

# Image Analysis exam Fall 2020

Technical University of Denmark

Written online exam, December 14, 2020

**Course name:** Image Analysis

**Course number:** 02502

**Number of Questions:** 25

**Aids allowed:** All aids allowed.

**Duration:** 4 hours

**Weighting:** All questions are equally weighted

**Contact during exam:** rapa@dtu.dk

**IT-Support during exam (by phone):** 45 25 04 00

**Notes:** The possible answers to each question are numbered from 1 to 6. A correct answer will be equivalent to 5 points. An incorrect answer will be equivalent to -1 points. Questions unanswered (equivalent to "do not know") will not produce points. The final grade is determined by the examiners.

You have a set of measurements that are gathered into a matrix, such that each row of  $X$  corresponds to all measurements of a particular type. Each column of  $X$  corresponds to a set of measurements from one particular trial :

$X =$

4	V	-21
-3	-2	5
-7	-3	10

From this, a covariance matrix is computed:

249	-50	-96
-50	13	26
-96	26	53

What is the missing value V?

Choose one answer

- 17
- 4
- 13
- 6
- 7
- Do not know

Your camera has a CCD chip that measures  $6.5 \times 4.5$  mm and an image taken with the camera has  $7800 \times 5400$  pixels. It can be assumed that  $f=b=2.3$  mm. The camera has been used to take an image of a 50 cm high reference object. On the image, the object is 400 pixels high. How far away from the camera is the reference object?

Choose one answer

- 0.83 m
- 3.45 m
- 7.22 m
- 4.54 m
- 6.15 m
- Do not know

You have taken a photo of a DTU sign with a width of 1.2 m from a distance of 7 m. The camera has a CCD chip that measures 5.8 x 4.2 mm and the image has 6960 x 5040 pixels. It can be assumed that  $f=b=1.5 \text{ mm}$ . How many pixels wide will the sign be in the photo?

Choose one answer

- 130
- 170
- 280
- 309
- 405
- Do not know

You have taken a photo of building with a camera with a horizontal field-of-view of  $42^\circ$ . The building can just fit into the photo and the photo is taken from a distance of 7 m. How wide is the building?

Choose one answer

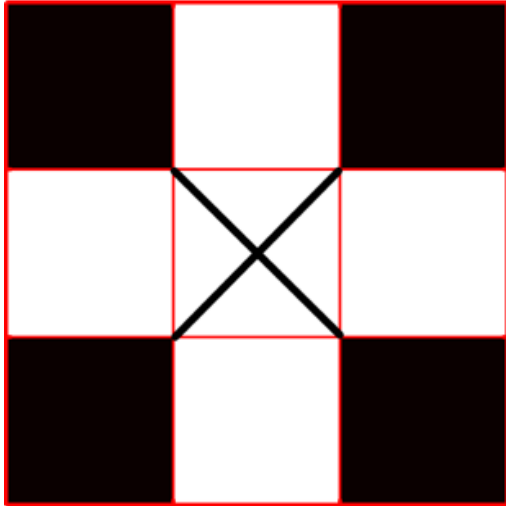
- 5.4 m
- 12.1 m
- 8.3 m
- 9.1 m
- 2.7 m
- Do not know

A 5 x 5 image has been coded using a *gray level run length code* of : 3, 10, 3, 17, 1, 58, 1, 60, 4, 21, 3, 75, 2, 5, 6, 8, 2, 2. This image is then thresholded with a threshold of 50 so pixels with values above are set to 1. Finally, a BLOB is found using 8-connectivity and the compactness of the BLOB is computed. The compactness is:

