Metaheuristic Algorithms and Their Application to Fuzzy Control, Fuzzy Modeling, Mobile Robot Navigation, and Finger Dynamics for Prosthetic Hand Myoelectric-Based Control

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***Abstract*—An optimization problem finds the best, or optimal, solution among all feasible solutions. An optimization problem consists of two key components: the objective function and the constraints, which are optional. The objective function evaluates and compares solutions in the context of all feasible solutions by calculating the desired quantity to be minimized or maximized. Constraints can be added to limit the possible values for the variables of the objective function and possibly to link these variables.**

The optimization algorithms find the solutions to the optimization problems (i.e., the optimal solutions) by trying variations of the initial solution and using the information gained to improve the solution. This solution finding can also be considered as learning, which is a popular topic nowadays. The complexity of classical algorithms is very high, which requires rather large amount of computation. Therefore, alternative algorithms with lower complexity are appreciated. Metaheuristic algorithms for finding optimal solutions have become very popular because they are much better in terms of efficiency and complexity than classical algorithms.

This presentation highlights some of the results obtained by the Process Control Group of the Politehnica University of Timisoara, Romania. The presentation will focus on representative applications implemented in the laboratories of the group, with real-time validation against experimental results, focusing on fuzzy control, fuzzy modeling, mobile robot navigation, and modeling and control of finger dynamics for prosthetic hand myoelectric-based control. Besides prosthetic hand myoelectric-based control, the results highlighted in the presentation include various laboratory equipment such as pendulum crane systems, multi-tank systems, servo systems, twin rotor aerodynamic systems, magnetic levitation systems, anti-lock braking systems, mobile robots, magnetic levitation systems, active mass damper systems, and shape memory alloy systems.

The development of myoelectric-based control systems for prosthetic hands includes several approaches: on-off control, proportional control, direct control, finite state machine control, pattern recognition-based control, posture control, and regression control. All of these approaches are considered in the framework of model-based control design, which requires accurate models of the human hand. The group considers the hand in such systems as a multi-input-multi-output nonlinear dynamical system, with inputs represented by myoelectric signals and outputs represented by finger angles at different joints.

The group obtained fuzzy models that were tested on a dataset covering approximately 450 s, and the results are encouraging. The system and model responses and performance indices indicate that the performance of the models has improved as the output has been sampled in the past and included as additional fuzzy model inputs.

The scope of development of these metaheuristic algorithms is to solve optimization problems involving tuning of low-cost fuzzy controllers, tuning of fuzzy models, in various schemes including adaptive ones, and solving optimization problems specific to mobile robot navigation.

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Keywords—fuzzy controllers, fuzzy models, lab equipment, metaheuristic algorithms, myoelectric-based control, mobile robots.