An Improved Comprehensive Evaluation Model of Software Dependability based on Rough Set Theory

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***Abstract*—Dependability of software, a major concern in many computer applications, can be improved through several means. But systematic approaches for its evaluation do not exist, which is the prerequisite for dependability control and improvement. Software dependability evaluation is an urgent problem to be solved. There is some subjectivity about weighting coefficient when applying fuzzy comprehensive evaluation model to evaluate software dependability. A new comprehensive evaluation model with combinational weight based on rough set theory was proposed in this paper. In this new model, subjective weight was obtained from expert's judgment by using the traditional fuzzy comprehensive evaluation method, and the objective weight was determined from statistical data by using the rough set theory. Then, a relatively reasonable weight was obtained by combining the subjective weight and the objective weight, which effectively avoids subjectivity of weighing coefficient in fuzzy comprehensive evaluation model. In the example, two different dependability evaluation results were derived from the traditional evaluation model and the improved model respectively. The comparative result proves the feasibility and validity of this improved comprehensive evaluation model.**

***Index Terms*—software dependability evaluation, fuzzy comprehensive evaluation, rough set theory, combinational weight, improved comprehensive evaluation model**

I. Introduction

Dependability has become an important attribute of computing systems. It is a generic term and encompasses several quality attributes of a system such as reliability, availability, safety, security, and maintainability. Dependability is defined as that property of a computer system such that reliance can justifiably be placed on the service it delivers. The service delivered by a system is its behavior as it is perceptible by its user(s); a user is another system (human or physical) which interacts with the former [1]. Software has been the bottleneck for achieving dependability while hardware has become more reliable. Many factors contribute to the increased concern with software for critical applications. They are: increase in size and complexity of software, more interaction between various modules of the software, real-time execution and interrupts and desire for more flexibility. As a result, software has become more error prone and fielded software is likely to have some residual bugs and errors. The challenge of developing dependable software becomes even more difficult when meeting complex, real-time, distributed and stringent high integrity requirements of computing systems [2].

Two issues must be addressed when developing dependability: achieving high dependability and assessing the achieved dependability. Several systematic approaches have been used to achieve high dependability, such as formal methods, fault tolerance techniques, testing and debugging. On the other hand, markov chains, fault trees, graphs and combinatorial methods have been employed for dependability assessment [3]. In references [4-6], one or two dependability attributes, such as reliability, safety and availability, were employed to measure dependability. In order to analyze dynamic systems' dependability, references [4] built a system reliability model and analyze system's reliability. Reference [5] evaluated reliability and availability for a computer system's dependability evaluation. An extensible framework for dependability evaluation was proposed in reference [6], based on which system's availability and reliability were analyzed. In [7-8], other relative indicators, such as MTBF and robustness, were measured for dependability evaluation. Constantinescu employed a GSPN (generalized stochastic Petri net) model to measure availability and MTBF for dependability analysis of a fault-tolerant COTS (commercial-off-the-shelf) processor [7]. Dependability benchmark was transformed to robustness benchmark in Reference [8], which presented a dependability benchmark for general-purpose operating systems and its application to six versions of Windows operating system and four versions of Linux operating system. Until now,

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there are very few comprehensive evaluation models to consider the contribution from every dependability attribute. The respective measurement, which does not consider the contribution from every dependability attribute, is not conducive to the further work, such as dependability control and improvement. Therefore, in order to make a comprehensive evaluation for software dependability, a practical, unified and comparable dependability evaluation model is needed. Fuzzy comprehensive evaluation is an effective decision-making method which can make an integrated evaluation to the multi-factors influenced object. Unit's bidding ability of electricity market was assessed by using fuzzy comprehensive evaluation approach in reference [9]. X. Cui, et al. quantitatively evaluated service quality of power supply in electricity market with four grades based on fuzzy comprehensive evaluation [10]. Pang Qinghua, et al. applied fuzzy comprehensive evaluation method to evaluate the flexibility of an enterprise production system, and got a result that the flexibility was close to the grade of good [11]. In reference [12], fuzzy comprehensive evaluation method was applied to solve the problem of an E-business system's software dependability evaluation; and result was drawn that the dependability was high. But in fuzzy comprehensive evaluation method, questionnaire or analytic hierarchy process (AHP), which depends on experts' knowledge and experience, is commonly used to determine the evaluation factors' weights. Inevitably, there is some subjectivity about weighting coefficient; thus the fuzzy comprehensive evaluation model needs to be improved when evaluating software dependability.

