Technical University of Denmark

Written exam, December 14, 2018

Course name: Image Analysis

Course number: 02502

Duration: 4 hours

Aids allowed: Alle aids allowed.

Weighting: All questions are equally weighted

Name:

Signature:

Desk no.:

Question	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answer	1	5	2	3	2	5	1	1	1	2	4	1	5	3	2

Question	16	17	18	19	20	21	22	23	24	25
Answer	3	1	4	4	1	5	3	1	3	4

Possible answers to each question are numbered from 1 to 6. The chosen number of the answer must be entered in the table above. In case you enter an incorrect number in the table this may be corrected by "inking out"the wrong number and instead placing the correct number below. Should there be any doubts in connection with a correction, the question will be considered as not answered. ONLY THE FRONT PAGE IS TO BE HANDED-IN.

If you decide to make a blank hand-in or leave the examination prematurely the front page must in all circumstances be handed-in. Rough drafts, calculations and comments will not be included in the evaluation. Only numbers included in the above table will be registered.

A correct answer will be equivalent to 5 points. An incorrect answer will be equivalent to -1 points. Questions unanswered as well as answer number six (equivalent to "do not know") will not produce points. The number of points required for a satisfactorily answered exam is finally determined by teacher during evaluation.

Please don't forget to state your name, signature, and desk number on the paper.

Exercise 18.1

To be able to do an image registration between a reference image and a template image, two sets of corresponding landmarks have been placed in the two images. The landmarks can be seen in the table below.

Landmarks in reference	x	y	Landmarks in template	x	y
a_1	3	-2	b_1	-1	5
a_2	X	2	b_2	6	4

Initially, the sum of squared distance objective function F is computed to be 73. What is the missing coordinate (X)?

1. 4
2. 3
3. -1
4. -2
5. 7
6. Do not know

Exercise 18.2

To be able to do an image registration between a reference image and a template image, two sets of corresponding landmarks have been placed in the two images. The landmarks can be seen in the table below.

Landmark i reference	x	y	Landmark i template	x	y
a_1	4	0	b_1	1	2
a_2	2	5	b_2	3	-3
a_3	1	-1	b_3	4	1

The optimal translation, that brings landmarks from the reference image over in the template image is found and applied to the landmarks. What is the change in the sum of squared distances objective function F?

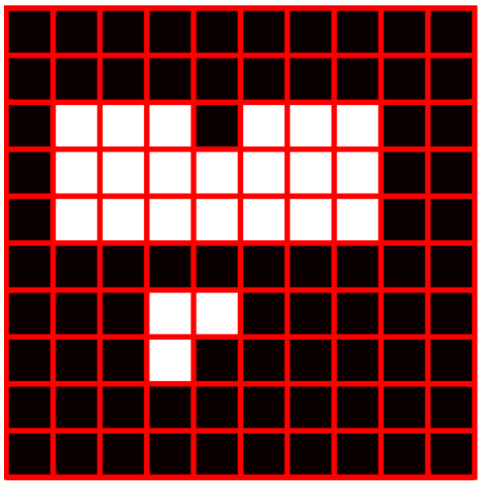
1. 8.23
2. 4.31
3. 1.08
4. 2.54
5. 5.67
6. Do not know

Exercise 18.3

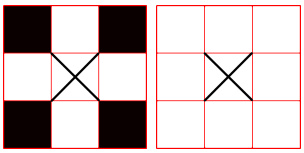
On the image seen in Figure 1 the operation

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

is performed, where SE1 og SE2 are seen in Figure 2. How many foreground pixels are there in the resulting image?



Figur 1: Binary image I. White pixels are foreground (1) and black pixels are background (0).



Figur 2: Left: SE1, Right: SE2. White pixels are foreground (1) and black pixels are background (0). The center is marked with a cross.