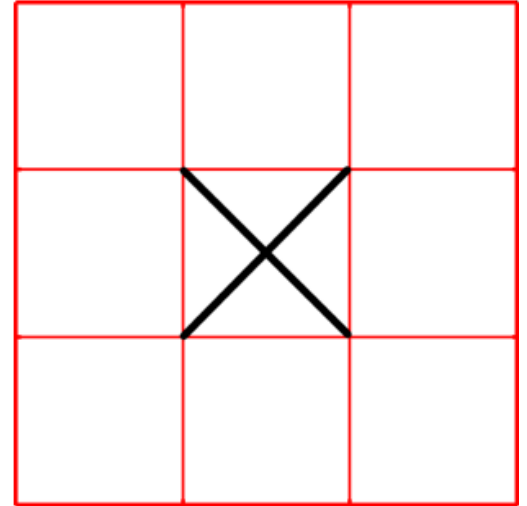
Choose one answer

- 0.625
- 1.532
- 0.75
- 2.1
- 0.3
- Do not know

A binary image using a 0-based (x, y) coordinate system has been coded using the *binary run-length code*: [2; (2, 3)], [3; (3, 4)], [3; (6, 6)], [4; (3,7)], [5; (4, 7)], [6; (5, 6)]. The decoded image (I) is processed with the morphological operation  $(I \ominus SE1) \bullet SE2$ . The cross in the structuring elements marks the center. How many foreground pixels are there in the resulting image?



SE1



SE2

Choose one answer

- 5
- 3
- 7
- 8
- 9
- Do not know

The RGB image seen in the figure is converted to the HSI color space. The pixels are thresholded by a threshold of 0.8 on the S values, so pixels with values above are set to foreground. How many foreground pixels are there in the resulting image?

R: 180 G: 200 B: 15	R: 245 G: 15 B: 40	R: 35 G: 80 B: 135
R: 10 G: 35 B: 18	R: 50 G: 56 B: 23	R: 25 G: 18 B: 72
R: 144 G: 28 B: 9	R: 98 G: 25 B: 163	R: 23 G: 130 B: 225

Choose one answer

- 4
- 3
- 8
- 9
- 1
- Do not know



A linear gray level transformation is applied to the image seen to the left. The desired minimum pixel value is 12 and the desired maximum pixel value is 196. After the transformation, the pixel values are rounded to the nearest integer. A template match is applied to the resulting image, with the template seen to the right. What is the normalized cross correlation in the marked pixel?

25	9	48	192	30
210	112	125	70	127
177	97	114	173	245
81	195	165	167	87
242	203	181	41	149

57	129	245
192	178	140
65	227	35

Template

Choose one answer

- 0.154
- 0.799
- 0.471
- 0.972
- 0.337
- Do not know

A gamma mapping with  $\gamma = 1.7$  is applied to the image below and the resulting pixel values are rounded to integers. Secondly, the gradient in each pixel is approximated using the horizontal and vertical Prewitt filters. What is the magnitude of the gradient in the marked pixel?

208	25	40	36	167
231	71	248	108	9
32	139	244	234	217
233	244	124	202	238
161	246	204	245	173

Choose one answer

- 63
- 78
- 121
- 157
- 189
- Do not know

A principal component analysis has been performed on a set of 3x3 images. The average image can be seen below and the 3 first Eigenvectors can be seen as columns in the matrix. A new image is synthesized by adding a linear combination of the 3 first Eigenvectors to the average image. The weights used are  $w_1 = 0.2$ ,  $w_2 = -0.7$ ,  $w_3 = 0.5$  what is the resulting pixel value in the upper left corner?

