Research on Reliability Model Evaluation of Satellite Communication System

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Abstract. Traditional model evaluation methods such as analytic hierarchy process (AHP) cannot provide specific theoretical basis for the later optimization of satellite communication system. To solve this problem, this paper presents an evaluation algorithm based on the reliability modelling process of satellite communication system. The algorithm combines the subjective analysis and objective data in the process of modelling to obtain the fuzzy quantitative evaluation value of the three links of system definition, mathematical model determination and reliability calculation in the process of modelling, and the final evaluation result is calculated by using Bayesian theory. The validity and feasibility of the algorithm are verified by an example, and some references are provided for the further optimization of the model.

1. Introduction

The performance and business requirements of the satellite communication system are gradually improved, making the composition and design of the satellite communication system more and more complicated [1], which brings many uncertain factors to the reliability of the satellite communication system, and also contributes to the reliability of the satellite communication system. The design brought severe tests [2,3]. The key to reliability research is to establish a reliability model. At present, there have been a lot of researches on the reliability model of satellite communication systems [4,5], for example, reliability models based on jump plane nodes, reliability models based on structural differences, and reliability models based on natural connectivity. With the continuous deepening of reliability model research, there are two problems that need to be solved urgently [6]:

1. Optimal choice of reliability model of satellite communication system. That is, how to choose the best model from different reliability models in a specific scenario.
2. Optimization of reliability model of satellite communication system. That is to improve the incomplete model, improve the accuracy and then put it into use.

At present, the evaluation methods used in the field of evaluation systems and transportation systems such as analytic hierarchy process and fuzzy evaluation method have been developed and mature [7,8], but the research on the reliability model evaluation of satellite communication systems is very limited. These mature evaluation methods are directly used in satellite communication systems and cannot meet our requirements, such as rapid reliability model development cycle, possible directions of model
optimization, and comprehensive model evaluation. In short, from the research situation at home and abroad, the evaluation of the reliability model of satellite communication system is still an open problem to be solved.

2. Traditional Evaluation Methods
At present, the commonly used evaluation methods, such as Expert Meeting Method and Delphi Method, rely too much on experts, and cannot get real results when the number of people is small, and the evaluation results are difficult to converge when the number of people is large. Clustering Analysis Method is to calculate the distance or similarity coefficient between the indicators to carry out systematic clustering, which requires a lot of statistical data, which is difficult in the development stage of satellite communication network reliability model. By comprehensive comparison, fuzzy comprehensive evaluation can solve multi-level problems according to different possibilities, so it is more suitable for satellite communication network reliability model.

Fuzzy comprehensive evaluation is to use fuzzy mathematics tools to comprehensively evaluate things under the influence of multiple factors [9]. Set $\{P_1, P_2, \ldots, P_n\}$ to be evaluated set of objects, where $x$ is to be assessed the number of objects. Provided $U = \{u_1, u_2, \ldots, u_m\}$ for the evaluation factor set, indicates the assessment estimated objects $P_i$ ($i \leq x$) of $m$ kinds of evaluation factors (evaluation index), where $m$ is the assessment of the number of factors. Provided $V = \{v_1, v_2, \ldots, v_n\}$ for the comment sentence set, showing each evaluation index evaluation levels, where $n$ is the total assessment of the number of levels (typically divided into 3~5 levels).

**Defined 1** Factors and evaluation set $V$ similarity metric is the degree of membership.

**Defined 2** The evaluation is conducted from A single factor $u_i$ to determine the membership degree of the evaluation object $P_i$ to the evaluation set $V$, referred to as single factor fuzzy evaluation.

The fuzzy relation matrix $R = [r_{i,j}]_{m \times n}$ between $U$ and $V$ can be obtained by single factor fuzzy evaluation of each evaluation factor in the evaluation factor set $U$. Where $r_{i,j}$ ($i \leq m, j \leq n$) represents the membership degree of the evaluation factor $u_i$ of the object to be evaluated to the evaluation comment $v_j$ ($j \leq n$). Finally Suitable Fuzzy Composite Operators "$\circ$" fuzzy weight vector $A$ and the fuzzy relation matrix $R$ intake line complex computation [10]. The fuzzy comprehensive evaluation vector $B = A \circ R = \{b_1, b_2, \ldots, b_n\}$ of the evaluated object is obtained. Where $b_j$ ($j \leq n$) represents the similarity between the evaluated object $P_i$ and the comment $v_j$ on the whole.

