COMPUTATIONAL TECHNIQUES IN GEOMATICS
ENGE 411

Lecture	**: 4**	**Year : IV**
Tutorial	**: 1**	**Part : I**
Practical	**: 2**	

Course Objectives:
The objective of this course is to equip students with the knowledge and skills to develop computational solutions for Geomatics Engineering problems. It aims to build awareness of a wide range of available tools and enable students to critically evaluate and select appropriate approaches. The course also develops an understanding of the underlying theory of numerical algorithms commonly used in geomatics software, fostering both practical competence and analytical capability.

1 Introduction (8 hours)

1.1 Fundamentals of computational techniques
1.2 Programming languages: Python, R and MATLAB for geomatics (Basic data structures, algorithms and programming concepts)
1.3 Geospatial software and tools
1.4 Geospatial data processing and management

2 Matrix Operations in Geomatics Engineering Problems (8 hours)

2.1 Solution of linear equations
2.2 Gauss method, Gauss-Jordan method
2.3 Eigenvalues and eigenvectors
2.4 Differentiation of matrices and quadratic forms

3 Coordinate System and Transformations (12 hours)

3.1 Coordinate system
3.2 Two-dimensional (2-D) and three-dimensional (3-D) transformations: Conformal, affine, projective transformation
3.3 2-D coordinate transformation by general least squares
- 3.3.1 Adjustment in cartesian geodetic system
- 3.3.2 Adjustment in curvilinear geodetic system
- 3.3.3 Adjustment in local system

3.4 3-D coordinate transformation by general least squares

4 Blunder Detection in Horizontal Networks (8 hours)

4.1 Blunders
- 4.1.1 Priori method for blunder detection

- 4.1.2 Posteriori blunder detection
- 4.2 Outliers detection: Data snooping and tau criterion
- 4.3 Reliability of adjusted control network
- 4.4 Statistical blunder detection

5 Dynamic Mode Filtering and Prediction (12 hours)

- 5.1 Prediction, filtering and smoothing
- 5.2 Static mode filter: Real-time moving averages and sequential least adjustment
- 5.3 Kalman filtering process
- 5.4 Kalman filter and the least squares method
  - 5.4.1 Relationship; Linear, linearized and extended Kalman filter
  - 5.4.2 System model and process noise model
  - 5.4.3 Real-time trajectory estimation and GNSS/INS integration

6 Network Design (12 hours)

- 6.1 Pre-analysis of survey observations
  - 6.1.1 Survey tolerance limits
  - 6.1.2 Pre-analysis models
  - 6.1.3 Trigonometric leveling problems
- 6.2 Network design model: 2-D and 3-D
- 6.3 Simulation of network: 2-D, 3-D; Monte-Carlo and agent based modelling
- 6.4 Computer optimization: Cholesky decomposition; Storage optimization; Spareness and optimization of the normal matrix

Tutorial (15 hours)

1. Geospatial analysis: Principal component analysis (PCA)
2. Remote sensing: Processing and analyzing satellite images
3. Network analysis: Analyzing and optimizing transportation and utility networks
4. Monte Carlo method and applications
5. Agent-based model and applications
6. Spatiotemporal big data analytics and applications
7. Spatial smoothing and spatial interpolation

Practical (30 hours)

1. Matrix operations in geomatics problems:
   i. Solution of linear equations
   ii. Gauss method, Gauss-Jordan method
   iii. Eigen values and eigenvectors
   iv. Differentiation of matrices and quadratic forms
2. 2-D and 3-D coordinate transformations
3. 2-D and 3-D datum transformations
4. Blunder detection and computer optimization (Cholesky decomposition)

5. Algorithm development and application labs on Kalman Filtering

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	8	8
2	8	8
3	12	12
4	8	8
5	12	12
6	12	12
Total	**60**	**60**

* There may be minor deviation in marks distribution.

References

1. Liu, L., Wang, F. (2016). Computational methods and GIS applications in social science. CRC Press.
2. Krakiwsky, E. J., Abousalem, M. A. (1991). Adjustment of observations (Latest Edition). University of New Brunswick.
3. Wells, D. E., Krakiwsky, E. J. (1971). The methods of least squares (Latest Edition). University of New Brunswick.
4. Wolf, P. R., Brinker, R. C. (2012). Elementary surveying. Pearson.
5. Ghilani, C. D. (2017). Adjustment computations: Spatial data analysis. Wiley.
6. Ogundare, J. O. (2018). Understanding least squares estimation and geomatics data analysis. Wiley.