# UNIVERSITY OF OSLO

## Faculty of Mathematics and Natural Sciences

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| **Exam:** | **IN5520 / IN9520 – Digital image analysis** |
| **Date:** | **Friday December 10, 2021** |
| **Exam hours:** | **09.00-13.00 (4 hours)** |
| **Number of pages:** | **6 pages** |
| **Enclosures:** | **None** |

**It is important that you read the cover pages carefully before you start.**

**General information:**

- Important messages during the exam are given directly from the course teacher on the course's semester page. It is therefore important that you check the course's semester page regularly.
- Your answer should reflect your own independent work and should be a result of your own learning and work effort.
- All sources of information are allowed for written home exams. If you reproduce a text from books, online articles, etc., a reference to these sources must be provided to avoid suspicions of plagiarism. This also applies if a text is translated from other languages.
- You are responsible for ensuring that your exam answers are not available to others during the exam period, neither physically nor digitally.
- Remember that your exam answers must be anonymous; do not state either your name or that of fellow students.
- If you want to withdraw from the exam, press the hamburger menu at the top right of Inspera and select "Withdraw".
- You should spend your time in such a manner that you get to answer all exercises.
    - If you get stuck on one question, move on to the next question.
- Your answers should be **short**, typically a few sentences and / or a sketch should be sufficient.
- Do not give just a numerical answer, but demonstrate your reasoning.
- There are 6 exercises. They are weighted proportional to the number of sub-questions.
- During the exam, there will be a Zoom session for questions starting at 10.00 and 12.00. Look through the exercise set before this to identify all your questions. When you join the Zoom session, you will be placed in a waiting room and admitted to the meeting room with course teachers when there are no other students in the meeting room. In the meeting room, you should ask questions orally. The Zoom sessions will be ended when there are no more students in the waiting room and at least 15 minutes has passed since the Zoom session started. Link to the Zoom session will be placed at the course webpage and sent to students on email a couple of days before the exam.

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### Collaboration during the exam:

It is not allowed to collaborate or communicate with others during the exam. Cooperation and communication will be considered as attempted cheating. A plagiarism control is performed on all submitted exams where text similarities between answers are checked. If you use notes that have been prepared in collaboration with others before the exam, this might be detected in a plagiarism control. Textual similarities such as these can be considered by graders as a show of low independence or even attempted cheating. Refrain from copying/pasting from notes made in collaboration with others.

### Use of sources:

The answer must be written with an academic standard. Read UiO's website Use of sources and citations

### Cheats:

Read about what is considered cheating on UiO's website.

## Digital hand drawing / file upload

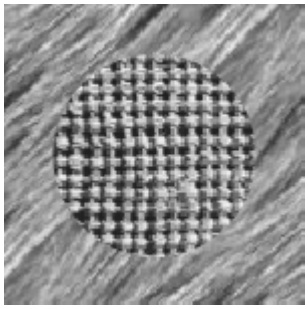
You have been given 30 min. extra time for uploading files (e.g. digital hand drawings). Check out how to submit digital hand drawings

## Contact information: User support exam

*Good luck!*

# Exercise 1: Detection of circle with different texture

You will in this task segment and detect the circle with different texture than its surroundings in the following gray level image with 150x150 pixels. For segmentation you will use the gray level co-occurrence matrix (GLCM), and for detection of circle you will use the Hough transform.



a) Assume you have extracted one local window from within the circle and one local window from a region outside the circle, e.g. in the upper left quadrant. Discuss how you would choose the GLCM parameters so that the resulting GLCMs are most different.

b) Assume you have obtained GLCMs that are more concentrated along the diagonal for one texture than for the other texture in the image. Propose one common GLCM feature that could be used to capture this difference and explain why it will provide different values for the different textures.

c) Describe how you would compute a GLCM feature image for the initial image. Include a discussion of how you would choose the value of any new parameter.

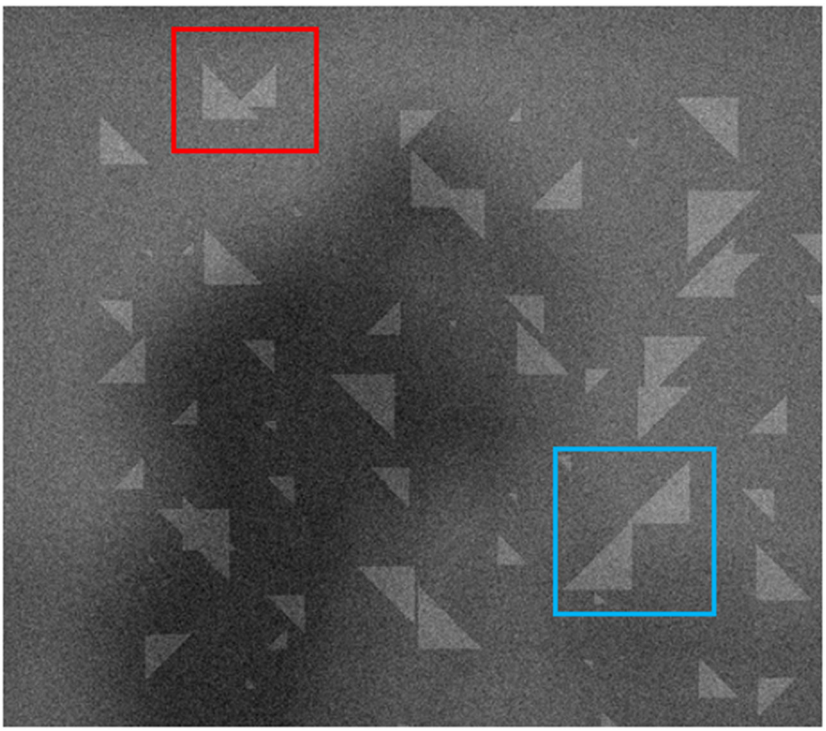
d) Assume you have applied a global threshold on the GLCM feature image to obtain a binary image which could be seen as a segmentation of the circle with different texture in the initial image. Describe how you could use mathematical morphology to obtain a binary image with foreground pixels only at or close to the boundary of the circle.