However, the traditional fuzzy comprehensive evaluation method cannot solve the problems caused by the correlation between various links in the reliability model modelling process. Therefore, based on the modelling process of satellite communication network reliability model, this paper improves the traditional fuzzy evaluation method and designs a fuzzy quantitative evaluation method.

3. Fuzzy quantitative evaluation method
The second chapter shows that the object set by the $x$th element of the composition $Part = \{P_1, P_2, \ldots, P_n\}$; since the satellite communication system complexity, the factors set into data element set $UD = \{u_{d_1}, u_{d_2}, \ldots, u_{d_m}\}$ and the index factor set $UC = \{u_{c_1}, u_{c_2}, \ldots, u_{c_n}\}$, indicators factor set by the evaluation data element $u_{d_s}$ ($s \leq md$) of $mc_s$ an indicator element composition; The comment set is set to $n$ levels, ie $V = \{v_1, v_2, \ldots, v_n\}$. The quantitative evaluation of the model is defined as follows:

**Definition 3** $\forall u_{d_s} \in UD$ ($s \leq md$), if for the evaluation $u_{d_s}$ of $mc_s$ data elements of an index factor values $UC_{u_{d_s}} = \{u_{d_1s}, u_{d_2s}, \ldots, u_{d_{mc_s}s}\}$ are valid it is present, the presence of a functional
relationship \( f \), such that the formula (1) established, then \( Q(ud_{i}) \) to evaluate the data elements \( ud_{i} \) quantified assessment of estimated values.

\[
Q(ud_{i}) = f\left( p(u_{c_{1}}^{ud_{i}}), p(u_{c_{2}}^{ud_{i}}), \ldots, p(u_{c_{mc}}^{ud_{i}}) \right), s \leq md
\]  

(1)

Wherein, \( u_{c_{t}}^{ud_{i}} (t \leq mc_{i}) \) is the comprehensive evaluation value of the data factor \( ud_{i} \) to be evaluated on its corresponding evaluation indicator factor \( uc_{t} \), \( p(u_{c_{t}}^{ud_{i}}) \) represents the probability of the corresponding fuzzy evaluation value.

Each index factor in \( UCUd_{i} \) is judged separately, and a fuzzy matrix \( R_{i}=[r_{n}^{uc_{i}}]_{n=1}^{\alpha} \) is constructed, in which \( r_{n} \) indicates that the evaluated index factor \( uc_{t}^{ud_{i}} \) has the degree of comment \( jv_{j} \). \( A=\{a_{1}, a_{2}, \ldots, a_{mc_{i}}\} \) is the weight fuzzy vector on the index factor set \( UCUd_{i} \), representing the importance of each element in \( UCUd_{i} \), which is obtained by entropy weight coefficient method [11]. Finally, the fuzzy set is obtained by compound operation transformation:

\[
B_{i} = A \cdot R_{i} = (b_{1}, b_{2}, \ldots, b_{mc_{i}}), s \leq md
\]

(2)

Among them, \( b_{j} \) represents the degree to which \( ud_{i} \) of the evaluated data factor has the evaluation \( v_{j} \), namely the membership degree of \( v_{j} \) to the fuzzy set \( B_{i} \).

The probability \( p(u_{c_{t}}^{ud_{i}}) \) of the fuzzy evaluation value in Equation (1) is obtained from Equation (2), namely, the ratio of the maximum membership degree to the total membership degree:

\[
p(u_{c_{t}}^{ud_{i}}) = \frac{\max(B_{t})}{\sum_{j=1}^{mc_{i}} b_{j}}, t \leq mc_{i}, s \leq md
\]

(3)

After the probability \( p(u_{c_{t}}^{ud_{i}}) (t \leq mc_{i}) \) of the fuzzy evaluation value of each indicator factor \( uc_{t}^{ud_{i}} \) in the data factor \( ud_{i} \) is obtained, the quantitative evaluation value \( Q(ud_{i}) \) of \( ud_{i} \) needs to be fused and calculated, that is, the functional relationship \( f \) in Equation (1) is determined. Neither the prior probability nor the subjective experience can be fully believed in the evaluation of the model, so the Bayesian theory can be used to combine the two information organically. Considering the independence of each index factor, the posterior probability of \( ud_{i} \) can be obtained by using the total probability formula and Bayes' theorem:

\[
p(ud_{i}|uc_{1}^{ud_{i}}, \ldots, uc_{mc}^{ud_{i}}) = \frac{p(u_{c_{1}}^{ud_{i}}, \ldots, u_{c_{mc}}^{ud_{i}}|ud_{i})}{p(u_{c_{1}}^{ud_{i}}, \ldots, u_{c_{mc}}^{ud_{i}})} = \frac{\prod_{t=1}^{mc_{i}} p(u_{c_{t}}^{ud_{i}}|uc_{t}^{ud_{i}})}{p(ud_{i})}, s \leq md
\]

