Question 18.1

A 6x6 image is filled with values given by the *gray level run length* encoding: 4, 100, 5, 90, 6, 50, 1, 200, 4, 140, 3, 210, 4, 70, 4, 17, 5, 5. The image has a 0-based (x,y) coordinate system with origin in the upper left corner. The image is converted to a binary image by applying a threshold of 195, where all pixels above the threshold are set to 1 and the rest to 0. At last, a *morphological dilation* is performed using SE1 from Figure 1. How many foreground pixels are there in the resulting image?

1. 9
2. 12
3. 10
4. 11
5. 13
6. Do not know

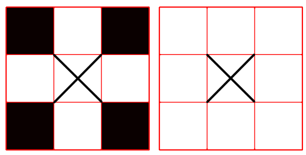

Figure 1: Left: SE1, Right: SE2. White pixels are foreground (1) and black pixels are background (0). The center is marked with a black cross.

Question 18.2

The point $(x, y) = (4, 7)$ is first transformed with the transformation matrix:

$$\begin{bmatrix} 4 & 2 \\ 3 & 5 \end{bmatrix} \tag{1}$$

and then with a rotation matrix (rotating counter clockwise) with $\theta = 15°$. What is the final result?

1. (-7.3, 16.4)
2. (32.1, 23.9)
3. (42.3, -3.6)
4. (16.8, 53.2)
5. (76.2, 43.4)
6. Do not know

Question 18.3

A binary image is encoded with a *binary run-length coding*. A 0-based (x,y)-coordinate system with origin in the upper left corner is used:

[2; (1,2)],[2, (5,6)],[3,(3,3)],[4,(4,4)],[5,(4,4)],[6,(4,4)]

On this image, a BLOB analysis is performed with *8-connectivity*. What is the *bounding box ratio* of the largest BLOB?

1. 0.95
2. 0.80
3. 1.10
4. 1.40
5. 1.25
6. Do not know

Question 18.4

On the image in Figure 2 a threshold of 145 is applied and the result is a binary image. The binary image is then encoded with a *binary chain coding*. A 0-based (x,y)-coordinate system with origin in the upper left corner is used. What will the encoding be?

1. (1,1)(006523)
2. (1,2)(106533)
3. (2,2)(100533)
4. (2,1)(010532)
5. (3,1)(110512)
6. Do not know

10	15	30	40	15
40	170	180	180	20
50	50	160	160	60
60	62	150	130	143
70	80	100	20	10

Figure 2: Grayscale image

Question 18.5

You have a camera with a *field-of-view* of 35° both horizontally and vertically. The cameras *focal length* is 20 mm and it can be assumed that $f = b$. What should the height of the CCD chip be, in order to take an image of the whole *field-of-view*?

1. 8.2 mm
2. 9.8 mm
3. 13.7 mm
4. 10.1 mm
5. 12.6 mm
6. Do not know

Question 18.6

On the image seen in Figure 3, a *linear gray level mapping* is performed, such that the new maximum value in the image is 220 and the new minimum value in the image is 30. Subsequently an *optimal path* with *dynamic programming* is calculated from the top to the bottom of the image. What is the total *cost* for the path found?

1. 170
2. 123
3. 145
4. 176
5. 181
6. Do not know

193	180	20	112	125
189	8	177	97	114
100	71	16	195	165
167	12	242	203	181
44	25	9	48	192

Figure 3: Grayscale image

Question 18.7

On the image seen in Figure 4, a filtering with a 3x3 minimum rank filter is first performed, and then a filtering with a 3x3 median filter is performed. What is the result in the pixel marked with a circle?

1. 3
2. 21
3. 33
4. 67
5. 59
6. Do not know

193	135	3	42	115	137
192	199	86	154	21	254
97	238	41	67	58	20
145	33	203	167	233	113
19	145	79	176	39	27
14	120	135	191	211	245

Figure 4: Grayscale image

Question 18.8

In a grayscale image, the pixel value in the position (121.6, 237.2) is calculated using bilinear interpolation. The closest four pixels and their values are:

x	y	value
121	237	73
122	237	108
121	238	65
122	238	X

The interpolated value in the point (121.6, 237.2) is 87.24. What is X?

1. 45
2. 57
3. 61
4. 65
5. 72
6. Do not know

Question 18.9

The RGB values in the image seen in Figure 5 are converted to HSI values. What are the S-values for the first row of the image?

1. $[0.61, 0.17, 0.52]$
2. $[0.53, 0.85, 0.43]$
3. $[0.57, 0.98, 0.34]$
4. $[0.87, 0.54, 0.73]$
5. $[0.67, 0.74, 0.70]$
6. Do not know

R: 120 G: 40 B: 20	R: 20 G: 150 B: 60	R: 30 G: 20 B: 150
R: 170 G: 20 B: 190	R: 20 G: 110 B: 20	R: 70 G: 20 B: 250
R: 120 G: 25 B: 20	R: 140 G: 20 B: 30	R: 70 G: 20 B: 40

Figure 5: RGB image

Question 18.10

A gamma mapping with $\gamma = 1.16$ is performed on the image seen in Figure 6. All pixel values are made integers (by removing decimals) and then the image is filtered with a *Vertical Sobel* filter. To avoid *the border problem*, the image is extended with the value 0 (zero padding). What is the result in the marked pixel?

