University of Calgary
Schulich School of Engineering
Department of Electrical and Computer Engineering

ENEL 563 Biomedical Signal Analysis
Midterm Exam

Tuesday, 8 March 2011, ENC 033
9:30 − 10:45 a.m. (75 minutes)
Total Marks: 20

Instructions:

1. This is a closed-book, closed-notes exam.
2. Calculators and electronic devices of any kind are not allowed.
3. Answer all (four) questions.
4. In case of problems requiring numerical or algebraic manipulation, show all steps clearly.
5. In case of problems requiring algorithms, provide the reason or logic for each step.
6. Specify units or dimensions when appropriate.
7. In drawing plots of signals, spectra, etc., label the axes clearly.

Question 1: Draw a sketch of an electrocardiogram (ECG) and the corresponding carotid pulse signal over one cardiac cycle. Label the important waves and events and explain the relationships between the two signals.
(3 marks)

Question 2: You are given an ensemble of M signals, $y_k(n)$, $k = 1, 2, \ldots, M$, with each signal having N samples, indexed as $n = 1, 2, \ldots, N$. Write mathematical equations or expressions for the following:

1. The ensemble or synchronized average, $s(n)$, of the M signals.
2. The total power of the difference, error, or noise between the result of averaging, $s(n)$, and all of the given signals, $y_k(n)$, $k = 1, 2, \ldots, M$.
3. The total power of the result, $s(n)$.
4. The signal-to-noise ratio of the result.

(5 marks)

Question 3: You are given two signals, $x(n)$ and $y(n)$, $n = 0, 1, 2, \ldots, N$. Write a mathematical equation or expression to derive the normalized correlation coefficient between the two signals.

Suppose that $x(n) = u(n) - u(n-4)$, where $u(n)$ is the unit step function, and $y(n) = x(n-8)$. Sketch the signals $x(n)$ and $y(n)$. Compute the correlation coefficient (without normalization) between the two signals and plot the result. Explain the relationships between the signals and the result.

(6 marks)

Question 4: A digital filter is specified by the difference equation

$$y(n) = \frac{1}{4} \sum_{k=0}^{k=3} x(n-k).$$

where $x(n)$ is the input and $y(n)$ is the output.

1. Give an equation for and draw a sketch of the impulse response of the filter.
2. Draw the signal flow graph of the filter.
3. Derive the transfer function of the filter.
4. Derive the magnitude and phase parts of the frequency response of the filter.
5. What is the gain of the filter at 0 Hz and $f_s/2$ Hz, where f_s is the sampling frequency?
6. Explain the nature and effects of the filter.

(6 marks)

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