

Exam in Computer Assisted Image Analysis

1TD377 and 1TT341, Jan 13, 2010

- time: 8:00 to 13:00
- place: Polacksbacken, skrivsal (examination hall)
- tools: dictionary
- grades: 3: 20pts; 4: 26pts; 5: 34pts

The cover sheet must always be filled in and returned even if no exam questions have been answered. Write your name on all papers that you hand in. Do not use red ink. Start on a new paper for each new question. Sort the answer sheets in the order of the questions before you turn them in. Use drawings and figures to illustrate your answers when suitable. Please write your answers to questions 3, 5 and 6 in English (Swedish is optional for the other questions). Results will be posted on the Student Portal (Studentportalen).

GOOD LUCK!

/Amin, Milan, Patrik, Gustaf and Hamid

1 True or False 5p

Each correct answer gives 0.5p, and each incorrect answer gives -0.5p. You can not get less than 0p in total.

- A highpass filter corresponds to an edge enhancing filter in the spatial domain.
- Due to psycho-visual redundancy lossless compression can be more effective than lossy compression.
- Convex deficiency (D) is the the set difference $S - H$, where H is the convex hull of the set S.
- The classical hierarchical clustering algorithm is an example of an unsupervised classifier.

- e) Rotational independence of a chain code can be achieved by using the first difference of the chain code.
- f) LZW is a universal coding method, i.e., LZW can be used for compressing any data.
- g) For a maximum likelihood classifier the distribution for a class can be defined using the mean vector and the covariance matrix.
- h) A 24-bit RGB image has 8 bits in each channel.
- i) Lossy compression will always generate smaller file sizes than with lossless compression.
- j) Neural networks operate under the assumption that all classes have a Gaussian distribution.

2 Compression 5p (Gustaf)

- a) Name the different types of redundancies that can be present in images and specify if they can be dealt with using lossless and/or lossy data compression. (3p)
- b) Transform coding is a family of often lossy coding methods. A common file format using transform coding is the JPEG format. How does transform coding work in general? (2p)

3 Segmentation 5p (Milan)

- a) Explain the concept of region based segmentation. Account for both the top-down and the bottom-up approach. (3p)
- b) Describe the watershed algorithm in your own words (using a 1-D continuous grey-level "image" to support your answer is optional). (2p)

4 Image analysis fundamentals 5p (Amin)

- a) Problem Solving Using Image Analysis is often described with some fundamental steps. This is often shown as a diagram such as the one in figure 1. Which steps should be listed in the empty boxes numbered 1-4. Also, give a short description of each of these fundamental steps. (2p)
- b) An image with corresponding histogram is shown in figure 2. Greylevel transforms have been used to transform the image and the resulting histograms after transformation are shown (a, b and c). Combine each histogram (a, b and c) with the corresponding transfer function (1, 2 and 3). (Motivate you choice, answers

without motivation will give 0 points.) (2p)

c) Contrast and brightness can be changed by modifying a neutral transfer function shown in figure 3. How can the transfer function be modified in order to increase contrast? How can the transfer function be modified in order to decrease the brightness? (1p)

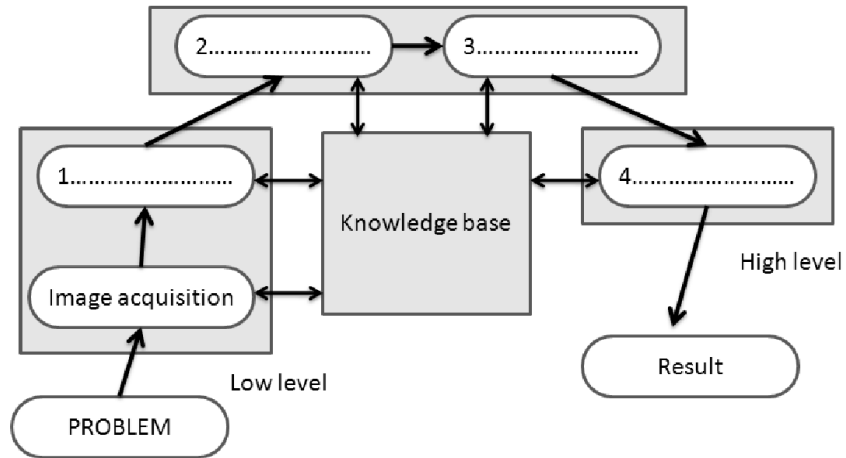


Figure 1: Fundamental steps of the image analysis process.

