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Assessment of Software Reliability of Information-Control Systems Based on Fuzzy Automata

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ABSTRACT: In order to determine the type of process mapping of software to function in a mode of formation of functional failure it is presented as a process of operation of the fuzzy automata. Based on the results, the functioning of the software in the form of an algorithm of fuzzy automata for software reliability presented in a way so it is possible to estimate the ratio of 'the total number of states - the number of functional failures' as an implementation of the algorithm of fuzzy mathematics. The example of reliability estimation of a real computer system software is given.

KEYWORDS: softwarereliability, information-control systems, software failure, functional failure, formation mode, linguistic model of the system, cause-and- effect relationships.

I. INTRODUCTION

The issues related to improving the performance of computer systems (CS) are currently very topical. In this context, the reliability of software as one of the components of quality of functioning is of particular importance. In general, the computer system includes a complex of technical means (CTM) and software. Of greatest interest is the reliability of the whole system, but given that the physical nature of the CTM and the software is different, it should be assumed that a unified evaluation of reliability of functioning of the entire system can be formulated with regard to a number of restrictions.

Reliability of CTM determined by conventional methods of analysis used in the theory of reliability. Reliable operation of the software, as will be shown below, it is advisable to evaluate the methods based on the ideas of fuzzy logic. Software as a product of human intellectual activity, has all the attributes that are inherent in this type of activity: blurred productions major challenges not formalized criteria and constraints, the need to make a decision in the case of insufficient (or unreliable) source of information, etc.. On the other hand, as a product for industrial use , the software must possess all the attributes of this product: the metric for comparing performance, etc..

It should be noted the dual nature of the term "reliability" is applied to software. If the concept of failure in the technical means of uniquely formulated, the physical reasons for the "technical failure" clear and usually unambiguous, then the concept of "software failure" is to some extent subjective.

For example, the flashing of the display screen from one air traffic controller is considered functional failure, but another manager in this situation is working properly. In addition, if it is possible to eliminate the situation in which the function is performed by software, the failure of the software is not fixed and the reason is not detected. Thus, as software upgrades during its accompanying software failure concept is modified.

Difficulties in trying to use of traditional theory to software reliability due to the fact that in the real world functional Sun failures because the software is relatively rare, so reliable statistics on the basis of which can be made objective conclusions can be made only after many millions of hours of sun, and although the significance of these failures is extremely high, to apply their analysis and probabilistic methods impractical, furthermore, these estimates may give an erroneous result basically.

Nevertheless, the assessment of the reliability of the software (fault tolerance) so far performed using indicators that are probabilistic nature [1, 2].

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For example, in [1] the probabilistic characteristics activities as operating time to first failure in the execution of programs (FER) in some forms can be considered as the criteria of reliability programs. It is necessary to further knowledge about the operation of the software after the failure in the recovery process.
Software computer systems is a product of human intellectual activity, which is inherent in the production of eyestrain and statement of the main tasks, criteria and constraints, as well as the inability to use the analysis of the absolute ratings [1].

II. SOFTWARE RELIABILITY ASSESSMENT

In determining the reliability index of the functioning of the software it is necessary to consider the causal relationships that exist in the software in the formation of functional failure, which it is advisable to treat the formation of the state of the software, in which the functions assigned to the armed forces, performed partially.
It is known that the procedure for the determination and calculation of the index changes the software to function due to the incompleteness of information, mathematical models used unreliable, weak formalization of the main tasks. The main sources of incomplete information are:
- a test set of input sets (IS) that does not coincide with the actual set of IS that take place under conditions of real operation of the computer system;
- subjectivity of the definition of the concept of "functional failure", FF;
- unreliability and / or insufficiency of statistics regarding the number of type of IS and FF [2,3].
The functioning of the software in the normal mode and in the formation of a functional failure is advisable to present as a fuzzy limited automata [4].
Assuming that is the only way NAv - X4 = {X4*} functional failure, the transition matrix Θ can be interpreted as the ratio of a finite set of fuzzy inputs X1 to a finite set of fuzzy outputs X4, And the quality of the functioning of the software can be represented as a tuple $<X1, X4, k_y, \Delta_T, T>$.
Here X4, X1 are fuzzy finite sets functional faults and input sets, respectively ranked by the values of the membership functions (the coefficients of significance $\mu_{(x)} \to [0,1]$ k_y is some function of X1, X4 (in general, fuzzy), $k_y = \to\to f(X1, X4)$; T is the time during which X1 and X4 are determined, and the interval for scanning the input and output X1 и X4; Δ_T .
As a measure of the reliability of software of CS for preliminary estimates, the ratio of the number of sets X1 ranked by the value of the membership function and reflecting the "significance" of the VL from the point of view of its influence on the formation of the FF, to the number of FF-X4, also ranked by the value of the membership function [5, 6].
The "significance" of IS depends on the type of subset of IS that pertain to the subset described by the fuzzy statement (the HIGH probability) is less important for the formation of a functional failure than the IS described by the statement (IS probability LOW).
Analysis of the reasons that led to the search for a new indicator of the quality of the software, the possible ways and prerequisites for the synthesis of such an indicator, indicates the need to build an algorithm of fuzzy arithmetic (FA), which has compared with the traditional higher constructivism. Consideration of the logical-linguistic model of the process of functioning in the mode of education Functional failure determines the appropriateness of its representation in the form of a fuzzy mapping of the set of functional failures to the set input sets.
When determining the type of mapping, the process of functioning of the software in the mode of formation of the FF is represented as the process of functioning of a fuzzy automata (FAu). On the basis of the representation of the process of functioning, an algorithm for estimating the reliability of software based on the relation "total number of states-the number of functional failures" as an implementation of the fuzzy mathematics algorithm is proposed in [7].
Let us turn to the example of reliability assessment of software of information-control systems based on the data bank of a real system.
To evaluate the reliability of the software, a program-algorithmic complex was developed, the basis of which is the database (DB). The input (IS) is the number of objects under control (CS); Inputs from the keyboard, the processor load was not taken into account, which allowed selecting a scan interval of 5.
The output (output state) is defined as "the external manifestation of the situation at the same (or near) times as the input". In this case, both the system messages (protocol) and the actions of the personnel (if they were needed) were used to estimate the output state in the absence of messages [8].

