Tfy-99.3275 - Biosignal Processing

Exam 21.12.2007 09:00-12:00

For each question a maximum of 6 points can be earned (thus: 5 * 6 = 30 points in total). Possible points from the exercises will be added to these points.

You may answer the questions in English as well as in Finnish.

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1. Answer shortly to the following questions:
   a) Give an example of an (almost) deterministic biosignal and a stochastic biosignal (2p)
   b) Describe aliasing graphically in the time domain. (2p)
   c) What do does the phase response of a filter tell us? Why is it important for many biosignal processing applications that the phase response is linear? (2p)

2.
   a) One way to extract small signals from a noisy background is to use synchronized averaging. Describe *in detail* how this averaging technique works and how the signal-to-noise ratio improves and what kind of assumptions you use when applying this technique. (3p)
   b) A researcher designs an artefact-detection algorithm for EEG signals on the basis of a few publicly available EEG 'normal subject' data records that are known to be artefact free. Using this data he derives as detection limits [mean-3*standard deviation, mean+3*standard deviation] employing the idea that in such case about 99.7% of artefact-free data will be accepted for further processing. However, upon trying out the algorithm in a 'real-life' situation in a hospital, the results are disappointing – many false alarms (false artefact detections) are generated. Give three possible reasons why this could happen. (3p)

3.

A home health monitoring system consists of a weight scale, a noninvasive blood pressure meter and a beat-to-beat heart rate meter. The subjects are instructed to measure their weight every morning, blood pressure every morning and evening, and heart rate continuously during daytime. The data are recorded for one year. The data are stored and transferred automatically to a database. Your task is to analyze the data and calculate the correlation between the signals and to identify possible regular rhythms such as a week rhythm in the signals.

   a) List two typical special challenges for signal analysis in the personal health monitoring setting (such as described above). Provide an example how each of these challenges may occur (e.g. by using the setting described above). (2p)
   b) Describe a possible strategy for estimating the correlation between heart rate and blood pressure signals. (2p)
   c) Describe a possible method for estimating the power spectral density of the blood pressure signal in this example application. (2 p)

4.

a) Give three examples of artefacts/disturbances that can occur when measuring electrophysiological data and explain how we can avoid them (or at least decrease their effect) in the measurement set-up (that is, not using signal processing methods). (3p)

b) Explain why we need feature selection in many signal processing applications and describe 2 techniques to perform feature selection (3p)

5.

When building a system to automatically detect a condition of 'cardiac failure' in an intensive care unit we have knowledge available about how a clinician may decide whether a patient state of 'cardiac failure' is present or whether the patient is 'normal'. He makes a decision on the basis of recorded signals 'Cardiac Index', 'filling pressure', body temperature and 'urine output'. His knowledge is summarised as follows

The patient has cardiac failure, if:

- The patient has low Cardiac Index ($CI < 2.0$) and high filling pressure ($FP > 10$)
- (optional) The patient has a low body temperature ($T < 32C$)
- (optional) The patient has low urine output (less than 0.5 - 1.0 ml/kg/h, over 2h)

a) With this knowledge available, if you had to implement a system recognizing cardiac failure, what kind of pattern recognition / classification system would you use in first instance? Why? (2p)

b) Suppose you have built the system that automatically classifies recorded data into 'cardiac failure' or 'normal' using the knowledge above and you are going to test it with a test set. You get the following confusion matrix.

true patient state patient state according to developed system	normal	cardiac failure
normal	12057	3940
cardiac failure	1154	4833

What are the sensitivity, specificity, accuracy, and positive and negative prediction values of this system? (2p)

c) From the confusion matrix in b) it appears your system is not perfect, although you developed it with help from a clinician and used his knowledge in it. Give two reasons why the performance may be less than optimal. (2p)

[END]