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A REVIEW ON APPROACHES AND MODELS PROPOSED FOR SOFTWARE RELIABILITY TESTING

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Abstract- Reliability testing of software is the key area of concern now-a-days; specially with the software which are safety critical and security prone systems. There is always a need of high software reliability. Most of the present models for evaluation of software reliability are based on statistical and probability approach. When we look into the use of these models for software reliability testing, we observe that there are possibilities of imprecision in the reliability estimation. For removing this imprecision, the Fuzzy logic and Fuzzy expert systems are used within various researches. The use of Fuzzy logic for reliability estimation can enhance the reliability of software even during the early stages of software development. Here we are giving a comparison analysis of few approaches and models proposed so far, for the estimation of software reliability and its improvement using Fuzzy logic.

Keywords: *Software quality, Software Reliability, Fuzzy logic, Reliability estimation.*

I. INTRODUCTION

Software testing is the integral part of Software development life cycle. It is the gateway to software usage for different purposes. Software testing is defined as “ the process of executing a program with the intent of finding errors.” By Glen Myers.

Errors may begin at very initial stage of software development as well as in later design and development stages. Mostly, in a software system design, 30-40% of the total system cost is used for software testing. Sometimes in more security and safety related systems the testing cost may reach to 3-5 times of the entire software development costs. The software and hardware are integrated and a full range of system tests are required to conduct to uncover errors at the software and hardware interface.

In real life, where software systems are used for applications, their assurance for reliability and safety becomes very important. In many sectors, the reliability assurance is justified by compliance with certain process standards. In recent times, there has been emerging the need to have an alternate approach to certify the reliability and safety of software based on some reasonable logics. In software engineering, these are referred as Software Assurance Case. But there has been a difference with the subjective nature of software assurance argument alone to which it is considered as Informal Logic compared to Formal mathematical logic. This has been an area of discussion in software engineering as there are many applications in software engineering that uses formal mathematical logic to achieve high confidence in software reliability and safety approaches. The role of assurance arguments and mathematical arguments in software reliability and safety can be understood as follows:

- Sometimes mathematical arguments make the core part of assurance arguments and provide justification to claim the certification.
- In some cases, assurance arguments are main justification arguments by which the mathematical arguments are formed.
- In some cases, both mathematical and assurance arguments merge together and explain each other.

II. REVIEW OF SOME APPROACHES AND MODELS PROPOSED FOR SOFTWARE RELIABILITY TESTING

Different approaches and models have been proposed for reliable software testing. These approaches and models are helpful in one or many ways to enhance the reliability of software system. Some of them are following:

A. : *Estimation of Software Testing Effort*

An approach was proposed for estimating Software Testing Efforts (STE) by Praveen Rajan Srivastava. For this , an algorithm was constructed to assess STE as 40-50% of software development. Effort estimate is used as input to project plans. This approach was based on the Software Testing Effort Estimation by Fuzzy model with the integration of COCOMO (i.e. Constructive Cost Model) Generally estimation of Software Development Efforts(SDE) including STE in COCOMO is dependent on one factor LOC (Line of Code) estimated by senior project manager developing on its own capability. Fuzzy logic helps to find exact confidence value (C) . Then this value can be used to estimate project size and SDE. Fuzzy logic is a powerful tool for solving real world problems with imprecise and uncertain information. In this model, fixed triangular

membership functions have been considered for the analysis. Then Fuzzy rules are derived from the functions which are further used to express the information for interpretation of the nature of STE. Implementation of Fuzzy logic allows the integration of numerical data with knowledge to resolve the cost and quality related problems of software engineering. The results obtained by this algorithm are very useful. However, there was a difficulty observed with the use of this model to determine and fine-tune the Fuzzy rules which depends on experience only. The interpretation of each Fuzzy rule is made by analyzing its basis and its output which provides a generalization capability within the domain.

