DIGITAL IMAGE PROCESSING
ENGE 425

Lecture	**: 3**	**Year : IV**
Tutorial	**: 2**	**Part : I**
Practical	**: 1**	

Course Objectives:

The objective of this course is to provide students with fundamental and advanced knowledge of digital image processing, with emphasis on digital and satellite imagery. Upon completion, students will be able to acquire, store, process, and analyze raster images; apply image enhancement, transformation, segmentation, and compression techniques; and utilize spectral and spatial domain methods for effective interpretation and practical applications of digital imagery.

1 Introduction (5 hours)

1.1 Digital imaging basics: Creation, storage, and processing of digital images
1.2 Satellite imagery overview: Importance in environmental monitoring and urban planning
1.3 Types of satellite imagery: Optical, infrared, radar images and their uses
1.4 Resolution concepts: Spatial, spectral and temporal resolution
1.5 Sensors in satellite imaging: Multispectral and hyperspectral sensors
1.6 Platforms for image acquisition: Satellites and drones
1.7 Image sampling and quantization: Representation and techniques

2 Image Enhancement in Spectral Domain (6 hours)

2.1 Feature space, multispectral ratios and vegetation indexes
2.2 Principal components, standard principal components
2.3 Maximum noise fraction, Tasselled cap components
2.4 Contrast enhancement global transforms, linear stretch, nonlinear stretch, stretch, reference stretch, local transforms
2.5 Color images, mean max stretch, normalization stretch, decorrelation stretch, color space transforms, spatial domain blending
2.6 Spatial filtering, convolution filters, mathematical properties of filters, linear filters, convolution, low pass and high pass filters, high boost filters, directional filters
2.7 Histogram equalization and matching, cumulative histogram

3 Image Enhancement in Frequency Domain (9 hours)

3.1 Introduction to Fourier transforms, Fourier analysis and synthesis, discrete Fourier transforms in 2D

3.2 The Fourier components, filtering with Fourier transforms, transfer functions system modelling using the Fourier transform

3.3 The power spectrum, scale space transforms, image resolution pyramids, zero crossing filters, Laplacian of Gaussian filters, difference of Gaussian filters wavelet transforms

4 Raster Image Color Modes and Preprocessing (7 hours)

4.1 RGB color model: Understanding and application

4.2 Grayscale conversion: Techniques for converting color images

4.3 CMYK color model: Introduction and applications

4.4 Color space transformations: Converting between color spaces

4.5 True color versus pseudo-colour: Differences and uses

5 Image Segmentation (6 hours)

5.1 Background, bottom up approach, top down approach

5.2 Point line and edge detection, thresholding, region based segmentation

5.3 Multi-resolution segmentation, watershed based segmentation

6 Image Restoration and Reconstruction (6 hours)

6.1 Model of image degradation and restoration process, noise models

6.2 Restoration in the presence of noise only, periodic noise reduction, linear

6.3 Position -invariant degradations, estimating degradation function, inverse filtering wiener filtering, geometric mean filtering, image reconstruction from projection

7 Image Compression (6 hours)

7.1 Fundamentals (Coding redundancy, spatial and temporal redundancy, irrelevant information, measuring image information, fidelity criteria)

7.2 Compression methods (Huffman coding, The discrete cosine transform (DCT), golomb coding, arithmetic coding, run-length compression, symbol based coding, black transform coding, wavelet coding), quantization, JPEG_LS and MPEG

Tutorial (30 hours)

1. Introduction to digital imaging basics and satellite imagery
2. Exploring and comparing raster bands
3. Analyzing histograms and enhancing image contrast
4. Converting and transforming color models (RGB, grayscale, CMYK)
5. Applying radiometric, atmospheric, and geometric corrections
6. Techniques for image smoothing, sharpening, and edge detection
7. Implementing PCA, MNF, and Tasselled cap transformations
8. Advanced techniques for image segmentation
9. Fundamentals of image compression

