DIGITAL TERRAIN MODELING

ENGE 414

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

Course Objectives:

The objective of this course is to provide fundamental knowledge and practical skills in Digital Terrain Modeling (DTM), including terrain data acquisition, processing, visualization, and 3D modeling. Students will learn to create and analyze raster-based terrain models and apply DTM techniques in civil engineering, surveying, geodesy, geophysics, geography, and environmental planning.

1 Introduction (3 hours)

- 1.1 Definition and importance of digital terrain model (DTM)
- 1.2 Historical development of terrain modeling
- 1.3 Stages of terrain model generation
- 1.4 Types of terrain models (DTM, DEM, DSM, CHM, nDSM, REM)
- 1.5 Applications of DTM
- 1.6 Challenges and opportunities in the field of terrain modeling

2 Terrain Descriptors and Sampling Strategies (6 hours)

- 2.1 General terrain descriptor
- 2.2 Numerical terrain descriptor
  - 2.2.1 Frequency spectrum
  - 2.2.2 Fractal dimension
  - 2.2.3 Curvature
  - 2.2.4 Covariance and auto correlation
  - 2.2.5 Semi variogram
- 2.3 Sampling techniques
  - 2.3.1 Types of sampling: Random, stratified, systematic, clustering
  - 2.3.2 Selective Sampling
  - 2.3.3 Sampling with one dimension fixed
  - 2.3.4 Sampling with two dimensions fixed
  - 2.3.5 Composite sampling: An integrate strategy

3 Data Acquisition for DTM (7 hours)

- 3.1 Cartographic source
  - 3.1.1 Scanning maps
  - 3.1.2 Removing noise

3.1.3 Contour detection, binarization and skeletonization
3.1.4 Contour following
3.2 Photogrammetric data source: Analog and digital photogrammetry
3.3 Satellite techniques: Radargrammetry, SAR interferometry and satellite setreogrammetry
3.4 Light detection and ranging (LiDAR): Spaceborne and airborne LiDAR
3.5 Global navigation satellite system (GNSS): Principles of GNSS measurement and its operation
3.6 Comparisons between DTM Data from different sources

4 DTM Data Structures (6 hours)

4.1 Data structure contour, grid and TIN
4.2 Storage and compression techniques of grid data
4.2.1 Cell-by-Cell storage
4.2.2 Run-length code
4.2.3 Quad tree
4.3 Creating TINs from grid and irregularly distributed data
4.4 Voronoi diagrams and Delaunay triangulation

5 Digital Terrain Modelling Manipulation (6 hours)

5.1 Surface classification: Functional versus solid, continuous versus non-continuous and smooth versus non-smoothed surfaces
5.2 Global and local interpolations methods: Inverse distance weighting (IDW), kriging and spline interpolations
5.3 Comparison of interpolation methods

6 DTM Derivatives and Volume Computations (6 hours)

6.1 DTM derivatives: Slope, aspect, curvature, view sheds and watershed
6.2 Volume computations from contour and grid data
6.3 Generating contour lines from grid data

7 Applications of DTM (7 hours)

7.1 Orthoimage of generation
7.2 Telecommunications
7.3 Flood prediction, data fusion
7.4 3D models and visualization.
7.5 Renewable energy site assessment (Wind and solar farms)

8 DTM Quality Assessment (4 hours)

8.1 Sources and types of errors in DTM
8.2 Techniques for error assessment
8.2.1 Filtering of random errors of the original data

8.2.2 Gross errors in grid data
8.2.3 Isolated gross error in irregularly distributed data
8.2.4 Cluster gross error in irregularly distributed data
8.2.5 Gross error in topologic relations of contours
8.3 Quality control: Concepts and strategy
8.4 DTM accuracy assessments
8.4.1 Approaches for DTM accuracy assessments
8.4.2 Distributions of DTM errors
8.4.3 Factor affecting DTM accuracy
8.4.4 Strategies for experimental tests
8.4.5 Requirements for checkpoints in experimental tests

Practical **(30 hours)**

1. DTM capturing
2. Automation & manual terrain extraction
3. Comparisons of different interpolation methods
4. Generation of DTM derivatives
5. Application:
   i. Case study analysis: Applying DTM in urban planning
   ii. Identifying potential natural hazards using terrain models
6. Accuracy assessments
   i. Assessing the accuracy of a DTM
   ii. Implementing quality control procedures in DTM projects

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	3	5
2	6	8
3	7	8
4	6	8
5	6	8
6	6	8
7	7	9
8	4	6
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Maune, D. F. (ed.). (2007). Digital elevation model technologies and applications: The DEM user's manual. American Society for Photogrammetry and Remote Sensing.
2. El-Sheimy, N., Valeo, C., Habib, A. (2005). Digital terrain modeling: Acquisition, manipulation, and applications. Artech House.
3. Li, Z., Zhu, Q., Gold, C. (2005). Digital terrain modeling: Principles and methodology. CRC Press.
4. Leberl, F. W. (1990). Radargrammetric image processing. Artech House.
5. European Space Agency. (2007). InSAR principles: Guidelines for SAR interferometry processing and interpretation. European Space Agency.
6. Davis, J. C. (2002). Statistics and data analysis in geology. Wiley.