A Software Test Metric Method Based on Fuzzy Logic

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ABSTRACT

Software test metric is a quantitative analysis in the software test processes. This paper introduces the method that applies fuzzy logic in software test metric, making software test metric more accurate and efficient. This method can increase liability and accuracy in software test and it is regarded as a practical software metric test.¹

KEYWORDS

Fuzzy logic; Testing metric; Software test

FUZZY LOGIC

Fuzzy logic was first proposed by LotfiZadeh in 1965, which applies fuzzy set and fuzzy rules to inference through imitating uncertainty concept judgment and reasoned thinking of human brain. Fussy logic solves plenty of uncertain problems derived from the lack of logoic “discipline”. Therefore, it can judge and decide effectively in uncertain environment.

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FUZZY LOGIC IN SOFTWARE TESTING METRIC

Software testing metric based on fuzzy reasoning, applies fuzzy weight allocation algorithm to deal with the relationship between software quality characteristics.

**Determination of Testing Item (Level) Fuzzy Set**

In the fuzzy theory, to compare similarities of fuzzy sets relating to variable \( C_i \) in two testing items \( P_m, P_n \), these two fuzzy sets must contain member functions of the two variables \( C_i(P_m) \) and \( C_i(P_n) \). This relationship implies the following If-then rules: \( \text{If} C_j(P_m) \text{is} A'_j \text{then} C_j(P_n) \text{is} A'_j \),

\[
S_k(P_m, P_n) \text{represents similarities between testing items } P_m, P_n \text{ and number } K \text{ fuzzy set that relates to linguistic variable } C_j: S_k(P_m, P_n) = \text{simp}(\mu_{A'_j}(P_m), \mu_{A'_j}(P_n))
\]

Where, simp is an uncertain function for calculating the similarity of two parameters. \( S^C_j(P_m, P_n) \) represents all semantically related similarities between two test items \( P_m, P_n \) and linguistic variable \( C_j: S^C_j(P_m, P_n) = \text{aggr}(S_k^C(P_m, P_n)) \),

Where, aggr(x) is a set of uncertain functions that compute the aggregation of the parameter x. Selecting the max-min aggregate function, is:

\[
S^C_j(P_m, P_n) = \text{max}(\text{min}(\mu_{A'_j}(P_m), \mu_{A'_j}(P_n)))
\]

**Weight Calculation of Quality Characteristics**

\( W_{i,j} \) is the weight of the quality feature attribute \( C_j \), which is the ratio of the number of test case steps associated with \( C_j \) in test case i to the \( C_j \) test steps in the whole test. The total weight \( W_i \) is the sum of \( W_{i,j} \) in the test item containing n test cases. The formula is:

\[
w_i = \sum_{j=1}^{n} w_{i,j} = \sum_{j=1}^{n} \left( \frac{\text{step}_{i,j} \times 100}{\text{step}_{c,j}} \right)
\]

In the above formula, \( \text{step}_{i,j} \) represents the number of steps of the number of i test case associated with \( C_j \). The correlation between linguistic variables and quality characteristics is low, nominal, average, high.

In software engineering practice, for ease of calculation, the weight vector is expressed as \( \vec{W} = (w_1, w_2 \ldots w_n) \), Where \( W_k \) is the weight value of the evaluation element k, and \( \sum_{k=1}^{n} W_k = 1 \) (\( \forall W_{k,1} \in [0,1] \))
Features and Applicable Conditions of the Method

Fuzzy logic is introduced to represent the fuzzy and uncertain interrelations between test cases and quality characteristics, which brings a more reasonable representation for the imprecise and uncertain interrelations between components in test cases. This method can effectively measure and evaluate the quality and effectiveness of the test project. Considering that the type of software has significant effect on the experimental measurement, this method is applicable to the general software type.

APPLICATION SAMPLE

An example is given to illustrate the application of multi-software test quality. To obtain the results, it is assumed that the “functional” is evaluated as indicator of software quality. The steps of software quality test are:(1) determining the "functional" indicators as A =

\( (a_1, a_2, a_3, a_4, a_5) = \) ("reliable", "maintenance", "right", "use", "functional", "compliance") (2) determine the evaluation level of the basic factors: E=(e_1, e_2, e_3, e_4) = (A,B,C,D). It is assumed that the lower level has assessed the secondary indicators of "functional" indicators according to the multi-factor software quality assessment, and the subordinate value of each secondary indicators at the level is obtained, which constitutes a membership value on the fuzzy relation A x E. Assume K membership value of each secondary indicator is:

\[
K = \begin{bmatrix}
0.30 & 0.60 & 0.10 & 0 \\
0.50 & 0.30 & 0.10 & 0.10 \\
0.40 & 0.45 & 0.10 & 0.05 \\
0.20 & 0.60 & 0.10 & 0.10 \\
0.60 & 0.20 & 0.20 & 0
\end{bmatrix}
\]

The values of each row in the hierarchy represent the membership value of each the secondary rating levels for the "Functional" indicator. For example, the values of the third row of the matrix indicate that the correctness indicator belongs to the A-level value of 40%, the subordinate B-level value is 45%, the subordinate C-level value is 10%, and the subordinate D-level value is 5% respectively.(3) The weight vector for the “functional” indicator provided by the evaluation scheme is W=[0.40 0.10 0.20 0.20 0.10 ].(4) The max-min synthesis operation is performed by the weight vector W and the evaluation matrix K to obtain the software quality evaluation result fuzzy set D:D=W×K=[0.35 0.50 0.11 0.04]

Within the result of the operation in the vector D, the value of d 2 component is the maximum value, therefore it can be determined that the evaluation value of the "functional" indicator is the emphasis level B, that is, the evaluation result of the program or software has been evaluated as level B.
evaluation is good, and the membership value is 50%. This result is consistent with the reasonable results of the experts' qualitative assessment, the results obtained from this experiment are more persuasive be data and supported by fuzzy set theory.

CONCLUSIONS

This paper promotes the fuzzy logic test metric significantly, improving effectiveness of software test and meanwhile reducing cost. Its application fulfills the characteristics of fuzzy logic and development of software engineering, and solves the problems of easy quality and uneasy quantity in test matrix and evaluation efficiently. Thus, it improves the accuracy and reliability of quality estimation for software test.

REFERENCES

1. Ting Zhang, 2011. “Software Test Metrics Based on Fuzzy Logic” [J]. Harbin Engineering University, School of Computer Science and Technology, 18(4).
5. Xin Lu, Jianming Liao, June, 2007. Software Quality Assessment Based on Fuzzy Set Theory [J]. School of Computer Science and Engineering, University of Electronic Science and Technology of China, 36(3).