Research on Robust Design and Optimization of Embedded Network Electronic Information System

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Abstract. At present, in the process of designing and optimizing the robustness of embedded network electronic information systems, it is found that many factors in the system have some correlation with robustness, and there are individual differences in the factors affecting robustness, which also have different effects on robustness at the same time. The optimization design of the calculation method for the robustness of the embedded network electronic information system is organically combined with chaos and particle swarm optimization, through experiments and simulations, it proves that the optimized design has high accuracy.

1. Introduction

Among the network operation platforms, the main system is the embedded network electronic information system. To measure whether the system can work normally under abnormal input environment and pressure environment, it is necessary to measure its robustness to achieve robustness. Optimization can effectively improve the safety and accuracy of system operation. Therefore, combining the characteristics of the corresponding system, it is of great significance to propose a robust optimization calculation method [1-2].

2. Embedded Network Electronic Information System

Embedded network electronic information system has a wide range of applications in real life. To design embedded network electronic information system scientifically and reasonably, it is necessary to realize a comprehensive and detailed analysis of the structural characteristics of embedded network electronic information system in combination with the corresponding constraints of its robustness, so as to realize the determination of the relevant robustness of the system. Simultaneously, in the embedded network electronic information system, various factors that affect the robustness are calculated accurately. In the design and calculation, there are parameters that are easily related to the corresponding robustness of the embedded network electronic information system [3-5].

2.1. Obtaining the approximate value of robustness

The type of failure factor of the embedded network electronic information system is set to $G$, the probability of each factor actually affecting the robustness is set to $P_i (i=1, 2, ..., G)$, and the robustness
of the embedded network electronic information system is set to $R$, so the calculation of $R$ can be achieved by the following formula:

$$ R = \prod_{i=1}^{G} (1 - P_i) $$

(1)

2.2. The conversion between the indicator and the robust approximation

The embedded network electronic information system's robustness index is set to $\beta_s$. When every factor that affects the robustness is subject to the normal distribution, $R$ and $\beta_s$ can achieve effective conversion by using the formula (2):

$$ R = \Phi(\beta_s) $$

(2)

In the formula (2), $\Phi(\beta_s)$ represents the corresponding function of the normal distribution of the embedded network electronic information system designed under the corresponding constraints of robustness. After obtaining the above formula, under the constraints of robustness, the embedded network electronic information system can be designed using the distribution function, but at this time there are still problems with poor robustness. One step in the design is to take effective measures to achieve Robust optimization design.

3. Robust optimization design of embedded network electronic information system

3.1. Failure probability calculation of embedded network electronic information system

In the system design, after obtaining the corresponding distribution function, it is necessary to analyze the structure characteristics of the system according to the corresponding system realization, and classify the failure modes of the system, which are mainly divided into two types according to the state, one is single limit state, the other is multi limit state. In different state types, the actual failure probability of the system should be calculated, and after the failure probability is obtained, the relevant functional functions for the robustness optimization of the embedded network electronic information system are obtained. In fact, there are two kinds of failure modes, one is multi limit state, the other is single limit state, and different states are determined according to the differences of variables. If various failure factors are in series in the failure mode of the system, and the internal variables of each failure factor have certain commonality, then the failure mode belongs to a single limit state; if one of the failure factors includes variable factors, then it is the failure mode in multiple limit states.

The calculation of the failure probability of the system is actually the intersection of the corresponding safety events of the system structure or the probability correlation calculation of the failure events. The actual calculation steps can be carried out according to the following methods:

1) Calculate the corresponding failure probability for the system in its single limit state. When the random vector contains some uncertain parameters, set its vector to $X=[X_1, X_2, ..., X_n]^T$. To achieve the calculation of the failure probability under a single limit state, you can use the following formula to perform specific calculations:

$$ R = P(G(X) \geq 0) = \int_0^{\infty} f(G)dG + p[g_1(X_1)] \geq 0 \cap g_n(X_n) $$

(3)

In the formula: $g_1(X_1)$ represents the failure function in the corresponding mode. $dG$ represents the probability of failure caused by unexpected events in the system, $f(G)$ represents the probability of failure caused by the quality of system components, $g_n(X_n)$ represents the concatenation of system failure factors, $p$ represents the system information assurance capacity coefficient, and $G(X)$ represents the proportion of system failure factors.

2) Calculation of multi-limit state failure probability of embedded network electronic information system.

