



Teaching Guide

| Identifying Data | | | | 2024/25 |
|--------------------------|--|--------|--------------------|---------|
| Subject (*) | Nonparametric Methods | Code | 614493111 | |
| Study programme | Mestrado Universitario en Técnicas Estadísticas (Plan 2019) | | | |
| Descriptors | | | | |
| Cycle | Period | Year | Type | Credits |
| Official Master's Degree | 1st four-month period | First | Obligatory | 5 |
| Language | Spanish | | | |
| Teaching method | Face-to-face | | | |
| Prerequisites | | | | |
| Department | Matemáticas | | | |
| Coordinador | Vilar Fernandez, Jose Antonio | E-mail | jose.vilarf@udc.es | |
| Lecturers | Vilar Fernandez, Jose Antonio | E-mail | jose.vilarf@udc.es | |
| Web | http://eio.usc.es/pub/mte/ | | | |
| General description | Nonparametric methods to estimate the probability distribution, probability density and regression functions are introduced, paying sparticular attention to the kernel smoothing techniques. The main nonparametric goodness-of-fit test procedures, association tests in contingency tables and nonparametric rank-based location tests for one, two and more than two samples are also presented. | | | |

Study programme competences / results

| Code | Study programme competences / results |
|------|---|
| A16 | CE1 - Coñecer, identificar, modelar, estudar e resolver problemas complexos de estatística e investigación operativa, nun contexto científico, tecnolóxico ou profesional, xurridos en aplicacións reais. |
| A17 | CE2 ? Desenvolver autonomía para a resolución práctica de problemas complexos surtidos en aplicación reais e para a interpretación dos resultados cara á axuda na toma de decisións. |
| A18 | CE3 - Adquirir coñecementos avanzados dos fundamentos teóricos subxacentes ás distintas metodoloxías da estatística e a investigación operativa, que permitan o seu desenvolvemento profesional especializado. |
| A19 | CE4 - Adquirir as destrezas necesarias no manexo teórico-práctico da teoría de probabilidade e as variables aleatorias que permitan o seu desenvolvemento profesional no eido científico/académico, tecnolóxico ou profesional especializado e multidisciplinar. |
| A20 | CE5 - Profundizar no coñecemento dos fundamentos teórico-prácticos especializados de modelado e estudo de distintos tipos de relacións de dependencia entre variables estatísticas. |
| A21 | CE6 - Adquirir coñecementos teórico-prácticos avanzados de distintas técnicas matemáticas, orientadas especificamente á axuda na toma de decisións, e desenvolver a capacidade de reflexión para avaliar e decidir entre distintas perspectivas en contextos complexos. |
| A23 | CE8 - Adquirir coñecementos teórico-prácticos avanzados das técnicas destinadas á realización de inferencias e contrastes relativos a variables e parámetros dun modelo estatístico, e saber aplicalos con autonomía suficiente nun contexto científico, tecnolóxico ou profesional. |
| B1 | CB6 - Posuír e comprender coñecementos que acheguen unha base ou oportunidade de ser orixinais no desenvolvemento e/ou aplicación de ideas, a miúdo nun contexto de investigación |
| B2 | CB7 - Que os estudantes saiban aplicar os coñecementos adquiridos e a súa capacidade de resolución de problemas en ámbitos novos ou pouco coñecidos dentro de contextos máis amplos (ou multidisciplinares) relacionados coa súa área de estudo |
| B3 | CB8 - Que os estudantes sexan capaces de integrar coñecementos e enfrontarse á complexidade de formular xuízos a partir dunha información que, sendo incompleta ou limitada, inclúa reflexións sobre as responsabilidades sociais e éticas vinculadas á aplicación dos seus coñecementos e xuízos |
| B4 | CB9 - Que os estudantes saiban comunicar as súas conclusións e os coñecementos e razóns últimas que as sustentan a públicos especializados e non especializados dun modo claro e sen ambigüidades |
| B5 | CB10 - Que os estudantes posúan as habilidades de aprendizaxe que lles permitan continuar estudando dun modo que habrá de ser en gran medida autodirixido ou autónomo. |
| B17 | CG1 - Coñecer, comprender e saber aplicar os principios, metodoloxías e novas tecnoloxías na estatística e a investigación operativa en contextos científico/académicos, tecnolóxicos ou profesionais especializados e multidisciplinares, así como adquirir as destrezas e competencias descritas nos obxectivos xerais do título. |



