Course guide
270968 - MLOPS - Machine Learning Systems in Production (Mlops)

Last modified: 14/07/2025

Unit in charge: Barcelona School of Informatics
Teaching unit: 747 - ESSI - Department of Service and Information System Engineering.

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: 2025 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: SILVERIO JUAN MARTÍNEZ FERNÁNDEZ

Others: Primer quadrimestre:
SANTIAGO DEL REY JUAREZ - 10
SILVERIO JUAN MARTÍNEZ FERNÁNDEZ - 10
MATÍAS-SEBASTIÁN MARTÍNEZ MARTÍNEZ - 10

PRIOR SKILLS

Those given by the subjects of the previous quarters of the master. Fundamentals of machine learning.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE10. Identify machine learning and statistical modeling methods to use and apply them rigorously in order to solve a specific data science problem
CE5. Model, design, and implement complex data systems, including data visualization
CE7. Identify the limitations imposed by data quality in a data science problem and apply techniques to smooth their impact

Generical:
CG3. Define, design and implement complex systems that cover all phases in data science projects
CG4. Design and implement data science projects in specific domains and in an innovative way

Transversal:
CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.
CT3. TEAMWORK: Ability to work as a member of an interdisciplinary team, as a normal member or performing direction tasks, in order to develop projects with pragmatism and sense of responsibility, making commitments taking into account the available resources.
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Basic:
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.
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 theoretical contents of the course are taught in the theory classes. These classes are complemented with practical examples and problems that students must solve in the Autonomous Learning hours.

In the laboratory sessions, the knowledge acquired in the theory classes is consolidated by solving problems and developing practices related to the theoretical contents. During the laboratory classes, the teacher will introduce new techniques and will leave an important part of the class for the students to work on the proposed exercises.

LEARNING OBJECTIVES OF THE SUBJECT

1.Interpret the basic concepts of Software Engineering for ML systems, especially in relation to the use and exploitation of MLOps practices.
2.Apply and analyze MLOps practices to build ML models, fostering reproducibility and quality assurance.
3.Apply and analyze MLOps practices to deploy ML models, fostering API development and component delivery.
4.Describe concepts and methods related to monitoring data obtained during the use of ML systems, in order to enable feedback loops in response to changes.

STUDY LOAD

Type	Hours	Percentage
Self study	100,0	64.94
Hours small group	27,0	17.53
Hours large group	27,0	17.53

Total learning time: 154 h

CONTENTS

Basic concepts of Software Engineering for ML systems (MLOps)

Description:
Motivation of the need of software engineering for ML systems. MLOps introduction and key concepts. Requirements engineering for ML. Collaborative development platforms.

MLOps practices to build ML models

Description:
The complexity and diversity of data science projects and ML systems call for engineering techniques to ensure they are built in a robust and future-proof manner. On this chapter we address software engineering best practices for data science projects software including ML components: version control systems; ML pipeline reproducibility and tracking; software measurement for ML; quality assurance for ML.

MLOps practices to deploy ML models

Description:
The complexity and diversity of ML systems call for engineering techniques to ensure they are deployed in a robust and production-ready manner. On this chapter we address software engineering best practices for ML components: software architecture for ML; deploying ML models; APIs for ML; packaging of ML components; automation of ML pipelines.

Monitoring data obtained during the use of ML systems

Description:
A key problem in software development is the evolution of the ML system in response to new needs. The analysis of the data obtained during the use of the ML system by its users, including their explicit comments, makes it possible to discover their real needs, which sometimes even they are not fully aware of. More and more we find software systems that need to be aware of their context in order to provide a correct service. This restriction requires them to monitor context data continuously, discover significant changes and react at runtime (eventually, almost in real time). This topic describes the problem and reviews some basic techniques: monitoring and telemetry; MLOps cycles and feedback loops.

ACTIVITIES

Study of basic concepts of Software Engineering for ML systems (MLOps)

Specific objectives:
1

Related competencies :
CE5. Model, design, and implement complex data systems, including data visualization
CG3. Define, design and implement complex systems that cover all phases in data science projects
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 5h 24m
Self study: 1h 48m
Theory classes: 3h 36m

Study of MLOps practices to build ML models

Specific objectives:
2

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.
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.
CE10. Identify machine learning and statistical modeling methods to use and apply them rigorously in order to solve a specific data science problem
CE7. Identify the limitations imposed by data quality in a data science problem and apply techniques to smooth their impact
CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.
CT3. TEAMWORK: Ability to work as a member of an interdisciplinary team, as a normal member or performing direction tasks, in order to develop projects with pragmatism and sense of responsibility, making commitments taking into account the available resources.

Full-or-part-time: 10h 48m
Self study: 3h 36m
Theory classes: 7h 12m

Study of MLOps practices to deploy ML models

Specific objectives:
3

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.
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.
CE5. Model, design, and implement complex data systems, including data visualization
CG4. Design and implement data science projects in specific domains and in an innovative way
CG3. Define, design and implement complex systems that cover all phases in data science projects
CT3. TEAMWORK: Ability to work as a member of an interdisciplinary team, as a normal member or performing direction tasks, in order to develop projects with pragmatism and sense of responsibility, making commitments taking into account the available resources.

