

COURSE OUTLINE

(1) GENERAL

SCHOOL			
ACADEMIC UNIT	Interdisciplinary Graduate Programme in the BRAIN and MIND sciences		
LEVEL OF STUDIES	POSTGRADUATE		
COURSE CODE	CS-577	SEMESTER	1o -2o
COURSE TITLE	Machine Learning		
INDEPENDENT TEACHING ACTIVITIES	WEEKLY TEACHING HOURS	CREDITS	
<i>if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits</i>	4	6	
<i>Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).</i>			
COURSE TYPE	Special background		
<i>general background, special background, specialised general knowledge, skills development</i>			
PREREQUISITE COURSES:	CS-150, CS-217, CS-380 or equivalent		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes		
COURSE WEBSITE (URL)	https://elearn.uoc.gr/		

(2) LEARNING OUTCOMES

<p>Learning outcomes</p> <p><i>The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.</i></p> <p><i>Consult Appendix A</i></p> <ul style="list-style-type: none"> • <i>Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area</i> • <i>Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B</i> • <i>Guidelines for writing Learning Outcomes</i>
<p>1. Knowledge: Having attended and succeeded in the course, the student understands the general problem of machine learning, including the basic theory, principles, and algorithms, as well as practical applications of the field.</p> <p>2. Understanding: Having attended and succeeded in the course, the student understands the problem of supervised learning, hypothesis testing, principles for designing classification algorithms (naive bayes classifier, decision trees, random forests, logistic regression, support vector machines), metrics of predictive performance, estimation of predictive performance, hyper-parameter optimization, feature selection algorithms, and basic principles of causal discovery.</p> <p>3. Application: Having attended and succeeded in the course, the student is able to apply their knowledge in a plethora of real datasets. More specifically, they can analyze data using and combining the above techniques, optimize the machine learning pipeline, produce predictive, diagnostic, and prognostic models, and estimate their predictive performance.</p> <p>4. Analysis: Having attended and succeeded in the course, the student is able to analyze the</p>

basic algorithmic principles and understand their pros and cons.

5. Synthesis: Having attended and succeeded in the course, the student is able to synthesize their knowledge to solve real research problems and applications. The project of the course offers the student the experience of writing and presenting to the scientific community a scientific paper.

6. Evaluation: Having attended and succeeded in the course, the student is able to evaluate and review research and applied works of machine learning regarding their quality as well as their soundness, identify problems of overfitting, and problems of overestimation of predictive performance.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

<i>Search for, analysis and synthesis of data and information, with the use of the necessary technology</i>	<i>Project planning and management</i>
<i>Adapting to new situations</i>	<i>Respect for difference and multiculturalism</i>
<i>Decision-making</i>	<i>Respect for the natural environment</i>
<i>Working independently</i>	<i>Showing social, professional and ethical responsibility and sensitivity to gender issues</i>
<i>Team work</i>	<i>Criticism and self-criticism</i>
<i>Working in an international environment</i>	<i>Production of free, creative and inductive thinking</i>
<i>Working in an interdisciplinary environment</i>	<i>.....</i>
<i>Production of new research ideas</i>	<i>Others...</i>
	<i>.....</i>

- Search, analysis and synthesis of data and information
- Decision making
- Autonomous work
- Generating new research ideas
- Working in an international environment
- Criticism and self-criticism
- Production of free, creative, and inductive thinking

(3) SYLLABUS

The purpose of the course is to provide a broad introduction to the field of Machine Learning including the basic theory, principles, and algorithms, as well as practical applications on real problems. The topics focus on supervised classification and include:

- (1) A brief reminder of basic probabilities
- (2) Statistical hypothesis testing
- (3) Classification algorithms: (Naive Bayes, Logistic Regression, Decision Trees, Random Forests, Support Vector Machines, Naive Bayes)
- (4) Metrics for measuring classification performance and the Area Under the Receiver's Operating Characteristic Curve.
- (5) Estimation of predictive performance (cross-validation, nested cross validation, bootstrap bias correction cv)
- (6) Automated Machine Learning (AutoML), theory and algorithms for model selection and tuning of hyperparameters
- (7) Feature Selection algorithms
- (8) Bayesian Networks and learning of causal relations and structures

(4) TEACHING and LEARNING METHODS - EVALUATION

<p style="text-align: center;">DELIVERY</p> <p style="text-align: center;"><i>Face-to-face, Distance learning, etc.</i></p>	Face-to-face																							
<p style="text-align: center;">USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY</p> <p style="text-align: center;"><i>Use of ICT in teaching, laboratory education, communication with students</i></p>	<ul style="list-style-type: none"> • email • course website • electronic submission of exercises • e-learn platform 																							
<p style="text-align: center;">TEACHING METHODS</p> <p><i>The manner and methods of teaching are described in detail.</i></p> <p><i>Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.</i></p> <p><i>The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</i></p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><i>Activity</i></th> <th style="text-align: center;"><i>Semester workload</i></th> </tr> </thead> <tbody> <tr> <td>Lectures</td> <td style="text-align: center;">52</td> </tr> <tr> <td>Tutorials</td> <td style="text-align: center;">0</td> </tr> <tr> <td>Study</td> <td style="text-align: center;">52</td> </tr> <tr> <td>Exercises/labs</td> <td style="text-align: center;">40</td> </tr> <tr> <td>Final project</td> <td style="text-align: center;">20</td> </tr> <tr> <td>Exams</td> <td style="text-align: center;">4</td> </tr> <tr> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> </tr> <tr> <td>Course total</td> <td style="text-align: center;">168</td> </tr> </tbody> </table>		<i>Activity</i>	<i>Semester workload</i>	Lectures	52	Tutorials	0	Study	52	Exercises/labs	40	Final project	20	Exams	4							Course total	168
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<p style="text-align: center;">STUDENT PERFORMANCE EVALUATION</p> <p><i>Description of the evaluation procedure</i></p> <p><i>Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other</i></p> <p><i>Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</i></p>	<p>Class attendance/participation</p> <p>Exercises/projects</p> <p>Oral/written exams</p>																							

(5) ATTACHED BIBLIOGRAPHY

- *Suggested bibliography:*

Artificial Intelligence: A Modern Approach, 4th US ed., Chapters 12 and 13.

GENERATIVE AND DISCRIMINATIVE, CLASSIFIERS: NAIVE BAYES AND LOGISTIC REGRESSION, Tom Mitchell, on line draft

Sections 8.1, 9.3, Probability and Statistics, M. deGroot (2nd Edition)

Section 9-9.1.17(Up-to Likelihood), Probability and Statistics, M. deGroot (4th Edition)

Chapter 3, Machine Learning, Tom M. Mitchell Sections 15.1, 15.2, first part of 15.3 in Elements of Statistical Learning.

Fawcett, ROC Graphs: Notes and Practical Considerations for Data Mining Researchers, <https://www.hpl.hp.com/techreports/2003/HPL-2003-4.pdf>

Tsamardinos, I., Greasidou, E. & Borboudakis, G. Bootstrapping the out-of-sample predictions for efficient and accurate cross-validation.

Mach Learn 107, 1895–1922 (2018). <https://doi.org/10.1007/s10994-018-5714-4>

Tsamardinos, I., Don't lose samples to estimation, Cell Patterns, 2022

Nello Cristianini, John Shawe-Taylor, An Introduction to Support Vector Machines and Other Kernel-based Learning Methods, Cambridge University Press, 2013

Borboudakis, G., Tsamardinos I., Forward-Backward Selection with Early Dropping, JMLR 2019

- *Related academic journals:*