245	38	65
140	66	208
35	214	62

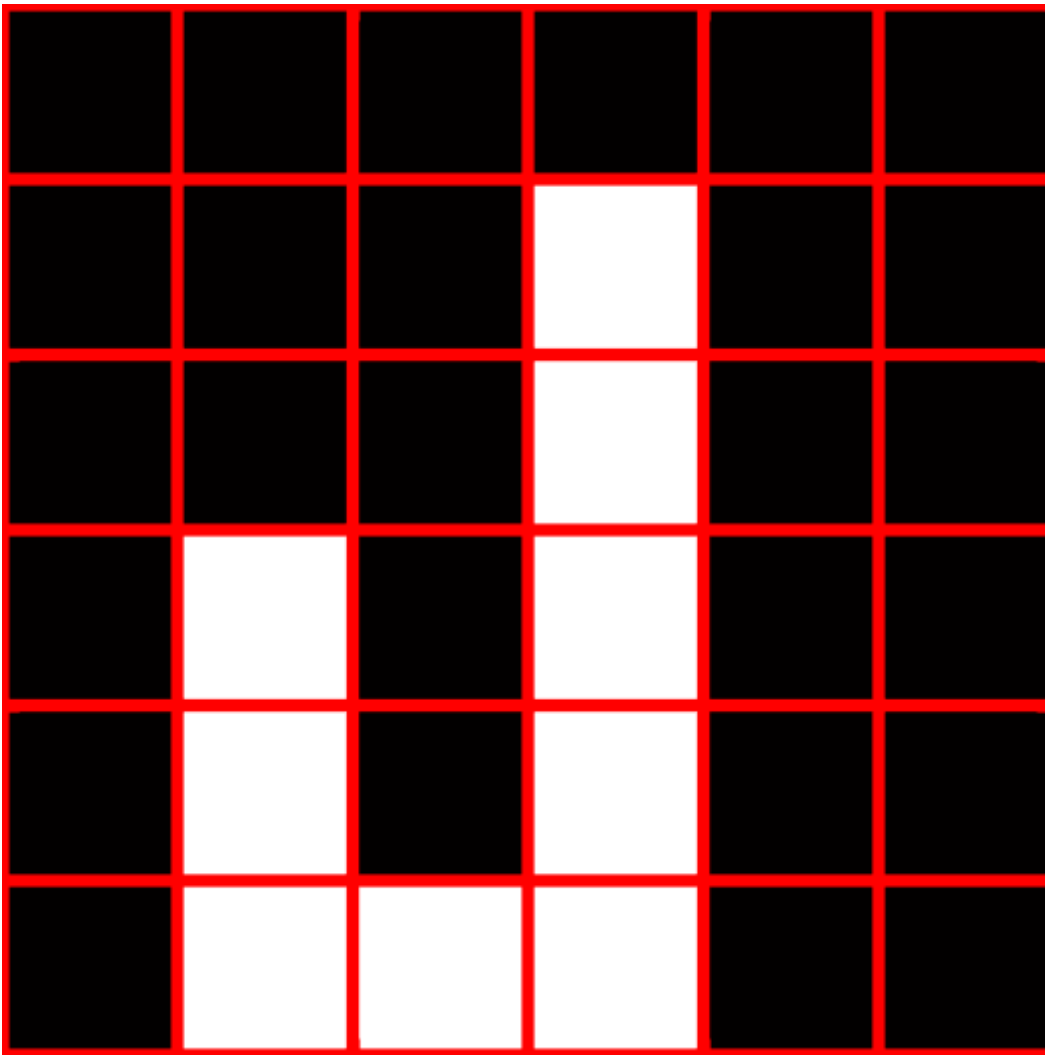
92.9264	54.9724	53.0798
34.9984	91.7194	77.9167
19.6595	28.5839	93.4011
25.1084	75.7200	12.9906
61.6045	75.3729	56.8824
47.3289	38.0446	46.9391
35.1660	56.7822	1.1902
83.0829	7.5854	33.7123
58.5264	5.3950	16.2182

Choose one answer

- 252
- 17
- 189
- 202
- 42
- Do now know

A 3x3 max-rank filter is applied to the image below. 0-padding is used to handle the border problem. This is followed by a threshold of 250, where pixels with values above are set to foreground. The resulting image is considered as the result of a pixel classification, where a foreground pixel is considered positive and the rest negative. The ground truth image can be seen further below. What is the *precision* of the algorithm?

