11 December 2007	**Image Understanding Exam**	10.00 – 11.30
Matr.Nummer: Kennzahl:	Nachname (Last Name): Vorname (First Name):	

The maximum number of points that can be obtained is 30. Please use the space provided for answering questions. The answers should be short but comprehensive. You may answer in English or German. **This is a closed-book exam.**

Bei der vorliegenden Prüfung können Sie eine maximale Anzahl von 30 Punkten erreichen. Bitte verwenden Sie den für die Beantwortung der Frage vorgesehen Platz und beantworten Sie die folgenden Fragen kurz aber aussagekräftig. Sie können die Fragen auf Englisch oder Deutsch beantworten. **Keine Unterlagen sind erlaubt.**

1 Mathematical Morphology

- What is *geodesic distance*? (1 point)

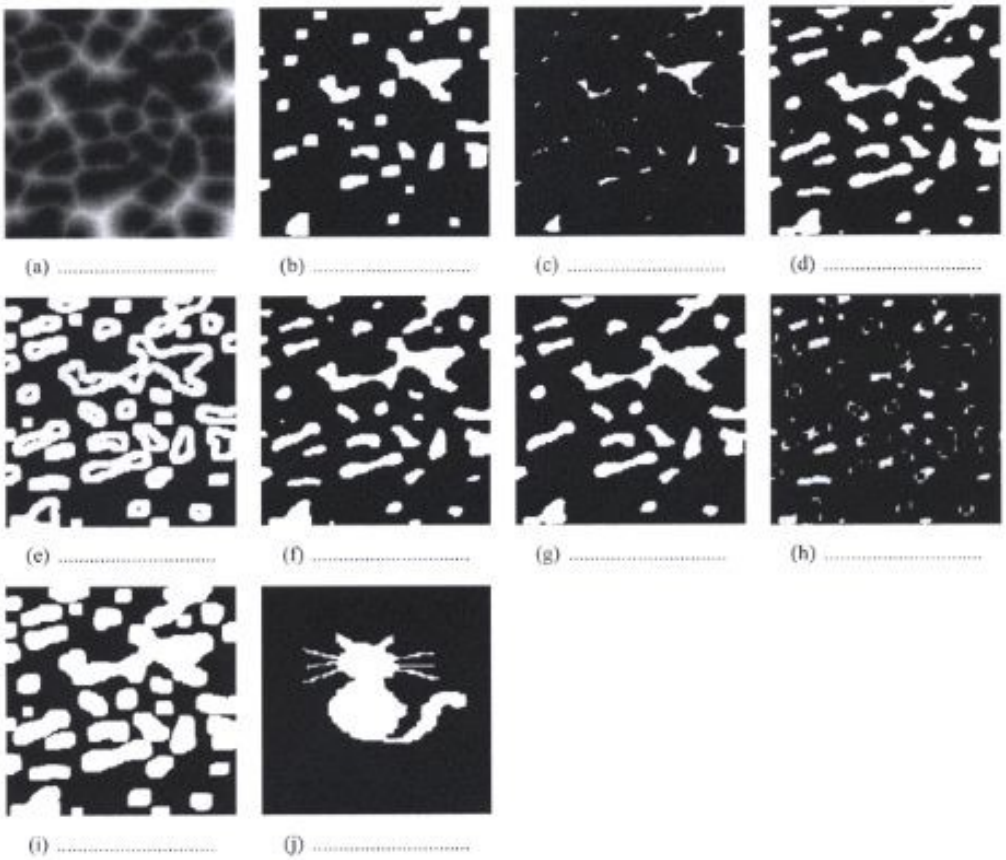
- What is an *extensive* operator? Give an example of an extensive operator. (2 points)

- On page 3 are some binary images. The foreground is shown by white pixels. Below each of these images, write a number corresponding to one of the operations listed at the top of page 2. The notation used is: ϵ_B — erosion, δ_B — dilation, γ_B — opening, φ_B — closing. For these operations, B is always a square structuring element of size 4. $R_X(Y)$ is the reconstruction by dilation of marker Y inside mask X. I is the original binary image. Not every label must be assigned to an image (i.e. there are more labels than images). (3 points)

The labels below are to be assigned to the images on the next page (write only the number from 1 to 15 below an image):

1. I (i.e. original image)
2. $\epsilon_B(I)$
3. $\delta_B(I)$
4. $\gamma_B(I)$
5. $\varphi_B(I)$
6. $R_I(\gamma_B(I))$
7. $R_I(\epsilon_B(I))$
8. $R_I(\delta_B(I))$
9. distance function applied to the foreground of I.
10. distance function applied to the background of I.
11. $\epsilon_B(I) - \delta_B(I)$
12. $\delta_B(I) - \epsilon_B(I)$
13. Top-hat with opening (i.e. white top-hat)
14. Top-hat with closing (i.e. black top-hat)
15. An image that is not involved in any of the operations.

