Tfy-99.275 - Signal Processing in Biomedical Engineering

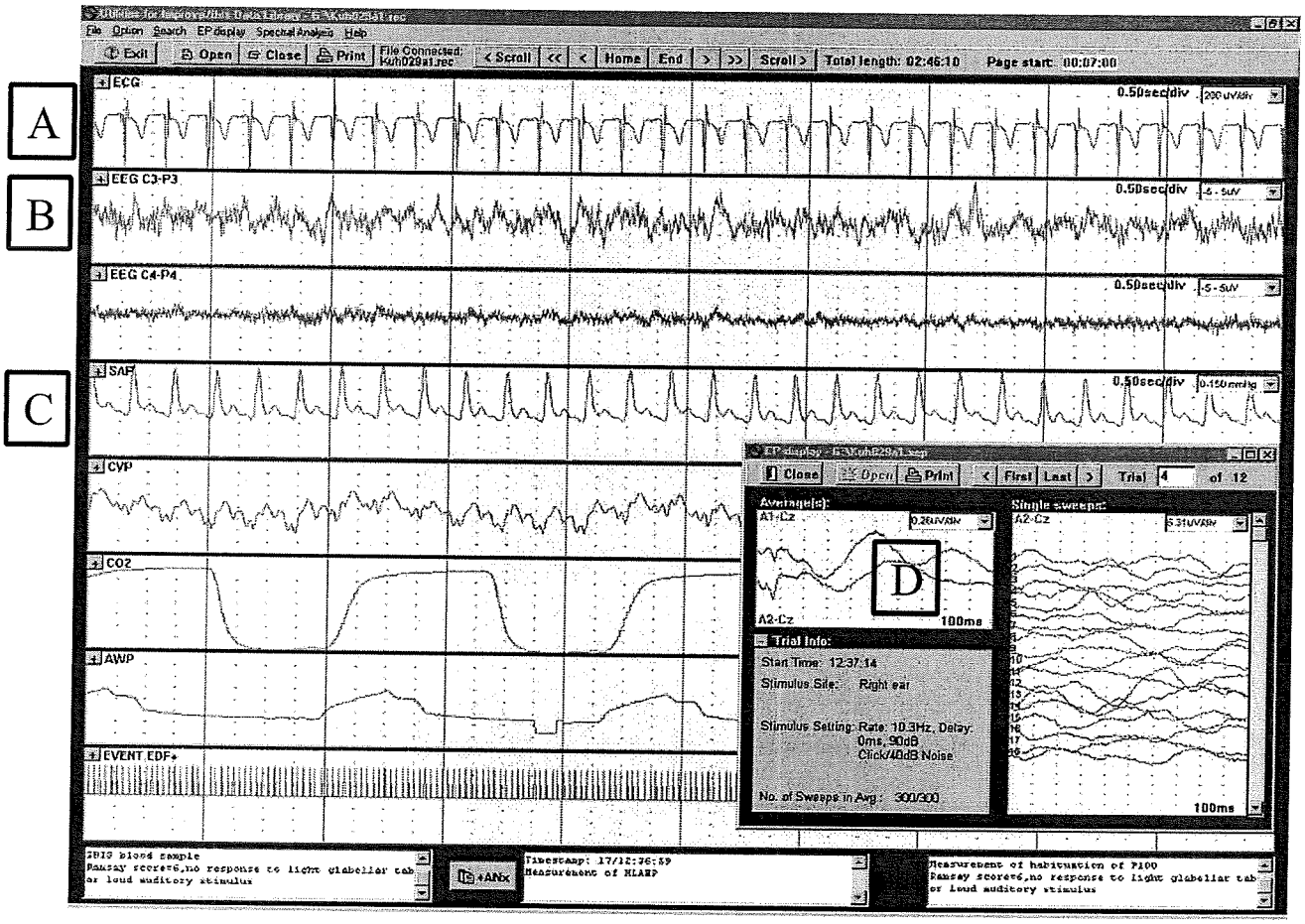
Exam 20.12.2004 **09:00-12:00**

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.

---

1. In the picture below you see part (20 seconds) of a recording of physiological signals measured from a patient in an intensive care unit.