Rough Set theory, introduced by Zdzislaw Pawlak in the early 1980s, is a new mathematical tool for data analysis and for reasoning from imprecise and ambiguous data, which gives the definition of illegibility and indefinite under the classified significance [13]. As an effective tool in dealing with vague and uncertainty information, it has attracted much attention of many researchers and practitioners all over the world, particularly for those experts in the area of artificial intelligence. The rough set theory has been applied to many fields successfully such as knowledge discovery, decision support, pattern recognition, machine learning, process control, and predictive modeling, etc. In [14], rough set theory was used to construct a good ensemble of classifiers for data mining applications. Reference [15] applied rough set theory to find the relationship between personal demographic attributes and long distance travel mode choice, which analyzed the collected data by surveys based on the rough set theory. Feng Han, et al. used rough set theory to find out the simplest evaluation rules of electricity-generating enterprises' performance [16]. And this theory has already been applied to determine indexes' weights in evaluation model. To avoid subjectivity of weight coefficient, Yitian Xu, et al. built a comprehensive evaluation model about listed-corporation based on rough set theory, in which the computation of weighting coefficient is transformed into importance of attributes [17].

Actually, both of experts' judgment and historical data are important to evaluation in most time. Considering the deficiencies of weight determination in fuzzy comprehensive evaluation method, an improved fuzzy comprehensive evaluation model with rough-set theory based combinational weight is proposed in this paper. First of all, fuzzy comprehensive evaluation model, the traditional software dependability evaluation model, is given. And then, the improved software dependability evaluation model is explained. Based on the model, the combinational weight determining method is presented. Finally, the proposed model is applied to evaluate software's dependability and the comparing result proves its validity.

II. FUZZY COMPREHENSIVE EVALUATION MODEL

As developed over the past three decades, dependability is an integrating concept that encompasses the following attributes [1]:

the readiness for usage leads to availability,

the continuity of service leads to reliability,

the non-occurrence of catastrophic consequences on the environment leads to safety,

the non-occurrence of unauthorized disclosure of information leads to confidentiality,

the non-occurrence of improper alterations of information leads to integrity,

the ability to undergo repairs and evolutions leads to maintainability.

Dependability requirements are different in various applications. Not all of the attributes will be important to the same degree in every system. In this context, a fuzzy comprehensive evaluation method is employed for the dependability evaluation modeling.

A. Fuzzy comprehensive evaluation method

The fuzzy comprehensive evaluation method is a revolution to the method of giving a mark by force which divided evaluated-area into several segments, stipulate every score forcibly and weight the evaluated thing using the rigid scale. Fuzzy comprehensive evaluation is a combination of qualitative and quantitative evaluation method. It is an effective method especially to the complicated system with plenty of hierarchies and fuzzy factors. The integral conclusion of evaluation, no matter for the multi-characters system, or for the multi-factors system, can be calculated out clearly in this way, and it can reflect the character by the grade of membership clearly.

Following is the principle procedures of this method [18]:

1. Define model input, the set of judgment factors $f_i (i = 1, 2, \cdots, n)$. Factor set is made up of elements that affect the judgment object.

2. Set linguistic variable $V = (v_1, v_2, \cdots, v_m)$. $V_i\ (i = 1, 2, \cdots, m)$ represents all kinds of possible evaluation results.

3. Define weight of the judgment factor $A=(a_1,a_2,\cdots,a_n)$. Each factor has different importance degree during the evaluation process. In order to reflect the importance of each factor, it is a must to give corresponding weight to each factor.

4. Compute fuzzy matrix $R_i=(r_{i1},r_{i2},\cdots,r_{im})$. R is denoted the fuzzy matrix of element f_i on grade of v_j.

