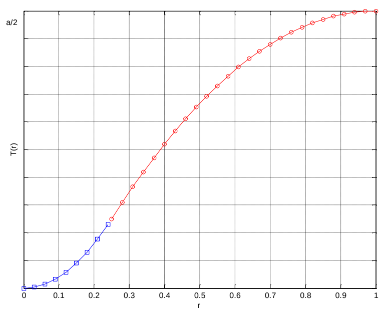
1.1

$$p(r) = \begin{cases} 4ar & 0 \le r \le 1/4 \\ -\frac{4ar}{3} + \frac{4a}{3} & \frac{1}{4} \le r \le 1 \end{cases}$$

$$s = T(r) = \int_0^r 4awdw = 2aw^2 \Big|_0^r = 2ar^2 \qquad 0 \le r \le 1/4$$

$$s = T(r) = \frac{a}{8} + \int_{\frac{1}{4}}^{r} \left(-\frac{4aw}{3} + \frac{4a}{3}\right) dw = \frac{a}{8} + \left(-\frac{2aw^2}{3} + \frac{4aw}{3}\right)\Bigg|_{\frac{1}{4}}^{r} =$$

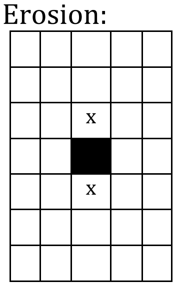
$$\frac{a}{8} + \left(-\frac{2ar^2}{3} + \frac{4ar}{3}\right) - \left(-\frac{2a}{3 \cdot 4 \cdot 4} + \frac{a}{3}\right) = -\frac{2ar^2}{3} + \frac{4ar}{3} - \frac{a}{6} \qquad \frac{1}{4} \le r \le 1$$



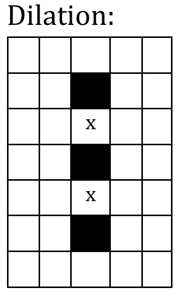
1.2 Increase λ. The velocity field will become smoother and consistent.

1.3

Erosion:



Dilation:



1.4 Linear diffusion filtering is the same (with proper parameters) as filtering with Gaussian filter.

2. 1-j 2-b 3-f 4-h 5-e

3.1 3-bits: GLCM: 8 x 8

3.2 Textural entropy $\approx -16 \cdot \frac{1}{16} \cdot log_2\left(\frac{1}{16}\right) = 4$,

$p(i,j) \approx 1/16$, for a uniformly random image with Ng=4,

(compare with Lab3 “cooc” for random.png image)

3.3 translation invariant: a(1), a(2), a(3)

rotation invariant, e.g. | a(1) | , |a(2)| , |a(3)|

3.4 liver volume segmentation, fire detection, ...

4.1 (a)

> density are such stationary points. The *mean shift procedure*, obtained by successive
>
> - computation of the mean shift vector $\mathbf{m}_{h,G}(\mathbf{x})$,
> - translation of the kernel (window) $G(\mathbf{x})$ by $\mathbf{m}_{h,G}(\mathbf{x})$,
>
> is guaranteed to converge at a nearby point where the estimate (11) has zero gradient, as will be shown in the next section. The presence of the normalization by the density estimate is a desirable feature. The regions of low-density values are of no interest for the feature space analysis and, in such regions, the mean shift steps are large. Similarly, near local maxima the steps are small and the analysis more refined. The mean shift procedure thus is an adaptive gradient ascent method.

