UNIVERSITY OF CALGARY

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

ENEL 563 BIOMEDICAL SIGNAL ANALYSIS

Final Examination

Wednesday, December 15, 2004 ENA 3 Time: 12:00 – 3:00 p.m.

Total: 50 Marks

NOTE:
1. This is a closed-book exam.
2. Calculators with text/program storage capabilities are not allowed.
3. Answer all questions.
4. In case of problems requiring numerical or algebraic manipulation, show all steps clearly.
   In case of problems requiring descriptive answers, provide clear statements in point form; long essays are not required.
   In case of problems requiring algorithms, provide the reason/logic for each step.
5. Specify units or dimensions when appropriate.
6. In drawing plots of signals, spectra, etc. label the axes clearly.

Marks

3 **1.** Draw a schematic diagram of a motor unit including labels (names) for each part. Explain the generation of the EMG (electromyogram) signal, including the following:

1 a) single motor unit action potential

1 b) innervation ratio

1 c) temporal recruitment, and

1 d) spatial recruitment

(7) Include sketches of at least two sample EMG signals in your discussion.

1 **2.** a) Write an equation to define the cross-correlation between two signals.

2 b) Explain the computational procedures required to obtain the cross-correlation function

4 c) Derive an expression for the Fourier transform of the cross-correlation of two signals in terms of the Fourier transforms of the individual signals. Show all steps. If you use any property of the Fourier transform, give its proof.

(7)

3. The template of a signal is specified by the series of samples { 2, 3, -1 } for n= 0, 1, 2.

3 a) Design a matched filter to detect the signal. Give the impulse response and transfer function of the filter.

3 b) The signal specified by the series of samples { 1, -1, -2, 4, 6, -2, 1, -1, 0 } is applied to the matched filter. Compute the output and explain its characteristics.

(6)

3 **4.** a) Give an equation to define the mean frequency (centroidal frequency) of a power spectral density (PSD) function.

Explain the role of each item of your equation.

2 b) Explain how you would implement the procedure to obtain the mean frequency of a signal.

2 c) Draw schematic sketches of two PSD functions and indicate their approximate mean frequencies. Explain the difference between the two examples.

(7)

5. Describe the significance of the P wave in the analysis of ECG (electrocardiogram) signals.

Describe a method for the detection of P waves in an ECG signal. Explain the purpose and reasoning behind each step of your algorithm. Give at least one nontrivial equation representing a procedure in your algorithm.

Draw schematic sketches representing a sample input signal and the corresponding output at each stage of your method. (8)

6. Propose an algorithm to perform the segmentation of PCG (phonocardiogram or heart sound) signals into four parts per cardiac cycle as:

a) the first heart sound (S1)
b) systolic murmur (SM), if present
c) the second heart sound (S2), and
d) diastolic murmur (DM), if present

If your proposal includes the use of other signals, explain the need and rationale for the use of such signals. Explain the relationship between events in your reference signals and the events of interest in the PCG signal. Provide sketches of typical signals and the results of your methods to illustrate your procedures.

Document your procedures using a flowchart or an algorithmic listing. Give at least three nontrivial equations representing important steps in your procedures. (15)

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