

Anàlisi i Reconeixement de Patrons

2014/2015

Codi: 43340

Crèdits: 6

Titulació	Tipus	Curs	Semestre
4314660 Enginyeria Informàtica / Computer Engineering	OB	1	2

Professor de contacte

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Utilització de llengües

Llengua vehicular majoritària: anglès (eng)

Grup íntegre en anglès: No

Grup íntegre en català: Sí

Grup íntegre en espanyol: No

Prerequisites

Programming in Python, Matlab/Octave.

Good level of English.

Basic understanding of linear algebra, integration and derivation, and the concept of probability

The subject of Pattern Analysis and Recognition follows in the line of related undergraduate courses on e.g. artificial intelligence, reasoning, machine learning, computer vision, where basics of pattern analysis and recognition have been introduced. Although the course is designed to build up from a minimum amount of prior knowledge, exposure to these topics would be beneficial for the students.

Objectius

The focus of this course, apart from providing the theoretical basis of pattern analysis and recognition, is to demonstrate the tools and methodologies required for applying the received knowledge in real-life problems, and build up experience in a practical application sense.

The course will introduce the basics of a number of themes in different detail. A subset of these themes will be worked further through the development of project work. This structure allows the course to cover the issue of pattern recognition in considerable breadth through the lectures, introducing a number of concepts and methodologies, while at the same time it allows the students to acquire more in-depth experience with a subset of the themes examined through the practical work. In parallel, the course demands the students to work both autonomously to learn and expand their knowledge on the basis of the material introduced, as well as in teams to develop the practical work required.

In particular the following objectives are set for students attending this course:

- To develop a scientific way of thinking and acquire critical reasoning skills
- To develop their teamwork skills and work cooperatively in a group
- To develop their individual learning skills
- To build a good understanding of basic data analysis concepts such as normalization, regularization, probability, clustering.
- To have a working knowledge of various methodologies for regression and classification, including Bayesian Classification, Support Vector Machines, Nearest Neighbour Search, and Decision Trees.

- To acquire basic knowledge of structural pattern recognition, graph based methods, neural networks and graphical models.
- To build the ability to develop and evaluate pattern recognition systems apply them to solving real-world problems.

Competències

- Comunicar-se oralment i per escrit en llengua anglesa.
- Concretar i indicar resultats assegurant alts nivells de rendiment i qualitat.
- Que els estudiants siguin capaços d'integrar coneixements i enfrontar-se a la complexitat de formular judicis a partir d'una informació que, tot i ser incompleta o limitada, inclogui reflexions sobre les responsabilitats socials i ètiques vinculades a l'aplicació dels seus coneixements i judicis
- Ser capaç de dirigir obres i instal·lacions de sistemes informàtics, complint la normativa vigent i assegurant la qualitat del servei.
- Ser capaç de dirigir, planificar i supervisar equips multidisciplinaris.
- Ser capaç de dur a terme la direcció general, la direcció tècnica i la direcció de projectes de recerca, desenvolupament i innovació, en empreses i centres tecnològics, en l'àmbit de l'enginyeria informàtica.
- Ser capaç de fer modelatge matemàtic, càlcul i simulació en centres tecnològics i d'enginyeria d'empresa, particularment en tasques de recerca, desenvolupament i innovació en tots els àmbits relacionats amb l'enginyeria informàtica.
- Ser capaç de posar en marxa, dirigir i gestionar processos de fabricació d'equips informàtics, amb garantia de seguretat per a les persones i els béns, la qualitat final dels productes i l'homologació d'aquests.
- Ser capaç de projectar, calcular i dissenyar productes, processos i instal·lacions en tots els àmbits de l'enginyeria informàtica.
- Ser capaç d'analitzar les necessitats d'informació que es plantegen en un entorn i dur a terme totes les etapes del procés de construcció d'un sistema d'informació.
- Ser capaç d'aplicar mètodes matemàtics, estadístics i d'intel·ligència artificial per modelar, dissenyar i desenvolupar aplicacions, serveis, sistemes intel·ligents i sistemes basats en el coneixement.
- Ser capaç d'assegurar, gestionar, auditar i certificar la qualitat dels desenvolupaments, els processos, els sistemes, els serveis, les aplicacions i els productes informàtics.
- Tenir coneixements que aportin la base o l'oportunitat de ser originals en el desenvolupament o l'aplicació d'idees, sovint en un context de recerca

