Course guide
310629 - 310629 - 3D Data Processing

Last modified: 13/01/2025

Unit in charge: Barcelona School of Building Construction
Teaching unit: 751 - DECA - Department of Civil and Environmental Engineering.

Degree: BACHELOR'S DEGREE IN GEOINFORMATION AND GEOMATICS ENGINEERING (Syllabus 2016). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 4.5 **Languages:** Catalan

LECTURER

Coordinating lecturer: XABIER BLANCH GORRIZ

Others:

PRIOR SKILLS

Basic knowledge of computer science.
Skills in basic mathematics and statistics.
Knowledge of programming (Python)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
10. (ENG) Determinar, mesurar, avaluar i representar el terreny, objectes tridimensionals, punts i trajectòries.
1. (ENG) Determinar, mesurar, avaluar i representar el terreny, objectes tridimensionals, punts i trajectòries.
2. (ENG) Planificació, projecte, direcció, execució i gestió de processos de mesura, sistemes d'informació, explotació d'imatges, posicionament i navegació; modelització, representació i visualització de la informació territorial en, sota i sobre la superfície terrestre.
3. Capacity for the resolution of mathematic problems that can be set out in engineering. Aptitude to apply the knowledge about: linear algebra, geometry, differential geometry, differential and integral calculus, differential equations and in partial derivates, numeric methods, numeric algorithm, stadistics and optimization.
6. Basic knowledge about use and computer programmation, operative systems, databases and software programmes with application in the enginnering.
7. Capacity of spatial vision and knowlege of the graphic representation techniques, for traditional methods of metric and geometric geometry but also for applications of assisted design by a computer.

8. Knowledge, use and application of instruments and appopriate photogrametric methods for the fullfilment of cartographic.
9. Knowledge, use and application of the treatment techinques. Analysis of special data. Study of models applied to the engineering and architecture.
4. Knowledge, application and analysis of the processes of treatment of digital images and special information, proceding from airborne and satelite sensors.
5. Knowledge, use and application of instruments and fotogrametric methods and topographic adequated to the realization of non-cartographic raisings.
11. Knowledge and application of methods of minimun adjust quadratic in the scope of topo-geodesic observations, photogrametric and cartographic.

Generical:
16. Use of teams and instrumental: Capacity to select the necessary ressources to the achievement of the planned goals according to the quality requirements. Use of the teams, in adequated conditions, with professional efficiency and taking into account the limitations of the instruments and its context of use, in relation with the required precissions.

Transversal:
12. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 1. Planning oral communication, answering questions properly and writing straightforward texts that are spelt correctly and are grammatically coherent.
13. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.
14. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.
15. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.

TEACHING METHODOLOGY

Lectures (teacher-led)
Participatory expository classes (student-focused)
Guided practicals
Independent work (pre- and post-lectures)
Cooperative work
Project-based work (individual and group)
Problem-based learning (PBL)

LEARNING OBJECTIVES OF THE SUBJECT

The student will acquire the necessary knowledge to manage, process, and analyze 3D geospatial data, applying techniques such as classification, temporal analysis, and data structuring, using specialized tools to extract useful information for spatial models.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	27,0	24.00
Hours large group	18,0	16.00
Self study	67,5	60.00

Total learning time: 112.5 h

CONTENTS

T1: Introduction to 3D Data

Description:
Basic concepts of 3D geometry.
3D data formats (LAS, PLY, OBJ, etc.).
3D data sources (LiDAR, photogrammetry, laser scanner).

Specific objectives:
Identify and differentiate the main 3D data formats.
Recognize the various 3D data acquisition sources.

Full-or-part-time: 11h
Theory classes: 2h
Practical classes: 2h
Self study : 7h

3D Data Acquisition and Management

Description:
Planning 3D data acquisition projects.
3D data acquisition tools.
Management and storage of large volumes of 3D data.

Full-or-part-time: 11h
Theory classes: 2h
Practical classes: 2h
Self study : 7h

T3: 3D Data Preprocessing

Description:
Data filtering: removal of noise and outliers.
Data correction: compensation for systematic errors.
Data registration: alignment of point clouds.
Segmentation and clustering: techniques for identifying and grouping elements with similar characteristics.

Related activities:
P1: Georeferencing of Multitemporal Point Clouds
P2: Point Cloud Classification

Full-or-part-time: 29h
Theory classes: 5h
Practical classes: 7h
Self study : 17h

T4: 3D Data Analysis

Description:
Volume and surface calculation: Numerical methods for precise measurements.
Deformation analysis: Techniques for detecting and quantifying geometric changes.
Change detection: Methodologies for comparing multitemporal data.
Specific applications: Real-world use cases in various professional fields.
Data classification and segmentation.

