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A Fuzzy Inference Model for Reliability Estimation of Component Based Software System

Gopal Prasad Jaiswal [1], Ram Nivas Giri [2]
Research Scholar [1], Assistant Professor [2]
Department of Computer Science and Engineering
RITEE Raipur
CSVTU Bhilai, Chhattisgarh
India

ABSTRACT

Software reliability means the probability of the uninterrupted operation of a software system for a specified period of time in a specified environment. Software Reliability Modeling has been one of the much-attracted research domains in Software Reliability Engineering. Day by day software applications are growing more complex and with more emphasis on reuse. Component Based Software (CBSS) applications have developed. We concentrate in this paper is to provide an model for the Component Based Systems reliability estimation. This New reliability models are derived on fuzzy logic such as if-then rule to estimates software reliability depend on the component structure of code. The models can analyze dependent component, operation profile, reusability and most software reliability of the CBSS. Here, we are applying Fuzzy Inference System approach to estimate the reliability of component-based software system with respect to software reliability factor.

Keywords:- Component, Component Based Software system (CBSS), Fuzzy Logic, Fuzzy Inference System (FIS), Reliability, Application Complexity, Component Dependency, Operation Profile, Reusability, Fuzzification, Defuzzification, Rule Based Model, Path Based Model, Additive Model, etc.

I. INTRODUCTION

Software reliability is defined as the probability of failure – free software operation for a specified period of time in a specified environment. The reliability of a software product is usually defined to be "the probability of execution without failure for some specified interval of natural units or time" [1]. Software reliability is a feather of any software. Software reliability is depends on performance of successful operations and function as well as less complexity, maintainability, portability, flexibility and so on. Basically we can say that software reliability is a feather of the software that to be depend on another feather of the software. Hence, we cannot simply define it. In a binary form we can say that if software is correct and failure-free then its reliability is 1 else 0. Reliability is still predict probabilistically as

Software Reliability = [1-probability of failure]

Software reliability is mostly depending on reusability of the software because reliability of the software is directly proportional to its reusability. For this purpose many year ago object-oriented programming system (OOPS) concept is appear for software development. But he was not successful as per requirement. After that another concept is appear in development floor that is Component Based Software System (CBSS) Component Based Software System (CBSS) is a paradigm that aims at constructing and designing systems using a pre-defined set of software components explicitly created for reuse. Component based software development is most promising approach for software development today. This approach is based on the idea that software systems can be developed by selecting appropriate off-the-shelf components and then assembling them with well-defined software architecture [2]. This new software development approach is very different from the traditional approach in which software systems can only be implemented from scratch.

This paper presents Fuzzy Inference model for reliability estimation for the component based software system. Here we will use fuzzy logic for estimating the reliability of the software. Fuzzy logic provides logical capabilities as well as learning capabilities for decision making. Logically decision that is Fuzzy Inference System (FIS) based on fuzzy rule and learning capability based on training for decision making that is Adaptive Neuro Fuzzy Inference System (ANFIS). In this paper we will use Fuzzy Inference System (FIS) for reliability estimation of component based software system. Here, we are adopting different number of

membership functions (such as two and five number of membership functions) for estimation of component based software system and analysis which one better.

Rest of the paper is sorted out as follows Division-2 related research work Division-3 proposed framework. Division-4 proposed methodology for CBSS reliability. In Division-5, experiments and result analysis of different approaches has been calculated. Paper is concluded with a summary report and the description for future work in Division-6.

II. RELATED RESEARCH

In this software reliability estimation many number of models proposed for estimating CBSS reliability. We can summaries these approaches into three types [3]:

- Architecture Based Reliability Models
- Mathematical Model for Estimating CBSS Reliability
- Soft Computing techniques for estimating CBSS reliability