B. Software Reliability Assessment via Fuzzy Logic Model

In Software systems, the non-functional characteristics are very important while calculating software reliability. One of the many proposed approaches to evaluate such characteristics is given by Olga Georgieva and Aleksander Dimor using Fuzzy logic. In this approach it is stated that one can be satisfied by testing results if there is a trust that system will continue to perform according to expectations for a certain period of time ; i.e.; Time Between Failure (TBF) are satisfied. This Fuzzy model enables to calculate the TBF value using below steps:

- Fuzzification ; i.e. ; transformation of crisp values of Number of Failures (NF), Mean Time Between Failures (MTBF) and Time Between Failures (TBF) into degree of match with variables.
- The consequent value of individual rule is a fuzzy value.
- Application of “also” logical connector.
- Defuzzification i.e. transformation of overall fuzzy results of TBF into a crisp value.

This approach is better fit to dynamically changing failure behavior than the statistical approaches.

C. Improved Software Reliability Prediction through Fuzzy Logic Modeling

The another approach towards software reliability assessment using Fuzzy Logic and Normalized Root of Mean of the Square of Error (NRMSE) is given by Sultan Aljhdali & Narayan C. Debnath (Winona tate University USA). The models performances were measured in terms of NRMSE :

$$\frac{1}{n - 1} \sqrt{\sum_{k=1}^n \frac{(y(k) - \hat{y}(k))^2}{n}}$$

Where y(k) is the actual accumulated faults and $\hat{y}(k)$, k are the estimated accumulated faults.

The model structure was based on Takagi-Sugeno (TS) Fuzzy model suitable for large class of non-linear systems. The relation between system input u(k) and output y(k) is given as :

$$y(k) = f(\mu(k-1), y(k-1))$$

where function f is the static function. One of the used model is NARX (Nonlinear Auto-Regressive with eXogenous input)

$$y(k) = f(y(k-1), y(k-2), \dots, y(k-n+1), \mu(k-1), \mu(k-2), \dots, \mu(k-m+1))$$

With this approach, the entire system of software reliability research is considered useful for software development and testing industry.

D. A Fuzzy Model for Early Software Fault Prediction Using Process Maturity and Software Metrics

Sometimes it is good to catch a software fault early during software development and is helpful to achieve more reliable software within certain period of time and cost. A model was proposed by Ajeet Kumar & N. K. Goyal to predict total number of faults before testing with the help of Fuzzy expert system. The model was proposed to predict total number of faults at the end of each software development phase using reliability relevant software metrics and CMM level (Capability Maturity Model). Early fault prediction provides an opportunity for early identification of software quality and optimal development strategies. This consider two most significant factors ; Software metrics and Process maturity; for fault prediction. The software metrics are classified in three categories as Product metrics, Process metrics and Resource metrics. There are around thirty software metrics associated with SDLC, many of these are significantly used for reliability prediction. This model was implemented in MATLAB utilizing Fuzzy logic by identifying input/output variables, development of fuzzy profile of these input/output variables and fault prediction at the end of each phase of software development life cycle using fuzzy inference system. This model provides an insight towards software metrics and its impact on software fault during development process.

CONCLUSION

The review of different approaches and models in the proposed paper described that the use of Fuzzy logic is very useful in the field of Software testing . The reliability of software testing can be improved to a large extent by the use of fuzzy logic and used for building software reliability growth models. The entire system of software reliability research is

considered useful for software development and testing industry. At present we are investigating the use of genetic programming to solve the software

reliability growth modeling problem. The results obtained with these models and approaches are very encouraging. However, one of the greatest difficulties in using these models is determining and fine-tuning of fuzzy rules which depends on the exposure and experience of the decision maker. The use of fuzzy logic allows the integration of numerical data and expert knowledge and can be a powerful tool when tackling important problems in software engineering such as cost and quality prediction. In this study there are only four approaches have been considered to review the earlier researches. A number of extensions and applications of the model may be possible by using techniques like artificial neural networks and combination of neurons-fuzzy approach. These techniques can be used to model more complex problems and considerable need for applied research and strategy evaluation in this area using these techniques.

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