Course Information Form

Code		Title	Theory and Applications of Nature-inspired Algorithms	Credit Hours	3+0
Pre/co-requisites		Data Structures			
Course Instructor		Email		Course Coordinator	
Dr. Salman A. Khan		sakhan@pafkiet.edu.pk		Dr. Salman A. Khan	

Course Objectives

This course introduces students to the theory and applications of nature-inspired algorithms. Various intelligent techniques such as genetic algorithms, simulated evolution, stochastic evolution, Tabu search, simulated annealing, ant colony optimization, particle swarm optimization, honeybee colony optimization, extremal optimization, cuckoo search, and others will be covered. This will be supplemented by various complex optimization and decision-making problems along with underlying concepts such as unconstrained and constrained optimization, single-objective and multi-objective optimization, hybridization, etc.

Course Description

Optimization, Single-objective vs. Multi-objective optimization, Complex optimization problems and optimization objectives, Multi-objective optimization methods, Nature-inspired algorithms, Heuristics, Genetic algorithms, Simulated Evolution, Cuckoo Search, Stochastic Evolution, Simulated Annealing, Tabu search, Ant colony optimization, Particle Swarm optimization, Honeybee colony optimization, Extremal optimization, other algorithms, Hybridization and parallelization

Course Learning Outcomes

On successful completion of this course, students will be able to:

1. Critically analyze various nature-inspired algorithms and their characteristics.
2. Discuss principles and concepts associated with optimization and optimization methods
3. Analyze various well-known optimization problems in the context of nature-inspired computing
4. Apply nature-inspired algorithms to optimally solve a specific problem.
5. Develop a research oriented technical report on a subject related to the course topics, with personal insight and analysis

Textbook

There is no specific text book. Material from various sources will be provided.

References:

- Iterative Computer Algorithms with Applications in Engineering: Solving Combinatorial Optimization Problems, Sadiq M. Sait and Habib Youssef, IEEE Computer Society Press, 2000
- New Ideas in Optimization, David Corne et al., MacGraw Hill, 1999
- Multi-Objective Optimization in Computer Networks Using Metaheuristics, Yezid Donoso and Ramon Fabreqat, Taylor & Francis, 2007
- Different sources consisting of information from book chapters, journal articles, and conference papers.

Topics to be covered

Week	Topics Covered
1	Optimization Concepts: Local and global optima, Single-objective and multi-objective optimization, Constrained and unconstrained optimization, Local and global search
2	Pareto optimality in multi-objective optimization, Pareto-front, Popular Multi-objective optimization methods: Weighted sum, ε-constraint, Lexicographic ordering, Goal programming
3	Popular Multi-objective optimization methods (contd): Fuzzy logic, Importance of preferences in Multi-objective optimization, approaches to incorporate preferences
4	Metaheuristics and their characteristics, Genetic Algorithms (Population size, Crossover, Mutation); Simulated Evolution: Evaluation, Selection, Allocation;
5	Application examples
6	Simulated Annealing: Initial temperature, Cooling schedule, Cooling rate, Markov chain length, Metropolis procedure
7	Application examples of Simulated Annealing
8	Tabu Search and Application examples

9	Ant Colony Optimization: Stigmergy; Pheromone update; Pheromone trail; Heuristic value/attractiveness; Daemon actions
10	Application examples of Ant Colony Optimization
11	Particle Swarm Optimization:
12	Application examples of Particle Swarm Optimization
13	Honeybee colony optimization: Employed bees, Onlooker bees, Scout bees, Waggle dance, Application examples
14	Cuckoo Search and Other algorithms: (e.g. Firefly optimization; Biogeography based optimization etc.)
15	Advanced concepts: Hybridization; Parallelization Project presentations