

CSE473/573 Summer 2017 - Homework 3

Due date: 20 Jun 2018

June 11, 2018

1 Image Filtering- 40%

1. The derivative of a continuous function $f(x)$ can be written as

$$f'(x) = \lim_{\epsilon \rightarrow 0} \frac{f(x + \epsilon) - f(x)}{\epsilon} \quad (1)$$

or

$$f'(x) = \lim_{\epsilon \rightarrow 0} \frac{f(x + \epsilon) - f(x - \epsilon)}{2\epsilon} \quad (2)$$

What does ϵ represent in the context of digital image filtering? - 5%

2. The laplacian operator for a continuous function $f(x, y)$ is

$$L(f(x, y)) = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \quad (3)$$

and the discrete counterpart for Laplacian is

0	1	0
1	-4	1
0	1	0

Prove the equivalence between the continuous Laplacian equation and the discrete laplacian filter given above - 10%

3. Briefly explain how second order derivative filters can detect edges in an image - 5%
4. Convolve the image below with the 3x3 laplacian filter and show the result image. Also, mark the edges using your inference from Question 3 - 10%

0	0	0	0	0	0	0
0	0	1	1	1	1	0
0	0	0	0	1	1	0
0	0	0	1	1	1	0
0	0	0	0	0	0	0

5. What is the difference between linear and non-linear filters? Give one example for each - 5%
6. Describe briefly how non-maxima suppression works for edge thinning - 5%

2 2D Fourier Transform - Hands-on - 10%

Watch first 3 minutes of <https://www.youtube.com/watch?v=v743U7gvLq0>

Fourier analysis is a full-scale chapter, which we cannot cover in depth given the time constraint of the course. You are free to explore this area in depth and get back to me with any questions you have. Rather than focusing on theory, I would like you to start using fourier analysis as a tool.

Read through <https://homepages.inf.ed.ac.uk/rbf/HIPR2/fourier.htm> and implement one of the six exercises of your choice in Python and report your results

3 Image Features and Matching - 30%

1. How does SIFT features achieve scale invariance? Describe the steps involved - 5%

2. A feature matcher with a specific threshold -

finds 50 correct matches

fails to detect 20 correct matches

incorrectly detects 30 mismatches as matches

and correctly rejects 80 mismatches

Construct a confusion matrix out of this data and compute True Positive Rate, False Positive Rate, Positive Predicted Value and Accuracy of this feature matcher (Ref: Table 4.1 in Richard Szeliski Textbook) - 10 %

3. What is a ROC curve? What would be the shape of ROC curve of a feature matcher that uses an unbiased coin to report correct match, if it shows heads? Given a feature matcher fm1 and fm2 with area of ROC curves 0.95 and 0.75, which one would you choose and why? - 10%

4. Describe key steps in stitching Panorama from multiple images. Elaborate on Bundle Adjustment - 5%

4 Clustering and Segmentation - 20%

1. You are given two coins of identical appearance in a bag. You pick one of the coins and toss it for 5 times and put it back in the bag. You repeat the same experiment for 5 times and below are your observations

TTTTT
HHHHH
HHTHH
HTTTT
THTTT

Assume the bias of the coins to be 0.5 and 0.6. Apply expectation-maximization algorithm and find the bias estimates of the coins after first iteration. Read through the document below for better understanding of EM algorithm, which also has an example similar to the question - 10%

http://ai.stanford.edu/~chuongdo/papers/em_tutorial.pdf

2. Describe briefly how watershed segmentation works - 10 %