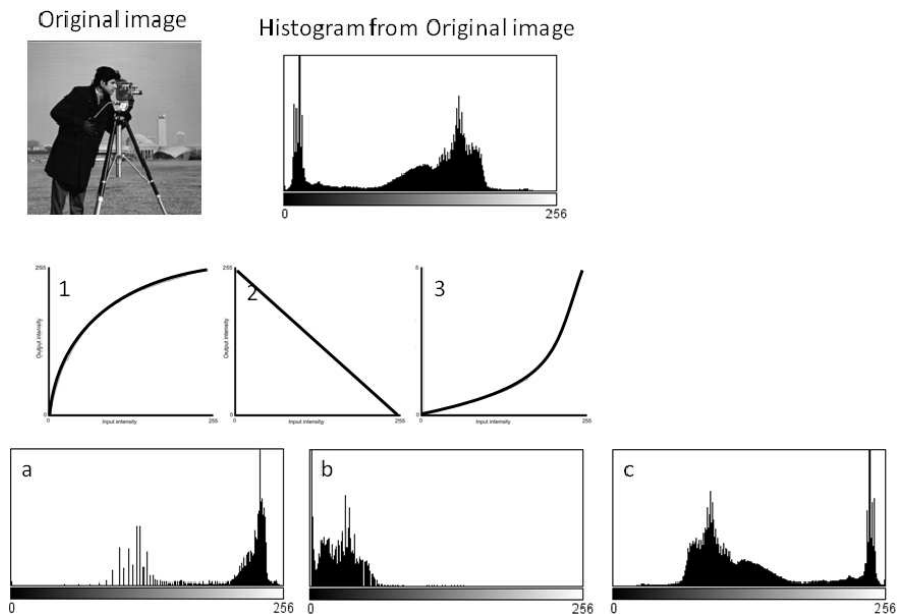


Figure 2: Image with corresponding histogram.

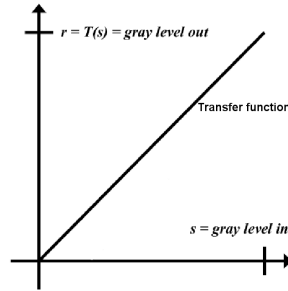


Figure 3: Transfer function.

5 Distance transform 5p (Milan)

- What is the result of a distance transformation of a binary image? (1p)
- Most often we think of a disc as something round. However, the shape of a disc is dependent on the distance function we use. Sketch a disc for the following distances: City-block, Chessboard, Chamfer(3,4), and Euclidean. (2p)
- How the distance transformation of a binary image can be used to find the skeleton? (2p)

6 Wavelet transform 5p (Milan)

- Describe how the short time Fourier transform (STFT) is used to build a spectrum of a non-stationary signal. (2p)
- What is the main drawback of STFT? (1p)
- Explain briefly how the problem is solved by continuous wavelet transform. (2p)

7 Classification 5p (Patrik)

- What is the possible decision boundary complexity of the three classifiers listed below? (1p)
 - Maximum likelihood (ML)
 - Minimum distance (MD)
 - Neural networks (NN)
- The k-means classifier tries to find natural groupings in the data set being analyzed. Give an account of the key steps of the k-means algorithm. (2p)

c) The minimum distance (MD) classifier is an optimal classifier given that a number of assumptions are made. Which assumptions are made when deriving the minimum distance classifier? (2p)

8 Practical image analysis 5p (Amin)

A biologist needs to analyse a large dataset of images taken of cells and he/she has asked you for help. Your task is to construct a fully automated analysis method. A sample image can be seen in figure 4.

The brighter regions in the image represent the nuclei of the cells. The task consists of segmenting the individual nuclei and then quantify how circular they are. The segmentation task is made more complicated by a large amount of overlapping nuclei.

Give a summary of how your analysis would be constructed in order to accomplish this task. (No code is needed only state what algorithms you would choose and what they accomplish. All steps should be clearly described and the choice of particular methods motivated. A flowchart with some comments to each of the steps is a good way of representing your complete analysis. Make sure that the output for each step of the analysis is the input to the next step.)

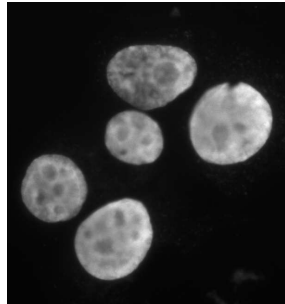


Figure 4: Sample image for image analysis task.