Course description

General information			
Course leader	**Nicolas LE HIR**		
Course title	**Graphs Algorithm and Matching**		
Study programme	**Title of Expert in Information Technology**		
Course status	**Graduate Program**		
Year	2		
Number of credits and mode of teaching delivery	ECTS student workload coefficient	3	
	Number of hours (L+E+S)	(14+0+60) 74	

1. COURSE DESCRIPTION

1.1. Course objectives

The module “Graphs Algorithm and Matching” focuses on processing data with graphs. Graphs are abstract mathematical objects used to represent the relationships between data points. This abstraction has been allowing the computer scientists and the mathematicians to formalise and to solve some complex problems.

1.2. Conditions for enrolment in the course

- Be familiar with graphs and with the notion of algorithmic complexity.
- Have elementary mathematical notions related to calculus (derivation).
- Be familiar with Python 3 and with the installation of new libraries.

The following elements will be helpful:

- Have elementary notions of probabilities.
- Have elementary notions of linear algebra.
- Be familiar with the scientific computing libraries as numpy.

1.3. Expected learning outcomes of the course

LO1: Implement the maximum matching problem.

LO2: Implement greedy algorithms to give an approximate solution to the matching problem.

LO3: Explain and implement the maximum flow using flow network.

LO4: Implement the Ford-Fulkerson algorithm, in bipartite and other graphs.

LO5: Build a graph from data.

LO6: Apply the notions of distance and similarity for given problem.

LO7: Analyse data by using contemporary tools.

LO8: Explain the clustering problem and explain and use the Spectral Clustering, applying to abstract data.

LO9: Explain and implement the K-means algorithm, applying to geometric data.

At the end of the module, the students will be familiar with several important problematics, related to graphs and data processing. They will also be familiar with the notion of a heuristic algorithm for clustering and for matching and will understand why using such a heuristic is often necessary.

1.4. Course content

The lectures are structured on two days.

Lecture 1 :

- Reminders on graphs
- The maximum matching problem
- Brute force approach
- Greedy algorithm
- Flow networks
- The maximum flow problem
- The Ford-Fulkerson algorithm
- Connection to the matching problem

Lecture 2:

- Building graphs for data
- Distances
- Probability distributions and random variables
- Maximum likelihood
- Optimization and gradient descent
- Correlation
- Kmeans clustering
- Similarities and spectral clustering

The project consists in processing the dataset chosen by the students.

The first part of the project focuses on building a metric in the dataset. It means to build a distance, or similarity, in order to compare the points in the dataset. During the lecture, several methods are studied to encourage the students to build a distance that gives the possibility to reflect some structures in the dataset. It leads to build a ‘compatibility graph‘.

The second part of the project consists in either performing a matching or a clustering in the graph. The choice between the two options depends on which information the students want to extract from the data. It needs the matching or the clustering to be implemented by the students, by using a heuristic of their own choice, or a defined algorithm. During the lectures, some examples of algorithms are given and studied.

1.5. Teaching delivery modes:	☒ lectures ☐ seminars and workshops ☒ exercises ☐ remote learning ☐ field work	☒ independent work ☐ multimedia and network ☐ laboratory ☒ mentoring ☐ other ________________
1.6. Comments	Presentation on given topics are part of the modules. The presentations are interactive, and the students can ask questions. The students work on coding exercises during the class. All the material of the module– course slides, exercises, and example of python scripts - is available on a repository.	

1.7. Student obligations

STUDENT ATTENDANCE
Class attendance is mandatory in the percentage prescribed by the Studies and examination regulations.

PASSING EXAM
Each groups of students must submit their results to the teachers and give an oral presentation based on their results. The results are reviewed by the academic staff during an oral examination. A justification of the project work can be explained by the students.

1.8. Monitoring[1] student work

Class attendance		Activity during class		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	

[1] IMPORTANT NOTES: Next to each method of monitoring student work it is necessary to insert an adequate share of each activity in ECTS credits, so the total number of ECTS credits corresponds to the credit value of the course. You can use empty fields for additional activities.

Project	100 %	Continuous assessment of knowledge		Student report		Practical work	
Portfolio							

1.9. Assessment and evaluation of student work during classes and the final exam

The students are assessed on the project results and the content. *

CONCRETE REVIEW OF EVALUATION METHODS

The maximum number of points that a student can earn in a course is 100. Grades are calculated according to the following criteria table within which the distribution of passing grades in terms of the number of points is applied.

Points	Grade
0,00 - 50,00	(E) unsatisfactory
50,01 - 58,00	(D) sufficient
58,01 - 75,00	(C) good
75,01 - 92,00	(B) very good
92,01 - 100,00	(A) excellent

The method of accumulating points is determined in this course in accordance with the elements of scoring as follows:

Criterion	Maximum points
Project	100
TOTAL	100

1.10. Required reading (at the moment of submitting the joint study programme report)

Python Software Foundation.“Python“, 2020. https://www.python.org/

Sickit-Learn.“Machine Learning in Python“, 2020. https://scikit-learn.org/stable/

NumPy.“NumPy“, 2020. https://numpy.org/

SciPy.“SciPy.org“, 2020. https://www.scipy.org/

1.11. Additional reading (at the moment of submitting the joint study programme report)

T. Cormen, C. Leiserson, R. Rivest, and C. Stein.“Introduction to Algorithms“. *The MIT Press*, 2nd edition, 2001.

Laurent Miclet, Antione Cornéjuols.“Apprentissage artificiel“. *Concepts et algorithmes/* Eyrolles, May 2018.

1.12. Number of copies of required reading in relation to the number of students who currently attend a course

Title	*Number of copies*	*Number of students*

1.13. Methods of quality monitoring that ensure the acquisition of knowledge, skills and competencies.

The content of each modules is continuously revised to teach the students on the most up-to-date notions and concepts of IT. Indeed, the range of skills and knowledge in this sector is constantly getting broader, with a larger perspective of working in many different fields.

To ensure the quality of the teaching, a Steering Committee supervises the Quality Management System. The evolution of the teaching content is revised and validated by the Development Council. The teachers as well as the administration staff are evaluated by the students themselves. Finally, the teaching content is analysed and determined by evaluating the skills during the internships, by the partner companies.