National University of Engineering (UNI)
School of Computer Science
Syllabus 2026-I

1. COURSE

AI368. Evolutionary Computing (Mandatory)

2. GENERAL INFORMATION

2.1 Course	:	AI368. Evolutionary Computing
2.2 Semester	:	10^{th} Semester.
2.3 Credits	:	4
2.4 Hours	:	2 HT; 4 HP;
2.5 Duration of the period	:	16 weeks
2.6 Type of course	:	Mandatory
2.7 Learning modality	:	Face to face
2.8 Prerrequisites	:	AI264. Deep Learning. (7^{th} Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Evolutionary Computing is a subfield of Artificial Intelligence inspired by natural selection and biological evolution. This course explores metaheuristic optimization algorithms such as Genetic Algorithms, Evolution Strategies, and Genetic Programming. These techniques are essential for solving complex optimization and search problems where traditional analytical methods are insufficient. Students will learn to design, implement, and analyze evolutionary systems applied to engineering, data science, and autonomous agents.

5. GOALS

- Understand the principles of natural selection applied to computation.
- Master the design of representations, operators, and fitness functions.
- Implement and tune Genetic Algorithms and Evolution Strategies.
- Analyze the convergence and performance of bio-inspired algorithms.
- Apply evolutionary techniques to multi-objective optimization problems.

6. COMPETENCES

AG-C08) Problem Analysis: Identifies, formulates, and analyzes complex computing problems. (Usage)

AG-C12) Uses systemic approaches to select, develop, apply, integrate, and manage secure computing technologies to achieve user objectives. (Usage)

7. TOPICS

Unit 1: Foundations of Evolutionary Computation (12 hours)	
Competences Expected: AG-C08,AG-C12	
Topics	**Learning Outcomes**
• Introduction to Evolutionary Algorithms (EAs) and biological metaphors. • The General Evolutionary Algorithm cycle: Initialization, Selection, Variation, Replacement. • Components: Populations, chromosomes, genes, alleles. • Fitness landscapes, genotype-phenotype mapping, and search spaces.	• Explain the relationship between biological evolution and artificial search processes [Familiarizarse] • Identify the components of a generic evolutionary algorithm and their roles [Usar] • Describe the concept of fitness landscapes and their impact on EA performance [Familiarizarse]
Readings : [ES15], [Bac96]	

Unit 2: Genetic Algorithms and Variants (16 hours)	
Competences Expected: AG-C08,AG-C12	
Topics	**Learning Outcomes**
• Canonical Genetic Algorithms (CGA): binary representation, selection schemes (roulette, tournament). • Genetic Operators: Crossover (single-point, uniform, arithmetic), Mutation (bit-flip, Gaussian). • Schema Theorem and Building Block Hypothesis. • Advanced GA variants: Real-coded GAs, Genetic Programming (GP) with tree representations.	• Design appropriate representations and operators for specific optimization problems [Evaluar] • Implement a canonical Genetic Algorithm for function optimization [Usar] • Apply Genetic Programming to symbolic regression or automatic programming tasks [Evaluar]
Readings : [ES15], [Mit98]	

Unit 3: Evolution Strategies and Evolutionary Programming (18 hours)	
Competences Expected: AG-C08,AG-C12	
Topics	**Learning Outcomes**
• Evolution Strategies (ES): (μ, λ) and $(\mu+\lambda)$ selection mechanisms. • Self-adaptation of strategy parameters (mutation step sizes). • Covariance Matrix Adaptation (CMA-ES). • Evolutionary Programming (EP) and its focus on behavioral evolution.	• Implement Evolution Strategies with self-adaptive mutation for continuous optimization [Evaluar] • Compare the performance of GAs vs ES on benchmark problems [Usar] • Explain the role of strategy parameter adaptation in convergence speed [Familiarizarse]
Readings : [ES15], [Deb01]	

Unit 4: Multi-objective and Hybrid Evolutionary Algorithms (18 hours)	
Competences Expected: AG-C08,AG-C12	
Topics	**Learning Outcomes**
• Multi-objective Optimization: Pareto optimality, dominance relations. • Multi-objective EAs: NSGA-II, SPEA2, MOEA/D. • Diversity preservation mechanisms and archiving strategies. • Memetic Algorithms: Hybridization with local search. • Constraint handling techniques in evolutionary search.	• Solve multi-objective problems using Pareto-based selection methods [Evaluar] • Design a memetic algorithm combining global and local search [Evaluar] • Evaluate the trade-offs between convergence and diversity in MOEAs [Usar]
Readings : [ES15], [Deb01]	

8. WORKPLAN

8.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

8.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

8.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

9. EVALUATION SYSTEM

********* EVALUATION MISSING ********

10. BASIC BIBLIOGRAPHY

[Bac96] Thomas Back. *Evolutionary Algorithms in Theory and Practice*. Oxford University Press, 1996.

[Mit98] Melanie Mitchell. *An Introduction to Genetic Algorithms*. MIT Press, 1998.

[Deb01] Kalyanmoy Deb. *Multi-Objective Optimization using Evolutionary Algorithms*. Wiley, 2001.

[ES15] Agoston E. Eiben and James E. Smith. *Introduction to Evolutionary Computing*. 2nd. Springer, 2015.