BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI

**INSTRUCTION DIVISION**

**FIRST SEMESTER 2021 - 2022**

**COURSE HANDOUT (PART II)**

**Date: 07/08/2021**

In addition to Part I (General Handout for all courses appended to the timetable) this portion gives further specific details regarding the course.

***Course No* : EEE G613 3 2 5**

***Course Title* : Advanced Digital Signal Processing**

***Instructor-in-charge* : Ramakant Yadav**

**1. Course Description:**

This course deals with introduction to random processes and spectral representation, modeling of AR, ARMA time-series processes, spectrum estimation, spectrum analysis and design of optimum (Wiener and Kalman) filters for estimating signals in noise, adaptive filters for estimating & predicting non-stationary signal and linear prediction. Some applications based on algorithms for adaptive statistical signal processing would be included.

**2. Scope and Objective:**

To provide a strong background on most important advanced DSP topics. It provides a comprehensive treatment of signal processing algorithms for modeling discrete-time signals, designing optimum filters, estimation of the power spectrum of a random process, and implementing adaptive filters. These are important topics that are frequently encountered in professional engineering, and major applications such as digital communication, array processing, biomedical signal processing and multimedia (speech and audio processing, image processing).

**3. Text Book:**

1. Monson H. Hayes, *Statistical Digital Signal Processing and Modeling*, Wiley-India, 2008.

**4. Reference books:**

1. Manolakis, D., Ingle, M., Kogon, S., *Statistical and Adaptive Signal Processing*, McGraw-Hill, 2000.

2. Simon Haykin, *Adaptive Filter Theory,* Pearson Education, Fourth Edition, 2002.

**5. Course Plan:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Lecture No.** | Topics to be covered | Learning Objectives | References |
| 1 | Introduction to the course, evaluation system |  | 1 |
| 2-4 | Background: z-transform, DTFT principles, matrix algebra, complex gradients | Fourier transform orthogonality principle | T1: 2 |
| 5-8 | Random variables and random processes and basic probability theory for statistical signal analysis | Difference between Random variables and random processes | T1: 3.1-3.3 |
| 9-13 | Special types of random processes, signal modeling and approximation methods (Pade, Prony) | Model approximation methods least square approach | T1: 4.1-4.4.4, 4.6 |
| 14-17 | Stochastic Models , AR, MA and ARMA | Difference between AR, ARMA and MA models | T1: 4.7 |
| 18-21 | Levinson-Durbin Recursion Algorithm and Lattice Filter Structure, Cholesky Decomposition | Efficient algorithm to compute filter coefficients and their practical implementation | T1: 5.1-5.2.2, 5.2.7, 6.2 |
| 22-25 | Introduction to filtering, Optimal FIR filtering: Wiener filter, | Optimum filters for various applications such as noise cancellation, removal of degradation | T1: 7.1, 7.2 |
| 26-28 | Kalman filters | Optimum filters for various applications such as noise cancellation, removal of degradation | T1: 7.4 |
| 29-30 | Non parametric spectrum estimation | Power spectrum estimation for non-stationary signals | T1: 8.2 |
| 31-33 | Minimum variance spectrum estimation, Parametric spectrum estimation, Frequency estimation: Pisarenko, MUSIC | Different algorithms to perform spectrum estimation | T1: 8.3,8.5,8.6 |
| 34-38 | Steepest descent algorithm and convergence analysis LMS, NLMS, Adaptive filters, Least Square methods and The RLS algorithm, Acoustic Echo Cancellation | Different types of algorithms for estimating filter coefficients in an optimal manner | T1: 9.2.1, 9.2.2, 9.2.3, 9.2.4, : 9.3, 9.4 |
| 39- 42 | Term Project presentations |  |  |

**5. Lab Experiments:**

|  |  |
| --- | --- |
| Practical No | Name of the experiment |
| 1. | Introduction to the lab  Introduction to MATLAB |
| 2. | Operations on matrices |
| 3. | Operations on random variable and random processes |
| 4. | Determine the autocorrelation and power spectral density |
| 5. | Signal Modeling using Pade' approximation |
| 6. | Signal Modeling using Prony’s approximation Method |
| 7. | Power Spectrum Estimation |
| 8. | Implementation of Levinson-Durbin Recursion Algorithm |
| 9. | Design of Weiner Filter for Filtering Application |
| 10. | Design of Weiner Noise Cancellation Filter |

**6. Evaluation Scheme:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage** | **Marks** | **Date & Time** | **Evaluation type** |
| Mid-Sem | 90 min | 25% | 25 | As per Timetable | Open Book |
| Quizzes, No makeup allowed |  | 10% | 10 | To be announced | Open Book |
| Lab (weekly Lab) |  | 10% | 10 | - | Open Book |
| Lab (Lab exam) |  | 5% | 5 | - | Open Book |
| Term Project |  | 10% | 10 | - | Open Book |
| Comprehensive | 3 hours | 40% | 40 | As per Timetable | Open Book |
| **Total** |  | **100%** | **100** |  |  |

**7. Chamber Consultation Hours:** To be announced in the class.

**8. Make-up Policy:** Make-up for the tests will be granted as per ID rules. In all cases prior intimation must be given to IC. **There will be no make-up for the term paper/project presentations and quizzes.**

**9. Notices:** Notices regarding the course will be displayed in CMS.

**10.** **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

**Instructor-in-Charge**

**EEE G613**