EKSAMENSOPPGAVE

Fakultet: **RealTek**

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

Tid: 20 desember, 2018 (*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 (25 p)

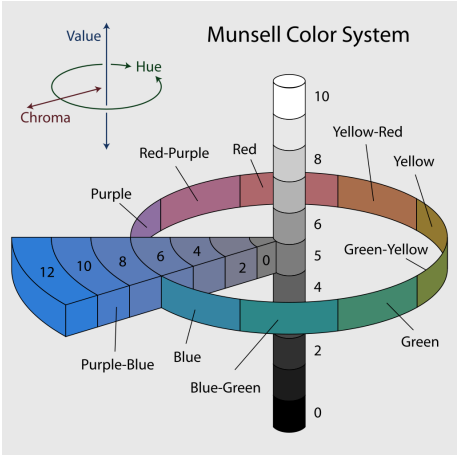
A. Describe shortly what is the difference between a point operation and a filter operation (5 p)
B. Give a short description of JPEG compression (maximum 5 lines) (5 p)
C. Name 3 types of smoothing filters (3 p)
D. Describe the principles of the Munsell colour space (make a drawing) (5 p)
E. Is the mean filter a linear or non linear filter ? (3 p)
F. What is the formula that gives the relation between number of bits and number of gray levels ? (4 p)

A) A point operation is when you carry out a mathematical operation on one pixel that changes the value for this one pixel. A filter is when you apply an operation on the center pixel and neighbour pixels in a defined window to change the value of the center pixel.

B) JPEG (or JPG) is an electronic image format developed by Joint Photographic Experts Group. It uses lossy compression techniques base don descret cosine trasnform.
The files end up smaller than with other non lossy compression techniques
JPEG is often used to store digital images, especially images on the internet

C) Gaussian, median, mean

D)



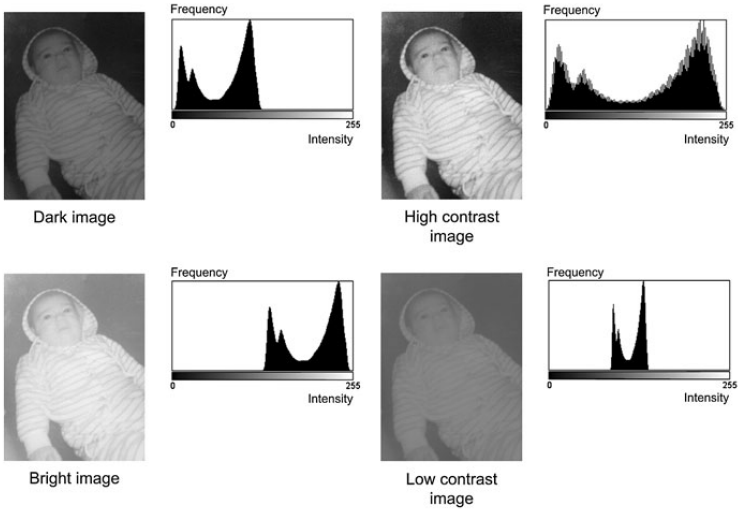
E) linear

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

EXERCISE 2: Histograms, texture and thresholding (25 poeng)

A. Draw a histogram of an image with low contrast (3p)
B. Name two texture feature algorithms (2p)
C. What is the limitation of a first order texture feature method ? (3p)
D. What does GLCM stand for, and how does it work ? (3p)
E. Name four statistical parameters to describe the shape of a histogram (4p)
F. Describe briefly the principle of Outsu thresholding (5p)

A. This a figure showing several histograms, only the low contrast one is required.



B. histogram analysis, Gray Level Co-occurrence Matrix (GLCM)

C. With a first order statistics analysis you cannot distinguish different types of geometry in the image. For example, you cannot see the difference between horizontal or vertical stripes

D. Gray Level Co-occurrence Matrix: A statistical method of examining texture that considers the spatial relationship of pixels is the gray-level co-occurrence matrix (GLCM). The GLCM functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a GLCM, and then extracting statistical measures from this matrix.

