A Novel Method for Allocating Software Test Cases

Amrita\textsuperscript{a},*, Dilip Kumar Yadav\textsuperscript{b}

\textsuperscript{a} Research scholar, National Institute of Technology, Jamshedpur- 831014, India
\textsuperscript{b} Associate Professor, Dept. of Computer Applications, National Institute of Technology, Jamshedpur- 831014, India

Abstract

Operational Profile is found to be an important technique for critical fault removal. Software Operational Profile (SOP) plays a vital role in reliability estimation, quality valuation, performance analysis and test case allocation of software. However, some problems are detected by software experts with the development of SOP as data resources are very limited and large effort is required to convert gathered data into point estimate. Also uncertainty is involved with SOP as it often changes during operational phase. Software operational profile plays a crucial role in improving the software quality. Therefore, in this paper, software test case allocation using fuzzy logic based on operational profile based is proposed and it takes usage data in terms of linguistic variable. The model is validated with the existing literature. Validation result is satisfactory.

© 2015 The Authors. Published by Elsevier B.V.

Keywords: software reliability; operational profile; fuzzy logic; severity; occurrence probability

1. Introduction

Software systems are growing large and complex. This type of system has multiple numbers of modules. It may be possible that some modules have more execution than the remaining ones. So, instead of allocating resources for lesser used part, resources should be allocated to most used part. Also there is need for assurance of reliability and quality of modules. Reliability is very important for some safety critical software, otherwise it will cause to human deaths also. Reliability is defined as the probability of failure free operation within a predefined time under a specified condition\textsuperscript{3}. As per user’s perspective, quality product can be obtained if
product is reliable and reliability can be obtained by testing the system. Previously traditional modelling and metrics was used for reliability as there were no expectations from users. However, in last few years, user’s orientation is changed towards quantitative expectation of the quality and reliability of the software. Therefore there is change towards modelling which is shifted from developer’s point of view to user’s point of view. User’s point of view is related to actual usage of the operation. Operational profile has been found best way to express the intended use of software in execution environment. Operational Profile is the quantitative characterization of the system usage. SOP has a set of operations with their occurrence probability. SOP has vital use in various applications. Developers face difficulty in developing SOP because it requires huge requirement of quantitative data which may or may not be available as it may be the case for a new release software. Moreover data collected in early stages are fuzzy in nature, so traditional methods are unable to develop SOP with fuzzy data. Some researchers suggested to use expert opinion to apply fuzzy in the development of SOP. Horgan et.al. suggested that there may be the cases when data collection is not appropriate and there is need to rely on educated guess, this is called expert opinion. According to this opinion, Kumar et.al. has given an approach for the development of SOP using fuzzy data. It is named as Fuzzy Software Operational Profile (FSOP), which is phase-wise approach, in which input record is fuzzified using generalized fuzzy profile by assigning occurrence probability for software operations based on expert opinion. The fuzzified profiles obtained from the experts are subjected to processing and post processing operations and thus the final Fuzzy Software Operational Profile (FSOP) can be obtained. After the development, now it is required to assign proper number of test cases in order to achieve reliability. Proper test case allocation plays an important role in estimating software reliability. In order to predict software reliability from test data, test cases have to be similar to the operational usage of the software. A good level of input coverage can be obtained by optimal allocation of test cases. In this paper, a model has been proposed to allocate test cases to the operational profile using Fuzzy Inference System. This model gives flexibility to the users to allocate test cases by giving appropriate priority to occurrence probability and severity of operations given by expert opinion. The rest paper is organized as follows. Section II discusses about previous work. The proposed model has been presented in section III. Results and validation are given in section IV. Finally section V provides conclusion.

2. Related Work

Researchers presented the use of Operational Profile and also how to allocate test cases based on it, but here comes one problem i.e. minutely observed, the problem of test case allocation for infrequent operations. Musa has given that considering only occurrence probability is not enough sometimes, because there may be the cases in which criticality of operation is important inspite its infrequency. Musa classified operations in two categories which are frequent, infrequent & critical operation. In musa’s paper, equal number of test cases are assigned to both frequent critical & frequent non-critical operation. Sravana has presented 4 categories which are frequent & critical operation, frequent & non-critical, infrequent & critical and infrequent & non-critical. Musa proposed methods for the allocation of test cases to infrequent operations which are:

2.1 Combine or trim infrequently occurring operations
2.2 Weight operational profile by criticality
2.3 Classify operations by category of criticality.

In 1997, Leung and Wong emphasized the importance of operation-based testing by allocating test cases using weighted criticality method. A method for the allocation of testcases to infrequent and critical operations has been presented by Arora et al. in 2005. In 2012 Srivastava et.al. has given an approach of allocating test cases based on the activity diagram. He proposed a TCBAD model that allocates test cases according to activity diagram, and activity diagram are used in representing the workflows of stepwise activity and actions with support for choice and iteration.

All the above approaches want to apply test cases without considering the other factors that are necessary to
keep in mind, while doing allocation of test cases. There are many different cases which affect reliability of a software, and it depends upon the application in which it is executing. Suppose software is employed in two different application web resource application and air traffic control system. Both applications are different and require different attention as users of web resource application, concerned about performed operation and least consider about criticality. So considering web resource application preference has been given to occurrence probability. In the other case of air traffic control, criticality of operation need to be care rather than performance, so preference will be given to criticality. Section 3 will present the model, which considers both occurrence probability and severity uses linguistic variables for the inputs.

