VNIVERSITAT DE VALÈNCIA

Course Guide
36419 Bayesian models

COURSE DATA

Data Subject	
Code	36419
Name	Bayesian models
Cycle	Grade
ECTS Credits	6.0
Academic year	2022 - 2023

Study (s)

Degree	Center	Acad. year	Period
1400 - Degree in Computer Engineering	School of Engineering	4	First term
1406 - Degree in Data Science	School of Engineering	3	First term

Subject-matter

Degree	Subject-matter	Character
1400 - Degree in Computer Engineering	16 - Optional subject	Optional
1406 - Degree in Data Science	6 - Statistical Modelling	Obligatory

Coordination

Name	Department
CONESA GUILLEN, DAVID VALENTIN	130 - Statistics and Operational Research

SUMMARY

Bayesian Models course aims to provide the necessary knowledge to address inference and prediction in statistical models from the Bayesian point of view. Tools of probability will be used (highlighting Bayes' Theorem as the central axis) to carry out the inferential and predictive process but now including the previous knowledge that we have about the problem. All this Bayesian learning process will be particularized in known models but also with more complex models such as Bayesian networks and, more generally, probabilistic graphical models will be presented. For complex models, numerical methods will be introduced to approximate the posterior distributions.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

For a correct follow-up of the course it will be essential to have assimilated everything learned in the previous courses in the subjects of probability and simulation, statistical inference and linear models

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

1400 - Degree in Computer Engineering

- C3 - Ability to recognise and develop computational learning techniques and to design and implement applications and systems that use them, including those for the automatic retrieval of information and knowledge from large volumes of data.
- Capacidad para participar activamente en la especificación, diseño, implementación y mantenimiento de los sistemas de información y comunicación.

1406 - Degree in Data Science

- (CG01) Knowledge of basic subjects and technologies that enable students to learn new methods and technologies, and to provide them with versatility to adapt to new situations.
- (CG03) Capability to elaborate models, calculations, reports, to plan tasks and other works analogous to the specific field of data science.
- (CG05) Analysis and synthesis capability in the preparation of reports and in the defence of ideas.
- (CT01) To be able to access (bibliographical) information tools and appropriately use them in the development of their daily tasks.
- (CT03) Ability to defend your own work with rigor and arguments and to expose it in an adequate and accurate way with the use of the necessary means.
- (CE09) To methodologically know and apply the concepts and techniques of probability and statistics necessary for the extraction of useful knowledge from data analysis.
- (CE15) Ability to model and analyse the uncertainty in data-based studies, as well as to know how to interpret and contextualise the results obtained.
- (CB4) Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.
- (CB5) Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

Learn the basic elements of Bayesian statistical learning (Competences: CB5, CG1, CT1, CE9, CE15)

Understand the power of the Bayesian concept of probability (Competences: CB5, CG1, CT1, CE9, CE15).

Combine expert and experimental information in basic inferential processes (Competencies: CB5, CG1, CG3, CT1, CE9, CE15).

Know how to work in inferential and predictive environments (Competences: CB5, CG1, CT1, CE9, CE15).

Know the concept of probabilistic graphical model (Competences: CB5, CG1, CT1, CE9, CE15).

Calculate joint probabilities using a Bayesian network (Competencies: CB5, CG3, CT1, CE9, CE15).

Know the inference algorithms of the probabilistic graphical models (Competences: CB5, CG1, CG3, CT1, CE9, CE15).

DESCRIPTION OF CONTENTS

1. Bayesian Statisctics basics

Probability as a quantifying tool for uncertainty.
Simulation of random variables.
Bayes' theorem: events and random variables.
The Bayesian learning process.

2. Bayesian inference and prediction

Statistical modelling and inference from the Bayesian perspective (model; likelihood function; parameters; parametric space; estimation and hypothesis testing).
Prior and posterior distributions.
Prior and posterior predictive distribution.
Bayesian inference and prediction as a description of posterior distributions and posterior predictive distributions.
Univariate models: proportions and Gaussian data.
Multivariate models: Gaussian data and generalization to more complex models.

3. Advanced Bayesian modelling

Inference and prediction in linear models and generalized linear models.
Models with random effects.
Bayesian hierarchical models.
Numerical approximations: MCMC, Hamiltonian approximation, INLA.

4. Bayesian networks

Graphical probability models
Directed Acyclic Graph: nodes, parents, children
Chain rule for joint probability.
Bayesian learning in networks.
Examples

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	32,00	100
Laboratory practices	20,00	100
Classroom practices	8,00	100
Development of group work	5,00	0
Development of individual work	10,00	0
Study and independent work	20,00	0
Readings supplementary material	10,00	0
Preparation of evaluation activities	10,00	0
Preparing lectures	15,00	0
Preparation of practical classes and problem	10,00	0
Resolution of case studies	10,00	0
TOTAL	**150,00**	

TEACHING METHODOLOGY

MD1 - Theoretical activities. Expository development of the subject with the participation of the students in the resolution of specific questions. Completion of individual evaluation questionnaires (Competences: GC01, CB5, CE09).

MD2 - Practical activities. Learning through problem solving, exercises and case studies through which skills are acquired on different aspects of the subject (Skills: CB2, CE15).

MD4 - Laboratory and / or computer classroom work. Learning by carrying out activities developed individually or in small groups and carried out in laboratories and / or computer classrooms (Competences: CT01, CE09, CE15).

EVALUATION

SE1 - Objective test with theoretical-practical questions that will account for 50% of the grade. (GC01, CB5, CE09)

SE2 - Preparation of a memory in pdf of the questions addressed in the practical sessions, which will represent 15%. The evaluation of this part may be recovered through a practical test that will be carried out on the same date as the theoretical test of the second call. (CB2, CE15)

SE3 - Continuous assessment, based on the participation and degree of involvement of the student in the teaching-learning process. This implication will be quantified through the resolution of problems and questions, which will be carried out in the classroom at the end of the practical sessions. These activities will be non-recoverable and will account for 35% of the grade (CT01, CE09, CE15).

It will be necessary to get a 5 in each part to be able to average and more than a 5 as a final grade to pass the course.

In any case, the evaluation system will be governed by the provisions of the Evaluation and Qualification Regulations of the University of Valencia for Degrees and Master's degrees: https://www.uv.es/graus/normatives/2017_108_Reglament_avaluacio_qualificacio.pdf

REFERENCES

Basic

- John K. Kruschke (2011). Doing Bayesian Data Analysis: A Tutorial with R and BUGS. Academic press Elsevier.
- T. M. Donovan y R. M. Mickey (2019) Bayesian Statistics for Beginners. Oxford University Press
- S. K. Ghosh, y B. J. Reich (2019). Bayesian statistical methods. Chapman & Hall; CRC

Additional

- D. Barber (2012). Bayesian Reasoning and Machine Learning. Cambridge University Press.