A. Architecture Based Reliability Models:

Shooman, 1976 “Structural models for software reliability prediction”, here consider the possible execution paths for estimating the reliability of an application. A sequence of components along different paths is obtained by either algorithmic or experimental testing [4]. Koziolek H., Becker, S., 2005 "Transforming operational profiles of software components for quality of service predictions" describe the role of a component as a transformer from one operational profile to another. Here components act as transformers to the operational profile and this transformation maybe based on extended service effect automata [17]. Cheung, 1980 “A user oriented software reliability model” user-oriented software reliability figure of merit is defined to measure the reliability of a software system with respect to a user environment. The reliability of a system is expressed as a function of the reliabilities of its components and the user profile, Means that the current behavior of a component is independent of its previous behavior. These models consider transfer among components to be Markov behavior, which means that the current behavior of a component is independent of its previous behavior. These models can be represented in two ways, namely, as composite models or as hierarchical models [5]. Zhang, F., Zhou, X., Chen, J., Dong, Y., 2008 "A novel model for component-based software reliability analysis" it is assumed that control flow transits from component i to component j, and the reliability of component j is calculated as Tij =Rij • Wij. This approach can characterize component reliability for an application when there are changes in the system’s operational profile [16]. Popostojanova and Trivedi, 2001; Cai et al., 2003; Gokhle, 2007 "Architecture based approach to reliability assessment of software systems" architecture-based reliability models such as state-based and path-based models and find out CBSS reliability depends not only on the architecture but also on the operational profile for the input[6] . Yacoub, S., Cukic, B., and Ammar, H., "Scenario based reliability analysis approach for component based systems" in 2004 propose an approach to reliability analysis called scenario based reliability analysis. This approach introduces component dependency graphs (CDGs) which can be extended for complex distributed systems. This approach is based on scenarios which can be captured with sequence diagrams, which means that the approach can be automated [7].

B. Mathematical Model for Estimating CBSS Reliability:

Dong, W., Huang, N., Ming, Y., 2008 “Reliability analysis of component-based software based on relationships of components” a new model for estimating CBSS reliability in which various complex component relationships are analyzed. The Markov model is used to solve these complicated relationships, which have a large impact on a system’s reliability. The results were used to develop a new tool to calculate software application reliability [8]. Huang, N., Wang, D., Jia, X., 2008 “An algebra-based reliability prediction approach for composite web services” proposed a technique based on algebra which provides a framework for describing the syntax and predicting the reliability of a CBSS. If operational profiles have been changed, the loop times of iteration will be changed [9]. Goswami V., Acharya, Y.B., 2009 “Method for reliability estimation of COTS components based software systems” proposed an approach to CBSS reliability analysis which takes the component usage ratio, which is the time allotted for a component’s execution out of the application’s overall execution time, into consideration. This approach can be used in real-time applications [10]. Seth, K., Sharma, A., Seth, A., 2010 “Minimum

spanning tree-based approach for reliability estimation of COTS based software applications" an algebra-based reliability prediction approach (Huang, N., Wang, D., Jia, X., 2008.) is to be used [11].

C. Soft Computing techniques for estimating CBSS reliability:

Dimov, Aleksandar, Sasikumar, and Punnekkat, "Fuzzy reliability model for component-based software systems" in 2010 a fuzzy reliability model for Component Based Software System (CBSSs), based on fuzzy logic and probability theory. A mathematical fuzzy logic model was based on necessity and possibility is proposed to predict the reliability of a CBSS. This model does not require component failure data because it is based on uncertainty. However, a mechanism is necessary to model the propagation of failure between components and failure behaviour [12]. Hai Hu, Chang-Hai Jiang, Kai-Yuan Cai, W. Eric Wong, Aditya P. Mathur, 2013 "Enhancing software reliability estimates using modified adaptive testing" proposed a software reliability estimation method using modified adaptive testing (MAT) for reliability of CBS. This approach can enhance the software reliability estimation testing by guiding test case selection process by providing more descriptive and accurate results [18]. Lo, J., 2010 "Early software reliability prediction based on support vector machines with genetic algorithms" proposed a software reliability estimation model based on an SVM and a GA. This model specifies that recent failure data alone are sufficient for estimating software reliability. Reliability estimation area for the SVM is determined by the GA. This model is less dependent on failure data than are other models [13]. Hsu, C., Huang, C., 2011 "An adaptive reliability analysis using path testing for complex component based software systems" proposed an adaptive approach for testing path reliability estimation for complex CBSSs. Path reliability estimation: these use sequence, branch, and loop structures. The proposed path reliability can be used to estimate the reliability of the overall application [14]. Tyagi, K., Sharma, A., 2012 "A rule-based approach for estimating the reliability of component-based systems" proposed an approach based on fuzzy logic for estimating CBSS reliability. In this approach, four critical factors were identified for estimating the reliability of a CBSS. They are used to design an FIS for the estimation [15]. Kirti Tyagi, Arun Sharma 2014, "An adaptive neuro fuzzy model for estimating the reliability of component-based software systems" propose a model for estimating CBSS reliability, known as soft computing model or an adaptive neuro fuzzy inference system (ANFIS), that is based on these two basic elements FIS and ANFIS, Here, we analysis its performance with that of a plain FIS (fuzzy inference system) for different data sets. This is a hybrid method that requires less computational time than traditional approaches and the previously proposed FIS approach [3].

