UNIVERSITAT DE BARCELONA

Week 1 – Information of the course:

Introduction to Machine Learning (IML)

Course 2023-2024

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Brief description

- This course provides an **introduction on Machine Learning**

- It gives an overview of many concepts, techniques and algorithms in machine learning, beginning with topics such as **classification** and **linear regression** and ending up with more recent topics such **support vector machines** and **recommender systems**

Brief description

- The course is divided into three main topics:
  - supervised learning, unsupervised learning, and machine learning theory
- Topics include:
  - (i) **Supervised learning** (linear decision, non linear decision)
  - (ii) **Unsupervised learning** (clustering, factor analysis, and visualization)
  - (iii) **Learning theory** (bias/variance theory, empirical risk minimization)
- The course will also draw from numerous case studies and applications, so that you'll also learn how to apply learning algorithms to computer vision, medical informatics, and signal analysis

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Summary

Introduction to Machine Learning

Unsupervised Learning			Supervised Learning					Decision Learning Theory
Cluster Analysis	Factor Analysis	Visualization	Non Linear Decision				Linear Decision	Basic concepts of Decision Learning Theory
K-Means, Fuzzy C-means, EM	PCA, ICA	Self Organized Maps (SOM) , Multi-Dimensional Scaling	Lazy Learning (K-NN, IBL, CBR)	Overfitting, model selection and feature selection	Kernel Learning	Ensemble Learning (Trees, Adaboost)	Perceptron, SVM	Bias/Variance, VC dimension, Practical advice of how to use learning algorithms

Contents

1. Introduction to Machine Learning
2. Introduction to unsupervised learning
3. Cluster analysis
   a) Classification of clustering algorithms
   b) K-Means, Bisecting K-Means, Fuzzy C-means
   c) EM. Introduction to Mixture of Gaussians
4. Factor analysis
   a) Principal Components Analysis (PCA)
   b) Independent Component Analysis (ICA)

Contents

5. Visualization

a) Self-Organized Maps (SOM)
b) Multi-dimensional Scaling (MDS)

6. A gentle introduction to supervised learning

a) The linear regression model
b) Descent optimization methods
c) Application of the learning model
d) Tour on Machine Learning terms

Contents

7. Lazy Learning
   a) Nearest Neighbour (NN) and kNN
   b) Instance-based Learning (IBL)
   c) Case-based Reasoning (CBR) foundations
8. Feature Selection
   a) Description of Wrappers, Filters, and embedded
   b) Feature Selection Perspectives (Search directions, Search Strategies)
   c) Measures for making the selection (based on information, distance, dependence, consistency, accuracy)

Contents

9. Model Selection
   a) Introduction to Model evaluation (performance metrics, confusion matrix, ROC curves, etc.)
   b) Model evaluation (hold-out, cross-validation, overfitting and underfitting, bias vs variance, regularization, etc.)
10. Kernel Learning
   a) Statistical learning theory
   b) Support Vector Machines (SVM)

Contents

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Organization of the course

Face-to-face scenario

- **Theoretical teaching** (Tuesday 10:00 to 12:00 room B2 at UB)
  - In-person activities

- **Theory/Practical**
  - In-person activities
  - **Face-to-face Theory/Practical** (Tuesday 12:00 to 13:00 room ID Group 1)
  - **Face-to-face Theory/Practical** (Tuesday 13:00 to 14:00 room ID Group 2)

Organization of the course

Face-to-face scenario

Theory/Practical Sessions

1. Teacher Maria Salamó (maria.salamo@ub.edu)
2. The time will be devoted to explain the **description** and **support material** for doing the practical exercises and solving doubts about these exercises.
3. **IMPORTANT No recordings of the face-to-face class will be performed**

Theoretical Sessions

1. Teacher Maria Salamó (maria.salamo@ub.edu)
2. The time will be devoted to:
    1. Summarize (30 to 60 minutes) the theory blocks of this week
    2. Perform question and answer sessions about theory
3. **IMPORTANT the support material explained in the face-to-face class will not be recorded**
4. The student may ask questions or may formulate a specific doubt about a topic. The teacher may repeat specific explanations to clarify or to provide support.
5. Short videos or additional material will be shared in the campus virtual by the teacher in case of specific common doubts to all students

Organization of the course

Face-to-face scenario

Campus Virtual (https://campusvirtual.ub.edu)

1. Provisional calendar
2. Theory – Slides of the course
   - Slides with the theory
   - Videos in specific theory blocks if necessary
3. Practical - Exercise text and instructions
   - Support slides for the practical
   - Description of the practical exercise in a pdf
   - Deliverable link in which the student will upload the code and the report of the practical exercise
4. Forum
   - Tool in which the student will write questions to the teacher. It allows to share the doubt and the answer to all the students, to avoid to repeat explanations.
   - Do not hesitate to use it! Other students might have the same doubt as you.
   - In addition, you can also help your mates by answering their questions if you have the answer.

