



Mathematical and Statistical Techniques

Master in Astrophysics, Particle Physics and Cosmology

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UNIVERSITAT DE
BARCELONA



Institut de Ciències del Cosmos

Mathematical and Statistical Techniques

Nature

measurements: $\theta \pm \Delta\theta$

comparison



extract information on random process from data

Theory (*)

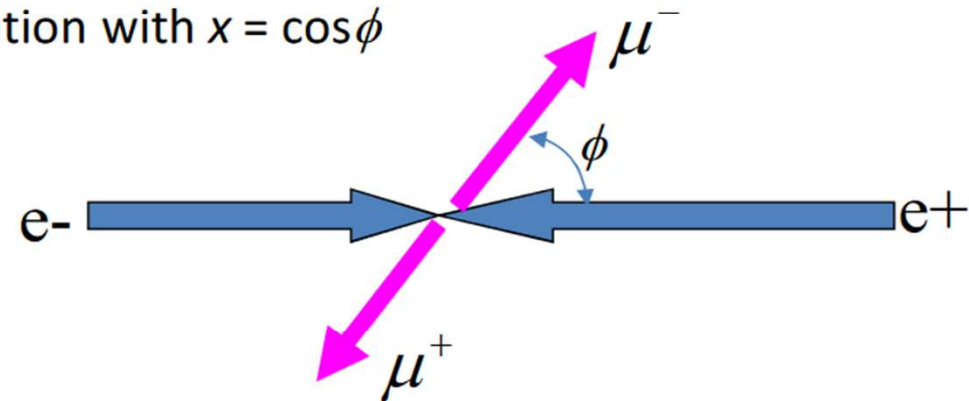
(*)

Part I: Probability and statistics

Theory model $f(\mathbf{x}; \theta)$. f will normally represent the expected number of observations as a function of some measurable quantities \mathbf{x} and some variables θ of the model that must be determined experimentally

Example: consider a scattering angle distribution with $x = \cos\phi$

$$f(x; \alpha, \beta) = \frac{1 + \alpha x + \beta x^2}{2 + 2\beta/3}$$



Part II: data analysis

NO theory model -> data analysis techniques: clustering, correlations,...

Part one: fundamentals of probability theory and statistics

- General review of probability theory
- Monte-Carlo
- Statistical Inference and significance test

Assignments: 1 set of problems + 2 exercises to be simulated in a computer (you can use your preferred language, only a random number generator is needed)

Part two: Multivariate Analysis and statistical treatment techniques

Introduction to multivariate analysis, statistical treatment techniques: concepts and main techniques, hands-on work using specialized software. Data Mining concepts.

- o Data analysis and representation
- o PCA
- o Clustering
- o Discriminant analysis
- o Neural Networks
- o Estimation of the PDF
- o Introduction to Data Mining (+Cloud Computing)

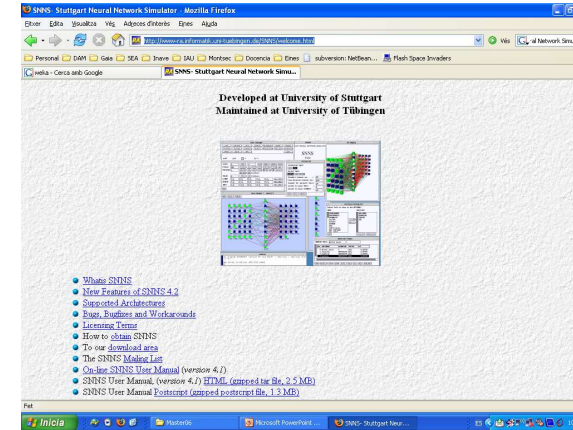
3 data análisis assignments

Part two: tools

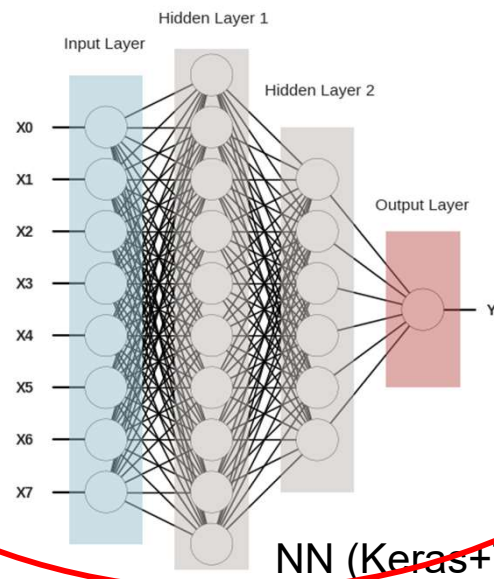
Weka



JNNS



Python



NN (Keras+Tensorflow)

(But you can use any Language*)

Course Material: Campus virtual

<http://campusvirtual.ub.edu>

The screenshot shows the virtual campus interface for the University of Barcelona. The top navigation bar includes the university logo, the name 'UNIVERSITAT DE BARCELONA', and menu items: 'Inici', 'Tauler', 'Els meus cursos', and 'El meu multimèdia'. On the right, there is a user profile icon and an 'Edit mode' toggle.

The main content area is titled 'Tècniques Matemàtiques i Estadístiques (2023-2024)'. Below the title, there are tabs for 'Curs', 'Paràmetres', 'Participants', 'Qualificacions', 'Informes', 'More', and 'Open LMS'. The 'Introduction' tab is selected.

The 'Introduction' section contains several resource blocks:

- Anuncis**: A block with a red speech bubble icon.
- Pla docent**: A block with a blue globe icon and the text 'Pla docent (568423)'. A 'Contreu-ho tot' link is visible to the right.
- Bibliografia**: A block with a blue globe icon and the text 'Bibliografia recomanada (568423)'. A 'Contreu-ho tot' link is visible to the right.
- Reference documents**: A block with a blue document icon, the text 'Course overview', and a 'Marca com a feta' button.
- Other resources**: A block with a 'Marca com a feta' button.

A left sidebar contains a navigation menu with categories like 'Introduction', 'Slides and course material', 'Assignments', 'Course tools', and 'Sample code and data files'. A blue question mark icon is located in the bottom right corner of the page.

Calendar and evaluation

6 credits

Part 1: weeks 1-6

Part 2: weeks 7-12

There will be no final exam for this course.

The average of the 6 problem assignments that will be given during this course, will compose the final global grading.