole method for you. You have to submit the results from running this function. You will also need to run few additional methods.

Note that the output numpy files for each step are provided. These are for your help and benefit, and it is used to compute accuracy for submission. You will not report results from the numpy files as your own

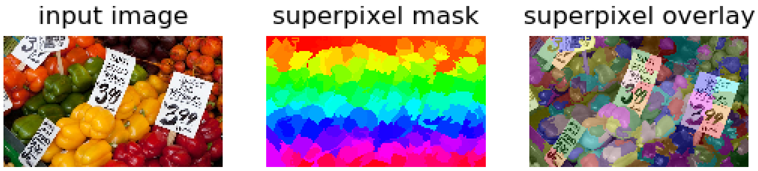
1.(8) Color Histogram Features

Implement the missing body of function `histvec()`, which creates a color histogram feature vector. Follow the comments in the code for the details. We call this in functions `img_reduce()` and `q1()`.

Run function `q1()`, which will generate two output images `q1_Superpixels.png` and `q1_result.png`. Include these outputs in the writeup.

Also, inspect the code in function `q1()` and answer the following question in one sentence:
Describe the object in the image that is covered by the superpixel used to compute the histograms in `q1()`.

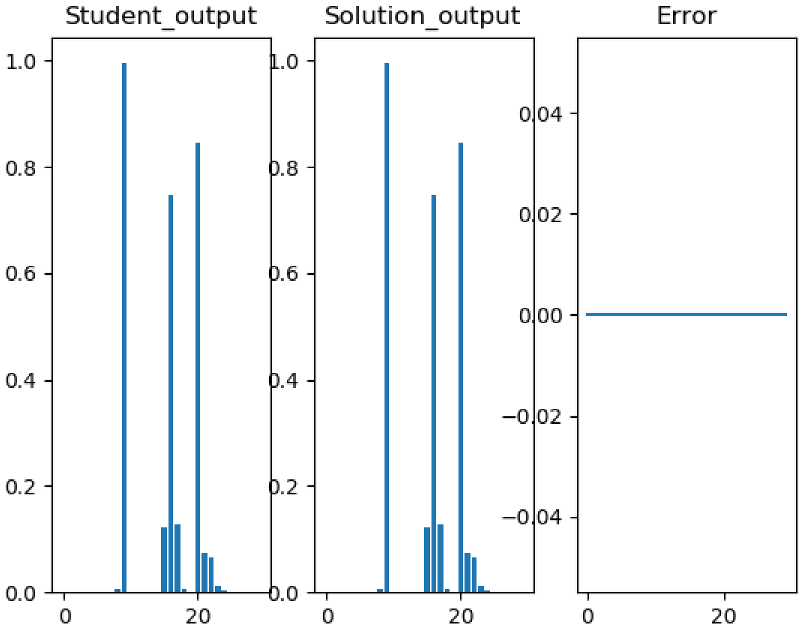
solution and rubric:
(5) Code added to `histvec()`.
(2) Output image present; the image result shows error close to 0.
If the error is not 0, but the code is correct, full points should be awarded.
This may be because a student used a different version of OpenCV, and, as a result, received a different output from SLIC.
(1) A yellow pepper is used to compute the histogram in the code. (be liberal with this answer).



input image

superpixel mask

superpixel overlay

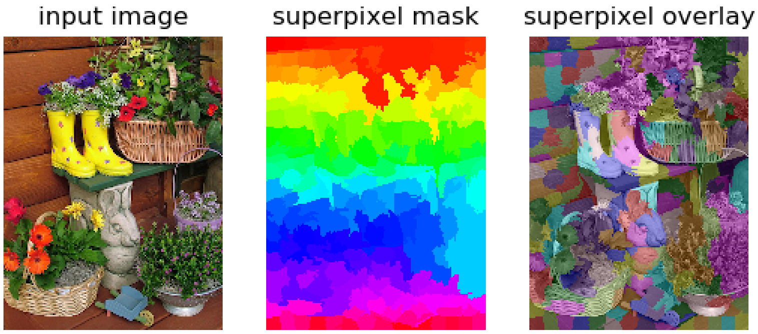


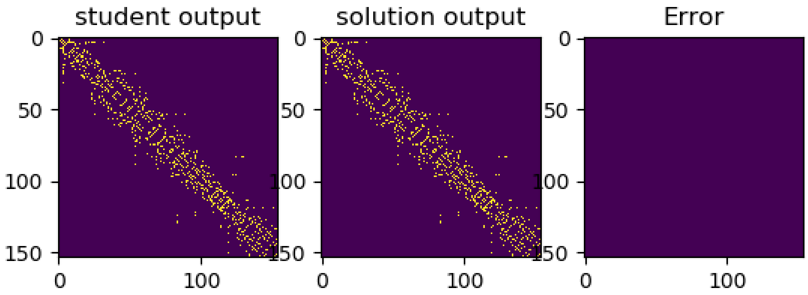
2.(15) Superpixel adjacency

(a) (7) Implement the missing body of function `seg_neighbor()`, which computes the adjacency matrix for the superpixel graph. Follow the comments in the code for the details. We call this in the graph cuts function.

