NBE-E4050 – Signal Processing in Biomedical Engineering

Exam 9 April 2019

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

A calculator is not needed nor allowed.
You may answer the questions in English or in Finnish.

1.

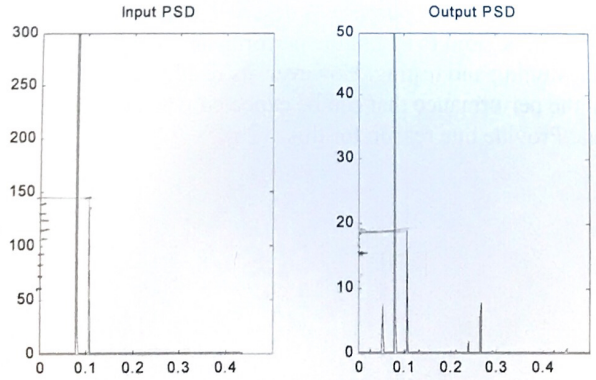
a) What does a *linear phase* response of a filter mean? (1p)
Explain why linear phase response of filters is a very useful property in many biomedical signal processing applications. (1p)

b) The sampling (Shannon) theorem is a well-known concept. In practical situations however, sampling at incorrect rates may occur. Give *two* reasons why this might happen. (2p)

c) Explain, in detail, how one can use the unit-impulse response, $h(n)$, to calculate the output of a linear time-invariant (LTI) system in response to any input sequence. (2p)

2.

a) We have a system whose input power spectral density (PSD) is provided on the left and the output PSD on the right. Is the system a linear time-invariant (LTI) system? Give arguments. (2p)



b) An AR model of a signal gives us the possibility to estimate the power spectral density (PSD) of the signal. However, to use that approach we need to check the validity of some assumptions; give two of them. (2 p)

c) The Wiener filter gives us the definition of a so-called optimal filter in the mean-squared error (MSE) sense. Implementing and using this filter in practice however is not that straightforward. What kind of problem is there especially if we want to use the filter in reality? (2p)

3.

a) Wavelet analysis is a popular technique to describe (biomedical) signals. What can you say about the frequency resolution of a wavelet transform when compared to that of a Fourier transform? (2p)

b) Describe how a median filter works, and give one positive and one less-positive property of this type of filter (2p).

c) From a signal processing point of view, adaptive filters (like, e.g., the adaptive linear element) and artificial neural networks are related. Give one example of a property that they have in common, and one in which they differ. (2p)

4.

a) What is the difference between a signal that behaves randomly and one that behaves chaotically? Give one example of a random signal and one of a chaotic signal (2p)

b) Segmentation is an important step in signal analysis. Describe one possible algorithm/method to carry out segmentation in which the segment size is not fixed but variable. (2p)

c) Give one example of a complexity measure, and an example of a practical application of it. (2p)

5.

a) In assessing the performance of a system we often use the terms like eg 'sensitivity' and 'positive prediction value'. Explain (either using formulas/example numbers, or words) what the two actually mean if we are talking about the performance of a system that is used to make a diagnosis classification like; "person has a disease" versus "person is healthy." (2p).

b) ROC curves can be used for different purposes – describe two of them. (2p)

c) k-fold cross validation can be used to assess the performance of eg a classifier - it uses different data for training and testing. However, its results are likely to be too positive compared to the performance that can be expected when using the data in 'real life' on new data. Provide one reason for this. (2p)

[END]