CSPE3008 EVOLUTIONARY COMPUTING (3-0-0)

Course Objectives:

The course aims to:

1. Introduce bio-inspired optimization techniques and evolutionary principles.
2. Teach various evolutionary algorithms and their applications to engineering problems.
3. Enable students to design, implement, and evaluate evolutionary computing systems.
4. Develop analytical and problem-solving skills using stochastic search methods.

Module - I: Introduction to Evolutionary Computing

Evolutionary Algorithms (Genetic Algorithms, Genetic Programming, Differential Evolution, Evolution Strategies, Covariance Matrix Adaptation, etc.). Biological evolution, natural selection, survival of the fittest, Search and optimization: deterministic vs stochastic, Fitness landscape, exploration vs exploitation, Overview of evolutionary computing techniques

Module - II: Genetic Algorithms (GA)

Representation: chromosomes, encoding (binary, real-coded, permutation). Operators: Selection methods (roulette, tournament, rank, elitism). Crossover techniques (one-point, multi-point, uniform, arithmetic). Mutation (bit flip, swap, Gaussian). Fitness functions. Convergence theory. Applications to optimization and engineering problems

Module - III: Evolution Strategies & Evolutionary Programming

Evolution Strategies (ES): (1+1) ES, (μ+λ) ES, (μ,λ) ES, Self-adaptation of mutation rates, Evolutionary Programming (EP), Genetic Programming (GP): GP fundamentals, Tree representation, Function set, terminal set, Crossover, mutation for trees, Symbolic regression, automated design, control problems

Module - IV: Swarm Intelligence

Particle Swarm Optimization (PSO): Velocity and position update, Global vs local best models. Ant Colony Optimization (ACO): pheromone trails, probability transitions, TSP and routing applications. Other methods (brief): Artificial Bee Colony (ABC), Firefly Algorithm, Differential Evolution (DE)

Module - V: Applications of Evolutionary Computing

Engineering optimization, Scheduling & routing, Signal processing, Control systems & robotics, Machine learning (feature selection, hyperparameter tuning), Multi-objective optimization (NSGA-II basics)

Course Outcomes (COs)

After completion, students will be able to:

CO1: Explain the fundamentals of evolutionary computation and natural selection principles.
CO2: Apply genetic algorithms and mutation-based search techniques to optimization problems.
CO3: Design and implement evolutionary strategies, genetic programming, and swarm intelligence methods.
CO4: Analyze performance, convergence, and complexity of evolutionary algorithms.
CO5: Apply evolutionary techniques to real engineering tasks (control systems, robotics, scheduling, routing, etc.).

Textbooks

1. Eiben, A. E. & Smith, J. E., Introduction to Evolutionary Computing
2. Goldberg, D. E., Genetic Algorithms in Search, Optimization, and Machine Learning
3. Kennedy & Eberhart, Swarm Intelligence

Reference Books

1. Simon, D., Evolutionary Optimization Algorithms
2. Bäck, T., Evolutionary Algorithms in Theory and Practice
3. Koza, J., Genetic Programming
4. Engelbrecht, Computational Intelligence