

# 02502 Image Analysis exam Fall 2021

Technical University of Denmark

Written exam, December 10, 2021

**Course name:** Image Analysis

**Course number:** 02502

**Number of Questions:** 20

**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.

A friend has asked you to make a system, that can identify climbing holds on photos from the friend's climbing gym. A photo of a climbing wall (ClimbingWall.png) is provided. Your system initially computes a binary image by applying an RGB threshold where pixels with  $R < 60$ ,  $G < 200$ , and  $B < 100$  are set to foreground (1) and the rest of the pixels are set to background (0).

Secondly, a morphological closing with a disk-shaped structuring element with radius = 3 is performed. When doing a dilation, pixels beyond the image border are assigned a value of 0 and when doing an erosion the pixels beyond the image border are assigned a value of 1 (the default Matlab behavior).

After this, all BLOBs that are connected to the image border are removed. Finally, all BLOBs in the image are found using 8-connectivity. How many BLOBs are found?

[Data for the question \(ClimbingWall.zip\).](#)

<https://resources.mcq.eksamen.dtu.dk/v1/4381abca-7508-4d16-a180-fbfb72d99ac2>

Choose one answer

- ☐ 455
- ☐ 64
- ☐ Do not know
- ☒ 536
- ☐ 712
- ☐ 324

Two similar images have been acquired (donald\_1.png and donald\_2.png). Six corresponding landmarks have been placed on the two images and are stored in the files donaldfixedPoints.mat and donaldmovingPoints.mat.

A similarity transform (translation, rotation, and scaling) has been performed that aligns the moving points to the fixed points. The computed transform is applied to the donald\_2.png photo. What is the RGB value at position (row=300, column=300, in a 1-based matrix coordinate system) in the transformed image?

[Data for the question \(Donald.zip\)](#)

<https://resources.mcq.eksamen.dtu.dk/v1/4114e137-1e3f-4b22-b1e1-e18a4f6e703e>

Choose one answer

- ☐ (240, 150, 11)
- ☐ (80, 216, 201)
- ☐ (85, 45, 210)
- ☐ (145, 33, 49)
- ☐ Do not know
- ☐ (10, 201, 89)

Six photos have been taken. They are named orchid001.png - orchid006.png. The dimensions of each photo are (W=400, H=533 pixels). In order to do some statistical analysis of the images, the average image of the six photos is computed. Finally, a threshold of 150 is applied to the average image so pixels above the threshold are considered as foreground and the rest as background. Which is the resulting image?

[Data for the question \(orchid1-6.zip\).](#)

<https://resources.mcq.eksamen.dtu.dk/v1/b858d23a-cded-412a-a2d9-39fb6a242b72>

Choose one answer

☐☐

Do not know

☐



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An analysis of the nutrients of (N=300) pizzas has been performed and (M=7) values have been measured per pizza (moisture, protein, fat, ash, sodium, carbohydrates, and calories). These measurements can be found in the **pizza.txt** file.

A principal component analysis (PCA) should be done on these data. How many principal components are needed to explain at least 95% of the variation in the data set?

[Data for the question \(pizza.zip\)](#)

<https://resources.mcq.eksamen.dtu.dk/v1/f8f9dca6-3001-4df3-a88f-9b8506b0381d>

Choose one answer

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

A scan has been done on a CT scanner and stored as a DICOM file. One of the slices of the scan is stored as a DICOM file called 1-131.dcm. Expert annotations of the liver (LiverROI.png), the spleen (SpleenROI.png), and bone (BoneROI.png) are also provided. By using the DICOM image and the mask images, gray-values representing the liver, the spleen, and the bone can be extracted.

The goal is to develop a minimum distance classifier based on the annotated data. What will be the gray-value range of the spleen?

[Data for the question \(1-131.zip\).](#)

<https://resources.mcq.eksamen.dtu.dk/v1/df2ccb18-52b7-442d-9ede-bcceb4dfe272>

Choose one answer

- ☐ [99, 482]
- ☐ [87, 505]
- ☐ Do not know
- ☐ [76, 420]
- ☐ [105, 498]
- ☐ [86, 455]

A photo containing bikes has been taken (bikes.png). An RGB threshold is applied to this photo, so pixels within the limits  $R < 100$ ,  $G > 200$  and  $B > 100$  are set to foreground (1) and the rest of the pixels are set to background (0).

