PD-Fuzzy Controller Tuned with PSO for Robot Trajectory Control

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Abstract: In this paper, a 2 DOF planar robot was controlled by Mamdani type-PD-Fuzzy Logic Controller (FLC) tuned with particle swarm algorithm (PSO). In a tuning process of PD-FLC, several trajectories were applied to the robot system. The parameters of fuzzy controller were updated based on squared mean error cost function. The PD-FLC tuned by PSO was tested with a different trajectory. The error of the joints occurred between 0.1331 and -1.8455e-4 for this trajectory. The simulation results obtained from this study show that the PD-FLC can achieve a good performance for any given trajectory.

Keywords: Fuzzy Controller, PSO, Robot trajectory control.

1. INTRODUCTION

Fuzzy Logic Control (FLC) is popular technique that has seen increasing interest in the past decades since it has a linguistic based structure and its performance are quite robust for non-linear systems. Many publications have been found in the area of design and stability of fuzzy control systems (Birdwell et al., 1994; Malki et al., 1994; Ham et al., 1996). However, one of the critical issues in fuzzy control design is how to ensure global and robust stability of the system under control.

The use of fuzzy logic to transform linguistic knowledge into actual control laws leads to the field of fuzzy control. The main idea of fuzzy control is to represent the knowledge about the use of the local controllers for control laws using logical rules. An FLC is composed by a *Knowledge Base,* that comprises the information given by the process operator in the form of linguistic control rules, *a Fuzzification Interface,* which has the effect of transforming crisp data into fuzzy sets, an *Inference System,* that uses them joined to the Knowledge Base to make inference by means of a reasoning method, and a *Defuzzification Interface,* that translates the fuzzy control action into a real control action using a defuzzification method. The generic structure of an FLC is shown in Fig. 2. Especially, fuzzy logic control has a better control effect in the cases of non-linear and time-varying of a system compared with classical control or modern control (Lee et al., 1993).

Most FLCs are designed based on the experience or knowledge of experts. However, it is often the case that no expert is available. In this case, fuzzy logic control rules and membership functions are usually found by using the trial-and-error method (Silva et al., 1995). An optimal design of control rules and membership functions is usually desired. Therefore, linguistic control rules and limits and type of membership functions have to be tuned for the given system.

Evolutionary algorithms regarding tuning the membership function parameters of FLC have been studied extensively in the literature. Many random search methods, such as genetic algorithm (Krohling et al., 2001), evolutionary computational techniques (Ghoshal, 2004; Gaing, 2004; Fogel, 2000) and simulated annealing (Kwok et al. 1994), have recently received much interest for achieving high efficiency and searching global optimal solution in problem space.

PSO is an optimization technique which provides random searching in the related domain. This search algorithm was introduced by Kennedy and Eberhart et al., (1995). PSO is mainly inspired by social behavior patterns of organisms that live and interact within large groups. In particular, PSO incorporates swarming behaviors observed in flocks of birds, schools of fish, or swarms of bees. The term PSO refers to a relatively new family of algorithms that may be used to find optimal or near to optimal solutions to numerical and qualitative problems. It is implemented easily in most of the programming languages since the core of the program can be written in a single line of code and has proven both very effective and quick when applied to a diverse set of optimization problems. PSO algorithms are especially useful for parameter optimization in continuous, multi-dimensional search spaces.

Wong et al. (2008) proposed a motion control structure with a distance fuzzy controller and an angle fuzzy controller for the two-wheeled mobile robot. They used PSO algorithm to automatically determine appropriate membership functions of these two fuzzy systems. Pulasinghe et al. (2005) developed fuzzy–neural networks (FNNs) for navigation of a mobile robot and for motion control of a redundant manipulator. They employed PSO to train the FNNs that can accurately output the crisp control signals for the robot systems. Mukherjee et al.(2007) studied regarding the determination of optimal PID gains for automatic voltage regulator (AVR). In this work, Craziness based particle swarm optimization (CRPSO) and binary coded genetic algorithm (GA) was used

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