Lecturer: Prof. Pascal Fua
Course: CS442 Computer Vision
Date: 2021/05/04
Duration : 45 minutes

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Mock Exam

SCIPER : **111111**

Do not turn the page before the start of the exam. This document is double-sided, has 7 pages, the last ones possibly blank. Do not unstaple.

- All questions have one or more correct answers.
- The grading scheme is such that random answering is discouraged:
  - Each answer of a multiple choice question is awarded +1 point if correct and −1 point if incorrect. If the **whole** question is left unanswered no points (positive nor negative) are awarded. Note that "correct" means that a true answer should be ticked and that a false one should be left unticked.

	Correct answers:	Student's answers:	Grading:
a)	■	■	+1
b)	□	■	-1
c)	■	□	-1
d)	□	□	+1

  - The scores for separate questions are **not clipped to 0**, that is, you can get negative score for a question. negative points for answering it incorrectly.
- Use a **black or dark blue ballpen** and clearly erase with **correction fluid** if necessary.
- If a question is wrong, the teacher may decide to nullify it.

Respectez les consignes suivantes | Observe this guidelines | Beachten Sie bitte die unten stehenden Richtlinien

choisir une réponse | select an answer Antwort auswählen	ne PAS choisir une réponse | NOT select an answer NICHT Antwort auswählen	Corriger une réponse | Correct an answer Antwort korrigieren
☒ ☑ ■	□	

ce qu'il ne faut **PAS** faire | what should **NOT** be done | was man **NICHT** tun sollte

Question 1 Let's assume we are capturing an image of two objects using a camera. One object is closer to the camera and the other object is further away from the camera. In the captured image, both objects have the same height. What is true about these two objects? Note: Both objects are clearly visible in the image and there are no atmospheric effects causing any distortions.

■ The object further away from the camera is taller.
□ Both objects have the same height.
□ The object closer to the camera is taller.
□ We cannot conclude about their heights using only one image.

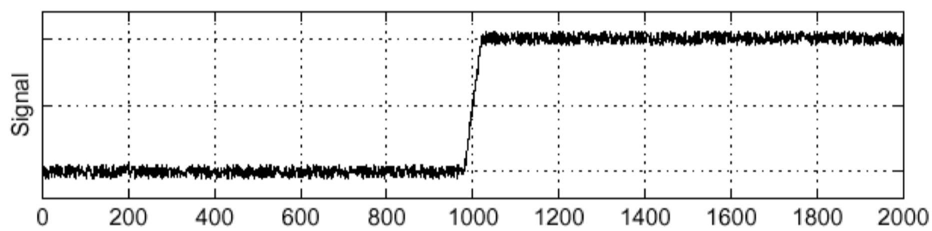
Question 2 Which statement(s) is(are) true about intrinsic and extrinsic parameter matrices?

■ Intrinsic parameter matrix converts image coordinates into pixels.
□ The projection matrix which is a function of extrinsic and intrinsic parameter matrices has 12 degrees of freedom.
■ Extrinsic parameter matrix converts world coordinates into camera coordinates.
□ The diagonal elements in the extrinsic parameter matrix account for different scaling in x and y direction of a pixel.

Question 3 What can happen to the image when you reduce the size of the hole in a pinhole camera?

■ Image can get sharper first and then will become blurry.
□ Image will get brighter.
□ The inverted-image become non-inverted.
■ Effects of diffraction can become visible.

Question 4



For the given signal f in this figure, which of the following statement(s) is(are) accurate?

■ The Gaussian kernel function can be used to remove the noise.
■ The Gaussian kernel function and differentiating function $\partial f/\partial x$ can be merged to one operator to speed up the edge detection.
■ A naive edge detection algorithm based on gradients performs poorly because of high frequency noise in the signal.
□ 1D convolution with a high-pass filter can effectively remove the high frequency noise.

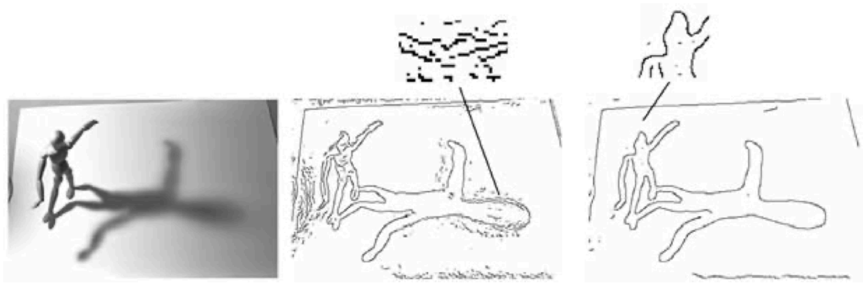
Question 5 Which of the following statement(s) is(are) true about removing high frequency noise from an image?

□ The Sobel operator is a suitable choice.
■ The discrete Fourier transform can be used.
■ Smoothing with a Gaussian kernel is fast because it is separable.
□ The Prewitt operator is a suitable choice.

Question 6 Which of the following statement(s) is(are) true about the edge detection algorithms?