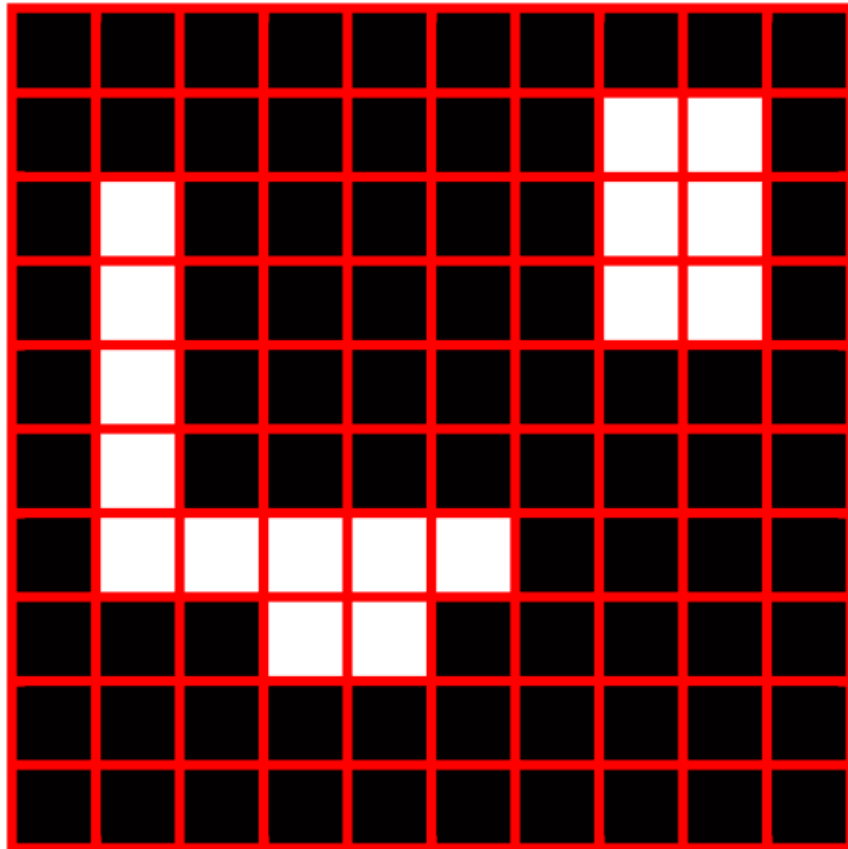
203	167	233	113	222	232
79	176	39	27	22	46
135	191	211	245	102	67
42	115	137	1	66	37
154	21	254	198	204	35
67	58	20	208	110	222



Choose one answer

- 0.78
- 0.56
- 0.87
- 0.67
- 0.95
- Do not know

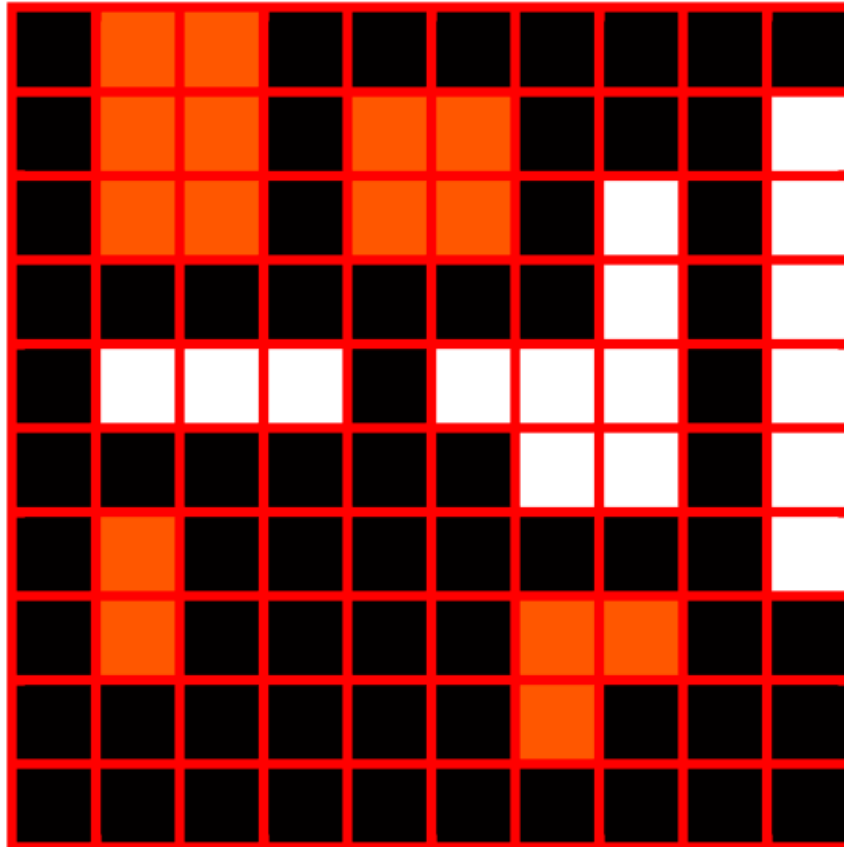
A BLOB analysis is performed on the image below using 4-connectivity. The following BLOB features are computed for the two found BLOBs: area, bounding box ratio, and compactness. What is the Euclidean distance between the two BLOBs in feature space?