10. Evaluating segmentation and compression quality metrics

Practical **(15 hours)**

1. Create and process digital images using software tools
2. Compare different satellite datasets (Optical, infrared, radar)
3. Generate and interpret histograms for various image bands
4. Apply color space transformations and conversion techniques
5. Perform radiometric, atmospheric, and geometric corrections on images
6. Use filters for image enhancement (Contrast stretching, smoothing, sharpening)
7. Execute PCA, MNF, and Tasselled cap transformations on sample datasets
8. Apply Fourier transform and various image filtering techniques
9. Implement segmentation algorithms on sample images
10. Apply image compression methods and evaluate their effectiveness

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	Mark distribution*
1	5	7
2	6	8
3	9	12
4	7	9
5	6	8
6	6	8
7	6	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Gonzalez, R. C., Woods, R. E. (2018). Digital image processing. Pearson.
2. Jain, A. K. (1989). Fundamentals of digital image processing (Latest Edition). Prentice Hall.
3. Gonzalez, R. C., Woods, R. E. (2014). Digital image processing using MATLAB. Pearson.
4. Salvatore, J. (2012). Digital image processing: An algorithmic approach with MATLAB. CRC Press.
5. Richards, J. A., Jia, X. (2013). Remote sensing digital image analysis: An introduction. Springer.
6. Li, H., Chen, Y. (2018). Introduction to remote sensing: Principles and concepts. CRC Press.
7. Jain, A. K. (2013). Data fusion and image analysis: An introduction. Springer.

DISASTER RISK ASSESEMENT
ENGE 426

Lecture	**: 3**	**Year : IV**
Tutorial	**: 2**	**Part : I**
Practical	**: 1**	

Course Objectives:
The objective of this course is to introduce principles and practices of disaster risk assessment, focusing on hazard identification, vulnerability analysis and risk evaluation. It integrates concepts from disaster risk management, geography and environmental science to provide a multidisciplinary understanding of disasters and their impacts.

1 Introduction to Disasters (7 hours)

1.1 Types of disasters
1.2 Disaster management cycle
1.3 Hazard, exposer, sensitivity, vulnerability, risk
1.4 Disaster risk reduction plan
1.5 Principle of disaster prevention and mitigation
1.6 Community based DRR and management (CBDRRM)
1.7 Multi-hazard risk assessment
1.8 Existing national and international framework of DRR

2 Hazard Identification and Mapping (7 hours)

2.1 Hazard types, assessment and mapping
2.2 Geological hazards: Earthquakes, landslides
2.3 Hydrometeorological hazards: Floods, droughts
2.4 Biological hazards: Epidemics, pandemics
2.5 Technological hazards: Industrial accidents, fires (Forest and urban), chemical spills
2.6 Multi-hazard assessment
2.7 Climate change and hazard dynamics

3 Vulnerability and Capacity Assessment (7 hours)

3.1 Definitions and evolution of vulnerability
3.2 Types of vulnerability: Physical, social, economic, environmental
3.3 Link between vulnerability and disasters
3.4 Indicators and measurement of vulnerability
3.5 Understanding capacity: Coping capacity and adaptive capacity
3.6 Community resilience: Reactive and proactive approaches
3.7 Livelihoods framework

3.8 Role of local knowledge and indigenous practices

4 Risk Assessment Methodologies (7 hours)

4.1 Introduction to risk-sensitive planning principles
4.2 Concepts of land use planning and zoning regulations (No-build zones, buffer zones)
4.3 Linkages between land use, hazards and risk
4.4 Climate change and land use nexus
4.5 Land use planning: Mitigation and adaptation
4.6 Risk sensitive land use planning process
4.7 Building codes and land development control
4.8 Land use planning and REDD (Reducing emissions from deforestation and forest degradation)
4.9 Nature-based solutions (Green infrastructure, watershed management)

5 Risk Sensitive Land Use Planning (7 hours)

5.1 Introduction to risk-sensitive planning principles
5.2 Concepts of land use planning and zoning regulations (No-build zones, buffer zones)
5.3 Linkages between land use, hazards and risk
5.4 Climate change and land use nexus
5.5 Land use planning: Mitigation and adaptation
5.6 Risk sensitive land use planning process
5.7 Building codes and land development control
5.8 Land use planning and REDD (Reducing emissions from deforestation and forest degradation)
5.9 Nature-based solutions (Green infrastructure, watershed management)