Organization of the course

Face-to-face scenario

Common doubts?

1. Am I obliged to attend the face-to-face session?
   - No, you are not obliged, however it is recommended
     - The support material will be available in the campus virtual and is sufficient.
     - Beware! No face-to-face video will be shared, and forum will answer to specific doubts
     - A week questionnaire will be solved in these sessions

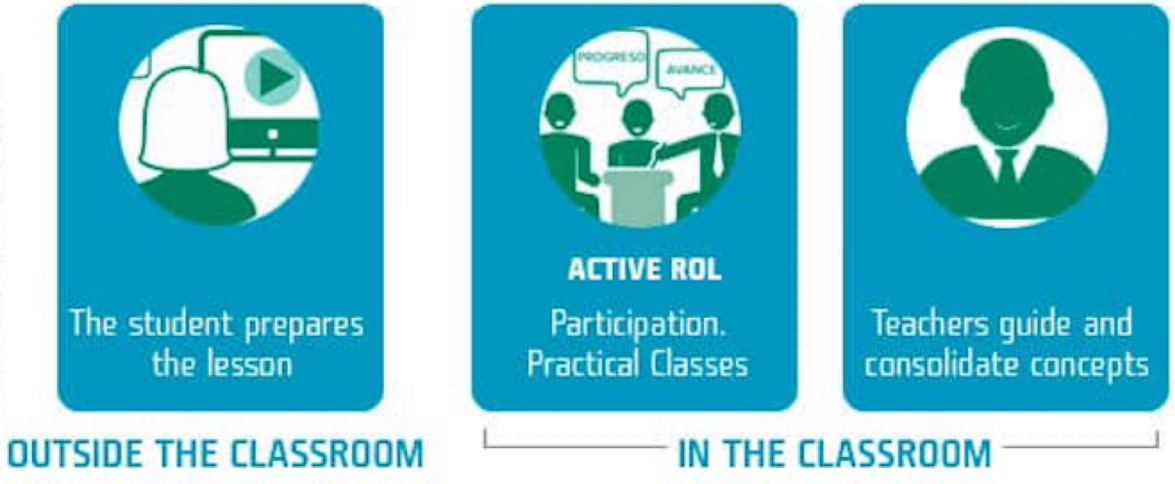
2. Am I obliged to attend practical sessions?
   - No, you are not obliged, however it is recommended
     - The teaching material will be available in the campus virtual and is sufficient.
     - Beware! No theory video will be shared every week, and practical sessions and forum will answer to specific doubts (question/answer) of the practical exercises

Organization of the course

Methodology

- Every week the corresponding theoretical lesson will appear in several blocks in campus virtual
  - Every Tuesday you will have the new lesson available on campus virtual
- During one week students prepare the lesson
- Next Tuesday **the theoretical session** will be devoted to summarize, discuss the contents of the lesson and question/answering
- A theoretical questionnaire will be done in the face-to-face theoretical class
- The practical exercises are done in the **face-to-face theoretical/practical classes** and are related to several lessons

It is very important your active role and to follow every week the theoretical lessons



Activities – work deliveries

- Work 1 – (W1)
  - Clustering exercise
- Work 2 – (W2)
  - Factor Analysis exercise
- Work 3 – (W3)
  - Lazy Learning or kNN Recommenders
- Work 4 – (W4)
  - Kernels exercise (mandatory)

This year work is done in groups of four

Evaluation

- The course is divided into two parts:
  - **Exam**: an exam at the end of the term
  - **Work**: Work deliveries during the semester

Mark = a x Exam + b x Work if exam>=3,5 and Work>= 4,5

This year **a** and **b** will be established as: *a = 0,4 and b = 0,6*

Exam = a final exam at the end of the term (9th January 2024)

Work = 0,30 x W1 + 0,2 x W2 + 0,30 x W3 + 0,2 x Tests

- Some Works may have an exam after the delivery. The mark will be a part of the Wx.
- **Tests** are the weekly theoretical questionnaires

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Calendar (1st version)

