Tfy-99.4275 – Signal Processing in Biomedical Engineering

Exam 14.01.09 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 home exercises will be added to these points.

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

1.

Answer shortly to the following questions:

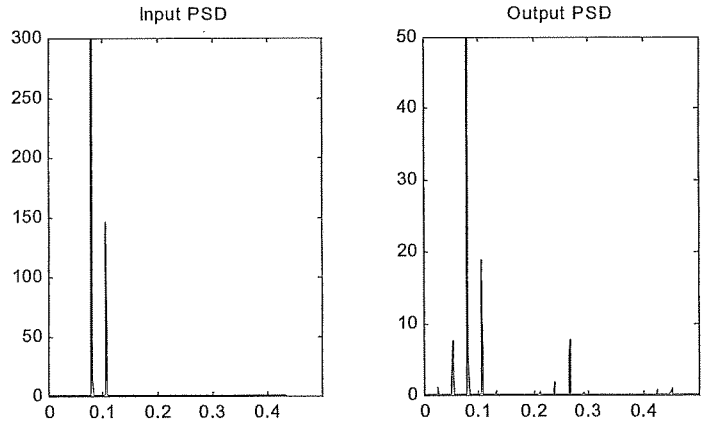
a) Stability and norms:

1 – Define the L_1, L_2 and L_∞-norms, and explain which features of the signal each of them emphasise, respectively. (2p)
2 – Define the term 'stability'. (1p)
3 – Suppose we have a linear system with impulse response $h(k)$, which is a rational function with zeros z_i and poles p_i. How do we know whether this linear system is stable or not? (1p)

b) Describe aliasing graphically in time- or in the frequency- domain. (2p)

2.

a) We have a system whose input 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)



In autoregressive modelling a signal is represented as an output of a mathematical model.

b) Give a mathematical presentation of the autoregressive (AR) model. (2 p)

c) 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)

3.
Using artificial neural networks (ANNs) is one way to approach classification problems.

a) What kind of problems are ANNs typically useful for? (think of properties of the problem to solve, data requirements etc) (2p)

Another popular technique concerns the use of wavelets to describe biomedical signals. Description of a signal using wavelets is quite similar to descriptions using Fourier series in the sense that in both cases an expansion of functions is used.

b) What can you say about the frequency resolution of both representations? (2p)

c) What is the difference between a scaling function and a wavelet function? (2p)

4.

a) Describe how a weighted median filter works. What is its main advantage over a 'usual' median filter? (2p)

b) Give an example of a complexity measure and briefly describe its working principle and give a possible example of its usage in biomedical signal processing (3p)

c) What is the difference between a signal that behaves randomly and one that behaves chaotically? (1p)

5.

a) In assessing the performance of a system we often use the terms 'sensitivity' and 'specificity'. 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; "disease present" or "disease not present." (2p).

For many systems that are developed using a training process, the minimization of the *error* is central to the training process. Usually, the error for an applied input pattern is calculated as the difference between the *desired* system output and the *actual* system output. The sum of magnitudes of the errors made on the test patterns is then used to assess the performance of the system.

b) Assume we want to develop a system that classifies patterns into 2 patient states to find the presence of a serious illness. The system is supposed to give outputs:
1 if the patient has an disease, and
0 if the patient does not have the disease.
Explain why in this particular case it might not be such a good idea to just straightforwardly add all magnitudes of errors to assess the performance/usefulness of the system and *propose an alternative*. (2p)

c) In a study investigating the performance of a possible monitor for measuring depth of sedation, the relationship between a clinician's observation of the patient state (graded on scale with numbers 1-6, see table below) and data values as obtained from the monitor is examined. What complications may arise when estimating performance based purely on comparing numbers of the monitor output

with numbers on this scale? There are several of them, mentioning ***two*** of them is enough. (2p)

Table 1: Ramsay scale for assessment of level of sedation

Scale Value	Patient is:
1	anxious or restless or both
2	co-operative, orientated and tranquil
3	responding to commands
4	giving brisk response to stimulus
5	giving sluggish response to stimulus
6	giving no response to stimulus

[END]