EKSAMENSOPPGAVE

Fakultet: **RealTek**

Eksamen i: **INF250** *emnekode* **Bildeanalyse** *emnenavn*

Tid: 21 desember, 2017 *ukedag og dato* 09:00 - 12:00 (3 timer) *kl. fra – til og antall timer*

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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.

Exercise 1: Techniques (22 p)

A. Describe shortly what is mean by a 24 bits full colour image and a binary image (3p)
B. Explain what is meant by: (5p)
    a. Spatial sampling
    b. Temporal sampling
    c. Quantification of pixel values
C. Describe the techniques Erosion and Dilation (5 p)
D. Name a method of first order texture analysis (2p)
E. Name a method of second order texture analysis (2p)
F. What is the formula that gives the relation between number of bits and number of gray levels ? (3 p)
G. Name 3 types of image format (2 p)

A. A 3-channel image, one in Red, one in Green and one in the Blue colour band. Each channel is an 8-bit image. A binary image has only two colours and is a 1-bit image.
B.
    a. Spatial sampling indicates how many pixels available in the detector to describe an object in an image.
    b. Time sampling indicate at the time interval images are taken of a target.
    c. Quantification of pixel values indicate the number of gray levels available to describe the light intensity in the image.
C. 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.
D. Histogram analysis
E. Gray Level Co-occurence Matrix (GLCM)
F. Number of graylevels = $2^{(bits)}$
G. JPEG, TIF, PNG, RAW

Exercise 2: Histogram and thresholding (28 poeng)

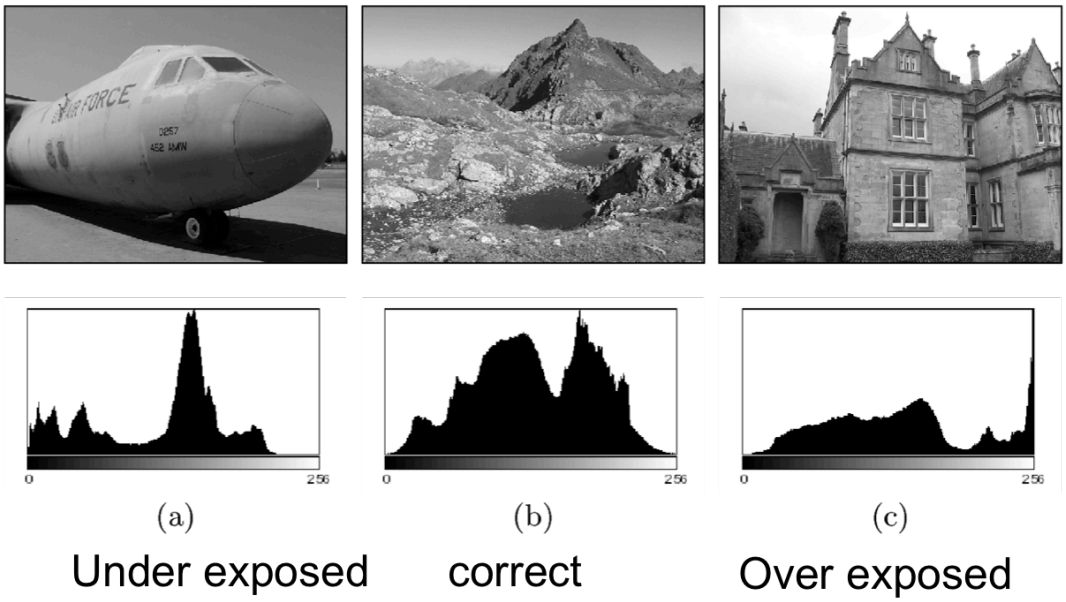
A. Explain how the histogram of an 8-bits image is contructed (3p)
B. Make a drawing and explain the histogram of an image that is: (5p)

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 :

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

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 $a_1 = 1$.

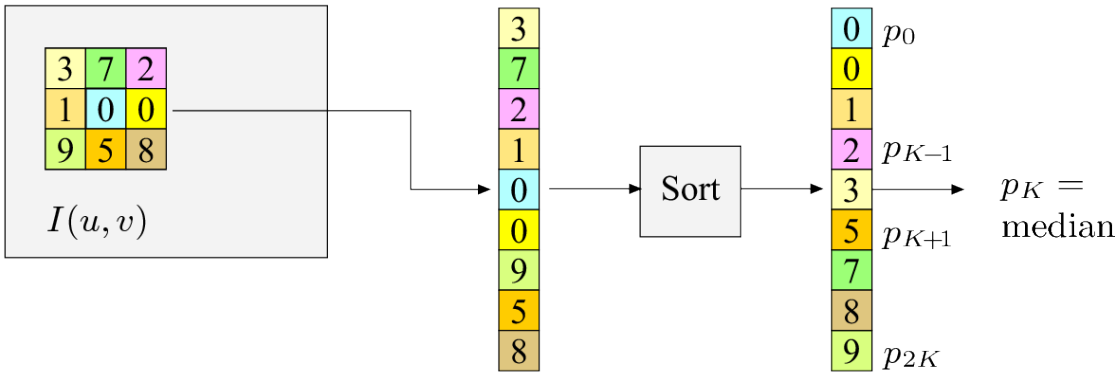
F. Instead of displaying all 255 pixel values individually, you can bin them to 32 bins. Binning involves grouping the pixel values into one instance of a graphic element. A bin may a histogram bar, whose height indicates the number of cases in the bin.

