Bildanalys – ESS060

Date, time and location: 2006-12-18, afternoon

Allowed material: Anything but personal advisors and laptops will be allowed, i.e. calculators, math tables and course book (Sonka, Jain, or Gonzales/Woods), lecture notes, exercises and personal notes.

Exam rounds: We will visit you at approximately 45 minutes after the beginning of the exam and one hour before the end.

Results: Results will be available on January 15.

Solutions: Solutions will be posted on the website shortly after the exam

Requirements for grades:

3:>=28
4:>=40
5:>=50

Project and lab reports should be submitted before January 1, 2006.

Good luck, Merry Christmas and a Happy New Year – Tomas Gustavsson

Problem 1

Consider the image grayscale, r, to be a continuous random variable with the range [0,1]. The image is subject to a grayscale transformation, s=T(r), where T(r) is single valued and s has got the range [0,1]. The transformation is such that the probability density function (referred to as the histogram in the discrete case) of s becomes a constant.

Answer *correct, not correct, or inconclusive* (it is not possible to provide an unmistakable answer to the question given the problem formulation). Each correct answer gives you one point. You may motivate or clarify your answer but no additional points will be given.

a) Given the probability density function of an image, it is always possible to reconstruct the image in a unique way.
b) A rotation of the image will not change its probability density function.
c) A mean filter applied to the image will not change its probability density function.
d) A median filter applied to the image will not change its probability density function.
e) A high-frequency painting is being close-up pictured by a digital camera resulting in a 6 bit 64 x 64 pixel image. The histogram of this result image is very close to the probability density function of a faithfully (in the sense of the Nyqvist sampling theorem) pictured version of the same scene.
f) The histogram turns into the probability density function (becomes the same) if the discrete image has got unlimited number of pixels per size unit and unlimited number of graylevels per pixel.

An arbitrary 512 x 512 input image with 8 bits per pixel is subject to a filtering operation applying the operator

00 01 00
01 96 01
00 01 00

Consider the filter to be normalized before it is being applied. Answer correct, not correct, or inconclusive to the questions below. Each correct answer gives you one point.

g) The histogram of the output image will be more smooth.
h) The mean image intensity will be preserved by the filtering
i) Following one filtering step, for each position in the output image the fraction of information that comes from the corresponding position in the input image is 96 percentage.
j) Following two filtering steps applying the same type of filter in a sequence, for each position in the output image the fraction of information that comes from the corresponding position in the original input image increases as compared to the case presented in i).

Problem 2

Consider two images I_1 and I_2. Extracted from the Fourier magnitude spectrum, F, nine texture features have been computed for both images. Consider a polar representation of the magnitude spectrum, F(r, fi). The frequency range is normalized to [0,1]. The values of the computed features are as follows:

$f_{1,1}$ $(0.0<r<0.1,\ 0<fi<360) = 100$
$f_{1,2}$ $(0.4<r<0.5,\ -10<fi<10) = 10$
$f_{1,3}$ $(0.4<r<0.5,\ 215<fi<235) = 100$
$f_{1,4}$ $(0.4<r<0.5,\ -80<fi<-100) = 10$
$f_{1,5}$ $(0.4<r<0.5,\ 135<fi<155) = 100$
$f_{1,6}$ $(0.9<r<1.0,\ -10<fi<10) = 10$
$f_{1,7}$ $(0.9<r<1.0,\ 215<fi<235) = 10$
$f_{1,8}$ $(0.9<r<1.0,\ -80<fi<-100) = 10$
$f_{1,9}$ $(0.9<r<1.0,\ 135<fi<155) = 10$