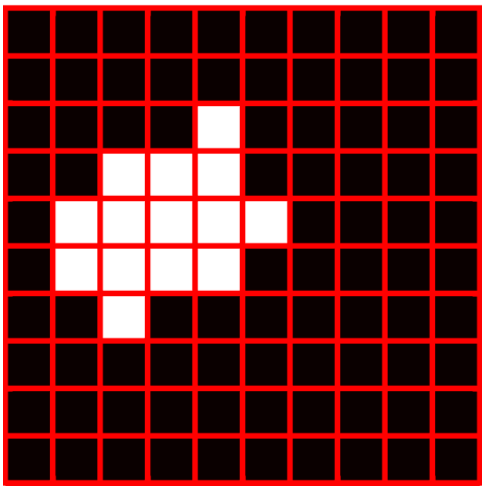
1. 4
2. 2
3. 3
4. 7
5. 9
6. Do not know

Exercise 18.4

On the image seen in Figure 3 the operation

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

is performed, where SE1 is seen in Figure 2. The resulting image is encoded using binary chain coding. It is a 0-based (x,y) coordinate system with origin in the upper left corner. What is the chain coding?



Figur 3: Binary image I. White pixels are foreground (1) and black pixels are background (0).

1. (3,4)(0, 1, 4, 3, 6, 2)
2. (2,3)(1, 0, 4, 3, 6, 2)
3. (2,4)(0, 0, 4, 4, 6, 2)
4. (2,4)(0, 1, 4, 3, 6, 2)
5. (2,3)(0, 5, 4, 3, 6, 2)
6. Do not know

Exercise 18.5

A camera has been used to take a photo of a painting. The photo has been taken of a distance of 1.5 meter and the horizontal field-of-view of the camera is 40° and the vertical field-of-view is 25°. The painting fits exactly into the photo. What is the physical size of the painting?

1. 58 x 23 cm
2. 109 x 67 cm
3. 98 x 56 cm
4. 126 x 87 cm
5. 89 x 73 cm
6. Do not know

Exercise 18.6

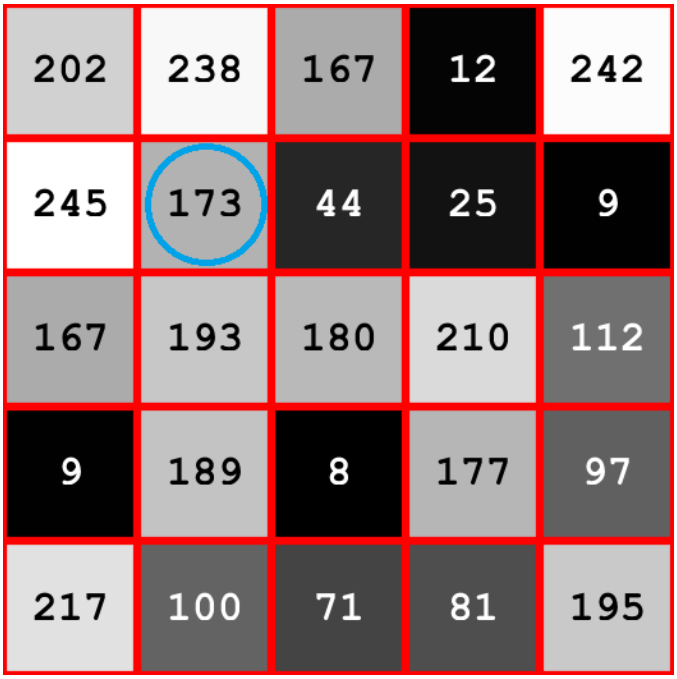
A gamma mapping with $\gamma = 1.12$ is performed on the image in Figure 4. All pixels are then rounded to integers. Dynamic programming is used to compute the optimal path from the top to the bottom of the resulting image. What are the values in the lowest row in the accumulator image?

1. 103, 215, 234
2. 101, 233, 250
3. 40, 122, 130
4. 50, 200, 121
5. 91, 239, 277
6. Do not know

Figur 4: Grayscale image.

Exercise 18.7

A linear gray level mapping is performed on the image seen in Figure 5. The resulting image has a minimum pixel value of 50 and a maximum pixel value of 150. The resulting image is filtered with a 3x3 minimum rank filter. What is the result in the marked pixel?

