Research on the Electrical Control System Building Mode based on Particle Swarm Optimization

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Abstract. In this paper, we conduct research on the electrical control system building mode based on the particle swarm optimization. Electrical control technology is mainly with the continuous development of the science and the technology, production technology is gradually appear new requirements, mainly from manual control to automatic control, from simple to the complex control and control devices, and as the storage system to the computer control system from the hard connection control of contact center. Due to simplify each particle in the particle swarm algorithm using the same evolutionary iteration formula makes the difference between in the late evolutionary particle is not strong, the algorithm is prone to premature and slow search speed. In the research, we optimize the traditional PSO to achieve the optimal solution.

Keywords: Particle Swarm Optimization, System Building, Electrical Control, Systematic Enhancement.

1 Introduction

The application of electrical control technology, mainly through the use of the electric power development as electrical technology began the energy use of the information dissemination and development of the two directions. Modern electrical control technology is mainly control the characteristics of large current weakness, combined with the strength and weakness. Electrical control technology is mainly with the continuous development of the science and technology, production technology is gradually appear new requirements, mainly from manual control to automatic control, from simple to complex control and control devices, and as the storage system to computer control system from the hard connection control of contact center.

The PC programming languages is similar to the ladder diagram and relay control circuit, ladder diagram of element names and symbols from the relay control circuit, only individual differences. From input/output signal and the control function, is the same. But the PC control and the relay control have many differences and there are mainly the following components that should be considered [1][2][3].

- Contact number is different. Relay control system of relay contact number is limited, and the "soft" relay ladder diagram for the contact with the infinite programming use.
- Work in a different way. In the control circuit of relay, the relay action at the same time when condition is met, namely according to the "parallel" way to work, and in the PC control system, controlled by the same conditions of the
"soft relay", depends on the application of the scanning sequence, namely according to the "serial" way to work, and to avoid the contact of the relay control in the competition and mismatch problem.

- The implementation of the different control methods. The realization of the function of the relay control system that is done through the hardware connection, single function, therefore, is not flexible, and PC control through software programming implementation, so flexibly and conveniently.

PSO algorithm parameters less, concept is simple and easy to implement can be used to solve the nonlinear and non-differentiable and more complex optimization problem such as peak, in the field of science and engineering in recent years, such as function optimization, neural network training, pattern classification and fuzzy system control, and other fields for a wide range of applications. At present, have put forward many algorithm for constrained optimization problems, and these algorithms can be divided into precise algorithm and modern heuristic algorithm. Precise algorithm often requires objective function or constraint function with good properties, such as continuous and differentiable objective function or feasible region F convex sets, etc. On the contrary, modern heuristic algorithms, including evolutionary algorithms, in solving constrained optimization problems, do not need to use the differentiability of the objective function and constraint optimization continuity conditions, etc. In recent years, evolutionary algorithm with it is as replacement algorithm for unconstrained optimization is of great potential that has caused great attention of the researchers. In this paper, we propose a novel electrical control system building mode based on the particle swarm optimization. In the later sections, we will discuss in detail.

2 The Particle Swarm Optimization Algorithm

PSO to simulate the flock foraging behavior in the process of migration and cluster, the use of swarm intelligence search out a good solution and the algorithm has fast convergence speed, less set parameters, and the advantages of algorithm easy to implement, so as wide attention by the academia, and widely applied to the function optimization and pattern classification, fuzzy control, neural network training, and the other engineering fields. Due to simplify each particle in the particle swarm algorithm using the same evolutionary iteration formula makes the difference between in the late evolutionary particle is not strong, the algorithm is prone to premature and slow search speed. Aiming at this problem, on the basis of the simplified particle swarm optimization algorithm, joined the grouping of hybrid leapfrog algorithm thought, this paper proposes a leapfrog simplified particle swarm algorithm [4][5].

Particle swarm algorithm divided into more groups to search at the same time, each group of general particle grouping run again after several generations. Particles iteratively in a simplified particle swarm optimal particles added to the team on the use of information, so that each group with different evolutionary iteration formula, ensure that the differences between the particles defined as the follows.

\[ v_i = (v_{i1}, v_{i2}, \ldots, v_{in}) \]

(1)

PSO, each solution of optimization problem is a bird in the search space, as this article is called particles. All particles have a fitness is determined by the function of
optimization, each particle has a speed decided they fly out direction and distance, and the optimal particle are to follow the current search in the solution space. Kennedy and Eberhart first proposed iterative formula is as follows.

\[ v(t+1) = v(t) + c_1 r_1 (p_{best} - x(t)) + c_2 r_2 (g_{best} - x(t)) \]

\[ x(t+1) = x(t) + v(t+1) \]  

(2)

