



Teaching Guide

Teaching Guide				
Identifying Data			2021/22	
Subject (*)	Statistical Modeling of High Dimensional Data	Code	614G02013	
Study programme	Grao en Ciencia e Enxeñaría de Datos			
Descriptors				
Cycle	Period	Year	Type	Credits
Graduate	1st four-month period	Second	Obligatory	6
Language	SpanishGalicianEnglish			
Teaching method	Face-to-face			
Prerequisites				
Department	Matemáticas			
Coordinador	Cao Abad, Ricardo	E-mail	ricardo.cao@udc.es	
Lecturers	Cao Abad, Ricardo López Cheda, Ana	E-mail	ricardo.cao@udc.es ana.lopez.cheda@udc.es	
Web	http://dm.udc.es/staff/ricardo_cao/			
General description	This course provides a first contact with the statistical modelization of high dimensional data: multivariate analysis methods, statistical tools and computer programs for the analysis of high dimensional data, identification of the advantages and disadvantages of the different methods, and critical procedures and interpretation of the results related to the proposed problem.			



Contingency plan	<p>1. Modification of the contents: No changes will be considered.</p> <p>2. Methodologies: ? Methodologies with no changes: Concept tests: a concept test will be carried out, approximately, in the middle of the quadrimester, using Moodle.udc.es. In the official exam date, in January 2022, a second concept test will take place, also using Moodle.udc.es. The qualification of each one of the concept tests will be 20% of the total qualification. Work in pair of students: which corresponds to the 20% of the total qualification, will be uploaded in Moodle.udc.es. The oral presentation oral (which is the 10%) will be carried out using TEAMS. Tests on R labs: a test related to R labs will be carried out, approximately, in the middle of the quadrimester, and it will be submitted by Moodle.udc.es. In the official exam date, in January 2022, a second test related to R labs will take place, and the submission will also be with Moodle.udc.es. The qualification of each one of the concept tests will be 20% of the total qualification.</p> <p>? Methodologies with changes: Oral presentation: they are not considered for the qualification. The oral presentation will be carried out using TEAMS in the time period assigned for the course in the faculty calendar. Moreover, these TEAMS classes may be complemented with explanatory videos to help students understand some specific concepts. ICT practicals: they are not considered for the qualification. If classes are not online, they consist of data analyses using statistical software (R). In case of lockdown, they will be replaced by explanatory videos with the development of the R labs proposed. These videos may be either recorded and uploaded in the time period assigned for the course, or previously uploaded to TEAMS. Furthermore, group tutorial classes will take place by TEAMS weekly (or more often, depending on the student?s demand).</p> <p>3. Personalized attention: Tools: Email, Videoconference (Teams), Moodle. Email: Daily. To solve questions, fix virtual tutorials and monitoring the group work. Videoconference (Teams): Two sessions per week, to make progress in the contents, in the time period assigned to the course in the faculty calendar. Moreover, individual and group tutorials will take place after being fixed by email. Moodle: Daily, depending on the student?s demand. Some forums related to the different topics will be available.</p> <p>4. Modifications in the assessment: The percentages of the qualification in each one of the tests will not be modified. The difference is that the oral presentation of the group work will be carried out by TEAMS, the concept tests (mid-term or final) will be submitted by Moodle, and the test related to the R labs will also be uploaded using the same platform.</p> <p>Note: During the course, two mid-term tests will be considered. The first one is related to the Topics 0-2, and the second one is related to Topics 3-4. Those students who pass the first tests will be allowed to avoid topics 0-2 in the final exam.</p> <p>5. Modifications in the bibliography or webgraphy: No changes will be considered. Students will have access to all the material they need in Moodle.</p>
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Study programme competences / results	
Code	Study programme competences / results
A17	CE17 - Capacidade para a construción, validación e aplicación dun modelo estocástico dun sistema real a partir dos datos observados e a análise crítica dos resultados obtidos.
A20	CE20 - Coñecemento das ferramentas informáticas no campo da análise dos datos e modelización estatística, e capacidade para seleccionar as máis adecuadas para a resolución de problemas.



B2	CB2 - Que os estudantes saiban aplicar os seus coñecementos ao seu traballo ou vocación dunha forma profesional e posúan as competencias que adoitan demostrarse por medio da elaboración e defensa de argumentos e a resolución de problemas dentro da súa área de estudo
B3	CB3 - Que os estudantes teñan a capacidade de reunir e interpretar datos relevantes (normalmente dentro da súa área de estudo) para emitir xuízos que inclúan unha reflexión sobre temas relevantes de índole social, científica ou ética
B7	CG2 - Elaborar adecuadamente e con certa orixinalidade composicións escritas ou argumentos motivados, redactar plans, proxectos de traballo, artigos científicos e formular hipóteses razoables.
B8	CG3 - Ser capaz de manter e estender formulacións teóricas fundadas para permitir a introdución e explotación de tecnoloxías novas e avanzadas no campo.
B9	CG4 - Capacidade para abordar con éxito todas as etapas dun proxecto de datos: exploración previa dos datos, preprocesado, análise, visualización e comunicación de resultados.
B10	CG5 - Ser capaz de traballar en equipo, especialmente de carácter multidisciplinar, e ser hábiles na xestión do tempo, persoas e toma de decisións.
C1	CT1 - Utilizar as ferramentas básicas das tecnoloxías da información e as comunicacións (TIC) necesarias para o exercicio da súa profesión e para a aprendizaxe ao longo da súa vida.