1. 10
2. -54
3. -73
4. 23
5. 13
6. Do not know

1	66	37	218	61	230
198	204	35	159	31	241
208	110	222	89	47	125
222	232	148	131	61	125
22	46	140	102	106	86
102	67	37	19	13	230

Figure 6: Grayscale image

Question 18.11

A BLOB analysis is performed on the image seen in Figure 7. The largest BLOB is found with *4-connectivity* and all other BLOBs are removed. Then the following is performed:

$$(\mathrm{I} \oplus \mathrm{SE1}) \ominus \mathrm{SE2},$$

where SE1 and SE2 are seen in Figure 1. How many foreground pixels are there in the resulting image?

1. 3
2. 12
3. 7
4. 8
5. 4
6. Do not know

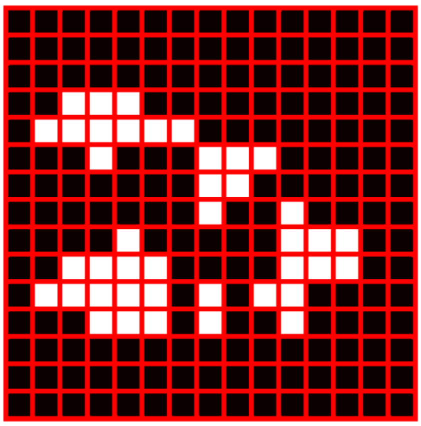

Figure 7: Binary image. White pixels are foreground (1) and black pixels are background (0).

Question 18.12

A BLOB analysis is performed on the image seen in Figure 7 with *8-connectivity*. In order to make a *BLOB classification*, a model with area 12 and *bounding box ratio* 0.75 is chosen. The area and *bounding box ratio* of the found BLOBs are also calculated and the one with the smallest Euclidean distance in *feature space* to the model is chosen. What is the distance for this BLOB?

1. 1.0
2. 3.2
3. 0.3
4. 4.7
5. 2.3
6. Do not know

Question 18.13

A *template matching* is performed with the template image seen in Figure 8 (right) on the image seen in Figure 8 (left). First the RGB template is converted to grayscale, where the value in a pixel is the *luminance* of the color (with decimals). What will the *cross correlation* in the pixel marked with a green circle be?

1. 80428
2. 70120
3. 91200
4. 102033
5. 99210
6. Do not know

208	139	204	9	167	210	195
231	244	36	217	44	177	203
32	246	108	238	180	81	48
233	40	234	173	8	242	125
161	248	202	193	71	9	114
25	244	245	189	12	112	165
71	124	167	100	25	97	181

R: 120 G: 40 B: 20	R: 20 G: 150 B: 60	R: 30 G: 20 B: 150
R: 170 G: 20 B: 190	R: 20 G: 110 B: 20	R: 70 G: 20 B: 250
R: 120 G: 25 B: 20	R: 140 G: 20 B: 30	R: 70 G: 20 B: 40

Figure 8: Left: Gray scale image. Right: Template as RGB

Question 18.14

A *template matching* is performed with the template image seen in Figure 8 (right) on the image seen in Figure 8 (left). First the RGB template is converted to grayscale, where the value in a pixel is the *luminance* of the color (with decimals). What will the *normalized cross correlation* in the pixel marked with a green circle be?

1. 0.65
2. 0.86
3. 0.91
4. 0.77
5. 0.72
6. Do not know

Question 18.15

You have made an algorithm that can classify objects to be either *cell* or *noise-object*. Your algorithm have been run on an image, where an expert have pointed out the real cell and noise-objects. The calculated *confusion matrix* is:

	Classified as noise	Classified as cell
Real noise	15	3
Real cell		76

A *true positive rate* of 0.9157 has also been calculated.

What is the missing number in the *confusion matrix*?

1. 3
2. 11
3. 4
4. 7
5. 14
6. Do not know

Question 18.16

In order to make a *pixel classification* in images of eyes, an expert has annotated areas in an image containing background, skin, eyebrow, iris and pupil. The original image contains pixel values between 0 and 255. The annotated pixel values are shown in Tabel 1. A *minimum distance classification* is performed on the image. What is the area of the iris in the image in figure 9?

1. 10
2. 8
3. 5
4. 7
5. 11
6. Do not know

tissue	pixel values
background	176, 178, 183
skin	81, 76, 72
iris	67, 68, 70
pupil	15, 25, 18
eyebrow	25, 42, 32

Table 1: Pixel values in the areas annotated by the expert.

181	181	176	80	81	82
180	178	80	74	75	76
177	80	77	74	66	65
80	78	76	68	65	16
80	78	68	67	19	17
79	79	70	69	18	18

Figure 9: Grayscale image

Question 18.17

In order to make a *pixel classification* in images of eyes, an expert has annotated areas in an image containing background, skin, eyebrow, iris and pupil. The original image contains pixel values between 0 and 255. The annotated pixel values are shown in Tabel 2. A *parametric classification* is performed on the image. What will a pixel with the value 71 be classified as?

