

02502 Image Analysis Exam Spring 2022

Technical University of Denmark

Written exam, May 18, 2022

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

Notes: There are five possible answers to each question and a "do not know" option. 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.

Path tracing

An optimal path through the image below has been found using dynamic programming. The path goes from the top to the bottom of the image. A 1-based Matrix coordinate system is used.

177	195	181	30	192
81	203	192	127	65
242	48	70	245	129
9	125	173	87	178
112	114	167	149	227

To compute the optimal path, an accumulator image is computed. The values in the accumulator image that are on the optimal path are found. What is the median value of values?

Choose one answer

- ☐ 341
- ☐ 201
- ☐ 156
- ☐ Do not know
- ☐ 270
- ☐ 398

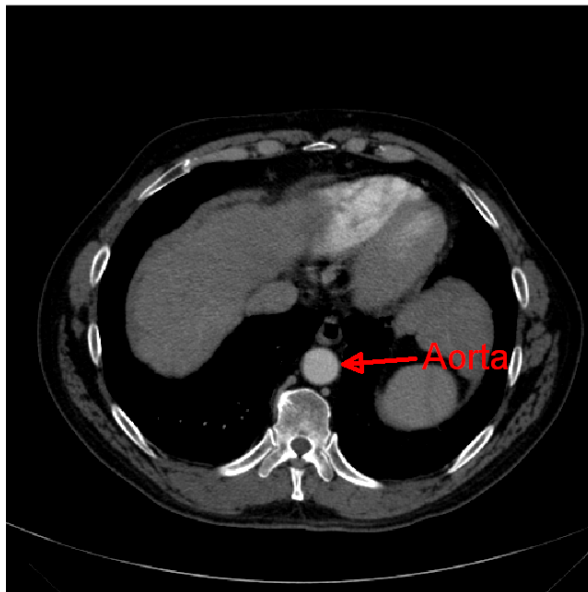
What is the optimal path through the image?

Choose one answer

- ☐ ([1,2], [2,3], [3,2], [4, 3], [5, 2])
- ☐ ([1,3], [2,3], [3,3], [4, 2], [5, 2])
- ☐ ([1,3], [2,3], [3,2], [4, 2], [5, 1])
- ☐ Do not know
- ☐ ([1,4], [2,4], [3,3], [4, 2], [5, 1])
- ☐ ([1,4], [2,3], [3,2], [4, 1], [5, 1])

Aorta analysis

A doctor would like to measure the size of the aorta in healthy patients. The aorta is the largest artery in the human body and can be seen as the circle-like structure here:



To develop an algorithm, CT scans with the aorta have been acquired. One of these scans is stored as a DICOM file and one slice is stored as a DICOM file called 1-442.dcm.

Data for the aorta question (<https://resources.mcq.eksamen.dtu.dk/v1/7ae96140-d51c-468a-a391-5f72ba010be6>)

To be able to see the difference between the liver and the aorta, an expert has marked a part of the liver and a part of the aorta in the DICOM image. The markings are stored as masks in AortaROI.png and LiverROI.png. By using the DICOM image and the mask images, the grey-values representing the aorta and the liver can be extracted. An optimal grey-value threshold between the aorta and liver is computed using a parametric classifier. What is this threshold?

Choose one answer

- ☐ 155
- ☐ 158
- ☐ 151
- ☐ 148
- ☐ 145
- ☐ Do not know

A threshold is set in the image, so all pixels with a value higher than $T=90$ are set to foreground (1) and the rest of the pixel to background(0).

A BLOB analysis is then performed using 8-connectivity. BLOBs connected to the image border are removed. For each BLOB, the area (A) and perimeter (P) are computed.

A measure of each BLOBs circularity (C) is computed by:

$$C = \frac{4\pi A}{P^2}$$

To find the aorta, only BLOBs with $C > 0.95$ and $A > 200$ pixels are kept.

We know that a pixel on the scan has a physical side length of 0.75 millimeter.

What is the area of the aorta in the scan?

