EE 561: Array Signal Processing

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| **Lecture Schedule** | | TBA | **Course Type, Semester** | | Elective,  Fall 2019 | | | |
| **Credit Hours** | | Three | **Pre-requisite** | | Linear Algebra (UG), Analog & Digital Communication (UG), Electromagnetic Theory (UG) | | | |
| **Instructor** | | Dr Syed Shah Irfan Hussain | **Contact** | | [ssirfanhussain@uet.edu.pk](mailto:ssirfanhussain@uet.edu.pk) | | | |
| **Office** | | Room No 106 or Wireless Communication lab, First Floor, EE Department | **Office Hours** | | TBA | | | |
| **Teaching Assistant** | | Not available | **Lab Schedule** | | NA | | | |
| **Course Description** | | Antenna arrays are used in many diverse applications such as satellite communications, radar, sonar, seismic exploration, wireless communications, and medical imaging. The optimum array processing associated with these applications is being implemented in modern systems and is still an active research area. This course will develop the fundamental principles of classical array processing and discuss techniques/algorithms for implementing these principles in design of arrays. Statistical characterization of space-time random processes that includes their relevant models, output statistics of an array when input is a space-time random process and orthogonal expansion of main output statistic will be developed. | | | | | | |
| **Measurable Learning Outcomes** | **CLOs** | **Description** | | | | | **PLOs & levels** | **Domains & Levels** |
| CLO1 | Understand basic concepts for analysis/synthesis of an arbitrary array and their specializations for both classical(deterministic) and statistical approach. | | | | | PLO 1, Low | Cognitive & 2 |
| CLO2 | Design linear and rectangular arrays by analytical/modern tools. | | | | | PLO 3, High | Cognitive, 6 |
| CLO3 | Develop snapshot models in frequency/time domain as well as models for Space-time random processes. | | | | | PLO 2, Medium | Cognitive, 3 |
| CLO4 | Solve the output statistics of arrays (when the input is a Space-time random processes) as well as eigenvalue decomposition of the primary statistic of interest (i.e. Spatial Spectral matrix) by analytical/modern tools | | | | | PLO 2, Medium | Cognitive, 3 |
| **Textbooks** | | **REQUIRED**:   1. Optimum array processing (OAP), Part IV of Detection, Estimation and Modulation theory, by Harry L.Van Trees, John Wiley & Sons, 2002   **OPTIONAL**:   1. Array Signal Processing (ASP), Concepts and techniques, by D. H. Johnson, J. E. Dudgeon, Prentice hall, 1993 2. Antenna theory and design (revised edition), by R. S. Elliott, IEEE Antennas & Propagation Society, IEEE press, John Wiley & Sons (Asia), 2005 3. Antenna theory, analysis & design, by C. A. Balanis, 3rd edition, John Wiley & Sons, 2005 4. Adaptive filter Theory, by S. Haykin, 4th edition, Pearson, 2002 5. Part 1, Detection, Estimation and Modulation theory, by Harry L.Van Trees, John Wiley & Sons, 1968 6. Part 3, Detection, Estimation and Modulation theory, Radar-sonar processing and gaussian signals in noise, by Harry L.Van Trees, John Wiley & Sons, 2001 | | | | | | |
| **Grading Policy vis-à-vis CLO Mapping** | | Class Participation/Assignment | | 10% | | CLO 1 | | |
| Quiz/Assignment1 | | 10% | | CLO 1 | | |
| Quiz/Assignment 2 | | 10% | | CLO 2 | | |
| Midterm | | 30% | | CLO 1, 3 | | |
| Final | | 40% | | CLO 2, 4, 5 | | |

**Lecture Plan**

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| **Week\*** | Topics | **Readings & CLOs** |
| **4** | **Arrays and Spatial Filters**  Introduction, Frequency-wavenumber response and Beam patterns, Uniform linear arrays (ULA), Uniformly weighted linear arrays, Array steering,  Array performance measures, Linear Apertures, Non-isotropic elements patterns | **Chapter 1 & 2**  **CLO 1** |
|  | **Quiz/Assignment-1** |  |
| **3** | **Characterization of Space-time Processes:**  Introduction, Snapshot models, Space-time random processes | **Chapter 5**  **CLO 3** |
|  | **\*\*Midterm** |  |
| **4** | **Synthesis of Linear arrays and apertures**  Spectral weighting, Array polynomials and the z-transform, Pattern Sampling in Wavenumber space  Minimum Beamwidth for Specified Sidelobe Level, Least squares error pattern synthesis, Minmax design, Null steering, Asymmetric beams, Spatially Non-uniform Linear Arrays, Beamspace processing, Broadband arrays | **Chapter 3**  **CLO 2** |
|  | **Quiz/Assignment-2** |  |
| **2** | **Planar arrays and** **apertures**  Rectangular arrays, Circular arrays, Hexagonal arrays | **Chapter 4**  **CLO 2** |
| **3** | **Characterization of Space-time processes**  Arrays and Apertures, Orthogonal expansions | **Chapter 5**  **CLO 4** |
|  | **\*\*Final Exam** |  |

\*\* MATALB codes to be provided in exams,