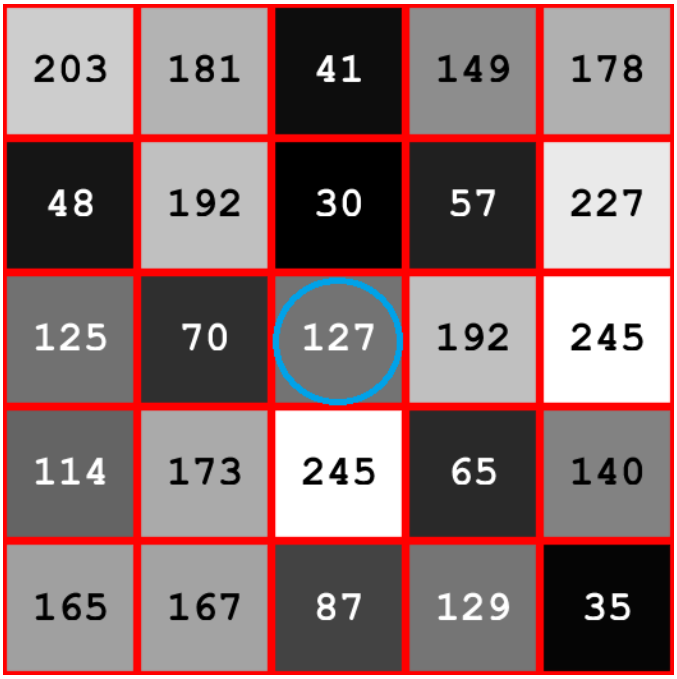


Figur 5: Grayscale image

1. 65
2. 43
3. 76
4. 123
5. 54
6. Do not know

Exercise 18.8

The image seen in Figure 6 is filtered using a 3x3 maximum rank filter. The resulting image is then filtered using a 3 x 3 median filter. What is the result in the marked pixel?



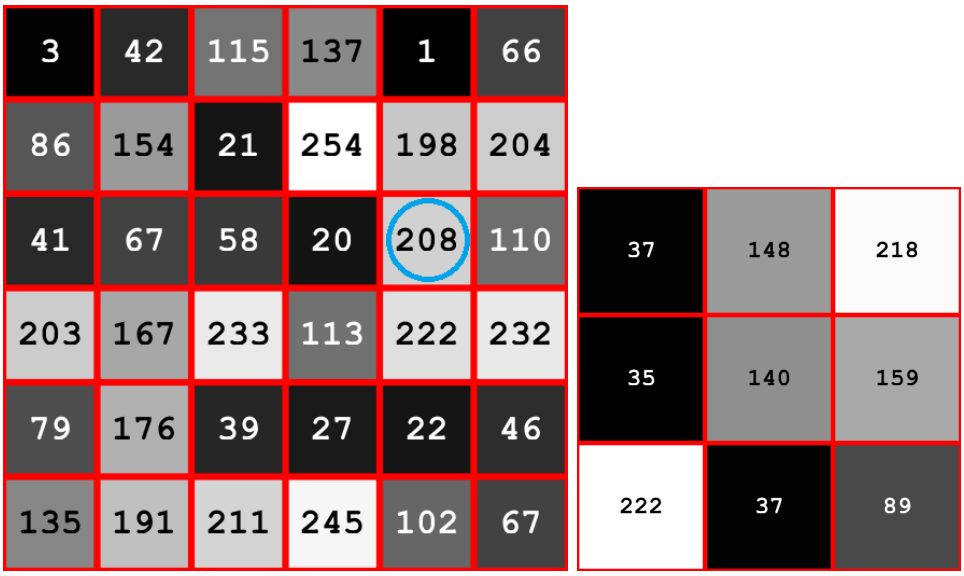
Figur 6: Grayscale image

1. 245
2. 192
3. 210
4. 173
5. 227
6. Do not know

Exercise 18.9

A template matcingh is performed on the image seen in Figure 7 (left) using the template seen in Figure 7 (right). What is the normalized cross correlation in the marked pixel?