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| B18 | CG2 - Desenvolver autonomía para identificar, modelar e resolver problemas complexos da estatística e da investigación operativa en contextos científico/académicos, tecnolóxicos ou profesionais especializados e multidisciplinares. |
| B19 | CG3 - Desenvolver a capacidade para realizar estudos e tarefas de investigación e transmitir os resultados a públicos especializados, académicos e xeneralistas. |
| B20 | CG4 - Integrar coñecementos avanzados e enfrontarse á toma de decisións a partir de información científica e técnica. |
| B21 | CG5 - Desenvolver a capacidade de aplicación de algoritmos e técnicas de resolución de problemas complexos no eido da estatística e a investigación operativa, manexando o software especializado axeitado. |
| C11 | CT1 - Desenvolver firmes capacidades de razoamento, análise crítica e autocrítica, así como de argumentación e de síntese, contextos especializados e multidisciplinares. |
| C13 | CT3 - Ser capaz de resolver problemas complexos en novos escenarios mediante a aplicación integrada dos coñecementos. |
| C14 | CT4 - Desenvolver unha sólida capacidade de organización e planificación do estudo, asumindo a responsabilidade do seu propio desenvolvemento profesional, para a realización de traballos en equipo e de xeito autónomo. |
| C15 | CT5 - Desenvolver capacidades para o aprendizaxe e a integración no traballo en equipos multidisciplinares, nos ámbitos científico/académico, tecnolóxico e profesional. |

| Learning outcomes | | | |
|--|---------------------------------------|-----------------------------------|--------------|
| Learning outcomes | Study programme competences / results | | |
| To become familiar with basic techniques of nonparametric estimation of the probability distribution function, the probability density function and the regression function. | AC18 AC19 AC20 AC21 AC23 | BJ1 BJ3 BJ5 BJ20 BJ21 | CJ13 |
| Get the know-how to apply the main nonparametric tests for goodness-of-fit and association. | AC18 AC19 AC20 AC21 AC23 | BJ1 BJ3 BJ5 BJ20 BJ21 | CJ13 |
| Get thorough knowledge about strengths and weaknesses of the nonparametric approach in data analysis. | AC16 AC17 AC19 AC21 AC23 | BJ2 BJ17 BJ20 BJ21 | CJ11 CJ13 |
| Develop autonomous competence to apply nonparametric tools in data analysis, in complex and/or multidisciplinary scenarios. | AC17 | BJ18 | CJ14 CJ15 |
| To know how present data analysis based on nonparametric techniques to both specialized and non-specialized audience. | | BJ4 BJ19 | |

| Contents | |
|---|---|
| Topic | Sub-topic |
| Nonparametric distribution estimation | The empirical distribution. Properties. Moments and quantiles estimation. |
| Classical one-sample nonparametric tests. | Goodness-of-fit tests: Kolmogorov-Smirnov test. Normality analysis: Q-Q plot, Lilliefors test, Shapiro-Wilk test, transformations for normality. One-sample location tests: sign test, Wilcoxon signed-rank test. |
| Two-sample tests. | Two-sample comparison: Kolmogorov-Smirnov test for two-samples, Mann-Whitney-Wilcoxon test. Extensions for three or more samples: Kruskal-Wallis test, Friedman test. |



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| Tests based on contingency tables. | Contingency tables analysis. Chi-squared tests for goodness-of-fit, homogeneity and independence on contingency tables. |
| Smoothing methods: nonparametric density estimation. | The histogram. Kernel density estimation. Assessment of density estimators. Smoothing parameter selectors in kernel density estimation: cross-validation and plug-in approaches. Multivariate kernel density estimation. |
| Nonparametric regression estimation. | Kernel regression. Local polynomial regression. k-nearest neighbor regression. Smoothing parameter selectors in kernel regression estimation: cross-validation and plug-in approaches. Loess algorithm. Spline regression: a brief introduction. |