$f_{2,1}$ $(0.0<r<0.1,\ 0<fi<360) = 100$
$f_{2,2}$ $(0.4<r<0.5,\ -10<fi<10) = 10$
$f_{2,3}$ $(0.4<r<0.5,\ 215<fi<235) = 10$
$f_{2,4}$ $(0.4<r<0.5,\ -80<fi<-100) = 10$
$f_{2,5}$ $(0.4<r<0.5,\ 135<fi<155) = 10$
$f_{2,6}$ $(0.9<r<1.0,\ -10<fi<10) = 10$
$f_{2,7}$ $(0.9<r<1.0,\ 215<fi<235) = 10$
$f_{2,8}$ $(0.9<r<1.0,\ -80<fi<-100) = 100$
$f_{2,9}$ $(0.9<r<1.0,\ 135<fi<155) = 100$

Answer *correct, not correct, or inconclusive* (it is not possible to answer the question given the problem formulation). Each correct answer gives you one point. You may motivate your answer but no additional points are given.

a) I_1 is overall smoother (has got more slowly varying pixel intensities) than I_2.
b) I_1 is more high-frequency at 45 degrees.
c) I_1 is more high-frequency at -135 degrees.
d) Both I_1 and I_2 present dominant edges oriented at 135 degrees, pretty much like the bug image discussed during the lecture.
e) Counting from left to right, I_1 has got more intensity variations in the horizontal direction
f) I_1 is a rotated (+45 degrees) version of I_2.

Consider two 2-bit images I_3 and I_4 with range [0,3] The associated non-normalized GLCM, direction is given by (dx=-1, dy=-1) and (dx=1, dy=1) for both images, are presented below (origo, is at the underlined position):

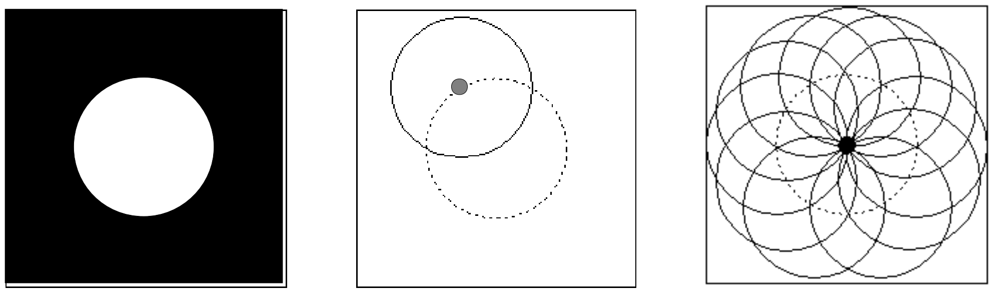
GLCM I_3
$\underline{02}$ 00 00 05
00 02 00 00
00 00 02 00
05 00 00 02

GLCM I_4
$\underline{14}$ 07 00 00
07 14 07 00
00 07 14 07
00 00 07 14

g) The size of I_4 is 8 x 8.
h) I_3 is more high-frequency in the horizontal direction than I_4.
i) By computing the GLCM texture Contrast, it can be seen that I_3 is more high-frequency in the horisontal direction than I_4.
j) I_3 has got more gray levels than I_4.

Problem 3

The figure below illustrates the principles of using the Hough Transform for circle detection. Assuming the circle's radius **r** is known, explain what you see in the plots (a, b, c). (3 x 2p)