The resulting binary image is morphologically closed using a disk-shaped structuring element with radius = 8.

When doing the closing, the pixels beyond the image border are assigned a value of 0 for the dilation and 1 for the erosion (the default Matlab behavior).

A ground truth segmentation is provided in the file boxROI.png.

What is the DICE score between your segmentation and the ground truth segmentation?

[Data for the question \(bikes2.zip\).](#)

<https://resources.mcq.eksamen.dtu.dk/v1/af613c6f-ff96-4aa1-affe-783dc6b707d4>

Choose one answer

- ☐ Do not know
- ☐ 0.87
- ☐ 0.98
- ☐ 0.93
- ☐ 0.65
- ☐ 0.77

You have been asked to design a vision system for a self-driving robot. The first system should be able to classify grass, road, and sky and is using a gray level camera (where a pixel value of 0 is black and 255 is white). For training, you have received the following gray values:

Grass: 68, 65, 67

Road: 70, 80, 75

Sky: 77, 92, 89

For a parametric classifier, your gray level class ranges would be?

Choose one answer

- ☐ grass [0, 69] , road ]69, 88], sky ]88, 255]
- ☐ grass [0, 65] , road ]65, 83], sky ]83, 255]
- ☐ grass [0, 76] , road ]76, 83], sky ]83, 255]
- ☐ grass [0, 79] , road ]79, 83], sky ]83, 255]
- ☐ grass [0, 70[ , road [70, 81[, sky [81, 255]

A scan has been done on a CT scanner and stored as a DICOM file. One of the slices of the scan is stored as a DICOM file called 1-131.dcm. A low threshold,  $T_1=85$ , and a high threshold,  $T_2=400$ , are defined. The scan is segmented by setting pixels with values that are higher than  $T_1$  and lower than  $T_2$  to foreground (1) and the rest of the pixels to background (0).

A morphological closing with a disk-shaped structuring element with radius=5 is performed on the binary image, followed by a morphological opening with a disk-shaped structuring element with radius=3. When doing a dilation, pixels beyond the image border are assigned a value of 0 and when doing an erosion the pixels beyond the image border are assigned a value of 1 (the default Matlab behavior).

A BLOB analysis is then performed using 8-connectivity and only BLOBs with an area between 1000 and 4000 pixels are kept. How many BLOBs are there in the final image?

[Data for the question \(1-131.zip\)](#)

<https://resources.mcq.eksamen.dtu.dk/v1/744c139c-2d18-4ce3-91df-ffd5262adf01>

Choose one answer

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

You have been asked to design a vision system for a self-driving robot. The first system should be able to classify grass, road, and sky and is using a gray level camera (where a pixel value of 0 is black and 255 is white). For training, you have received the following gray values:

Grass: 68, 65, 67

Road: 70, 80, 75

Sky: 77, 92, 89

For a minimum distance classifier, your gray level class ranges would be?

Choose one answer

- ☐ grass [0, 63] , road ]63, 75], sky ]75, 255]
- ☐ grass [0, 55] , road ]55, 106], sky ]106, 255]
- ☐ grass [0, 49] , road ]49, 104], sky ]104, 255]
- ☐ grass [0, 71[ , road [71, 81[, sky [81, 255]
- ☐ grass [0, 75] , road ]75, 98], sky ]98, 255]
- ☐ Do not know

A photo containing bikes has been taken (bikes.png). An RGB treshold is applied to this photo, so pixels within the limits  $R < 100$ ,  $G > 200$  and  $B > 100$  are set to foreground (1) and the rest of the pixels are set to background (0).

The resulting binary image is morphologically closed using a disk-shaped structuring element with radius = 8.

