Reliability Evaluation Method of Online Japanese Teaching Software Based on Bayesian Network

Jiayi Sun[1], Yue Wang[1(✉)], and Chao Song[2]

[1] School of Foreign Languages, Dalian University of Science and Technology, Dalian 116000, China
cynthiaw704@yahoo.jp.cn

[2] School of Innovation and Entrepreneurship, Dalian University of Science and Technology, Dalian 116000, China

Abstract. Software reliability is an important factor for evaluating software quality. Therefore, a reliability evaluation method of online Japanese teaching software based on Bayesian network is proposed. This method first constructs an index system for the reliability impact of online Japanese teaching software, then uses the weight factor judgment table method and the entropy weight method to calculate the combined weight of the evaluation index, and finally uses Bayesian network to calculate the reliability probability of online Japanese teaching software, compares the division standards, and obtains the reliability degree of online Japanese teaching software. The results show that the reliability of the three online Japanese teaching software tends to decline with the extension of application time; The reliability is above 0.9, and the reliability degree is the highest; The first software maintains the best reliability, followed by the second, and finally the third.

Keywords: Bayesian Network · Online Japanese teaching software · Weight Calculation · Reliability Evaluation · Entropy Weight Method

1 Introduction

Network technology has achieved great development, which has a profound impact on many fields such as learning and life. Higher education is also deeply affected by network technology, and is actively innovating in teaching mode, thus entering a new stage of development. In order to further improve the quality and effect of Japanese teaching and make it have a high level of personality and diversity, many colleges and universities are actively innovating the traditional teaching mode and making scientific use of the "Internet plus" technology. In specific teaching practice, Japanese teachers make scientific use of network technology and carry out online Japanese teaching [1]. Therefore, online Japanese teaching software has been applied, which can better promote Japanese teaching innovation and further improve Japanese teaching effect.

B. Wang et al. (Eds.): ICMTEL 2023, LNICST 532, pp. 424–437, 2024.
https://doi.org/10.1007/978-3-031-50571-3_31

However, the online Japanese teaching software is free of charge and allows users to improve the software, resulting in the failure elimination process of online Japanese teaching software largely affected by the change in the number of users. In addition, the rapid iteration of small versions of online Japanese teaching software and the continuous incremental development lead to the changing trend of failure data. In a period of time after the release of online Japanese teaching software, the reliability of the software will fluctuate greatly, so using a single reliability analysis model to describe the failure process of online Japanese teaching software often does not conform to the actual troubleshooting situation [2]. At present, many software reliability models with change points are used to analyze the failure data of online Japanese teaching software. Here, a change point based method is used to add new interpretation and evaluation indicators to the traditional reliability analysis model of online Japanese teaching software to describe the different troubleshooting processes of online Japanese teaching software.

Software reliability is an important field in computer engineering. Software reliability evaluation is an important part of software reliability research. Through software reliability evaluation, software reliability related parameters are quantified to build confidence in the use of software. The research of software reliability model is the core of software product reliability evaluation research, and is an important tool to evaluate, predict and analyze software reliability. The existing models describe software reliability to a certain extent, but their universality is limited due to the harsh assumptions or insufficient use of prior information. Bayesian network has the characteristics of graphical modeling method, which can carry out incomplete data reasoning and uncertainty reasoning. Compared with traditional modeling methods, Bayesian network has a significant progressiveness. This research focuses on the application of Bayesian network in software reliability evaluation, and proposes a reliability evaluation method for online Japanese teaching software based on Bayesian network.

2 Research on Reliability Evaluation of Online Japanese Teaching Software

2.1 Reliability Evaluation Technology

Online Japanese teaching software has been widely used because of its short development cycle, many online versions, fast update speed and other characteristics. Therefore, the reliability analysis of online Japanese teaching software has also received more and more attention. The essence of the development process of online Japanese teaching software is the development process voluntarily carried out by developers. The determination of the software release time is mostly determined by the core maintenance personnel according to the software development situation. Compared with the traditional closed source software, the debugging process of online Japanese teaching software largely depends on the community members and users. There will be some huge fluctuations in the failures detected after the release of the new version. It is difficult to express software reliability with a measurement parameter [3]. And different parameters may be used for different software and different applications. Like hardware reliability measurement, software reliability measurement can also apply methods and techniques of probability theory

and mathematical statistics, because software failures show randomness. In the field of software reliability, software reliability modeling is one of the earliest researches, the most abundant research results, and the most controversial aspects. Software reliability modeling aims to give the estimated value or predicted value of software reliability by statistical method according to the data related to software reliability (failure), which is one of the keys to understanding the behavior of software reliability in essence. It can be said that software reliability modeling is the basis of software reliability engineering practice and theoretical research.

