TAMPEREEN TEKNILLINEN YLIOPISTO

LTT - 4106 - Processing of Physiological Signals

Exam 14.05.2007

Answer the questions in English or in Finnish. 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.

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1 Basics.
a) Define the term and give an example of a biomedical signal, which may be considered to be (at least almost):
   1) Deterministic (1p)
   2) Stochastic (1p)
b) While developing biomedical signal processing methods one usually needs to collect a representative set of experimental data to be used in optimization of the methods. In which terms the experimental data needs to be *representative* and why? (2p)
c) EEG is sampled at 200Hz. You use DFT to transform the signal into the frequency domain. How long a data window you need (in seconds) to have a frequency resolution of 0.5Hz? (1p)
d) The recorded EEG signal is found to have low entropy. Define what this intuitively means. (1p)

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2 Home health monitoring
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 the awakening time. The data are recorded for one year. The data are stored and transferred automatically to a database. Your challenge 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 four typical special challenges for signal analysis in the home 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). (4p)
   b) Describe a possible strategy for estimating the correlation between heart rate and blood pressure signals. (1p)
   c) Describe two possible strategies for estimating the power spectral density of the blood pressure signal. (1p)

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3 Artefacts and noise
For the application of recording EEG signals, name and describe one potential source or cause of each of the following types of an artefact:
   a) high-frequency noise,
   b) periodic artefact, and
   c) a short-lasting, abrupt, artefact.
In each case, explain (in detail):
   1) what the cause of the artefact could be, and
   2) how you could remove or prevent the occurrence of the artefact. (6p)

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4 Artificial neural networks and wavelets
   a) In solving biomedical signal processing problems, use of artificial neural networks (ANNs) is one often-used method. For what kind of problems ANNs are typically useful for? (think, for example, of the type of problem to be solved, and properties of available data) (2 p)
   b) Another popular technique concerns the use of wavelets to describe biomedical signals. What are the differences in frequency resolution of wavelet and Fourier representations? (2 p)
   c) Give 2 examples in which the description of a biomedical signal using wavelets may be more appropriate than using a Fourier representation, and explain why wavelets are more appropriate. (2 p)

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5 Decision support systems and performance evaluation.
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'. In this example, he makes a decision on the basis of recorded signals 'Cardiac Index (CI)', 'Filling Pressure (FP)', 'Body Temperature (BT)' and 'Urine Output (UO)'. 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 the cardiac failure, what kind of pattern recognition / classification system would you use in first instance? Why? (2p)
   b) Suppose you have built a system that automatically classifies recorded data into 'Cardiac Failure' or 'Normal' using the knowledge above and you test it with a test data 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 have developed it with help from a clinician and used his knowledge in it. Give two reasons why the performance of the system may be less than optimal. (2p)

[END]