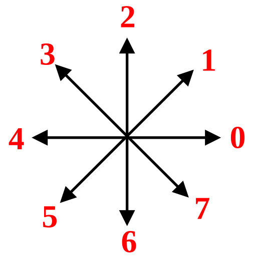
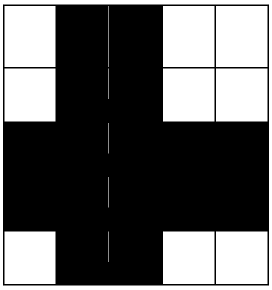
Some exercises from previous exams in INF4300/9305 Digital Image Analysis

Exercise 1, 2012: Chain Codes

You are given the 8-directional chain code and the object below, where black is object pixels.





a) Chain code the boundary of the object clockwise from the upper left pixel.

b) Which technique will make the code invariant to the choice of start point?
Demonstrate this by starting at lower right pixel of the object.

c) Which technique will make the code rotation invariant?
Demonstrate this by rotating the object π/2 counterclockwise and start at one of the same object points as above.

Exercise 2, 2012: GLCM

The Gray Level Cooccurrence Matrix method is a frequently used texture analysis method. In 2D gray level images we often use isotropic GLCMs based on symmetric matrices obtained for a given pixel distance in a limited number of directions.

a) How do you obtain a normalized symmetric Gray Level Cooccurrence matrix for a given (d,θ)?

b) In a 3D image, how many Gray Level Cooccurrence matrices do you need to accumulate to make an isotropic matrix describing the second order statistics covering all directions to the neareast neighbors of an image voxel (=volume pixel)?

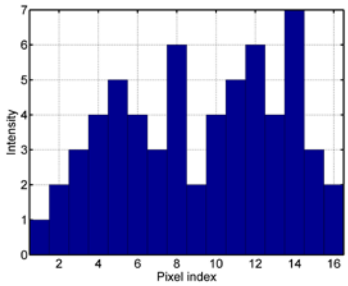
c) If you treat the GLCM as an image C(i,j), and compute the central moments $\mu_{1,0}$ and $\mu_{0,1}$, what are the values of these moments?

d) If you compute the three second order central moments of the normalized Gray Level Cooccurrence matrices $P(i,j|d, \theta, \omega)$ from a number of texture classes ω, which parameters derived from these three moments would give you first and second order statistics that are useful in order to classify the textures?

e) Given a NxN pixel gray level image having G gray levels (0,…, G-1), explain how you can use a non-normalized Gray Level Cooccurrence Matrix to estimate the graylevel threshold that will give you a binary output image that contains a minimum number of transitions from 0 to 1 or 1 to 0 as you traverse the binary image in the horizontal direction.

Exercise 3, 2012: Watershed segmentation

a) What characterizes a pixel where the watershed algorithm will construct a dam?
In the intensity profile below, please describe where the watershed algorithm will place a dam.

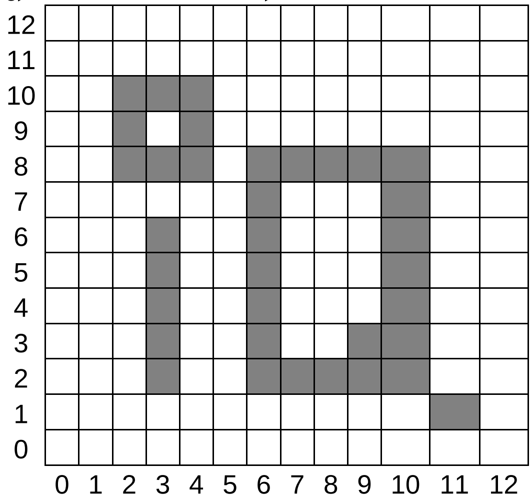


b) Assume that you are going to segment some round objects. You expect that the initial thresholding will produce results as illustrated below (white is foreground pixels.).