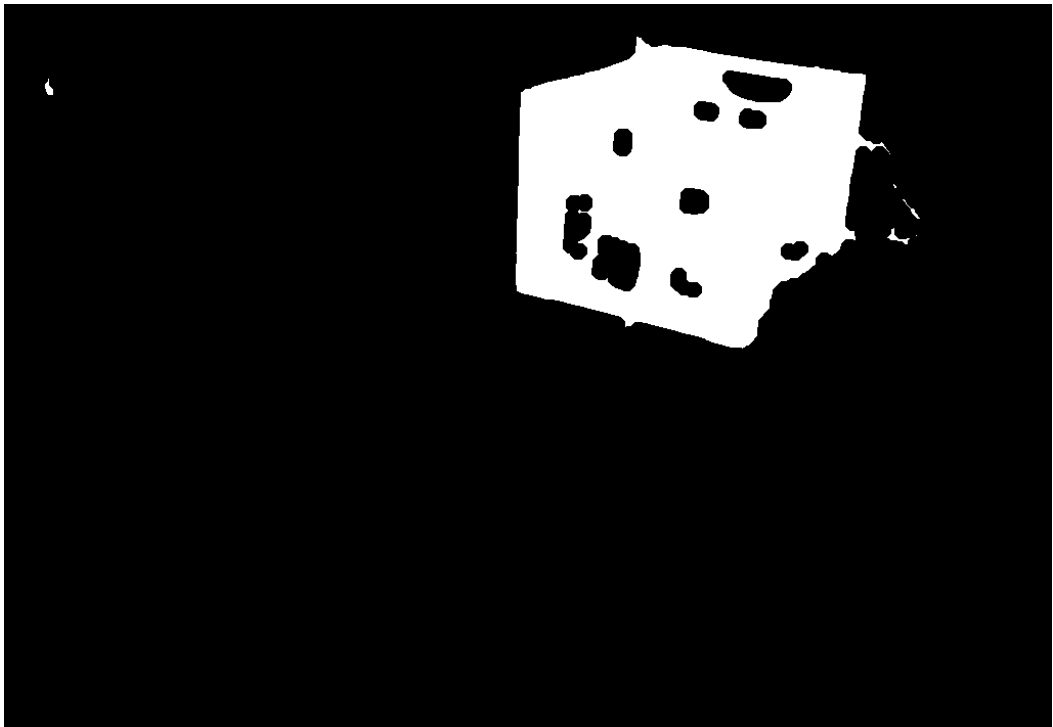
When doing the closing, the pixels beyond the image border are assigned a value of 0 for the dilation and 1 for the erosion (the default Matlab behavior).

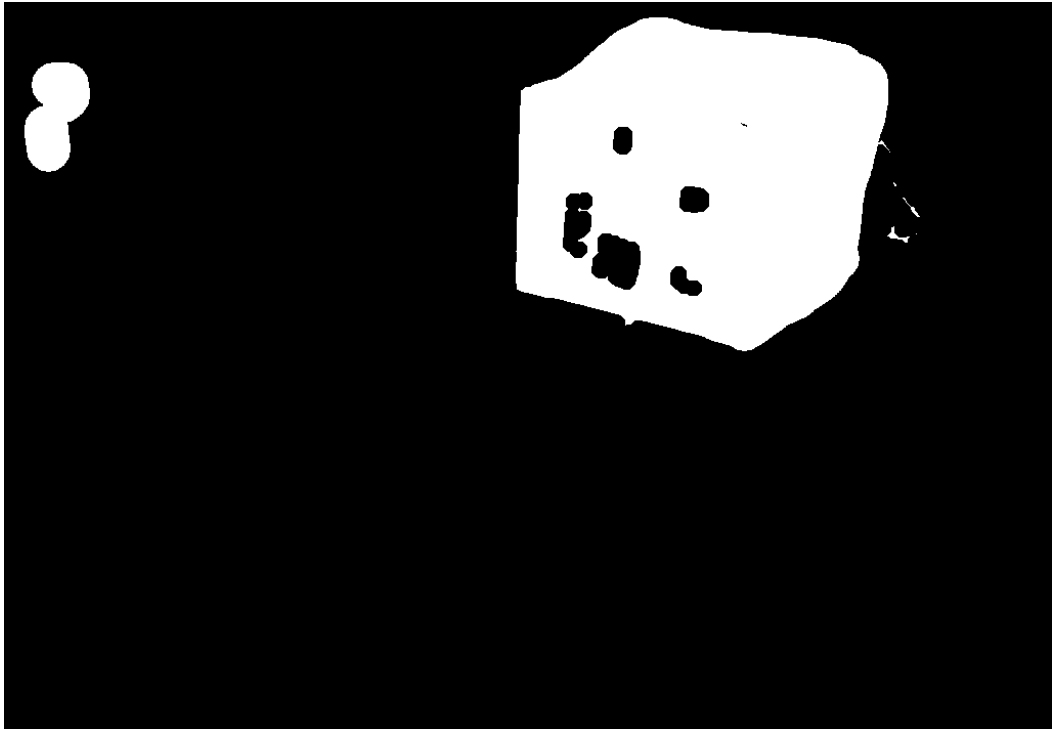
How does the resulting binary image look like?

