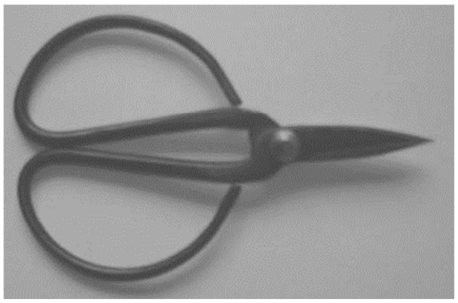
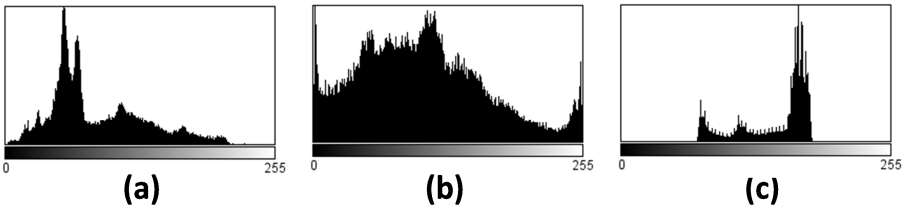
Exam Intelligent Sensors Theme 10 (4-12-2011, 10.30-12.00)

1. Consider a picture of a Chinese scissor.

   a. Which of the three histograms corresponds to the shown picture? Motivate your choice. (5p)





   b. Draw an example of a linear grayscale transformation that could enhance the contrast of the picture. (5p)

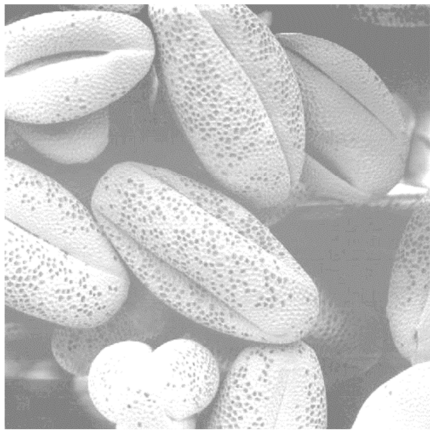
2. In a dishonest casino employees are ordered to secretly switch back-and-forth between a fair die and a loaded die. The loaded die has a 50 % chance of rolling a '6', whereas the chance of rolling a '1', '2', '3', '4' or '5' is 10%. On average casino employees switch between dices every 5 turns.

   a. Draw a Hidden Markov Model for the rolling of dices in this casino. Indicate the hidden states and the observed output of the model.(6p)
   b. Given that the casino employee starts with a fair die, calculate for each possible sequence of hidden states the probability of observing the sequence '1', '6', '6'. (8p)
   c. Describe the assumption upon which the Viterbi algorithm is based. (3p)
   d. A casino employee rolls the following sequence: '1', '6', '6'.
      Assuming that the casino employee starts with the fair die what is the most likely sequence of states according to the Viterbi algorithm. Does the Viterbi algorithm yield the best solution? (6p)

More questions on the reverse side!

3. On the image indicated with “Original” the following nine operations have been applied:

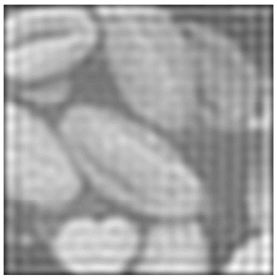
   A. Maximum filter
   B. Minimum filter
   C. Mean filter
   D. Threshold filter
   E. Ideal LowPass filter
   F. Ideal HighPass filter
   G. Laplace operator
   H. Sobel operator (both directions)
   I. Histogram equalization



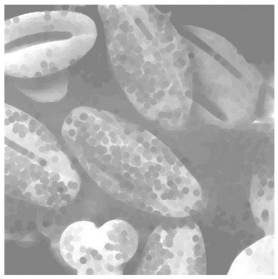
Original

The results of the nine operations are depicted below.

a. Denote for each of the images the corresponding operation. Motivate your choices. (12p).

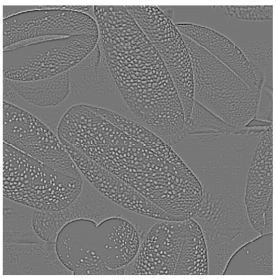


(1)

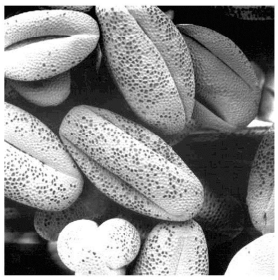


(2)

(3)



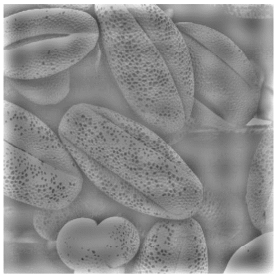
(4)



(5)

(6)

(7)

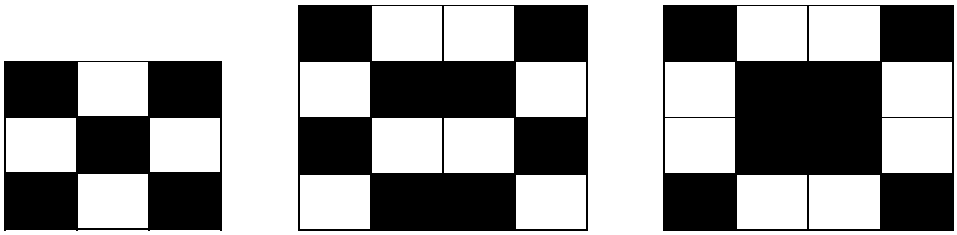


(8)

(9)

More questions on the next page!

4. Consider the following three patterns:



(a) (b) (c)

a. Construct a Hopfield network that is capable of recognizing pattern (a). Are there any other patterns that are recognized by this Hopfield network? (10p)
b. Write down the asynchronous update rule for an arbitrary Hopfield network. (4p)
c. Describe in words the phenomenon "Cross-talk". (3p)
d. Will a Hopfield network that is designed to recognize patterns (b) and (c) suffer from cross-talk? (3p)

5. This exercise deals with Principal Component Analysis (PCA). Consider the following four grey-scale images consisting of nine pixels.

2	0	0
0	2	0
0	0	2

(a)

0	0	2
0	2	0
2	0	0

(b)

0	2	0
0	2	0
0	2	0

(c)

1	1	0
2	2	2
0	0	0

(d)

a. Prove, by calculation, that the most important principal component for the nine-dimensional dataset represented by the two grey-scale images (a) and (b) is given by the vector $u = \frac{1}{2}(1, 0, -1, 0, 0, 0, -1, 0, 1)^T$. (10p)
b. Calculate the approximation $\tilde{c}$ of image (c) in the space formed by the principal component u. (7p)
   Calculate the error made by approximating image (c) with $\tilde{c}$.
c. Use the Mahalonabis distance to determine which of the images (a) and (b) is closest to image (c). (4p)
d. Use the Mahalonabis distance to determine which of the images (a) and (b) is closest to image (d). (4p)

THE END!

Maximum score: 90 points

Mark = 1 + (<collected score> / 10)