SIGNAL AND TRANSFORM

ENGE 203

Lecture : 3 **Year : II**
Tutorial : 0 **Part : I**
Practical : 2

Course Objectives:
The objective of this course is to provide students with an understanding of key signal processing techniques and their applications in geospatial data analysis. Students will learn to apply techniques like Fourier and wavelet transforms, along with digital filtering, to enhance and process spatial data. The course also equips students with advanced signal processing skills for practical geomatics applications.

1 Fundamentals of Signal Processing in Geomatics (7 hours)

1.1 Signals and systems: Understanding signals (Spatial data) and systems used in processing them
1.2 Signal representation: Techniques for representing spatial signals, such as elevation and spectral data
1.3 Sampling and quantization: Methods for converting continuous geospatial data into digital formats
1.4 Basic signal operations: Operations such as addition and scaling are applied to spatial datasets

2 Fourier Transform for Geospatial Analysis (7 hours)

2.1 Fourier series and transform: Decomposition of spatial signals into frequency components for feature analysis
2.2 Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT): Frequency analysis methods for raster data and satellite imagery
2.3 Spectral analysis: Identifying frequency patterns in geospatial data for classification tasks
2.4 Fourier in image processing: Enhancing and processing images using Fourier techniques

3 Digital Filtering Techniques for Spatial Data (7 hours)

3.1 Digital filters overview: Types of filters (low-pass, high-pass) used in spatial data enhancement
3.2 Filter design: Creating filters to remove noise and highlight features in geospatial datasets
3.3 Filter performance analysis: Evaluating the effectiveness of filters in improving data quality

3.4 Applications in geomatics: Practical use of filters for edge detection and smoothing in spatial data

4 Wavelet Transform and Multiresolution Analysis (8 hours)

4.1 Wavelet transform basics: Introduction to wavelets and their application in analyzing spatial data at different scales
4.2 Discrete wavelet transform (DWT): Techniques for multiresolution analysis of high-resolution satellite images
4.3 Wavelet-based image processing: Enhancing features and compressing images using wavelets
4.4 Multiresolution analysis: Improving the interpretation of spatial phenomena by analyzing data at various scales

5 Time-Frequency Analysis for Geospatial Data (8 hours)

5.1 Time-frequency representations: Analyzing geospatial data with varying features over time
5.2 Short-time Fourier transform (STFT): Handling non-stationary spatial signals for temporal analysis
5.3 Spectrogram analysis: Visualizing frequency changes in time-series geospatial data
5.4 Remote sensing applications: Analyzing time-series data from remote sensing platforms

6 Advanced Signal Processing Techniques (8 hours)

6.1 Adaptive filtering: Dynamic filters adjusting to changing characteristics in geospatial data
6.2 Principal component analysis (PCA): Reducing dimensionality and extracting key features from spatial data
6.3 Time-series analysis: Modeling and analyzing temporal changes in geospatial datasets
6.4 Signal reconstruction: Techniques for interpolating and enhancing missing or degraded data

Practical (30 hours)

1. Hands-on practice with fundamental operations on geospatial signals
2. Analyzing spatial data using Fourier techniques
3. Design and Test Digital Filters: Developing and applying filters to enhance spatial data
4. Enhancing and analyzing satellite images with wavelet techniques
5. Analyzing time-series data for dynamic geospatial changes
6. Implementing PCA and adaptive filtering in real-world scenarios

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Marks distribution*
1	7	10
2	7	10
3	7	10
4	8	10
5	8	10
6	8	10
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Oppenheim, A.V., Schafer, R.W. (2009). Discrete-Time Signal Processing (3rd edition). United Kingdom: Pearson.
2. Gonzalez, R. C., Woods, R. E. (2018). Digital Image Processing. United Kingdom: Pearson.
3. Proakis, J.G., Manolakis, D.K. (2014). Digital Signal Processing: Principles, Algorithms, and Applications. Pearson Education.
4. Daubechies, I. (1992). Ten Lectures on Wavelets. Switzerland: Society for Industrial and Applied Mathematics.
5. Bracewell, R. N. (2000). The Fourier Transform and Its Applications. India: McGraw Hill.
6. Rabiner, L. R., Gold, B. (1975). Theory and application of digital signal processing. India: Prentice-Hall.
7. Jain, A. K. (1989). Fundamentals of Digital Image Processing. India: Prentice Hall.