At present, in software reliability evaluation technology, there are mainly two evaluation methods that are concerned:

(1) Verification method based on software reliability test

The software reliability verification method is a test to verify whether the current reliability level of software meets the user's requirements under a given statistical confidence, that is, when the user receives the software, he determines whether it meets the reliability index specified in the software specification [4]. This method is generally carried out in the software acceptance stage and implemented with the participation of the software demander. The main process is to quantitatively evaluate the reliability of some or some software by using the reliability acceptance model recognized by both the supplier and the demander according to the fault conditions in the field test, so as to judge whether the software has reached the reliability agreed in its requirements specification.

(2) Method based on software reliability modeling

This method is also known as software reliability growth modeling, is the main content of current software reliability modeling. This method is mainly used in the development stage of software, and its failure situation also depends on the test. Different from the first method, the failure is modified while the test is carried out, and the collected failure behavior is modeled and analyzed, thereby estimates the actual level of software reliability and guides developers to the next steps. Testing is related to the elimination of defects. It is generally arranged to be executed in the system testing phase of the development process. The failures determined by the test are submitted to the developer for analysis and modification, and a new version of the software is established, and then the next test is performed. In this iterative process of "testing-debugging-new version", because the software bugs found in the software testing phase are continuously eliminated, the software reliability shows an increasing trend, so it is called software reliability growth modeling.

The reliability evaluation process of online Japanese teaching software is shown in Fig. 1.

2.2 Japanese Teaching Software Reliability Impact Index System

With the deepening of software reliability engineering research, software reliability evaluation has become an indispensable and important research content. The effectiveness of reliability assurance measures can not be judged without accurate evaluation methods.

The severity of the influence of reliability factors on software reliability is closely related to the level of software reliability. One is that these factors are taken from various

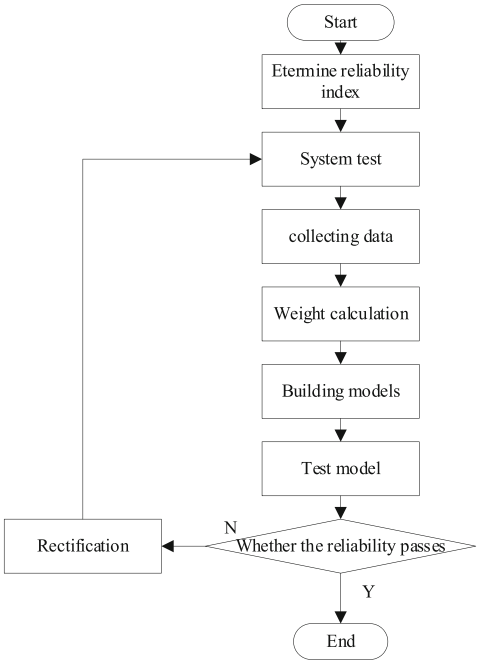

Fig. 1. Reliability Evaluation Process of Online Japanese Teaching Software

stages of the software development process, which can truly reflect that software reliability is affected by them from different perspectives; The level of sexuality is shown [5]. Therefore, on the basis of referring to relevant data, the principal component analysis method is used to summarize and summarize it, and a comprehensive evaluation index system for building software reliability is obtained, as shown Fig. 2.

The system is divided into two levels. The first level comprehensively evaluates software reliability from five major aspects, and the second level lists several main factors affecting each major aspect of software reliability, which is a detailed reliability factor. According to the degree of influence of these factors on software reliability, the metrics used are light, light, medium, heavy and heavy. According to the degree of influence, it can be determined that the software reliability belongs to the corresponding high, high, medium, low and low degrees. The more seriously the software reliability is affected, the lower its level [6]. For example, if the degree of software reliability affected is "heavy", the software reliability level is "low". Because there are many factors affecting a certain aspect of software reliability, and there are primary and secondary factors among them, the influence of the main factors can be highlighted through weight distribution, so as to achieve different degrees of importance.