Run function `q2()`, which will generate two output images `q2_Superpixels.png` and `q2_result.png`. Include these outputs in your writeup.

solution and rubric:
(5) Code added to `segNeighbors.m`.
(2) Image included in writeup and matches result below (to grader's eye). Error should be close to zero but need not be exactly zero.





(b) (5) Implement a small function to compute the average node degree. Report the average degree and include the code as plain text in the writeup. (No need to submit the original file.)

solution and rubric:
Average node degree = 5.33

(3) Code present
(2) Correct node degree

(c) (3) Why is the adjacency graph not a perfect banded diagonal matrix?

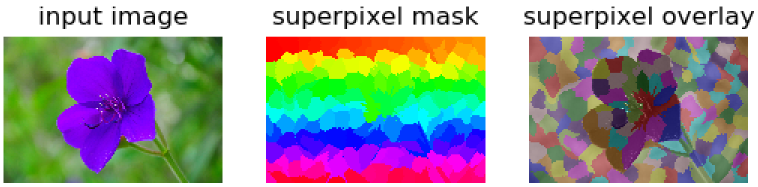
solution and rubric: (3) Because the graph is derived from superpixels and the edge structure of the graph is irregular. Any answer close to this is acceptable.

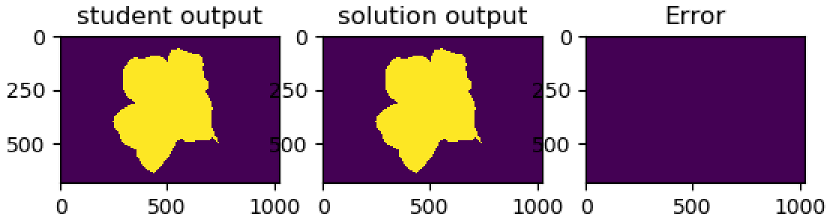
3.(17) Graph-cuts

(a) (8) Implement the missing two bodies of function `graphcut()`, which :- (1) creates the graph by defining the capacity matrix and (2) extract the results after running the max-flow/min-cut method. See the comments and refer to class notes for details.

Run `q3()`, which will generate two output images `q3_Superpixels.png` and `q3_result.png`. Include these outputs in your write-up.

solution and rubric:
(3) Code added to `graphcut()` for the capacity matrix creation.
(3) Code added to `graphcut()` for the extraction
(2) Image included in writeup and matches result below (to grader's eye). Error should be close to zero but need not be exactly zero.





(b) (5) In a few sentences, relate the adjacency matrix to the capacity image. Be sure to cover **all** nodes of the graph in your description.

solution and rubric:
capacity is calculated at only those points as where the value in the adjacency matrix is one. That is if there is an edge present, we will calculate the capacity of that edge. for the source and sink it is assumed that they are connected to each of the other superpixels so they will have some capacity with each of the interior superpixels (but source will not be connected to the sink)

+5 Description includes both superpixels and the source and sink.
-3 if it does not mention the source or sink / or the last 2 rows or columns).

(c) (4) Please explain why the capacity between adjacent nodes in the graph that have resulted from superpixels is downweighted with respect to the capacity between nodes in the graph and the special source and sink nodes.

solution and rubric:

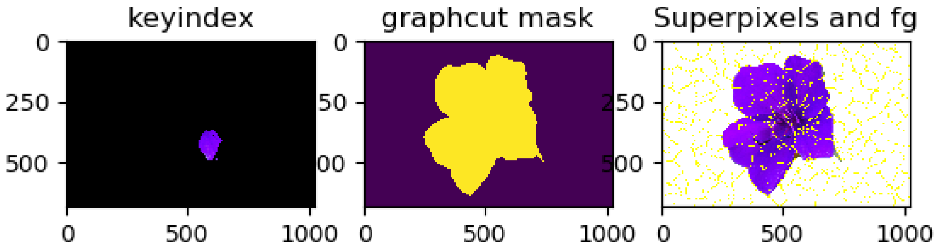
(4) Answer is because each node is connected directly to source/sink and yet to more than one other node. If we give these capacities the same general range, then flow will be available through all nodes and our energy function will not capture any structure. However, finding the *best* relative value between the two terms is a challenging optimization.
-2 if discussion present but does not mention anything related to the answer above.

4.(15) Graph-cuts Study

Use the function `example()` here and change accordingly (for each input image you will have two output images `example_Superpixels.png` and `example_result.png`). You can change other parts of the code too if needed, but be clear to note it.

