BIOMEDICAL ENGINEERING DEPARTMENT **MAY 2002**
CAIRO UNIVERSITY **OPEN BOOK**

BIOMEDICAL DIGITAL SIGNAL PROCESSING FINAL EXAM

Time Allowed: 2 Hours – Maximum Number of Points: 60 – Solve as Much As You Can

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PART I: Design Problems - Maximum Number of Points: 40

1. [8 Points] Consider a small magnetic resonance imaging system that is designed for analyzing chemical composition for pharmacological applications. The emitted signal from the sample inside this system can be detected using either a linear coil (only real signal is detected) or a quadrature (both real and imaginary signals are detected) coil. Assume the received signal to have a bandwidth of 2 MHz around a center frequency of 21MHz. Design a suitable and efficient sampling scheme for the signal received from each of the two available coils.

2. [4 Points] Describe how to design an optimal FIR filter to satisfy the following frequency domain response characteristics:

Frequency	0.1π	0.2π	0.5π	0.7π
Response	1	0.9	0.2	0.1

3. [8 Points] In a pulsed-wave Doppler system, the data points from the sample volume are received at a rate of 3000 samples/second. It is desired to process the incoming data to display a real-time spectrogram using 256-point windows (i.e., length in spectral direction is 256 points) given that the rate of display is 20 lines/second. Design a suitable digital signal processing algorithm to do that. In particular, describe how to compute the spectrogram from the available data and design a suitable overlapping scheme to meet the data display rate constraints.

4. [8 Points] In ECG, the real signal is sampled at a frequency of 250 Hz. In order to discriminate between different disease conditions, we would like to extract features from the acquired samples to assist in further classification. Propose suitable features and describe how to calculate them.

5. [8 Points] In functional MRI, the acquired data are contaminated with noise that belongs to the Rician noise model. Assuming that the noise can be measured from background areas in the image and that it may vary with time, describe a procedure to adaptively remove such noise efficiently.

6. [8 Points] In spectroscopy, it is desired to calculate an accurate power spectrum for a biomedical signal. Assume that the sampling rate is 1kHz and the number of samples is 1000 samples. Design an algorithm to calculate the power spectrum of the data given that the desired frequency domain resolution is 10 Hz. Make sure that the SNR of the resultant power spectrum is optimal.

PART II: Miscellaneous Problems - Maximum Number of Points: 30

7. [8 Points] It is desired to transform the following analog filter to a digital filter:

$$H(s) = \frac{s+1}{s^2+s+1}$$

Assume the sampling rate to be 1kHz. Calculate the digital filter transfer function.

8. [4 Points] Given an FIR filter with h(-1)=1, h(0)=0,h(1)=-1, calculate the output of filtering a periodic sequence x with period described as: x(0)=1, x(1)=2, x(2)=3, x(3)=4.

9.

1. Assuming a 100MHz sampling rate
2. Assuming that the real part of the signal was sampled at 50 MHz. Map the following frequencies to the DTFT frequency domain: 50 MHz, 30 MHz, 25 MHz, and 12 MHz.
3. Design a suitable FIR band-pass filter to filter only the signal part of the samples in part 3.
4. Repeat part 4 using IIR filter.
5. It is required to automatically classify the stage of the disease in the eye from the received echoes. Design a system that allows you to do that.
6. In recent research articles, looking at the spectrum of the received echoes can assist the diagnosis of the condition of the eye. Design a suitable system that allows you to do that.
7. In some cases, the signal received appears to be heavily contaminated with white noise. Propose a suitable solution to this problem.

Problem 2: In an embedded DSP system, a DSP processor that allows real time processing of data. The DSP system computes the spectrogram for a color Doppler system under the following conditions: window size= 1024, number of windows to compute per second=100, a hamming window is used in each case and averaging is not used. Estimate a suitable processing power for this processor.

PART II: Specific Application Problems - Maximum Number of Points: 30

Examples for other types of questions include:

1. Check on system linearity and stability.
2. Forward and inverse z-transform.
3. Solution of linear difference equations.
4. Properties of Fourier transform (i.e., linearity, scaling , etc.)
5. Linear and circular convolution of discrete sequences.
6. Formulation of linear system to design FIR filter with nonuniformly sampled frequency response.
7. 10 True/false question about the basics of DSP.

Best of Luck!