Choose one answer

- ☐ 293 mm²
- ☐ Do not know
- ☐ 440 mm²
- ☐ 212 mm²
- ☐ 476 mm²
- ☐ 77 mm²

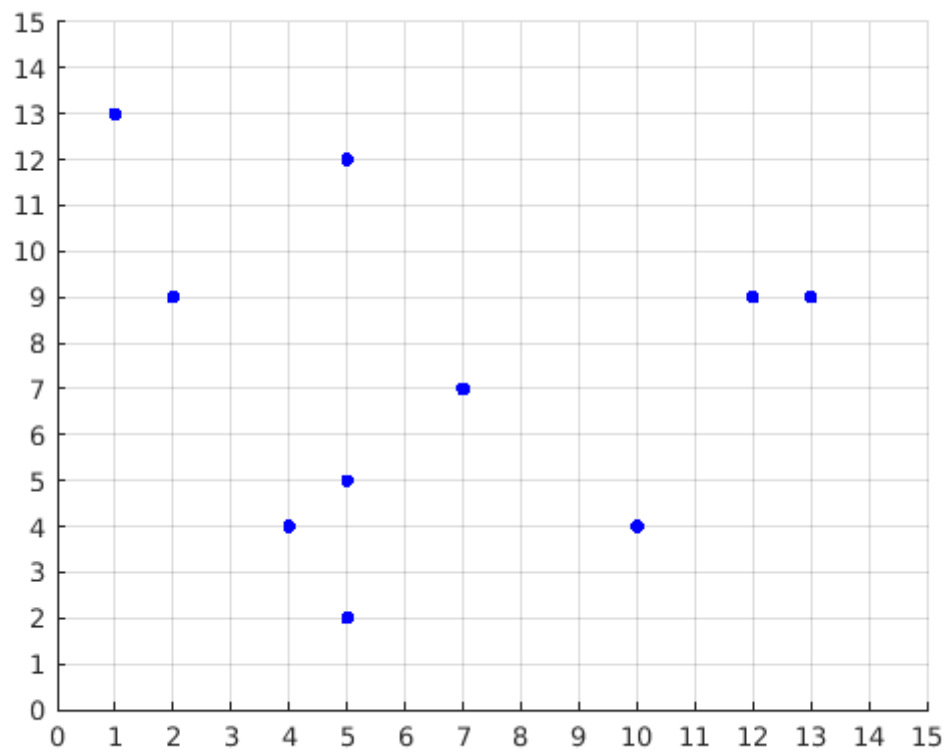
An expert has marked the aorta in the scan and the marking is stored as a mask in (AortaROI.png). By using the DICOM image and the mask image, grey-values representing the blood in the aorta can be extracted. In order to analyze the blood flow in the patient, the average and standard deviation of the grey-values of the blood are computed. They are?

Choose one answer

- ☐ 103 and 15
- ☐ 187 and 23
- ☐ 213 and 5
- ☐ Do not know
- ☐ 191 and 16
- ☐ 207 and 13

Hough Transformation

A Hough transform has been performed on the image with the points seen here:



Several lines have been found in the image and each have a set of $[\rho; \theta]$ parameters. One of these lines passes two of the points seen in the image. Which line is that?

Choose one answer

- ☐ $\rho = 9.9, \theta = 45^\circ$
- ☐ $\rho = 9.0, \theta = 90^\circ$
- ☐ Do not know
- ☐ $\rho = -4.9, \theta = -45^\circ$
- ☐ $\rho = 0.0, \theta = -45^\circ$
- ☐ $\rho = 5.0, \theta = 0^\circ$

The line that is parameterized with $\rho = 10$ and $\theta = 0^\circ$ passes through how many points?

Choose one answer

- ☐ 4
- ☐ 5
- ☐ 3
- ☐ 2
- ☐ 1
- ☐ Do not know
- ☐ 0

Car and road image analysis

In order to create a system for smart cars, some photos of roads and cars should be analysed.

In order to create a system that can recognize brightly colored cars, a photo of a car is provided. The photo called car.png shows one car. The goal is compute the size of the car by finding the unique color of the car. First the photo is converted from the RGB color space to the HSV color space. Then a binary image is created by setting all the pixels that have an S component higher than 0.7 to foreground and the rest of the pixels to background. The values of the H and V components are ignored. The binary image is morphologically eroded using a disk-shaped structuring element with radius=6. When doing the erosion, the pixels beyond the image border are assigned a value of 1 (the default Matlab behavior). The resulting image is morphologically dilated using a disk-shaped structuring element with radius=4. When doing the dilation, the pixels beyond the image border are assigned a value of 0 (the default Matlab behavior).