Learning outcomes			
Learning outcomes	Study programme competences / results		
Knowledge related to the main techniques of multivariate statistical analysis.	A17	B2 B8 B9 B10	C1
Awareness of the main problems when working with high dimensional data.	A17 A20	B2 B3 B9 B10	C1
Ability to select the main variables and models in real data problems.	A17 A20	B2 B3 B8 B9	C1
Ability to apply the main techniques of multivariate analysis to real or simulated datasets.	A17 A20	B2 B3 B7 B8 B9 B10	C1
Ability to interpret the results and awareness of the limitations of the different models related to multivariate statistical analysis.	A17 A20	B2 B3 B7 B8 B9 B10	C1
Ability to work with advanced software related to statistical analysis.	A20	B2 B10	C1

Contents	
Topic	Sub-topic



0. Multidimensional distributions	<p>0.1 Concept of multidimensional distribution</p> <p>0.2. Variance-covariance matrix. Linear transformations.</p> <p>0.3. Multidimensional normal: definition and properties.</p>
1. Dimension reduction methods	<p>1.1 Objectives of the Principal Component Analysis (PCA)</p> <p>1.2 Transformations to get incorrelation</p> <p>1.3 Obtaining the principal components</p> <p>1.4 Principal components and scale changes</p> <p>1.5 Interpretation of the principal components</p> <p>1.6 Factor analysis</p> <p>1.7 Multidimensional scaling</p>
2. Unsupervised classification	<p>2.1 Objectives of unsupervised classification: hierarchical and non-hierarchical methods</p> <p>2.2 Cluster analysis: approach and objectives</p> <p>2.3 Hierarchical tree or dendogram</p> <p>2.4 Similarities and discrepancies between observations</p> <p>2.5 Criteria for group formation: simple, complete chaining, group average, centroid method, Ward method</p> <p>2.6 Non-hierarchical distance-based methods: closest neighbors, k means, methods based on density estimation</p>
3. Supervised classification	<p>3.1 Objectives of supervised classification: classification rules and error criteria</p> <p>3.2 Discriminant factor analysis: approach, objectives and calculation of discriminant factors</p> <p>3.3 Fisher's linear discriminant analysis and quadratic discriminant analysis</p> <p>3.4 Maximum likelihood discriminant rule, Bayes rule, nonparametric discriminant rules</p> <p>3.5 Relationship with regression models with binary response</p> <p>3.6 Estimation of Probability of Incorrect Classification: Cross Validation and Bootstrap</p>
4. Models for high-dimensional data	<p>4.1 Variable selection in regression: significance tests.</p> <p>4.2 The problem of multiple contrasts: false discovery rate (FDR) and familywise error rate (FWER)</p> <p>4.3 Sparse coefficient regression models: ridge regression, lasso and their variants</p> <p>4.4 Selection of variables and models with sparse coefficients for classification</p>

Planning				
Methodologies / tests	Competencies / Results	Teaching hours (in-person & virtual)	Student?s personal work hours	Total hours
Oral presentation	A1 B2 B3 B4 C4	30	36	66
ICT practicals	A9 A12 A17 A18 A19 A20 A26 A33 A3 A4 A5 A6 A8 B7 B9 B10 C1 C2 C3	14	21	35
Multiple-choice questions	A19 A24 A25 A1 B3 B8	2	6	8
Problem solving	A17 A33 A2 B2 B5 B6 B7 B8 B10	14	21	35
Personalized attention		6	0	6

(*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies	
Methodologies	Description



Oral presentation	Presentation using the computer.
ICT practicals	Statistical data analysis using R.
Multiple-choice questions	Multiple-choice test on concepts.
Problem solving	Deciding statistical tools and strategies for problem solving. Model formulation for multivariate data. Algorithm formulation for high dimensional data analysis.

Personalized attention

Methodologies	Description
ICT practicals	Attendance and participation in lectures.
Problem solving	Written multiple choice test. Multivariate data analysis project. Practicals to be performed by the student.