5. Establish comprehensive evaluation matrix of evaluation elements:

$$B=A*R=(a_1,a_2,\cdots,a_n)\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}=(b_1,b_2,\cdots,b_m) \quad (1)$$

B is a fuzzy vector which not only represents all evaluation elements' contribution, but also reserves all degree of membership of every grade.

B. Establish the subjective weights of dependability attributes

Weight vector reflects the status and function of every factor in the decision-making process. Weightings establishment directly affect the final results of the evaluation. While using fuzzy comprehensive evaluation, sometimes it is difficult to determine the weight vector because the important degree of each factor is highly impossible to be expressed with a certain value. In fuzzy comprehensive evaluation model, the questionnaire method is traditionally used to establish the weights whose steps are as follows:

1. Design the expert evaluation form based on dependability evaluation factors.

2. Carry on expert survey, ask experienced experts to fill in the evaluation grade (check in the corresponding item). Every grade has value $b=(b_1,b_2,\cdots,b_m)$.

3. Count the number of experts who agrees with the j^{th} factor's i^{th} grade: k_{ij}.

4. Computer the factor's weighting:

$$a_i=\frac{\sum_{i=1}^{m}k_{ij}b_i}{\sum_{j=1}^{k}\sum_{i=1}^{m}k_{ij}b_i}.$$

This weight establishing method, which entirely depends on experts' experience, may lead to a biased evaluation result. To avoid the deficiency when determining attributes' weights, an improved model is given next.

III. IMPROVED SOFTWARE DEPENDABILITY EVALUATION MODEL

To overcome the subjectivity of weight determination in the fuzzy comprehensive evaluation model, an improved software dependability evaluation model is given as Fig. 1.

This model is built based on the fuzzy comprehensive evaluation model. The grey part is the innovative process comparing to the traditional evaluation method of software dependability. The objective weight is calculated from statistical data of software dependability. In the new model, subjective weight is replaced by combinational weight which taking both of experts' knowledge and objective data into consideration. The detailed evaluation process is given in next section.

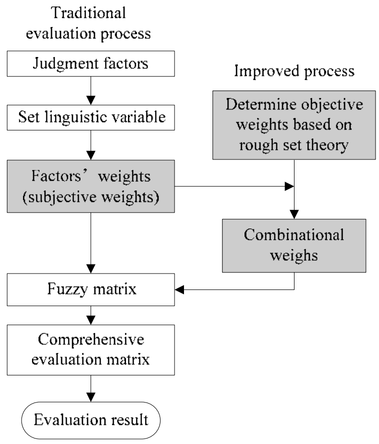

Figure 1. Improved software dependability evaluation model.

IV. NEW EVALUATION MODEL WITH COMBINATIONAL WEIGHT

A. Rough set theory

Since rough set theory as a new approach to decision making in the presence of uncertainty and vagueness was introduced by Pawlak in 1982 [13], it has attracted attention of researchers all over the world [19, 20]. During the last decades it has been applied in many different fields [21, 22] such as fault diagnosis, financial prediction, image processing, decision theory etc. Until now many advantages of rough set theory application have been founded [23-25], some of them are listed as follows:

1) It is based on the original data only and does not need any external information, unlike probability in statistics or grade of membership in the fuzzy set theory.

2) It accepts both quantitative and qualitative attributes and specifies their relevance for approximation of the classification;

3) It discovers important facts hidden in data and expresses them in the natural language of decision rules;

4) It contributes to the minimization of the time and cost of the decision making process;

5) It is easy to understand and offers straightforward interpretation of obtained results;

6) It takes into account background knowledge of the decision maker.

This theory defines the knowledge from a new angle which regards the knowledge as division of universe of discussing, and the knowledge itself has granularity. It is mainly used in the knowledge simplification and the knowledge dependent analysis.

The core of the rough set theory is to measure the importance of attributes and reduce attributes. The steps are as follows: Fist, delete redundant data and inconsistent part; then, withdraw essential information; third, produce decision-making rule; last, provide support for scientific management and making decisions [16].Some definitions would be given [26],

1. Information System: Given an information system $S=(U,A,V,f)$, where U is a finite set of objects called the universe, A is a finite set of attributes and is divided into two sets: the condition attributes C and the decision attributes D, such that $A=C\bigcup D$; V is a set of value of attributes; $f:U\times A\rightarrow V$ is called an information function that assigns particular values from domains of attributes to objects.