1. background
2. skin
3. eyebrow
4. iris
5. pupil
6. Do not know

Tissue	pixel values
background	176, 178, 183
skin	81, 76, 72
iris	67, 68, 70
pupil	15, 25, 18
eyebrow	25, 42, 32

Table 2: Pixel values in the areas annotated by the expert.

Question 18.19

You have a camera with a CCD chip of 7 mm x 7 mm. The image dimensions are 4200 x 4200 pixels. It can be assumed that $b = f$. From a distance of 2 meter you have taken a sharp photo of a 15 cm long object. In the image, the object has a length of 2000 pixels. What is the *focal length* of the camera?

1. 42 millimeters
2. 44 millimeters
3. 47 millimeters
4. 51 millimeters
5. 53 millimeters
6. Do not know

Question 18.20

A gray level profile of an image has been created along a line between the points (24.2, 43.2) and (253.7, 301.3). The point located in the middle of this profile is now transformed with the matrix:

$$\begin{bmatrix} 0.7 & 1 \\ -3 & 0.4 \end{bmatrix} \tag{2}$$

What will the resulting coordinate be?

1. (269.52, -347.95)
2. (-64.24, 102.31)
3. (-7.21, -23.74)
4. (306.32, 111.77)
5. (156.52, 35.38)
6. Do not know

Question 18.23

Using *dynamic programming* an *optimal path* is computed from the top to the bottom of an image. A Matlab matrix coordinate system is used. The result is an *accumulator image* and a *backtracing image*. The backtracing image is shown in figure Figur 10. The minimum value of the *accumulator image* is found in the pixel marked with a circle. What is the obtained *path*?

1	2	2	3	5
2	2	3	3	4
2	1	2	3	5
1	1	2	3	5

Figure 10: Backtracing image

1. $P = [(1,3),(2,5),(3,2),(4,2),(5,3)]$
2. $P = [(1,1),(2,3),(3,1),(4,2),(5,2)]$
3. $P = [(1,1),(2,1),(3,3),(4,3),(5,2)]$
4. $P = [(1,2),(2,2),(3,2),(4,3),(5,4)]$
5. $P = [(1,3),(2,1),(3,2),(4,3),(5,3)]$
6. Do not know

Question 18.24

Using *dynamic programming* an *optimal path* is computed from the top to the bottom of the image shown in Figure 11. A Matlab matrix coordinate system is used. What are the values in the second row of the *accumulator image*?

177	195	181	30	192	140
81	203	192	127	65	35
242	48	70	245	129	38
9	125	173	87	178	66
112	114	167	149	227	214
97	165	41	57	245	65

Figure 11: Grayscale image.

1. $[258, 380, 222, 157, 95, 175]$
2. $[234, 310, 232, 145, 85, 143]$
3. $[256, 342, 242, 161, 76, 154]$
4. $[223, 313, 218, 143, 81, 152]$
5. $[274, 393, 225, 169, 99, 179]$
6. Do not know

Question 18.25

You have made an algorithm which can classify objects into two classes. The two classes are: *cell* and *noise object*. In the left image shown in Figure 12 an expert has colored actual cells green and noise objects red. The cells found with your algorithm can be seen in the right image. What is the *specificity* of your algorithm?

1. 0.56
2. 0.91
3. 0.83
4. 0.67
5. 0.75
6. Do not know

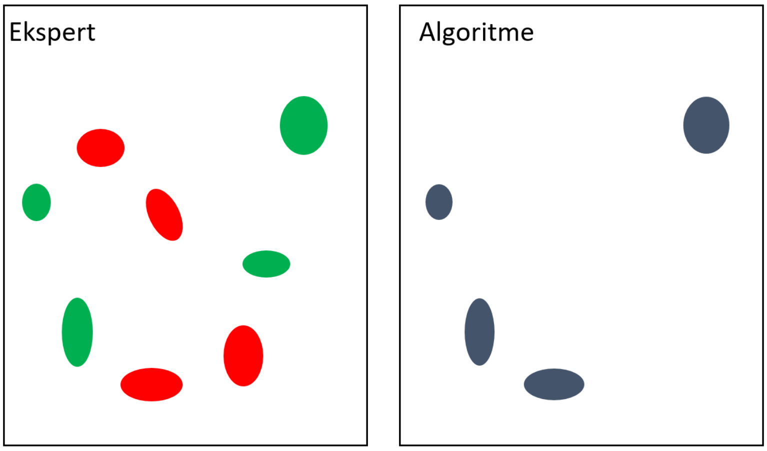

Figure 12: Cell classification. Left: An expert's evaluation. Right: The result of the algorithm.

Answers

Exercise	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answers	2	4	5	1	5	1	2	2	5	3	3	1	1	2	4

Exercise	16	17	18	19	20	21	22	23	24	25
Answers	2	4		2	1			4	1	5