e) Describe how you could apply the Hough transform to detect the circle with different texture in the initial image.

f) If the region with different texture is elliptical but not circular, suggest a way to detect the ellipse using the Hough transform without using a 5-dimensional accumulator matrix. In particular, specify how all 5 parameters of the ellipse can be obtained.

## Exercise 2: Identifying and counting triangles

Assume that you are assigned the task of designing an algorithm than can count the number of equiangular solid triangular objects in images. The input is a gray level image, and it may contain some noise. The purpose of this exercise is to suggest all steps in an algorithm, and justify them based on how/why you think the algorithm will work. Use the image in the figure below when discussing your approach.



a) Discuss if you want to apply any preprocessing step, and which effect in the image they should aim to reduce/remove.

b) Discuss steps necessary to obtain a region-based representation of the image.

c) Briefly mention 3 different features/approaches you could use to determine if a given region object is a triangle. Select one of these as your recommended feature/approach.

d) If triangles overlap, like in the blue or red regions in the figure above, suggest a method to split overlapping regions into two objects.

## Exercise 3: A classification application

a) You are to work on a data set with medical images taken from three different hospitals (100 gray level images from each hospital), and you observe some changes in contrast and brightness between the images. Discuss if you want to do any preprocessing on the images prior to feature extraction and classification.

b) Discuss how you would divide the data into train, validation, and test subsets. Please justify your answer.

c) **PhD students ONLY:** How would you measure and report how well a particular classifier performs? Justify your answer.

## Exercise 4: General feature extraction questions

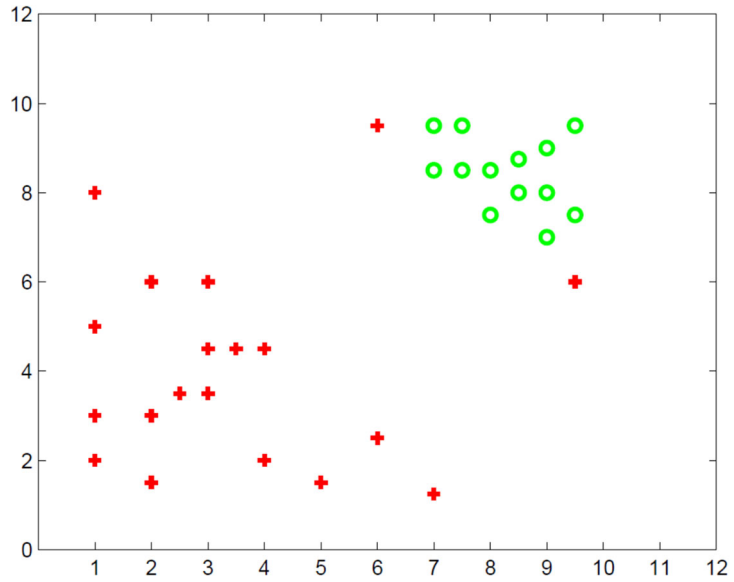
a) Describe briefly two approaches that use second-order central moments to obtain shape features that are invariant to rotation.

b) Describe briefly each step in an algorithm to compute an object-oriented bounding box.

c) You have a 10-dimensional feature vector for a data set with labels and you want to gain insight into how the features separate the classes. Propose a method to do this.

## Exercise 5: Support vector machines (SVM)

Assume the following is a scatter plot of the feature values for the set of training samples. Green circles indicate one class, and red plusses indicate the other class.




a) Describe by words the criterion function that a linear SVM with slack variables tries to optimize.

b) For a general SVM with a radial basis function kernel and a large value of σ (let us discard C in this subtask), sketch where the boundary may be.

c) For a general SVM with a radial basis function kernel and a small value of σ (let us discard C in this subtask), sketch where the boundary may be.

d) Draw a point which will not change the decision boundary from c) learned for a small value of σ. Your sketch should include the original scatter plot and the new point.

e) Draw a point which will significantly change the decision boundary from c) learned for small values of σ, and a rough sketch of the new decision boundary. Your sketch should include the original scatter plot, the new point and the new decision boundary.

## Exercise 6: Feature selection

Assume that you have data from 3 classes with equal diagonal covariance matrices, and that the class means on the training data are:

$$\mu_1 = \begin{bmatrix}1\\1\end{bmatrix} \quad \mu_2 = \begin{bmatrix}2\\3\end{bmatrix} \quad \mu_3 = \begin{bmatrix}4\\6\end{bmatrix}$$

a) If you want to do feature selection based on a measure of class separation based on Euclidean distance between the classes, discuss briefly which distance you would select for these 3 classes.

b) Compute your selected criterion for the classes above.

c) **PhD students ONLY:** Compute the ranking of the features based on sequential backward feature selection for this criterion.

***Thank You for Your Attention!***