[car.png \(https://resources.mcq.eksamen.dtu.dk/v1/bab078f7-2947-4d46-b39b-6fe1be6587fb\)](https://resources.mcq.eksamen.dtu.dk/v1/bab078f7-2947-4d46-b39b-6fe1be6587fb).

How many foreground pixels are there in the final image?

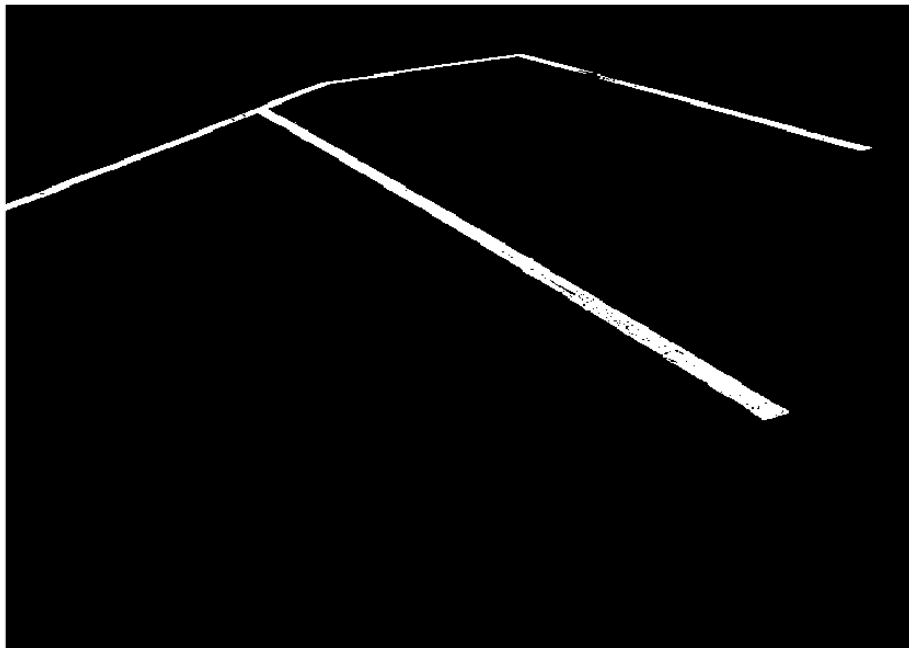
Choose one answer

- ☐ Between 10000 and 11000
- ☐ Between 30000 and 31000
- ☐ Do not know
- ☐ Between 41000 and 42000
- ☐ Between 17000 and 18000
- ☐ Between 23000 and 24000

A photo has been taken of a piece of road with some parking lots marked with white lines. The goal is to recognize the white lines.

[road.png\(https://resources.mcq.eksamen.dtu.dk/v1/2de3a87d-b056-459a-bfd5-1c8e50152631\)](https://resources.mcq.eksamen.dtu.dk/v1/2de3a87d-b056-459a-bfd5-1c8e50152631)

First the photo is converted from the RGB color space to the HSV color space. Then a binary image is created by setting all the pixels that have a V component higher than 0.9 to foreground and the rest of the pixels to background. The values of the H and S components are ignored. The BLOBs in the binary image are found using 8-connectivity. The BLOBs that are connected to the image border are not removed. The area (in pixels) of all BLOBs are computed and all BLOBs that have an area less than a minimum area is removed. What is this minimum area if the result should be that there is only two BLOBs remaining and that the result looks like this image:



Choose one answer

- ☐ 44
- ☐ 1047
- ☐ 5123

☐ Do not know

☐ 13021

☐ 57

The perfect spoon

A new company called Spoonz.com wants to create the perfect wooden spoon. To get started, they are analyzing existing spoons and have taken six photos of used spoons. They are named spoon1.png - spoon6.png. The dimensions of each photo are (W=200, H=550 pixels).

Data for the questions: spoonz.zip (<https://resources.mcq.eksamen.dtu.dk/v1/14806ade-977f-4b12-8854-8d5b16f1d98e>)

In order to base their new product on statistical properties of used spoons, they want you to do a principal component analysis (PCA) on the grey values of the images. For this you can use the helper functions **pc_evector.m** and **sortem.m**.

After the PCA, we only keep the principal components that in total explain at least 65 percent of the total variation in the set of photos. The photo, spoon1.png, is now projected into this low-dimensional PCA space. What are the coordinates in PCA space?

