Statistical Digital Signal Processing

Week 16 Assessment: Final Exam and Project Assignment

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Final Exam: Instruction

Before starting the final exam, please review the following important instructions:

- Carefully read each question before responding.
- The exam consists of multiple-choice, short-answer, true or false questions and, project assignment.
- Complete the exam independently.
- Use your time effectively.

Evaluation modalities and Exam Structure

- 30 Multiple choice questions
- 5 True or False questions
- 5 Short answer questions
- 1 Project assignment

Time allotted: 90 minutes
Total point: 100%

Questions

Part I: Multiple Choice

- **Instruction:** Choose the correct answer from the given alternatives (2 pts each)

Questions (1/30)

1. Which of the following best defines a random signal??

   A) A signal whose values can be predicted exactly at all times

   B) A signal generated by a deterministic equation only

   C) A signal whose values cannot be predicted with certainty and are described probabilistically

   D) A periodic signal with a fixed frequency

Questions (2/30)

2. Which statistical measure indicates the spread of a random signal around its mean value?

A) Frequency

B) Variance

C) Correlation coefficient

D) Amplitude Spectrum

Questions (3/30)

3. What is the primary purpose of signal modeling?

A) To increase the sampling frequency of a signal

B) To provide a mathematical representation of a signal for analysis and processing

C) To eliminate all noise from a signal

D) To convert analog signals into digital signals

Questions (4/30)

4. In signal modeling, model order refers to:

A) The amplitude of the signal

B) The number of samples in the signal

C) The complexity of the model, typically determined by the number of parameters or coefficients

D) The signal bandwidth

Questions (5/30)

5. What is the primary objective of the Least Squares (LS) method in deterministic signal modeling:

A) To maximize the signal energy

B) To minimize the sum of squared modeling errors

C) To eliminate all noise components

D) To increase the model order indefinitely

Questions (6/30)

6. The denominator polynomial in a Padé approximation allows the model to represent:

A) Poles of the system or signal model

B) Only signal amplitudes

C) Noise components exclusively

D) Sampling frequencies

Questions (7/30)

7. What is the main objective of the all-pole Prony method in deterministic signal modeling?

A) To represent a signal using only zeros

B) To represent a signal using an all-pole transfer function whose impulse response approximates the given signal

C) To estimate only the signal amplitude

D) To compute the Fourier transform directly

Questions (8/30)

8. Which set of coefficients must be estimated first in the all-pole Prony method?

A) Numerator coefficients only

B) Fourier series coefficients

C) Pole (denominator) coefficients

D) Window coefficients

Questions (9/30)

9. Compared with the all-pole Prony method, Shank's method generally provides:

A) Less modeling flexibility because it uses fewer parameters

B) Identical results for every signal

C) Better approximation for signals that require both poles and zeros in their representation

D) A model that contains only zeros

Questions (10/30)

10. Which stochastic signal model represents the current sample as a linear combination of past samples plus a random excitation?

A) Moving Average (MA) model only

B) Autoregressive (AR) model

C) Fourier series model

D) Prony model

Questions (11/30)

11. Which statement best describes an ARMA (Autoregressive Moving Average) model used in stochastic signal modeling?

A) It contains only autoregressive (AR) terms and no moving average (MA) terms.

B) It contains only moving average (MA) terms and no autoregressive (AR) terms.

C) It combines both autoregressive (AR) and moving average (MA) components to model a stochastic signal.

D) It models deterministic signals using Fourier coefficients only.

Questions (12/30)

12. What is the primary advantage of the Levinson-Durbin recursion algorithm?

A) It computes the Fourier transform efficiently.

B) It solves the Yule-Walker equations with reduced computational complexity.

C) It estimates the signal mean directly.

D) It removes noise from any signal.

Questions (13/30)

13. Which of the following is a key characteristic of a lattice filter?

A) It requires the computation of the FFT.

B) It is based on a cascade of stages using forward and backward prediction errors.

C) It can only implement FIR systems.

D) It does not use reflection coefficients.

Questions (14/30)

14. What is the primary objective of an FIR Wiener filter?

A) To maximize the signal bandwidth

B) To minimize the mean square error (MSE) between the desired signal and the filter output

C) To increase the noise power in a signal

D) To compute the Fourier transform of a signal.

Questions (15/30)

15. The coefficients of an FIR Wiener filter are obtained by solving:

A) The Fast Fourier Transform equations

B) The Prony equations

C) The Wiener-Hopf equations

D) The Laplace transform equations

Questions (16/30)

16. Which information is required to design an FIR Wiener filter?

A) Only the signal amplitude

B) Only the filter order

C) Input signal autocorrelation and cross-correlation between input and desired signals

D) Only the Fourier coefficients of the signal

Questions (17/30)

17. What distinguishes an IIR Wiener filter from an FIR Wiener filter?

A) The IIR Wiener filter has only feedforward coefficients.

B) The IIR Wiener filter contains both feedforward and feedback components.