[Data for the question \(bikes.zip\)](#)

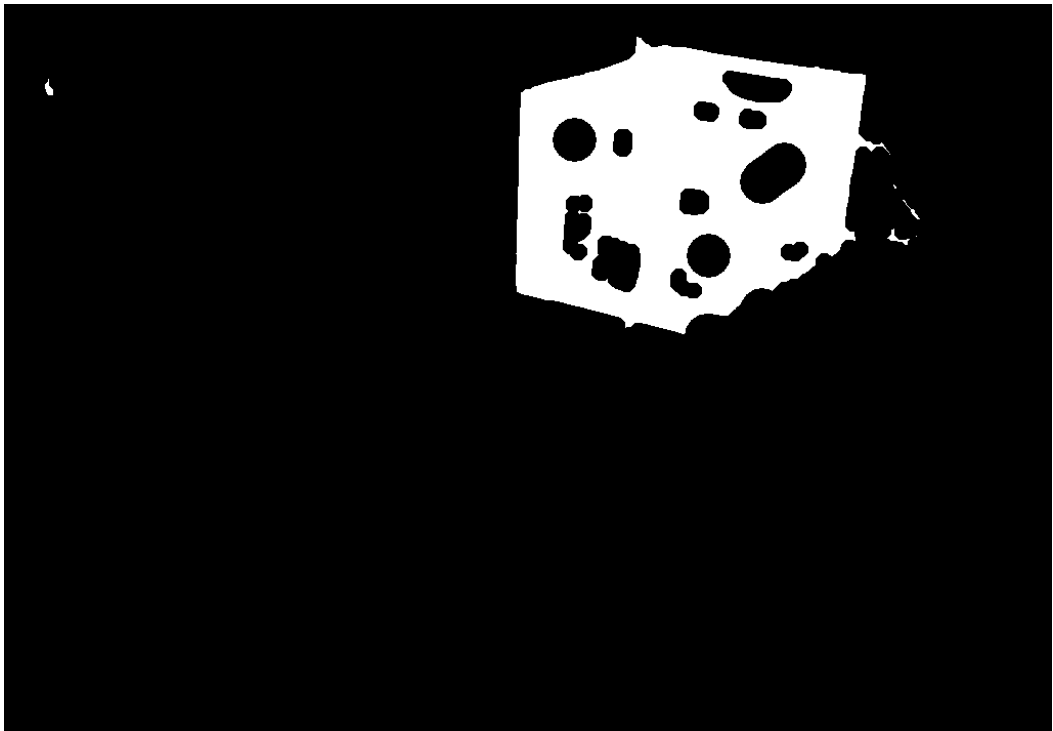
<https://resources.mcq.eksamen.dtu.dk/v1/4f808afa-23ae-4bf1-898b-570b6108a049>