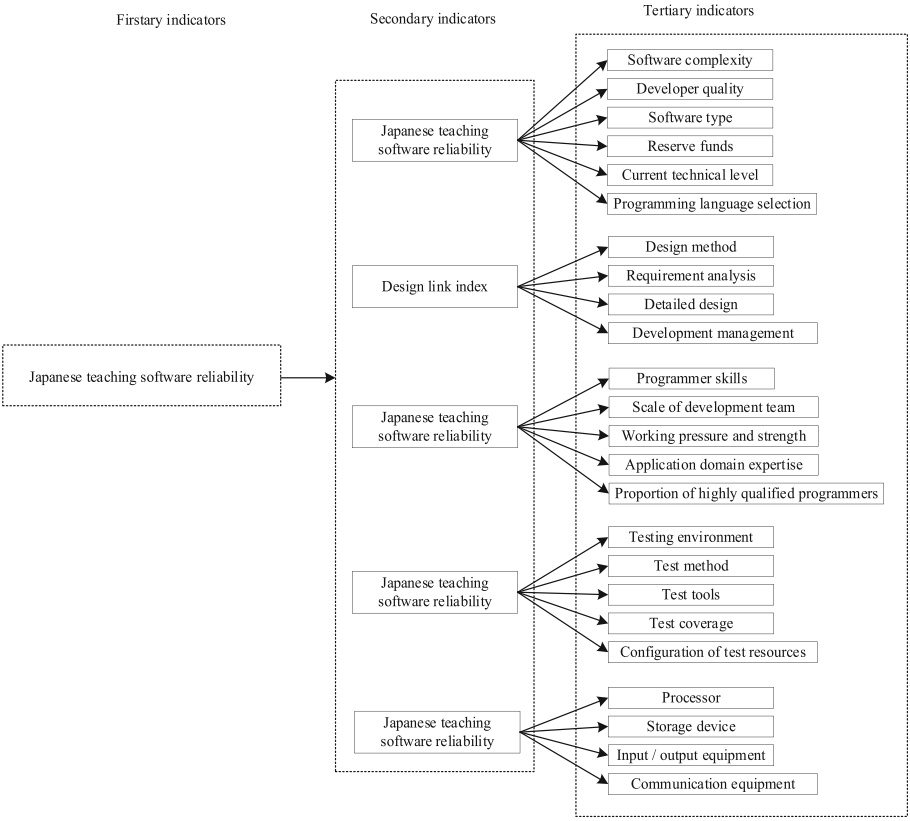

Fig. 2. Japanese teaching software reliability impact index system

2.3 Calculation of Reliability Impact Index Weight

The weights can also be called weighting coefficients or weights, which are used to indicate the relative importance of each evaluation index in the population. When determining the weight of each indicator in the indicator system, it is necessary to start from the entire indicator system, coordinate the relationship between the evaluation indicators, and then allocate their weights reasonably according to the role and effect of each indicator on the whole. It can be seen from the previous chapter that the established software reliability evaluation index system is a multi-indicator evaluation system including 5 secondary indicators. The different proportions of different indicators in the reliability evaluation will affect the evaluation results. Therefore, how to determine the weight of indicators is particularly important.

There are usually two ways of empowerment, one is subjective empowerment, and the other is objective empowerment. Since subjective empowerment reflects the subjective will of decision-makers, its empowerment results are too subjective. However, the objective weighting method is too dependent on the sample data, and the calculation steps are complex, which can not reflect the subjective will of decision makers. In the

field of software reliability evaluation, there are many factors affecting software reliability, and it is impossible to scientifically and comprehensively weight the indicators only by relying on personal experience or individual sample data. Therefore, this paper considers to adopting a comprehensive method of determining the weight combining subjective and objective factors.

(1) The subjective weighting method includes the weight factor judgment table method and the analytic hierarchy process. The weight factor judgment table method mainly relies on the more authoritative or experienced evaluators in the professional field, who form an evaluation expert group, fill in the corresponding weight factor judgment table according to the established rules, and then pass the weights filled in by the experts. The factor judgment table is used to determine the weight value. In the process of filling in the weight factor judgment table by the expert group, there may be some contradictions in which the importance does not match. Therefore, it is necessary to check the consistency of the weight factor judgment table filled in by the expert group to ensure the importance of each index. Coordination [7].
(2) Objective weighting method mainly includes entropy weight method and factor analysis method. In the entropy weight method, entropy is a measure of the uncertainty of the system. If the information entropy of an indicator is smaller, the greater the amount of information contained in the indicator, and the greater its proportion in the evaluation. Since it does not rely on subjective judgment, the entropy weight method is more objective and accurate. It can be used to screen out indicators that do not contribute much to the indicator system, and finally obtain more objective indicator weight values.