Assessment

Methodologies	Competencies / Results	Description	Qualification
Oral presentation	A1 B2 B3 B4 C4	Oral presentation of the work (in pairs of students) mentioned in the "Problem solving" item.	10
ICT practicals	A9 A12 A17 A18 A19 A20 A26 A33 A3 A4 A5 A6 A8 B7 B9 B10 C1 C2 C3	Computer labs using the open statistical software R.	40
Problem solving	A17 A33 A2 B2 B5 B6 B7 B8 B10	Work (in pairs of students) related to the topics 0-3 of the course.	10
Multiple-choice questions	A19 A24 A25 A1 B3 B8	Comprehension tests.	40

Assessment comments



The assessment will be carried out through two tests on R labs, a work in pairs of students, as well as two written concept tests. The first of the tests on R labs and the first of the concept tests will be held approximately in the middle of the semester, and they will be related to topics 0-2. The corresponding second tests of both R labs and concepts will be held in the official exam date, in January 2022. These second tests will include all the topics given in the course, but those students who pass each of the first tests will be allowed to avoid topics 0-2 so that they will be evaluated only in topics 3-4.

Both the qualification of the R labs tests and the qualification of the concept tests will be 40% of the total qualification each, while the remaining 20% will correspond to the pairs student work, that has to be presented orally, in the second half of the semester. The half of the score of this pairs work (10% of the total score) corresponds to its oral presentation.

In summary, the assessment scoring will be the following:

Work in pairs: 20% of the total score (10% solving the practical exercise in R and 10% oral presentation). **Concept tests:** two concept tests will be carried out (each one of them corresponds to the 20% of the total score). The first of the exams, related to Topics 0-2, will take place in the middle of the quadrimester. The second exam, related to Topics 3-4, will be carried out the day of the official exam. Note that students will avoid Topics 0-2 in the second exam if they pass the first exam, unless they pass it but want to get a higher score. Moreover, if students do not take the first exam, they will be evaluated (the day of the official exam) with two parts: one related to Topics 0-2 and another related to Topics 3-4. The sum of these two parts is the 40% of the total score. **Tests on R labs:** following the same idea as for the concept tests, there will be two tests on R labs (each one of them corresponds to the 20% of the total score), using statistical software, R. The first exam, related to the R labs of Topics 0-2, will take place in the middle of the quadrimester. The second exam, related to the R labs of Topics 3-4, will be carried out the day of the official exam. Note that students will avoid Topics 0-2 in the second test on R labs if they pass the first exam, unless they pass it but want to get a higher score. Moreover, if students do not take the first exam, they will be evaluated (the day of the official exam) with two parts: one related to Topics 0-2 and another related to Topics 3-4. The sum of these two parts is the 40% of the total score. To pass the subject is necessary to obtain a score of at least 5 out of 10 overall.

On July opportunity, students could avoid those tests with scores of at least 4 out of 10 in January tests. Only students that didn't take any test will be qualified as NON ATTENDANT in the first opportunity (January-February). In July (2nd opportunity) only students that didn't take the final exam will be qualified as NON ATTENDANT.

If a student wants to take a test in a specific official language (Spanish or Galician), he/she must inform the professor at least 1 week in advance.

Sources of information

Basic	<ul style="list-style-type: none"> - Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis. Wiley - Chatfield, C., Collins, A. J. (1980). Introduction to multivariate analysis. Chapman & Hall - Giraud, C. (2014). Introduction to High-Dimensional Statistics. Chapman & Hall/CRC - Goldstein, M., Dillon, W. R. (1984). Multivariate Analysis: Methods and Applications. Wiley - Jambu, M. (1991). Exploratory and Multivariate Data Analysis. Boston, Academic Press - Jobson, J.D. (1994). Applied Multivariate Data Analysis. Springer-Verlag - Johnson, R. A., Wichern, D. W. (2007). Applied multivariate statistical analysis. Prentice Hall - Koch, I. (2014). Analysis of Multivariate and High-Dimensional Data. Cambridge University Press - Mardia, K.V., Kent, J.T., Bibby, J.M. (1994). Multivariate Analysis. Academic Press. Academic Press - Muirhead, R.J. (1982). Aspects of multivariate statistical theory. John Wiley & Sons - Rencher, A.C. (1998). Multivariate Statistical Inference and Applications. Wiley - Wainwright, M.J. (2019). High-Dimensional Statistics: A Non-Asymptotic Viewpoint. Cambridge University Press
Complementary	

Recommendations

Subjects that it is recommended to have taken before



Introduction to Databases/614G02008

Linear Algebra/614G02001

Multivariable Calculus /614G02006

Discrete Mathematics/614G02002

Fundamentals of Programming II/614G02009

Fundamentals of Programming I/614G02004

Statistical Inference/614G02007

Probability and Basic Statistics/614G02003

Subjects that are recommended to be taken simultaneously

Regression Models/614G02012

Subjects that continue the syllabus

Simulation and Resampling Techniques/614G02036

Statistical Analysis of Complex Data/614G02031

Machine Learning III/614G02026

Information Retrieval/614G02027

Machine Learning I/614G02019

Machine Learning II/614G02021

Statistical Analysis of Dependent Data/614G02022

Other comments

(*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.