See PAMIMeanshift.pdf (on handouts), page 606

4.2 MeanShift :
x1=[28 62 98 109 134 158 172] mean(x1) = 108.7
x2 =[142 73 142 175 106 173 131] mean(x2)= 134.57
mean shift vector = [108.7-98 134.57-142]=[10.71 -7.42]

4.3 Mean Shift

Data points:

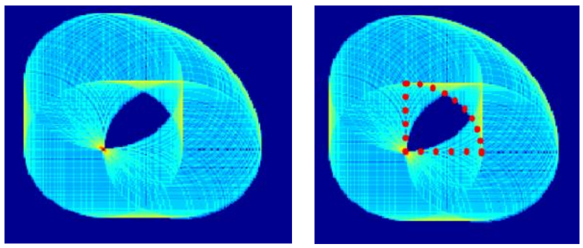
1				5	
1				5	
1				5	
1				5	
1	2			5	
1	2		4	5	6

Mean Shift filtering:
Assume for example an uniform kernel with width h=2. Then the pixels with values 1 and 2 will converge to a datapoint $\boldsymbol{y}_{\boldsymbol{1},\boldsymbol{con}} = 1.25$ and pixels with 4, 5, 6 will converge to $\boldsymbol{y}_{\boldsymbol{2},\boldsymbol{con}} = 5$
Mean Shift Clustering:
Let for example $h_s = 1$ (spatial domain) $h_r = 1$ (range domain)
Then the clusters $C_p,\ p = 1,2$ are:
C_1 = { pixels having value 1 or 2}, C_2 = {pixels having value 4, 5 or 6}
Label assigning:
L1=1 for pixels belonging to C1, L2 = 2 for pixels belonging to C2
Final segmentation:

1	1	2	2
1	1	2	2
1	1	2	2
1	1	2	2

5.1 Brightness cost: for example cost(x,y)= max(f) – f(x,y)
(Compare exam 041214, problem 5)
The numerical solution will depend on the brightness cost,
but the final path should be “roughly” vertical (and in the middle part of the image).

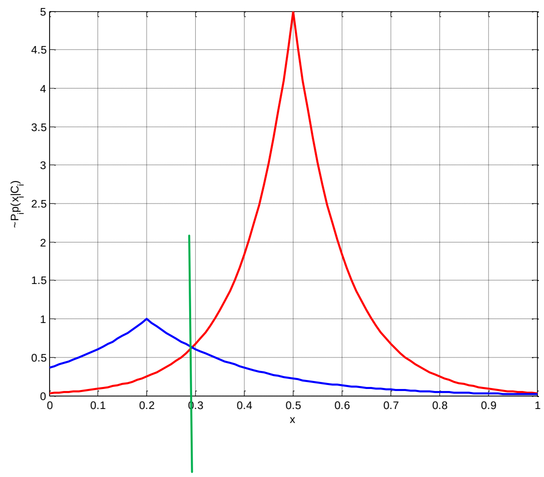
5.2 Hough (left), (right = with some points belonging to the edges)



6.1 Two lines. P1 and P3 represent the same line.

6.2

$$\exp\big(-5(x-0.2)\big) = 5\exp\left(-10(0.5-x)\right) \quad \Rightarrow$$
$$-5x+1 \;=\; ln(5)\; -5+10x \quad \Rightarrow$$
$$6-ln(5) \;=\; 15x \quad \Rightarrow$$
$$T = T_{opt} = x = \frac{6-ln(5)}{15} \approx 0.29$$



Total area A = R + B (Red + Blue)

R= $2 \cdot \int_{0.5}^{1} 5 \cdot exp(-10(x-0.5))\ dx \approx 0.99$

B= $\int_{0.2}^{1} \exp\big(-5(x-0.2)\big)\,dx + \int_{0}^{0.2} \exp\left(-5(0.2-x)dx\right. \approx 0.32$

Positive == Object
Negative == Background

Type I Error (False Positive = False Object) : $\int_0^T 5\exp\big(-10(0.5-x)\big)\,dx \approx 0.06$

Type II Error II (False Negative = False Background): $\int_T^1 \exp\left(-5(x-0.2)dx\right. = 0.12$

Minimum error = (Error I + Error II)/A = (0.06+0.12)/1.31≈ 0.14
Sensitivity = (B – Error II)/B = (0.32-0.12)/0.32 ≈ 0.625
Specificity = (R – Error I)/R = (0.99-0.06)/0.99≈0.94