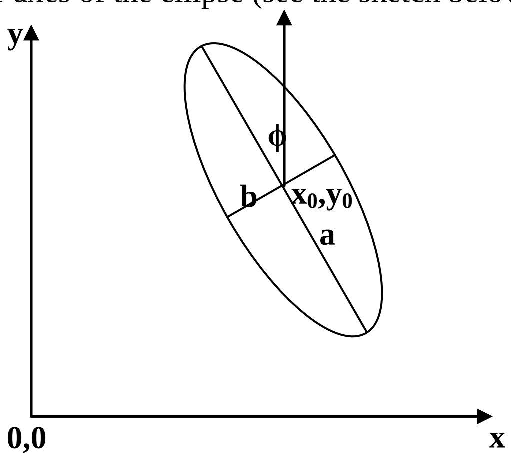
We want to separate the two components of this object into two approximately elliptical objects. Describe how this can be done using the watershed algorithm, and indicate in a figure what the solution looks like.

Exercise 6, 2012, for PhD-students: The Hough Transform

a) Apply the Hough transform for straight lines to the 12x12 pixel binary image below, using the normal representation, and mark the accumulator values of the SIX most prominent maxima in their proper (θ,ρ)-locations within the accumulator matrix given in the enclosure. D_8, the *chess distance*, is used to measure distance from (x,y)=(0,0).



b) A fairly common Hough representation of an ellipse in the (x,y)-image plane is 5-dimensional: x_0 and y_0 to describe the centre of the ellipse, ϕ to describe the orientation (anticlockwise from the vertical y-axis), and the pair (a,b) to describe the length of the semi-axes of the ellipse (see the sketch below).



Someone suggests using the normal (θ,ρ) - representation of the major axis, together with (a,b), in order to represent an ellipse.
Please indicate the parameters θ and ρ of the normal representation of the major axis.

c) If the major axis is rotated around (x_0,y_0), which curve will the major axis of the ellipse describe in the positive (θ,ρ)-plane? Please explain.

d) Is this a unique representation of an ellipse?

Enclosure 2, Exam, INF4300/INF9305, December 14, 2012

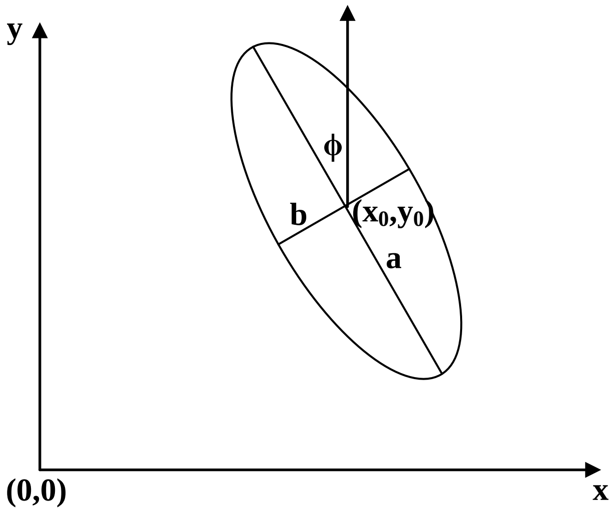
Exercise 6a, 2012, for PhD-students:: Hough Transform

Apply the Hough transform to the 12x12 pixel binary image, using the normal representation, and mark the accumulator values of the SIX most prominent maxima in their proper (θ,ρ)-locations within the accumulator matrix.

π/2													
π/4													
0													
	0	1	2	3	4	5	6	7	8	9	10	11	12

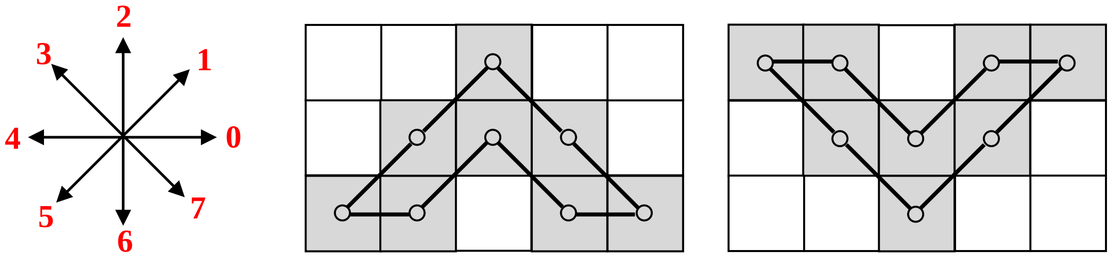
Exercise 6b, 2012, for PhD-students:: Hough Transform

Please indicate the parameters θ and ρ of the normal representation of the major axis.