6 Disaster Risk Reduction (DRR) Strategies (5 hours)

6.1 Introduction to global DRR policy
6.2 Sendai framework for disaster risk reduction (2015–2030)
6.3 DREM policies and strategies of SAARC, ASEAN, EU
6.4 DREM policies and strategies of United Nations, World Bank, Asian Development Bank
6.5 Paris agreement on climate change
6.6 National disaster response framework
6.7 National disaster risk reduction and management policies
6.8 Transboundary approaches

7 Databases and Disaster Information (5 hours)

7.1 Types and sources of disaster-related data and information, national database (DRR portal, BIPAD)

7.2 International database (Desinvetar, EmDat)
7.3 Developing appropriate databases at the community to the national level
7.4 Database coordination, sharing, and communication over time and space
7.5 Risk communication
7.6 Early warning 4 All

Tutorial **(30 hours)**

1. Prepare risk sensitive land use plan of municipality
2. Good practices of disaster management in South Asia
3. Prepare the community bases early warning system
4. Landslide inventory mapping and hazard zonation
5. Climate change and impending flood hazard
6. Glaciers inventory mapping and hazard zonation

Practical **(15 hours)**

1. Modelling risk, hazard and vulnerabilities (HEC-HMS, HECRAS, GEE, ML)
2. Land use change models (Cellular automata, agent based modeling, Markov chains, artificial neural network
3. Application of UAV in disaster management

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	Mark distribution*
1	7	10
2	7	10
3	7	10
4	7	10
5	7	10
6	5	5
7	5	5
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. United Nations International Strategy for Disaster Reduction. (2009). UNISDR terminology on disaster risk reduction. United Nations.
2. Twigg, J. (2015). Disaster risk reduction. Overseas Development Institute.
3. Comprehensive Disaster Management Programme. (2014). Bangladesh urban earthquake resilience project. World Bank & Earthquakes and Megacities Initiative.

4. Bhandari, M. P. (2024). The nexus of climate change and land-use: Global scenario with reference to Nepal. River Publishers.
5. Deutsche Gesellschaft für Internationale Zusammenarbeit. (2020). A guidebook for preparation of local disaster and climate resilient plan. GIZ.
6. Dewan, A. M. (2013). Hazards, risk, and vulnerability. In Floods in a megacity: Geospatial techniques in assessing hazards, risk and vulnerability (pp. 35–74). Springer.
7. Wisner, B., Blaikie, P., Cannon, T., Davis, I. (2004). At risk: Natural hazards, people’s vulnerability and disasters. Routledge.
8. Shrestha, R., Nepali, P. B., Dahal, T. P. (2021). Towards sustainable land management: State-of-the-art in land use policies of Nepal. In Examining international land use policies, changes, and conflicts (pp. 351–369). IGI Global.

WEB MAPPING AND VIZUALIZATION

ENGE 427

Lecture	**: 3**	**Year : IV**
Tutorial	**: 2**	**Part : I**
Practical	**: 1**	

Course Objectives:

The objective of this course is to equip students with the knowledge and skills required to design, develop, and deploy interactive web-based geospatial applications. Upon completion, students will be able to apply cartographic principles and modern web technologies to create effective web maps, manage and optimize geospatial data for online visualization, and develop web mapping applications, mashups, and spatial and spatio-temporal information services.

1 Distributed GIS Architecture (5 hours)

1.1 Evolution of distributed GIS transition from desktop-bound GIS to client-server and service-oriented architecture (SOA)

1.2 System components: Roles of the data server (PostgreSQL/PostGIS), map server (GeoServer) and web client

1.3 Network protocols for geomatics: HTTP/HTTPS, request/response headers and RESTful API principles for spatial data

1.4 Cloud versus On-Premise GIS: Scalability, latency issues and infrastructure requirements for hosting spatial services

