UNIVERSITY OF OSLO

Faculty of Mathematics and natural sciences

Exam :	INF3300/INF4300 — Digital image analysis
Date :	Thursday 13. December 2007
Time :	14.30-17.30
Number of pages:	5 pages plus 1 page enclosure
Enclosure:	1 sheet containing a figure/plot, at the end of the exam text.
Allowed aid:	Calculator

- Read all the exam paper before you start solving the exercises. Please check that the exam paper is complete. If you lack information in the exam text or think that some information is missing, you may make your own assumptions, as long as they are not contradictory to the "spirit" of the exercise. In such a case, you should make it clear what assumptions you have made.

- Please note that all parts of the exercises have equal weight. You should spend your time in such a manner that you get to answer all exercises shortly. If you get stuck on one question, move on to the next question.

- Some of the questions are based on printed figures or plots included in the exam text. An extra copy of this sheet is included at the end of the exam text. Please draw your solution on this sheet, mark it with your candidate number and include it in your solution.

- Your answers should be short, typically 1-3 sentences should be sufficient.

Good luck!!

Exercise 1. Features, statistical moments.

Statistical moments are given by:

$$m_{p,q} = \sum_x \sum_y x^p y^q f(x, y)$$

Let us assume that we are working with binary images.

a) What does the 0. order moment, $m_{0,0}$ measure? Insert the correct values in the formula and show what this gives.

b) How can we find the center of mass for an object based on moments?

c) How can we make moments invariant to position?

d) How can you find the orientation of an object based on moments? You don't have to include the exact formula.

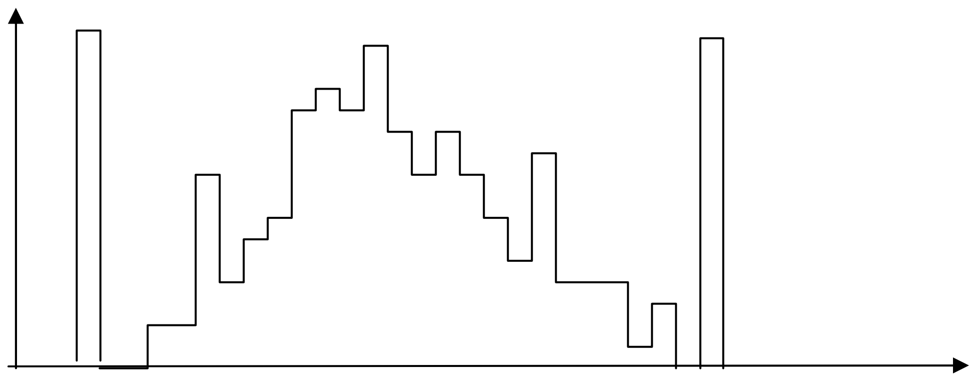
Exercise 2. Watershed segmentation.

a) Explain briefly the principle behind the Watershed algorithm.

b) What happens if we apply Watershed segmentation directly on a noisy greylevel image?

c) Which alternative preprocessing methods can be used to improve the performance of Watershed segmentation?

d) The figure below shows the intensity profile for a grey level image (the grey levels along a line in the image has been plotted). Draw the edges that Watershed segmentation will result in on this image. Remember to draw you result on the enclosed sheet.



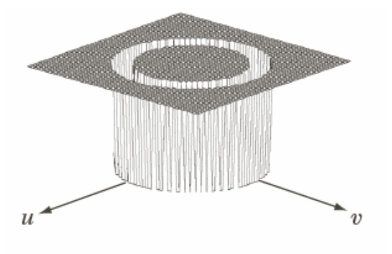
Exercise 3: Fourier transform

a) What does the convolution theorem state?

b) What is the disadvantage of using an ideal filter?

c) The filter $H(u,v) = 1 - e^{-D^2(u,v)/2D_0^2}$ is given. What kind of filter is this? What is D_0?

d) We have a filter with the frequency response (plot of the filter in the Fourier domain) given below. What kind of filter is this?