Choose one answer

- ☐ 1724
- ☐ Do not know
- ☐ 8593, -7149
- ☐ 1031, 523, 121
- ☐ -403, 12
- ☐ -341, 123, 1031, 81

Spoonz.com would like to try to only model the spoon and not the background. Therefore a threshold of 100 is applied to all spoon photos, so all pixel above the threshold is set to 1 and the rest of the pixels to 0.

An image based PCA is then performed on the thresholded images. For this you can use the helper functions **pc_evecs.m** and **sortem.m**.

How many percent of the total variation does the first principal component explain?

Choose one answer

- ☐ 91.9
- ☐ 82.3
- ☐ Do not know
- ☐ 57.1
- ☐ 44.4
- ☐ 39.1

Spoonz.com would like to know how an average spoon could look like and therefore the average of the six spoon photos should be computed. The average photo should be computed using the original grey value images.

What is the value of the pixel at position (row=500, column=100, when using a 1-based matrix-based coordinate system) in the average image?

Choose one answer

- ☐ Do not know
- ☐ 234
- ☐ 190
- ☐ 123
- ☐ 89
- ☐ 45

A transformation matrix that can transform point positions should be computed. The point should first be rotated (counterclockwise) 20 degrees followed by a uniform scaling of 2 and finally the point should be translated with (3.1, -3.3).

The transformation matrix is used to transform the point with coordinates (10, 10). What is the resulting position?

Choose one answer

- ☐ (11.1, 19.3)
- ☐ (23.1, 11.8)
- ☐ (15.1, 22.3)
- ☐ (7.1, 10.3)
- ☐ (32.2, 10.1)
- ☐ Do not know

Soccer player analysis

A soccer organization has collected player data for 2964 soccer players. For each player a score has been given for short passing, long passing, acceleration, sprint speed, agility and stamina. These measurements can be found in the `soccer_data.txt` (<https://resources.mcq.eksamen.dtu.dk/v1/7af2cea5-0c37-4298-8ba9-7a6285b788a2>) file.

A principal component analysis (PCA) has been performed on the soccer data.

After the PCA, the soccer player data (short passing, long passing, acceleration, sprint speed, agility and stamina) are projected into PCA space. What is the maximum value of absolute value of all the projected player values?