III. PROPOSED FRAMEWORK

In Division-2 research work to read various models that to be proposed reliability estimation model and conclude that all the models have their own restriction to estimate the reliability of the Component Based Software System (CBSS). We have proposed a soft computing model But still soft computing model have various techniques are available. Some soft computing techniques are listed below:

- Fuzzy Inference System (FIS)
- Artificial Neural networks (NN) and Adaptive Neuro Fuzzy Inference System (ANFIS)
- Evolutionary Algorithms (EA)
- K-Nearest Neighbour (K-NN)
- Support Vector Machines (SVM)
- Probabilistic Reasoning (PR) or Probabilistic Logic (PL)
- Evolutionary Computation (EC)
- Genetic Algorithms (GA)
- Chaos Theory (CT)
- Hybrid Model

Our proposed soft computing model is based on fuzzy logic that to be overcome previously researched restriction and estimates the nearest reliability of the Component Based Software System (CBSS).

We are using fuzzy logic for software reliability estimation. Fuzzy logic is basically if-then rules syntactically. They will provide logical capabilities as well as learning capabilities for decision making. Logically decision that is Fuzzy Inference System (FIS) and learning capability based decision making that is Adaptive Neuro Fuzzy Inference System (ANFIS). In this paper we are using Fuzzy Inference System (FIS) for reliability estimation of component based software system.

Fuzzy Inference System: A Fuzzy Inference System (FIS) is a way of mapping an input space to an output space using fuzzy logic. FIS framework is displayed at fig. 1. FIS uses a collection of fuzzy membership functions and rules, instead of binary logic, to reason about data. The rules in FIS (sometimes may be called as fuzzy expert system) are fuzzy production rules of the form [19] [25] [26]:

if I then J, where I and J are fuzzy statements.

For example, in a fuzzy rule
if P is low and Q is high then R is medium.
Here P is low; Q is high; R is medium are fuzzy statements; P and Q are input variables; R is an output variable, low, high, and medium are fuzzy sets.

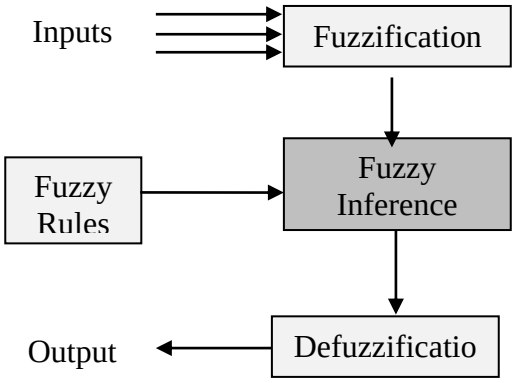

Fig. 1 Framework of Fuzzy Inference System

IV. PROPOSED METHODOLOGY

In this paper we will use soft computing techniques for software reliability estimation of Component Based Software System (CBSS). It paper is based on fuzzy logic based computing technique, and we are use Fuzzy Inference System (FIS). This model is performed logical rules in to some input variables. There so we will use some software feathers as a input variables for the calculation of the software reliability. Those feathers are listed below:

A. Reusability:

Reusability means how to use any component in multiple times without any failure or any other restriction called software reusability. The reliability of a component is directly proportional to its reusability. Component reusability is calculated on the basis of components feathers [3] [20] [21] [22] [23] [24].

Component Reliability ∝ Reusability

Reusability of the any software will be based on attributes, sub-attributes and there selected metrics. Here we are discussed about reusability attributes or Evolutionary model [20] that is reusability of the software is depending upon various attributes. This attributes are listed with their sub-attributes below Table I:

Table I Attributes and their Sub-attributes

S. No.	Attributes	Sub-Attributes
(1)	Understandability	Comments and Size
(2)	Portability	Independence
(3)	Maintainability	Complexity
(4)	Variability	Abstractness
(5)	Flexibility	Instability

Table I Evolutionary Model

According to software Evolutionary mode,

Reusability of Package = [0.2*Understandability +0.2*Variability+0.2*Portability+0.2*Maintainability + 0.2*Flexibility]

According to Reusability attribute model reusability of any package is calculating as follows:

B. Operation Profile:

Operation profile means how much number of operations was performed successfully. It will be directly proportional to its reliability [3] [15].