| Planning | | | | |
|--------------------------------|--|--------------------------------------|-------------------------------|-------------|
| Methodologies / tests | Competencies / Results | Teaching hours (in-person & virtual) | Student's personal work hours | Total hours |
| Guest lecture / keynote speech | A16 A18 A21 A23 B1 B3 B17 B20 C11 C13 | 20 | 15 | 35 |
| Seminar | A16 A17 A19 A20 A21 A23 B2 B3 B5 B17 B18 B19 B20 B21 C11 C13 | 7 | 5.25 | 12.25 |
| ICT practicals | A17 A19 A20 A21 A23 B2 B5 B18 B19 | 7 | 5.25 | 12.25 |
| Problem solving | A16 A17 A19 A23 B2 B3 B5 B18 B19 B20 B21 C11 C13 C14 C15 | 0 | 28.5 | 28.5 |
| Case study | A16 A17 A19 A21 A23 B2 B3 B4 B5 B18 B19 B20 B21 C11 C13 C14 C15 | 0 | 21 | 21 |
| Supervised projects | A17 A19 A21 A23 B2 B4 B5 B18 B19 B20 B21 C11 C13 C14 C15 | 0 | 9.5 | 9.5 |
| Workshop | A16 A17 B2 B3 B4 B17 B18 B19 C11 C13 C14 C15 | 1 | 2.5 | 3.5 |
| Objective test | A16 A17 A18 A19 A20 A21 A23 B20 B21 C11 C13 | 0 | 3 | 3 |
| Personalized attention | | 0 | 0 | 0 |

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

| Methodologies | |
|--------------------------------|--|
| Methodologies | Description |
| Guest lecture / keynote speech | The theoretical principles of the nonparametric tools and procedures for their application in practice will be introduced. Their interest in applications will be illustrated by using specific real examples from different disciplines, highlighting advantages and limitations. Students participation will be strongly encouraged. |
| Seminar | Specific problems and suitable approaches to get them solved will be presented in seminars. The main objective is to show how the concepts and algorithms exposed in the keynote speeches are useful to face these problems. |



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| ICT practicals | Interactive sessions addressed to solve specific exercises by using scripts with free code from R software. The lecturer will support and supervise the right application of the knowledge and skills gathered by the students. |
| Problem solving | Issues, exercises and examples that can be addressed by using nonparametric techniques of inference and modeling will be provided to be individually solved by students. |
| Case study | Specific study cases will be proposed to be solved in group and/or individually. |
| Supervised projects | Solutions for exercises and study case will be supervised by the lecturer. |
| Workshop | Case study analyzed in detail by students will be presented and discussed. |
| Objective test | Written examination to assess the the acquisition of knowledge. |

Personalized attention

| Methodologies | Description |
|---------------------------------------|--|
| ICT practicals Supervised projects | The ICT practicals will be conducted to solve exercises by using scripts with free code from R software. This way, students must thoroughly understand the used R-packages, particularly the main functions and the type of generated outputs. To reach this objective as soon as possible, personalized attention is desirable and will be provided during the session. |

Assessment

| Methodologies | Competencies / Results | Description | Qualification |
|---------------------|--|--|---------------|
| Workshop | A16 A17 B2 B3 B4 B17 B18 B19 C11 C13 C14 C15 | The defence in the workshop of a supervised work is worth 5% of the global mark. | 5 |
| Supervised projects | A17 A19 A21 A23 B2 B4 B5 B18 B19 B20 B21 C11 C13 C14 C15 | A detailed development of the proposed study case, completed either individually or in group, is worth up to 10% of the global qualification. | 10 |
| Objective test | A16 A17 A18 A19 A20 A21 A23 B20 B21 C11 C13 | The final objective test is a written exam consisting of several theoretical-practical questions on the key contents of the subject, including proper interpretation of the results obtained from the R software. This exam is mandatory and the attained mark is worth up to 70% of the global qualification. | 70 |
| Problem solving | A16 A17 A19 A23 B2 B3 B5 B18 B19 B20 B21 C11 C13 C14 C15 | Solving and timely delivery of exercises proposed during the course will be part of the continuous evaluation. Correct answers in this item is worth up to 7.5% of the global qualification. | 7.5 |
| Case study | A16 A17 A19 A21 A23 B2 B3 B4 B5 B18 B19 B20 B21 C11 C13 C14 C15 | Solving and timely delivery of case study proposed during the course will be part of the continuous evaluation. Correct answers in this item is worth up to 7.5% of the global qualification. | 7.5 |

Assessment comments



Presentación á avaliación: Considérase que un estudante concorre a unha convocatoria cando participa en actividades que lle permiten obter cando menos un 50% da avaliación final. A cualificación obtida conservarase entre as oportunidades (ordinaria e extraordinaria) dentro da convocatoria de cada curso.

Oportunidade extraordinaria de recuperación (proba de xullo): O peso da avaliación continua na oportunidade extraordinaria de recuperación (proba de xullo) será o mesmo que na avaliación ordinaria. Na segunda oportunidade de avaliación (recuperación), realizarase un exame e a nota final será o máximo de tres cantidades: a nota da avaliación ordinaria, a nota do novo exame e a media ponderada do novo exame e a avaliación continua.

