Solutions 071219

1)
1-e-III (gray level reduction – loss of contrast resolution)
2-a-II (ideal low-pass filtering – ringing)
3-d-IV (interpolation – jagged boundaries)
4-b-I (median filtering - Loss of corners and small details)
5-c-V (Butterworth low-pass filtering - Loss of detail resolution)

2a)

$h_{z=-1}$:	$h_{z=0}$:	$h_{z=+1}$:
1 1 1	1 1 1	1 1 1
1 1 1	1 -26 1	1 1 1
1 1 1	1 1 1	1 1 1

b)
-1 -1 2
-1 2 -1
2 -1 -1

c) 46

Sorted elements:

[32 32 38 38 39 39 40 41 43 44 45 45 46 **46**
47 48 49 50 52 52 53 55 58 59 65 75 99]

➔ Median = 46

d) assuming sampling interval Δ=1,
5 + 8 cos u + 4 cos v + 6 cos (u+v) + 2 cos (u-v)

1 2 3
4 5 4
3 2 1

$$5\exp(-j0) + 4\exp(-ju) + 4\exp(ju) + 2\exp(-jv) + 2\exp(jv) + 1\exp\big(-j(u-v)\big) + 1\exp\big(j(u-v)\big) + 3\exp\big(-(u+v)\big) + 3\exp\big(j(u+v)\big) = 5 + 8\cos u + 4\cos v + 6\cos(u+v) + 2\cos(u-v)$$

3a)
1 – III – C
2 – II – A
3 – I – B

b) 24

4a) The following pixels positions will be part of the final edge map: (0,2), (1,2), (2,2), and (3,2). The pixels at positions (0,2), (2,2), and (3,2) will all survive T_{high} and therefore will be part of the edge map . The pixel at position (1,2) survives T_{low} and is a neighbor to a pixel surviving T_{high} and therefore will also be part of the edge map. The pixels at positions (1,0) and (3,0) do survive T_{low} but are not neighbors to any pixel surviving T_{high}. Therefore, these pixels will not be part of the edge map

b) Hough transform
c) See textbook

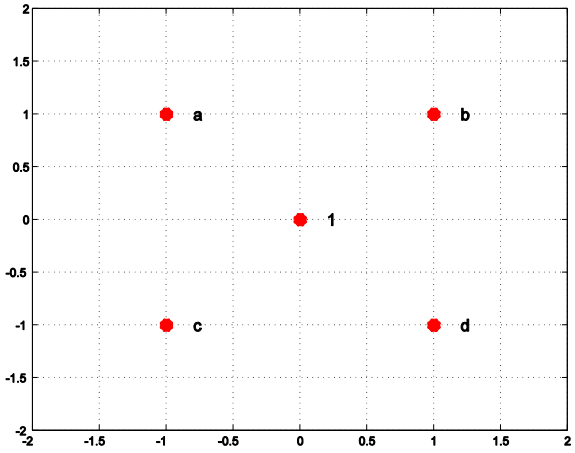
d) Dynamic programming
e) See textbook

5a)

i) Correct
ii) Not correct
iii) Not correct
iv) Not correct

b) The way the hit-miss structure elements are defined will give a one-pixel thin skeleton structure
c) For structures that are not elongated the algorithm is sensitive to boundary noise.
d) It will close holes
e) It will close holes on a larger scale
f) Image processing takes an image as input and produces another image as output (mostly with the same dimension). Image analysis takes an image as input and produces a quantitative description of that image (in terms of a few numbers).
g) The student will pass.

6a)



i) c + 1 + b = a + 1 + d
ii) – a – c + b + d = 2 (edge detection x-direction)
iii) – a – b + c + d = 4 (edge detection y-direction)
iv) (a + b + c + d) + (a + b + c + d) = 28

In iv) use $\varphi = m_{2,0} + m_{0,2}$, which is rotationally invariant. We could use $\mu_{2,0} + \mu_{0,2}$, (see Hue moment invariants, Φ_1, Lecture 7) which is invariant with respect to rotation, translation and scale. But this will lead to very complex equations, not easy to solve.

$$m_{0,2} = \sum_{x,y} x^0 y^2 f(x,y) = 1^2 \cdot a + 1^2 \cdot b + 0^2 \cdot 1 + (-1)^2 \cdot c + (-1)^2 \cdot d = a + b + c + d$$

This gives:
a = 2, b = 3, c = 4, and d = 5

Matlab:
>> [a,b,c,d]= solve('c+b=a+d', '-a-c+b+d=2','-a-b+c+d=4','a+b+c+d=14');

Center of gravity:
X-coordinate: $m_{1,0}/ m_{0,0}$ = (- 2 - 4 + 3 + 5) / (2 + 3 + 1+ 4 + 5) = 2 / 15
Y-coordinate: $m_{0,1}/ m_{0,0}$ = (- 4 - 5 + 2 + 3) / (2 + 3 + 1+ 4 + 5) = -4 / 15