1. 0.78
2. 0.65
3. 0.98
4. 0.92
5. 0.83
6. Do not know

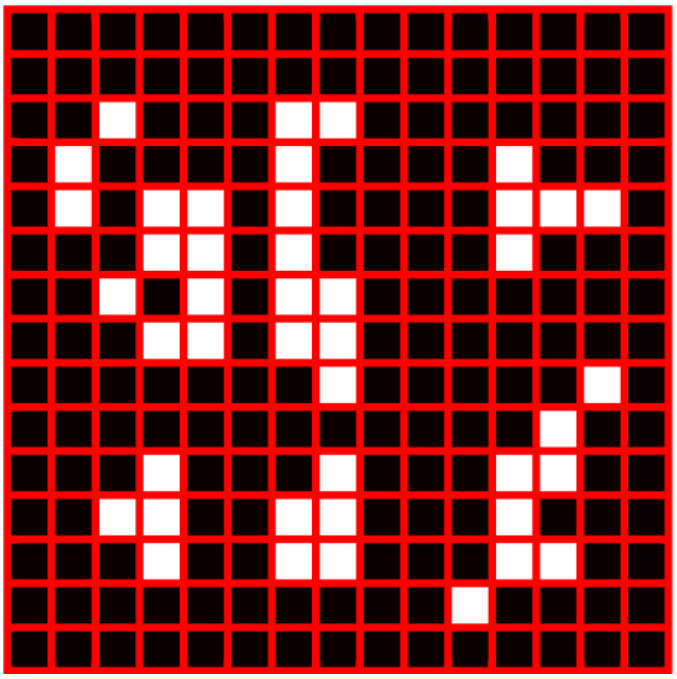


Figur 7: Left: Gray scale image. Right: Template

Exercise 18.10

A BLOB analysis is performed on the image seen in Figure 8 using 8-connectivity. The smallest BLOB is kept. Now each pixel in this BLOB is considered a landmark and the Frobenius norm is computed from these landmarks. The Frobenius norm is:

1. 0.43
2. 1.63
3. 0.89
4. 2.32
5. 2.05
6. Do not know



Figur 8: Binary image I. White pixels are foreground (1) and black pixels are background (0).

Exercise 18.11

A BLOB analysis is performed on the image seen in Figure 8 using 8-connectivity. The smallest and the largest BLOB are kept. For use in BLOB classification the area and the bounding box ratio are computed. What is the euclidean distance between the two BLOBs in feature space?

1. 4.98
2. 9.12
3. 5.64
4. 7.28
5. 1.32
6. Do not know

Exercise 18.12

The point $(x, y) = (5, 4)$ is transformed using the transformation matrix

$$\begin{bmatrix} 1.2 & 4.2 \\ -1.2 & 2.1 \end{bmatrix} \tag{1}$$

The result is then transformed using:

$$\begin{bmatrix} -0.6 & 1.1 \\ X & 1.2 \end{bmatrix} \tag{2}$$

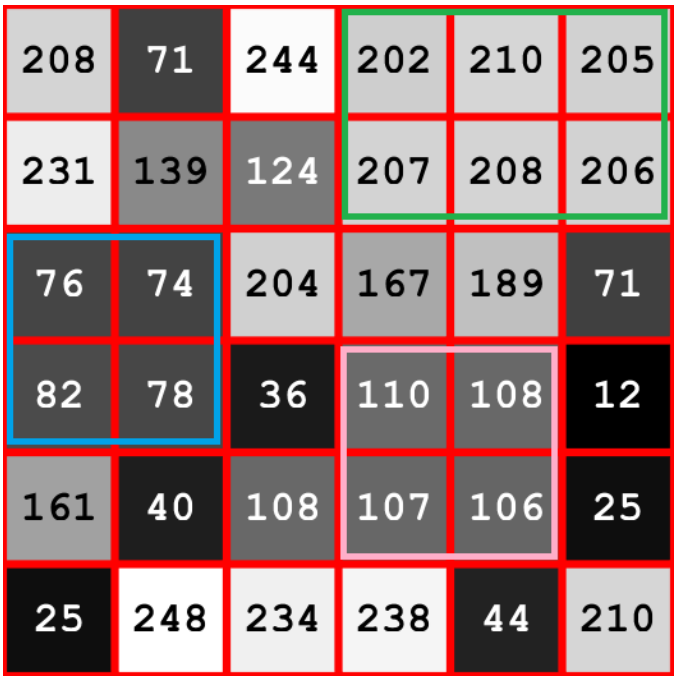
The result is (-11.04, 12). What is X:

1. 0.4
2. 1.2
3. -0.3
4. -2.1
5. 4.1
6. Do not know

Exercise 18.13

In order to do a pixel classification an expert has annotated three areas in the image seen in Figure 9. The expert has annotated a car (green marking), a bush (blue marking) and the road (pink marking). A minimum distance classifier should be used. What is the class range for the road class?