(4)

Where, \( p(ud_{i}) \) is the prior probability of data factor \( ud_{i} \). The result combines the prior probability of data factor and subjective experience, that is, both objective data and subjective factors are taken into account. Therefore, the quantitative evaluation value of \( ud_{i} \) is:

\[
Q(ud_{i}) = f\left( p(u_{c_{1}}^{ud_{i}}), p(u_{c_{2}}^{ud_{i}}), \ldots, p(u_{c_{mc}}^{ud_{i}}) \right) = \frac{\prod_{t=1}^{mc_{i}} p(u_{c_{t}}^{ud_{i}}|uc_{t}^{ud_{i}})}{p(ud_{i})}, s \leq md
\]

(5)

All data in the data factor set \( UD=\{ud_{1}, ud_{2}, \ldots, ud_{md}\} \) are independent of each other, so the quantitative evaluation value of \( Pt_{l} \) to be evaluated can be further fused by Bayesian theory to obtain the comprehensive quantitative evaluation value of "Pt_{l} :
Wherein, $p(P_{t_i})$ is the prior probability of $P_{t_i}$ of the object to be evaluated.

After the above evaluation, the evaluation result set $Q(\text{Part}) = \{Q(P_{t_1}), Q(P_{t_2}), \ldots, Q(P_{t_n})\}$ of all objects can be obtained, and the evaluation values of all objects can be fused to obtain the final evaluation value $EVA$:

$$EVA = \sum_{i=1}^{n} k_i \cdot Q(P_{t_i})$$  \hspace{1cm} (7)$$

Among them, $k_i$ represents the weight of object $k_i$ in this evaluation, which can be determined according to the actual application of the model.

### 4. Fuzzy quantitative evaluation based on reliability modeling process

The current common evaluation methods are all simple evaluations of the model as a whole, but these evaluation methods cannot accurately find the parts of the model that need to be optimized [12]. Therefore, this paper proposes an evaluation method based on the reliability model establishment process to evaluate each link in the reliability model modeling process, so that the final result can reflect the weak links of reliability modeling and provide directions for further optimization of the model.

#### 4.1. Satellite communication system reliability model modeling process

Reliability models are divided into basic reliability models and mission reliability models [13]. Satellite communication systems are extremely complex, so mission reliability models are usually established. Figure 1 is the process from establishment to use and optimization of the reliability model of the satellite communication system [14].

![Fig 1 The reliability model of satellite communication system is established and optimized](image)

#### 4.2. Fuzzy quantitative evaluation of reliability models for satellite communication networks

This chapter mainly evaluates the three links in the process shown in Figure 1, namely, Specifying System Definitions (SD), Determining Mathematical Models (DM), and Reliability Calculations (RC). The evaluation result reflects the accuracy of the reliability model of the satellite communication system to be evaluated. When the evaluation result is not ideal, it can provide a basis for further optimization of the model [15].

It can be seen from Chapter 3 that the evaluation reliability model needs to set three sets, which are object set, factor set and evaluation set. The object set Part is composed of three processes SD, DM and RC established by the reliability model, namely $\text{Part} = \{P_{t_{SD}}, P_{t_{DM}}, P_{t_{RC}}\}$. The evaluation set $V$ is composed of five evaluation levels, namely $V = \{\text{non-conforming}, \text{relatively non-conforming}, \text{general}, \text{relatively conforming}, \text{conforming}\}$. The factor set is composed of data factor set $UD$ and indicator factor set $UC$. 

$$Q(P_{t_i}) = p\left(P_{t_i} | u_{d_1}, u_{d_2}, \ldots, u_{d_m}\right) = \prod_{i=1}^{m} Q(u_{d_i})$$

$$= \prod_{i=1}^{m} \frac{Q(u_{d_i})}{p(P_{t_i})}^{u_{d_i}} , \quad I \leq x$$  \hspace{1cm} (6)$$
The data factor set $UD$ is determined based on the actual situation of each process established by the reliability model of the satellite communication system and is objective. The $SD$ data factor investigation model can complete tasks and the number of functions, the number of performance parameters when the model failure is defined, the performance parameter range (confidence interval) when the system fails, the failure criterion, etc., and then the data can be characterized by different units to obtain Data set $UD_{sd} = \{ud_{sd_1}, ud_{sd_2}, \ldots, ud_{sd_{md}}\}$, where $SD_{md}$ represents the amount of data.

