Comp 254, Image Processing and Analysis
Spring 2002, Prof. Guido Gerig

Assignment 2: Statistical Pattern Recognition

Out: Thursday Feb-21-2002
Due: Thursday Mar-07-2002

Required Readings: Haralick handouts, papers, Canny handout, papers

I. Theoretical Problems

Problem 1: Haralick local fit in 1-D

Given the problem of fitting a 1-D discrete signal by a local polynomial fit $f(r) = \sum_i a_i P_i(r)$

- Index range: $[-2, -1, 0, 1, 2]$
- Discrete natural polynomial set: $\{1, r, 2^2, r^3, r^4\}$
- Discrete orthogonal polynomial set: $\{1, r, r^2 - 2, r^3 - 17/5r, r^4 + 3r^2 + 72/35\}$

1. Show that the orthogonal polynomial set is indeed orthogonal given the index range.
2. Calculate the weight masks used to fit a local neighborhood of a signal a) for a natural basis and b) for an orthogonal basis.

Hint: Follow descriptions given in Haralick's Edge and Ridge/Valley papers and in the course handouts.

Problem 2: Directional derivative of Gaussian

Consider a 2-dimensional Gaussian kernel

$$\frac{1}{(2\,\pi \cdot \sigma^2)} e^{-(\frac{x^2+y^2}{2\sigma^2})} \; .$$

Show, that the first derivative in direction ϕ, expressed by the normal $\underline{n}$, can be re-written as

$$G_{\underline{n}} \;\; = \;\; \frac{\partial G}{\partial \underline{n}} = \underline{n} \cdot \nabla G \; .$$

Hint: Choose new coordinates $(\hat{x}, \hat{y})$ as a frame rotated towards (x, y) by angle ϕ, express $\frac{\partial G(x,y)}{\partial \underline{n}}$ as $\frac{\partial G(\hat{x},\hat{y})}{\partial \hat{x}}$, and $\cdots$.

II. Practical Problems

Problem 3: Haralick polynomial fit

Write a program to fit a digital 2-D image with local polynomial as described by Haralick.

- Use the set of nine (3x3) filters as derived in Haralick's Step Edge paper.
- Divide your image into (3x3) blocks (remember this is just a sampling at each second pixel), fit each block with the 2-D polynomial, and reconstruct the (3x3) values using the polynomial fit.
- Create a difference image between the original and the reconstructed. Discuss what you observe.
- Repeat the previous steps but fit the neighborhood of each pixel and reconstruct each pixel's value by the fit (not using the subsampling as in the previous step).
- Use images available for assignment 1 or any other kind of image you like.

Bonus Question

Use the 5x5 masks as described in Haralick's Ridges/Valleys paper and apply the steps outlines above.