2. Approximations: X is a muster, C is an equivalence relation. The lower approximation of X is denoted by C_(X). Its definition is as follows,

$$C\_(X)=\bigcup\{Y\in U/C; Y\subseteq \tilde{X}\}. \quad (2)$$

And the upper approximation of X is denoted by $C^{-}(X)$. Its definition is as follows,

$$C^{-}(X)=\bigcup\{Y\in U/C; Y\cap \tilde{X}\neq\varnothing\}. \quad (3)$$

3. Dependence of Attributes: The purpose of discussing Dependence of Attributes is to analyze the inner relation among data. In the theory about rough set, the degree of dependence among attributes is measured by $\gamma_C(D)$, it is defined as follows.

If $D,C\subseteq A$ and $k=\gamma_C(D)=Card(POS_C(D))/Card(U)$, we say D is the degree dependency of $k\ (0\le k\le 1)$, denoted by $C\Rightarrow_k D$. Where $POS_C(D)=\bigcup_{X\in U/D} C\_(X)$ is called C positive universe of D, $Card(U)$ is denoted by the radix of U set.

B. Objective weight establishment based on rough set theory

When evaluating something with multi-index, it is known that some indexes have vital significance to the evaluation results while some not. If such indexes are removed, it would correspondingly change the evaluation results. This shows that such indexes are very important. This could be described as the positive universe of the rough set theory.

According to definition 3, the degree of influence that removes a subset of condition attributes C_i from a certain set of condition attributes C which affect the set of decision attributes D, could be measured by the subtract of the degree of dependence among attributes, as $\mathrm{Sig}(C_i)=\sigma_{CD}(C_i)=\gamma_C(D)-\gamma_{C-Ci}(D)$. Then the objective weight of C_i is

$$\beta_i=\frac{Sig(C_i)}{\sum_{i=1}^{n}Sig(Ci)}. \quad (4)$$

C. Combinational weight establishment

In order to get a more reasonable evaluation result, the subjective and objective weights are combined in the new software dependability evaluation model. The linear combinational weight method is used to determine the weights of indexes, as,

$$w_i=\eta\alpha_i+(1-\eta)\beta_i\ (i=1,2,\ldots n). \quad (5)$$

Where, α_i and β_i are the subjective weight and the objective weight respectively. $\eta\ (0<\eta<1)$ is the favorable coefficient of weight whose value can be determined according to different conditions. For example, if experts' knowledge is more reliable relatively, η can be large $(0.5<\eta<1)$; and if the historical data are more convincing, η can be small $(0<\eta<0.5)$.

The combinational weights replace the subjective weights in the fuzzy comprehensive evaluation model. Then, the comprehensive evaluation matrix and evaluation result can be induced.

V. CASE STUDY

A. Evaluate software dependability with the traditional fuzzy comprehensive evaluation model

Apply the traditional fuzzy comprehensive evaluation method to evaluate one kind of aviation software's dependability.

1. The evaluation factors are divided into two levels, f_i and f_{ij}. Evaluation grade is "very important, important, medium, unimportant, and very unimportant". Linguistic variable is "very high, high, medium, low, and very low".

2. Establish the subjective weights from the questionnaire result. The questionnaire is as table 1.

$f=(0.382,0.341,0.053,0.029,0.027,0.168)$

$f_1=(0.121,0.417,0.270,0.192)$

$f_2=(0.470,0.297,0.045,0.121,0.068)$

$f_3=(0.114,0.144,0.184,0.558)$

$f_4=(0.200,0.080,0.200,0.520)$

$f_5=(0.230,0.140,0.210,0.140,0.040,0.070,0.170)$

$f_6=(0.198,0.49,0.312)$

3. Single factor evaluation result.

$$R_1=\begin{bmatrix}0.5 & 0.5 & 0 & 0 & 0\\ 0.25 & 0.75 & 0 & 0 & 0\\ 1 & 0 & 0 & 0 & 0\\ 0.667 & 0.333 & 0 & 0 & 0\end{bmatrix}$$

