Particle Swarm Optimization Algorithm in Improved Electrical Control System

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Abstract. In today's social background where high-tech emerges endlessly, various production fields in our country have fully entered the era of mechanical automation and electrical automation, and electrical control systems have been widely used in our country's electrical appliance manufacturing industry. This paper is based on the theoretical analysis of the particle swarm optimization algorithm. Based on this optimization algorithm, a brand-new particle swarm optimization algorithm is obtained. It is applied to the electrical control system to improve it and makes full use of the improved particle swarm optimization algorithm. The existing electrical control system is optimized. This article firstly analyzes the types of common electrical control systems, puts forward some basic methods to improve the control system, and then explains the effective techniques for improvement, hoping to make reference to the improvement of electrical control systems later in this article. This article first improves the particle swarm optimization algorithm, adding the ability to adjust the control system and dynamic learning factors, focusing on strengthening the later stage of the optimization of the particle swarm algorithm and the ability to converge to improve the efficiency of the calculation. The second is to improve the traditional particle swarm optimization algorithm and update the calculation method of the formula to reduce the possibility of selecting undesirable particles and affecting the optimization results. Finally, through MATLAB and reverse simulation analysis, compared with the traditional electrical control system algorithm, the improved particle swarm optimization algorithm has a faster convergence speed and high control system efficiency. The experimental research results show that the particle swarm optimization algorithm proposed in this paper has a huge advantage compared with other algorithms, and its parameter optimization gives full play to the powerful performance of the electrical control system.

Keywords: Particle Swarm Optimization Algorithm, Electrical Control System, Improved PSO Algorithm, Control Optimization Analysis
1. Introduction

Through innovation and scientific research, electrical automation engineering control systems enable electrical automation products to continuously enter domestic and foreign markets. Further expand the coverage and application areas of electrical automation engineering control systems [1-2]. The development trend of domestic and foreign markets is guided by innovation, focusing on quality improvement, making products meet the requirements of the green economy and low-carbon economy era, and attaching importance to the training and training of professional talents [3]. With the popularity of electrical automation control systems in various fields in China, high-tech has become the key to further improving the automation level and reliability of the system.

To this end, technical personnel in related fields in my country have gradually combined intelligent technology with electrical automation technology through theoretical research and a large amount of practice, which has important value for improving corporate efficiency and social productivity [4]. It can be said that the particle swarm optimization algorithm studied at this stage is one of the foundations of more advanced automation technology in computer algorithms, and has good application value in electrical automation control systems [5]. Nowadays, as a very mature technology, electrical automation has the characteristics of low construction cost, high production efficiency and high standardization level. This technology is mainly based on the computer system to achieve control, and can complete different production tasks according to actual needs [6].

Through the combination of intelligent technology and particle swarm optimization algorithm, the remote control of the electrical automation control system can be realized. After continuous optimization and improvement of PLC technology, the performance of the electrical engineering has been very mature, and it has strong anti-interference ability and The excellent system function effectively guarantees the efficiency and quality of electrical engineering operation, and serves the enterprise production well [7-8]. PLC technology is a digital control system that realizes instruction functions by operating the application program in the programming memory [9]. In recent years, the electrical engineering industry has developed rapidly, and PLC technology has achieved rapid development. Its control functions have changed in terms of form and price. The program is operated in an orderly manner in accordance with electrical engineering instructions, so that independent control programming has a certain order Therefore, it optimizes the overall adjustment and control of the system and realizes the effective application of the technology at the level of sequential control [10].

2. The establishment and optimization of particle swarm algorithm

2.1. The establishment of particle swarm algorithm

First set in a D-dimensional vector space. Since the i-th particle shown in a search set composed of N different particles is represented as a D-dimensional vector, as shown in formula (1):

$$X_i = (x_{i1}, x_{i2}, ..., x_{iD}), i = 1, 2, ..., N$$

Then the flying speed of the i-th particle is also a D-dimensional vector which is the same as formula (1), which is recorded as formula (2):
\[ V_i = (v_{i1}, v_{i2}, ..., v_{iD}) \text{, } i = 1, 2, ..., N \] (2)

The optimal position of the \( i \)-th particle searched from the beginning to the current position becomes the individual extreme number, which is recorded as the formula (3):

\[ P_{\text{best}} = (p_{i1}, p_{i2}, ..., p_{iD}) \text{, } i = 1, 2, ..., N \] (3)

\[ g_{\text{best}} = (g_{1}, g_{2}, ..., g_{D}) \text{, } i = 1, 2, ..., N \] (4)