Choose one answer

☐☐



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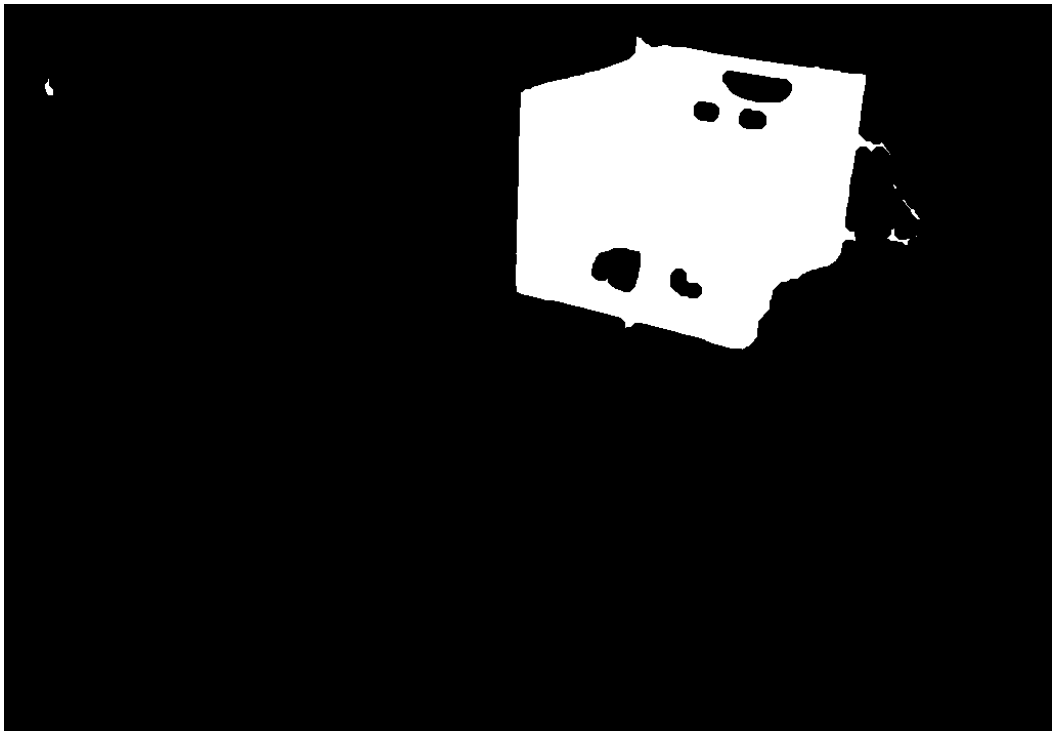


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Do not know

Six photos have been taken. They are named orchid001.png - orchid006.png. The dimensions of each photo are (W=400, H=533 pixels). A principal component analysis (PCA) is performed on the grey values of the six images. For this you can use the helper functions **pc\_evector.m** and **sortem.m**.

After the PCA, the first principal component is transformed back into an image. What is the value in this image at position (row=10, column=10) when using a 1-based matrix-based coordinate system?

[Data and scripts for the question \(ImagePCA\\_1.zip\)](#)

<https://resources.mcq.eksamen.dtu.dk/v1/057f463f-da26-45e2-9b92-85d17a6a7c10>

Choose one answer

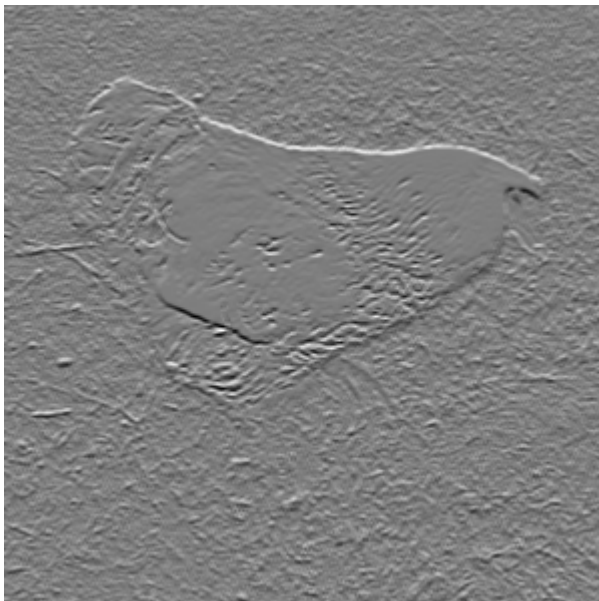
- ☐ -0.129
- ☐ Do not know
- ☐ 0.031
- ☐ 0.412
- ☐ -0.001
- ☐ 0.002

The photo called bird.png is converted from the RGB color space to the HSV color space. A new image is created by copying only the S component of the input image. The new image is then filtered with a vertical Prewitt filter (the default Matlab fspecial Prewitt filter) using border replication. The filtered image looks like this (you can use `imshow(I, [])` to show an image called I):

