March 10, 2006

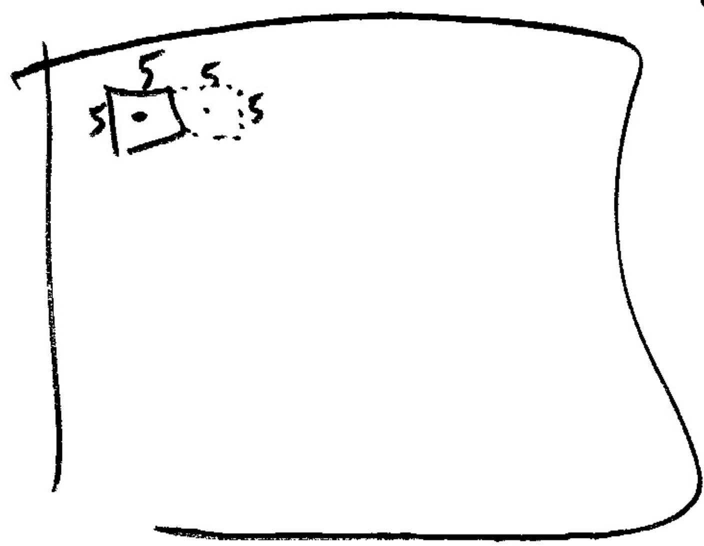
Local Enhancements

Using local histogram Analysis

Define square or rectangle neighborhood about each pixel. , move center of "window" across the image.

At ~~each~~ each location : compute histogram in the window

Do hist. eq.



Use local stats for Enhant

stat $\longrightarrow$ mean, variance:

global mean: $M_G = \sum_{i=0}^{L-1} r_i \; p(r_i)$

$r_i \rightarrow$ intensity level i

$i = 0, \ldots L-1$

global variance $= Var_G = \sum_{i=0}^{L-1} (r_i - M_G)^2 \; p(r_i)$

Local mean:

Let S_{xy} neighborhood, subimage centered around (x, y).

local mean $= m_{S_{xy}} = \sum_{(s,t) \in S_{xy}} r_{st} \; p(r_{st})$

local varian $= \sigma^2_{S_{xy}} = \sum_{(s,t) \in S_{xy}} [r_{st} - m_{S_{xy}}]^2 \; p(r_{st})$

Goal: Enhance dark areas while leaving the bright area as unchanged as possible.

- Detect region that have both.

(a) dark → local mean has to be small compared to global mean.

$$m_{S_{xy}} \leq k_0 \, m_G$$

local mean

$0 \leq k_0 \leq 1$ constant

global mean

$k_0 \simeq 0.4$

(b) Low contrast

$$\sigma_{S_{xy}} \leq k_2 \, \sigma_G$$

local var

$k_2 > 0$ constant

global var

$k_2 \simeq 0.4$

(c) not too low of contrast.
leave flat region unchanged

$$\sigma_{S_{xy}} \geq K_1 \, Var_G$$

$$K_1 \simeq 0.01$$

$$g(x,y) = \text{processed} = \begin{cases} E \, f(x,y) & \text{if } M_{S_{xy}} \leq K_0 M_G \\ & K_1 \, Var_G \leq \sigma_{S_{xy}} \leq K_2 \, Var_G \\ 0 & \text{otherwise.} \end{cases}$$

Enhancement using Arithmetic / Logic Operations

Logic: AND, OR, NOT $\longrightarrow$ functionally complete.

NAND $\longrightarrow$ functionally complete.

NOT $\longrightarrow$ negative transformation

AND OR $\longrightarrow$ Masking.

Image Subtraction

$$g(x,y) = f(x,y) - h(x,y)$$

mask.