$$R_2=\begin{bmatrix}0.75 & 0.25 & 0 & 0 & 0\\ 0 & 1 & 0 & 0 & 0\\ 0.4 & 0.6 & 0 & 0 & 0\\ 0.75 & 0.25 & 0 & 0 & 0\\ 1 & 0 & 0 & 0 & 0\end{bmatrix}$$

$$R_3=\begin{bmatrix}0.889 & 0.111 & 0 & 0 & 0\\ 0.333 & 0.667 & 0 & 0 & 0\\ 1 & 0 & 0 & 0 & 0\\ 0.667 & 0.333 & 0 & 0 & 0\end{bmatrix}$$

$$R_4 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \end{bmatrix}$$

$$R_5 = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{bmatrix}$$

$$R_6 = \begin{bmatrix} 0.5 & 0.5 & 0 & 0 & 0 \\ 0.611 & 0.246 & 0.143 & 0 & 0 \\ 0.75 & 0.25 & 0 & 0 & 0 \end{bmatrix}$$

TABLE I.
QUESTIONNAIRE RESULT OF WEIGHTS

Evaluation Factors		Weight
Dependability f	Availability	0.382
	Reliability	0.341
	Safety	0.053
	Confidentiality	0.029
	Integrity	0.027
	Maintainability	0.168
Availability f_1	f_{11}	0.121
	f_{12}	0.417
	f_{13}	0.27
	f_{14}	0.192
Reliability f_2	f_{21}	0.47
	f_{22}	0.297
	f_{23}	0.045
	f_{24}	0.121
	f_{25}	0.068
Safety f_3	f_{31}	0.114
	f_{32}	0.144
	f_{33}	0.184
	f_{34}	0.558
Confidentiality f_4	f_{41}	0.20
	f_{42}	0.08
	f_{43}	0.20
	f_{44}	0.52
Integrity f_5	f_{51}	0.23
	f_{52}	0.14
	f_{53}	0.21
	f_{54}	0.14
	f_{55}	0.04
	f_{56}	0.07
	f_{57}	0.17
Maintainability f_6	f_{61}	0.198
	f_{62}	0.49
	f_{63}	0.312

4. Evaluation result with the subjective weight.

$$B_1 = A_1 \bullet R_1 = (0.56, 0.44, 0, 0, 0)$$

$$B_2 = A_2 \bullet R_2 = (0.53, 0.47, 0, 0, 0)$$

$$B_3 = A_3 \bullet R_3 = (0.705, 0.295, 0, 0, 0)$$

$$B_4 = A_4 \bullet R_4 = (0.48, 0.52, 0, 0, 0)$$

$$B_5 = A_5 \bullet R_5 = (0.14, 0.55, 0.21, 0, 0)$$

$$B_6 = A_6 \bullet R_6 = (0.632, 0.298, 0.07, 0, 0)$$

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \\ B_6 \end{bmatrix} = \begin{bmatrix} 0.56 & 0.44 & 0 & 0 & 0 \\ 0.53 & 0.47 & 0 & 0 & 0 \\ 0.70 & 0.30 & 0 & 0 & 0 \\ 0.48 & 0.52 & 0 & 0 & 0 \\ 0.14 & 0.55 & 0.21 & 0 & 0 \\ 0.63 & 0.30 & 0.07 & 0 & 0 \end{bmatrix}$$

$$A = (0.382, 0.341, 0.053, 0.029, 0.027, 0.168)$$

$$B = A \bullet R = (0.555, 0.425, 0.017, 0, 0).$$

The percentages of “very high”, “high”, “medium”, “low”, and “very low” are shown in Fig. 2.

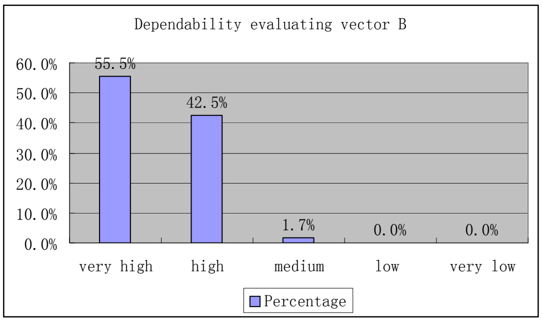

Figure 2. Dependability evaluating vector B.