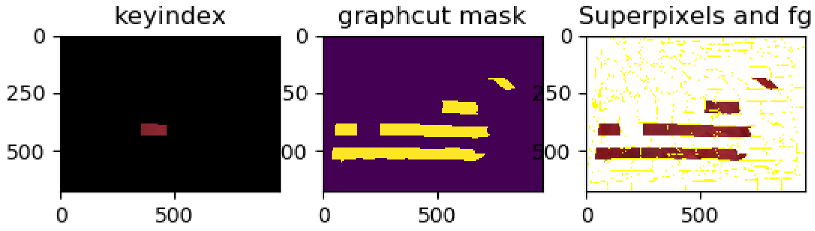
(a) (2) Run function `example()` as provided to run through a full example and show the resulting segmentation on the flower. Include the result in your write-up.

solution and rubric: (2) Image result present.



(b) (5) Run `example()` using the `flag1.jpg` image. Manually select a stripe on the flag. Are you able to get a full segmentation of the stripe and no other regions? If so, explain what you did to make this possible. If not, explain why this is hard. Include an rendering of the figure to substantiate your explanation either way.

solution and rubric:
(2) Image result present.
(3) Discussion present.
Possible annswer: I do not think it is possible because the difference in color along a stripe outweighs the spatial proximity. If a different weight is used on the distance parameter then most likely other stripes will be cued as foreground. However, a student may prove it possible...



(c) (5) Run function `example()` using the `porch1.png` image. Are you able to segment the boots perfectly? If so, explain what you did to make this possible. If not, explain why this is hard. Include an rendering of the figure to substantiate your explanation either way.

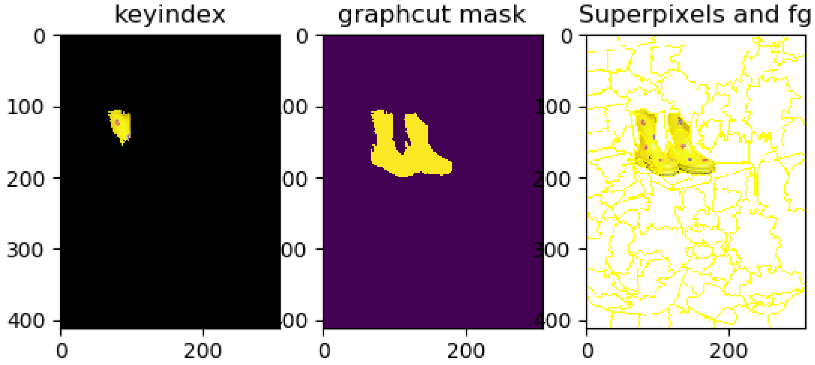
solution and rubric:

(2) Image result present.

(3) Discussion present.

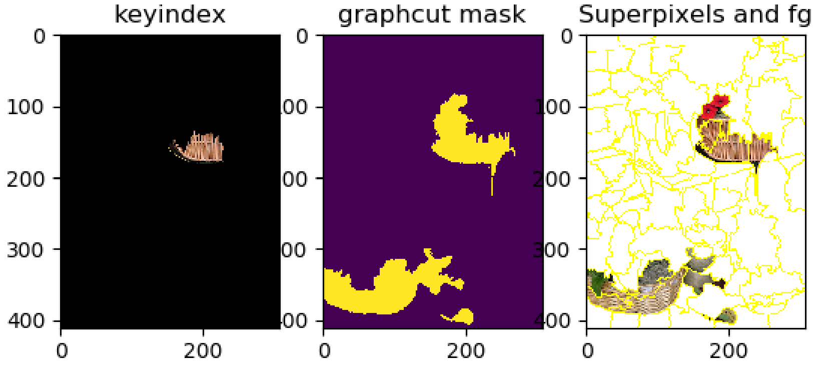
Either answer is possible here. If yes, then you probably had to change the superpixel code. If no, then you explain that the colors of the butterflies on the boots is different than than color of the boots themselves, yet not far away. Students may also choose to discuss the irregularity of the boot edges, which results from the shape of the superpixels. This is also an acceptable discussion.

-3 if the discussion does not match the figure.



(d) (3) On the `porch1.png` image again, are you able to segment either of the baskets perfectly? My guess is no. Can you describe (but do not implement) a way to change this system to make this more possible?

solution and rubric: (3) Discussion present. Change descriptor feature from color histogram to HOG or texture histogram.



Submission Process: Submit a single typewritten pdf with your answers to these problems, including all plots and discussion. Submit the pdf to Gradescope.

For coding assignments, include your code verbatim in your writeup for each question. Pack the original program files into one zip file and upload it to Canvas. **Code should be well-commented for grading**

Grading and Evaluation: The credit for each problem in this set is given in parentheses at the stated question (sub-question fraction of points is also given at the sub-questions). Partial credit will be given for both paper and python questions. For python questions, if the code does not run, then limited or no credit will be given.