Set $g(x)$ as the failure function in the corresponding failure mode, $g=[11, 12, 21, 22, ..., mn, ...1n]$, and use the following formula to calculate the failure probability of multiple limit states:
$R_i = R \times (G(X) \geq 0) \cup f_d (G) dG = P\left[\begin{array}{l}
g_{11}(X_{11}) \geq 0 \
g_{12}(X_{12}) \geq 0 \
g_{1n}(X_{1n}) \geq 0
g_{21}(X_{21}) \geq 0 \
g_{22}(X_{22}) \geq 0 \
g_{2n}(X_{2n}) \geq 0
g_{31}(X_{31}) \geq 0 \
g_{32}(X_{32}) \geq 0 \
g_{3n}(X_{3n}) \geq 0
\end{array}\right]$ (4)

3) Calculation of the robust optimization objective function of the embedded network electronic information system. Based on the acquired failure probability, the robust function of the embedded network electronic information system is given. Suppose $x_1, x_2, x_n$ represent $n$ independent embedded network electronic information system failure variables. If they originate from the same parent, have the same distribution, and have the same mean and variance, then $\mu$ and $\sigma^2$ respectively represent their mean value and variance value. The probability of a random failure event represented by $A$ is $P(A)$. When the experiment is performed $n$ times, $m$ represents the frequency of failure event $A$, and $W(A)=m/n$ represents the frequency of failure event. The robust optimization objective function of the embedded network electronic information system can be calculated using the following formula:

$$\lim_{n \rightarrow \infty} p = \left\{ \frac{mR_i \times \mu \cdot \sigma^2}{nRW(A) - m/n(x_1, x_2, x_n)} - p(A) \right\} F(\varepsilon \geq 0)$$ (5)

In the formula, $F$ represents the statistical function of the robust optimization area of the system, $\lim p$ represents the robust optimization function function of the embedded network electronic information system, and $\varepsilon \geq 0$ represents the robust optimization range of the system.

3.2. Robust optimization design of embedded network electronic information system

On the basis of determining the robust optimization objective function of the embedded network electronic information system, the algorithm combining chaos optimization and particle swarm optimization is integrated. The obtained robust optimization function is used to search the robust optimization area of the embedded network electronic information system dynamically. The objective function value of the robust optimization of the embedded network electronic information system is calculated. Row global optimization. The specific steps are detailed as follows:

1) The objective function value of robust optimization of embedded network electronic information system is calculated. According to the robust function of the embedded network electronic information system, the robust optimization region of the embedded network electronic information system is searched dynamically, and the objective function value of the robust optimization of the embedded network electronic information system is calculated, which can be expressed by the following formula

$$M^{(K)} = \frac{A_i^{(K)} - A_i^{(K-1)}}{\lim_{n \rightarrow \infty} p \times \mu \cdot \sigma^2 [\beta_S]}$$ (6)

$$\frac{M^{(K)} - M^{(K-1)}}{M^{(K)}} = \beta \cdot \varepsilon \geq 0$$ (7)

In the formula, $M^{(K)}$ represents the objective function value of robust optimization of the embedded network electronic information system, $A_i^{(K)}$ represents the allowable robustness index of the system, and $\beta S^{(K)}$ represents the system’s robust optimization normal distribution function. $\beta e\geq 0$ represents the range of dynamic search for the robust optimization area, $A_i^{(K-1)}$ represents the upper limit of $A_i^{(K)}$, and $M^{(K-1)}$ represents the value range of the objective function value.

2) On the basis of obtaining the objective value of the robust optimization of the embedded network electronic information system, the speed and position of the updated particles are calculated. Then update the speed and position of the particles, the expression is as follows:

$$v_{id}^{(k)} = wv_{id}^{(k-1)} + c_1r_1(p_{id} - s_{id}^{(k-1)}) + \beta \cdot \varepsilon - c_2r_2(p_{gd} - s_{id}^{(k-1)})M^{(K)}$$ (8)
In the formula, $v_{id}^{(k)}$ represents the program parameters of the system robust optimization, $w$ represents the weight, $r_1$ and $r_2$ represent random numbers between $[0, 1]$, $p_{id}$ represents the individual fitness value of each particle, and $p_{gd}$ represents the global pole value.

3) Use the chaos factor to identify the main failure modes of the embedded network electronic information system, perform a robust analysis of the system structure, and calculate whether each particle satisfies its constraint conditions, then the particle $\lambda=0$, otherwise, $\lambda=1$. Get particle value with

$$\lambda = \frac{p_{g}^{(k)} - z_{min}^{(k)} \ast z_{id}^{(k)}}{p_{g}^{(k)} - z_{max}^{(k)} \ast v_{id}^{(k)}}$$

In the formula, $z_{k_{min}}$ and $z_{k_{max}}$ respectively represent the upper and lower bounds of the $k$-th iteration particle search, and $\lambda$ represents the penalty factor.

4) Calculate the optimal position $p_{g}^{(k)}$ of the current particle swarm and perform chaos optimization. Its expression looks like this:

$$p_{g}^{(k)} = z_{k_{min}} + \lambda \ast (z_{k_{max}} - z_{k_{min}})^2$$

$$p_{g}^{(k)} = p_{g}^{(k)} - z_{k_{min}} \ast (z_{k_{id}} + v_{id}^{(k)})$$

5) Update the current optimal position of the particle swarm obtained by the above formula. If the preset calculation accuracy or the number of iterations is used, the search stops and the result is output. Otherwise, the next step is performed.

