Computer Assisted Image Analysis II

HT 2013

Exam 2013-12-18

time:	08.00–13.00	
place:	Polacksbacken, Skrivsal	
tools:	pen or pencil and paper, 1 hand-written sheet with notes	
grades:	0–17	fail
	18–24	3
	25–32	4
	33–40	5

OBS: Please use drawings and figures to illustrate your answers when suitable. Use a new page for each new question, make sure that you write your exam code (or name) on each page, and remember that the top left corner will be hidden by the staple. It is OK to use both front and back sides of the paper. You may write your answers in English or Swedish, but not with red ink.

Results will be forwarded to the student office no later than January 08.

GOOD LUCK!

1. Evaluation of segmentation results (Carolina)

You are evaluating N different tumor segmentation algorithms to be used in combination with a radiation therapy instrument. By outlining the tumor in a CT image, the radiation therapy can be optimized so that the patient will receive ionizing radiation at the site in the body where the tumor resides, while other parts of the body are exposed to a minimum of radiation.

Assume that you have a manual segmentation result that can be considered as the truth.

a) Describe how the Dice similarity measure can be used to evaluate the *N* different methods. (1p)

b) The outcome of the treatment of the patient will be different if parts of the tumor are not exposed to radiation (areas missed) or parts of the surrounding tissue are exposed to radiation (areas that should not receive radiation are exposed). Explain how Recall and Precision can be measured to evaluate the *N* different methods in a more detailed way. (2p)

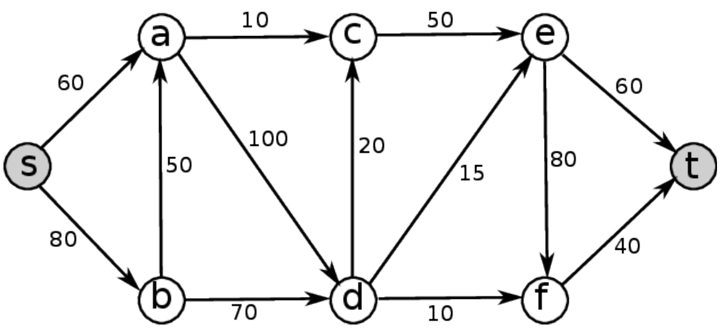
c) The Hausdorff approach for evaluating segmentation results also takes the distance between the outlines into account. Propose a method for how the Hausdorff distance can be implemented using the distance transform. (2p)

2. Graph cuts (Filip)

a) Use the Ford-Fulkerson algorithm to calculate the maximum s-t flow on the graph shown in below. The numbers in the figure indicate the capacity of each edge. Show your calculations. (2p)

b) Based on the results from the max-flow calculations, what is the capacity of the minimum s-t cut on the graph? Which edges are included in the minimum s-t cut? (1p)

c) In the course, we have seen that image segmentation can be formulated as an optimization problem. With this approach, we first define an *energy functional* that measures the "goodness" of any segmentation. Then, we use an optimization method to find a segmentation that is as good as possible, according to the energy functional. Some optimization methods find *locally optimal* solutions, while others are guaranteed to find *globally optimal* solutions. Discuss the differences between these two types of optimization methods. What are their advantages and disadvantages? (2p)



3. Edges (Cris)

a) In the first filtering lecture we established that the first derivatives (gradient) is used to detect edges. What features of the edge are encoded in the gradient? How? (1p)

b) Discuss different filters that estimate the derivative, and give pros and cons for each. (2p)

c) The Canny edge detector is a very popular algorithm to detect edges. How does it use the gradient? (1p)

d) You want to create a Gaussian derivative filter *h* that estimates the derivative along *x* in a 2D image. Is there a smallest sigma that is practical? How many samples do you need for the kernel? (1p)

$$h(x,y)=\frac{\partial}{\partial x}\left(\frac{1}{2\pi\sigma}e^{\frac{-x^2+y^2}{2\sigma^2}}\right)$$

4. Classification (Anders)

a) Explain and contrast the concepts of supervised vs. unsupervised classification. (2p)

b) Explain how the algorithm “K-nearest neighbours” works and point out at least one good and one bad aspect of using it. (2p)

c) Many algorithms exist that produce linear classifiers, i.e. where the separating surfaces are lines, planes or hyper-planes. Explain an efficient technique to enhance such classifiers to deal with much more complicated class boundaries. (1p)

5. Measurement (Cris)

You are given the image below, and are tasked with measuring the diameter of the coins. Consider these 5 ways to accomplish this task:

1) Thresholding + point counting to estimate area
2) Thresholding + chain code to estimate perimeter
3) The Canny edge detector + RANSAC fitting of circle model
4) The Canny edge detector + the Hough transform for circles
5) Gradient magnitude + the Radon transform for circles

a) Specify the possible pitfalls or biases in each method. (2p)

b) Make a guess for which of these methods is the most precise and which is the least precise. Give your reasoning. (1p)

c) Make a guess for which of these methods is the fastest, and which is the slowest. Give your reasoning. (1p)

6. Interpolation (Cris)

a) Given that interpolation is a convolution, describe how you would compute an interpolation using the Fourier Transform. (3p)

b) Describe an experiment you would do to compare various interpolation schemes, so that you could see which one has the smallest error. To design this experiment you need to establish what *error* means in this case, and how you could measure it. (2p)

7. Digital geometry (Robin)

A point (pixel) *p* in the square grid is simple if

– there is exactly one object component in an 8-neighborhood of *p*, and

– there is exactly one background component in an 8-neighborhood of *p*, edge connected to *p*.

a) In which configurations in the figure below is the center point (pixel) simple? (1p)

b) Intuitively, what is a simple point in the continuous space R^2? (1p)

c) Why are simple points usually a key component of skeletonization algorithms? (1p)

d) Give a definition of simple point in the hexagonal grid. (2p)

8. Motion analysis (Anders)

a) Give examples of image features (patches) in 2-D where you have complete information about the motion, partial information and no information. (3p)

b) Explain with your own example in 1-D how intensity changes, from one frame to the next, can affect the optical flow estimate. Make it simple, i.e. the two images are both 1-D signals, there is a global motion and the intensity changes are either additive or multiplicative from one image frame to the next. (2p)