The data factor of DM examines the sensitivity and robustness of the model. Sensitivity is the relative change of the model when a certain parameter changes slightly, that is, the ratio of the change to the original value; if the model does not depend on the assumptions relative to the actual situation Accuracy, the model is robust, and the data set $UD_{dm} = \{ud_{dm_1}, ud_{dm_2}, \ldots, ud_{dm_{md}}\}$ is obtained, where $DM_{md}$ represents the amount of data.

The data factor of RC examines the computational complexity and space complexity of the model, and obtains the data set $UD_{rc} = \{ud_{rc_1}, ud_{rc_2}, \ldots, ud_{rc_{md}}\}$, where $RC_{md}$ represents the amount of data.

The index factor set UC is to evaluate whether each element in the data factor conforms to the rules, which is determined by the evaluation expert and is subjective. The evaluation criteria mainly include completeness, consistency, accuracy and real-time [16].

(1) Completeness (CM): Refers to whether the data is missing, it may be that the entire data record is missing, or it may be that some field information is missing.

(2) Consistency (CN): refers to whether the data is standardized and whether the data collection format is uniform.

(3) Accuracy (AC): refers to whether there are errors or abnormalities in the data information.

(4) Real-time (TM): refers to the delay time of data, that is, the time interval from when it is generated to when it can be viewed.

The above evaluation standards correspond to the three links of the reliability model, SD, DM, and RC. The index factor sets are $UC_{sd} = \{CM, AC\}$, $UC_{md} = \{CM, TM, AC\}$, and $UC_{rc} = \{TM, CN, AC\}$ respectively.

Since each index factor has a different dimension, it is necessary to standardize the values of $x$ models under the same index factor $uc_{i}^{md}$ [17], as shown in formula (8):

$$
\left(uc_{i}^{md}\right)_{y} = \frac{(uc_{i}^{md})_{y} - E(uc_{i}^{md})}{S(uc_{i}^{md})}, t \leq mc_{i}, s \leq md, y \in x
$$

(8)

Wherein $(uc_{i}^{md})_{y}$ represents the $y$ th Model $uc_{i}^{md}$ evaluation value indicators $E(uc_{i}^{md})$ and $S(uc_{i}^{md})$ is $uc_{i}^{md}$ the mean and standard values for all evaluation index difference model.

Then convert the standardized index factor $(uc_{i}^{md})_{y}$ into a value in the interval $[0,1]$ , as shown in formula (9)

$$
\left(uc_{i}^{md}\right)^{*} = \frac{(uc_{i}^{md})_{y} - \min\left((uc_{i}^{md})_{y}\right)}{\max\left((uc_{i}^{md})_{y}\right) - \min\left((uc_{i}^{md})_{y}\right)}, t \leq mc_{i}, s \leq md, y \in x
$$

(9)

Fuzzy quantitative evaluation of the above data can get the final quantitative evaluation value $EVA$ of the model.
5. Algorithm Simulation and Analysis

5.1. Evaluation simulation example verification

Herein is selected from the viewpoint model invulnerability reliability analysis of a satellite communication system, a satellite communication system provided with a N number nodes, respectively, based on the jump plane node, and natural structural differences of the three methods of establishing the communication system Reliability evaluation model. Now use the fuzzy quantitative evaluation method of this article to evaluate and compare these three models.

(1) Determine three sets

The index factor set of the object set, evaluation set and factor set has been given in Chapter 4, namely, the object set \( \text{Part} = \{P_{SD}, P_{DM}, P_{RC}\} \), \{definition of reliability, determination of reliability mathematical model, reliability calculation \}, evaluation set \( \text{V} = \{\text{No In line with, relatively inconsistent, generally, relatively in line, in line }\} \), the index factor sets corresponding to the three objects are \( \text{UC}_{SD} = \{u_{SD}^{PO}, u_{SD}^{PO}\} \), \( \text{UC}_{UD} = \{u_{UD}^{MD}, u_{UD}^{MD}, u_{UD}^{MD}\} \), \( \text{UC}_{RC} = \{u_{RC}^{CN}, u_{RC}^{CN}, u_{RC}^{AC}\} \).