- [ ] Deep learning methods are usually faster than the traditional edge detection methods.
- [ ] Convolutional neural networks cannot be combined with traditional algorithms to improve the detection.
- [x] For Canny edge detection the scale and the threshold settings must be chosen according to the application requirements.
- [x] Edge detection can be used for gradient-based tracking.

Question 7
In this figure, (a) is the input image and (b) is the edge detection result from Canny algorithm with scale $\sigma = 2$ and threshold $T1 = 1, T2 = 255$. Which of the following option(s) can improve the result to (c)?



(a) (b) (c)

- [ ] Run non-maxima suppression multiple times until (c) is observed.
- [x] Increase the scale and adjust the thresholds.
- [ ] Run Canny algorithm with the same setting multiple times until (c) is observed.
- [ ] Decrease the scale and adjust the thresholds.

Question 8 When using the ST min-cut algorithm to segment an image:

- [ ] node weights are proportional to pixel intensity.
- [x] two extra nodes are added.
- [x] the algorithm operates on very sparse graphs.
- [x] measures are taken to avoid short cuts.

Question 9 Region growing...

- [ ] works by directly minimizing a loss function.
- [ ] uses global cues when treating individual pixels.
- [x] is an instance of a greedy algorithm.
- [x] always converges.

Question 10 Some segmentation algorithms require that for each image processed, some examples of foreground and/or background pixels are provided. Those algorithms include:

- [x] Region Growing
- [ ] CNNs (such as U-net)
- [x] Graph theoretic methods
- [ ] Histogram splitting

Question 11 The key advantage(s) of using the Level Set Formalism for curve evolution is(are) that

- ☐ it explicitly represents the border/surface of the object.
- ☐ it's easier to control the smoothness of the curve.
- ☐ the user doesn't have to specify an initial curve.
- ■ it can change curve topology during evolution.

Question 12 Which statement(s) is(are) *true* about the Hough transform?

- ☐ When detecting ellipses, it is necessary to define an R-table.
- ■ When detecting a circle with a known radius, a 2D accumulator array is used.
- ■ It can detect partially visible circles.
- ☐ It can only detect lines and circles.

Question 13 State-of-the-art techniques in image delineation use Convolutional Neural Networks (CNNs). Which of the following statement(s) is(are) true with regards to that?

- ■ Binary cross-entropy can be used as one of the loss terms when training CNNs for delineation.
- ■ U-Net is a commonly used architecture to perform image delineation.
- ■ When performing iterative refinement to improve delineation, the same network can be used in each iteration.
- ☐ CNNs output a graph of the delineated paths.

Second part, essay question

Please answer in the space provided using a black or dark blue pen.
Leave the tick boxes empty; they are reserved for the corrector.

Question 14: We want to delineate several structures/shapes in the image below. They are indicated by letters A, B, C and D.

Figure 1: Areal view of the Rolex Learning Center and its surroundings.

1. Given that the user has manually specified points A and B, what is the most efficient algorithm to delineate the road edge connecting them? What properties of the road edge make it applicable?

   0 1 2 3 4 5

   Live-wire with 1D dynamic programming. Since the user has specified two points and there is a clear edge due to the high contrast between the road and the grass, we can use Live-wire algorithm. Since the road segment is approximately linear in the direction of A-B, we can use the 1D dynamic programming implementation.

2. The Hough transform can be used detect the shape C. Write down the steps of the algorithm you would implement.

   0 1 2 3 4 5 6 7 8

   - **Make an R-table for the shape to be located.**
   - **Form an accumulator array of possible reference points and initialize it to zero.**
   - **For each edge point,**
     * **Compute the possible centers,**
     * **Increment the accumulator array**
   - Find the maximum value in the accumulator array and return the corresponding parameters.

3. We now want to delineate the two squares highlighted in green near D. The green curve has been drawn manually and it surrounds these two squares. Our goal is to make it to fit the target. Which algorithm can be used to do it and what is the main reason to select this algorithm?

   0 1 2 3 4 5

   Level-set algorithm. It allows the curve to change its topology during curve evolution.

Question 15 : A student who is interested in computing gradient magnitudes of an image has written the following code snippet. Based on that, answer the questions.

```
import numpy as np
import cv2

# 1. Load a grayscale image
image = cv2.imread('images/test_image.png',0)

# 2. Convert to float from uint8
image = np.float32(image)

# 3. Compute gradients in x and y directions using the Sobel filter
grad_x = cv2.Sobel(image,ddepth=-1,dx=1,dy=0,ksize=3)
grad_y = cv2.Sobel(image,ddepth=-1,dx=0,dy=1,ksize=3)

# 4. Compute gradient magnitudes
grad_mag = np.sqrt(grad_x + grad_y)
```

1. Why is the data type of 'image' converted from 'uint8' to 'float32' in line #2.?

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uint8 can only hold integer values between 0 and 255. We can have pixel values outside this range when we apply Sobel filter. Therefore we convert it to 'float32' which can hold these values.

2. During the implementation the student has made a mistake. What is it?

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In line #4, when computing the magnitude, he has forgotten to take the square of 'grad_x' and 'grad_y'