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## Examination in Statistical Image Analysis, March 7, 2001

Written examination March 7, 2001, 8.45-12.45 in room ML 3.

Literature and notes may be brought for this written examination.

In the written examination there are two problems. You are supposed to answer both of them, and in the judgement they have the same weight. Answers may be given in English or Swedish.

**Problem 1.** Suppose that you have a set 10 images of haddocks and 10 images of whittings, eight of these images are shown in Figure 1 below. The object is to construct by use of these data a method for discrimination between the two species.

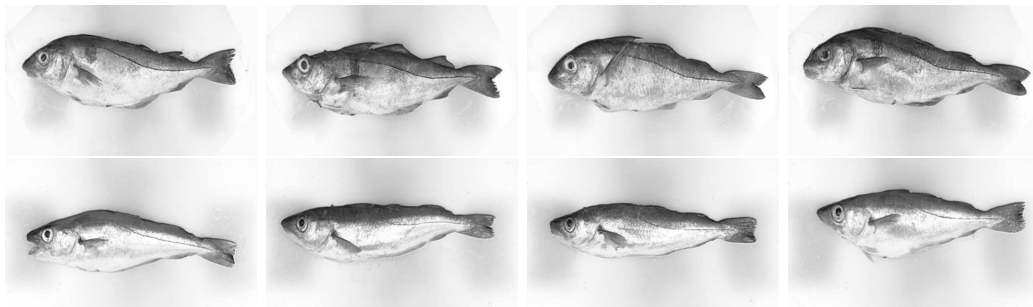


Figure 1: Haddocks in the upper row and whittings in the lower row

- a) Suggest two features that could be used for discrimination. Sketch how you could implement the computation of these features from the images, e.g. by use of a program system like matlab. Describe in words how you may implement the computations (without giving programs).
- b) Give statistical models for the data for the two features and for the 10 plus 10 fishes in the data set. Consider both a model leading to linear discrimination and a model leading to quadratic discrimination. Sketch plots showing the difference between the corresponding two discrimination methods. How would you estimate parameters in the models?
- c) Suggest 10 features for the discrimination and one or (preferably) several methods for selecting 3 features out of these in an optimal way.

**Problem 2.** Figure 2 shows two microscope images with nerve cells viewed against a background with a net of squares. The images are taken with an interval of 1 minute and 15 seconds. The cells can move and they can divide. The black rectangle surrounds a cell that has moved slightly to the left in the time interval between the image acquisitions.

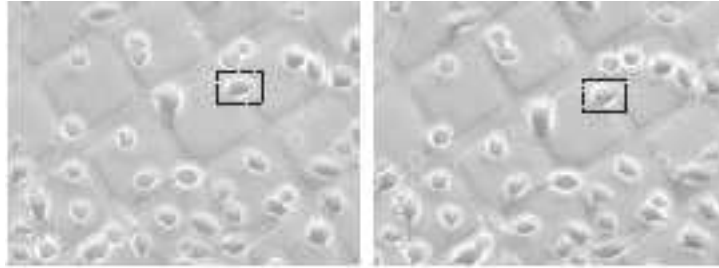


Figure 2: Nerve cells

- a) Regard first one of the images. Discuss how one can construct an image analysis method to count the nerve cells and how to estimate the positions of the cell centres (with a suitable definition of cell centre). Discuss briefly how one can test the hypothesis that the positions of the cell centres are completely randomly distributed, that is distributed as points from a Poisson process. Regard the images and discuss what types of deviations from a completely random distribution you may expect.
- b) Suppose you have computed estimates of the cell centres in both images. Suggest a method for estimating the distribution of the cell centre movements. Assume for instance that the motion follows a two-dimensional normal distribution and discuss how you can estimate the parameters of this distribution.
- c) Try to formulate a statistical model for the positions of cell centres in a sequence of several consecutive images, taken say with an interval of 1 minute and 15 seconds as for the two images in Figure 2. Consider both possible motion and possible division of cells, although not more than one division in the time interval between two consecutive images.