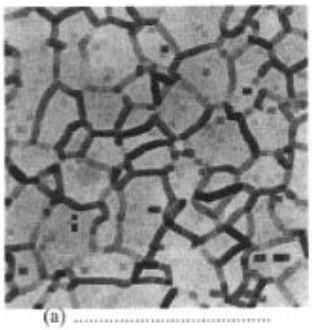
9 January 2008	**Image Understanding Exam**	14.00 – 15.30
Matr.Nummer: Kennzahl:	Nachname (Last Name): Vorname (First Name):	

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.

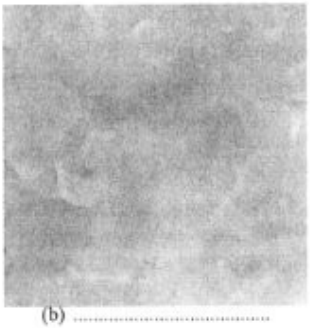
Bei der vorliegenden Prüfung können Sie eine maximale Anzahl von 30 Punkten erreichen. Bitte verwenden Sie den für die Beantwortung der Frage vorgesehen Platz und beantworten Sie die folgenden Fragen kurz aber aussagekräftig. Sie können die Fragen auf Englisch oder Deutsch beantworten.

1 Mathematical Morphology

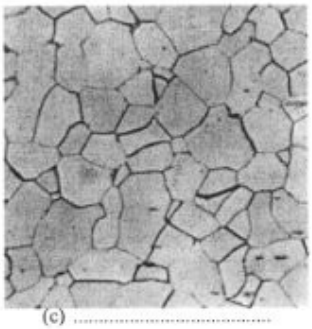
- Below are three greylevel images. One is the original image (size 256×256 pixels), one is the erosion of the original image and the other is the dilation of the original image. Both these are done with a square structuring element of size 2. Write in the labels *original*, *erosion* and *dilation* below the images. (1 point)



(a) .....



(b) .....



(c) .....

- What is *idempotency*? Name one morphological operator which is idempotent. (2 points)

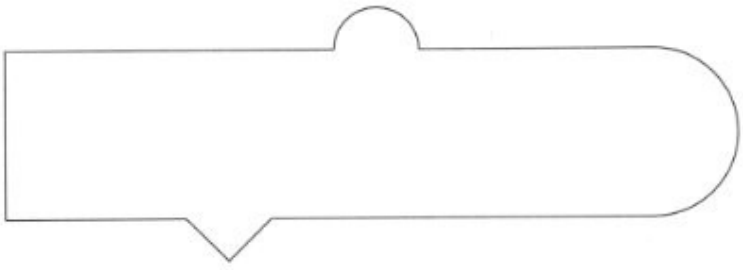
- Explain the difference between morphological dilation and morphological *geodesic* dilation. Illustrate the difference using one-dimensional functions. (2 points)

- Describe what the h-maxima transformation does and how it works. Illustrate your description with a diagram showing how it works on a one-dimensional function. (2 points)

- Describe the *hit-or-miss transform* for a binary image, being sure to mention why a *composite structuring element* is used. (2 points).

2 Skeletons

- Draw the Euclidean skeleton of the following shape (1 point):



- Which digital skeletonisation algorithm is guaranteed to produce a skeleton which is homotopic to the original shape? (Give only its name) (1 point)

3 Colour

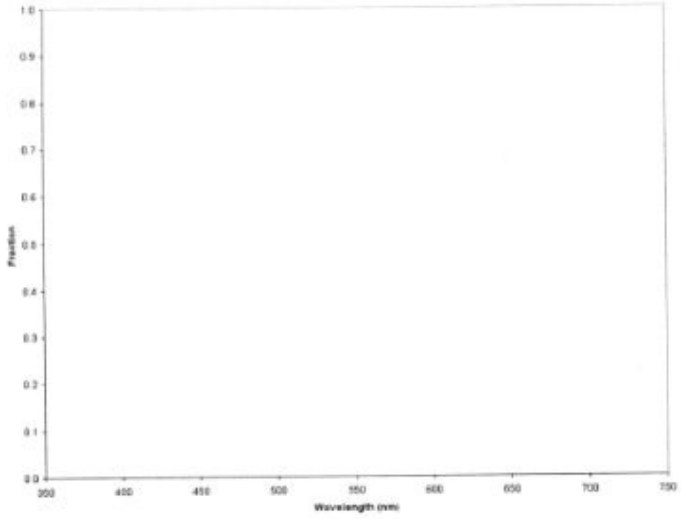
- What is meant by *marginal processing* and *vectorial processing* of colour images? (1 point)

- What is *computational colour constancy*? Describe how and why computational colour constancy could play an important role in algorithms for the automatic recognition of objects in colour images. (2 points)

- You apply a 3×3 averaging filter to a *hue* image. Calculate the average hue for the following neighbourhood of pixel values (note that the numbers represent angles measured in degrees) (2 points):

350	6	10
10	355	290
320	0	1

- 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 any colour space other then RGB. (1 point)

4 Texture

- Calculate the co-occurrence matrix $P_{0°,1}$ for the following 4×4 image containing 4 greylevels ($0°$ indicates the horizontal direction.) (2 points)

2	0	0	2
2	0	3	1
1	3	3	2
1	2	3	3

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

5 Segmentation

- Explain how the watershed segmentation algorithm can be modelled as a flooding of a topographical surface. Demonstrate how it works on a one-dimensional function. (3 points)

- How does the use of minima imposition change the segmentation produced by the watershed algorithm? (1 point)

6 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)

- Why is it difficult to develop an algorithm that can recognise all cars in the following images? Give three reasons. (1 point)

  1.

  2.

  3.