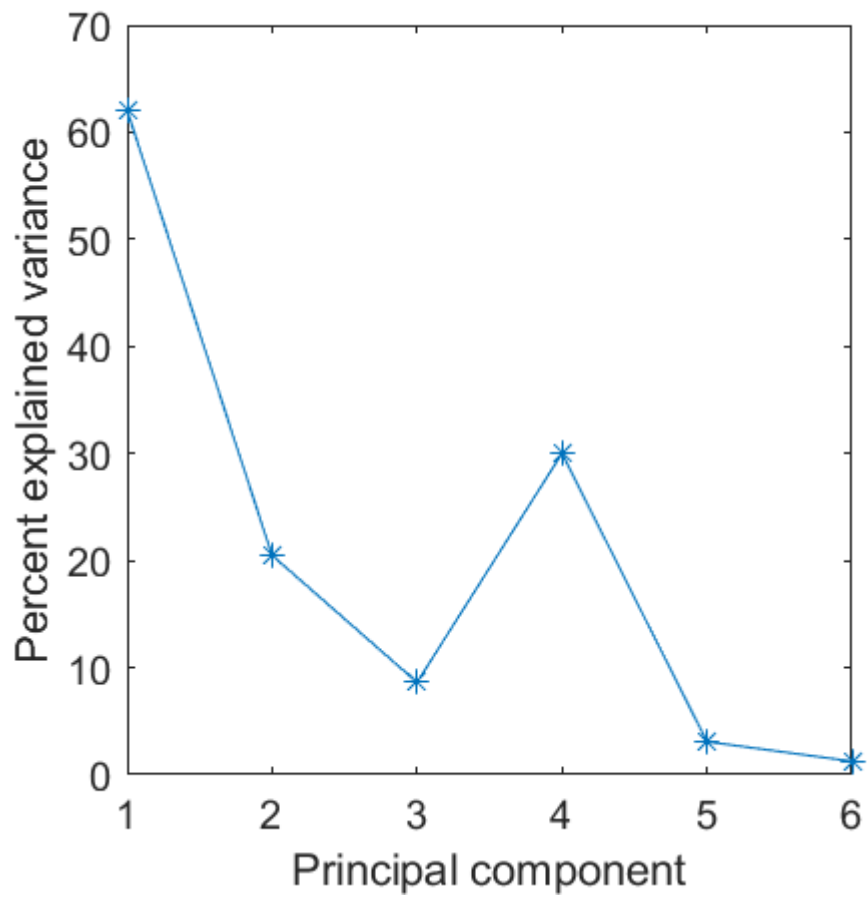
Choose one answer

- ☐ 10.23
- ☐ 106.08
- ☐ 127.12
- ☐ Do not know
- ☐ 63.11
- ☐ 51.04

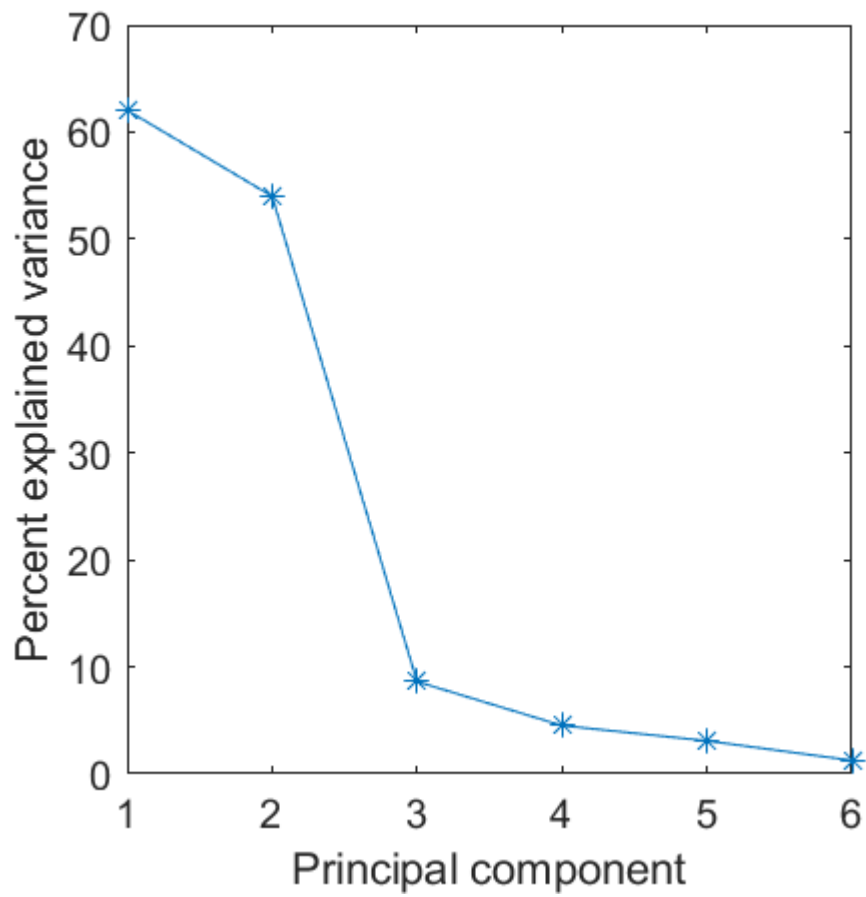
After the PCA, the amount of the total variation explained by each principal component has been plotted. Which plot is that?

