

EEE 507 - Multi-Dimensional Signal Processing

This course is concerned with understanding signals of more than one variable and with systems for processing them. The most common examples of these signals include images, video, multivariate data, and arrays of sensors commonly encountered in sonar and geophysical exploration.

Prerequisite: EEE404 or EEE 407 or equivalent.

Topics to be covered:

I. Multi-D Discrete-Time(Space) Signals and Systems

I.1 Representation of Multi-D Signals, Special 2-D Sequences

I.2 Multi-D Linear Shift-Invariant Systems, Discrete Convolution

I.3 Separable Systems

I.4 Implementation and Computational Cost

I.5 Fourier Representation of Multi-D Discrete-Time Signals and Systems

II. Multi-D Sampling

II.1 The Sampling Theorem, Reconstruction

II.2 Rectangular Sampling

II.3 General Periodic Multi-D Sampling

II.4 2-D Hexagonal Sampling

II.5 Sampling Density, The Nyquist Density

II.6 Processing Signals Sampled on Arbitrary Lattices

III. Multi-D Discrete Fourier Transform (DFT)

III.1 Computable Transform for Multi-D Finite-Length Signals

III.2 Properties: Periodicity, Discrete Fourier Series

III.3 Rectangular Discrete Fourier Transform

III.4 Circular Convolution

III.5 Implementation: Direct, Row-Column Decomposition

III.6 Multi-D Vector-Radix Fast Fourier Transform

III.7 Computational Complexity and Storage Issues

III.8 General DFT for Signals Sampled on Arbitrary Lattices

III.9 Discrete Cosine Transform (DCT) and relation to DFT

IV. Multi-D Finite Impulse Response (FIR) Digital Filters

IV.1 Direct Implementation, DFT-based implementation, Block Processing

IV.2 Window-based Designs

IV.3 Optimal Least-Squares Designs

IV.4 Optimal Constrained Designs

IV.5 Fast Design and Realization Using Transformations

- V. Multi-D Infinite Impulse Response (IIR) Digital Filters
 - V.1 Two-D Difference Equations, Recursive Computability
 - V.2 Z-Transform: Definition, Region of Convergence, Properties
 - V.3 System Functions, Stability Analysis
 - V.4 Implementation: Recursive, Iterative

VI. Processing of Propagating Space-Time Signals

- VI.1 Space-Time Signals, Plane Waves
- VI.2 Space-Time Filtering
- VI.3 Array Processing, Beamforming
- VI.4 Weighted Delay and Sum Beamformer
- VI.5 Seismic Migration, Geophysical Processing

VII. Multi-D Signal Restoration and Reconstruction

- VII.1 Reconstruction from Projections, Back-Projection Algorithm
- VII.2 Reconstruction from Phase or Magnitude