B. Evaluate software dependability with the improved fuzzy comprehensive evaluation model

1. The dependability attributes statistics of other ten aviation software is as table 2

TABLE II.
ATTRIBUTES STATISTICS

U	f1	f2	f3	f4	f5	f6
1	0.09	0.35	0.41	0.18	0.13	0.24
2	0.15	0.25	0.35	0.34	0.17	0.34
3	0.18	0.27	0.25	0.25	0.16	0.28
4	0.12	0.33	0.21	0.18	0.14	0.34
5	0.33	0.29	0.22	0.26	0.26	0.35
6	0.13	0.19	0.17	0.16	0.15	0.34
7	0.13	0.31	0.26	0.12	0.15	0.19
8	0.11	0.29	0.22	0.33	0.22	0.21
9	0.10	0.25	0.35	0.19	0.32	0.26
10	0.23	0.18	0.37	0.11	0.22	0.15

2. Discretize the data in table 2 (1— <0.18, 2— 0.18~0.34, 3— >0.34). The discretized data are as table 3.

TABLE III.
DISCRETIZED DATA

U	f1	f2	f3	f4	f5	f6
1	1	3	3	2	1	2
2	1	2	3	2	1	2
3	2	2	2	2	1	2
4	1	2	2	2	1	2
5	2	2	2	2	2	3
6	1	2	1	1	1	2
7	1	2	2	1	1	2
8	1	2	2	2	2	2
9	1	2	3	2	2	2
10	2	2	3	1	2	1

1) U/f={1},{2},{3},{4},{5},{6},{7},{8},{9},{10}
U/ind(f_1)={1},{2},{3,4},{5},{6},{7},{8},{9},{10}
$POS_{f=\{f1\}}(f) = \{1,2,5,6,7,8,9,10\}$
$Sig(f_1) = 1-8/10 = 0.2$.

2) U/ind(f_2)={1,2},{3},{4},{5},{6},{7},{8},{9},{10}
$POS_{f=\{f_2\}}(f) = \{3,4,5,6,7,8,9,10\}$
$Sig(f_2) = 1-8/10 = 0.2$.

3) U/ind(f_3)={1},{2,4},{3},{5},{6,7},{8,9},{10}
$POS_{f=\{f_3\}}(f) = \{1,3,5,10\}$
$Sig(f_3) = 1-4/10 = 0.6$.

4) U/ind(f_4)={1},{2},{3},{4,7},{5},{6,},{8},{9},{10}
$POS_{f=\{f_4\}}(f) = \{1,2,3,5,6,8,9,10\}$
$Sig(f_4) = 1-8/10 = 0.2$.

5) U/ind(f_5)={1},{2,9},{3},{4,8},{5},{6,},{7},{10}
$POS_{f=\{f_5\}}(f) = \{1,3,5,6,7,10\}$
$Sig(f_5) = 1-6/10 = 0.4$.

6) U/ind(f_6)={1},{2},{3},{4},{5},{6},{7},{8},
{9},{10}
$POS_{f=\{f6\}}(f) = \{1,2,3,4,5,6,7,8,9,10\}$
$Sig(f_6) = 1-10/10 = 0$.

3. After normalization, the objective weight of these attributes is,

$\beta = (0.125, 0.125, 0.375, 0.125, 0.25, 0)$.

4. As mentioned before, the subjective weight is $\alpha = A = (0.382, 0.341, 0.053, 0.029, 0.027, 0.168)$. Let η=0.5, the combinational weight is obtained as,

$W = (0.254, 0.233, 0.214, 0.077, 0.138, 0.084)$.

As shown in Fig. 3, weight changed obviously.