- Describe what the h-maxima transformation does and how it works. Illustrate your description with a diagram showing how it works on a function of one variable (i.e. greylevels in a single row). (2 points)



(a) ..... (b) ..... (c) ..... (d) .....

(e) ..... (f) ..... (g) ..... (h) .....

(i) ..... (j) .....

2 Greyscale image processing

- What is the aim of *histogram equalisation*? (1 point)

- Write down a 3×3 convolution kernel that can be used to detect horizontal edges in an image. (1 point)

3 Skeletons

- Give one of the definitions for the skeleton of a set in Euclidean space. (1 point)

- Name a digital skeletonisation algorithm which always produces a skeleton homotopic to the input image. (1 point)

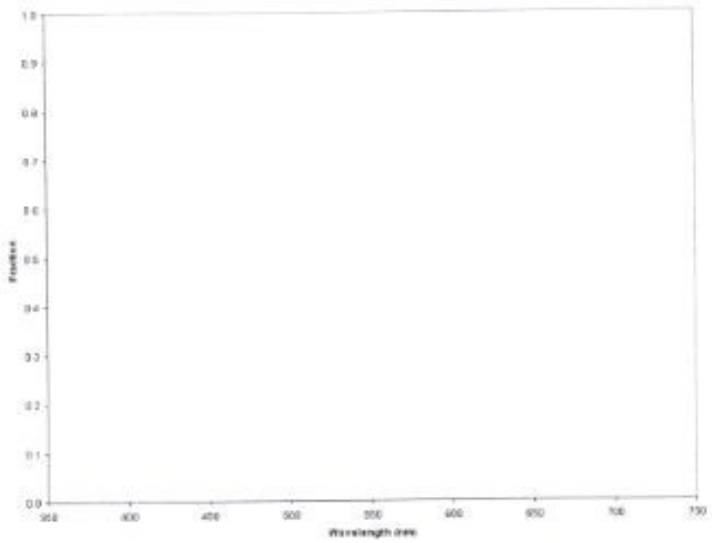
4 Colour

- What could be a good reason to use the CIELAB colour space? (1 point)

- Describe how an Opponent Colour Space (OCS) is constructed from the RGB space. (1 point)

- What is *gamma correction*? Why do video cameras apply a gamma correction? What is the typical value of γ for a computer monitor? (2 points)

- Draw, as a function of wavelength λ, what the transmittance $\tau(\lambda)$, absorption $\alpha(\lambda)$ and reflection $\rho(\lambda)$ could look like for a *blue, translucent plastic material*. Use the axes below. Label the curves clearly. Don't forget the conservation of energy! (2 points)



- Give the name of and describe one simple algorithm that can be used to estimate the colour of the illuminant of an image. (1 point)

5 Texture

- Describe how a morphological granulometry curve for a greyscale image is calculated. What is implied by the use of negative sizes for the structuring element? What information can one obtain from the granulometry curve? How does this information depend on the structuring element used? How is the *pattern spectrum* calculated from the granulometry curve? (3 points)

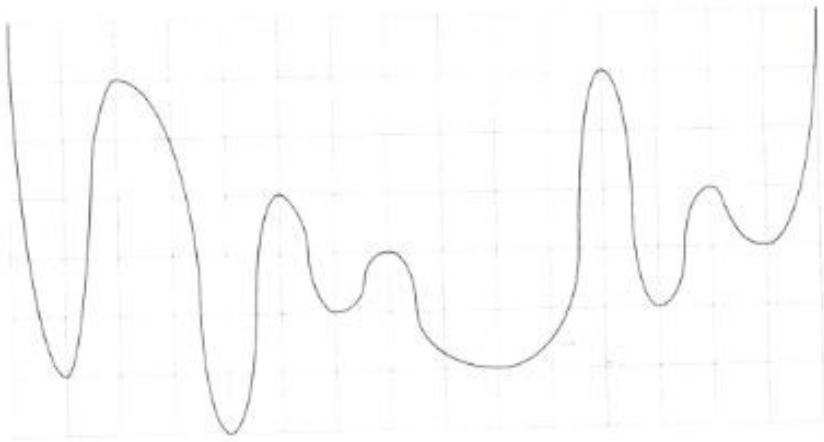
- Give the name of any texture analysis algorithm, except the granulometry. (1 point)

6 Segmentation

- What is the difference between *Edge-based segmentation* and *region-based segmentation* approaches? Why is the *Watershed segmentation algorithm* considered to be a combination of edge-based and region-based approaches? (2 points)

- Explain how a watershed hierarchy using *synchronous flooding* is built. On the given example function, do **ONLY ONE** of the following for a *synchronous flooding based on depth*:
  - draw the resulting hierarchy. The order in which the basins fuse should be clear from the hierarchy.
  - draw the resulting minimum spanning tree. Make sure that the weights on the edges are given. Take one grey block in the diagram as having a width and height of 1.

  (2 points)



7 CBIR and Object Recognition

- What is the *Semantic Gap* and why does it exist? (1 point)

- What are *narrow image domains* and *broad image domains*? Give an example of each. (2 points)