Component Reliability ∝ Operation Profile

C. Component Dependency:

Component dependency is feather of software. It gives information about how much component is dependent on another component [3] [15].

Component dependency ∝ (1 / reliability)

D. Application Complexity:

Application complexity is feather of any software that gives information about complexity of the software. Application complexity is directly proportional to number of component [3] [15].

Application Complexity ∝ (1 / reliability)

After the calculating these above software feathers, we are applying FIS soft computing technique in these calculated feathers (ex.-reusability, operation profile, and component dependency and application complexity) for reliability estimation of the Component Based Software System (CBSE). Fig.-2 described flow chart of our proposed model that to be given below:

V. EXPERIMENTS, OBSERVATIONS AND RESULT ANALYSIS

Table-II Software reliability analysis of FIS

Inputs feathers				FIS Output Reliability	
Application Complexity	Operation Profile	component Dependency	Reusability	3 membership functions	5 membership functions
0.703988662	0.140793109	0.851358641	0.775565915	0.179635353	0.331058397
0.704845012	0.140797131	0.851868132	0.776380979	0.179968596	0.331245331
0.443147251	0.387896017	0.81008991	0.562640442	0.483979923	0.323375651
0.450605782	0.405385044	0.832507492	0.562405104	0.5	0.425774082
0.557010478	0.475951475	0.883116883	0.646119443	0.5	0.56692347

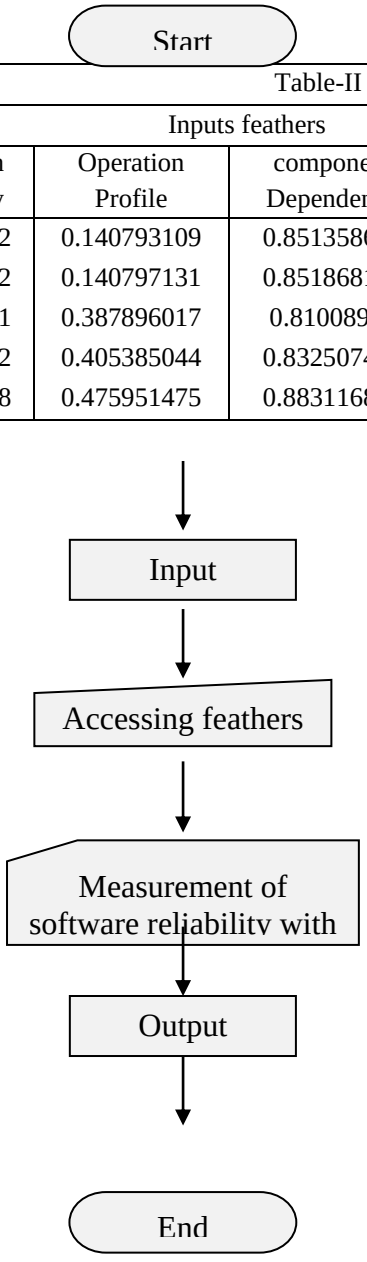

Fig. 2 Flow chart of proposed methodology

In this part, we are applying our methodology in between number of freeware software. We collected software data from www.sourceforge.net. Here we will use software data as a Jasmin and pBeans. Both the software is various versions are available in the www.sourceforge.net. After collecting the software data sets we are calculate the above described feather (ex.-reusability, operation profile, and component dependency and application complexity) for the estimation of software reliability. After this we are applying our FIS model.

Fuzzy Inference System model: we are using describes feathers as a input data set and calculated software reliability with three and five membership function separately. In FIS with three membership function total 81rules defined for fuzzy inference engine and calculate software reliability. Similarly for five membership functions total 625 rules are defined for fuzzy inference engine and calculate software reliability with basis of three membership function and five membership function separately.

The software reliability analysis of FIS is to be listed in above Table-II.

VI. CONCLUSION AND FUTURE SCOPE

We are estimate the reliability of CBSS. CBSS reliability is to be estimated by the FIS with two different number of membership function. After compression of the output reliability values for different input sets, than we are analysis that FIS model with five membership function is provide better result as per three memberships function based FIS Model. Here, CBSS reliability estimation performed in only four factors that is Reusability, Operational profile, Component dependency and Application complexity. But CBSS reliability affected by more other factor like Availability, Performance, Fault density, Software quality, Together with functionality, Capability, Install ability Usability, Serviceability, Capability, Install ability and Maintainability. Also we can extend this model for ANFIS with five membership function. So the addition of this factor as well as ANFIS model with five membership function is left for future work.

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