Exam in Computer Assisted Image Analysis I

Exam A, January 2, 2018

- Time: 8:00 to 13:00
- Place: Bergsbrunnagatan 15, Hall 1
- Tools: Dictionary, one A4 sheet (2-sides) with handwritten notes
- Grades: 3: 20 pts; 4: 26 pts; 5: 34 pts

The cover sheet shall always be filled in and returned even if no exam questions have been answered. Write your name on all papers that you hand in. Do not use red ink. Start on a new paper for each new question. Sort the answer sheets in the order of the questions before you turn them in. Use drawings and figures to illustrate your answers when suitable. Please write answers in English. Results will be posted on the Student Portal (Studentportalen).

GOOD LUCK!

/Filip, Damian

1 True or False, 5p

Each correct answer gives 0.5p, and each incorrect answer gives -0.5p. You can not get less than 0p in total.

(a) Increasing the contrast of an image is an example of spatial filtering.

(b) JPEG image compression is lossless.

(c) The convex hull of an object always contains the object itself.

(d) The zero frequency component of the Discrete Fourier Transform of an image equals the sum of all pixel values.

(e) The Gaussian filter is an example of a high-pass filter.

(f) The histogram of an image contains all information needed to reconstruct the image itself.

(g) The Fourier transform of an image contains all information needed to reconstruct the image itself.

(h) (200, 200, 0) represents a purple color in the RGB system (8 bit uint used)

(i) The number of regions produced by the watershed segmentation algorithm equals the number of local minima in the image.

(j) The Hough transform is typically used to reduce aliasing artifacts in an image.

2 Image enhancement/Pointwise operations, 5p

(a) Name three applications where image arithmetic can be useful and describe them briefly. (1 p)

(b) Consider an 8-bit grayscale image with the following pixel values:

0	10	120
20	127	235
130	245	255

For each of the following calculate the new pixel values and draw the intensity transfer function: (3 p)

- Increase the brightness by 25.
- Increase the contrast by 2.
- Calculate the negative (complement) image.

(c) What is an image histogram? What kind of information can we get from it? (1 p)

3 Filtering, 5p

(a) Let I be an image with N pixels, and let H be an image with $M < N$ pixels. Computing the convolution $I \otimes H$ in the spatial domain requires $\mathcal{O}(NM)$ operations. Explain how the same convolution can be computed efficiently using the fast fourier transform. What is the computational complexity of the resulting algorithm? (2p)

(b) Explain, step by step, how you would remove the pattern from the image below. (3p)

4 Morphological operations, 5p

(a) Describe at least three different morphological set operations (other than erosion and dilation). (1p)

(b) What is the effect of erosion and dilation, respectively? (1p)

(c) What is a structuring element? Draw a useful structuring element (do not forget to indicate where the origin is!). (1p)

(d) Compute morphological dilation on the 1-shape in the 8x8 image below with the structuring element in c) (1p)

(e) Compute morphological erosion in the same image with the same structuring element. (1p)

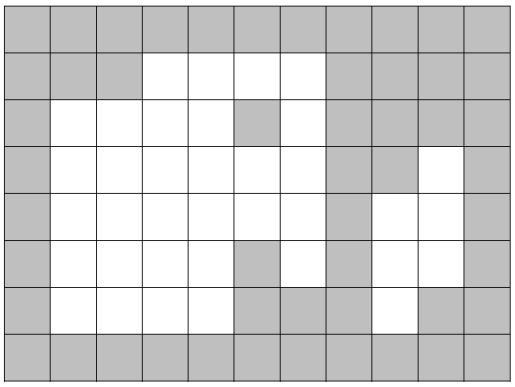
0	0	0	0	0	0	0	0
0	0	1	0	1	1	0	0
0	1	1	1	0	1	1	0
0	0	1	1	0	1	1	0
0	0	1	1	1	1	0	0
0	0	1	1	1	0	0	0
0	0	1	1	0	0	0	0
0	0	0	0	0	0	0	0

5 Segmentation, 5p

(a) What is global threshold segmentation? How can you calculate it? (1 p)

(b) What is local threshold segmentation? How can you calculate it? (1 p)

(c) Calculate the distance transform for the following binary image (gray is background and white is foreground): (1 p)



Use the approximated distance measure:

1.5	1	1.5
1	0	1
1.5	1	1.5

(d) You segmented a microscopy image and obtained the following binary result. How can you separate the three overlapping objects using image processing? Your approach should be automatic (no user input) and independent from the number of objects in the image. (2 p)

6 Feature extraction/Object description, 5p

(a) Name three ways to represent/describe a complex shape boundary and briefly explain how they can be used. (3p)

(b) Consider the following segmented fruit images. Suggest a collection of descriptors you could use to classify them. (2p)

7 Classification, 5p

(a) Explain the difference between supervised and unsupervised classification. For each of them give one application example. (1 p)

(b) You were asked to train an image classifier to solve a problem with three possible classes. All the data you received is 200 images of class A, 300 images of class B and 500 images of class C. How would you divide this dataset into the training, validation and test sets? Motivate answer. (2 p)

(c) Name four supervised classifiers. Briefly explain one of them (2 p)

8 Image coding and color, 5p

(a) Is run-length coding lossless or lossy? How is it performed? (1 p)

(b) What is coding redundancy, inter-pixel redundancy and psycho-visual redundancy? Give examples of how these redundancies can be reduced in image coding and compression. (2 p)

(c) Explain the color spaces RGB, CMY and HSL. For each color space, give an example when that color space is to prefer over the other two. (2 p)