Tfy-99.4275 – Signal Processing in Biomedical Engineering

Exam 22.12.08 16:00-19:00

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.

1.

The Nyquist sampling theorem is a well-known concept in signal processing; not adhering to it may cause serious problems (aliasing).

a) Give 2 possible reasons, one biomedical and one technical, why sometimes this theorem is not adhered to even if the experimenter is well-aware of its existence (2p)

b) Give one possible use in signal processing of the L1 norm (1p)

c) What does a linear phase response of a filter mean? (1p) Explain why linear phase response of filters is a very useful property in many biomedical signal processing applications (2p)

2.

a) To obtain the power spectrum of a signal we can use either parametric or non-parametric methods. Give two differences (advantages/disadvantages) in their applicability when comparing the two methods. (2 p)

b) A researcher obtains the power spectrum of Figure 1 (next page) by analysing her data using the periodogram method. She has 1024 data points which she analysed as one segment of 1024 points. She thinks that the data exhibit two narrow peaks around 0.02 Hz and 0.08 Hz and a broad peak around 0.1 Hz. She asks for your help to find a 'better' method of spectral analysis to see if these features are actually present in the spectrum. What would you recommend and why? *Be specific.* (4 p)
(Notes:
- the researcher cannot obtain any more data from this experiment but she can do more experiments of the same type, if necessary. Due to limitations on the experimental design, however, the length of one data record is limited to that corresponding to the spectrum in the Figure 1.
- there are possibly several solutions/recommendations of methods you could give; describing one method of your choice is enough)

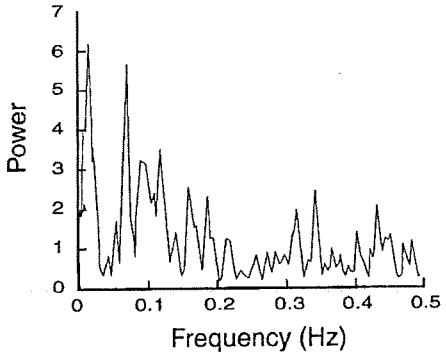

Figure 1: Power spectrum (periodogram)

3.

a) Describe in detail how we can use an adaptive filter to cancel noise present in an ECG recording that is caused by electrosurgical equipment in the operating room. (Include a schematic drawing showing the main principles; inputs, outputs, give learning rule etc.) (4 p)

b) Give 2 reasons why use of wavelets may be preferred over the short-term Fourier transform to describe time-frequency contents in many biomedical signals (2p).

4.

c) Give 2 reasons why Bispectral analysis could be useful to analyse (biomedical) signal (2p)

d) Describe how a return map (Poincaré plot) is constructed. Give an example of its usage. (2p)

e) Give an example of a complexity measure and briefly describe its working principle (2p)

5.

a) Suppose you have developed 2 different biosignal interpretation systems for detecting a certain patient state (disease vs. 'normal') in a hospital. One uses neural networks and the other one uses an expert system. Supposing they have exactly the same performance and functionality - which one would be easier to 'sell' to the hospital staff? Why? (2 p)

b) The systems were designed using a data set consisting of recorded data labeled with accompanying 'patient states' as defined by expert clinician Dr. X in Hospital H. What kind of problems might you encounter when introducing your system to another hospital? How would you decide when your performance is 'good enough' for introducing it on the market? (2 p)

c) Suppose you have built the system that automatically classifies recorded data into 'disease A' or 'normal' cases 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	disease A
normal	8723	783
disease A	231	2900

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

[END]