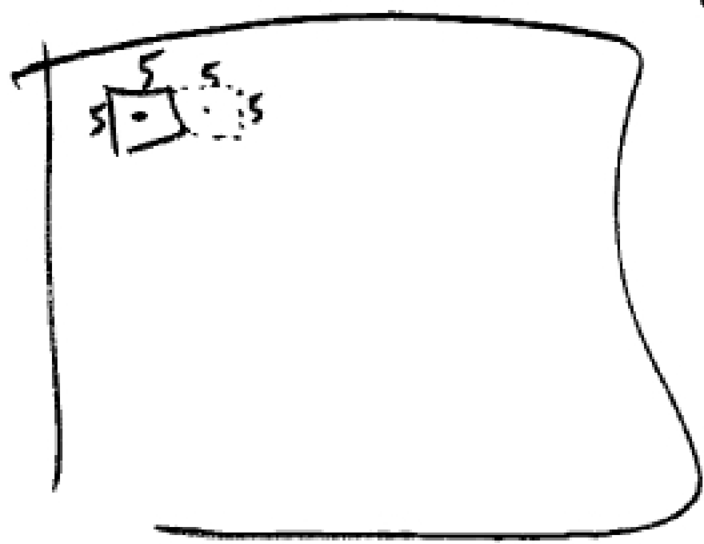
Local Enhancement

Using local histogram Analysis

Define square or rectangle neighborhood over 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 Enhancement

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

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

- Detect region that have both.

(a) dark $\longrightarrow$ local mean has to be small compared to global mean.

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

local mean

global mean

$0 \le k_0 \le 1$ constant

$k_0 \simeq 0.4$

(b) Low contrast

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

local var

global var

$k_2 > 0$ constant

$k_2 \simeq 0.4$

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

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

$K_1 \simeq 0.01$

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

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

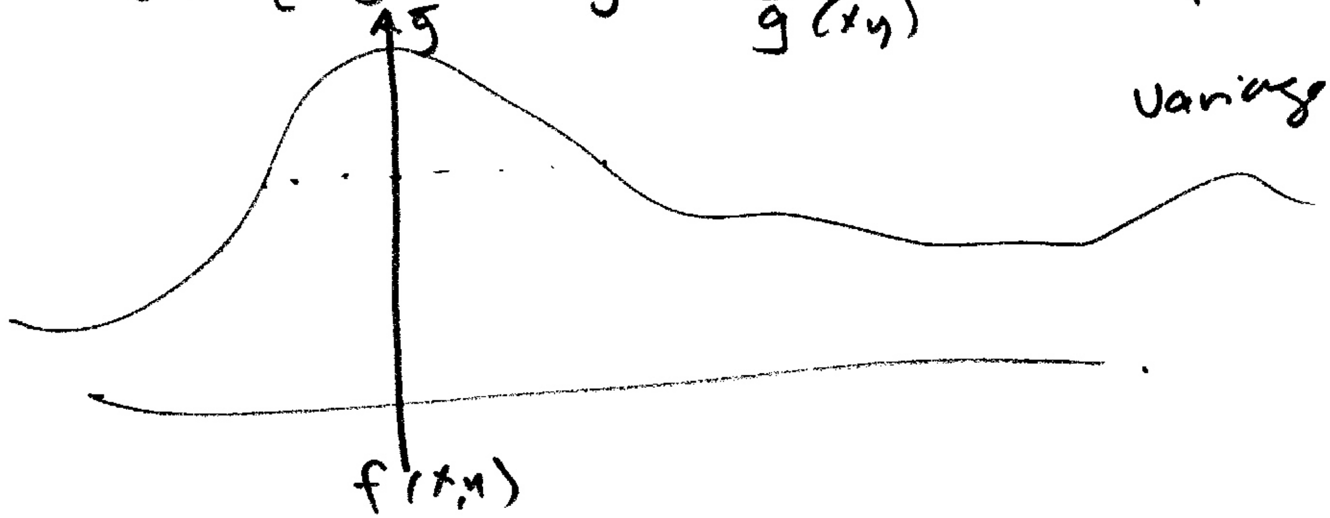
series of noisy images $\{g_i(x,y)\}$.

