Practice Exam

Note that in the actual exam, no calculators, no books, and no notes allowed.

Question 1: ____ out of ____ points
Question 2: ____ out of ____ points
Question 3: ____ out of ____ points
Question 4: ____ out of ____ points
Question 5: ____ out of ____ points
Question 6: ____ out of ____ points
Question 7: ____ out of ____ points
Question 8: ____ out of ____ points

Total Score:

Grade:
**Question 1: True or False?**

Tell whether each of the following statements is true or false by checking the appropriate box. Do not check any box if you do not know the right answer, because you will lose points for incorrect answers.

<table>
<thead>
<tr>
<th>Statement</th>
<th>True</th>
<th>False</th>
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<tbody>
<tr>
<td>a) For mean shift segmentation, we need to know the number of regions in advance.</td>
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<td>b) The Hough transform can only be used to detect straight lines.</td>
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<td>c) The median filter is especially well-suited for removing salt-and-pepper noise.</td>
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<td>d) The difference code of a curve does not change when we rotate the curve by 90 degrees.</td>
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<td>e) The Laplacian convolution filter computes the second derivative of the input image.</td>
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<td>f) When we move backward, the direction of optical flow throughout our visual field is perpendicular to the gradient of its magnitude.</td>
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<td>g) Textures with the same gray co-occurrence matrices are always identical.</td>
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<td>h) When we expand a binary image A and then shrink the result, we always obtain image A again.</td>
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<td>i) The slope density function of a triangle is zero everywhere except for three sharp peaks.</td>
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<td>j) There is no 2D shape with greater compactness (i.e. a smaller value for $P^2/A$) than a circle.</td>
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Question 2: Efficient Range Imaging

Imagine that you want to do range imaging through triangulation. In order to be efficient, you decide to use a pattern of eight vertical lines that only needs to be shifted by the distance between neighboring lines in order to measure the depth of all visible points in the scene. In order to avoid associating points with an incorrect vertical line, you take multiple images of the same scene with the pattern in the same position. In each picture, a different subset of lines is projected.

a) What is the minimum number of pictures that you need to take for each projection angle in order to be sure to determine the number of the line that any point belongs to? Why?

b) Derive a general formula that tells you for a given number of lines the minimum number of pictures necessary. Explain how you derived the formula.
Question 3: Polyline Splitting

Describe the algorithm for polyline splitting to approximate the shape of a contour by a sequence of connected straight lines. Use diagrams to illustrate the concept.
Question 4: Slope Density Functions

(a) Draw the slope density function of the following contour (let us say that an angle of $0^\circ$ means downward):

(b) Describe how this function changes if you mirror the contour along a horizontal axis, i.e., turn it upside-down. You can describe it in words or draw another diagram.
Question 5: Errors in Depth Perception

Having two eyes, we are able to perceive the depth (z-distance) of an object through binocular disparity information. As you know, we can also give our computer vision system two cameras and let it do the same thing. The question is: How accurate is its estimation of depth, and on what factors does this accuracy depend?

The main problem here is the limited accuracy and resolution of the cameras. Let us say that the actual position of an object in the camera image may be up to one millimeter to the left or to the right of its actual position. For example, if the left camera measures \( x_l = 5.3 \text{ mm} \), it means that the object’s actual position could be anywhere between \( x_l = 5.2 \text{ mm} \) and \( x_l = 5.4 \text{ mm} \).

(a) Given this camera accuracy, what is the z-range that an object could have (i.e., the minimum and maximum z-distance possible), if the cameras with baseline \( b = 10 \text{ cm} \) and focal length \( f = 20 \text{ cm} \) measure positions \( x_l = 6.1 \) and \( x_r = 5.1 \)? If you do not remember the equation, try to derive it; it is not very difficult.

(b) What do you think will happen if the object is much further away from the system? Will the error in z-distance measurement (i.e., the z-range) increase or decrease? Why?

(c) What do you think will happen if we keep the object in the same place as in (a), but increase the distance between the cameras, i.e., the baseline \( b \)? Will the error in z-distance measurement (i.e., the z-range) increase or decrease? Why?

(d) If we increase the baseline, another problem becomes more and more difficult. What problem is that?
**Question 6: Teaching the Artificial Brain**

Describe the basic principles underlying supervised learning in artificial neural networks. For example, how is the network “presented” with the information that it is supposed to learn? How does the learning happen, i.e., what changes in the network, and based on what criteria? Use at least two paragraphs to outline the most important ideas. Do not use any equations.
Question 7: Signature, Please!

Use the diagram on the right to sketch the signature of the contour on the left. It does not have to be perfectly scaled. Choose any starting point you like and indicate it on the contour on the left.

Question 8 (Bonus Question): Tricking the Difference Image Technique

In difference images, pixel values greater than zero (or greater than a certain threshold) are thought to reflect moving objects in the scene. However, this does not always have to be the case. There are other factors besides object motion that can cause non-zero values in a difference image. List as many such factors as you can think of.