C) The IIR Wiener filter does not minimize mean square error.

D) The IIR Wiener filter can only process deterministic signals.

Questions (18/30)

18. What is a major advantage of an IIR Wiener filter compared to an FIR Wiener filter?

A) It always guarantees linear phase.

B) It requires more coefficients for the same performance.

C) It can often achieve similar performance with a lower filter order.

D) It does not require statistical information about the signal.

Questions (19/30)

19. What is the primary purpose of a discrete Kalman filter?

A) To compute the Fourier transform of a signal

B) To estimate the state of a dynamic system from noisy measurements

C) To generate random signals

D) To design analog filters

Questions (20/30)

20. What is the main difference between parametric and non-parametric spectrum estimation methods?

A) Parametric methods require a signal model, while non-parametric methods estimate the spectrum directly from the data.

B) Non-parametric methods require a signal model, while parametric methods do not.

C) Both methods always produce identical spectral estimates.

D) Parametric methods can only be applied to deterministic signals.

Questions (21/30)

21. Which of the following is a non-parametric spectrum estimation method?

A) Burg method

B) Yule-Walker method

C) Periodogram

D) AR modeling

Questions (22/30)

22. What is the main idea behind the Bartlett method in spectrum estimation?

A) Apply a high-order AR model to the signal

B) Average periodograms of non-overlapping segments of the signal

C) Use autocorrelation truncation and Fourier transform

D) Apply adaptive filtering before spectral estimation

Questions (23/30)

23. What is the main idea behind the Welch method in spectrum estimation?

A) Average modified periodograms of overlapping segments of the signal

B) Apply a high-order ARMA model to the signal

C) Use cross-correlation truncation and Fourier transform

D) Apply FIR adaptive filtering before spectral estimation

Questions (24/30)

24. What is a key assumption in parametric spectrum estimation methods?

A) The signal has no structure and is purely random

B) The signal follows a known model such as AR, MA, or ARMA

C) The spectrum is computed only using FFT

D) The signal must be periodic

Questions (25/30)

25. Which of the following is an example of a parametric spectrum estimation method?

A) Periodogram

B) Welch method

C) Yule-Walker method

D) Bartlett method

Questions (26/30)

26. What is the main characteristic of an FIR adaptive filter?

A) Its coefficients remain fixed during operation

B) It updates its coefficients automatically based on an error criterion

C) It only works for deterministic signals

D) It does not require input signals

Questions (27/30)

27. Which algorithm is commonly used to update the coefficients of an FIR adaptive filter?

A) FFT algorithm

B) LMS (Least Mean Squares) algorithm

C) Yule-Walker method

D) Levinson-Durbin recursion

Questions (28/30)

28. Which of the following best describes the structure of an FIR adaptive filter?

A) It uses feedback only

B) It uses both feedforward and feedback paths

C) It uses only feedforward tapped-delay line structure

D) It has no memory elements

Questions (29/30)

29. What distinguishes an IIR adaptive filter from an FIR adaptive filter?

A) It has only feedforward structure

B) It has both feedforward and feedback (recursive) structure

C) It does not use an error signal

D) It cannot be adapted in real time

Questions (30/30)

30. Which of the following is a common challenge in IIR adaptive filtering?

A) Excessive memory usage due to FIR structure

B) Stability issues due to feedback components

C) Inability to process signals

D) Lack of error computation

Questions

Part II: True or False Questions

- **Instruction:** Say true if the statement is correct and say false if the presented statement wrong (2 pts each).

Questions (1-5/5)

1. The least squares (direct) signal modeling method has low computational complexity and is well-suited for delay-sensitive applications
2. One application of the Wiener filter is the linear prediction of stationary random signals
3. The Welch method is a non-parametric spectrum estimation technique
4. Adaptive filters are used for estimating non-stationary random signals
5. IIR adaptive filters are non-recursive adaptive filters

Questions

Part III: Short Answer Questions

- **Instruction:** Give short answer for the following questions (2 pts each).

Questions (1-5/5)

1. A random signal whose statistical properties do not change with time is Knows as?
2. Which type of deterministic signal modeling requires solving of non-linear equation?
3. Which algorithm is efficient to solve Toeplitz normal equations?
4. Which non parametric spectrum estimation method is used windowing of estimated autocorrelation values in the process of power spectrum estimation?
5. What is the other name of recursive adaptive filter?

Questions

Part IV: Project Assignment (20 pts)

Questions (1/1)

1. Using MATLAB simulation, compare the resolution and the spectral masking performance of the modified periodogram while using Bartlett window and Hamming window for the process $x(n)$ given by:

$$x(n) = 0.1\sin(0.26\pi n + \phi_1) + 2\sin(0.32\pi n + \phi_2) + v(n)$$

Where:

$v(n)$ Is unit variance white noise

ϕ_1, ϕ_2 Are uniformly distributed from $-\pi$ *to* π

Note: use the length of data samples equal to 128

Thank You!