Resultats d'aprenentatge

1. Comunicar-se oralment i per escrit en llengua anglesa.
2. Concretar i indicar resultats assegurant alts nivells de rendiment i qualitat.
3. Identificar les millors representacions que es puguin definir per resoldre problemes de reconeixement de patrons.
4. Identificar les millors representacions que es puguin definir per resoldre problemes tant d'anàlisi com de reconeixement de patrons.
5. Modelar, dissenyar, desenvolupar i avaluar una solució per a un problema concret de reconeixement de patrons.
6. Que els estudiants siguin capaços d'integrar coneixements i enfrontar-se a la complexitat de formular judicis a partir d'una informació que, tot i ser incompleta o limitada, inclogui reflexions sobre les responsabilitats socials i ètiques vinculades a l'aplicació dels seus coneixements i judicis
7. Seleccionar les tècniques apreses i entrenar-les per solucionar un projecte concret de reconeixement de patrons.
8. Ser capaç de dirigir obres i instal·lacions de sistemes informàtics, complint la normativa vigent i assegurant la qualitat del servei.
9. Ser capaç de dirigir, planificar i supervisar equips multidisciplinaris.
10. Ser capaç de dur a terme la direcció general, la direcció tècnica i la direcció de projectes de recerca, desenvolupament i innovació, en empreses i centres tecnològics, en l'àmbit de l'enginyeria informàtica.
11. Ser capaç de fer modelatge matemàtic, càlcul i simulació en centres tecnològics i d'enginyeria d'empresa, particularment en tasques de recerca, desenvolupament i innovació en tots els àmbits relacionats amb l'enginyeria informàtica.

12. Ser capaç de posar en marxa, dirigir i gestionar processos de fabricació d'equips informàtics, amb garantia de seguretat per a les persones i els béns, la qualitat final dels productes i l'homologació d'aquests.
13. Ser capaç de projectar, calcular i dissenyar productes, processos i instal·lacions en tots els àmbits de l'enginyeria informàtica.
14. Tenir coneixements que aportin la base o l'oportunitat de ser originals en el desenvolupament o l'aplicació d'idees, sovint en un context de recerca

Continguts

Theme 1 - Basic Concepts

- Linear Regression
- Normalization
- Logistic Regression
- Regularization, bias-variance decomposition, Sparsity, sparse methods
- Dimensionality reduction (PCA, ICA, spectral methods)

Theme 2 - Bayesian Perspective

- Probabilities
- Bayesian Decision Theory
- Bayes' theorem
- Bayesian classification
- Bayesian Interpretation of linear regression

Theme 3 - Clustering

- Gaussian Mixture models
- Expectation Maximisation
- K-means clustering
- Hierarchical clustering
- Nearest Neighbour Search

Theme 4 - Kernel methods

- Kernel methods
- Support Vector Machines
- Support Vector Regression

Theme 5 - Structural Pattern Recognition

- Graph representations
- Structural pattern recognition

Theme 6 - Ensemble methods

- Decision trees / decision forests
- Ensemble methods
- Boosting / bagging

Theme 7 - Advanced Topics

- Neural Networks
- Graphical Models

Metodologia

The learning process will be based on 2 types of activities: lectures focused on theoretical background and the development of a practical project.

THEORETICAL LECTURES

During these class sessions, the contents of the course will be presented and discussed. The students will be provided with digital material and bibliographic references. The lectures apart from offering a sound theoretical background, will cover all material necessary to develop the course project. All material necessary to follow the theoretical lectures will be provided through the "Campus Virtual" online platform.

PROJECT DEVELOPMENT

The students will be required to develop a project throughout the course. The projects will be the result of teamwork, where small groups of students will be formed in the beginning of the course and work together throughout the course duration.

The project will have the form of a practical solution to a given problem, where the groups will be required to make use of the knowledge acquired during the course, and produce a software solution (code) and a written report. The groups will have the obligation to present their work at the end of the course.

The development of the project will be guided through follow-up sessions every two weeks. During these sessions the requirements for the next stage of the project will be discussed and the students will have a chance to present progress up to date, expose problems, and discuss possible solutions with the teaching staff. Apart from the bi-weekly follow-up sessions, the students are expected to make use of the contact hours with the teaching staff to discuss open questions throughout the course.