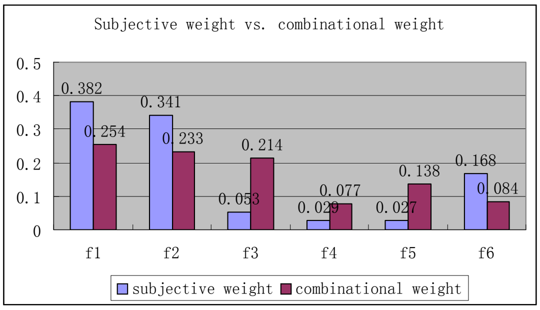

Figure 3. Subjective weight and combinational weight.

Evaluation result with the combinational weight is,
$B' = W \bullet R = (0.525, 0.427, 0.035, 0, 0)$.

The percentages of "very high", "high", "medium", "low", and "very low" are shown in Fig. 4.

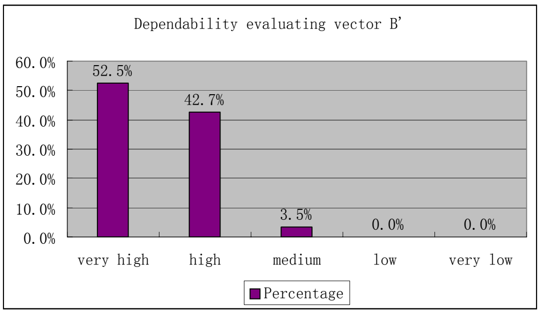

Figure 4. Dependability evaluating vector B'.

C. Evaluate results analysis

1. From both of the evaluating vectors (B and B'), according to the maximum membership degree principle, it can be concluded that this software has "very high" dependability.

2. However, the percentages of "very high", "high" and "medium" are all changed in the results, which attributes to the weight change, shown as Fig. 5.

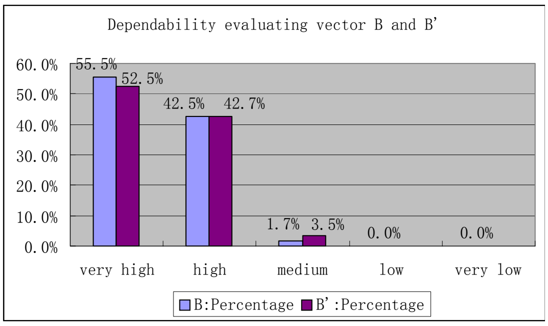

Figure 5. Dependability evaluating vector B and B'.

Weight coefficients depend on questionnaire result completely in traditional fuzzy comprehensive evaluation model; while in the improved model, objective data are employed, with the experts' experience taken into consideration at the same time. With combinational weight, the new model can avoid the bias of the subjective weight to a great extent and get a more reasonable evaluation result.

3. Value of the favorable coefficient η is determined by different conditions, which influences the evaluation result. Table 4 shows the combinational weight with different η value. As a result, the evaluation result will change with different combinational weight.

TABLE IV.
COMBINATIONAL WEIGHT WITH DIFFERENT η VALUE

η	f_1	f_2	f_3	f_4	f_5	f_6
0.1	0.151	0.147	0.343	0.115	0.228	0.017
0.2	0.176	0.168	0.311	0.106	0.205	0.034
0.3	0.202	0.190	0.278	0.096	0.183	0.050
0.4	0.228	0.211	0.246	0.087	0.161	0.067
0.5	0.254	0.233	0.214	0.077	0.139	0.084
0.6	0.279	0.255	0.182	0.067	0.116	0.101
0.7	0.305	0.276	0.150	0.058	0.094	0.118
0.8	0.331	0.298	0.117	0.048	0.072	0.134
0.9	0.356	0.319	0.085	0.039	0.049	0.151

4. The combinational weight determination process can be used to weigh level-2 factors f_{ij} and improve level-2 factors' weights if necessary.

VI. CONCLUSION

In the software dependability evaluation, index's weight may affect the accuracy and the validity of the results greatly. In the most time, the reasonable weight determination should reflect both of the experts' subjective judgment and the objective information of index. This paper applies a new comprehensive evaluation model with combinational weight based on rough set theory to evaluate software's dependability. This model, taking both of the objective information of index and the experts' judgment into consideration, can effectively avoid subjectivity about weighing coefficient in fuzzy comprehensive evaluation. The result shows that the proposed model is not only feasible but also more reasonable compared with the traditional software dependability evaluation method.

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