Exercise 4. Texture.

a) What does the Gray Level Co-occurrence Matrix (GLCM) contain?

b) How large is the GLCM matrix?

c) How can we measure GLCM features that are independent of direction?

d) A feature based on GLCM is given by:

$$\sum_{n=0}^{G-1} n^2 \{ \sum_{i=1}^{G} \sum_{j=1}^{G} P(i,j) \}, \quad | i-j |= n$$

What does this feature measure? Justify your answer briefly.

e) Create a new texture feature from the GLCM that emphasize the contrasts for high intensity values.

Exercise 5: Hough transform

The polar representation of a line is given by $\rho = x \cos\theta + y \sin \theta$. Assume that we have an image of size NxN.

a) What range of values can θ take for arbitrary lines in this image?

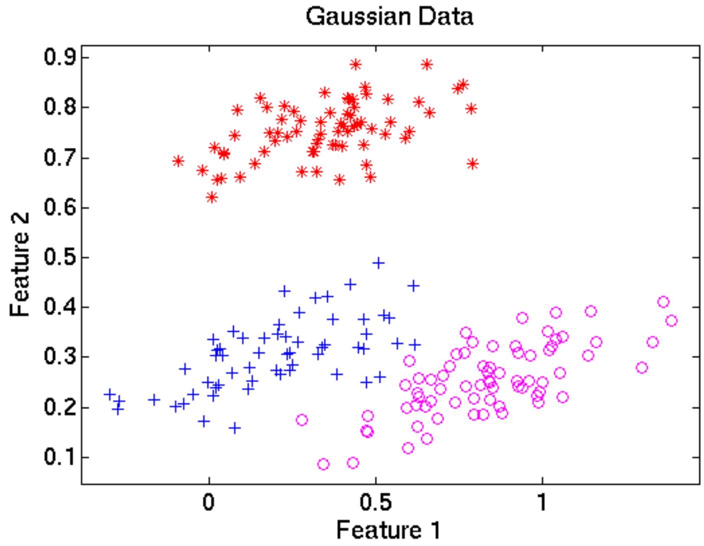
b) What range of values can ρ take for arbitrary lines in this image?

c) What kind of structure will one point in the (x,y)-plane result in in the (ρ,θ)-plane?

d) Given the point x=0, y=0. Indicate/sketch the curve that this gives in the (ρ,θ)-plane and justify you answer briefly.

e) Given the point x=1, y=0. Indicate/sketch the curve that this gives in the (ρ,θ)-plane and justify your answer briefly.

Exercise 6: Classification



In the figure above, a scatter plot of features from a training data set with three classes is given. Class 1 is marked with *, class 2 with +, and class 3 with o.

a) Look at the figure above. Sketch the mean values for the different classes on the enclosed sheet.

b) Assume that the three classes have equal prior probability and equal covariance matrices. Draw the decision boundary you get if this is the training data set for a Gaussian classifier with uncorrelated features where we use a diagonal covariance matrix.

c) Consider now only class 1 and 2, marked * and +. How will the decision boundary change if class 1 has twice as high prior probability as class 2?

d) The discriminant function for a classifier that used Euclidean distance is given by $g(x)=\|x-\mu_k\|^2$. In one of the weekly exercises we showed that this was equivalent to using the discriminant function:

$$g_K(x) = x^T \mu_K - \frac{1}{2}\mu_K{}^T \mu_K$$

Which equation can we specify to get an expression for the decision boundary between two classes (call the classes *k* and *j*)?

e) Given a classification problem with two classes and two features with mean values $\mu_1 = \begin{bmatrix} 1 \\ 4 \end{bmatrix}$, $\mu_2 = \begin{bmatrix} 2 \\ 2 \end{bmatrix}$,

Find an equation for the decision boundary for this problem, based on the answer from d).

Candidate number