Choose one answer

☐

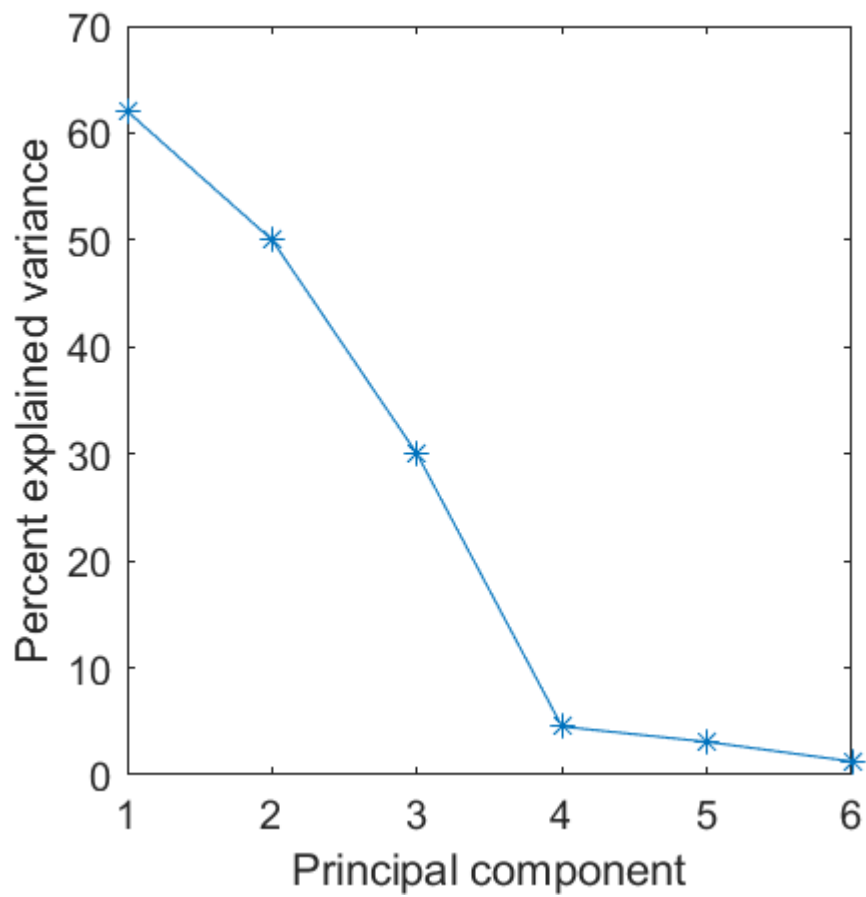


☐

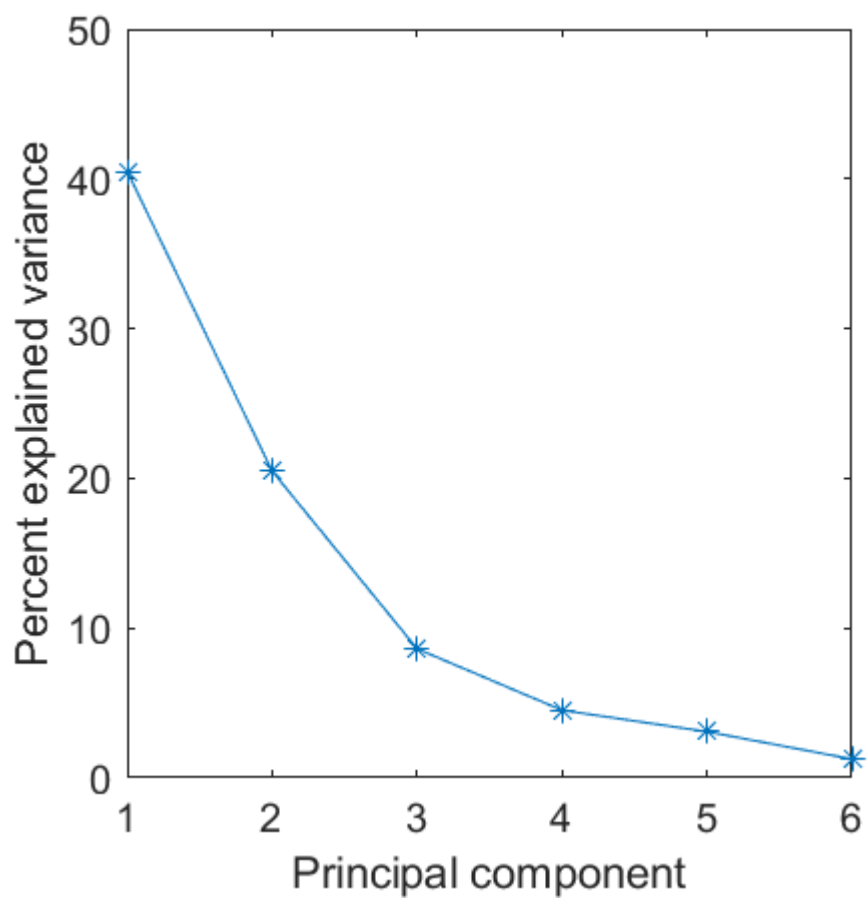


☐ Do not know

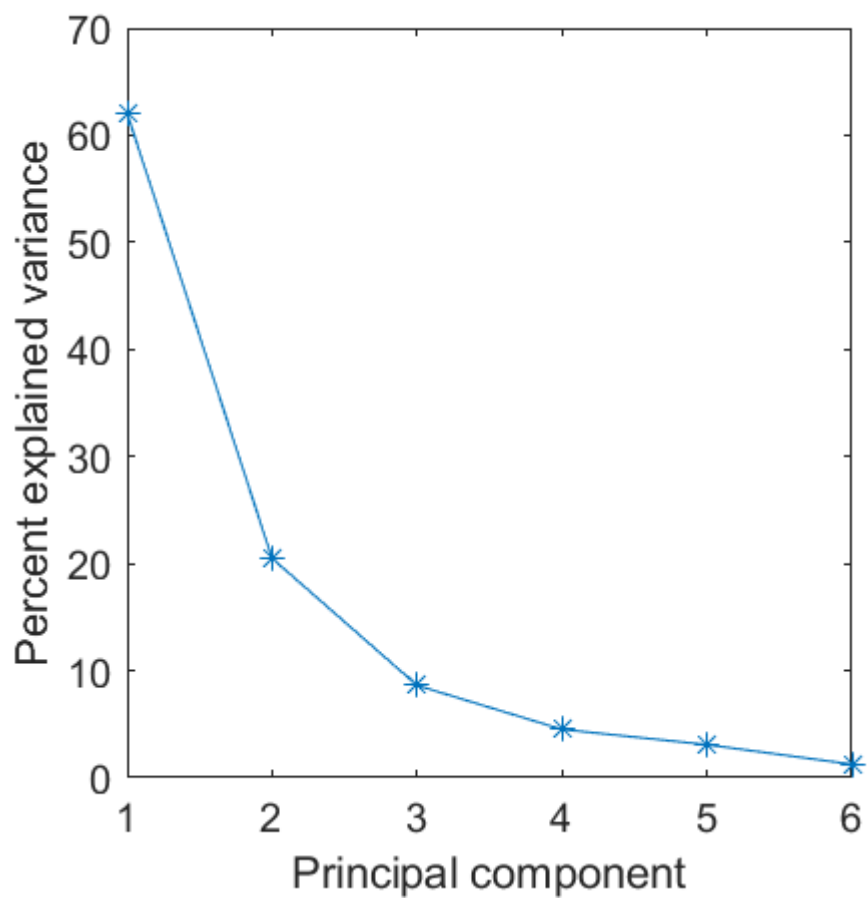
☐



○



○



Grain classification

A spectral camera is used to automatically classify different types of grain to avoid lower quality grains being sold as high quality grain. An expert has manually annotated training images and it has been found that using just one spectral channel, the pixel values of the grain can be modelled as three separate normal distributions:

- Bad quality grain: $N(25, 10^2)$
- Medium quality grain: $N(52, 2^2)$
- High quality grain: $N(150, 30^2)$

A parametric classifier is used to find the pixel value that separates the medium quality grain from the high quality grain. What is this value?

Choose one answer

- ☐ 47.3
- ☐ 59.6
- ☐ Do not know
- ☐ 51.3
- ☐ 63.1
- ☐ 68.6

A minimum distance classifier has been computed using the expert data. What is the pixel value that separates the bad quality from the medium quality grain?

Choose one answer

- ☐ 78.2
- ☐ 19.3
- ☐ Do not know
- ☐ 101.4
- ☐ 51.8
- ☐ 38.5

Volcano analysis

A group of researchers aims to predict volcano eruptions. Using a new device, two values are measured and it is hoped that using these values it is possible to predict eruptions. Over a ten years period, values were measured for passive volcanoes and for erupting volcanoes. The measured values are:

Passive volcanoes (class 1):

- (1.2, 1.1)
- (2.9, 0.4)
- (1.7, -2.7)
- (1.8, -0.3)
- (3.2, 1.3)
- (3.1, -0.9)

Erupting volcanoes (class 2):

- (0.5, 1.7)
- (1.4, -2.1)
- (2.7, -0.8)
- (2.0, 0.5)

To discriminate between the two classes, a linear discriminant analysis (LDA) has been performed on the above data.

You should use the supplied LDA.m function to solve the questions.

LDA.m (<https://resources.mcq.eksamen.dtu.dk/v1/2f1c5758-11f0-4f62-a056-9c298d3e317d>)

The found LDA classifier is used on the training data. How many erupting volcanoes (class 2) are wrongly being classified as being passive?

