Applied computational intelligence

Course introduction

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About Me...

- Chemical Engineer at the University of Cagliari (Italy)
- Post-graduate Researcher in NTNU (Norway)
- Industrial Engineering PhD at the University of Cagliari (Italy)
- Post-Doctoral Researcher in HUT/AALTO (Finland)
- *Bolsista* CAPES at the Federal University of Campina Grande (Brazil)
- Professor at the Federal University of Ceará (Brazil)

... and about this course

The course gives an introduction to **intelligent systems** and their applications to engineering problems.

Computational Intelligence

It is a methodology involving computing that exhibits an ability to learn and/or to deal with new situations, such that the system is perceived to possess one or more attributes of reason, such as generalisation, discovery, association and abstraction.

Computational intelligence systems usually comprise hybrids of paradigms:

- **Artificial neural networks** to imitate critical learning.
- **Evolutionary algorithms** to automatically discover novel solutions.
- **Fuzzy systems** to mimic the human thought process with vague information.

Course content

Statistical learning

- We will focus on the **data analysis**
  - ⇝ Specific emphasis on practice of predictive modelling
- We will define predictive modelling as the process of developing a mathematical tool or model that generates an accurate prediction.
- The term predictive modelling may stir associations such as machine learning, pattern recognition, and data mining.
  - ⇝ Predictive modelling encompasses much more than the tools and techniques for uncovering patterns within data.
- The practice of predictive modelling defines the process of developing a model in a way that we can understand and quantify the model's prediction accuracy on future, yet-to-be-seen data.

Course content

Statitical learning

Content

- General strategies:
  - A short tour of the predictive modelling process.
  - Data pre-processing.
  - Overfitting and model tuning.
- Linear regression models:
  - Linear regression and its cousins.
  - Nonlinear regression models.
  - Regression trees.
- Classification models:
  - Discriminant analysis and other linear classification models.
  - Nonlinear classification models.

Course content

Statistical learning

Course material

- **Lecture handouts**
- **Selected papers**
- **Useful books**


M. Kuhn and K. Johnson, *Applied Predictive Modeling*[1], 2013


T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning: Data Mining, Inference and Prediction*[2], 2008


G. James, D. Witten, T. Hastie and R. Tibshirani, *An Introduction to Statistical Learning with Applications in R - 2nd Edition*[3], 2014


S. Haykin. *Neural Networks: A Comprehensive Foundation*, 2007

[1] Book material available here: `http://appliedpredictivemodeling.com`
[2] Book available here: `https://hastie.su.domains/ElemStatLearn/`
[3] Book available here: `https://www.statlearning.com`

Course content

Fuzzy systems

- A fuzzy system is the component of computational intelligence that emulates the imprecise nature of human cognition.
- It mimics the approximate reasoning of humans by representing vague terms in a quantitative way.
- This allows inferring numerically in the computer with a different type of logic, called fuzzy logic, which is much closer to the real world than the crisp logic.
- In this way the computer “knows” the meaning of vague terms, such as “slightly better” or “not very high” and can use them in calculating the logical solution.
- The final results from fuzzy logic are not fuzzy at all.

Course content

Fuzzy systems

Course material

- **Lecture handouts**
- **Selected papers**
- **Useful books**


T. Ross, *Fuzzy Logic with Engineering Applications*, 2016


S. Marsili-Libelli, *Environmental systems analysis with Matlab*, 2016


K. Passino. *Fuzzy control*[4], 1998

[4] Book available here: `http://www2.ece.ohio-state.edu/~passino/FCbook.pdf`

Course content

Evolutionary computing

- Evolutionary computation automatically generates solutions of a given problem with defined fitness by simulating natural evolution in a computer.
- The process begins with creation in the computer of a random population of artificial individuals, such as mathematical expressions, binary strings, symbols, structures, etc.
- In each phase of simulated evolution, a new population is created by genetic computer operations, such as mutation, crossover, copying, etc.
- As in natural evolution, only the best and the brightest survive and are selected for the next phase.
- Due to the random nature of simulated evolution it is repeated several times before selecting the final solutions

Course content

Evolutionary computing

Course material

- **Lecture handouts**
- **Selected papers**
- **Useful books**


M. Melanie. An Introduction to Genetic Algorithms, 1999


A.E. Eiben and J.E. Smith, *Introduction to evolutionary computing*, 2015

Course format

The course consists of (FACE-TO-FACE) classes and (ON/OFF-LINE) activities.