Choose one answer

- 2
- 3
- 4
- 5
- 6
- Do not know

A BLOB analysis is performed on the image below using 4-connectivity, where all pixels that are not black are considered foreground. This is followed by a BLOB classification, where BLOBs with an area less than 5 are classified as positive and the rest as negative. The ground truth is marked so white BLOBs are negative and orange BLOBs are positive. What is the accuracy of the classification algorithm?



Choose one answer

- 0.54
- 0.71
- 0.96
- 0.87
- 0.62
- Do not know



## Mark the incorrect statement below

Choose one answer

- When doing shape analysis, a shape represented by landmarks can be considered a point in a high-dimensional space
- Point correspondence means that a landmark on one shape is placed on the same location on a similar shape
- When doing principal component analysis on a set of shapes, The first Eigenvector describes the average shape
- A statistical shape model can be used as a generative model for shapes
- An iterative optimizer solves an optimization problem by performing many small operations over and over
- Do not know

We would like to make a system that can classify tables, chairs and floors in indoor photos. For that a minimum distance classifier is used. An expert has marked representative regions in the image below, where the table is marked with blue, the chair is marked with green and the floor is marked with yellow. What are the resulting class ranges?

177	199	202	30	192	140
81	203	207	127	156	167
242	48	70	245	177	145
9	125	173	87	178	66
112	114	167	66	89	214
97	165	41	94	96	65

Choose one answer

- [0, 123], [124, 182], ]182, 255]
- [0, 117], [117, 176], ]176, 255]
- [0, 123], [124, 210], ]210, 255]
- [0, 68], [69, 182], ]182, 255]
- [0, 98], [99, 168], ]168, 255]
- Do not know

An underwater photo has been taken and the goal is to use a *parametric classifier* to label the pixels into the following classes: rock, fish, plant, coral, and sand. An expert has marked regions in the photo: rock (pink), fish (blue), plant (green), coral (white), and sand (yellow). A pixel with value 100 will be classified as:

208	90	97	145	42	58	27	66
62	212	145	120	154	233	245	204
237	149	55	59	50	39	1	110
89	140	14	86	167	211	92	232
110	130	135	41	176	137	89	46
64	10	17	21	191	254	80	67
157	193	238	79	115	20	22	37
121	192	210	230	205	113	102	35

Choose one answer

- rock
- fish
- plant
- coral
- sand
- Do not know

A line profile is sampled in an image with startpoint  $(x, y)=(15.3, 76.6)$  and endpoint  $(x, y)=(164.4, 13.3)$ . The position in the middle of the profile is computed and the pixel value is sampled using bilinear interpolation. The closest pixel values are:

x	y	value
89	44	33
90	44	212
89	45	126
90	45	87

The found value is rounded to the nearest integer and the result is:

Choose one answer

- 201
- 97
- 154
- 86
- 113
- Do not know

## Mark the incorrect statement below

Choose one answer

- When using a lossy image format when storing an image, you are not guaranteed that the pixel values are exactly the same as in the original image
- When fitting an active shape model to a new image, one approach is that each point of the shape model is moved to where there is a high gradient in the image.
- Having a *strong prior* in a statistical shape model can mean that an image that contains a sign of sickness can be fitted to look like a healthy person.
- The first Eigenvector describes the major variation seen in a data set
- Automatic thresholding is based on morphological opening
- Do not know

Big-data analysis of traffic camera images in New York has shown that photos of traffic signs and traffic lights both can be described by normal distributions of intensity values. You are asked to use parametric image classification to find the optimal threshold between the two classes. The two distributions are:

- Traffic signs:  $N(7, 2^2)$
- Traffic lights:  $N(15, 5^2)$

What is the threshold?

Choose one answer

- 9.4
- 10.3
- 13.7
- 12.2
- 7.2
- Do not know

To be able to do a landmark-based 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:

Landmarks in reference	x	y	Landmarks in template	x	y
a1	3	3	b1	6	7
a2	4	2	b2	3	7
a3	7	3	b3	2	2

Before the registration, the first point in the reference image is rotated with  $11^\circ$  using a rotation matrix (rotating counter-clockwise). What is the squared distance objective function  $F$  between the two point-sets?

Choose one answer

- 41.2
- 53.4
- 77.3
- 101.2
- 23.2
- Do not know

To be able to do a landmark-based 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:

Landmarks in reference	x	y	Landmarks in template	x	y
a1	1	6	b1	5	9
a2	8	8	b2	4	3
a3	3	2	b3	6	5

The points in the reference image are translated using a translation vector of  $t=(-2, 5)$ . What is the change in the squared distance objective function  $F$  between the two point-sets?

Choose one answer

- 89
- 46
- 77
- 123
- 99
- Do not know



An optimal path from the top to the bottom of the image seen below is found using dynamic programming. What is the value of the accumulator image at the marked pixel position?

208	244	108	173	71	112	181	245
231	246	234	193	12	97	192	87
32	40	202	189	25	195	70	149
233	248	245	10	210	203	173	57
161	244	167	167	177	48	167	192
25	124	9	44	81	125	41	65
71	204	217	180	242	114	30	129
139	36	238	8	9	165	127	178