E. mean, standard deviation, kurtosis, skewness

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: Describing objects in an image (25 poeng)

In this exercise you are given the RGB image shown in Fig. 1a). The task is to use image analysis techniques that you have learned to segment out the apples and pears, and to automatically classify the object as an apple or pear.

Describe all the steps you go through, starting with importing the image.
You may describe in the form of a text or a pseudo code. If you use pseudo code you must also write a short description of what the code does.

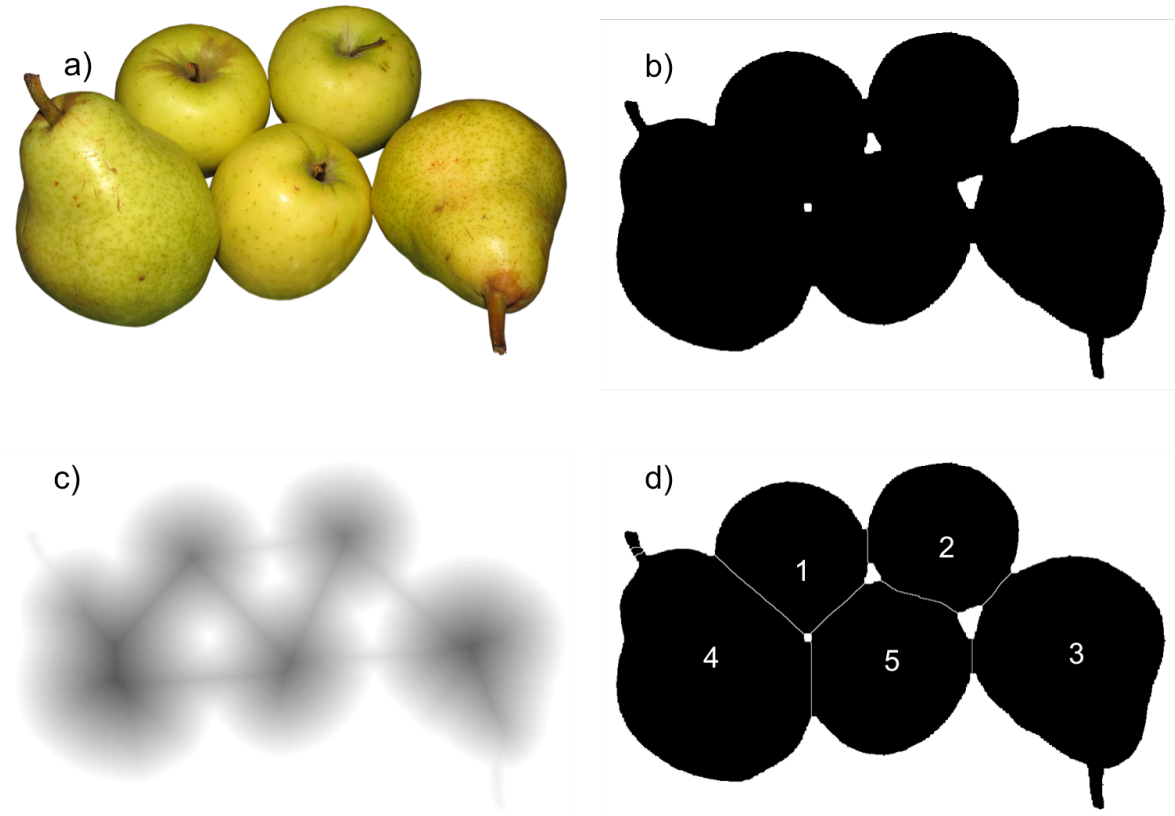


Figure 1: Original RGB image and some of the intermediate steps you need to describe in exercise 3.

Import the RGB image (Fig. 1a) and convert it to an 8-bit image (using the function rgb2gray for example).