Exercise 1, 2011: Chain Codes

You are given the 8-directional chain code and the two objects below.



a) Chain code the boundary of the Λ-shaped object clockwise from the lower left pixel.

b) Which technique, based on the 8-directional <u>absolute</u> chain code, can be used to make a description of the Λ-shaped object that is independent of the start point? Demonstrate this by starting at the top pixel of the object, instead of the lower left.

c) The V- shaped object is a rotation of the Λ-shaped object. Which technique, based on the clockwise <u>relative</u> chain code, will give you the same description of the two objects, independent of the start point? Demonstrate this by starting at the upper left pixel of the V-shaped object.

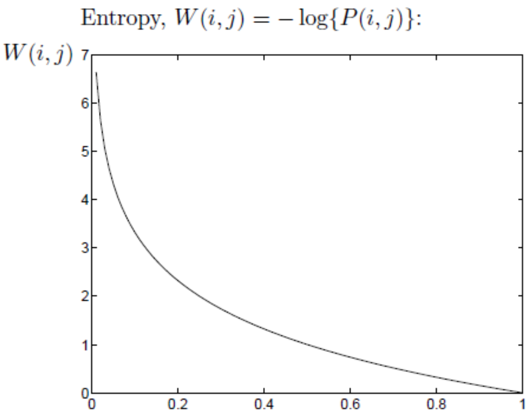
Exercise 3, 2011: GLCM

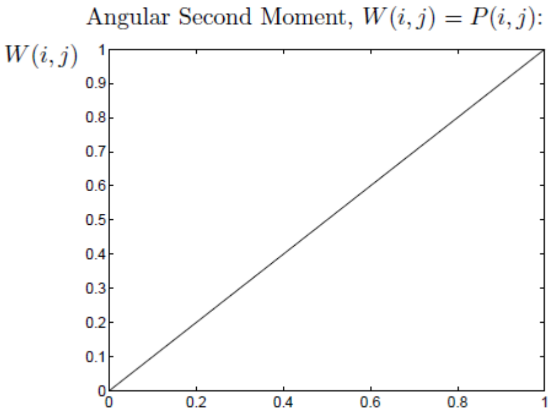
To the right you see a remote sensing image showing both steep slopes, deep valleys, flat grassland, numerous small streams, and some man-made constructions. Two subregions are incircled.

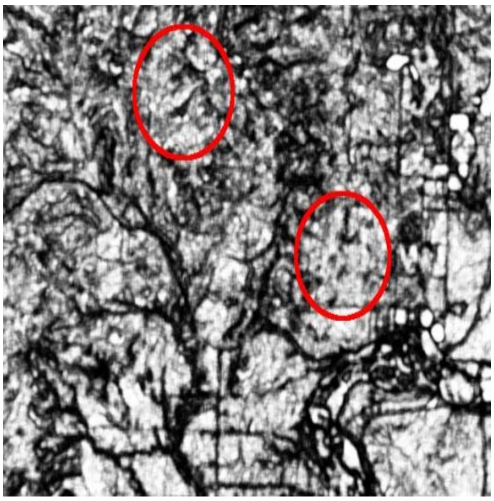
The two texture feature images at the bottom of the page were made using a moving window to compute a normalized GLCM and deriving two features that are using weight functions based on the value of the matrix elements, namely ENTROPY and ASM. The two equations are:

$$ENT = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j) W_{ENT}(i,j), \quad P(i,j) > 0; \qquad ASM = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1} P(i,j) W_{ASM}(i,j)$$

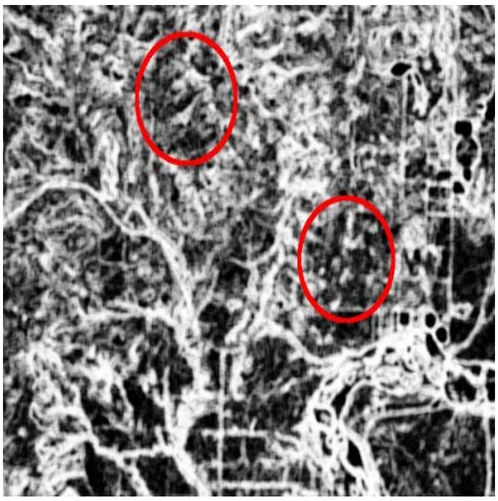
Where the weights are functions of the GLCM element probabilities, given by two curves:







Left feature image



Right feature image

a) A direction invariant normalized GLCM was computed with a pixel offset of 1. Explain the steps of this computation.

b) Based on what you observe in the circled regions and elsewhere in the two feature images, explain which is ENTROPY and which is ASM, and give some reasons.

