Course guide
270532 - DSIGE - Software Development for Geographic and Spacial Information

Last modified: 03/02/2025

Unit in charge: Barcelona School of Informatics
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: MASTER'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2012). (Optional subject).
MASTER'S DEGREE IN INNOVATION AND RESEARCH IN INFORMATICS (Syllabus 2012). (Optional subject).
MASTER'S DEGREE IN DATA SCIENCE (Syllabus 2021). (Optional subject).

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: RODRIGO IGNACIO SILVEIRA ISOBA

Others: Segon quadrimestre:
FABIAN MAXIMILIAN KLUTE - 10
RODRIGO IGNACIO SILVEIRA ISOBA - 10

PRIOR SKILLS

- Basic knowledge of data structures
- Basic knowledge of algorithmic technique

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CTE12. Capability to create and exploit virtual environments, and to the create, manageme and distribute of multimedia content.
CTE7. Capability to understand and to apply advanced knowledge of high performance computing and numerical or computational methods to engineering problems.

Generical:
CG4. Capacity for mathematical modeling, calculation and simulation in technology and engineering companies centers, particularly in research, development and innovation tasks in all areas related to Informatics Engineering.
CG6. Capacity for general management, technical management and research projects management, development and innovation in companies and technology centers in the area of Computer Science.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.

Transversal:
CTR4. INFORMATION LITERACY: Capability to manage the acquisition, structuring, analysis and visualization of data and information in the area of informatics engineering, and critically assess the results of this effort.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Basic:
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.

TEACHING METHODOLOGY

The course will consist of presentations of the main theoretical topics, followed by a discussion of the more practical aspects associated with them, and the presentation of practical tools to address them.

LEARNING OBJECTIVES OF THE SUBJECT

1.Learn what geographic information systems (GIS) are.
2.Analyze concrete problems that a GIS must be able to solve.
3.Study some of the algorithms behind GIS.
4.Learn different ways to represent and process geographic and spatial data.

STUDY LOAD

Type	Hours	Percentage
Hours large group	27,0	36.00
Self study	48,0	64.00

Total learning time: 75 h

CONTENTS

Introduction to geographic information systems, spatial information, and geometric algorithms.

Description:
Main principles of spatial information and geographic information systems. Examples of GIS applications. Introduction to geometric algorithms. Relation between the implementation of a GIS and geometric algorithms.

Map representation, combination and overlay of geographic subdivisions.

Description:
Introduction to map overlay. Unification of coordinate systems. Data structures for representing maps and geographic subdivisions. Algorithms for calculating overlaps of subdivisions. Algorithms and data structures for locating points in geographic subdivisions.

Digital terrain models, vector and raster terrains

Description:
Models for representing terrains. Raster and TIN (triangulated irregular network) models. Basic algorithms for rasters and TINs. Traversal and location in TINs. Conversion between different terrain models.

Algorithms for terrain analysis: visibility and hydrology problems

Description:
Applications of terrain analysis in visibility and hydrography. Calculation of viewsheds and watersheds in rasters and TINs. Removal of local minima and other artifacts.

Voronoi diagrams applied to facility location and pattern analysis problems

Description:
Definition of Voronoi diagram. Applications to GIS. Algorithms for constructing the Voronoi diagram.

Basic algorithms for digital cartography: map generalization and labeling

Description:
Introduction to maps and cartography. Principles of map design. Cartographic symbolization and generalization. Line simplification, Douglas-Peucker algorithm. Map labeling.

Extra topics to be chosen by the students.

Description:
The specific topics will be defined by the students and the instructors during the first half of the course.

ACTIVITIES

Introduction

Specific objectives:
1

Related competencies :
CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.
CG6. Capacity for general management, technical management and research projects management, development and innovation in companies and technology centers in the area of Computer Science.
CTR4. INFORMATION LITERACY: Capability to manage the acquisition, structuring, analysis and visualization of data and information in the area of informatics engineering, and critically assess the results of this effort.

