Computer Vision

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Final exam 29 janvier 2009

Warning: This exam has THREE PARTS. These parts will be graded separately by James L. Crowley (part I) and Peter Sturm (Part II) and by and Edmond Boyer (Part III). Provide your answers to each part on SEPARATE pages. Make sure your NAME, page number and the exam part (I, II or III) are marked on EVERY page.

You may use any printed material or course notes. All answers must be written in ink on official exam paper. You may answer the questions in English or in French. You must write LEGIBLY. Illegible text will not be graded.

PART I

You have been hired to design a system to aid the production of televised football matches. Your system will use a bank of cameras mounted above the stadium such that every part of the field is visible to at least 2 cameras. Your task is to provide an image with an overhead view of the field onto which labels are projected for each of the players, the referee, and the ball. In addition to the official markings, the field is marked with a grid of white lines every 10 m. This grid is to be used to calibrate your cameras.

1) (3 points) Explain how to use a Sobel edge detector and a Hough transform to find the grid lines on the field. How can you determine the number of cells for the Hough transform?

2) (3 points) The team for each player can be determined by the colors of their uniform. Explain how to use a ratio of color histograms to detect and locate the members of each team? How do you initialize the histograms? How many cells should you use in each histogram? How can you calculate the position of each player?

3) (4 points) You have been given the following receptive fields in one and two dimensions: $G_1(m)$ et $G_2(m,n)$.

$$G_1(m) = e^{-\frac{1}{2}m^2} \qquad G_2(m, n) = e^{-\frac{1}{2}(m^2+n^2)} \qquad \text{for } m, n \in [-5, 5].$$

a) What is the value of the standard deviation, σ, for $G_1(m)$?

b) How many times would you need to the binomial filter $b_1(m) = [1, 1]$ with itself to obtain a binomial filter with the same standard deviation as $G_1(m)$? What are the coefficients of this binomial filter?

c) Given an image $P(m,n)$, show that $P(m,n)*G_2(m,n) = [P(m,n)*G_1(m)]*G_1(n)$

d) How many multiplications and additions are required to compute $P(m,n)*G_2(m,n)$ and $[P(m,n)*G_1(m)]*G_1(n)$?