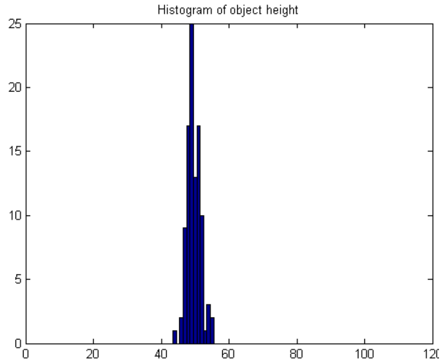
c) There are also GLCM features where the weighting is a function of the element position. Two examples of this are Inertia (INT) and Inverse Difference Moment (IDM), given by

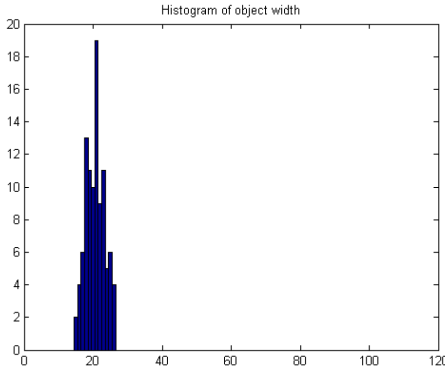
$$INT = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}(i-j)^2 P(i,j) \ ; \qquad IDM = \sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\frac{1}{1+(i-j)^2} P(i,j)$$

Discuss the two features in terms of local contrast and homogeneity.

Exercise 4, 2011: Morphology

A gray level image ***f (x,y)*** contains 100 dark objects on a lighter background. The background has varying intensity. The dark objects have a size distribution as indicated in the figures below, showing the histograms of object width and height.





a) Which morphological operation would you use in order to estimate the varying intensity in the image?

b) What should the structuring element look like?

c) Let ***g(x,y)*** be the image after a correction of the background intensity, but before segmentation by thresholding. Give an expression for ***g(x,y)*** given the structuring element and the operation in a).

d) Let ***h(x,y)*** be the image after thresholding. Which morphological operation would you use to split connected objects in ***h(x,y)***?

e) Which morphological operation would you use to connect fragmented objects?

f) Given a line in a gray level image. The line has pixel values

$f_1(x,y)$ = [1 2 3 4 5 4 3 2 1 2 3 3 3 3 3 3 3 3 3 3]

Compute $g_1(x,y)$, the result after a morphological opening by a the structuring element [1 1 1]. You can either give a graph, or give the values of $g_1(x,y)$.

Exercise 5, 2011: Moments and Hough Transform

Assume that you have thresholded a gray level image ***f(x,y)*** into a binary image ***b(x,y)*** containing a solid object (pixel value = 1) and background pixels (pixel value 0).
We are going to use general discrete moments $\boldsymbol{m_{pq}}$ defined as

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

a) Describe a moment-based approach to find the centre of mass of the object.

b) Assume that the object is rectangular and rotated, located somewhere in the image. Describe a moment-based approach to estimate the orientation of the object.

c) The normal representation of a line segment in the (x,y)-plane is given as

$$\rho = x\cos\theta + y\sin\theta$$

Indicate the parameters $\boldsymbol{\rho}$ and $\boldsymbol{\theta}$ in the first sketch of the enclosed sheet.

d) If we translate the origin to the centre of mass of the rectangle, apply a gradient detector to the binary image, and use the "normal representation" Hough Transform with the gradient magnitude and the gradient direction as input, we get peaks in the Hough space illustrated by ***red dots*** in the second sketch of the enclosure.

   Assume that the rectangle has sides ***a*** and ***b*** (***a***>***b***), and has an orientation $\boldsymbol{\theta}$ relative to the x-axis in the image, where $-\pi/2 \leq \theta \leq \pi/2$.
   Please fill in the proper parameters into the seven empty ovals in the second sketch in the enclosure, and give reasons for your choises.
   Please remember to mark this enclosure with your candidate number and include it in your solution.

e) What happens to the height of the peaks in the (ρ,θ)-plane as the rectangle becomes more like a square?

