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B.E/B.Tech (Full Time) DEGREE END SEMESTER EXAMINATIONS, APRIL/MAY 2014
ELECTRONICS AND COMMUNICATION ENGINEERING (7th SEMESTER)
(REGULATION 2008)

EC 9037 – ADVANCED DIGITAL SIGNAL PROCESSING

Time : 3 Hrs Max. Marks :100

Answer ALL Questions

PART-A (10 x 2 = 20 Marks)

1. What is meant by "ensemble average"?
2. Write the Yule-Walker equation for an ARMA process.
3. What is meant by "asymptotically unbiased estimate"?
4. Define the "variability" of an estimate.
5. Bring out the difference between filtering operation and smoothing operation.
6. What is the primary limitation of Wiener filter?
7. Draw the block diagram of an adaptive noise canceller.
8. Summarize the steps in the "Steepest Descent Algorithm".
9. Bring out the significance and necessity of "multiresolution analysis".
10. What is the limitation of STFT?

PART-B (5 x 16 = 80 Marks)

11 (i) With necessary equations, explain in detail about 2-D Fast wavelet transform. (8)
(ii) With a neat diagram, explain in detail about the concept of "homomorphic filtering". (8)

12.a)(i) Consider x(n) as a random process that is generated by filtering white noise w(n) with a 1st order linear time invariant filter having a transfer function, $H(z) = 1/[1- 0.25z^{-1}]$. Determine the autocorrelation function. (8)

(ii) The power spectrum of a WSS process x(n) is $P_x(e^{j\omega}) = [25\text{-}24\cos\omega]/[26\text{-}10\cos\omega]$. Find the whitening filter H(z) that produces unit variance white noise when the input is x(n). (8)

(OR)

12.b)(i) Let x be a random variable with mean m_x and variance σ_x^2 and let x_i for i=1,2…N where N is the independent measurements of the random variable x. With the sample mean defined by

$$\hat{m}_x = \frac{1}{N}\sum_{i=1}^{N} x_i$$, determine whether or not the sample variance $$\hat{\sigma}_x^2 = \frac{1}{N}\sum_{i=1}^{N}\left(xi - \hat{m}_x\right)^2$$ is

unbiased, i.e., $E(\hat{\sigma}_x^2) = \sigma_x^2$?. (8)

(ii) Derive the expression for the mean and variance of an ergodic signal x(n) and also mention the mean ergodic theorems. (8)

13.a) Explain the method of smoothing of the periodogram by deriving an expression for variance and show that how periodogram smoothing reduces the variance of the periodogram. (16)

(OR)

13.b)(i) Determine the autocorrelation sequence $r_x(k)$ given the reflection coefficients, $\Gamma_1 = \Gamma_2 = \Gamma_3 = 0.5$ and the modeling error is $\varepsilon_3 = 2(0.75)^3$. (10)

(ii) Using spectral factorization, find a moving average model of order 2 for a process whose autocorrelation sequence given as $r_x = [3, 1.5, 1]^T$. (6)

(P.T.O)

14.a) Starting from the basic principles, derive the expression for the error covariance matrix, $P(n|n)$ interms of the Kalman gain vector. Also summarize the steps involved in Kalman filtering problem. (16)

(OR)

14.b)(i) Derive the expression for a forward prediction error and backward prediction error for a $(j+1)^{th}$ order FIR lattice filter. Realize the obtained equations as a 2-port network. (8)

(ii) A signal x(n) is observed in a noisy and reverberant environment, $y(n) = x(n) + 0.8x(n-1) + v(n)$ where v(n) is a unit variance white noise that is uncorrelated with x(n). x(n) is a WSS AR(1) random process with autocorrelation, $r_x = [4,2,1,0.5]^T$. Determine the causal IIR Wiener Filter H(z) that produces the minimum mean square error. (8)

15.a) A process x(n) is formed by passing white noise w(n) through a filter that has a system function

$$H(z) = \frac{1}{1 - 0.08z^{-1} - 0.9z^{-2}}$$

The variance of the white noise is $\sigma_w^2 = (0.19)(0.18)$. The LMS algorithm with two coefficients is used to estimate a process d(n) from x(n).

(i) What is the maximum value for the step size, μ, in order for the LMS algorithm to converge in the mean?

(ii) What is the time constant for convergence?

(ii) What value for the step size would you use to maximize the rate of convergence of the weights?

(iii) If the cross-correlation between x(n) and d(n) is zero,

$$E\{d(n)x^*(n)\} = 0$$

What are the optimum filter coefficients $\mathbf{w} = [w(0),w(1)]^T$? (16)

(OR)

15.b)(i) The first three autocorrelations of a process x(n) are $r_x(0) = 1$, $r_x(1) = 0.5$, $r_x(2) = 0.5$. Design a two coefficient LMS adaptive linear predictor for x(n) that has a misadjustment M=0.05 and also find the steady state mean square error. (8)

(ii) With a neat bock diagram, briefly explain the working of an adaptive channel equalizer. (8)