

Exam in Computer Assisted Image Analysis I

March 11, 2011

- time: 14:00 to 19:00
- place: Polacksbacken, skrivsal (examination hall)
- tools: dictionary
- grades: 3: 20pts; 4: 26pts; 5: 34pts

The cover sheet shall always be filled in and returned even if no exam questions have been answered. Write your name or code 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. Results will be posted on the student portal.

PS. Please remember to answer the course evaluation page in the student portal.

GOOD LUCK!

/Anders, Bettina, Cris, Gustaf, Patrik and Robin.

1 Yes or No, 5p

Each correct answer gives 0.5p, and each incorrect answer gives -0.5p. A left out answer gives 0p. You can not get less than 0p in total on this exam question.

- a) Is it true that any real and odd image has a real and odd Fourier transform?
- b) Is the set of centers of maximal discs always connected?
- c) Is it possible to combine several *lossless* compression methods?
- d) Is K-means a supervised classifier?
- e) Is the 3rd statistical moment a measure of the skewness of the distribution?
- f) Is it true that in image processing, both the input and output of algorithms are typically images?
- g) The Laplacian of an image is a non-linear transformation ?
- h) Is the median filter sensitive to outliers?
- i) Does the perceived color of an object only dependent on the light source and the actual color of the object?
- j) Is it true that watershed on the inverted image is an example for a top-down region-based segmentation?

2 Point-wise operations 5p (Anders)

Given a small image, 16×16 pixel 3-bit grayscale, with the histogram:

$$\text{count}(0) = 0$$

$$\text{count}(1) = 2$$

$$\text{count}(2) = 1$$

$$\text{count}(3) = 69$$

$$\text{count}(4) = 5$$

$$\text{count}(5) = 179$$

$$\text{count}(6) = 0$$

$$\text{count}(7) = 0$$

where $\text{count}(x) = n$ means that there are n pixels with intensity x in the image.

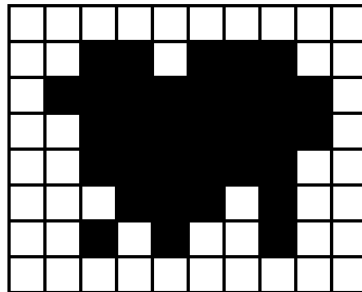
a) Stretch the histogram using brightness and contrast adjustment so that the full dynamic range (3 bit integers) is used. (2p)

b) Stretch the histogram using histogram equalization. (2p)

c) Are these transformations reversible? (i.e. you can undo the transformation and get back to the original image again, by applying another pixel-wise operation.) Please explain. (1p)

3 Distance transforms, 5p (Robin)

- a) What is the distance transform of a binary image? (1p)
- b) Depending on the distance function (city block, chessboard, ...), a weighted distance transform can be more or less rotation dependent. What does rotation dependent mean? (1p)
- c) Calculate the 3-4 distance transform on the object in the image below. (1p)



- d) The distance transform is useful for computing the skeleton of an object. Which properties should a skeleton have? Draw a shape (an object) and its skeleton (approximately). (1p)
- e) Give at least two applications of the distance transform. (1p)

4 Coding and compression, 5p (Gustaf)

You are a new employee at a startup company, FoodQ, developing an automatic food quality control system based on image analysis. They are acquiring RGB images of food passing by the camera on a conveyor belt. You have received images from an initial test but the images contain artifacts from heavy JPEG compression.

You have been called to a technical meeting as the *image analysis expert* to explain to the rest of the software people *what* type of artifacts you observe, *why* they form and suggest *possible solutions* to the problem in terms of image file-formats and choice of compression methods.

Please write down the main points of your talk.

5 Fourier domain, 5p (Cris)

The Fourier transform of the 1D function $f(t) = \cos(\omega_0 t)$ is

$$F(\omega) = \pi [\delta(\omega - \omega_0) + \delta(\omega + \omega_0)] \quad .$$

a) What is the Fourier transform of $f(x, y) \cdot g(x, y)$, if the Fourier transforms of $f(x, y)$ and $g(x, y)$ are $F(u, w)$ and $G(u, w)$? (2p)

b) If $f(x, y) = \cos(w_0 x)$, what is $F(u, w)$? (1p)

c) Give the Fourier transform of the 2D image

$$f(x, y) = 3 \cos(0.3x) \cos(0.2y) \quad .$$

(2p)

6 Object description 5p (Patrik)

a) In Figure 1 you can find a small image with 3 greyvalues. Calculate the co-occurrence matrix for the image using the operator $P = \text{"one pixel right"}$. (3p)

b) Calculate the maximum probability and entropy scores for the co-occurrence matrix. (2p)

1	2	2	3	3
2	1	1	1	3
1	2	2	2	1
2	1	3	1	2
3	1	2	3	2

Figure 1: Greyscale image containing 3 greyvalues.

7 Local neighborhood operations 5p (Anders)

- a) Convolve the image below with a 3×3 window filled with ones. (1p)
- b) Compute the local median using a 3×3 window in the image below. (2p)
- c) Compute the Laplacian of the image below. (2p)

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

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Use zero-padding (*i.e.* assume pixels outside the image are zero).

8 Segmentation 5p (Bettina)

In the course we talked about a segmentation method that is called thresholding.

- a) Explain global and local thresholding. (1p)
- b) Segment the image in Figure 2 (intensity values on supplementary sheet) with thresholding into foreground (brighter) and background (darker). Is global or local thresholding more suitable for this task? Explain every step you perform in detail and reason how you choose the threshold(s). (2p)
- c) What is the reason to label a segmented image? (0.5p)
- d) Use the two-pass label algorithm (and a 8-connected neighborhood) to label the result from (b) and explain the steps that you perform. (1.5p)



Figure 2: Original.

An answer sheet is attached in the end of the exam.

