Universitat Autònoma de Barcelona

2023/2024

Stochastic Processes

Code: 104859
ECTS Credits: 6

Degree	Type	Year	Semester
2503852 Applied Statistics	OB	2	2

Contact

Name: Antoni Sintes Blanc

Email: antoni.sintes@uab.cat

Teaching groups languages

You can check it through this link. To consult the language you will need to enter the CODE of the subject. Please note that this information is provisional until 30 November 2023.

Teachers

Jordi Joan Tur Escandell

Alan Morte Piferrer

Prerequisites

It is advisable to have successfully completed the following mandatory courses: Càlcul 1, Àlgebra lineal, Introducció a la probabilitat, Eines informàtiques per a l'estadística i Probabilitat and Distribucions multidimensionals.

Objectives and Contextualisation

We introduce the students into the theory of the stochastic processes, with a special emphasis on how they can be used to mathematically model several examples and real situations. More precisely, the main part of the course is devoted to deal with Markov chains, which provide one of the more important tools in stochastic modeling, with a lot of applications, for example in biology, medicine or queuing theory. We introduce discrete-time and continuous-time Markov chains and, due to its highly level of applicability, we specially treat the Poisson process, as a example of birth and death processes, and branching processes. During the course mathematical proofs will be mostly avoided, although we give a reference for them, and we focus on the applications of the methods and techniques to particular examples. Indeed, one of the principal aims consists that students learn to choose the convenient method in order to model some phenomenon, and also to implement it as well as to extract conclusions.

Another major objective is to introduce the Brownian motion, which represents the paradigmatic example of stochastic process with non-countable state space. Its definition will be motivated, emphasizing all variety of fields where Brownian motion can be applied, and some of its properties will be studied. We also introduce some processes related to Brownian motion, such as the Brownian bridge and the geometric Brownian motion.

Finally, the last aim of the course is that the students learn to use the software R in order to simulate different types of stochastic processes and extract the pertinent conclusions in view of the phenomenon that is being modeled.

Competences

- Select statistical models or techniques for application in studies and real-world problems, and know the tools for validating them.
- Summarise and discover behaviour patterns in data exploration.

Learning Outcomes

1. Identify the different attributes of a Markov chain.
2. Identify the distribution of service time in stochastic processes.
3. Identify the time distribution between two consecutive arrivals at the system in stochastic processes.
4. Recognise the need to use models of stochastic processes.
5. Use graphics to display the fit and applicability of the model.

Content

1. Introduction to stochastic processes

2. Discrete-time Markov chains

3. Branching processes

4. Poisson process

5. Continuous-time Markov chains

6. Brownian motion

Methodology

The theoretical and problem sessions will be carried out in a classroom. These sessions will be devoted to the presentation of theoretical aspects and the solution of problems. Problem lists will be supplied along the course.

The computer sessions will be carried out in a computer room. In these sessions, studens will solve some problems related to the methods introduced during the course using R

The gender perspective goes beyond the contents of courses, since it implies also a revision of teaching methodologies and interactions between students and lecturers, both inside and outside the classroom. In this sense, participative teaching methodologies that give rise to an equality environment, less hierarchical in the classroom, avoiding examples stereotyped in gender and sexist vocabulary, are usually more favorable to the full integration and participation of female students in the classroom. Because of this, their effective full integration and participation of female students in the classroom. Because of this, their effective implementation will be attempted in this course.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem classes	14	0.56	1, 3, 4
Theoretical classes	26	1.04	1, 3, 4
Type: Supervised			
Computer sessions	12	0.48	1, 3, 4
Type: Autonomous			
Personal study, problem solving and computer work	90.5	3.62	1, 3, 4

Assessment

Continued assesment

There are two partial exams,
EP1 and
EP2, both with a second chance or recovery exam,
EF1 and
EF2. To pass the subject, it is necessary that the
NC course grade (weighted average of the two partial exams) is greater than or

equal to
4, with
min(EP1,EP2)>=3.

In addition, it is also necessary that the mark of the practice exam is grea
3.5. Then the final grade
NF is calculated by making
NF = 0.2*P + 0.8*NC, where
P is the practice grade.

In the recovery exam, the
NC course mark is recovered. The practical mark is not recovered but is taken into account to calculate the final r

We say
R the recovery note, calculated with the following formula
R = 0.5*[max(EP1,EF1)+max(EP2,EF2)]. Then the final

NCD course grade is calculated as
NCD = 0.3*NC + 0.7*R.

Note that
NCD depends on recovery and also on the
NC course grade. In this case, the final mark will be
NF = 0.2*P + 0.8*NCD if the condition
min(max(EP1,EF1),max(EP2,EF2))>=3 is met. Otherwise, the final grade will be

min(NF, 4.5).

Unique evaluation

A final exam, EFU, is carried out, which has a second opportunity or recovery exam, ERU, if necessary. The EFU final exam has 2 parts, EFU1 and EFU2, which take place in a single day, one in the morning and one in the afternoon. In the same way,the ERU recovery exam has 2 parts, ERU1 and ERU2, which take place in a single day, one in the morning and one in the afternoon.

The content of the first part (of the two exams, EFU and ERU) coincides with that of the EP1 exam of the continuous evaluation. The content of the second part (both exams, EFU and ERU) coincides with that of the EP2 exam of the continuous evaluation.

To pass the subject in this modality, it is necessary that the final grade NFU (weighted average of the two parts, EFU1 and EFU2) is greater than or equal to 5, being min(EFU1,EFU2)>=3.5. Otherwise, it is necessary to take the recovery exam, and then the final grade, NFUR, is calculated as follows:

NFUR = 0.3*NFU + 0.35*[max(EFU1,ERU1)+max(EFU2,ERU2)] if the condition min[max(EFU1,ERU1) , max(EFU2,ERU2)]>=3 is met, or min(NFUR, 4.5) if this condition is not met.

Note (valid for both evaluation options): In no case are the second chance (or recovery) options to raise grades that are >= 5.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final exam	50	3	0.12	1, 2, 3, 4
Midterm exam	30	2	0.08	1, 3, 4
Practical exam	20	2.5	0.1	5, 1, 3, 4

Bibliography

Borovkov, Konstantin. Elements of stochastic modelling. Second edition. World Scientific Publishing Co., 2014.

Dobrow, Robert P. Introduction to stochastic processes with R. John Wiley & Sons, 2016.

Rincón, Luis. Introducción a los procesos estocásticos. Las Prensas de Ciencias, Fac. de Ciencias, UNAM. It can be downloaded from: http://www.matematicas.unam.mx/lars/flip-procesos/flip-en-pdf/procesos2012.pdf

Pinsky, Mark A. and Karlin, Samuel. An introduction to stochastic modeling. Fourth edition. Elsevier/Academic Press, 2011.

Software

We will use the statistical software R:

R Core Team (2021). R: A language and environment for statistical computing.
R Foundation for Statistical Computing, Vienna, Austria.
URL https://www.R-project.org/.