The combination of subjective and objective weighting method has the advantages of both subjective weight and objective weight. It analyzes and makes decisions on various indicators that affect software reliability. The results not only reflect the opinions of the expert group, but also conform to the objectiveness reflected in the sample data. The fact makes the indicator weights more scientific and reasonable. In this paper, the weight factor judgment table method is used subjectively, and the entropy weight method mentioned above is used objectively, and then the two weighting methods are organically combined, and finally the comprehensive weight value is obtained.

Weight Factor Judgment Table Method

The process of weight factor judgment table method is as follows:

Step 1: Determine the quantitative standard of indicators. The weight factor judgment table method mainly judges the importance of each index according to the judgment matrix. The methods to determine the importance of each index can be divided into proportional scale method and exponential scale method. This paper adopts the proportional scale method, which is based on the evaluation standard of the difference between matter and substance, and uses the 1–9 scale method to judge the grade for evaluation, as shown in Table 1.

Step 2: Construct the judgment matrix.

Table 1. 1–9 proportional scaling method

Value meaning	Scale
Indicates that the two factors are equally important	1
Indicates that one factor is slightly more important than the other	3
Indicates that one factor is significantly more important than the other	5
Indicates that one factor is more important than the other	7
Indicates that one factor is extremely important compared with the others	9
The median value of the above two adjacent judgments	2, 4, 6, 8
The ratio of one element to another	Reciprocal of the above numbers

The expert fills in the weight factor judgment table, and then the expert scores the pairwise comparison of the metrics to obtain the judgment matrix G.

$$G = \begin{pmatrix} g_{11} & g_{12} & \cdots & g_{1n} \\ g_{21} & g_{22} & \cdots & g_{2n} \\ \cdots & & & \\ g_{n1} & g_{n2} & \cdots & g_{nn} \end{pmatrix} = \left(g_{ij}\right)_{nn} \tag{1}$$

In the formula, g_{ij} represents the relative importance score of Japanese teaching software reliability impact indicator i and Japanese teaching software reliability impact indicator j; n represents the number of indicators.

Step 3: Check the consistency of the judgment matrix.

The actually obtained judgment matrix does not necessarily strictly meet the consistency requirements. In practical applications, it is not strictly required that all judgment matrices strictly meet the consistency requirements. When the degree of inconsistency is within the allowable range, subsequent operations can be performed. In practical applications, the consistency ratio C is mainly used to detect whether the judgment matrix meets the consistency requirements. The consistency judgment criterion in actual use is: when the consistency ratio $C < 0.1$, the judgment matrix satisfies the inequality, then the matrix satisfies the consistency, otherwise it is judged that the matrix does not meet the consistency.

Step 4: calculate the weight.

Make statistics on the judgment matrix G that has passed the consistency test.

1) Calculate the score A_{ik} of each line of evaluation index.

$$A_{ik} = \sum_{i=1}^{n} g_{ij} \tag{2}$$

In the formula, k represents the expert number.

2) Calculate the average score B_i of the evaluation index.

$$B_i = \sum_{k=1}^{N} \frac{A_{ik}}{N} \tag{3}$$

In the formula, N represents the number of experts.

3) Calculate the evaluation index weight w_i.

$$w_i = \frac{B_i}{\sum_{i=1}^{n} B_i} \tag{4}$$

Entropy Weight Method

The entropy weight method is a kind of objective weighting method, which has been widely used at home and abroad in recent years. The smaller the entropy value of the index, the greater the variation of the index value, the greater the amount of information provided, and the greater the weight of the index [8].

Step 1: Assuming that the number of research objects is m, the indicator matrix is

$$H = \left(h_{pj}\right)_{mn} \tag{5}$$

Step 2: Normalize each indicator in the matrix and record it as $\hat{h}_{pi}$, then establish the proportion of each evaluation indicator and record it as R_{pi}.

$$R_{pi} = \frac{\hat{h}_{pi}}{\sum_{p=1}^{m} \hat{h}_{pi}} \tag{6}$$

In the formula, R_{pi} represents the proportion of the p evaluation index.