Realización fraudulenta de las pruebas o actividades de evaluación:

Una vez comprobada, implicará directamente la calificación de suspenso en la convocatoria en que se cometa: el/la estudiante será calificado con ?suspenso? (nota numérica 0) en la convocatoria correspondiente del curso académico, tanto si la comisión da falta se produce en la primera oportunidad como en la segunda. Para esto, se procederá a modificar su cualificación en el acta de primera oportunidad, si fuese necesario.

Sources of information

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|----------------------|--|
| Basic | <p>Fan J., Gijbels I. (1996) <i>Local polynomial modelling and its applications</i>. Monographs on Statistics and Applied Probability 66. Chapman & Hall/CRC. Gibbons J.D, Chakraborti S. (2010) <i>Nonparametric Statistical Inference</i> (5th edition). Statistics: Textbooks and Monographs. Chapman & Hall/CRC. Hollander M., Wolfe D.A., Chicken E. (2014) <i>Nonparametric Statistical Methods</i> (3rd edition). Wiley Series in Probability and Statistics, Wiley. Silverman, B. W. (1986) <i>Density Estimation for Statistics and Data Analysis</i>. Monographs on Statistics and Applied Probability 26. Chapman & Hall/CRC. Wand M.P., Jones M.C. (1995) <i>Kernel smoothing</i>. Monographs on Statistics and Applied Probability 60. Chapman & Hall/CRC.</p> <p>Fan J., Gijbels I. (1996) Local polynomial modelling and its applications. Monographs on Statistics and Applied Probability 66. Chapman & Hall/CRC. Gibbons J.D, Chakraborti S. (2010) Nonparametric Statistical Inference (5th edition). Statistics: Textbooks and Monographs. Chapman & Hall/CRC. Hollander M., Wolfe D.A., Chicken E. (2014) Nonparametric Statistical Methods (3rd edition). Wiley Series in Probability and Statistics, Wiley. Silverman, B. W. (1986) Density Estimation for Statistics and Data Analysis. Monographs on Statistics and Applied Probability 26. Chapman & Hall/CRC. Wand M.P., Jones M.C. (1995) Kernel smoothing. Monographs on Statistics and Applied Probability 60. Chapman & Hall/CRC.</p> |
| Complementary | <p>Bowman A.W., Azzalini A. (1997) <i>Applied Smoothing Techniques for Data Analysis</i>. Oxford: Oxford University Press. McKean J.W., Kloeke J. (2014) <i>Nonparametric Statistical Methods using R</i>. The R Series. Chapman and Hall/CRC. Simonoff J.S. (1996) <i>Smoothing methods in statistics</i>. Springer Series in Statistics. New York: Springer. Smeeton N.C, Sprent P. (2007) <i>Applied Nonparametric Statistical Methods</i> (4th edition) Chapman & Hall/CRC Texts in Statistical Science. Chapman & Hall/CRC. Wasserman L. (2006) <i>All of Nonparametric Statistics</i>. Springer Texts in Statistics. New York: Springer. Bowman A.W., Azzalini A. (1997) Applied Smoothing Techniques for Data Analysis. Oxford: Oxford University Press. McKean J.W., Kloeke J. (2014) Nonparametric Statistical Methods using R. The R Series. Chapman and Hall/CRC. Simonoff J.S. (1996) Smoothing methods in statistics. Springer Series in Statistics. New York: Springer. Smeeton N.C, Sprent P. (2007) Applied Nonparametric Statistical Methods (4th edition) Chapman & Hall/CRC Texts in Statistical Science. Chapman & Hall/CRC. Wasserman L. (2006) All of Nonparametric Statistics. Springer Texts in Statistics. New York: Springer.</p> |

Recommendations

Subjects that it is recommended to have taken before

Subjects that are recommended to be taken simultaneously



Subjects that continue the syllabus

Other comments

It is advisable that students have basic notions on probability calculus and statistic. Also it is desirable to possess regular skills to manage computers, and particularly knowledge of statistical software. To be able of understanding the practical sense of the learnt methods will allow to improve the learning process. Students are strongly advised and encouraged to participate actively in the learning process, including the regular attendance of the theoretical and practical sessions. As regards the application of the current regulations on gender equality, it is worthy remarking that: The gender perspective will be implemented in this subject (by using a gender-inclusive language, promoting the participation of all the students regardless of their gender,...). We will work to identify and modify biases and sexist attitudes, supporting changes in the framework in order to modify them and to promote values of respect and equality. We will try to detect cases of gender-discrimination, promoting the actions necessary to correct them.

(*)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.