Choose one answer

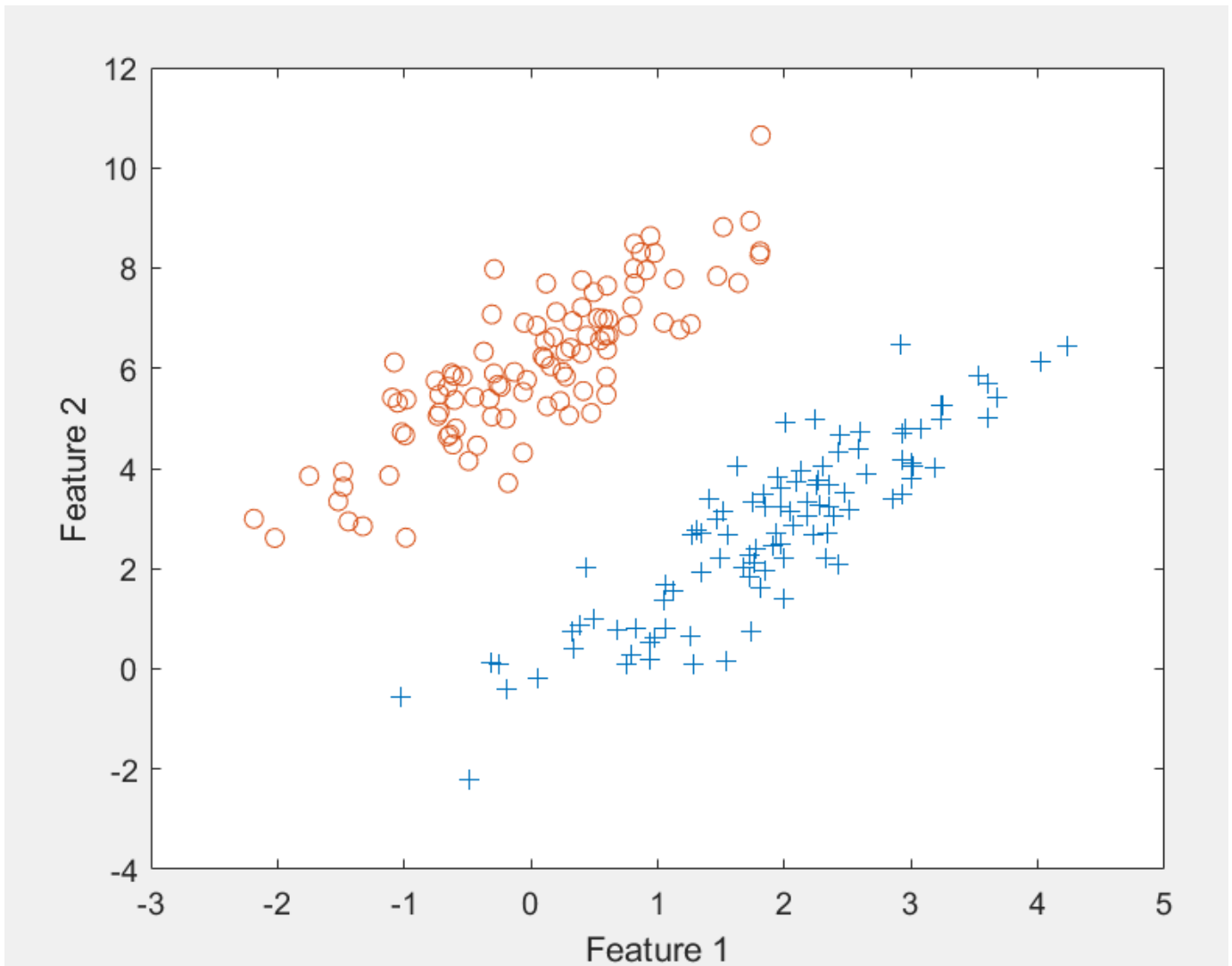
- 156
- 295
- 308
- 276
- 143
- Do not know

A company producing farming machines wants you to develop an automated system for plant identification. The specific plant typically has red leaves and is often found on brown farmland surrounded by green crops. What could be the pipeline that you would use to solve the task?

Choose one answer

- Image acquisition, HSI color thresholding, morphological operations, BLOB analysis, feature classification
- Image acquisition, landmark registration, chain coding
- Binary run-length coding, PCA analysis, histogram stretching, morphological closing
- Hough transformation, parametric classification, confusion matrix, grey-level run length coding
- Gaussian filtering, active shape model, binary chain coding, automatic thresholding
- Do not know

To make an image-based classification system for two different objects, a set of training images has been acquired and two features have been computed for all the objects in the images. In the image below, the two classes (the two types of objects) are plotted in feature space, where class one is blue and class two is orange. A linear discriminant analysis (LDA) has been performed and a *decision boundary* has been computed. It can be described by which equation?



Choose one answer

- $y = 1.7x + 2.5$
- $y = -3x - 4$
- $y = x + 5$
- $y = 7.2x - 1$
- $y = -x + 2$
- Do not know



Two images have been registered using a state-of-the-art software package for image based registration. The registered images can be seen below. The mean squared difference (MSD) similarity metric was used for registration. What is the MSD for the two images?

<b>0</b>	<b>252</b>	<b>204</b>
<b>221</b>	<b>135</b>	<b>58</b>
<b>156</b>	<b>122</b>	<b>127</b>

169	250	237
186	196	148
227	148	4

Choose one answer

- 1450
- 7061
- 2341
- 10829
- 3764
- Do not know