EKSAMENSOPPGAVE

Fakultet: **RealTek**

Eksamen i: **INF250** (*emnekode*) **Digital image analysis** (*emnenavn*)

Tid: 29 mai, 2019 (*ukedag og dato*) 09:00 - 12:00 (3 timer) (*kl. fra – til og antall timer*)

Faglærer: Ingunn Burud mob. 40219286 (*Navn, tlf*)

Tillatte hjelpemidler:

A1: ingen kalkulator, ingen andre hjelpemidler

Oppgaveteksten er på: 3 (*antall sider inkl. vedlegg*)

Består eksamensoppgaven av deloppgaver, skal det opplyses om hvor mye hver av disse teller.

Emneansvarlig: Ingunn Burud

Sensor: Ingrid Måge

Read through the whole exam first.
The exam consists of 4 exercises. The points for each question is marked.

I recommend to use a new sheet of paper for each exercise.
You may write in English or Norwegian

EXERCISE 1: Techniques (20 p)

A. Name 3 types of image format (3 p)
B. Name a method of first and second order texture analysis (4 p)
C. What is meant by spatial resolution of a digital image ? (4 p)
D. What is a low pass filter ? (3 p)
E. What is the effect of a low pass filter on an image ? (3 p)
F. What is the formula that gives the relation between number of bits and number of gray levels ? (3 p)

A) A kernel (structuring element) of any shape is scanned over the image, and the center pixel is replaced by the minimum (erosion) or maximum (dilation) value of the overlapping region.
B) 1st order: Histogram analysis; second order: Gray Level Co-occurrence Matrix (GLCM)
C) I filter that lets low frequencies pass and high frequencies filtered out.
D) It will smooth the image

E) number of gray levels = 2^n , where n is the number of bits

EXERCISE 2: Finding objects (30 poeng)

A. What is the area and the perimeter of an object ? (5 p)
B. What is a chain code ? (5 p)
C. What is the difference between a 4- and 8-connected chain code ? (5 p)
D. What is watershed and how can it be used to segment objects in an image ? (5 p)
E. What is meant by "shrink and grow" of an object ? (5 p)
F. What is a Canny filter ? (5p)

A) area = number of pixel, perimeter

$$P(R) = \sum_{i=0}^{M-1} length(C_i')$$

B) (from Wikipedia)

A chain code is a lossless compression algorithm for monochrome images. The basic principle of chain codes is to separately encode each connected component, or "blob", in the image.

For each such region, a point on the boundary is selected and its coordinates are transmitted. The encoder then moves along the boundary of the region and, at each step, transmits a symbol representing the direction of this movement.

This continues until the encoder returns to the starting position, at which point the blob has been completely described, and encoding continues with the next blob in the image.

C)

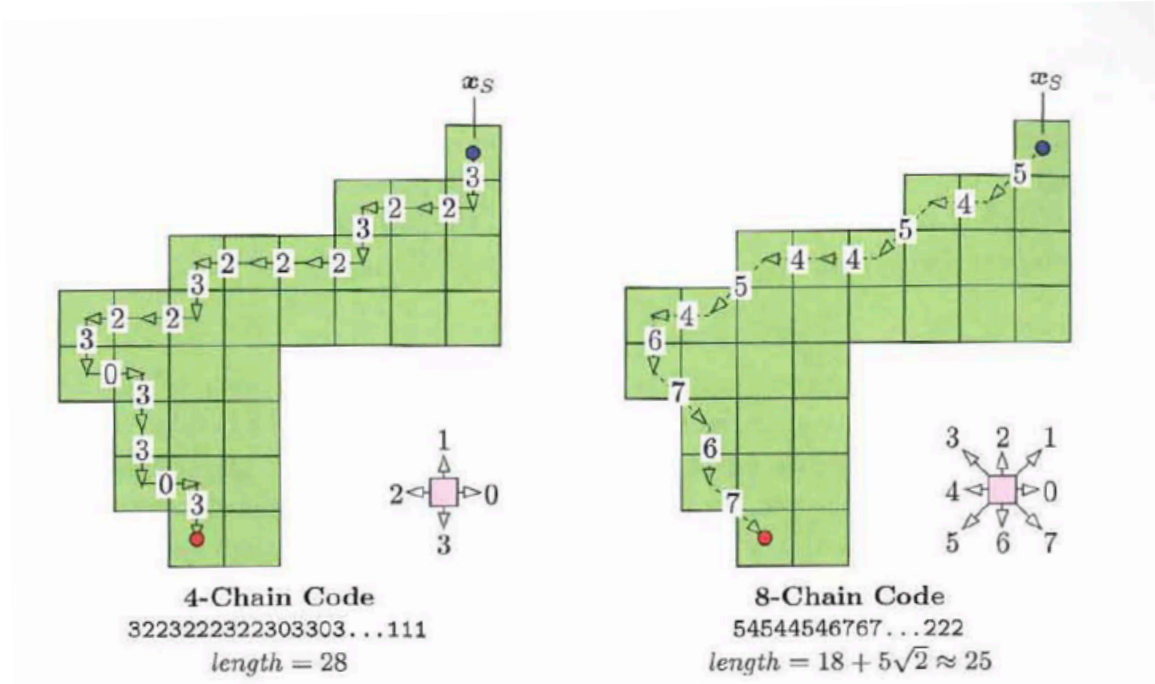


Figure 2.14 Chain codes with 4- and 8-connected neighborhoods. To compute a chain code, begin traversing the contour from a given starting point x_S. Encode the relative position between adjacent contour points using the directional code for either 4-connected (left) or 8-connected (right) neighborhoods. The length of the resulting path, calculated as the sum of the individual segments, can be used to approximate the true length of the contour.