Step 3: Calculate the entropy value of the indicator. Calculated as follows:

$$D_{pi} = \frac{\sum_{p=1}^{m} \left(R_{pi} - \ln R_{pi}\right)^2}{\ln m} \tag{7}$$

In the formula, C_{ij} represents the entropy value of the evaluation index.

Step 4: calculate the difference coefficient of the index and record it as C_{pi}.

Step 5: calculate the weight of the evaluation index. The calculation formula is as follows:

$$v_i = \frac{C_{pi}}{n - \sum_{i=1}^{n} C_{pi}} \tag{8}$$

In the formula, v_i represents the weight of the i indicator.

Combining Weights

Combining the weights calculated by the above two methods, the combined weights are obtained, and the results are as follows:

$$u_i = \frac{w_i v_i}{\sum_{i=1}^{n} (w_i + v_i)} \tag{9}$$

In the formula, u_i represents the combined weight of the i indicator.

This chapter shows the importance of adopting the combination of subjective and objective weighting method by summarizing the shortcomings of the subjective and objective weighting method, and finally introduces the calculation steps of the subjective and objective combination weighting method used in this paper, and determine the weight value of each first-level index in the software reliability evaluation index system.

2.4 Evaluation of Bayesian Network Model

Bayesian network is a probabilistic network. Based on Bayesian formula, the network based on probabilistic reasoning is visualized. The so-called probabilistic reasoning is the process of obtaining the probability information of other unknown evaluation indicators by analyzing the relationship between evaluation indicators after knowing the information of some evaluation indicators. Bayesian networks based on probabilistic reasoning are proposed to solve the problems of uncertainty and incompleteness, and are widely used in many industries. They have great advantages in solving the damage state assessment of complex systems [9].

Bayesian Networks is a tool that comprehensively uses probability theory and graph theory to analyze and reason uncertain events. It is an organic combination of Bayesian methods and graph theory, and can be expressed as a directed acyclic graph of the probability dependence between evaluation indicators. The development of Bayesian statistics and graph theory provides a solid foundation for Bayesian network theory, while the development and wide application of computer technology and artificial intelligence promote the improvement and development of Bayesian networks. The basic theoretical framework of Bayesian networks consists of three parts, including network representation, network modeling and network reasoning. In the modeling of Bayesian networks for complex large-scale systems, it is necessary to first complete the two key steps of network parameter learning and network structure learning. How to learn to establish Bayesian networks from known data is one of the hot issues in current Bayesian network research.

The modeling of Bayesian network can be generally divided into three steps: first, determine the evaluation index set and evaluation index domain, then determine the network structure, and finally determine the node condition probability table. In the process of modeling, we generally need to make a compromise in two aspects: on the one hand, in order to achieve sufficient accuracy, we need to build a large and rich network model; On the other hand, it is necessary to consider the cost of building and

maintaining models and the complexity of probabilistic reasoning [10]. In fact, building a Bayesian network is often an iterative and interactive process of the above three steps.

(1) Determine the evaluation indicator set and evaluation indicator field. It is mainly to select an appropriate set of evaluation indicators under the guidance of experts in the field. In some cases, certain strategies are required to select important factors from the evaluation indicators provided by experts. At the same time, it is also necessary to determine the evaluation indicator field, that is, the possible values of these evaluation indicators.
(2) Determine the network structure. Based on the evaluation index node, the Bayesian network structure is constructed in two ways: the network structure is specified by expert knowledge; A large number of training sample data are used to learn and determine the Bayesian network structure, which expresses the causal relationship between evaluation indicators.

Based on the above process, a Bayesian network for software reliability evaluation is established. Through historical data statistics and experimental data, study the value range and discretization method of each impact index, quantify the causal relationship between each index and reliability, and establish a risk reasoning network with software operation as the main line. In combination with the development law and risk element division results, the connection node is established to determine the inference network structure, as shown in Fig. 3.