On-line activities

- Quizzes and discussion
- Group on Telegram
  https://t.me/+9UnTeqOXRRlkNmVh

Off-line activities

- Homework to be returned through SIGAA
- Reading material
- Discussion

Hands-on approach

- Project work on specific applications
- Extend the computational intelligence techniques to your own data (or given data)

Course format

The course consists of (FACE-TO-FACE) classes and (ON/OFF-LINE) activities.

Languages

- Material in English.
- Lectures in “Portuguese”.
- HW in a programming language of **your choice**.

Grading

- Written exams
  ⇝ 50% of the final score
- Homework
  ⇝ 40% of the final score
- Seminar presentation
  ⇝ 10% of the final score

Homework format

The homework will be in the **format of a conference paper** following the IEEE (Institute of Electrical and Electronics Engineers) Manuscript Templates for Conference Proceedings[5].

Papers must not exceed **6 pages** and must include the following sections:

- Abstract: You introduce the main objective and overview of the work
  - ⇝ Provide a short and informative view of the paper and its scope and results.
- Introduction: Here, you provide some context and background
  - ⇝ Briefly, explore the literature in order to define how and why the methods that you will be using have been already applied.
  - ⇝ Provide references.
- Methods: Here, you explain the methods/algorithms that you will be using
  - ⇝ Describe the main features of the method.
- Results: Discuss your results.

[5] Templates in Word and LaTeX available here: IEEE or Overleaf

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Homework format

The homework will be in the **format of a conference paper** following the IEEE (Institute of Electrical and Electronics Engineers) Manuscript Templates for Conference Proceedings[5].

The work can be done **individually or with max 4 co-authors**

- You should do an equal amount of work
  - ⇝ Everyone should share the responsibility of the tasks
  - ⇝ HW must contain a clear statement of each one contribution to the work
- Everyone must reach a common understanding and knowledge on the methods
- Effective communication
  - ⇝ Make sure both of you is able to be have a word about their ideas and problems
  - ⇝ Listen effectively and do not be critical
- Time management
  - ⇝ Attend and arrive on time to all group meetings
  - ⇝ Keep on task (limit talk about non-related events)

[5] Templates in Word and LaTeX available here: IEEE or Overleaf

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Homework format

The homework will be in the **format of a conference paper** following the IEEE (Institute of Electrical and Electronics Engineers) Manuscript Templates for Conference Proceedings[5].

There will be three homework projects:

- HW1: Data analysis
- HW2: Methods for regression
- HW3: Methods for classification
- HW4: To be defined/agreed

The grading and evaluation of the homework is based on the:

- Level of difficulty.
- Comments and discussion on the results.
- Quality of the results and the paper.

[5] Templates in Word and LaTeX available here: IEEE or Overleaf

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HW presentation format

Among the 3 main HW assignments you will choose one to present to the class.

- You have been allocated **10 minutes** of effective presentation time and **plus 10 minutes** given to Q&A.
  - ⇝ Extra time will be penalised. It is a discourtesy to your audience and the other speakers to exceed your allotted time.
  - ⇝ There is no excuse for using more than your allotted time.
  - ⇝ Rehearse your presentation several times.
- Each member of the pair must talk.
- The presentations must convey the message in clear and sharp manner, including giving outline of the key principles, facts and results.
- In addition to the questions regarding the specific HW presented, you should be able to answer questions on the remaining HW.

Course introduction

Exam format

There will be two home exams, covering the whole course content

- **Theoretical questions** ⇝ Short essay answers.
  - ⇝ The goal is you to demonstrate your knowledge on the topics and critical thinking. So, you should:

    Write your answer clearly, so it is possible decode your writing and understand your ideas.

    Choose your words carefully ⇝ not using the appropriate terminology severely diminished your chances of a good grade.
- **Exercises** ⇝ No need of programming.
  - ⇝ The goal is you to demonstrate your knowledge on the topics.
- **Specific questions on the HW assignments** ⇝ Short essay answers.
  - ⇝ The goal is you to demonstrate your contribution to the HW projects.

