**Degree competences to which the subject contributes**

**Specific:**
1. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and/or statistical or operations research technique more appropriate to apply this model to the situation or problem.
2. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.
3. CE-9. Ability to implement statistical and operations research algorithms.
4. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.
5. CE-4. Ability to use different inference procedures to answer questions, identifying the properties of different estimation methods and their advantages and disadvantages, tailored to a specific situation and a specific context.

**Transversal:**
4. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
7. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

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**Prior skills**

1. This course presupposes knowledge of linear algebra: diagonalization of a symmetric matrix, vector projection, vector derivation of linear and quadratic functions.
2. It is also necessary to have successfully completed a course on statistical inference covering the classical univariate tests (Student's t test, Fisher's F test).
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Teaching methodology

Language: the first part of the course (50%) will be taught in English, and the second part (50%) will be taught in Spanish.

Theoretical sessions: conventional lecture classes according to the schedule made known at the start of the course.

Problems: problems serve to underpin the theoretical concepts addressed in the theory sessions. Students are asked to hand in some problems during the course.

Practicals: the facilities of matrix programming are employed to carry out a multivariate analysis. Practical work is assessed. The R programming language is used. Practicals are done individually.

Project: students work on the multivariate analysis of a particular database using the methods taught in this course. The project is carried out by groups of 3 or 4 students. Results of the project are presented orally in class. Each group writes a report about their project and hands this in.

Learning objectives of the subject

A student that has successfully completed the course will be able to:

1. Recognize the multivariate nature of a particular database.
2. Explain the advantage of a multivariate approach over a traditional univariate approach.
3. Explain the aims of the most commonly used multivariate methods (principal component analysis, correspondence analysis, factor analysis, multidimensional scaling, MANOVA, discriminant analysis, cluster analysis, etc.).
4. Identify the most appropriate multivariate method for the analysis of a particular database.
5. Implement the most basic multivariate methods using matrix calculations in the R environment.
6. Apply multivariate descriptive statistics to a set of variables.
7. Apply the basic principles of dimension reduction.
8. Apply the necessary transformation for a particular analysis (selection of the metric).
9. Perform multivariate visualization of data sets on the computer.
10. Interpret visual representations (biplots) of multivariate data sets.
11. Explain the multivariate normal distribution and its properties.
12. Give the definition of the most basic multivariate statistical tests.
13. Apply the most common multivariate hypothesis tests regarding mean vectors and covariance matrices.
14. Apply linear and quadratic discriminant analysis to data stemming from different populations, obtaining the discriminant functions under the assumption of multivariate normality, and classify the individuals of unknown group status.
15. Enumerate the basic clustering methods.
16. Apply different algorithms for creating clusters.
17. Interpret the results of the most commonly used multivariate methods.
18. Apply factor analysis and extract the common dimensions of a set of variables.
19. Apply repeated measurement analysis, profile analysis, and two-way MANOVA.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 30h</th>
<th>24.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
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<tr>
<td></td>
<td>Hours small group: 15h</td>
<td>12.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities: 0h</td>
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<tr>
<td></td>
<td>Self study: 80h</td>
<td>64.00%</td>
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</table>
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## Content

<table>
<thead>
<tr>
<th>Multivariate descriptive statistics</th>
<th>Learning time: 61h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 15h</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 6h</td>
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<tr>
<td></td>
<td>Self study: 40h</td>
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</table>

### Description:

### Related activities:
Several practicals, problems and the project of the course.

### Specific objectives:
Perform a multivariate descriptive analysis, both graphically and numerically, for quantitative and categorical data tables.

<table>
<thead>
<tr>
<th>Multivariate statistical inference.</th>
<th>Learning time: 29h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 9h</td>
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<tr>
<td></td>
<td>Self study: 20h</td>
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</tbody>
</table>

### Description:

### Related activities:
Practicals and problems.

### Specific objectives:
Apply multivariate statistical inference.
## Discriminant analysis and cluster analysis.

<table>
<thead>
<tr>
<th>Learning time: 32h</th>
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</thead>
<tbody>
<tr>
<td>Theory classes: 7h 30m</td>
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<tr>
<td>Practical classes: 4h 30m</td>
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<tr>
<td>Self study : 20h</td>
</tr>
</tbody>
</table>

### Description:

### Related activities:
Practicals and problems.

### Specific objectives:
Apply discriminant analysis and cluster analysis and the interpret results of these methods.

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## Qualification system

Assessment is based on two exams, one midterm exam halfway the course and the other at the end of the course. Practical, problems and project are also assessed. The final course grade is based on the exam results (70 %) and on the problems, practicals and a project (40 %). The final grade for the course is a weighted mean of the different parts: exams (70%, 35% first exam, 35% second exam), practicals and assignments (15%), project (15%, a written report). Those students who pass the first exam are not required to sit the same subjects again in the first part of the final exam.
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Bibliography

Basic:


Complementary:


Others resources:

Computer material

Lecture slides

Slides.