NATURE-INSPIRED OPTIMIZATION ALGORITHMS APPLIED TO FUZZY
CONTROL, FUZZY MODELING, MOBILE ROBOTS AND OPTICAL
CHARACTER RECOGNITION

Radu-Emil Precup

Department of Automation and Applied Informatics, Politehnica University of Timisoara
Bd. V. Parvan 2, RO-300223 Timisoara, Romania
E-mail: radu.precup@upt.ro

Abstract

The plenary talk deals with the presentation of several applications of nature-inspired
optimization algorithms (NIOAs) obtained by the Process Control group of the
Department of Automation and Applied Informatics with the Politehnica University of
Timisoara, Romania. The algorithms include Simulated Annealing (SA), Particle Swarm
Optimization (PSO), Gravitational Search Algorithms (GSAs), Charged System Search
(CSS), hybrid and adaptive versions. Aspects concerning the design and tuning of
Mamdani and Takagi-Sugeno fuzzy controllers with dynamics focused on proportional-
integral fuzzy controllers (PI FCs) and the general formulation of Takagi-Sugeno fuzzy
models are first discussed. The optimal tuning of fuzzy controllers is carried out by the
definition of optimization problems with the tuning parameters of the fuzzy controllers
defined as vector variables, and with objective functions expressed as the weighted sums
of functions that depend on the (absolute or squared) control error and of the output
sensitivity functions of the state sensitivity models with respect to process parametric
variations. The NIOAs minimize the objective functions to achieve optimal fuzzy control
systems with reduced parametric sensitivity, and optimal PI-FCs for nonlinear servo
systems are offered. The NIOAs are next applied to the optimal tuning of the parameters
of Takagi-Sugeno fuzzy models for Anti-lock Braking Systems and for magnetic
levitation systems. Initial Takagi-Sugeno fuzzy models of the process are derived on the
basis of the modal equivalence principle by placing a set of linearized process models at
several operating points in the rule consequents. The vector variables in the optimization
problems are a part of the parameters of the input membership functions. The NIOAs are
inserted in optimal path planning algorithms for mobile robots. The multi-objective
optimization is considered as the NIOAs use two to four objective functions to generate
optimal trajectories for mobile robots in static environments while avoiding collisions
with the obstacles and danger zones that might exist in the environment. The NIOAs
solve the optimization problems by minimizing the objective functions, producing
optimal collision-free trajectories in terms of minimizing the length of the paths and also
assuring that the generated trajectories are at a safe distance from the danger zones. Some
details on the implementation of training algorithms for convolutional neural networks in
optical character recognition (OCR) applications are discussed. The training algorithms involve NIOAs in combination with the popular back-propagation in order to achieve performance improvements by avoiding local minima. A comparison between our training algorithms is carried out and illustrated in terms of the analysis of convergence, computational cost and accuracy for a benchmark problem specific to OCR applications.

References (selected)