Full-or-part-time: 11h
Self study: 7h
Theory classes: 4h

Map representation, combination and overlay of geographic subdivisions

Specific objectives:
2, 3, 4

Related competencies :
CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CTE12. Capability to create and exploit virtual environments, and to the create, manageme and distribute of multimedia content.
CTE7. Capability to understand and to apply advanced knowledge of high performance computing and numerical or computational methods to engineering problems.
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.
CG4. Capacity for mathematical modeling, calculation and simulation in technology and engineering companies centers, particularly in research, development and innovation tasks in all areas related to Informatics Engineering.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 11h
Self study: 7h
Theory classes: 4h

Digital terrain models

Specific objectives:
2, 3, 4

Related competencies :
CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CTE12. Capability to create and exploit virtual environments, and to the create, manageme and distribute of multimedia content.
CTE7. Capability to understand and to apply advanced knowledge of high performance computing and numerical or computational methods to engineering problems.
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.
CG4. Capacity for mathematical modeling, calculation and simulation in technology and engineering companies centers, particularly in research, development and innovation tasks in all areas related to Informatics Engineering.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 12h
Self study: 7h
Theory classes: 5h

Voronoi diagrams

Specific objectives:
2, 3, 4

Related competencies :
CB9. Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CTE12. Capability to create and exploit virtual environments, and to the create, manageme and distribute of multimedia content.
CTE7. Capability to understand and to apply advanced knowledge of high performance computing and numerical or computational methods to engineering problems.
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.
CG4. Capacity for mathematical modeling, calculation and simulation in technology and engineering companies centers, particularly in research, development and innovation tasks in all areas related to Informatics Engineering.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 11h
Self study: 7h
Theory classes: 4h

Algorithms for terrain analysis

Specific objectives:
2, 3

Related competencies :
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CTE12. Capability to create and exploit virtual environments, and to the create, manageme and distribute of multimedia content.
CTE7. Capability to understand and to apply advanced knowledge of high performance computing and numerical or computational methods to engineering problems.
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.
CG4. Capacity for mathematical modeling, calculation and simulation in technology and engineering companies centers, particularly in research, development and innovation tasks in all areas related to Informatics Engineering.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 11h
Self study: 7h
Theory classes: 4h

Basic algorithms for digital cartography

Specific objectives:
2, 3

Related competencies :
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CTE12. Capability to create and exploit virtual environments, and to the create, manageme and distribute of multimedia content.
CTE7. Capability to understand and to apply advanced knowledge of high performance computing and numerical or computational methods to engineering problems.
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.
CG4. Capacity for mathematical modeling, calculation and simulation in technology and engineering companies centers, particularly in research, development and innovation tasks in all areas related to Informatics Engineering.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 11h
Self study: 7h
Theory classes: 4h

Extra topics to be defined during the course

Specific objectives:
2, 3

Related competencies :
CB6. Ability to apply the acquired knowledge and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.
CTE12. Capability to create and exploit virtual environments, and to the create, manageme and distribute of multimedia content.
CTE7. Capability to understand and to apply advanced knowledge of high performance computing and numerical or computational methods to engineering problems.
CTE11. Capability to conceptualize, design, develop and evaluate human-computer interaction of products, systems, applications and informatic services.
CG8. Capability to apply the acquired knowledge and to solve problems in new or unfamiliar environments inside broad and multidisciplinary contexts, being able to integrate this knowledge.
CG4. Capacity for mathematical modeling, calculation and simulation in technology and engineering companies centers, particularly in research, development and innovation tasks in all areas related to Informatics Engineering.
CTR6. REASONING: Capacity for critical, logical and mathematical reasoning. Capability to solve problems in their area of study. Capacity for abstraction: the capability to create and use models that reflect real situations. Capability to design and implement simple experiments, and analyze and interpret their results. Capacity for analysis, synthesis and evaluation.

Full-or-part-time: 8h
Self study: 6h
Theory classes: 2h

GRADING SYSTEM

Evaluation will be based on a final project that will consist of theory and bibliography research tasks about a concrete GIS problem, and in class participation.

BIBLIOGRAPHY

Basic:
- Longley, P.A. [et al.]. Geographic information systems & science. 4th ed. Hoboken, NJ: Wiley, 2015. ISBN 9781118676950.
- Kreveld, M. van [et al.]. Algorithmic foundations of geographic information systems. Berlin: Springer, 1997. ISBN 3540638180.
- Xiao, N. GIS algorithms. Thousand Oaks, CA: SAGE Publications, 2015. ISBN 9781446274330.

Complementary:
- O'Sullivan, D.; Unwin, D.J. Geographic information analysis. 2nd ed. Hoboken: John Wiley & Sons, 2010. ISBN 978-0470288573.
- DeMers, M.N. Fundamentals of geographic information systems. 4th ed. Hoboken: Wiley, 2009. ISBN 978-0470129067.
- Kimerling, A.J.; Buckley, A.R.; Muehrcke, P.C.; Muehrcke, J.O. Map use: reading, analysis, interpretation. 8th ed. Redlands, California: ESRI Press Academic, 2016. ISBN 978-1589484429.