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Hybrid Genetic: Particle Swarm Optimization Algorithm

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Summary. This chapter proposes a hybrid approach by combining a Euclidian distance (EU) based genetic algorithm (GA) and particle swarm optimization (PSO) method. The performance of the hybrid algorithm is illustrated using four test functions. Proportional integral derivative (PID) controllers have been widely used in industrial systems such as chemical process, biomedical process, and in the main steam temperature control system of the thermal power plant. Very often, it is difficult to achieve an optimal PID gain without prior expert knowledge, since the gain of the PID controller has to be manually tuned by a trial and error approach. Using the hybrid EU–GA–PSO approach, global and local solutions could be simultaneously found for optimal tuning of the controller parameters.

7.1 Introduction

During the last decade, genetic algorithm-based approaches have received increased attention from the engineers dealing with problems, which could not be solved using conventional problem solving techniques. A typical task of a GA in this context is to find the best values of a predefined set of free parameters associated with either a process model or a control vector. A possible solution to a specific problem can be encoded as an individual (or a chromosome), which consists of group of genes. Each individual represents a point in the search space and a possible solution to the problem can be formulated. A population consists of a finite number of individuals and each individual is decided by an evaluating mechanism to obtain its fitness value. Using this fitness value and genetic operators, a new population is generated iteratively which is referred to as a generation. The GA uses the basic reproduction operators such as crossover and mutation to produce the genetic composition of a population. Many efforts for the enhancement of conventional genetic algorithms have been proposed. Among them, one category focuses on modifying the structure of the population or on the individual's role while another category is focused on modification/efficient control of the basic operations, such as crossover or mutation, of conventional genetic algorithms [9].

The proportional integral derivative (PID) controller has been widely used owing to its simplicity and robustness in chemical process, power plant, and electrical

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systems [1]. Its popularity is also due to its easy implementation in hardware and software. However, using only the P, I, D parameters, it is often very difficult to control a plant with complex dynamics, such as large dead time, inverse response, and for power plants having a high nonlinear characteristics [5]. Recently, there has been a growing interest in the usage of intelligent approaches such as fuzzy inference systems, neural network, evolutionary algorithms, and their hybrid approaches for the tuning of a PID controller [1–4, 6, 7].

This chapter introduces a hybrid approach consisting of genetic algorithm and particle swarm optimization (PSO) algorithm. To obtain an advanced learning structure, there are two processing steps in the proposed method. In the first step, Euclidean distance is used to select the global data for crossover and mutation operators to avoid local minima, and to obtain fast convergence. In the second step, in order to enhance the learning efficiency of GA, PSO strategy is applied. The proposed approach focuses on the advantage of PSO into the mutation process of GA, for improving the GA learning efficiency. A PSO like search proceeds through the problem space, with the moving velocity of each particle represented by a velocity vector. Therefore, global and local optimal solution can be simultaneously achieved and the most appropriate parameter of the PID controller can be selected for the given plant and system [11].

We first illustrate the performance of the proposed hybrid approach using four test functions. Further the performance of hybrid EU–GA–PSO approach is validated by tuning a PID controller of a automatic voltage regulator (AVR). The chapter is organized as follows: In Sect. 7.2, we introduce the hybrid approach using Euclidean distance-based genetic algorithm and PSO algorithm with some simple illustrations. Detailed experiment results for function optimization are illustrated in Sect. 7.3 followed by PID controller tuning in Sect. 7.4. Some Conclusions are also provided in the end.

7.2 Hybrid Approach Using Euclidean Distance Genetic Algorithm and Particle Swarm Optimization Algorithm

7.2.1 Particle Swarm Optimization Algorithm

The PSO algorithm conducts search using a population of particles which correspond to individuals in a genetic algorithm [8, 10]. A population of particles is initially randomly generated. Each particle represents a potential solution and has a position represented by a position vector. A swarm of particles moves through the problem space, with the moving velocity of each particle represented by a velocity vector. At each time step, a function representing a quality measure is calculated by using as input. Each particle keeps track of its own best position, which is associated with the best fitness it has achieved so far in a vector. Furthermore, the best position among all the particles obtained so far in the population is kept track as output. In addition to this global version, another local version of PSO keeps track of the best position among all the topological neighbors of a particle. At each time step, by using the individual best position, and global best position, a new velocity for particle