ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

615001055 - Bioinspired Algorithms For Optimization

DEGREE PROGRAMME

61IW - Grado En Ingenieria Del Software

ACADEMIC YEAR & SEMESTER

2023/24 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	615001055 - Bioinspired Algorithms For Optimization
No of credits	6 ECTS
Type	Optional
Academic year ot the programme	Fourth year
Semester of tuition	Semester 8
Tuition period	February-June
Tuition languages	English
Degree programme	61IW - Grado en Ingenieria del Software
Centre	61 - Escuela Tecnica Superior De Ingenieria De Sistemas Informaticos
Academic year	2023-24

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Cristian Oliver Ramirez Atencia (Subject coordinator)	1108	cristian.ramirez@upm.es	Sin horario. Will be informed during the lectures
Angel Panizo Lledot	1216	angel.panizo@upm.es	Sin horario. Will be informed during the lectures

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Probabilidad Y Estadistica

- Algoritmica Y Complejidad

- Inteligencia Artificial

3.2. Other recommended learning outcomes

- Heuristic Search

- Statistical hypothesis testing

- Tree and graph structures

- Python

4. Skills and learning outcomes *

4.1. Skills to be learned

CC15 - Knowledge and application of the fundamental principles and basic techniques of intelligent systems and their practical application.

CT2 - Problem solving: Identify, analyse and define the significant elements that constitute a problem in order to solve it judiciously and effectively.

CT3 - Oral communication: Expressing one's own ideas, knowledge and reflections clearly and appropriately through the spoken word, adapting to the characteristics of the situation and the audience in order to achieve understanding.

CT8 - Teamwork: To be able to work as a member of an interdisciplinary team in order to contribute to the development of projects with pragmatism and a sense of responsibility, assuming commitments taking into account the available resources.

4.2. Learning outcomes

RA443 - The student is able to model and optimize real problems using bio-inspired algorithms

RA445 - The student is capable of statistically evaluation and comparing bio-inspired algorithms for test and real problems

RA444 - The student is capable of handling advanced techniques for constraint, multi-modality and multi-objective modelling in bio-inspired computing

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This subject covers the topic of Bioinspired Metaheuristics, which are a class of optimization algorithms that are inspired by natural phenomena. The course will delve into the different types of bio-inspired algorithms, including evolutionary algorithms, such as genetic algorithms and genetic programming, and swarm intelligence algorithms, such as particle swarm optimization and ant colony optimization. Furthermore, evaluation mechanisms such as sensitivity analysis, benchmarking and visualization, and test problems will also be discussed. Finally, the subject will also cover advanced techniques like Multi-Objective and Multi-Modal Optimization, strategies for handling constraints, dynamic and robust optimization, parallelism and co-evolution, memetic and local search techniques or using surrogate models. In brief, the subject will provide a comprehensive understanding of the various bio-inspired algorithms, their properties, applications and how to evaluate their performance. The subject will have a strong practical part, where the student will analyze, design, implement and test algorithms to solve real-world problems, using the different techniques explained.

5.2. Syllabus

1. Introduction to Metaheuristics
    1.1. What are Metaheuristics?
    1.2. The bio-inspired zoo
    1.3. Fundamentals of bio-inspired algorithms (codifications, evaluation, convergence/diversity)
2. Evolutionary Algorithms
    2.1. Genetic Algorithms
    2.2. Genetic Programming
    2.3. Applications
3. Swarm Intelligence
    3.1. Particle Swarm Optimization (PSO)
    3.2. Ant Colony Optimization (ACO)
    3.3. Applications
4. Multi-Objective and Multi-Modal Optimization
    4.1. Multi-Modal Optimization
    4.2. Multi- and Many-Objective Optimization
    4.3. Metrics
5. Constraint handling techniques
6. Evaluation mechanisms
    6.1. Parameter Settings and sensitivity analysis
    6.2. Comparison of Algorithms
    6.3. Visualization methods
    6.4. Test Problems
7. Advanced topics
    7.1. Improved methods: Memetic algorithms and local search
    7.2. Parallelism and Co-evolution
    7.3. Dynamic and Robust Optimization
    7.4. Surrogate models

