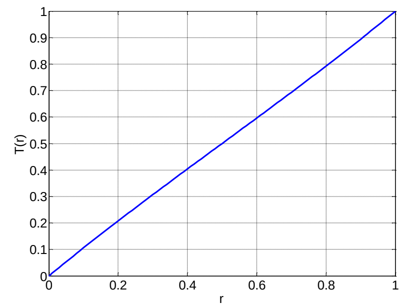
Exam 2011-Apr-27



P1.1:

$$p(r) = a \cdot \left[e^{-(r-0.5)} + e^{(r-0.5)}\right]$$

$$T(r) = \int_0^r p(w)dw = a\left[-e^{-(r-0.5)} + e^{(r-0.5)}\right] - a\left[-e^{0.5} + e^{-0.5}\right]$$

P1.2:

Use some edge filters and calculate gradients in x and y directions:

fx = [-1 0 1;
-1 0 1;
-1 0 1]/6

fy = [1 1 1;
0 0 0;
-1 -1 -1]/6

R = [17 18 13
14 16 12
13 14 12]

gradRx = imfilter(R,fx); gRx = gradRx(2,2); % and in the same way for G and B color bands
gradRy = imfilter(R,fy); gRy = gradRy(2,2); % and in the same way for G and B color bands

Construct D matrix with the following entries, where D-matrix elements are R,G,B x-y gradients:

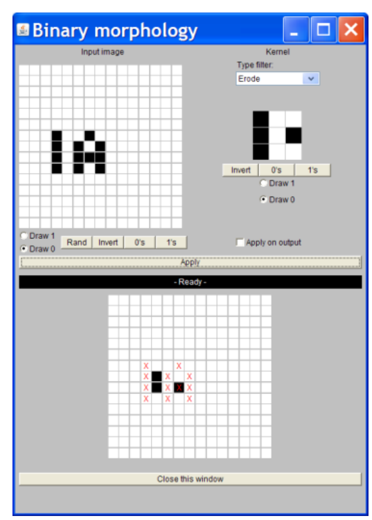
$$D = \begin{bmatrix} gRx & gRy \\ gGx & gGy \\ gBx & gBy \end{bmatrix}$$

λ = largest eigenvalue of $D^T D$

Gradient magnitude = $\sqrt{\lambda}$
Gradient orientation = largest eigenvector of $D^T D$

// see Lecture 4, page 58

P1.3:



1.3b)
$B = \{(-1,-1),(-1,0),(-1,1),(1,0)\}$.
$X = \{(2,1),(2,2),(2,3),(2,4),(4,1),(4,2),(4,3),(5,2),(5,4),(6,1),(6,2),(6,3)\}$

1.3c)
$p = (3,3)$
$p + b = \{(2,2),(2,3),(2,4),(4,3)\} \in X \rightarrow p = (3,3)$ *is a part of solution*

$P = (4,2)$
$P + b = \{(3,1),(3,2)(3,3),(5,2)\} \notin X \rightarrow p = (4,2)$ *is NOT part of solution*

P2:
(a) k= -0.577 q =600
(b) problems with computer memory (not enough), many voting matrix entries will be empty → waste of memory, long execution times
P2.2 voxel – 3D picture element = volume element, snaxel – snake element (snake node), texel – texture element

Exam 2011-Apr-27

P3: (1-g), (2-f), (3-h), (4-c), (5-i)

P4 : mean –shift

P1 P2 P3
P4 P5 P6
P7 P8 P9

Let y1 be the initial position of the kernel: y1 = (9, 2 , 1, 8)

P1 = (3, 2, 5, 3) - 5 points
P4 = (9, 8, 1, 8) - 3 points
P5 = (9, 2, 1, 8) - 1 point

d1 = (y1 –P1)/h = [(9, 2, 1, 8) – (3, 2, 5, 3)]/h = (6, 0, -4 , 5)/9
|d1|^2 = (6*6+0*0*4*4+5*5)/(9*9) = 0.9506 → w1= 0.0494 (Epanechnikov! w=1-x)

d4 = (y1-P4)/h = [(9, 2, 1, 8) – (9, 8, 1, 8)]/h = (0, -6,0,0)/9
|d4|^2 = 0.4444 → w4 = 1-0.4444 = 0.5556

d5 = (y1 –P5)/h = [(9, 2, 1, 8) – (9, 2, 1, 0)]/h = (0, 0, 0, 0)
|d5|^2 = 0 → w5 = 1

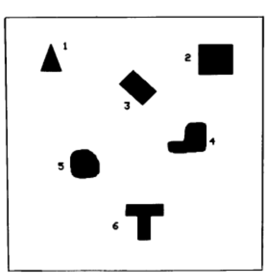
P1 = [3, 2, 5, 3] → g1 = w1 = 0.0494
P4 = [9, 8, 1, 8] → g4 = w4 = 0.5556
P5 = [9, 2, 1, 8] → g5 = w5 = 1

$$\mathbf{y}_{j+1} = \frac{\sum_{i=1}^{n} \mathbf{x}_i g\left(\left\|\frac{\mathbf{x}-\mathbf{x}_i}{h}\right\|^2\right)}{\sum_{i=1}^{n} g\left(\left\|\frac{\mathbf{x}-\mathbf{x}_i}{h}\right\|^2\right)}$$

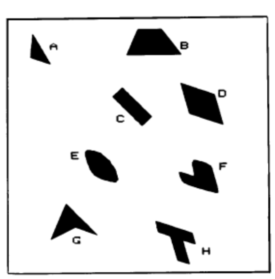
Calculate y2= (5*g1*P1 + 3*g4*P4 + 1*g5*P5)/(5*g1+3*g4+1*g5) ≈ [8.49 5.43 1.34 7.58]

(b) just one cluster (with all of the data points)
(c) three clusters

P5.1 See Exercise BD-5
P5.2: $2 \cdot 3^7 = 4374$
P5.3: Invariant feature with respect to affine linear transformations. Can be used for detection e.g. distorted (e.g. slanted) objects.



Left: Templates



Right: The shapes to be recognized with affine invariants.

Exam 2011-Apr-27

P6:
(c)

$error\ E1\ = 2 \cdot \int_0^{T1} P_1 p(x|C1)dx \qquad area\ A1\ = \int_0^1 P_1 p(x|C_1)dx$

Sensitivity = (1-E1)/A1

$error\ E2\ = \int_{T1}^{T2} P_2 p(x|C_2)dx \qquad area\ A2\ = \int_0^1 P_2 p(x|C_2)dx$

Specificity = (1-E2)/A2

(b) Total error = (E1 + E2)/(A1+A2)

(d) in theory never, in practice for ca $0.2 < T < 0.8$

(e) T1=T2 = 0.5 (all pixels will be classified as background)

(a)

$$P_1 \cdot \frac{1}{\sigma_1\sqrt{2\pi}}\ exp\left(\frac{-(x-m)^2}{2\sigma_1^2}\right) = P_2 \cdot \frac{1}{\sigma_2\sqrt{2\pi}}\ exp\left(\frac{-(x-m)^2}{2\sigma_2^2}\right) \Longrightarrow$$

$$T1 = \ x_1 = \quad -\sqrt{A} + m \approx 0.36$$
$$T2 = \ x_2 = \quad \sqrt{A} + m \approx 0.64$$

where

$$A = \left\{ \ln\left(\frac{P_1}{P_2}\right) + \ln\left(\sigma_2/\sigma_1\right) \right\} \cdot \frac{2\sigma_1\sigma_2}{(\sigma_2^2 - \sigma_1^2)}$$