Related activities:
P2: Point Cloud Classification
P3: Comparison of Multitemporal Point Clouds and Change Detection

Full-or-part-time: 29h
Theory classes: 5h
Practical classes: 7h
Self study : 17h

T5: 3D Modeling

Description:
Surface modeling: TIN, triangular meshes, NURBS surfaces.
Object modeling: Creation of 3D models from point clouds.
Statistical analysis of 3D data.

Related activities:
P4: Generation of Terrain Models and Cartography

Full-or-part-time: 17h
Theory classes: 2h
Practical classes: 5h
Self study : 10h

T6: 3D Visualization

Description:
3D visualization tools.
Creation of 3D cartographic products.
Virtual and augmented reality.

Full-or-part-time: 15h 30m
Theory classes: 2h
Practical classes: 4h
Self study : 9h 30m

ACTIVITIES

P1: Georeferencing of Multitemporal Point Clouds

Description:
Import and visualize data in a point cloud processing software (CloudCompare, PCL libraries in Python, etc.).
Identify common control points (if georeferencing errors are simulated) or use automatic registration techniques (ICP, etc.) to align the clouds.
Clean the clouds by removing noise, outliers, and duplicate points. Artifacts can be intentionally introduced for students to practice cleaning techniques.
Visualize the results.

Specific objectives:
Familiarize with basic point cloud manipulation operations.
Apply registration and georeferencing techniques.
Learn how to identify and remove noise and outlier

Full-or-part-time: 3h
Self study: 3h

P2: Point Cloud Classification

Description:
Classify 3D data into relevant categories (ground, vegetation, buildings, vehicles, etc.).
Supervised, unsupervised, or a combination of both classification methods will be used.

Specific objectives:
Understand the principles of point cloud classification.
Apply different classification algorithms (e.g., based on geometry, reflectivity, etc.).
Evaluate the quality of the classification (e.g., through visual inspection or comparison with reference data).

Full-or-part-time: 3h
Self study: 3h

P3: Comparison of Multitemporal Point Clouds and Change Detection

Description:
Compute distances between the clouds to identify areas of vertical change (e.g., excavations, fills, vegetation growth).
Visualizing the differences using heat maps or contour lines.
Quantifying the changes in volume or area.

Specific objectives:
Apply techniques for comparing point clouds.
Identify and quantify changes over time.
Interpret the results of change analysis in a geographic context.

Full-or-part-time: 3h
Self study: 3h

P4: Generation of Terrain Models and Cartography

Description:
Filter ground points (class "ground").
Generate a Digital Terrain Model (DTM) using triangulation (TIN) or interpolation techniques.
Derive cartographic products from the DTM, such as contour lines, slope maps, and aspect maps.

Specific objectives:
Understand the process of generating a DTM from point clouds.
Apply different interpolation techniques.
Derive cartographic products useful for terrain analysis.
Integrate different types of LiDAR data to create 3D representations.

Full-or-part-time: 3h
Theory classes: 3h

GRADING SYSTEM

Continuous assessment (70%):
- 4 mini-projects (15% each)
- Cooperative exercises in class, online quizzes, participation (10%)

Final activity (30%)

EXAMINATION RULES.

Attendance at practical activities, exams, and the submission of all deliverables are mandatory and, therefore, a necessary condition for evaluation. Failure to submit the practical assignments will result in a grade of NS (Not Submitted).

BIBLIOGRAPHY

Basic:
- Zhilin, Li ; Gold, Christopher. Digital terrain modeling : principles and methodology [on line]. 2005. Boca Raton-Florida: CRC Press, 2005 [Consultation: 16/06/2020]. Available on: https://www.taylorfrancis.com/books/9780429205071. ISBN 0-415-32462-9.
- Florent Poux. 3D Data Science with Python: Building Accurate Digital Environments with 3D Point Cloud Workflows. 1a. O'Reilly Media, ISBN 978-1098161330 / 1098161335.
- Wei Gao, Ge Li. Deep Learning for 3D Point Clouds. 1a. Springer, 2024. ISBN 978-9819795697.

Complementary:
- Xudong Ma. 3D Deep Learning with Python [on line]. 1st Edition. Packt, 2022 [Consultation: 11/01/2025]. Available on: https://www.packtpub.com/en-us/product/3d-deep-learning-with-python-9781803247823/chapter/part-1-3d-data-processing-basics-1/section/part-1-3d-data-processing-basics-basics. ISBN 9781803247823.

RESOURCES

Hyperlink:
- Open3D. https://www.open3d.org/- CloudCompare documentation. https://www.danielgm.net/cc/