[Data for the question \(bird.zip\)](#)

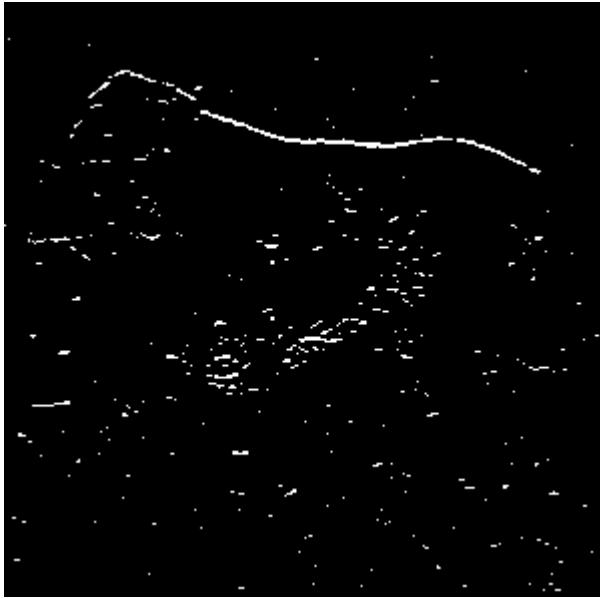
<https://resources.mcq.eksamen.dtu.dk/v1/0de713e3-889e-4726-be33-fd5e4abbd6e6>

Choose one answer

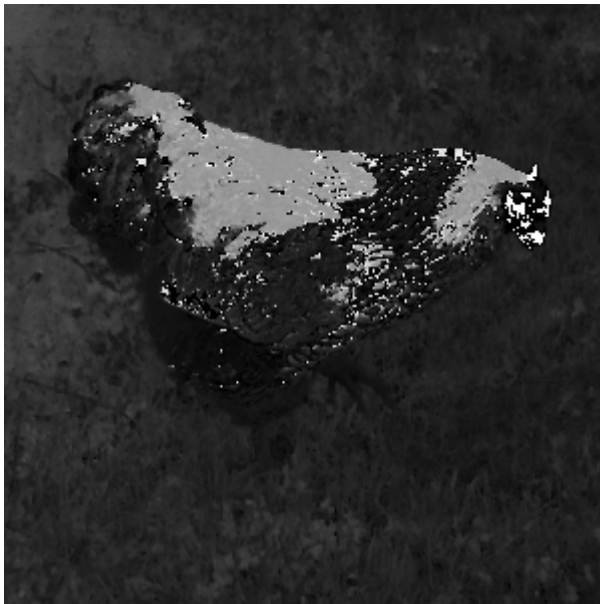
☐☐☐

Do not know

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Seven photos have been taken. They are named orchid001.png - orchid007.png. The dimensions of each photo are (W=400, H=533 pixels). A principal component analysis (PCA) is performed on the grey values of the six images (orchid001.png - orchid006.png). For this you can use the helper functions **pc\_evector.m** and **sortem.m**.

The photo called orchid007.png is now projected to the PCA space, where only the first principal component is kept. What is the projected value?

[Data and scripts for the question \(ImagePCA\\_2.zip\)](#)

<https://resources.mcq.eksamen.dtu.dk/v1/f3afe438-ddab-4d36-8700-1c99484fb465>

Choose one answer

- ☐ 2134
- ☐ 6311
- ☐ Do not know
- ☐ 9123
- ☐ 731
- ☐ -102

The photo called water\_gray.png is filtered using a 3x3 median filter. A linear histogram stretching is then performed on the filtered image so the new image has a maximum pixel value of 230 and a minimum pixel value of 12. What is the pixel value at (row=20, column=20) in the new image (a 1-based matrix coordinate system is used)?

[Data for the question \(water\\_gray.zip\)](#)  
(<https://resources.mcq.eksamen.dtu.dk/v1/e167ef8d-05aa-43ca-9103-b6ec75830e72>).