Suppose the data factor set in this simulation is:

\( \text{UD}_{SD} = \{u_{SD}, u_{SD}, u_{SD}, u_{SD}, u_{SD}\} \) = \{The number of tasks that the model can complete, The number of functions that can be completed, The number of performance parameters, The confidence interval of performance parameters when the system fails, The failure criterion} \)

\( \text{UD}_{DM} = \{u_{DM}, u_{DM}, u_{DM}, u_{DM}, u_{DM}\} \) = \{Sensitivity of indicator 1, Sensitivity of indicator 2, Sensitivity of indicator 3, Sensitivity of indicator 4, Whether the model is robust or not} \)

\( \text{UD}_{RC} = \{u_{RC}, u_{RC}\} \) = \{Time complexity, Space complexity\}

(2) Get the data factor set

Analyse the three models, firstly analyse the model to obtain the data factor set of SD link and RC link, which is the result in Table 1.

| Model to be evaluated | UD_{SD} | UD_{RC} |
|-----------------------|---------|---------|
| Reliability model based on hopper node | 4 3 4 95% 2 | \(O(N^2)\) \(S(N^2)\) |
| Reliability model based on structural differences | 3 4 4 95% 2 | \(O(N^2)\) \(S(N^2)\) |
| Reliability model based on natural connectivity | 2 4 5 97% 3 | \(O(N)\) \(S(N)\) |

The data factor value of the DM link requires the model sensitivity, and the local sensitivity analysis method is used [18]. Only one of the parameters is set as a variable, and the other parameters take the center value. The sensitivity of the reliability model with respect to this parameter is the amount of change each time the parameter changes.

In the reliability model based on jump plane nodes, the reliability \( R_{1} = f_{1}(u_{DM}, u_{DM}, u_{DM}, u_{DM}) \) of the satellite communication system consists of the number of low-reliability nodes \( u_{DM} \), the number of failed nodes \( u_{DM} \), the reliability of low-reliability nodes \( u_{DM} \), and the high-reliability nodes \( u_{DM} \). In the reliability model based on structural differences, the reliability of the satellite communication system \( R_{2} = f_{2}(u_{DM}, u_{DM}, u_{DM}) \) is determined by the total number of paths \( u_{DM} \) with the path length of 1 between any two nodes, the total number of
paths $ud_{23}^2$ with the path length of 2 between any two nodes, and the total number of paths $ud_{31}^2$ with the path length of 3 between any two nodes. In the reliability model based on natural connectivity, the reliability of satellite communication system $R_{ud} = f_3\left(ud_{23}^1, ud_{31}^1\right)$ is determined by the number of nodes $ud_{31}^1$, and the mean value of natural connectivity $ud_{31}^1$. Therefore, the data factor values of the DM link are shown in Table 2.

**Table 2 The data factor values of DM during the modeling process**

| Model to be evaluated | $ud_{DM}$ | $ud_{DM}$ | $ud_{DM}$ | $ud_{DM}$ | $ud_{DM}$ |
|-----------------------|------------|------------|------------|------------|------------|
| Reliability model based on hopper node | 0.01 | 0.02 | 0.6 | 0.6 | 1 |
| Reliability model based on structural differences | 0.07 | 0.01 | 0.01 | — | 1 |
| Reliability model based on natural connectivity | 0.01 | 0.3 | — | — | 1 |

Table 3 to Table 5 are the quantitative evaluation values of data factors $ud$ for different index factors $uc$ of each model in the three links. The data performance is measured according to the evaluation set $V$, and the value range is $[0,1]$. For example, if the fault criterion of the reliability model of the satellite communication system based on the jump surface node is general, the corresponding $uc_{CM}$ is 0.6. To ensure that the experiment is rigorous and accurate, the following results are based on the average value of the evaluation data of 50 evaluation experts.