When the searched number is the ideal extreme value, the speed and position information of the particles are updated according to formula (5) and formula (6).

\[ v_{ij}(t + 1) = v_{ij}(t) + c_{1}r_{1}[p_{ij}(t) - x_{ij}(t)] + c_{2}r_{2}[p_{g\text{best}}(t) - x_{ij}(t)] \] (5)

\[ x_{ij}(t + 1) = x_{ij}(t) + v_{ij}(t + 1) \] (6)

In the above formula, \( c_{1} \) and \( c_{2} \) are two different learning factors in the particle swarm optimization algorithm, \( r_{1} \) and \( r_{2} \) are two randomly generated numbers between 0 and 1. The postgraduate entrance examination increases the particle search The process randomness at the optimal time. \( v_{ij}(t) \) represents the velocity of a particle in a group, and the user can set the maximum value of the particle velocity according to their actual problems.

2.2. Improved particle swarm optimization algorithm

Then the velocity and position change formula of the \( d \)-dimensional component of the \( i \)-th particle in the target search space is as follows:

\[ v_{id}(t + 1) = wv_{id}(t) + c_{1}r_{1}(p_{id}(t) - x_{id}(t)) + c_{2}r_{2}(p_{g\text{best}}(t) - x_{id}(t)) \] (7)

\[ x_{id}(t + 1) = v_{id}(t + 1) + x_{id}(t) \] (8)

\[ w = w_{s} - (w_{s} - w_{e}) \cdot \frac{g}{g_{\text{max}}} \] (9)

The update formula of particle velocity is as follows:

\[ v_{id}(t + 1) = wv_{id}(t) + c_{1}r_{1}(p_{id}(t) - x_{id}(t)) + c_{2}r_{2}(p_{g\text{best}}(t) - x_{id}(t)) + c_{3}r_{3}(s_{id}(t) - x_{id}(t)) \] (10)

2.3. Optimization of particle algorithm speed and position update

Define similarity.

The rules for determining the similarity between particles and other particles in the population are as follows:

\[ S_{1} = F_{i} \cap F_{j} \]

\[ S_{2} = F_{i} - F_{j} \] (11)

At the same time, to measure the characteristics of other particle species in the algorithm population and the characteristics and degree of particle \( i \) against the defined index, calculate according to formula (12):
The wolf changed, formula solution improved algorithm.

Based on the above-mentioned similarity rule, the known number of the similarity of particle i is calculated according to formula (13):

$$\text{SIM}_i = \frac{|\text{Sim}|}{N}$$

Finally, perform interactive operations on the particles, but before the interactive operations, the user must first calculate the interaction probability of particle i according to formula (14) as shown in (15):

$$\text{Interrate}_i = (1 - \text{SIM}_i) \times e^{-\text{SIM}_i}$$

3. Application of improved wolf pack algorithm model in particle swarm optimization algorithm

Improve the wandering behavior: it is the behavior of artificial wolves searching for prey in the solution space, and its ultimate goal is to find areas with higher prey odor in the hunting ground space.

Improve the summoning behavior: When the wolf i runs towards the wolf according to formula (1), the position in the M-dimensional space is:

$$x^{k+1}_{id} = x^k_{id} + \text{step}_b \times (g^k_{id} + x^k_{id}) / |g^k_{id} - x^k_{id}|$$

The step length quickly rushed to the position of the wolf. After improving the formula (1), the formula (2) is as follows:

$$x^{k+1}_{id} = x^k_{id} + \text{step}^{k+1}_{bid}$$

$$\text{step}^{k+1}_{bid} = w \times \text{step}^{k+1}_{bid} \times (b^k_{id} + x^k_{id}) / |b^k_{id} - x^k_{id}|$$

According to formula (2). According to the odor concentration, the value of w is adaptively changed, and the calculation formula of W is as follows:

$$w = w_{max}, F \leq F_{avg}$$

$$w = w_{min}, \frac{(w_{max} - w_{min}) \times (F - F_{min})}{(F_{avg} - F_{min})}, F \leq F_{avg}$$

The wolf will approach the head wolf from all positions, and attack until the distance between the wolf and the head wolf is $d \leq d_{near}$. When $d \leq d_{near}$, the algorithm will enter the siege behavior.