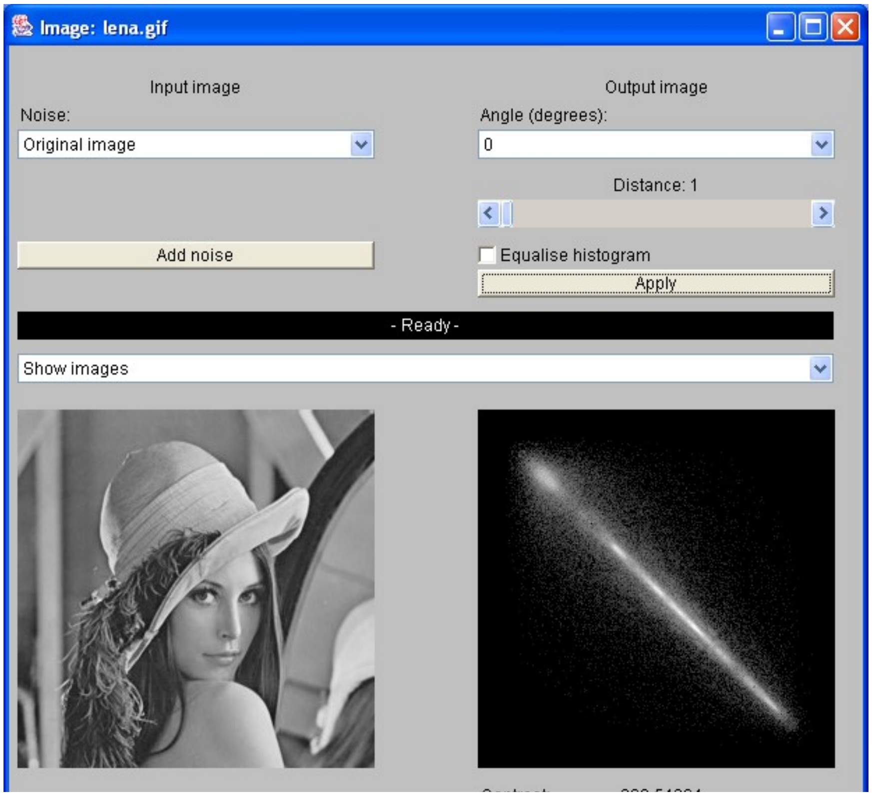


a) b) c)

In what situations do you think the following thresholding schemes would perform well:

a) Fixed thresholding. (1p)
b) The Triangle algorithm, where a line is constructed between the maximum of the histogram at brightness b_{max} and the lowest value b_{min} in the image. The distance **d** between the line and the histogram h[b] is computed for all values of b from $b = b_{min}$ to $b = b_{max}$. The brightness value b_o where the distance between $h[b_o]$ and the line is maximal is chosen the threshold value. (2p)
c) Local thresholding. (1p)

Problem 4



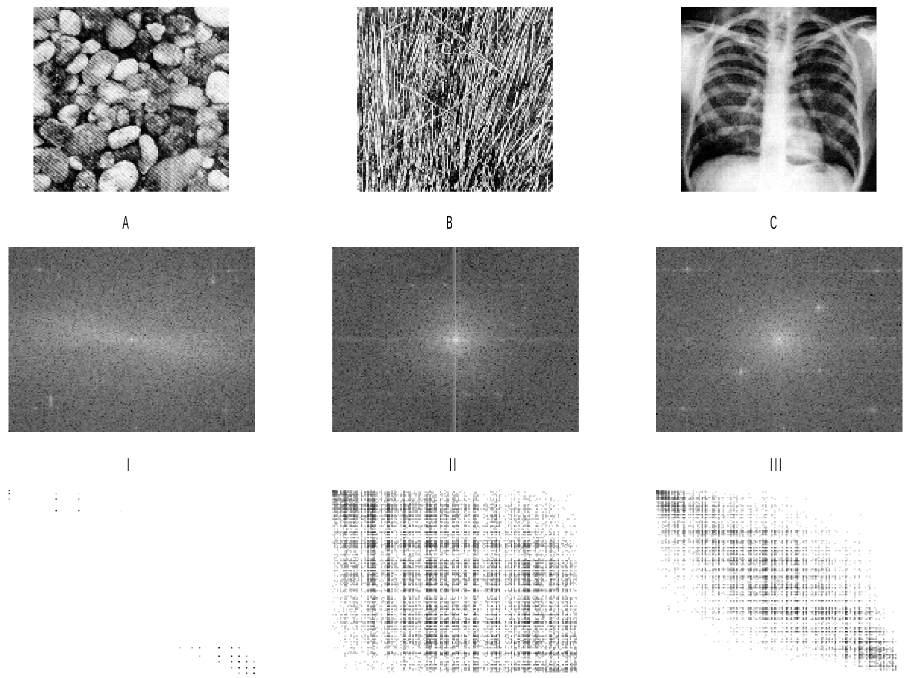
Consider the image above. Answer *correct, not correct, or inconclusive* (it is not possible to answer the question given the problem formulation). Each correct answer gives you one point. You may motivate your answer but no additional points are given.