3. Model architecture

This model presents two inputs severity and occurrence probability to the fuzzy inference system for applying fuzzy rules, which is then combined to obtain fuzzy set. Now this fuzzy set is defuzzified to get its equivalent crisp value. After getting its crisp values, test case allocation will be performed. Test case will be allocated based on the criticality and probability of occurrences. There are 4 possible categorization of these two inputs, based on that total number of test cases will be allotted. These are frequent & critical operation, frequent & non-critical, infrequent & critical and infrequent & non-critical. So as it is known than operational profile is developed for the most used part, emphasis is given more on frequent and critical operation, but it is not always necessary that only frequent operations are critical. There may be a case where the operation is infrequent and still it is critical. For ex. Missile launching is infrequent operation but its criticality is high. Previously Musa has given equal number of test cases to both operations. Here are the steps for the models by giving two inputs and finding the final output which is total number of test cases.

3.1 Defining membership function for both input and output function.
3.2 Design fuzzy rules for each input and output function.
3.3 Combine all fuzzy sets and defuzzify it in order to get its crisp value.
3.4 The resultant crisp value is its output function.

3.1 Defining membership function for input and output function:

Membership function is used to describe the fuzziness of a fuzzy set. Membership functions can be presented by graphical representation, it includes many shapes but there is restriction on using different shapes. The assignment process can be done by either some intuitive method or some procedure. Different methods for assigning membership values to fuzzy variables are intuitive, inference, rank ordering, angular fuzzy sets, neural networks, genetic algorithm. In intuitive method, membership value is assigned based on the human intelligence and its capability of thinking. In inference method, knowledge is used to perform deductive reasoning. Rank ordering uses the concept of polling by individual, group or some committee. Angular functions are applied in quantitative description of linguistic variables of truth values. Genetic algorithm uses the concept of Darwin’s theory and it follows some steps for assigning membership values to fuzzy variables. Triangular membership function is used for representing linguistic states of input and output functions.

<table>
<thead>
<tr>
<th>Table 1: Fuzzy ranges for input and output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input</strong></td>
</tr>
<tr>
<td>Occurrence probability (0,1)</td>
</tr>
<tr>
<td>Severity (0,1)</td>
</tr>
<tr>
<td>Output Number of test cases (0,20)</td>
</tr>
</tbody>
</table>
3.2 Designing Fuzzy rules:

Fuzzy rules are the basis for a knowledge based system. The AND rules of the IF_THEN form have been used in the proposed model. IF part of the rules are the Antecedents, whereas the THEN part are the Consequents. In our proposed model, the antecedents are the software input metrics and the consequents are expected total number of defects before testing. For each rule, value of the consequent is assessed by the domain expert. In this paper there are two input variables i.e. occurrence probability and severity and their 5 and 4 linguistic states respectively, so there are total 20 rules. These rules are as follows:

1. If (occurrence probability is very low) and (severity is minor) then number of test cases is very low.
2. If (occurrence probability is very low) and (severity is major) then number of test cases is low.
3. If (occurrence probability is very low) and (severity is critical) then number of test cases is medium.
   ..... 
19. If (occurrence probability is very high) and (severity is critical) then number of test cases is high.
20. If (occurrence probability is very high) and (severity is catastrophic) then number of test cases is very high.
3.3 Defuzzification

Defuzzification is the translation of a fuzzy quantity to a crisp quantity, just as fuzzification is the conversion of a crisp quantity to a fuzzy quantity. Various methods are available for defuzzification, which are max-membership principle, centroid method, weighted average, mean max, centre of sums and centre of largest area. Centroid method of defuzzification is used in the proposed model. This method is the most common and physically appealing of all the defuzzification methods. In order to obtain the number of test cases to be allocated for a particular software operation, the defuzzified value is normalized to the total number of test cases. Defuzzified value of the no. of test cases for operation 4 is shown in Fig. 5.

Fig. 4 Architecture of Proposed Model
4. Prediction Results and Model Validation

In 1997 Leung and Wong \(^2\) has given a fuzzy model for test case allocation in which importance is given to both occurrence probability and severity. Sravana et.al \(^7\) proposed test case allocation using fuzzy Operational profile. In this paper, a FSOP has been used for both frequent and infrequent operation. In order to check the adequacy of the model, equal importance is given to both severity and occurrence probability. Results obtained from Leung & Wong, Sravana et.al. and the proposed model is shown in table 2. As it is shown from table, total number of test cases is reduced in the proposed model and it can be shown by Fig. 6 given below. As we know that, it is always required to cover all possibilities with minimum number of test cases which will in turn reduce the testing effort. FSOP is used to cover all possible operations, frequent, infrequent, critical or not critical.

<table>
<thead>
<tr>
<th>No. of operations</th>
<th>Occurrence Probability</th>
<th>Severity</th>
<th>Leung Model ([2])</th>
<th>Sravana Model ([7])</th>
<th>Proposed Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.3</td>
<td>0.3</td>
<td>20</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>0.4</td>
<td>0.2</td>
<td>17</td>
<td>14</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>0.1</td>
<td>0.4</td>
<td>9</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>0.2</td>
<td>0.1</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>(\Sigma)</td>
<td>1</td>
<td></td>
<td>50</td>
<td>50</td>
<td>45</td>
</tr>
</tbody>
</table>

Number of test cases have been reduced in the proposed model which clearly shows that the presented work performs better than the previous models. Proposed model covers all possibility with minimum number of test cases, also it includes more number of linguistic variables for input states suggested by experts. For Operation 4, no. of test cases is modified to 5 for optimality.
5. Conclusion

This paper proposes fuzzy inference-based test case allocation using operational profile. This proposed method takes linguistic information of the two inputs, severity and occurrence probability. The proposed method is more convenient, reliable and eliminates ambiguities present in the earlier models. This model takes more number of linguistic variables for the inputs as suggested by expert, which results in more accurate result. The proposed model is very useful in enhancing the software quality and reliability at the reduced testing-efforts which in turn reduces the software development cost.

References