Ensemble Averaging

$$g(x,y) = f(x,y) + \eta(x,y)$$ → noise uncorrelated with itself and with img. zero mean

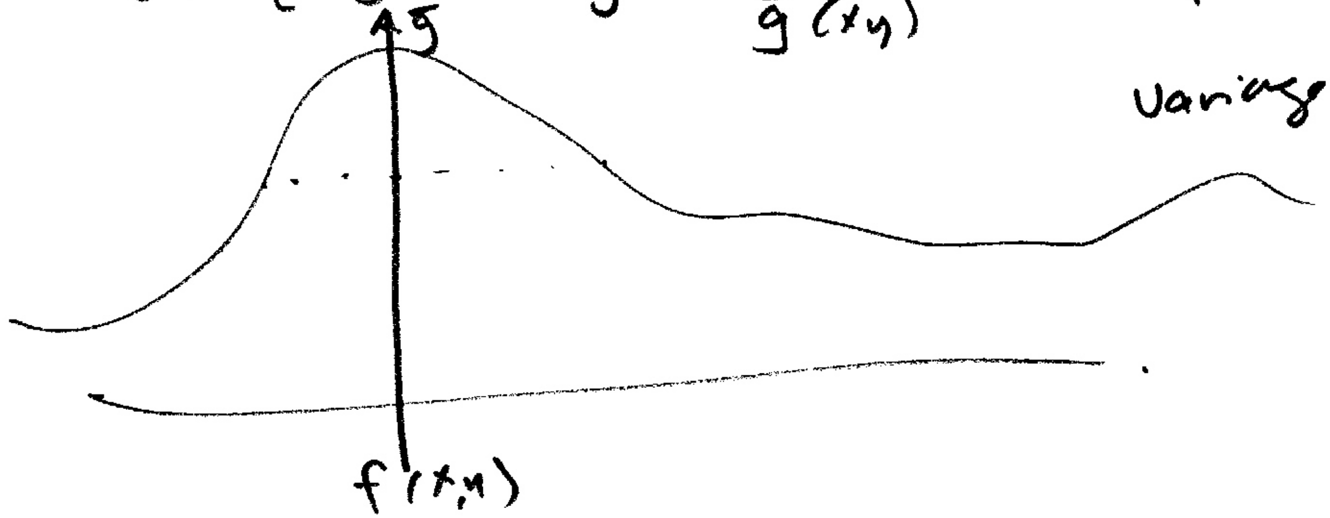
Series of noisy images $\{g_i(x,y)\}$.

estimate → $$\bar{g}(x,y) = \frac{1}{K}\sum_{i=1}^{K} g_i(x,y)$$

$$E[\bar{g}(x,y)] = f(x,y)$$

$$\mathrm{Var}[\bar{g}(x,y)] = \sigma^2_{\bar{g}(x,y)} = \frac{1}{K}\sigma^2_{\eta(x,y)}$$

variance of $\bar{g}$ shrink as $K \uparrow$



Spatial Filtering

LSI. $\longrightarrow$ FIR.

$$g(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{+b} w(s,t)\, f(x+s, y+t)$$

filter.

If $w(s,t) \longrightarrow$ LPF $\longrightarrow$ blurring

- blurs edges
- remove noise

$w(s,t) \longrightarrow$ HPF $\longrightarrow$ sharpening

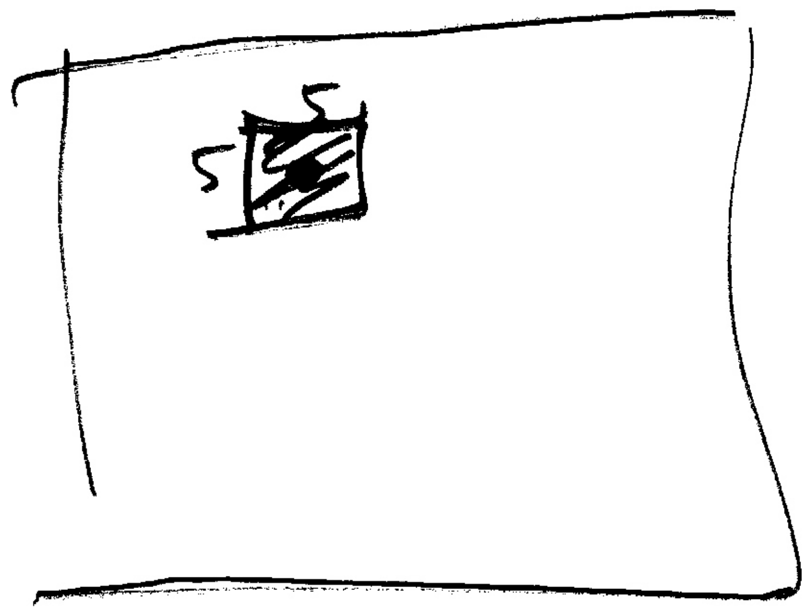
- sharpen edge
- accentuate noise

Order Statistics:

→ Median

→ Max

→ Min.