1. $]79, 135]$
2. $]95, 155]$
3. $]89, 146]$
4. $]87, 139]$
5. $]93, 157]$
6. Do not know



Figur 9: Expert markings on a gray scale image

Exercise 18.14

In order to make a pixel classification in images of roads, an expert has annotated areas in an image containing cars, roads, signs, pedestrians and dogs. The original image contains pixel values between 0 and 255. The annotated pixel values are shown in Table 1. A parametric classification is performed on the image. What will a pixel with the value 101 be classified as?

1. car
2. road
3. sign
4. pedestrian
5. dog
6. Do not know

Class	pixel values
Car	210, 212, 207
Road	23, 25, 21
Sign	101, 103, 105
Pedestrian	98, 96, 101
Dog	55, 56, 61

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

Exercise 18.15

A 5 x 5 image is filled with values given by the *gray level run length* code: 2, 100, 1, 18, 5, 110, 1, 20, 3, 55, 1, 22, 3, 170, 1, 30, 4, 67, 1, 45, 3, 82. A Matlab matrix coordinate system is used. An optimal path from the top to the bottom of the image is computed using dynamic programming. What is the value in the backtracing image at position (5,2).

1. 1
2. 2
3. 3
4. 4
5. 5
6. Do not know

Exercise 18.16

Your camera has a focal length of 20 mm and a CCD chip that measures 7 x 5 mm. The images taken with the camera have dimensions 7168 x 5120 pixels. It can be assumed that $b = f$. You have captured a sharp photo of a car that is 4 m long from a distance of 25 m. How long is the car on the image in pixels?

1. 4120
2. 2910
3. 3277
4. 1712
5. 3765
6. Do not know

Exercise 18.17

The RGB values in the image seen in Figure 10 are converted to HSI values. A new image is created by using the I values. This image is then filtered with a vertical Sobel filter. What is the result in the middle pixel (red marking) ?

1. 101
2. 89
3. 76
4. 107
5. 56
6. Do not know

R: 10 G: 140 B: 24	R: 48 G: 15 B: 98	R: 134 G: 202 B: 11
R: 187 G: 201 B: 16	R: 78 G: 198 B: 98	R: 232 G: 44 B: 78
R: 15 G: 30 B: 46	R: 154 G: 234 B: 38	R: 98 G: 211 B: 13

Figur 10: RGB image

Exercise 18.18

The RGB values in the image seen in Figure 10 are converted to HSI values. A threshold is set so all pixels with an S value above 0.7 are set to 1 and the rest to 0. How many pixels with a value of 1 are there in the two first rows of the image?

1. 1
2. 2
3. 3
4. 4
5. 5
6. Do not know

Exercise 18.19

The point $(x, y) = (8, 5)$ is transformed using the transformation matrix:

$$\begin{bmatrix} 5.1 & 4.2 \\ 2.2 & 3.1 \end{bmatrix} \tag{3}$$

The new position is used to sample a pixel value in an image using bilinear interpolation. The closest four pixels are:

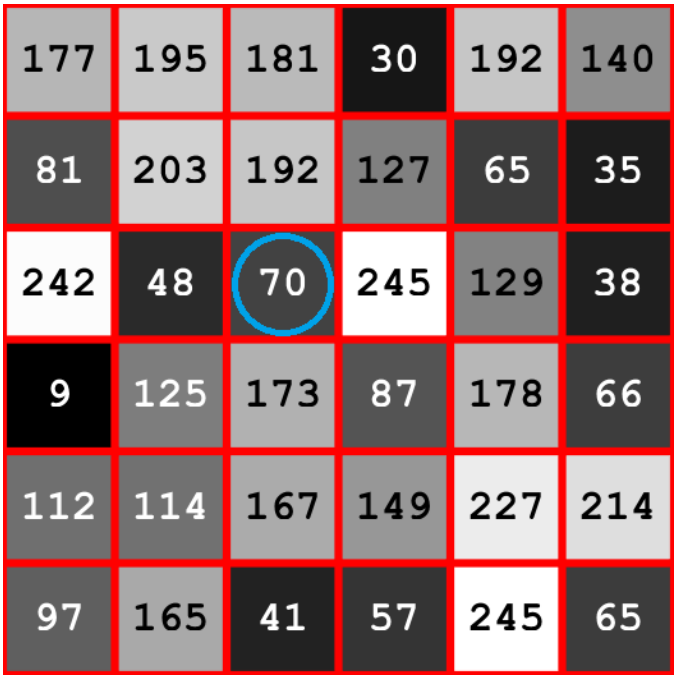
x	y	value
61	33	56
62	33	172
61	34	203
62	34	17

What is the interpolated value (rounded to an integer) in the point?