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 3: Filters (25 poeng)

A. What is a high pass filter ? (4 p)
B. Explain what is meant by linear and non linear filtering (5p)
C. Describe the technique called Unsharpen Mask (5p)
D. Name a smoothing filter (3p)
E. Describe a 3x3 pixels median filter with text or a drawing (or both) (3p)
F. How can we say that a median filter removes noise ? (5p)

A. A high pass filter that lets high frequency signals, e.g. fine structures, pass through and filters out low frequency signals.
B. Linear filters combine pixel values in a linear way, i.e., as a weighted summation. The results from a linear filter is completely specifed by the coefficients of the filter matrix. Properties for linaer filters are : Commutativity, Linearity, Associativity, x/y separability. A non-linear filter is a filter where the linearity properties break down.
C. USM is a technique to increase the sharpness using edge detections. The mask M is generated by subtracting a smoothed version of the image from the original image. To obtain the sharpened image the mask is added to the original image, weighted by a factor a, which controls the amount of sharpening
D. Mean filter, gaussian filter
E. A 3x3 pixel median filter looks at the 3x3 neighbour matrix around the center pixel, and computes the median value of these pixels for the output median filtered image.

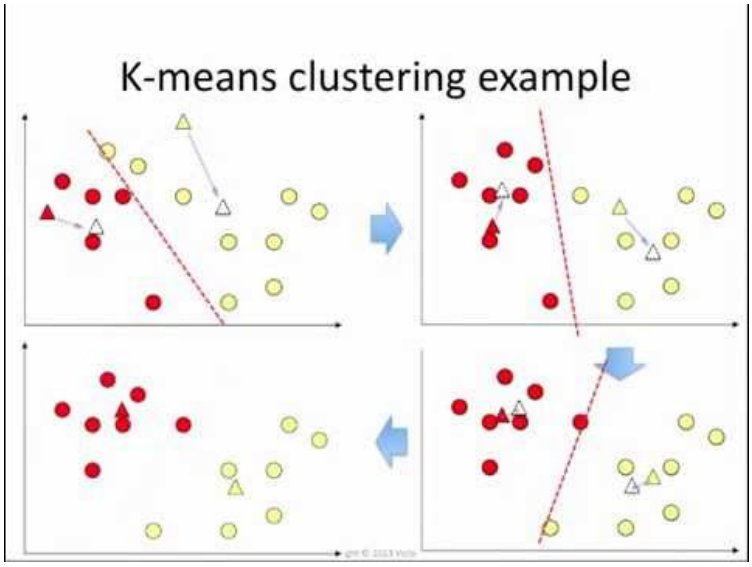


F. Median filter removes spurious positive and negative pixel values, and therefore removes noise related to these.

EXERCISE 4: Spectral image analysis (25 p)

A. Describe briefly what a hyperspectral image is (4 p)
B. Describe a way to use a hyperspectral imge for mapping vegetation in a region (5p)
C. What is the principle of K-means clustering, describe with a few words an a drawing (5p)
D. How can you apply PCA on a hyperspectral image ? (5p)
E. How can you decide how many components that is reasonable to include in a PCA? (3p)
F. Name a technique of supervised classification (3p)

A. A hyperspectral image has two spatial dimensions and one spectral dimension. There are more than 100 spectral bands in a hyperspectral image.
B. 1) applying a cluster algorithm to see if vegetation comes out as one class, 2) compute a vegetation index and apply a thresholding to the NDVI image, 3) Applying a supervised classification
C. *k*-means clustering is a method of vector quantization that aims to partition *n* observations into *k* clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster.



D. In order to apply PCA on a hyperspectral image you need to unfold the hyperspectral image cube so that you have one large vector (the unfolded x,y dimension) with a spectrum for each element. The PCA algorithm can be applied to this vector. The PCA will result in score vectors for each component that can be refolded to score images.
E. By inspecting the graph of eigenvalues for each component you may determine the number of components reasonable to include. When including one more component does not yield any more information it does not need to be included. This depends always on the application and what you are looking for.
F. For example: Spectral Angle Mapper