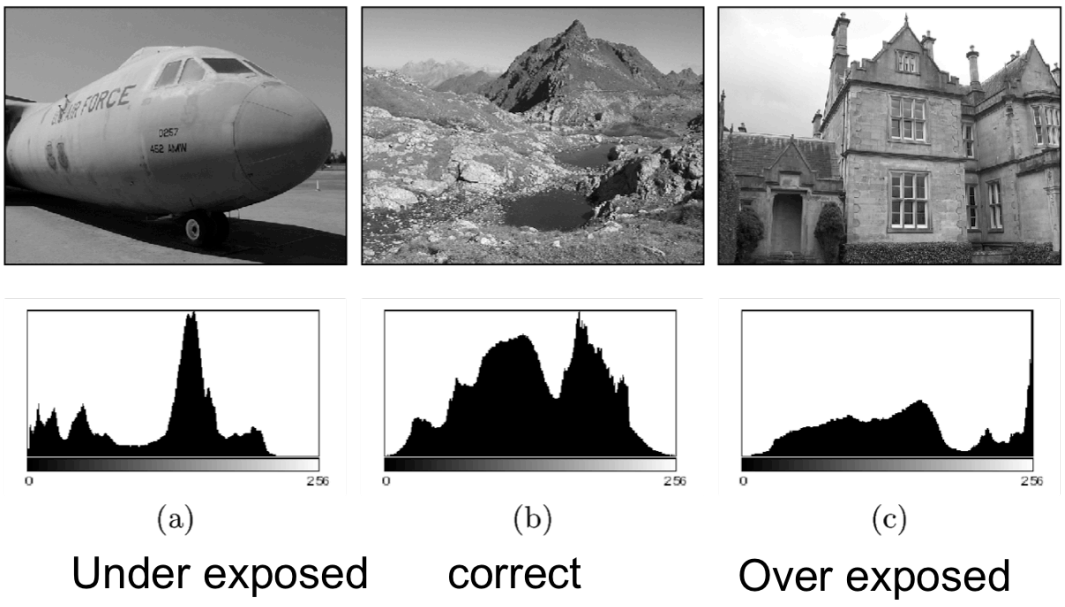
F. Otsu's method is a global thresholding technique. It uses the histogram of the image for threshold searching process. It maximizes "between class variance" of the segmented classes. Otsu proves that Minimizing "within class variance" is same as maximizing "between class variance" of the segmented classes. And maximizing "between class variance" is computationally less expensive than minimizing "within class variance".

EXERCISE 3: Histograms (25 poeng)

A. Explain how the histogram of an 8-bits image is contructed
B. Make a drawing and explain the histogram of an image that is: (5p)
   a. underexposed
   b. correctly exposed
   c. overexposed
C. Explain the process of histogram equalisation, write the formula if you remember it (5p)
D. What is the effect of histogram eualisation ? (3 p)
E. What is meant by thresholding of an image ? (3p)
F. Explain how the histogram of an 8-bit image can be reduced to for example a 32 bin histogram (4p)
G. Describe briefly the principle of of Outsu thresholding (5p)

A. An image histogram is a type of histogram that acts as a graphical representation of the tonal distribution in a digital image. It plots the number of pixels for each tonal value.

B.



C. Histogram equalisation implies mapping the given histogram to wider and more uniform distribution, so the intensity values are spread over the whole image. The operation can be done by making the cumulative histogram as linaer as possible through a point operation :

$$f_{\text{eq}}(a) = \left\lfloor \mathsf{H}(a) \cdot \frac{K-1}{MN} \right\rfloor$$

where H is the cumulatibe histogram, M and N the dimensions of the image, K the number of gray levels (255 in an 8-bit image).

D. It improves the contrast in the image by streching out the intensity range.

E.

Thresholding an image is a special type of quantization that separates the pixel values in two classes, depending upon a given threshold value a_{th} that is usually constant. The threshold function $f_{\text{threshold}}(a)$ maps all pixels to one of two fixed intensity values a_0 or a_1; i. e.,

$$f_{\text{threshold}}(a) = \begin{cases} a_0 & \text{for } a < a_{\text{th}} \\ a_1 & \text{for } a \geq a_{\text{th}} \end{cases} \tag{4.5}$$

with $0 < a_{\text{th}} \leq a_{\text{max}}$. A common application is *binarizing* an intensity image with the values $a_0 = 0$ and $a_1 = 1$.

F. Instead of displaying all 255 pixel values individually, you can bin them to 32 bins. Binning involves grouping the pixel values into one instance of a graphic element. A bin may a histogram bar, whose height indicates the number of cases in the bin.

G. The Outsu algorithm assumes that the image contains two classes of pixels following a bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal.

EXERCISE 4: Spectral image analysis (25 p)

A) What is the difference between an RGB image and a hyperspectral image ? (5p)
B) What kind of information can you get from a hyperspectral image that you can not get in an RGB image ? (5p)
C) What is the difference between supervised and unsupervised classification ? (5p)
D) Give an example of a supervised classification algorithm (2p)
E) Imagine that you have a hyperspectral image with tablets containing the active ingredient paracetamol. In between there are some tablets that are fake and do not contain paracetamol. You are given the task to detec the fake tablets. Describe the procedure you would try to carry out this task. (8 p)