Full-or-part-time: 10h 48m
Self study: 3h 36m
Theory classes: 7h 12m

Study of concepts for monitoring data obtained during the use of ML systems

Specific objectives:
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.
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.
CE5. Model, design, and implement complex data systems, including data visualization
CG4. Design and implement data science projects in specific domains and in an innovative way
CG3. Define, design and implement complex systems that cover all phases in data science projects
CT3. TEAMWORK: Ability to work as a member of an interdisciplinary team, as a normal member or performing direction tasks, in order to develop projects with pragmatism and sense of responsibility, making commitments taking into account the available resources.

Full-or-part-time: 10h 48m
Self study: 3h 36m
Theory classes: 7h 12m

Practical development of an end-to-end project of MLOps practices in the context of ML-based systems

Description:
The student will progressively develop a practice that allows him to exercise the basic concepts introduced in the theory part. It will be developed in teams of 4-5 students. The resulting software, duly documented, will be uploaded to a code repository. The team will present a report, written in English, summarizing the main aspects of the practice. This is, the process of building and deploying an ML component of an ML-based system, and an evaluation of the accuracy of the models and algorithms used.

Specific objectives:
1, 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.
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.
CE10. Identify machine learning and statistical modeling methods to use and apply them rigorously in order to solve a specific data science problem
CE5. Model, design, and implement complex data systems, including data visualization
CE7. Identify the limitations imposed by data quality in a data science problem and apply techniques to smooth their impact
CG4. Design and implement data science projects in specific domains and in an innovative way
CG3. Define, design and implement complex systems that cover all phases in data science projects
CT2. Sustainability and Social Commitment. To know and understand the complexity of economic and social phenomena typical of the welfare society; Be able to relate well-being to globalization and sustainability; Achieve skills to use in a balanced and compatible way the technique, the technology, the economy and the sustainability.
CT3. TEAMWORK: Ability to work as a member of an interdisciplinary team, as a normal member or performing direction tasks, in order to develop projects with pragmatism and sense of responsibility, making commitments taking into account the available resources.
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 95h 48m
Self study: 70h 36m
Laboratory classes: 25h 12m

Presentation of the summary of an existing article about MLOps

Description:
The student will present the summary of a scientific article. All students need to present (at least) once. Presenters need to make at least one question to the other presentations to foster discussions. Lecturers prepare a list of articles.

Specific objectives:
1

Related competencies :
CE5. Model, design, and implement complex data systems, including data visualization
CG3. Define, design and implement complex systems that cover all phases in data science projects
CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 8h 12m
Self study: 6h 24m
Guided activities: 1h 48m

Presentation of the practical development of an end-to-end project of MLOps practices in the context of ML-based systems

Specific objectives:
1, 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.
CB8. Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.
CE10. Identify machine learning and statistical modeling methods to use and apply them rigorously in order to solve a specific data science problem
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CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Full-or-part-time: 8h 12m
Self study: 6h 24m
Guided activities: 1h 48m

GRADING SYSTEM

The grade is calculated by weighting the grade of the project (weight 90%) and grade of an article presentation in theory (weight 10%). Both activities are mandatory.

NOTA-FINAL = 90% ProjectGrade + 10% ArticlePresentation

In the project grade, the completion of the project and the individual work are graded. As a result, each student's final project grade is determined from the following formula:

ProjectGrade = TeamGrade * IndivFact

The project's overall TeamGrade grade takes into account the application of software engineering practices.

The individual factor IndivFact is a multiplicative factor among 0 and 1.2 (and similarly, cannot make ProjectGrade grow beyond 10). This factor is obtained from the evaluation that the teacher makes about the participation of the student in the project development and the evaluation that the team mates make on this very participation.

BIBLIOGRAPHY

Basic:

- Hulten, Geoff. Building intelligent systems: a guide to machine learning engineering [on line]. California: Apress, 2018 [Consultation: 16/09/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5357977. ISBN 9781484234327.

Complementary:

- Lanubile, Filippo; Martínez-Fernández, Silverio; Quaranta, Luigi. "Teaching MLOps in Higher Education through Project-Based Learning". 2023 IEEE/ACM 45th International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET) [on line]. [Consultation: 15/01/2024]. Available on: https://arxiv.org/pdf/2302.01048.pdf.- Kästner, Christian. Machine learning in production: from models to products. Cambridge, Massachusetts: MIT Press, 2025. ISBN 9780262049726.
- Chen, Cathy. Reliable Machine Learning [on line]. Boston: O'Reilly Media, Inc., 2022 [Consultation: 16/09/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=30130756. ISBN 9781098106225.
- Haviv, Yaron; Gift, Noah. Implementing MLOps in the Enterprise [on line]. Sebastopol: O'Reilly Media, Inc., 2023 [Consultation: 16/09/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=30978817. ISBN 9781098136543.
- Ameisen, Emmanuel. Building machine learning powered applications: going from idea to product [on line]. Bejing: O'Reilly Media, Inc., 2020 [Consultation: 16/09/2025]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=6027247. ISBN 9781492045106.