The project will be structured in three parts, covering the following knowledge areas:

1. Regression, regularization and dimensionality reduction
2. Bayesian classification and clustering
3. Support Vector Machines, and decision forests

Each part will have a duration of about 4-5 weeks and will result to a course deliverable.

Activitats formatives

Títol	Hores	ECTS	Resultats d'aprenentatge
Tipus: Dirigides			
Conferències	26	1,04	1, 6, 11, 14
Sessions de seguiment del projecte	14	0,56	1, 2, 3, 4, 5, 6, 7, 9, 11, 13, 14
Tipus: Autònomes			
Desenvolupament del projecte	45	1,8	3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14
Estudi individual	40	1,6	3, 4, 5, 7, 10, 11

Avaluació

The evaluation of the student will be done in a continuous process that will take into account the evaluation of the project results, the participation of the students during the lecture and project sessions, and the final exam.

The deliverables expected are as follows:

D.1.1 Partial Report and Code (group) #1 (PR1)

D.1.2 Partial Report and Code (group) #2 (PR2)

D.1.3 Final Project Report and Code (group) (PR3)

The evaluation activities foreseen are:

E.2.1 Project Defence (group and individual) (PD)

E.2.2 Final Examination (individual) (FE)

The final grade will be calculated in the following manner:

$$\text{FINAL GRADE} = 0.1 * \text{PR1} + 0.1 * \text{PR2} + 0.1 * \text{PR3} + 0.3 * \text{PD} + 0.4 * \text{FE}$$

The minimum grade for each of the deliverables and evaluation activities is 5.

The grade of 4.5 will appear in the student's record in the case that the final grade calculation yields a grade greater or equal to 5, but the student has not reached the minimum requirement in one of the evaluation activities.

Active participation and positive contributions during the classes will result to a rounding of decimal points upwards. In order to opt for a "Matricula d'Honor" it is necessary to have demonstrated an active participation.

The partial reports of the project will be every 4-5 weeks. All deliverables are obligatory.

Any late submission of any of the project deliverables will be evaluated if and only if it takes place before the subsequent project deliverable due date, while the maximum grade awarded in such a cases will be limited to 7/10.

In the case of failing any of the project deliverables, the group will have the opportunity to resubmit a corrected version of the deliverable, before the day of the final exam.

A no-show in the final exam (FE) implies a "no-show" in the qualification record.

There will be a recovery examination that will permit students to obtain a pass on the theoretical part of the course in the case they have failed the final examination (FE). The date of the recovery examination will be proposed by the School.

All examinations will be adjusted according to the calendar of the School. The due dates for project deliverables will be published on the online platform of the course and are subject to scheduling changes to adapt to any possible incidence. Any changes will be announced through the online platform which is understood to be the principal mechanism for information exchange between the teaching staff and the students.

Without prejudice to other disciplinary action deemed appropriate, and in agreement with the academic regulations in force, any irregularities committed by a student that may lead to an alteration of the final qualification will be graded with a zero (0). For example, plagiarism, copying, etc., during an evaluation activity will involve immediate failure of the activity with a zero (0). In such an incident, the evaluation activities will be indicated with the failing reason, and will not be recoverable. If it is necessary to pass any of these evaluation activities to pass the course, this course will be failed directly, without the opportunity to recover in the same year.

Activitats d'avaluació

Títol	Pes	Hores	ECTS	Resultats d'aprenentatge
Defensa del projecte	0.3	8	0,32	1, 2, 9, 10, 11, 13
Examen final	0.4	2	0,08	1, 3, 4, 5, 6, 7, 14

Bibliografia

The principal references for this course are:

"Pattern Recognition and Machine Learning (Information Science and Statistics)", C. Bishop, Springer, 2007

Altres referències bàsiques:

"Pattern Classification", R. Duda, P. Hart, D. Stork, 2nd edition, Wiley-Blackwell, 2000

"Artificial Intelligence: A Modern Approach", S. Russell, P. Norvig, 3rd edition, Pearson, 2013

Interesting Web links:

Stanford's Machine Learning Course, Coursera, <https://www.coursera.org/course/ml>

Machine Learning Summer School Lectures, Video Lectures, http://videlectures.net/mlss09uk_cambridge/