Week	Month	Tue	Theory Block	Theoretical class	Evaluation	Theoretical/Practical class
0	Sep	12	T1. Introduction to ML	none	none	none
1		19	T2. Clustering: Part 1	Information of the course and T1	none	W1. Clustering (Session 1)
2		26	NO CLASS change of schedule	none	none	NO CLASS change of schedule
3	Oct	3	T3. Clustering: Part 2	T2	none	W1. Clustering (Session 2)
4		10	T4. Factor Analysis: PCA and ICA	T3	T1, T2	W1. Clustering (Session 3)
5		17	T5. Visualization: SOM & MDS	T4	T3	W1. Clustering (Session 4) (deliver W1)
6		24	T6. Introduction to Supervised Learning	T5	T4	W2. A gentle introduction to PCA and visualization (Session 1)
		31	NO CLASS MID-term exams	none	none	NO CLASS MID-term exams
6	Nov	7	T7. Lazy Learning	T6	T5	W2. A gentle introduction to PCA and visualization (Session 2) (deliver W2)
7		14	T8. Feature Selection	T7	T6	W3. Lazy learning and FS (Session 1)
8		21	T9. Model Selection	T8	T7	W3. Lazy learning and FS (Session 2)
9		28	T10. SVM and Kernels	T9	T8	W3. Lazy learning and FS (Session 3)
	Dec	5	T11. Recommender Systems	T10	T9	W3. Lazy learning and FS (Session 4)
10		12	T12. Special Class	T11	T10	W3. Lazy learning and FS (Session 5) (deliver W3)
11		19		T12	T11	W4. A practical exercise (deliver W4)
12	Jan	9	Final EXAM		EXAM	

Remarks

- All the information of the course will be in Campus Virtual https://campusvirtual.ub.edu
  - **You have access or you will obtain soon, meantime, I will use racó** https://**raco.fib.upc.edu/**
- Work is in groups of 4 but the score is individual for each student
  - An individual questionnaire is done after each delivery, that will be used to weight the mark obtained by each member of the group
- Bring your own laptop computer (face-to-face classes)
  - Install previously **Python 3.7** and **Pycharm IDE**
- **Deliveries should be in Python in a PyCharm project**
  - **Late deliveries**: work or projects submitted late will mean the deduction of 1 point per day (out of 10) from the final mark
  - **Copy of deliveries**: all the groups involved will obtain 0 points

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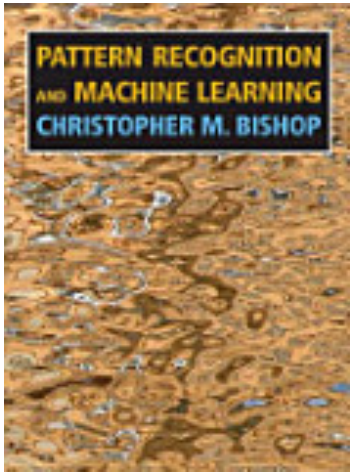
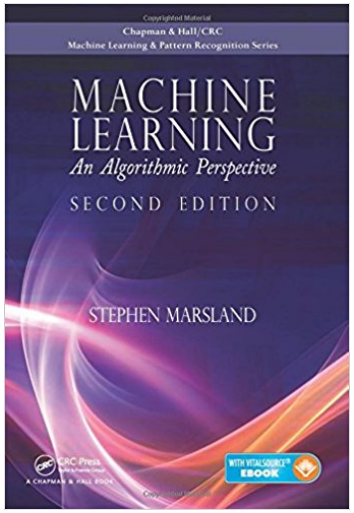
Bibliography





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- Marsland, Stephen, *Machine Learning: An algorithmic Perspective*, 2nd ed. CRC Press, 2015. ISBN: 978-1-466-58328-3

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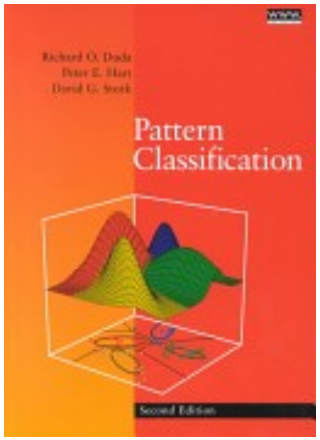

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- Tom Mitchell, *Machine Learning*. McGraw-Hill. ISBN 0-07-042807-7

Tools

- Python

  https://www.python.org/

  http://scikit-learn.org/

- PyCharm

  https://www.jetbrains.com/pycharm/