6) During the robust optimization design of the embedded network electronic information system, the remaining 80% of the group is generated arbitrarily in the searched space, bypassing step 3).

In summary, it can be shown that the robust optimization principle of the embedded network electronic information system effectively completes the robust optimization design of the embedded network electronic information system.

4. Experiment and simulation prove

According to the effective improvement of the chaotic particle swarm algorithm mentioned above, the corresponding robustness and corresponding optimization method of the embedded network electronic information system obtained based on this need to carry out practical experiments based on its theory and pass The test scientifically verifies the validity of the method. In the simulation experiment, MATLAB7.0 is used to effectively build the corresponding robust simulation platform of the embedded network electronic information system. When the optimization model and the corresponding conditions of the parameter values are consistent, the corresponding robustness of the system and its optimization design experiments are achieved by improving the algorithm.

4.1. Experiment 1

Experiments on the optimization design of the robustness of the embedded network electronic information system by using improved algorithms and decision efficiency evaluation methods (A algorithm), information detection and fault diagnosis methods (B algorithm), after several experiments, And after different number of experiments, the robustness under different algorithms is effectively compared, the comparison results are shown in Table 1. Through scientific comparison, it is found that in the optimization design of system robustness, it is better to use the improved algorithm than the other two algorithms. The reason why the improved algorithm is better than the other two algorithms is mainly because it is based on the actual structure of the system first. The characteristics are analyzed in detail, and the system failure mode is effectively divided into two different states: multi-limit state and single limit state. The effective calculation of the system failure probability is implemented for the two different states, and the failure probability is obtained. Based on this, the
function of the system's robustness corresponding to the optimization function is given, which promotes a more secure design of the robustness of the system.

| Experiment times | Improved algorithm | A algorithm | B algorithm |
|------------------|--------------------|-------------|-------------|
| 1                | 96                 | 83          | 78          |
| 2                | 97                 | 86          | 77          |
| 3                | 97                 | 85          | 77          |
| 4                | 95                 | 87          | 78          |
| 5                | 97                 | 86          | 75          |
| 6                | 96                 | 85          | 77          |
| 7                | 96                 | 85          | 75          |
| 8                | 95                 | 86          | 77          |

4.2. Experiment 2

The experiment of robust optimization design of embedded network electronic information system is carried out by using improved algorithm, A algorithm and B algorithm respectively. Under different experiment times, the comparison results of the running time of three algorithms are shown in Table 2.

| Experiment times | Improved algorithm | A algorithm | B algorithm |
|------------------|--------------------|-------------|-------------|
| 1                | 0.25               | 0.55        | 0.69        |
| 2                | 0.27               | 0.54        | 0.68        |
| 3                | 0.29               | 0.54        | 0.69        |
| 4                | 0.25               | 0.56        | 0.68        |
| 5                | 0.25               | 0.54        | 0.69        |
| 6                | 0.29               | 0.54        | 0.69        |
| 7                | 0.27               | 0.54        | 0.67        |
| 8                | 0.27               | 0.55        | 0.68        |

It can be seen from Table 2 that the time efficiency of the improved algorithm is much higher than that of other algorithms, because the improved algorithm combines chaos optimization and particle swarm optimization, uses the acquisition function to dynamically search the robustness optimization area of the embedded network electronic information system, and carries out the embedded network by calculating the robustness optimization objective function of the embedded network electronic information system The global optimal solution of the robust design of the network electronic information system accurately realizes the robust optimal design of the embedded network electronic information system.

The above experiments can prove that the robust optimization method of embedded network electronic information system based on the improved chaos particle swarm optimization algorithm has a good applicable value.

5. Concluding

When the current algorithm is used to optimize the robustness of the system, it is difficult to determine the global optimal solution of the system, and there is a big error in the optimal design. A robust optimization method of embedded network electronic information system based on improved chaos particle swarm optimization algorithm is proposed. The structural characteristics of embedded network electronic information system are analyzed in detail. The failure mode of embedded network electronic information system is divided into single limit state and multiple limit states. The failure probability of embedded network electronic information system under two states is calculated. Based on the obtained failure probability, the robust optimization function of embedded network electronic information system is given. Combining optimization with particle swarm optimization, the obtained
function function is used to search the robust optimization region of embedded network electronic information system dynamically, and the global optimal solution of the robust design of embedded network electronic information system is obtained by calculating the robust optimization objective function of embedded network electronic information system. The simulation results show that the robust optimization method based on the improved chaos particle swarm optimization algorithm has high accuracy and good applicability.

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