2 Web Foundations for Geomatics (6 hours)

2.1 Spatial interface design: Using HTML5 and CSS3 (Flexbox/Grid) to create responsive, full-screen map layouts

2.2 JavaScript for spatial logic: Functional programming, event handling (Map clicks/bounds changes) and JSON parsing

2.3 The document object model (DOM): Programmatic manipulation of map legends, sidebars and information pop-ups

2.4 Asynchronous web GIS: Implementing AJAX and API

3 Spatial Data Exchange and Standards (6 hours)

3.1 OGC interoperability: The necessity of open standards in engineering; Introduction to XML, GML and KML

3.2 Web-optimized formats: Structure and implementation of GeoJSON, TopoJSON and Well-Known Text (WKT)

3.3 Vector tiling: Understanding Mapbox Vector Tiles (MVT) and Protobuf (PBF) for high-performance rendering

3.4 Coordinate reference systems (CRS) on the web

4 Web Map Services (WMS) and Tile Management (5 hours)

4.1 WMS operations: Detailed study of GetCapabilities, GetMap and GetFeatureInfo parameters and exceptions
4.2 Map tiling and caching: Concepts of TMS (Tile Map Service), WMTS and server-side caching
4.3 Raster data delivery
4.4 Security and authentication

5 Web Feature Service (WFS) and Data Transaction (6 hours)

5.1 Vector data interaction
5.2 Transactional web GIS (WFS-T): Engineering workflows for web-based data entry and database editing (Insert, Update, Delete)
5.3 Filter encoding (FE)
5.4 WFS output negotiation: Managing data formats between the server and diverse client environments

6 Cartographic Styling for the Web (5 hours)

6.1 Styled layer descriptor (SLD): Authoring XML styling rules for server-side map rendering in GeoServer
6.2 Client-Side rendering engines
6.3 Thematic mapping logic
6.4 Advanced symbology: Handling multi-attribute styling, priority labeling and scale-dependent visibility

7 Web Mapping Libraries and APIs (6 hours)

7.1 Leaflet.js: Architecture of lightweight mapping libraries, plugin ecosystems and mobile-first design
7.2 OpenLayers: Handling complex engineering tasks, specialized projections, and advanced geometry drawing tools
7.3 MapLibre/Mapbox GL JS: Utilizing hardware acceleration for 3D terrain, tilt, and rotation
7.4 API mashups: Integrating external spatial APIs (OpenRouteService for routing, nominatim for geocoding)

8 Spatio-Temporal Data and Deployment (6 hours)

8.1 Visualizing time
8.2 3D Web GIS: Introduction to CesiumJS for 3D global visualization and integration of BIM/CityGML data
8.3 Performance engineering: Data minification, Gzip compression and leveraging content delivery networks (CDNs)

8.4 Deployment workflows: Version control with Git and hosting mapping applications on GitHub Pages or cloud VPS

Tutorial **(30 hours)**

1. Optimization techniques for serving multi-spectral imagery and DEMs via the web
2. Implementing API keys and basic token authentication for private map services
3. Constructing complex spatial and attribute queries using XML-based filter specifications
4. Using Canvas and WebGL (Canvas versus SVG) for dynamic vector styling
5. Programmatic creation of Choropleths, Heatmaps and Dot-Density maps using JavaScript
6. Techniques for rendering 4D data (3D + Time) using time-enabled WMS and playback sliders
7. Introduction to HTML, CSS and JavaScript basics

Practical **(15 hours)**

1. Create a simple static webpage using HTML and CSS
2. Overview of Leaflet.js and OpenLayers
3. Implement a basic interactive map using Leaflet.js
4. Discuss the workflow of developing a web mapping application
5. Build a simple web mapping application that displays markers on a map
6. Building a web mapping application
   i. Overview, define the application
   ii. Assess and collect data
   iii. Determine the software download and install the software,
   iv. Install data
   v. Test software and data

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	5	7
2	6	8
3	6	8
4	5	7
5	6	8
6	5	6
7	6	8
8	6	8
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Murray, S. (2017). Interactive data visualization for the web. O’Reilly Media.
2. Crickard, P. (2014). Leaflet.js essentials. Packt Publishing.
3. Kraak, J. M., & Brown, A. (2014). Web cartography: Map design for interactive and mobile devices. CRC Press.
4. Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2015). Geographic information systems and science. John Wiley & Sons.