Salt + Pepper noise

Impulse noise.

Sharpening Spatial Filters

<u>objective</u>: highlight or enhance detail.

<u>LSI</u> $\rightarrow$ FIR $\rightarrow$ HP.

Derivative operation.

first order

$$\frac{\partial f}{\partial x}$$

2nd order

$$\frac{\partial^2 f}{\partial x^2}$$

1D signal

$$\frac{\partial f}{\partial x} = f(x+1) - f(x)$$

$$\frac{\partial^2 f}{\partial x^2} = f(x+1) + f(x-1) - 2f(x)$$

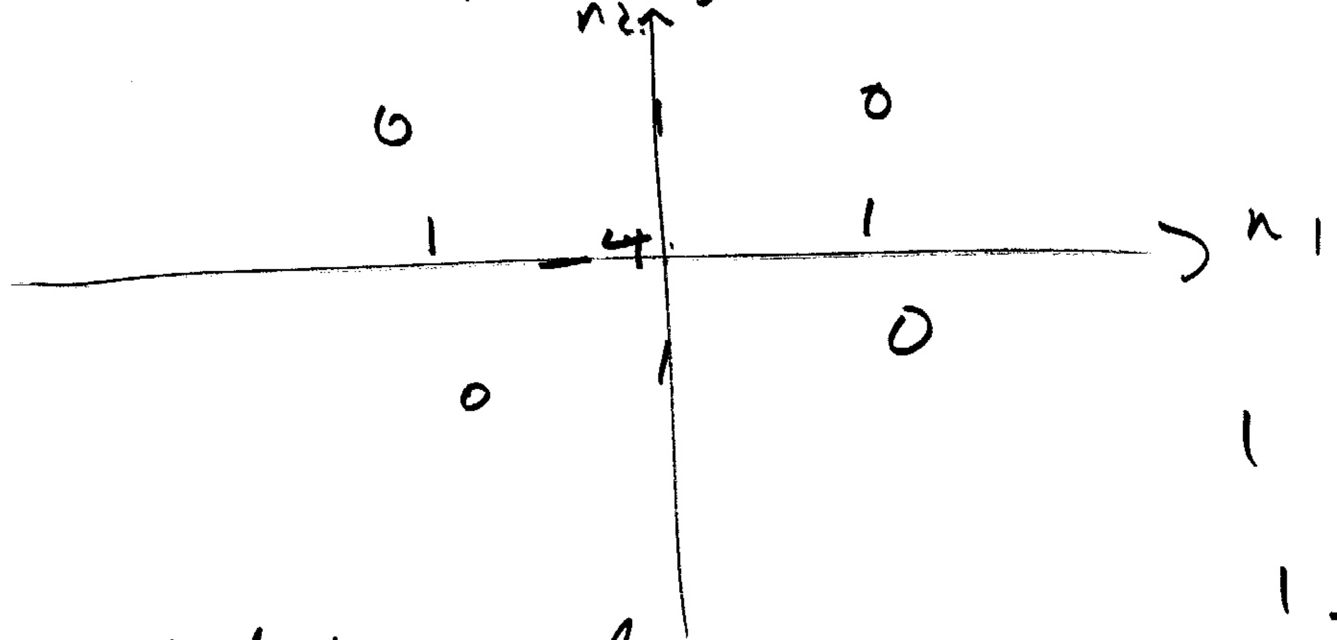
2nd order derivative

Simplest isotropic. $\nabla^2 f$ = Laplacian = $\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$

$$\frac{\partial^2 f}{\partial x^2} = f(x+1, y) - f(x-1, y) - f(x, y)$$

$$\frac{\partial^2 f}{\partial y^2} = f(x, y+1) + f(x, y-1) - 2f(x, y)$$

$$\nabla^2 f = f(x+1, y) + f(x-1, y) + f(x, y+1) + f(x, y-1) - \underline{4} f(x, y)$$



$$\begin{matrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{matrix}$$

Show, include diagonals

$$g(x, y) = \begin{cases} f(x, y) - \nabla^2 f(x, y) \\ \end{cases}$$