$$d_{near} = \frac{1}{D + \sum_{d=1}^{D} |\text{mix}_d - \text{mix}_d|}$$

Among them: $d_{near}$ is the distance between the wolf and the wolf when the siege is initiated, $\omega$ is the distance judgment factor, the size of $\omega$ directly determines whether to enter the siege behavior, the
greater the \( \omega \), the faster the convergence speed, but if it is too large, the summoning behavior will fall into change. It can be considered that the wolf with the largest concentration of prey odor is the direction of the prey. The artificial wolf needs to move forward with a small step length, and carefully search for the odor concentration of the nearby prey, that is, the value of the fitness function, which is the formula used to express the siege behavior of the wolf pack As follows:

\[
x_{k+1} = x_k + \xi_k \lambda \ast \text{step}_c \ast |G_{k} - x_{k}|
\] (19)

\( \lambda \) is a uniformly distributed random number between \([-1, 1] \); \( \xi_k \) is the adjusted value of the siege, and the setting method is as follows:

\[
\begin{cases}
  \xi_0 = M \\
  \xi_k = c \ast \xi_{k-1}
\end{cases}
\] (20)

To this end: \( c \in [0.9, 0.999], M = 1 \)

**Table 1.** Initialized particle set scheme

| Program | New construction/expansion | Number of new circuits |
|---------|---------------------------|------------------------|
|         |                           | F1 | F2 | F3 | F4 | F5 |
| T1      | 1                         | 2  | 2  | 2  | 1  | 2  |
| T2      | 1                         | 0  | 1  | 2  | 1  | 0  |
| T3      | 2                         | 0  | 2  | 0  | 2  | 0  |
| T4      | 2                         | 0  | 0  | 0  | 1  | 1  |
| T5      | 1                         | 1  | 1  | 1  | 2  | 1  |

4. Evaluation results and research

4.1. Algorithm evaluation and analysis

**Table 2.** Analysis of the improved and newly optimized particle swarm plan

| Program | New construction/expansion | Number of new circuits | Electrical system coefficient |
|---------|---------------------------|------------------------|------------------------------|
|         |                           | F1 | F2 | F3 | F4 | F5 |                  |
| T1      | 1                         | 2  | 2  | 2  | 1  | 2  | 0.357            |
|         |                           |    |    |    |    |    | 0.563            |
As shown in the plan analysis table of the new optimized particle swarm optimization after the data analysis in Table 2, in the upper multi-objective model, after calculating and comparing the safety, adaptability and coordination of the particle swarm optimization plan, the plan T1, T2 and T5 are put into the elite set and updated according to the position and velocity of each particle. Particle update formula. A new particle scheme was obtained, as shown in Table 2.

| T2 | 1  | 0  | 1  | 2  | 1  | 0  | 0.363 |
|----|----|----|----|----|----|----|--------|
| T5 | 1  | 1  | 1  | 1  | 2  | 1  | 0.599  |

As shown in Figure 1, when the final running time is fixed, the energy consumption of the engine optimized by the standard particle swarm optimization algorithm is stable at about 150, while the optimization result of the improved particle swarm optimization algorithm is stable at about 100. It is about 8.93% higher than the standard particle swarm optimization algorithm, effectively reducing
energy consumption. In terms of fitness and convergence, the standard particle swarm optimization algorithm converges at about 150, while the improved particle swarm optimization algorithm converges at about 125 to reach the optimal solution. The fitness is also higher than the standard particle swarm optimization algorithm. Improve operation efficiency and accuracy.

4.2. Application of PLC technology in electrical control systems

PLC technology controls the data points in the system through the network, so that some complicated or difficult programs can be realized. Aiming at sequential or combinatorial logic problems, PLC technology can flexibly control the software programs on the system, so as to realize the control of multiple switches, reduce system control costs and improve the ensemble. As mentioned above, in electrical engineering and its automation system In the application of PLC technology, it is necessary to clarify the work flow of electrical engineering-related enterprises, rationally apply science and technology, strengthen the stability and reliability of the application of technology in the system, and clarify the direction of technological development so that the electrical engineering industry can develop steadily.

5. Conclusion

In summary, electrical automation control systems have been applied to electrical equipment, automobile production, medical treatment and other fields, involving all aspects of people's production and life. Its effect and influence are huge. By optimizing the design in terms of the impact of the system architecture, the level of system automation is further improved, and the probability of failure and loss are reduced. The electrical automation control system based on the improved particle swarm optimization algorithm will have more complete control modules, and the operating efficiency, stability and reliability of the entire system will be greatly improved, and will further make important contributions to the development of society.

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