DPSO inside whether early or late, each particle swarm is divided into three parts, near optimal particle part of its weight is very small, the main responsible for the exploitation on the near global optimal point; And far away from the particle part of its weight is always a maximum, the main responsible for exploration in the global scope; And particles in the middle of its weight is change as algebra and the distance change, linear smaller and the optimization can be expressed as formula 3.

\[ f_i(X) = \begin{cases} \max(0, g_i(X)) & 1 \leq i \leq q, \\ h_i(X) & q + 1 \leq i \leq m \end{cases} \]

\[ q(X, t) = \text{Worst-fit}(t) - \frac{\min(f(X) + r \sum_{i=1}^{m} f_i(X))}{\max(f(X))} \]

(3)

Because DPSO improve convergence problems, mainly in to explore ability does not affect the situation as far as possible, in the hope of improving the convergence performance and better performance is in particle to find the advantage for the first time, will not fly out of the neighborhood, and produce jitter, oscillation phenomena. From an average convergence algebra in the improvement of performance and can be found that the DPSO than PSO performance is improved. Therefore, we set the basis function as the follows for the further enhancement and optimization.

<table>
<thead>
<tr>
<th>Name and code</th>
<th>Formula</th>
<th>Dim x</th>
<th>Range [l_{min}, l_{max}]</th>
<th>Optimal f</th>
<th>Goal for f</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphere β</td>
<td>( f_i(X) = \sum_{i=1}^{N} x_i^2 )</td>
<td>30</td>
<td>([-100,100]) (10^0)</td>
<td>0</td>
<td>10^-4</td>
</tr>
<tr>
<td>Griewank β</td>
<td>( f_i(X) = \sum_{i=1}^{N} \frac{x_i^2}{4000} - 1 + \prod_{i=1}^{N} \cos\left(\frac{\sqrt{2} x_i}{\sqrt{N}}\right) )</td>
<td>30</td>
<td>([-600,600]) (10^0)</td>
<td>0</td>
<td>10^-4</td>
</tr>
<tr>
<td>Rastring β</td>
<td>( f_i(X) = \sum_{i=1}^{N} \left( x_i^2 - 10\cos(2\pi x_i) + 10 \right) )</td>
<td>30</td>
<td>([-100,100]) (10^0)</td>
<td>0</td>
<td>10^-4</td>
</tr>
<tr>
<td>Ackley β</td>
<td>( f_i(X) = -20 \exp\left(\frac{-1}{5} \sqrt{\frac{1}{N} \sum_{i=1}^{N} x_i^2}\right) - \exp\left(\frac{1}{5} \sum_{i=1}^{N} \cos\left(2\pi x_i\right)\right) + 20 + e )</td>
<td>30</td>
<td>([-100,100]) (10^0)</td>
<td>0</td>
<td>10^-5</td>
</tr>
</tbody>
</table>

Fig. 1. The Basis Function for Testing

In order to avoid the algorithm into local optimum and improve the convergence of the algorithm, need in algorithm implementation process, to keep the particle swarm the higher species diversity. In the figure 2, we show the principles.
3 Electrical Control System

Intelligent level of modern engineering machinery is higher and higher, with the unprecedented development of the general electronic technology and that computer control technology, electrical components used in engineering machinery is more and more widely, the performance of the electrical components quality and electrical system layout is reasonable affect the performance of the whole machine is becoming more and more obvious, not only affect the maneuverability and stability, and even play a key role on the safety of the whole machine [6].

Fig. 2. The Demonstration of the Particle Swarm Optimization
The basic characteristics of machine tool electrical system can be organized as the follows. (1) Electrical system should be based on reliability, but also to be advanced, such as the use of new combination function of electrical components, the use of the new power electronic and power electronic devices, etc. (2) To a series of technical measures in the electrical system that make it adapt to the wider environmental conditions, such as the need to be able to adapt to the ac power supply voltage fluctuations, within the grid system on noise interference has certain inhibitory effect, but also conforms to the national standard of electromagnetic compatibility requirements, internal system does not interfere with each other, also can resist the external interference, also not to the external radiation destructive interference. (3) In the design of electrical systems and components for general use in the selection of reliability, fault tolerance and redundancy technology. All components selected as the most mature and conform to the relevant international standards and to obtain the authorization certification of new products.

4 Summary

In this paper, we conduct research on the electrical control system building mode based on the particle swarm optimization. Today, in the rapid development of the electromechanical integration gradually, grasp the electrical control circuit design, is to do a good job of the basis of mechanical and electrical work. And the key problem of the design work is the correctness of the design ideas and principles, on the basis of this to ensure that the designed product is the scientific and reasonable and effective. We integrate the PSO to enhance the traditional methodology that will be beneficial for enhancing the robustness of the system.

References