Advanced Algorithms

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Contact details

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- Office hours
  - Friday, 11:00am -12:00pm

- Course web site
  - http://www.inf.unibz.it/~zini/AA

Course structure

- **Credits**: 4
- **Lectures**: 24 hours
- **Labs**: 12 hours
- **Timetable**
  - Lectures: **Friday**, 8:30am-10:30am,
    D002 Lecture room, Ser-D
  - Labs: **Friday**, 2:00pm-3:00pm
    E331 Computer room, Ser-E
  - **Please check the course webpage and/or the online timetable for variations**

Assessment

- **Project (P) – maximum 14 points (40% of mark)**
  - In a team of maximum 2 students
  - A **positively assessed** (i.e., at least 8 points) project is **required** for taking the **final exam**!!
    A **passed** project counts for the **3 regular exam sessions**
- **Final exam (E) – maximum 16 points (60% of mark)**
  - Written questions and exercises
- **Optional assignments (A) – maximum 2 points**
- **Final grade (G)**
  - **G = E + P + A**
  - To pass: **P ≥ 8** points **and** **E ≥ 10** points

Goals of the course

- We will focus on various **paradigmatic computational problems** arising from real world scenarios
- We will see a range of **efficient algorithms** to solve these problems
  - algorithms for **special kinds of problems**
  - algorithms that are **powerful and general**
- We will learn how to **implement** some (or parts) of the introduced algorithms
- We will see **practical applications** of the presented algorithms

Learning outcome

- Increase your **knowledge** about advanced **paradigms** of **algorithm design**
- Introduce the most useful and powerful **information structures** along algorithms for solving some relevant problems
- Study some **core computer science problems** that have a large applicability in several different areas
- Enhance your **ability** to select the best and efficient way for **encoding problems**

How?

- **12 two-hours frontal lectures**
  - theory, examples, and quizzes
- **12 one hour labs**
  - **Exercises** (fundamental for the written exam!)
  - **Java** and or **MATLAB®/Octave** will be used by the students to implement (parts of) the algorithms presented in the lectures
- **Homework**
  - Studying the slides is not enough
  - The students should also
    - Study on the suggested books
    - Do the proposed exercises and assignments
    - Ask questions in class or during the office hours

Syllabus

- Elements of complexity theory
- Algorithms with numbers
- Elements of graph theory
- Greedy algorithms
- Linear programming and simplex algorithm
- Network optimization algorithms
- Approximation algorithms
- Randomized algorithms
- Evolutionary algorithms
- Algorithms for linear and logistic regression
- Online algorithms

Course material

- Course slides
  - Available at http://www.inf.unibz.it/~zini/AA the day after the lecture
- Textbooks
  - **Algorithms**
    by S. Dasgupta, C.H. Papadimitriou, and U.V. Vazirani, McGraw-Hill Higher Education 2008.
    - Copies are available in the library
    - A draft copy is available on the web:
      http://www.cs.berkeley.edu/~vazirani/algorithms.html
  - **Introduction to Evolutionary Computing**
    by Gusz Eiben, Jim Smith, Springer 2003
    - Available on the web: http://www.cs.vu.nl/~gusz/ecbook/ecbook.html
- Other useful material
  - **Online lectures** (https://class.coursera.org/ml/lecture/preview)
    by Andrew Ng (http://cs.stanford.edu/people/ang/)
    on Coursera (http://www.coursera.org/)

Project

- The project is conducted **individually** or in **small groups** (2 students)
- **Choose** the **advanced algorithm** you like the most
- **Implement** it (or part of it) using Java or MATLAB®/Octave
- **Validate** the implementation on some use cases
- **Research 3 real word application** on which your champion algorithm has been applied
  - Explain how the computational problem underlying each application has been **modeled** to be treated with the algorithm
  - Explain which are the **reasons** why the algorithm has been chosen for each 3 applications and **critically analyze** pros and cons of the choice
  - **Compare and contrast** the selected algorithm with other algorithms for realizing the same 3 applications
- The project **results** include:
  - A written **report** of not more than 4.000 words
  - An **algorithm implementation**

Project – structure of the report

- Executive **summary**
- 1 **section** including the **description** of the selected **algorithm**
- 1 **section** describing how you have **implemented** it (e.g., provide the class and interaction diagrams and describe them, or describe the MATLAB®/Octave functions)
- 1 **section** for each of the 3 real world applications on which the algorithm has been applied
  - 1 subsection including the **description** of the **application** and how it has been **modeled** to be treated with the algorithm
  - 1 subsection including the **reason** why the algorithm has been applied to the application and **critical analysis** of pros and cons of the choice
  - 1 subsection that **compares** and **contrasts** the selected algorithm with **other algorithms** for realizing the same application
- 1 **section** including **conclusions** and **observations**
- **Citations** to the scientific papers and other material you reference in the report

Project – evaluation

- Submit 1.5 pages **draft** with your idea I'll revise it (we'll decide a deadline)
- The **report** must be **compliant** with the **structure** defined in the previous slide
- The **writing** must be **clear and neat**
- The report must show that you have:
  - **Well understood the selected algorithm**
  - **Deeply analyzed its application to the 3 specific fields**
  - **Compared in details the algorithms with other approaches**
- The project **results** will be **presented** in a **seminar** (15 mins for each presentation) in front of the class
  - The presentation must be understandable and raise the audience attention
  - The presenters must be able to reply to the questions of the other participants

Acknowledgements

- Part of the slides are adapted from those by **Valeria Fionda** (Free University of Bozen-Bolzano)
- Other slides are adapted from those by **Yijia Chen** (Shanghai Jiaotong University)
- Some material comes from the Machine Learning online course by **Andrew Ng** (Stanford University) available on Coursera
- The organization of the course takes inspiration from **Francesco Ricci** (Free University of Bozen-Bolzano)