**Table 3 The quantitative evaluation value of the modelling process SD**

| Model to be evaluated | $ud_{SD}$ | $ud_{SD}$ | $ud_{SD}$ | $ud_{SD}$ | $ud_{SD}$ |
|-----------------------|------------|------------|------------|------------|------------|
| Reliability model based on hopper node | 0.647 | 0.769 | 0.705 | 0.972 | 0.831 | 0.985 | 0.693 | 0.817 | 0.950 | 0.960 |
| Reliability model based on structural differences | 0.718 | 0.803 | 0.920 | 0.892 | 0.695 | 0.818 | 0.796 | 0.758 | 0.615 | 0.918 |
| Reliability model based on natural connectivity | 0.727 | 0.834 | 0.911 | 0.995 | 0.883 | 0.808 | 0.849 | 0.847 | 0.954 | 0.940 |

**Table 4 The quantitative evaluation value of the modelling process DM**

| Model to be evaluated | $ud_{DM}$ | $ud_{DM}$ | $ud_{DM}$ | $ud_{DM}$ | $ud_{DM}$ |
|-----------------------|------------|------------|------------|------------|------------|
| Reliability model based on hopper node | 0.667 | 0.800 | 0.872 | 0.808 | 0.659 | 0.807 | 0.859 | 0.773 | 0.653 | 0.932 | 0.759 | 0.863 | 0.772 | 0.667 | 0.679 |
| Reliability model based on structural differences | 0.991 | 0.788 | 0.617 | 0.639 | 0.889 | 0.920 | 0.669 | 0.807 | 0.851 | - | - | - | - | - | - |
| Reliability model based on natural connectivity | 0.885 | 0.927 | 0.989 | 0.993 | 0.781 | 0.942 | - | - | - | - | - | - | - | - | - |

**Table 5 The quantitative evaluation value of the modelling process RC**

| Model to be evaluated | $ud_{RC}$ | $ud_{RC}$ |
|-----------------------|------------|------------|
| Reliability model based on hopper node | 0.791 | 0.817 |

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Reliability model based on structural differences  | 0.817  | 0.642  | 0.809  | 0.761  | 0.858  | 0.905  
Reliability model based on natural connectivity | 0.855  | 0.924  | 0.997  | 0.643  | 0.824  | 0.908  

(3) Obtain the fuzzy quantitative evaluation value

After normalizing the data standards in Table 3 to Table 5, the fuzzy quantitative evaluation value of each link can be obtained by using the algorithm in this paper, and then the evaluation results of each link of the model are merged twice to obtain the reliability of each satellite communication system. The fuzzy quantitative evaluation value EVA of the model is shown in Table 6

| Model to be evaluated                          | SD   | MD   | RC   | Fuzzy quantitative evaluation value EVA |
|-----------------------------------------------|------|------|------|----------------------------------------|
| Reliability model based on hopper node        | 0.677| 0.767| 0.850| 0.411                                  |
| Reliability model based on structural differences | 0.738| 0.895| 0.662| 0.437                                  |
| Reliability model based on natural connectivity | 0.901| 0.927| 0.922| 0.770                                  |

According to EVA, the three models are ranked as follows:
Based on the jump plane node < Based on the structural difference < Based on the natural connectivity

The above results are consistent with the results obtained by analysing the reliability models of three satellite communication systems in literature [19], which confirms the accuracy of the algorithm in this paper

5.2. Model optimization analysis

Considering the complexity of the satellite communication system, the reliability model is usually not directly put into use, that is, the reliability model needs to be optimized, and the algorithm proposed in this paper can provide direction for further optimization of the model.

Take the optimization of the reliability model of a satellite communication system based on structural differences as an example: first observe the evaluation results of each link in Table 6. The evaluation value of RC is 0.662, which is the lowest evaluation value of the three links, so the RC link is improved first; (6) and, the RC assessment depends links in Table 1 in each of the data elements $ud$ complex evaluation, according to the formula (5) can be seen $ud$ integrated in the evaluation value by its corresponding factor evaluation index $uc$ decision on the evaluation value the evaluation results are shown in table 5 the last analysis table; Table 5 each evaluation value, "time complexity", $ud_{rc}$ in the "real time", $uc_{DM}$ evaluation on the minimum value, that is 0.642, and the resulting "real time." The reason for the difference is the high time complexity of the reliability algorithm.

In summary, when optimizing the reliability model of a satellite communication system based on structural differences, first consider reducing the time complexity of this algorithm.

6. Conclusion

Reliability model is the key of reliability analysis of satellite communication system. Reliability model evaluation is one of the key points of reliability model development and reliability analysis research.

This paper presents a fuzzy quantitative evaluation method based on the reliability modelling process, which combines objective data and subjective analysis to evaluate the reliability model, and the results are complete.
The evaluation results provide the basis for the optimal selection of the satellite communication system reliability model under specific scenarios, and provide a reference for the further optimization of the reliability model.

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