Exam format

There will be two home exams, covering the whole course content

- Same format of ordinary exams
  - ⇝ You are given extra time to scan your solutions and prepare a PDF to upload.

    The assignment will be returned through SIGAA.

    The system will close in 3 hours after the assignment.

    Late submissions via email will not be accepted.
- You are of course not allowed to collaborate with others.
- Make sure you know how to scan and get a PDF before the exam starts.

Tentative schedule ⇝ It might be subject to changes

Wednesday	Friday
Oct. 23 No Class	Oct. 25 No Class
Oct. 30 Statistical learning A first tour on predictive modelling	Nov. 1 Statistical learning Data pre-processing
Nov. 6 Encontros Universitários	Nov. 8 Encontros Universitários
Nov. 13 Statistical learning Data pre-processing	Nov. 15 Feriado Nacional
Nov. 20 Feriado Nacional - Dia da Consciência Negra	Nov. 22 Statistical learning Data pre-processing
Nov. 27 Statistical learning Regression	Nov. 29 Statistical learning Regression
Dec. 4 Statistical learning Regression	Dec. 6 Statistical learning Regression
Dec. 11 Statistical learning Regression	Dec. 13 Statistical learning Regression
Dec. 18 Statistical learning Classification	Dec. 20 Statistical learning Classification
Dec. 25 Recesso escolar	Dec. 27 Recesso escolar
Jan. 1 Recesso escolar	Jan. 3 Recesso escolar
Jan. 8 Statistical learning Classification	Jan. 10 Statistical learning Classification
Jan. 15 Revision for Exam	Jan. 17 Exam
Jan. 22 Statistical learning Classification	Jan. 24 Statistical learning Classification

Wednesday	Friday
Jan. 29 Evolutionary computing	Jan. 31 Evolutionary computing
Feb. 5 Fuzzy systems	Feb. 7 Fuzzy systems
Feb. 12 Revision for exam	Feb. 14 Exam
Feb. 19 Student seminars	Feb. 21 Student seminars
Feb. 26 Student seminars	Feb. 28 Student seminars
Mar. 5	Mar. 7

Course policy

- You are responsible for all material covered in class.
- You are responsible for the assigned readings and for the project works.

Academic integrity[6]

- **Honesty is the foundation of good work**.
- Trust the value of your own intellect.
- Undertake research honestly and credit others for their work.
- Demonstrate your own achievement.
- Accept corrections as part of the learning process.
- **Plagiarism will not be tolerated**
  - ⇝ HW grade will be set to zero.
  - ⇝ Names will be reported.

[6] https://integrity.mit.edu

Course outcomes

After the completion of the course you should be able to...

- Foundational principles for building predictive models.
- Intuitive explanations of many commonly used predictive modelling methods
  - ⇝ Classification problems
  - ⇝ Regression problems
- Principles and steps for validating a predictive model.
- Foundational principles on evolutionary computation and fuzzy systems.

Contacts

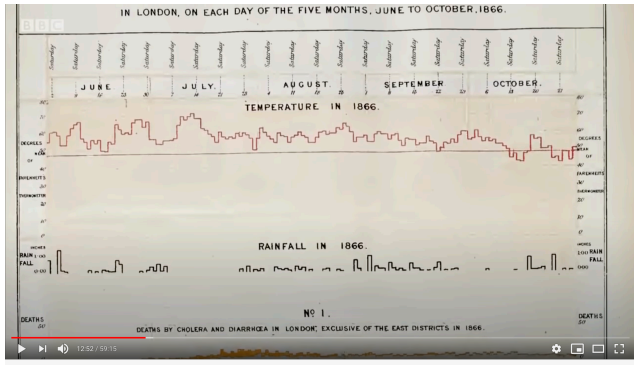
You can contact me by email or in Telegram

- Office hours: Fridays 18:00 – 19:30
  Place: Google Meet
  meet.google.com/unh-jcgg-rgq
  Bloco 725 - Sala 2 (First floor)
- Email: michela.mulas@ufc.br

All communication will take place through SIGAA/Telegram Group and my official email address.

Any email or contact coming from different sources have to be ignored.

The joy of data



The Joy of Data - BBC Documentary

Source: https://www.youtube.com/watch?v=l6oKriR-RjM