Choose one answer

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ Do not know

The found LDA classifier is used on the training data. Some erupting volcanoes (class 2) are wrongly being classified as being passive. What are the probability values of these wrongly classified volcanoes?

Choose one answer

- ☐ [0.13]
- ☐ [0.27, 0.39]
- ☐ [0.32, 0.76]
- ☐ Do not know
- ☐ [0.54]
- ☐ [0.40, 0.43, 0.65]

You are asked to create an automated system that can locate blue parking signs in standard color photos. The parking signs are round. What approach could work?

Choose one answer

- ☐ Gamma mapping, morphological dilation, Hough transformation, BLOB analysis
- ☐ Transform from RGB to HSV color space, statistical shape analysis, gamma mapping
- ☐ Do not know
- ☐ Transform from RGB to greyscale, geometric transformation, Hough line detection
- ☐ Prewitt filtering, linear histogram stretching, BLOB analysis, Hough analysis
- ☐ Transform from RGB to HSV colorspace, color threshold in HSV space, BLOB extraction, BLOB classification using the circularity feature

Image Compression

A grey scale photo has been acquired and the goal is to test different types of image compressions on the photo.

208	208	208	202	202	202
231	231	231	231	193	193
193	193	193	167	167	167
167	36	36	36	36	36
36	40	40	217	217	217
25	25	25	25	25	25

The image is compressed using gray-scale run length encoding. What is the result?

Choose one answer

- ☐ 3, 204, 3, 202, 4, 231, 1, 193, 4, 137, 6, 36, 2, 40, 3, 217, 6, 25
- ☐ 3, 208, 3, 202, 4, 22, 5, 193, 4, 16, 6, 36, 2, 40, 3, 217, 6, 25
- ☐ 3, 208, 3, 202, 5, 231, 5, 193, 7, 167, 6, 36, 2, 40, 3, 217, 6, 25
- ☐ 3, 208, 3, 202, 4, 231, 5, 139, 4, 167, 6, 36, 5, 40, 3, 217, 6, 25
- ☐ 3, 208, 3, 202, 4, 231, 5, 193, 4, 167, 6, 36, 2, 40, 3, 217, 6, 25
- ☐ Do not know

A threshold of 230 is used on the image, so all pixels above the threshold is set to foreground (1) and the rest is set to background (0). The image has a 0-based (x, y) coordinate system. The binary image is encoded using a chain code. What is the result?

Choose one answer

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

A threshold of 215 is used on the image, so all pixels above the threshold is set to foreground (1) and the rest is set to background (0). The image has a 0-based (x, y) coordinate system. The binary image is encoded using binary run-length coding. What is the result?

Choose one answer

- ☐ [1; (0, 3)], [2; (1, 5)]
- ☐ [1; (0, 3)], [2; (1, 5)]
- ☐ [1; (0, 3)], [4; (3, 5)]
- ☐ Do not know
- ☐ [2; (1, 3)], [4; (3, 5)]
- ☐ [1; (2, 3)], [4; (3, 5)]

Landmark based registration

Two photos with toy figures have been taken with a standard camera (play1.png and play5.png). Five landmarks have been placed on the photos and stored in the files playfixedPoints.mat and playmovingPoints.mat.

Data for the question on landmarks (<https://resources.mcq.eksamen.dtu.dk/v1/bf3a1764-c483-48fa-a238-48e82c6e6966>)

A similarity transform (translation, rotation, and scaling) has been computed so that it aligns the moving points to the fixed points. The computed transform is applied to the play5.png photo.

After the transformation, a threshold is applied to the transformed image, so pixels below 180 are assigned to foreground (1) and the pixels above 180 are background (0).

A reference image called reference.png is provided. The DICE score between the reference image and the transformed (and thresholded) image is computed. What is this DICE score?

Choose one answer

- ☐ Between 0.75 and 0.80
- ☐ Between 0.80 and 0.85
- ☐ Do not know
- ☐ Between 0.85 and 0.90
- ☐ Between 0.70 and 0.75.
- ☐ Between 0.90 and 0.95

What is the Euclidean distance between the first landmark in the fixed points and the first landmark in the moving points?

Choose one answer

- ☐ 86.1
- ☐ 97.1
- ☐ Do not know
- ☐ 132.4
- ☐ 181.2
- ☐ 165.7