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

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

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

variance of $\bar{g}$ shrinks as K ↑



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

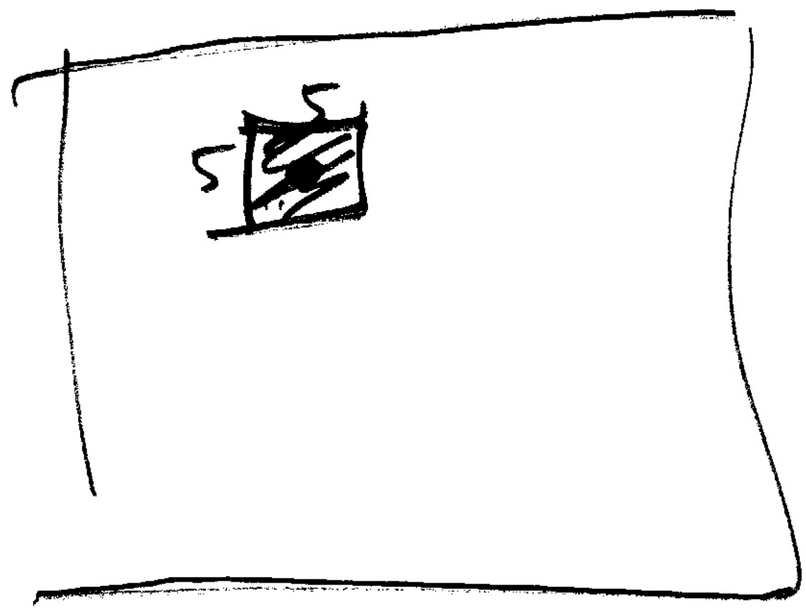
$w(s,t) \longrightarrow$ HPF $\longrightarrow$ sharpening → sharpen edge → accentuate noise

Order Statistic:

→ Median

→ Max

→ Min.



Salt + Pepper noise

Impulse noise.

Sharpening Spatial Filters

objective : highlight or enhance detail .

LSI $\longrightarrow$ FIR $\longrightarrow$ HP.

Derivative operation.

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

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

1D signal

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

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

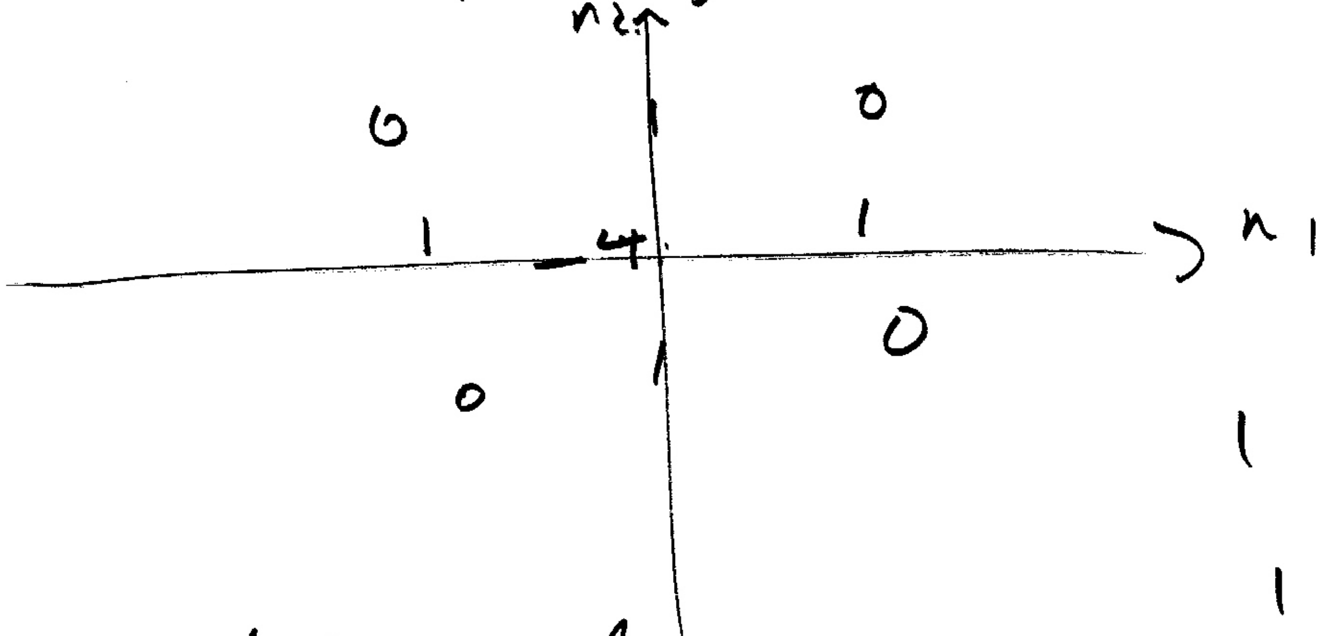
2nd order derivative

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

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

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

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



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

Show, include diagonals

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