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Examination in Statistical Image Analysis, March 15, 2005

Course code Chalmers: TMS016, Gothenburg University: Statistisk Bildbehandling

Written examination March 15, 2005, 8.30–12.30 in house V.

Literature and notes may be brought for this written examination. All types of pocket calculators are allowed but not computers. In the written examination there are two pages and two problems. You are supposed to answer both problems, and in the judgement they have the same weight. Answers may be given in English or Swedish.

Problem 1.

In a two-colour microarray experiment images were obtained separately for two colour channels: red cy5 (here corresponding to wild-type Arabidopsis) and green cy3 (corresponding to one transgenic Arabidopsis line). Figure 1 below shows to the left the signal intensity for the red channel in one part of the array with 9 spots and to the right a detail with the central of these nine spots. The signal is registered in two bytes, and the signal thus lies between 0 and $2^{16} - 1 = 65535$. Consider modeling of images such as the right part of Figure 1.

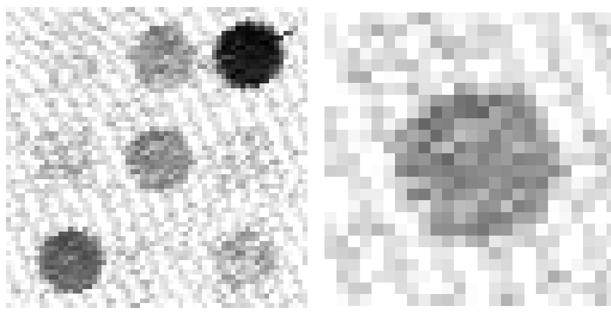

Figure 1: Left: red channel image of nine spots in a microarray experiment. Right: a detail with 25×25 pixels of the left image corresponding to the central spot. In the images black corresponds to high signal intensity.

a) Formulate a statistical model for an image such as the right part of Figure 1. Assume that the registered intensity consists of a sum of a signal part and a noise part. The signal part is assumed to be constant (with a given spot amplitude) within a circle with a given spot centre and a given spot radius. The noise part is assumed to consist of normal variates with a constant mean and a constant variance. These noise normal variates are assumed to be independent for different pixels. The parameters corresponding to spot centre, spot radius, spot amplitude, noise mean and noise variance are assumed to different for different spots.

b) Suggest a method for estimating the parameters for a given spot based on data such as those shown in the right part of Figure 1.

c) Look at the images in Figure 1. Discuss how reasonable the different assumptions for the modelling described in **a)** above seem.

Problem 2.

Eggs of parasites of swines can be detected in fecal samples from the animals. Figure 2 shows images of eggs from seven subspecies of *Eimeria* parasites. Suppose that we want to discriminate between subspecies and that we have an image analysis algorithm that finds the contour of the eggs and the distances X and Y defined in the following way. We assume that the contour of the eggs is convex. Let P_1 and P_2 be two points on the contour maximally apart. Let X be the distance between P_1 and P_2. Let L_1 be the line going through P_1 and P_2. Let P_3 be the point on L_1 midway between P_1 and P_2, and let L_2 be the line through P_3 perpendicular to L_1. Let Y be the distance between the two points on the contour where L_2 crosses the contour. Draw an image showing these points, lines and distances. Put $Z = Y/X$. We want to discriminate between parasite subspecies by use of Z only. Consider for simplicity the case with two parasite subspecies.

a) Formulate a statistical model for discrimination between the two species by use of Z.

b) Suppose that we have images of n_1 eggs of variety 1, and n_2 eggs of variety 2. Give formulas for estimation of the parameters in the model in **a)**.

A. Daugschies et al. / Veterinary Parasitology 81 (1999) 201–210 205

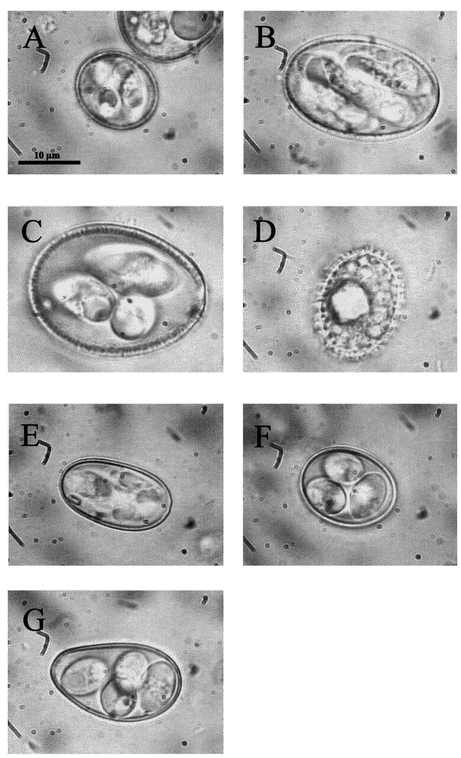

Fig. 1. Oocysts of group 1 (A: *E. perminuta*, B: *E. polita*, C: *E. scabra*), group 2 (D: *E. spinosa*) and group 3 (E: *E. debliecki*, F: *E. suis*, G: *E. porci*) *Eimeria* spp.

Figure 2: Figure from Daugschies et al. (1999) Differentiation between porcine *Eimeria* spp. by morphological algorithms, Veterinary Parasitology 81, 201–210, showing egg shapes for seven subspecies.