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Thus, the pairs "input-output" were obtained (26.27 $\Rightarrow$ counts 2.11.16). The selected scan interval allowed one to get at least 200 measurements per day ("input-output" pairs), which were then analysed using the proposed technique.
Let's explain the individual fields of the database: number. 4, 5, 6, 7, 8 - "situation category - expert evaluation of the output state", has gradations 0.1, 0.3, 0.7, 1.0. The value 1.0 means the total loss of the functions performed, 0.1 the loss by 10%, and so on.
Two cases were considered: the system before modernization (C1) and the system after modernization (C2). In order to simplify the calculations and their "transparency", only those situations ("input-output" pairs) were taken into account, for which the membership functions ("significance") are not lower than 0.01 $\div$ 0.1. The measurement time is a day, the scanning interval is 5 minutes. [9].
C1: input sets (input) in accordance with their "significance" (effect on the formation of functional failure):

$$X11 = \{19/0.18,\ 20/0.2,\ 22/0.12),$$

The output state (the number of functional failures) is produced similarly:

$$X41 = \{1/0.16,\ 2/0.66,\ 4/0.01\}$$

C2:

$$X12 = \{28/0.113,\ 30/0.101,\ 33/0.07\},$$
$$X42 = \{2/0.195,\ 3/0.56,\ 5/0.024\}.$$

Let us calculate the value of k_y for Cl and C2 systems:

$k_y^1 = X1^1 : X4^1$ =

19	0.18
20	0.20
22	0.12

:

1	2	4
0.16	0.66	0.01

=

19	20	22
19/0.16	20/0.16	22/0.12
9.5/0.18	10/0.12	11/0.12
4.75/0.01	5.0/0.01	5.5/0.01

=

$\cong$ {9.5/0.18, 10/0.2, 11/0.12};

$k_y^{(2)} = X1^2 : X4^2$ =

28	0.113
30	0.161
33	0.09

:

2	3	5
0.190	0.56	0.024

=

28	30	33
14/0.113	15/0.161	15.5/0.07
9.53/0.113	10/0.161	11/0.07
5.6/0.02	6/0.02	6.6/0.02

=

$\cong$ {9.33/0.113, 10/0.101, 11/0.07}.

To determine the preferences, we formulate a standard of reliable software functioning. In particular, such a model can be a system of statements, for example: a) (NO FUNCTIONAL FAILURE DOES NOT HAPPEN IN THE FOLLOWING OF INPUT SETS), or b) (WITH INPUT KITS WITH A SIGNIFICANCE COEFFICIENT 0.5 $\div$ 1 (i.e. FROM THE BODY OF HH «D») THE QUANTITY OF FUNCTIONAL REFUSALS SHOULD NOT EXCEED 10% OF THE NUMBER OF (IS) FROM THE SUBSTATION) or others. For case a), the tuple has the form (0, 0). We compute the "distance" separating the reliability index of C1 and C2 from the standard. As is known, linear and quadratic distance between fuzzy sets A and B is calculated as:

$$d(A,B) = \sum_{j=1}^{n} Mod(\mu_A(x_j) - \mu_B(x_j));$$

$$e(A,B) = (\sum_{j=1}^{n} (\mu_A(x_j) - \mu_B(x_j))^2)^{1/2}.$$

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It can be noted that even without carrying out calculations $d_1(O,k_y^{(1)}) \succ d_2(O,k_y^{(2)})$, $e_1(O,k_y^{(1)}) \succ e_2(O,k_y^{(2)})$, that since d1({0},{0.18, 0.2, 0.12}) >d2({0}, {0.133, 0.161, 0,07}).

Thus, the reliability of the functioning of software C2 is higher than the first, because $k_y^{(2)}$ it is closer to the standard than $k_y^{(1)}$.

Note that such a conclusion could be made if we assume that all IS and FF are equivalent, that is, clear, or by applying the index of comparison of fuzzy numbers. In the first case, $k_y^{(1)}$ =61/7, $k_y^{(2)}$ =91/10, т. е $k_y^{(1)}$ =8.7 $\prec$ $k_y^{(2)}$ =9.1,, in the second case $k_y^{(1)}$ =10/0,2 $\succ$ $k_y^{(2)}$ =10/0,101.

Note that $k_y^{(1)}$ and $k_y^{(2)}$ are approximated by the statement (approximately 10).

III. CONCLUSION

Thus, algorithms for performing fuzzy arithmetic operations based on the application of maxmin-composition together with the matrix form of FA operations are developed. The high efficiency of the proposed algorithm of FA, its constructiveness and machine reliability is shown. The analysis, several experiments with real computer system, showed the expediency of using the value k_y=$X1/X4$as an indicator of the reliability of the operation of the computer system.

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