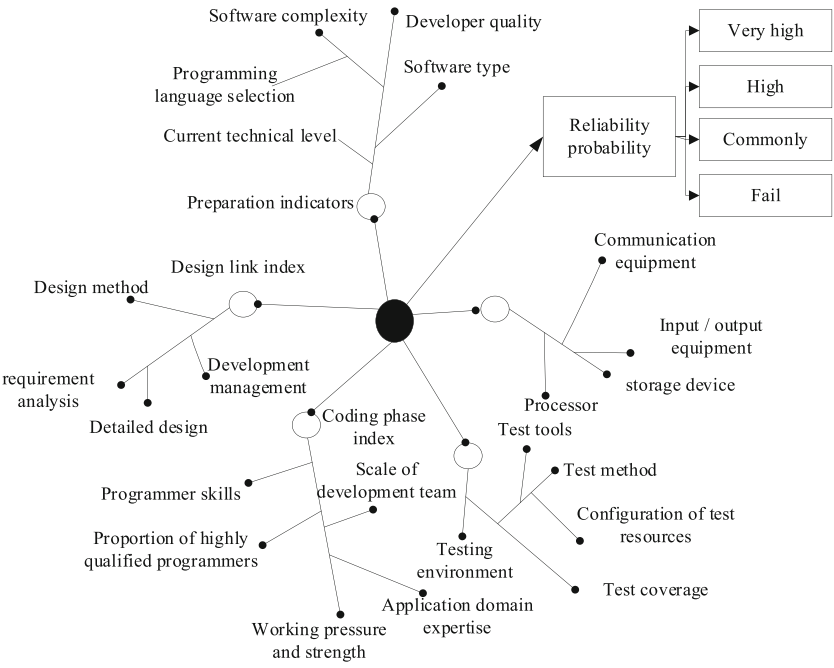

Fig. 3. Bayesian network model for software reliability evaluation

According to the results, the targeted rectification suggestions are given, the online Japanese teaching software is optimized, and the reliability evaluation is completed.

3 Evaluation Test

3.1 Test Cases

A one month evaluation test was conducted with 3 online Japanese teaching software as the object.

(1) The first one is well compatible with a variety of GNSS standard formats and protocols, GNSS received specific data protocol formats and some external communications, and can meet the requirements of real-time PPP applications.
(2) The second one is the GNSS data processing and analysis software package that can run on Linux and Windows operating systems.
(3) The third one is an object-oriented multi-functional software library that can meet the needs of various end users and support multithreading processing.

Based on the weight factor judgment table method and entropy weight method, the calculated weights of the evaluation indicators are shown in Table 2.

3.2 Reliability Assessment Results

Bayesian network model is used to test the reliability of three Japanese teaching software. The results are shown in Fig. 4.

The following three points can be seen from Fig. 4:

(1) With the extension of the application time, the reliability of the three Japanese teaching software shows a downward trend;
(2) The reliability of the three Japanese teaching software is above 0.9, and its reliability is the highest.
(3) The reliability of the three Japanese teaching software is the best maintained by the first software, followed by the second, and finally by the third.

4 Conclusion

The further development of science and technology urgently needs high reliability software and hardware. The increasing use of computers makes the consequences caused by computer failures more and more serious. For example, in people's daily life, software failures cause a lot of inconvenience and even damage. For example, in the field of public infrastructure, the failure of subway or aircraft operation systems may lead to delays or even major casualties. For example, in the financial field, software failures may lead to major economic losses. Therefore, its reliability has become a widespread concern. Therefore, a Bayesian network based reliability evaluation method for Japanese teaching software is studied. The results are as follows: the model makes full use of prior information, takes into account incomplete error removal and error removal time, and introduces the influence of reliability factor coefficient, which expands the application scope of reliability assessment and improves the accuracy of software reliability assessment. At the same time, because it is based on Bayesian classical mathematical theory, it enhances the stability of reliability assessment.

Table 2. Evaluation index weight table

Level III indicators	The first Japanese teaching software	The second Japanese teaching software	The third Japanese teaching software
Software complexity	0.25	2.32	1.84
Developer quality	0.36	1.25	3.22
Software type	0.42	1.22	1.25
Reserve funds	1.22	1.21	0.12
Current technical level	1.72	1.36	0.15
Programming language selection	0.85	2.02	1.41
Design method	1.36	1.21	2.36
Requirement analysis	1.52	1.01	2.10
Detailed design	2.33	0.21	0.21
Development management	2.58	1.62	0.40
Programmer skills	0.25	1.54	3.21
Proportion of highly qualified programmers	0.14	2.32	1.25
Scale of development team	0.54	4.21	1.41
Working pressure and strength	0.63	2.32	1.55
Application domain expertise	0.23	0.14	2.87
Testing environment	0.20	2.36	5.21
Test method	1.52	2.20	4.12
Configuration of test resources	4.21	1.05	2.36
Test coverage	4.30	0.25	1.66
Test tools	3.22	1.21	1.35
Processor	2.82	2.33	1.22
Storage device	0.41	2.41	0.64
Input / output equipment	2.84	2.74	0.41
Communication equipment	3.84	2.12	4.15