1. 103
2. 155
3. 165
4. 139
5. 198
6. Do not know

Exercise 18.20

We want to compute the magnitude of the gradient in the marked pixel in Figure 11. The gradient in the x and y direction are approximated using a horisontal and vertical Prewitt filter. What is the gradient magnitude?

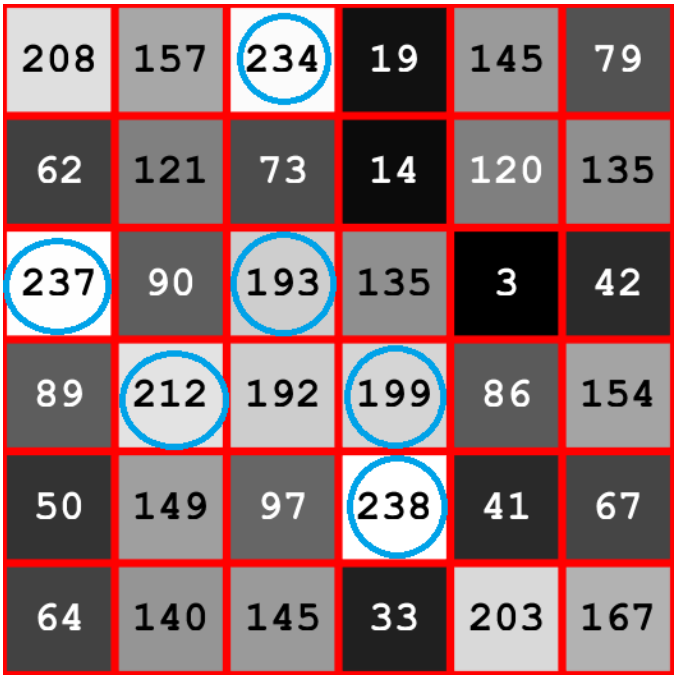


Figur 11: Grayscale image

1. 160
2. 132
3. 120
4. 176
5. 189
6. Do not know

Exercise 18.21

In the image seen in Figure 12 each pixel is an organic cell. An expert has marked diseased cells with a blue circle. Our algorithm works by setting a treshold of 200 and all pixels above the threshold are classified as diseased cells and the rest are healthy. What is the true positive rate of our algorithm?



Figur 12: Grayscale image

1. 0.45
2. 0.78
3. 0.82
4. 0.55
5. 0.67
6. Do not know

Exercise 18.22

You have made an algorithm that can classify objects to be either *car* or *background*. Your algorithm has been run on an image, where the cars have been annotated. The calculated *confusion matrix* is:

	Classified as background	Classified as car
Real background	8	2
Real car	3	7

What is the accuracy of your algorithm?

1. 0.62
2. 0.87
3. 0.75
4. 0.91
5. 0.81
6. Do not know

Exercise 18.23

Your camera has a focal length of 25 mm and a CCD chip that measures 4 x 3 mm. The images taken with the camera has dimensions 5200 x 3900 pixels. It can be assumed that $b = f$. You have captured a sharp photo of a completely round street sign from a distance of 4 meters. On the image, the radius of the sign is 2200 pixels. What is the surface area of the sign (in m^2)?

1. 0.23
2. 0.45
3. 0.16
4. 0.65
5. 0.11
6. Do not know

Exercise 18.24

Which one of the following statements is not correct?

1. A Prewitt filter can be used to enhance edges
2. BLOB classification can be used to analyse binary objects in an image
3. Histogram stretching makes an image larger
4. Bilinear interpolation is used to sample pixel values in an image
5. Minimum distance classification is useful when each class has the same variance
6. Do not know

Exercise 18.25

A camera is mounted on top of a conveyer belt transporting tomatoes. The goal is to create an algorithm that can count the number of red tomatoes passing the camera. What approach can you use to solve the task?

1. RGB to grey. Image registration. Prewitt filter.
2. RGB to grey. Morphological closing. Bilinear interpolation.
3. Pixel classification. Median filter. Morphological dilation.
4. RGB to HSI conversion. Threshold of H-values. BLOB analysis and classification.
5. Image registration. Shape analysis. Gradient filter.
6. Do not know