ADVANCED GIS AND REMOTE SENSING

ENGE 351

Lecture	**: 3**	**Year : III**
Tutorial	**: 0**	**Part : II**
Practical	**: 3**	

Course Objectives:

The objective of this course is to provide advanced knowledge of GIS and remote sensing techniques for processing, analyzing, and interpreting spatial data, and to develop the ability to apply spatial analysis and modeling for solving real-world geospatial problems.

1 Introduction (3 hours)

1.1 Web GIS, mobile GIS, cloud GIS, location based services (LBS)
1.2 Advanced sensor technologies: Hyperspectral imaging, thermal sensors
1.3 Remote sensing data acquisition and quality assessment
1.4 Applications in environmental monitoring, urban planning and disaster management

2 Spatial Data Interpolation and Analysis (6 hours)

2.1 Spatial data processing and analysis
2.2 Interpolation techniques: Nearest neighbor, inverse distance weighting (IDW), spline, Kriging
2.3 Surface validation and uncertainty: Cross-validation techniques, error metrics (RMSE and mean prediction error), uncertainty and standard error mapping

3 Multi-Criteria Decision Analysis (MCDA) (8 hours)

3.1 Principles of spatial decision support
  3.1.1 Decision-making workflow
  3.1.2 Constraints versus factors
  3.1.3 Data normalization and standardization
3.2 MCDA weighting and evaluation techniques
  3.2.1 Boolean overlay (Pass/fail)
  3.2.2 Weighted linear combination (WLC)
  3.2.3 Analytic hierarchy process (AHP)
  3.2.4 Fuzzy logic modeling (Membership and overlay)
  3.2.5 TOPSIS (Similarity to ideal solution)
3.3 Sensitivity analysis and model validation
  3.3.1 Weight sensitivity analysis
  3.3.2 Error propagation

3.3.3 Model validation protocols

4 Network Analysis and Optimization (6 hours)

4.1 Network components and connectivity
- 4.1.1 Geometric and logical network elements (Edges, junctions and turns)
- 4.1.2 Connectivity and topology rules
- 4.1.3 Network attributes and impedance modeling (Cost, restrictions and hierarchy)

4.2 Routing and pathfinding algorithms
- 4.2.1 Shortest path and time-based optimization
- 4.2.2 Multi-stop routing
- 4.2.3 Closest facility analysis

4.3 Service area and facility allocation
- 4.3.1 Isochrone and service area generation
- 4.3.2 Location-allocation modeling
- 4.3.3 Origin-destination (OD) cost matrix analysis

5 Remote Sensing Image Fusion and Multi-Resolution Analysis (8 hours)

5.1 Characteristics of hyperspectral and thermal image

5.2 Techniques for image fusion: Panchromatic, multispectral and hyperspectral data fusion

5.3 Multi-resolution analysis and feature extraction

5.4 Application of fusion techniques in environmental and urban studies

6 Spectral Unmixing and Dimensionality Reduction (4 hours)

6.1 Spectral unmixing and endmember extraction

6.2 Linear spectral mixture analysis

6.3 Dimensionality reduction techniques (Principal component analysis (PCA)

7 Spatial Modeling and Simulation (6 hours)

7.1 Spatial simulation models: Cellular automata, agent-based models

7.2 Predictive modeling and risk assessment

7.3 Integration of spatial models with remote sensing data

8 Emerging Trends in GIS and Remote Sensing (4 hours)

8.1 Big data analytics and GIS

8.2 Machine learning and AI applications in remote sensing

8.3 Integration of IoT and GIS for real-time monitoring

8.4 Innovations in sensor technology and data analytics

8.5 Advanced applications: Precision agriculture, smart cities, and climate change

Practical **(45 hours)**

1. Exploration of spatial data analysis and surface generation using Ordinary Kriging
2. Evaluation of interpolation accuracy using cross-validation techniques and error metrics (RMSE/MPE)
3. Site suitability modeling using analytic hierarchy process and weighted linear combination
4. Implementation of Fuzzy Membership functions and Fuzzy overlay for complex susceptibility modeling
5. Building logical network topologies with connectivity rules and impedance attributes
6. Pathfinding optimization and generation of distance or time-based isochrones
7. Strategic facility placement modeling and origin-destination travel cost calculations
8. Enhancing spatial resolution through pan-sharpening and multi-sensor data integration
9. Extraction of land surface temperature and analyzing urban thermal patterns
10. Feature extraction and noise reduction using PCA transformation
11. Endmember extraction and fractional abundance mapping via linear mixture analysis
12. Dynamic land-use change modeling using Cellular Automata or Machine Learning classifiers

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	3	4
2	6	8
3	8	10
4	6	8
5	8	10
6	4	6
7	6	8
8	4	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Bolstad, P. (2019). GIS fundamentals: A first text on geographic information systems. XanEdu Publishing Inc.

2. Campbell, J. B., Wynne, R. H. (2022). Introduction to remote sensing. The Guilford Press.
3. Cressie, N., Wikle, C. K. (2011). Statistics for spatio-temporal data. John Wiley & Sons.
4. DeMers, M. N. (2009). Fundamentals of geographic information systems. John Wiley & Sons.
5. Jensen, J. R. (2015). Introductory remote sensing. Pearson Education.
6. Mather, P. M., Koch, M. (2022). Computer processing of remotely sensed images: An introduction. John Wiley & Sons.
7. Zhang, Y., Xu, B. (2022). Big data and machine learning in geospatial analysis. Springer.