Choose one answer

- ☐ 217
- ☐ Do not know
- ☐ 199
- ☐ 240
- ☐ 167
- ☐ 155

A customer has asked you to design a prototype system for the inspection of children's plastic balls. You are setting up a camera with a CCD chip that measures  $5.4 \times 4.2$  mm and that has a focal length of  $f=15$  mm. It can be assumed that  $b=f$ . The photos from the camera have dimensions  $6480 \times 5040$  pixels. The camera is placed 1.5 meter from the ball, where the photos of the balls passing by are sharp. An example ball has been tested and the diameter of the ball is 2400 pixels on the photo. What is the physical diameter of the ball?

Choose one answer

- ☐ 25 cm
- ☐ 17 cm
- ☐ Do not know
- ☐ 15 cm
- ☐ 12 cm
- ☐ 20 cm

A friend has asked you to make a system, that can identify climbing holds on photos from the friend's climbing gym. A photo of a climbing wall (ClimbingWall.png) is provided. Your system initially computes a binary image by applying a RGB threshold where pixels with  $R < 60$ ,  $G < 200$ , and  $B < 100$  are set to foreground (1) and the rest of the pixels are set to background (0).

Secondly, a morphological closing with a disk-shaped structuring element with radius = 3 is performed. When doing a dilation, pixels beyond the image border are assigned a value of 0 and when doing an erosion the pixels beyond the image border are assigned a value of 1 (the default Matlab behavior).

After this, all BLOBs that are connected to the image border are removed. All BLOBs in the image are found using 8-connectivity. The area and the perimeter of the found BLOBs are computed and only the BLOBs with an area larger than 300 pixels and with a perimeter less than 500 are kept. How many BLOBs are there in the final image?

[Data for the question \(ClimbingWall.zip\)](#)

<https://resources.mcq.eksamen.dtu.dk/v1/aa038bce-2948-4b26-8b06-5bc4e74c81d2>

Choose one answer

- ☒ 20
- ☐ 23
- ☐ Do not know
- ☐ 24
- ☐ 15
- ☐ 18



An analysis of the nutrients of (N=300) pizzas has been performed and (M=7) values have been measured per pizza (moisture, protein, fat, ash, sodium, carbohydrates, and calories). These measurements can be found in the **pizza.txt** file.

A principal component analysis (PCA) should be done on these data. The nutrients of a new pizza are computed by adding 3 times the first principal component to the mean nutrient values. What is the moisture level of this new pizza?

[Data for the question \(pizza.zip\).](#)

<https://resources.mcq.eksamen.dtu.dk/v1/673b1f3c-65c2-4fa2-8baf-a2e9f7b85ad7>

Choose one answer

- ☐ 39.6
- ☐ 43.1
- ☐ Do not know
- ☐ 41.7
- ☐ 40.3
- ☐ 38.2

A vision system to classify two plant species as seen from a farming machine should be developed. What could be the main components in this system?

Choose one answer

- ☐ Gray-scale camera, morphological closing, dynamic programming.
- ☐ Pin hole camera, Hough-transformation, gamma-mapping.
- ☐ RGB camera, gamma-mapping, inverse threshold.
- ☐ Pin hole camera, dynamic programming, image registration.
- ☐ RGB camera, RGB thresholding, BLOB analysis, linear discriminant analysis (LDA) of BLOB features.
- ☐ Do not know

Two similar images have been acquired (donald\_1.png and donald\_2.png). Six corresponding landmarks have been placed on the two images and are stored in the files donaldfixedPoints.mat and donaldmovingPoints.mat. The center of mass (the average landmark position) has been computed for both sets of points. What is the Euclidean distance between these two center of masses?

[Data for the question \(Donald.zip\)](#)

<https://resources.mcq.eksamen.dtu.dk/v1/795303d5-a5d4-48c6-b826-4f6848df71f6>

Choose one answer

- ☐ 10.7
- ☐ 17.2
- ☐ 1.1
- ☐ 6.4
- ☐ Do not know
- ☐ 3.4

A path tracing using dynamic programming has been used to compute the optimal path from the top to the bottom of the image seen below. A 1-based Matrix coordinate system is used. What is the value of the back-tracing image at position (row=5, column=3)?

208	71	244	202	173	180
231	139	124	245	193	8
32	244	204	167	189	71
233	246	36	9	100	12
161	40	108	217	167	25
25	248	234	238	44	210

Choose one answer

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