The following two questions are intended for the PhD-students:

f) What is the (approximate) orientation of the rectangle relative to the x-axis of the image, given the positions of the peaks in the Hough space in the sketch? Explain your reasoning, and make a simple drawing of the rectangle in the (x,y)-coordinate system.

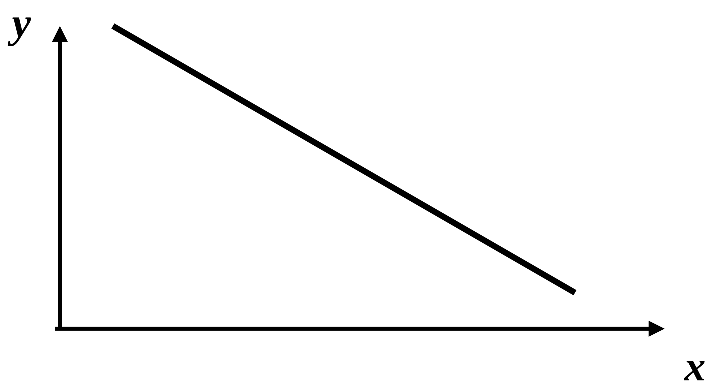
g) Explain what happens to the positions of the peaks in the $(\boldsymbol{\rho},\boldsymbol{\theta})$-plane
   a. If the rectangle is turned into a square of sides ***s***.
   b. As the square is rotated through 360 degrees in the (x,y)-plane.

Enclosure to exam paper, INF4300, Wednesday December 13, 2011

Candidate number:

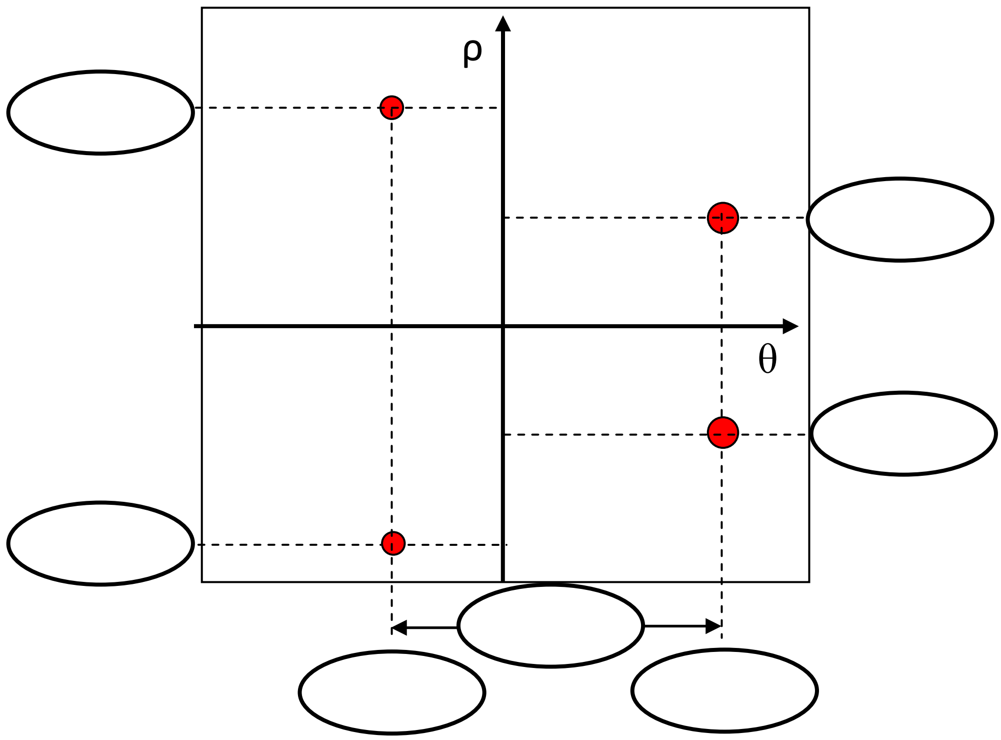
This sketch is part of Exercise 5 c.

Indicate the parameters ρ and θ of the normal representation of the line segment..



This sketch is part of Exercise 5 d.

Please fill in the proper parameters /values into the seven empty ovals



Good Luck !