EVOLUTIONARY COMPUTATION FOR SINGLE AND MULTI-OBJECTIVE OPTIMIZATION

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PRE-REQUISITES : Elementary Mathematics and Programming

INTENDED AUDIENCE : Final and Pre-final year UG students, PG Students and Candidates from Industries

INDUSTRIES APPLICABLE TO : All R&D industries that involve design and optimization of product and system

COURSE OUTLINE :

Evolutionary computation (EC) is a sub-field of computational intelligence that use ideas and get inspiration from natural evolution. It is based on Darwin's principle of evolution where the population of individuals iteratively performs search and optimization. EC techniques can be applied to optimization, learning, design and many more. This course will concentrate on the concepts, algorithms, hand-calculations, graphical examples, and applications of EC techniques. Topics will be covered include binary and real-coded genetic algorithms, differential evolution, particle swarm optimization, multi-objective optimization and evolutionary algorithms, and statistical assessment. Students will be taught how these approaches identify and exploit biological processes in nature, allowing a wide range of applications to be solved in industry and business. Students will have the opportunity to build and experiment with several different types of EC techniques through-out the course.

ABOUT INSTRUCTOR :

Prof. Deepak Sharma is an Associate Professor in the Department of Mechanical Engineering, Indian Institute of Technology (IIT) Guwahati, India. He obtained his Ph.D. and M.Tech. degrees from IIT Kanpur, India. Prior to joining IIT Guwahati, he has worked with many international research teams at Helsinki School of Economics, Finland; Université de Strasbourg, France; National University of Singapore, Singapore, Karlsruhe Institute of Technology, Germany, and Asian Institute of Technology, Bangkok, Thailand. He was awarded for NVIDIA Innovation Award in 21st IEEE International Conference of High Performance Computing in 2014, DAAD's Research Stays fellowship for summer 2013, best student paper awards in IEEE Congress on Evolutionary Computation (CEC) conferences in 2007 and 2008. He has been constantly involved in many sponsored and consultancy projects from SERB, Ministry of Heavy Industries and Public Enterprises. He has published more than 50 papers in the journals and conferences of high repute. His research interests include Optimization and Soft Computing Techniques for Design and Optimization, Evolutionary Multi-Objective Optimization, and GPU Computing.

COURSE PLAN :

Week 1: I ntroduction and Principles of Evolutionary Computation (EC):Introduction to Optimization, Generalized Formulation, Scope of Optimization via Applications, Characteristic of Optimization Functions;Principles of EC: Natural Evolutional and Genetics, Generalized Framework, Behavior and Typical run of EC, Advantages and Limitations
Week 2: Binary-Coded Genetic Algorithm (BGA): Introduction, Binary Representation and Decoding, Working Principle of binary coded GA (BGA), BGA on Generalized Framework,Operators, Hand Calculations, Graphical Examples;
Week 3: Real-Coded Genetic Algorithm (RGA): Concepts and Need of Real-Coded GA (RGA), Algorithm, RGA on Generalized Framework, Operators, Hand Calculations, Graphical Examples, Case studies;
Week 4: Other EC Techniques: Differential Evolution (DE): Introduction, Concepts, Operators, Algorithm, DE on Generalized Framework, Graphical Examples, Case studies; Particle Swarm Optimization (PSO): Introduction, Concepts, Operators, PSO on Generalized Framework, Graphical Examples, Case studies;
Week 5: Constraint Handling Techniques : Generalized Constraint Formulation, Karush Kuhn Tucker (KKT) conditions, Penalty Function Method, Parameter-Less Deb's Method, Hand Calculations, Graphical Examples, Case studies
Week 6 : Introduction to Multi-Objective Optimization : Introduction, Generalized Formulation, Concept of Dominance and Pareto-optimality, Graphical Examples, Terminologies, Difference with Single-objective optimization, Approaches to multi-objective optimization;
Week 7: Classical Multi-Objective Optimization Methods : Classical Multi-Objective Optimization Methods: Weighted- Sum Method, ε-Constraint Method, Weighted Metric Methods, Hand Calculations, Difficulties with Classical approaches, Ideal Multi- Objective Optimization Approach;
Week 8: Multi-Objective Evolutionary Algorithms (MOEAs): Introduction, MOEAs on generalized Framework, Algorithms: NSGA-II, SPEA2, Graphical Examples, Case Studies; Hypervolume Indicator (HV) for Performance Assessment