Nature-inspired Optimization Algorithms Applied to Fuzzy Control, Fuzzy Modeling, Mobile Robots and Optical Character Recognition

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PLENARY TALK

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. 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.