Apply a threshold, Outsu or other algorithm, then explore with morphological techniques like dilation and erosion to make a binary image containing the fruits as shown in Fig. 1b).

Once you have a satisfactory binary image, apply the watershed algorithm to split overlapping objects. The watershed first computes a distance map as shown in Fig. 1c) and from this "topographic" map one may increase the background level (filling up with water) to see which objects are separated. After the watershed has successfully split all the objects you can apply a measuring algorithm that computes shape paramters for all the objects. Some shape parameters for the these objects look like this:

	Area	Mean	StdDev	Circ.	AR	Round	Solidity
1	48497	255	0	0.852	1.071	0.934	0.977
2	44132	255	0	0.837	1.173	0.853	0.981
3	98663	255	0	0.819	1.292	0.774	0.981
4	86095	255	0	0.677	1.196	0.836	0.928
5	59743	255	0	0.858	1.075	0.930	0.978

Now one may distinguish the apples from pears by using the area, roundness or circularity or a combination of these. If there were many more objects on could carry out a PCA to distinguish the two groups.

EXERCISE 4: Spectral image analysis (25 p)

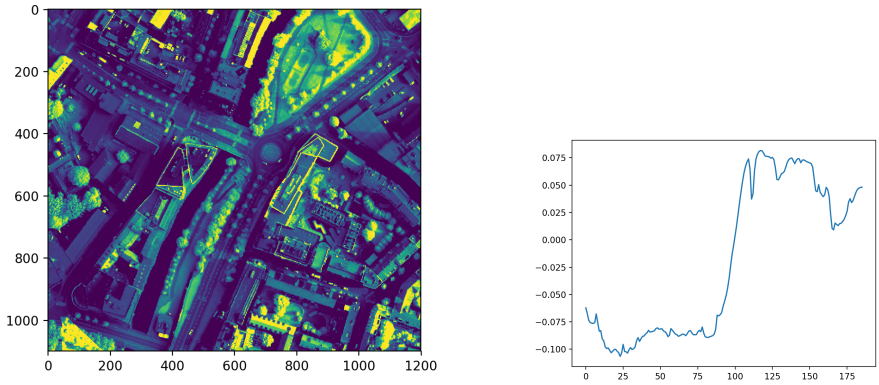
A. What is meant by a linescan camera and what is an alternative method of obtaining a hyperspectral image ? (5p)
B. Give a short description of the principle of PCA (principle component analysis)(5p)
C. Explain what you can see in the scores and loadings of a PCA of a hyperspectral image. Illustrate with a figure or two. (7p)
D. How do you select number of components for a PCA analysis ? (5p)
E. What is the main difference between K-means algorithm and Gaussian Maximum Likelihood Classification ? (3p)

A. A linescan camera means that one dimension of the detector records the spatial variation and the other records the spectrum for each pixel of the line. This means that you need to scan line by line over time and then stitch these together to get a 2-dimensional spatial image for all the spectral bands.
B. From Wikipedia :**Principal component analysis** (**PCA**) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables (entities each of which takes on various numerical values) into a set of values of linearly uncorrelated variables called **principal components**.

   If there are *n* observations with *p* variables, then the number of distinct principal components is *min(n-1,p)*. This transformation is defined in such a way that the first principal component has the largest possible variance(that is, accounts for as

much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to the preceding components. The resulting vectors (each being a linear combination of the variables and containing *n* observations) are an uncorrelated orthogonal basis set. PCA is sensitive to the relative scaling of the original variables.

C. The scores tell us something about the samples, the loadings about the variables. In a hyperspectral image each pixel is a variable and the wavelength bands are the variables. The score image indicate the pixels in the image with the large variance and the loading plots indicate which bands that contribute to this variance.



Example of score image and loading plot for a hyperspectral image.

D. You can use the plot of cumulative variance to select how many components are reasonable to include in you analysis. Typically there will be a bend on the curve where increasing the number of components will have limited influence on the analysis.

E. K-means is a non supervised clustering algorithm whereas GMLC is a supervised classification algortithm.