a) If we increase Distance to 4, the pattern in the GLCM plot will shift downwards along the diagonal.
b) If we change Angle to 90 degress, the GLCM plot will change slightly.
c) If we add Gaussian noise with mean = 0 and variance = 20, the GLCM plot will loose much of its structure (type of shape).
d) If we add 10% of Salt-and-Pepper noise, the GLCM plot will look pretty much the same but add intensities in the upper left and lower right corners.
e) If we add Gaussian noise with mean = 30 and variance = 0, the GLCM plot will keep its structure (type of shape) but become wider.
f) If we rotate the image 90 degrees, the GLCM plot will change slightly.

g) Describe by words how texture analysis by GLCM and Fourier-based texture analysis both can be carried out for non-oriented low-frequency region and 8 (4 x 2) oriented medium- and high-frequency regions. (2p)

h) Discuss pros and cons with the GLCM and Fourier based texture analysis algorithms. (2p)

Problem 5



1 2 3

Consider the three images A, B, C, the three Fourier Spectra I, II, and III, and the three GLCM plots 1, 2, and 3. Answer *correct, not correct, or inconclusive* (it is not possible to answer the question given the problem formulation). Each correct answer gives you one point. You may motivate your answer but no additional points are given.

a) Image A should be associated with Spectrum III because in this spectrum there is no dominant orientation. Furthermore, the four dots equally distributed around the origo of the spectrum plot can be explained by an oriented raster phenomena in image A.
b) Image A should be associated with Spectrum II because in this spectrum there is no dominant orientation. Furthermore, the vertical and horisontal line structures visible in the spectrum plot can be explained by an oriented raster phenomena in image A.
c) Image B should be associated with GLCM 3 because the orientation of the GLCM is such that it represents a 90 degree rotation of the almost vertically oriented grass straws.
d) Image B should be associated with the elongated Spectrum I because this image presents elongated structures.
e) Image C should be associated with GLCM 1 because of its gray level distribution.
f) The low-frequency content of Image A and B is different.

g) Describe Image A in terms of frequency content (magnitude, orientation) (2p)
h) Describe Image B in terms of GLCM appearance (given a certain pixel-pair distance and orientation. (2p)

Problem 6

Answer *correct, not correct, or inconclusive* (it is not possible to answer the question given the problem formulation). Each correct answer gives you one point. You may motivate your answer but no additional points are given.

a) Active Shape Modeling (ASM) generally performs better for object segmentation than Active Contour Modeling (ACM) if shape statistics are available.
b) As a cost minimizing computational tool, Dynamic Programming and Exhaustive Search would typically not lead to the same result.
c) Dynamic Programming can not be used for circle detection or detection of any closed contour.
d) Using un-weighted variation modes of the Point Distribution Model, it is always possible to synthesize shapes which have been seen in the training set.
e) The ACM algorithm converges faster than does the ASM algorithm.
f) Dynamic Programming converges faster than does the ACM.
g) In the Optical Flow algorithm, spatial and temporal derivatives can be estimated from an image pair and used for estimating a vector image in which each image point contains a vector where magnitude represents velocity for that point and orientation represents motion direction for the same point.
h) Dynamic Programming for boundary detection can not be generalized for detection of 2D surfaces.
i) Subregion local image correlation will give the same results as the Optical Flow algorithm.
j) The lecturer presenting the ESS060 course is a bastard.