There are many aspects of software reliability models that require further research:

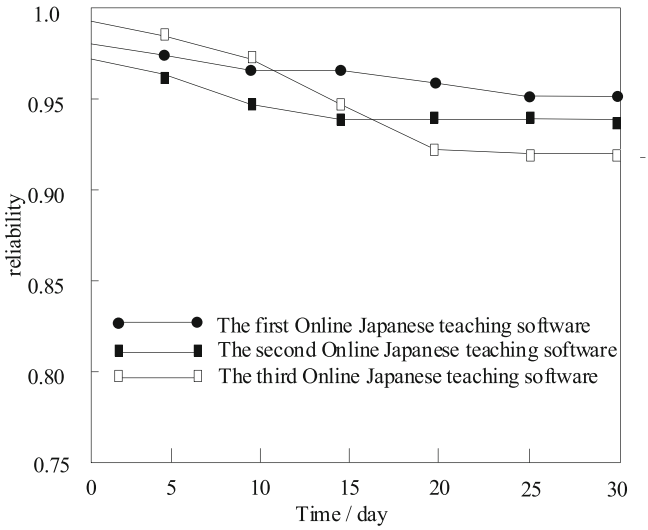

Fig. 4. Reliability Evaluation Results

(1) The model aspect can be further studied, and more candidate reliability growth models can be proposed for different data sets.
(2) The evaluation index of model fitting prediction effect can be further expanded. In addition, for different Japanese teaching software, different weights can be added to the theoretical optimal model index, and a more suitable model for the software can be selected.
(3) Further comparative research can be carried out on the specific effects of combined and non-combined models in prediction. At the same time, according to the change characteristics of different cumulative data curves of failures, combined models are used for classification research.

Aknowledgement. The Design and Development of "Zhaozhi Japanese" Public Welfare Teaching Platform for the Elderly.Source: Undergraduate Innovation and Entrepreneurship Training Program of Dalian University of Science and Technology.

References

1. Juangsih, J., Emzir, E., Rasyid, Y.: The needs analysis of four primary language skills in developing japanese teaching materials for tourism purposes. Jurnal Pendidikan Bahasa dan Sastra **20**(2), 185–196 (2021)
2. Liu, C., Chen, Q.: Current situation and suggested measures of japanese teaching in colleges and universities based on computer aid. J. Phys. Conf. Ser. **1744**(3), 32–41 (2021)
3. Zhang, T.: The application of positive psychology in japanese teaching. Clausius Scientific Press **3**(6), 88–93 (2021)
4. Zheng, G., Zhu, J.: Japanese translation teaching corpus based on bilingual non parallel data model. J. Intell. Fuzzy Syst. Appli. Eng. Technol. **40**(2), 3731–3741 (2021)

5. Liu, X., Xie, N.: Grey-based approach for estimating software reliability under non-homogeneous Poisson process. Syst. Eng. Electron. Technol. (English) **33**(2), 360–369 (2022)
6. Qiu, H., Yan, X., Peng, R.: Research on software reliability model considering multiple types of faults. Operat. Res. Manag. Sci. **31**(4), 104–108 (2022)
7. Fang, H., Li, C.: Component software reliability prediction method based on copula function model. Comput. Simulat. **39**(5), 352–355,365 (2022)
8. Liu, Y., Yang, Y.: Software reliability analysis method based on uncertain fault tree. J. Tianjin Univ. Sci. Technol. **37**(1), 52–55,63 (2022)
9. Li, K., Lei, Y., Zhang, Z.: Software reliability evaluation method based on component impact factor. Comput. Eng. Design **43**(1), 165–170 (2022)
10. Zhang, B., Hai, S., Wei, J.: Research on embedded software reliability prediction model based on continuous collaborative machine learning algorithm. Microcontrollers Embedded Syst. **22**(1), 39–42,47 (2022)