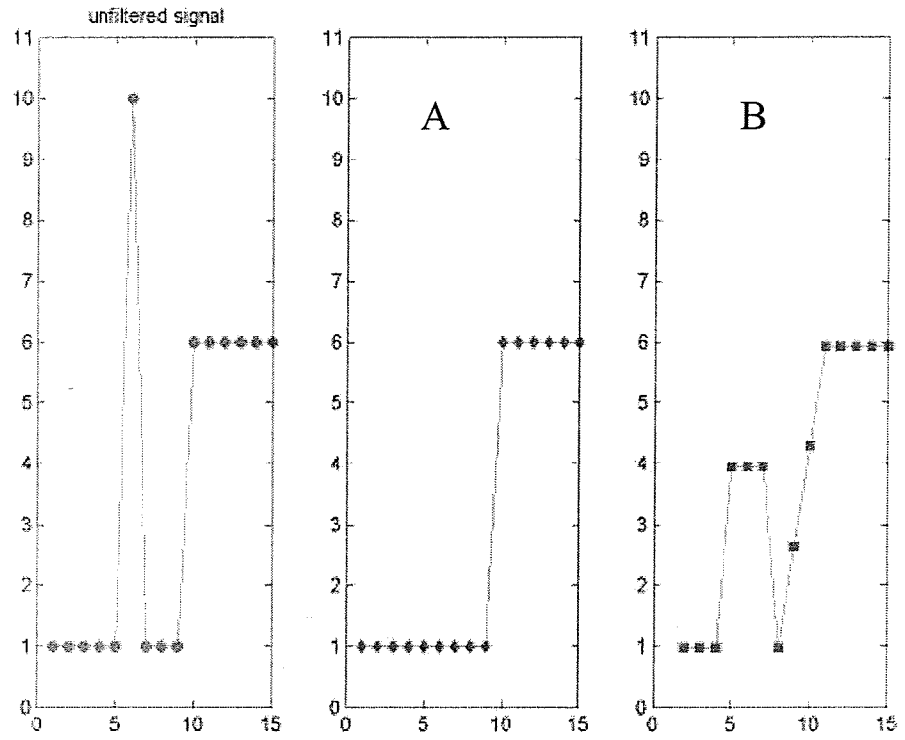


a) Consider the signals marked A (cardiac activity (ECG) data), B (brain activity (EEG) data), C (blood pressure (SAP) data), and D (brain activity (evoked potential) data).
Which of these signals may, for practical purposes, considered to be: (2p)
1 - (almost) deterministic
2 - stochastic
3 - transient
4 - (almost) periodic

b) Suppose you would like to check whether signal B can be considered to be (weakly) stationary or not, describe a method how you could do that. (2p)

c) Signal B was sampled at a rate of 250 Hz. In order to avoid aliasing we need to use an anti-aliasing filter on the data before sampling. What would be the best cut-off frequency of an ***ideal*** anti-aliasing filter in this case? How should you choose the cut-off frequency (qualitatively as compared to the ideal case) if you implement the anti-aliasing filter in practice? (2p)

2.



The signal in the left panel of the figure above is filtered with 2 different filters (both having 3 filter coefficients). Output of the filter A is depicted in the middle panel, and the output of the filter B is depicted on the right.

a) One is the output of a FIR filter and one of a median filter - which is which? (1p)
b) Name two possible advantages and one disadvantage of a median filter when compared to a FIR filter. (3p)
c) If we use an adaptive filter containing one adaptive linear element that updates its (randomly initialised) weights using the *delta rule* to minimise mean squared errors, the filter weights (or: coefficients) will eventually converge so that we get an optimal filter output. If we use as filter a neural network that uses the *generalised delta rule* to update weights to minimise mean squared errors there is no guarantee that we will eventually get an optimal output. Wherein lies the difference? (more than one answer possible, but one good one will suffice). (2p)

3.

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) Explain how one can obtain data compression by using a wavelet transform. For what kind of (general shape of) signals would you use wavelets? (2p)
c) What is the difference between a wavelet function and a scaling function? (2p)

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) 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)

5.

a) If we have extracted a set of features that covers many different aspects of a recorded signal, why would one want to reduce the size of such a feature set in many applications? (2p)
b) Many methods to perform feature selection exist. Describe two of them. (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 that has arbitrary, but ordered, numbers, 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]