Speech Signal Processing

Exercise 4

1. Signal estimation

   (a) Given is a signal $x(n)$, which is produced by an autoregressive (AR) process:

   $$x(0) = 1,00 \quad x(1) = -0,75 \quad x(2) = -0,1042$$
   $$x(3) = 0,0781 \quad x(4) = 0,3859$$

   Additionally we are given the predictor coefficients of different orders:

   1. order: $a_1 = -0,4$
   2. order: $a_1 = -0,5556 \quad a_2 = -0,3889$
   4. order: $a_1 = -0,75 \quad a_2 = -0,6667 \quad a_3 = -0,5 \quad a_4 = 0,0$

   (b) Compute the function values of $y(n)$ with initial value $y(0) = 1$. Use the predictor coefficients of 1st, 2nd and 4th order.

   (c) Sketch $x(n)$ and $y(n)$ (for all orders) and compute the error signal $e(n)$ between $x(n)$ and $y(n)$.

   (d) What is most probably the order of the original AR process which produced $x(n)$?

2. Principal Component Analysis (PCA)

   (a) Given are the data values of the two classes K_1 and K_2:

   $$x_1 = \begin{pmatrix} -1 \\ 1 \end{pmatrix} \; x_2 = \begin{pmatrix} 2 \\ 2 \end{pmatrix} \quad y_1 = \begin{pmatrix} -2 \\ 0 \end{pmatrix} \; y_2 = \begin{pmatrix} 1 \\ -1 \end{pmatrix}$$

   (b) Sketch the data values and compute the overall mean M_0 and the class specific means M_1 and M_2.

   (c) Calculate the covariance matrix C and determine its eigenvalues.

   (d) Transform the data values in the one dimensional space by using the eigenvector related to the biggest eigenvalue. Interpret your solution.

3. Linear Discriminant Analysis (LDA)

   (a) Estimate the within class covariance matrix S_W and the total covariance matrix S_T by using the data values from the last exercise.

   (b) Compute the LDA-matrix and transform the data points into the one dimensional space.

   (c) Compare the results to the results you got with PCA.