6. Schedule

6.1. Subject schedule*

Week	Classroom activities	Laboratory activities	Distant / On-line	Assessment activities
1	**Topic 1- Introduction** Duration: 04:00 Lecture			
2	**Topic 2 - Evolutionary Algorithms** Duration: 04:00 Lecture			
3	**Topic 2 - Evolutionary Algorithms** Duration: 04:00 Lecture			
4	**Topic 3 - Swarm Intelligence** Duration: 04:00 Lecture			
5	**Topic 3 - Swarm Intelligence** Duration: 04:00 Lecture			
6	**Topic 4 - Multi-Objective and Multi-modal Optimization** Duration: 04:00 Lecture			
7	**Topic 4 - Multi-Objective and Multi-modal Optimization** Duration: 02:00 Lecture **Topic 5 - Constraint Handling Techniques** Duration: 02:00 Lecture			
8	**Topic 6 - Evaluation mechanisms** Duration: 02:00 Lecture	**Presentation of Practical Proposals** Duration: 02:00 Laboratory assignments		
9	**Topic 6 - Evaluation mechanisms** Duration: 02:00 Lecture **Topic 7 - Advanced Topics** Duration: 02:00 Lecture			
10		**Project development** Duration: 04:00 Laboratory assignments		

11		**Project development** Duration: 04:00 Laboratory assignments		
12		**Project development** Duration: 04:00 Laboratory assignments		
13		**Project development** Duration: 04:00 Laboratory assignments		
14		**Project development** Duration: 04:00 Laboratory assignments		
15		**Presentation of project and results** Duration: 04:00 Laboratory assignments		**Project (RA443, RA444, RA445)** Group work Continuous assessment and final examination Presential Duration: 02:00
16				
17				**Theory exam (RA443, RA444, RA445)** Written test Continuous assessment and final examination Presential Duration: 02:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
15	Project (RA443, RA444, RA445)	Group work	Face-to-face	02:00	40%	4 / 10	CT2 CT3 CT8
17	Theory exam (RA443, RA444, RA445)	Written test	Face-to-face	02:00	60%	4 / 10	CT2 CC15

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
15	Project (RA443, RA444, RA445)	Group work	Face-to-face	02:00	40%	4 / 10	CT2 CT3 CT8
17	Theory exam (RA443, RA444, RA445)	Written test	Face-to-face	02:00	60%	4 / 10	CT2 CC15

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Theory exam (RA443, RA444, RA445)	Written test	Face-to-face	02:00	60%	4 / 10	CT2 CC15
Project (RA443, RA444, RA445)	Group work	Face-to-face	02:00	40%	4 / 10	CT2 CT3 CT8

7.2. Assessment criteria

Progressive Evaluation

To pass the course, the student must do a practical project assingment (PA) and get, at least, a 4 over 10 points and do the theoretical exam (TE), obtaining, at least, a 4 over 10 points.

The project assignment will consist of the project code submission and a in-class presentation of the obtained results.

The final grade, will be: Final grade = PA * 0.4 + PE*0.6

This final grade should be at least 5 over 10 to pass the course

Referred (re-sit) examination

To pass the course doing this call for exam, the student must do a practical project assignment (PA) and get, at least, 4 points out of 10 in each, and do the theoretical exam (TE), obtaining, at least, a 4 over 10 points.

The final grade, will be: Final grade = PA * 0.4 + PE*0.6

This final grade should be at least 5 over 10 to pass the course

If the student does not get the minimum grade in any of the evaluation activities he/she will fail the course and his/her final grade will be the minimum of the grades of the different activities done.

ATTENTION:

If any type of fraud is detected in any of the evaluation activities, the student/s will get a zero as final grade in the current convocatory and the teacher may propose a special and equivalent exam in the next call for exam.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Moodle of the subject	Web resource	Moodle Platform from UPM where learning resources (slides, documentation, software, among others) can be found
PCs in laboratories	Equipment	PCs organized in laboratories with projector cannon and black/whiteboard
Nature-inspired optimization algorithms	Bibliography	Yang, X. S. (2020). Academic Press.
Evolutionary Optimization Algorithms: Biologically Inspired and Population-based Approaches to Computer Intelligence	Bibliography	Simon, D. (2013). Wiley.
Essentials of Metaheuristics	Bibliography	Luke, S. (2013). Lulu.
Handbook of Metaheuristics	Bibliography	Gendreau, M., Potvin, J.-Y. (2010). Springer.
Evolutionary algorithms for solving multi-objective problems	Bibliography	Coello, C. A. C., Lamont, G. B., & Van Veldhuizen, D. A. (2007). Springer.
Evolutionary Computation 1: Basic Algorithms and Operators	Bibliography	Bäck, T., Fogel, D.B., Michalewicz, Z. (2000). IOP Publishing Ltd.
Evolutionary Computation 2: Advanced Algorithms and Operators	Bibliography	Bäck, T., Fogel, D.B., Michalewicz, Z. (2000). IOP Publishing Ltd.

9. Other information

9.1. Other information about the subject

The students will have to propose a final project that will be developped by them. The teachers will encourage projects that are involved with ODS 6, ODS 7, ODS 9, ODS 11, ODS 12 and ODS 13.