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Critical Insight into Maintainability and Reliability Assessment Aspects of Software Systems Using Soft Computing Approaches

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ABSTRACT

Maintaining software has always been a difficult task. In most cases,maintaining software takes greater time and effort than its development time. Also, predicting the software maintainability makes the process more complex. Reliability in terms of application software is characterized as the functioning of software i.e. carrying out its operations without any failure is the most important requirement of the Software. Researchers and developers are working on devising various techniques/algorithms for better prediction of these two aspects. Soft computing techniques like Fuzzy Logic, NeuralNetwork,Hybrid and several others have been extremely used for this purpose.In the present paper, detailed survey has been conducted on the various techniques for predicting reliability and maintainability of software system.

Keywords: Fuzzy Logic, Artificial Neural Network, Hybrid, SRGM, Genetic Algorithm

1. INTRODUCTION

Maintenance of software is the activity performed to keep system working, as and when the software changes after the deployment. Currently, published research literature proposed various techniques, to measure and predict software maintainability. Researchliterature also describes various features of maintainability and further showing scope to identify new features, to enhance the software maintainability measurement and prediction techniques.

Maintain ability defines the ease with which a software system or component to be agreed,in dynamic environment to perform as desired by correcting faults and other attributes in order to sustain its performance.There exists four categories of maintenance namely corrective, adaptive, perfective and preventive found in literature.

2. Literature Review

Many researchers have designed and developed different techniques to predict maintainability and reliability. The present work is divided into two sections: General Approach and Soft Computing Approach. Papers under General Approach considered analytical or mathematical models while soft computing involves various techniques like fuzzy logic, neural networks, Genetic algorithms and others. We have analyzed both the characteristics i.e. Maintainability and reliability separately which are discussed in subsequent section.

3. Maintainability Evaluation

There are no criteria or fixed formula to measure or evaluate the maintainability. To increase systems functionality and systems complexity, many researchers have given different terminology and methods to evaluate

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maintainability. Software maintainability is very important. If it is not handled and estimated in a proper manner then it would have a major and direct impact on money and time for software owners to make it cost effective.

3.1. General Approach

Tiwari & Sharma[1] define maintainability as critical because of costly action. Most recent advancement methodologies like component-based, aspect-oriented and others have a noteworthy assessment. This paper leads a nitty determined overview on the work done by distinctive specialists in this behavior. Hence there is an in numeral need to investigate the practicality inside and out to distinguish the qualities and sub-attributes on which maintainability depends.

Riaz et al [2] showed that a survey-based methodologywhere the objective is to check the maintainability criteria for the programming applications based on databases, with inputs from 40 programming expertsfor getting maintainability indicators for databases based on relational programming methods.Riaz et al [3] presented the results after analyzing the 56 software projects for evaluating the maintainability of relational database applications by using Case Based Reasoning (CBR), Classification and Regression Trees (CART) techniques. Result shown that CBR was better than CART in positions of prediction accuracy.

3.2. Soft Computing Approach

Grover et al [4] discussed about the maintenance of Component based systems(CBS). Theyfocused on maintainability concepts that include investigation .They proposed two characteristics trackability and portability and thussuggested a new maintainability model for CBS.Here authors have mentioned the advantages of component based systems that include low cost with high quality product.

Ardil et al [5] investigated the models based on diverse indicators for NASA's public domain by using Perl programming language. In this paper Mamdani Based Fuzzy Inference System and Neuro-fuzzybased system were assessed in terms of maintenance. The outcomes are documented in terms of accuracy,Mean Absolute Error (MAE), Root Mean Squared Error (RMSE).As a result Neuro fuzzy model can be used for maintenance as compared to other models.

Kaur et al [6] worked on calculating software Maintenance effort by using techniques like Artificial Neural Network, Fuzzy Inference systems and adaptive Neuro–Fuzzy. And in the end they found that Adaptive Neuro Fuzzy inference system technique is the most exact model.

Kumar et al [7] compared fuzzy logic and artificial neural network in calculating defect density of later software product delivery. The paper showed that artificial neural network offer better results as compared to other approach.

Sinha et.al[8] usedsupport vector machine(SVM) concept in association with the radial basis function method(RBFM) for improving the performance and accuracy. This helps in minimizing the generalization error and provides vast applications in the field of optical character recognition, recognition of objects, face recognition and so on. Result shows that SVM is better than RBFN.

Dhaka and Aggarwal [9] inspected the application of Artificial neural network for software quality prediction by means of object-oriented metrics. They implemented two approaches ward neural network and Hopfield neural networkto predict defects and efficient discovery mechanisms.

Sharma and Bhardwaj [10] evaluate the software maintainability by using neural network and relegalized the role of software maintainability in early stages for corrective measures.They mentioned Defect density a prime factor and usedeclipse project data for validation purpose.

Mewada et al [11] mentioned ANN, Fuzzy Logic and Evolutionary Computation ,Genetic Algorithms and Metaheuristic based Particle Swarm Optimizationtechnique for solving real-world ambiguities. The

authors illustrated that Adaptive Neuro-Fuzzy Inference System (ANFIS),gave significant results for designing an efficient software effort evaluation model.

Malhotra and Chug[12] considers five real life examples and showed that Object oriented software maintenance is possible using FFNN modelling approach and considers seven OO metrics for the same. The experimental results shown, this novel metric suite provides promising results in the field of remote servers, accessing huge databases and maintaining software also.

Tiwari and Sharma[13] forecast the maintainability for software applications by using an artificial neural network based approach. It also endorses Analytical Hierarchy Process approach by taking into consideration of twenty class room based projects.

Kumar et al[14]has evaluated the ANN model using historical data to predict the maintainability. Factors considered are multiple condition countnode, percentage comments and total lines of code. Beta results are achieved with 15 neurons, feed forward back propagation algorithm and trainbr learning algorithm in case of prediction.

Sheshasaayee and Jose[15]worked on the aspects of object oriented software development which maximizes the modularization rate. This paper demonstrated streamline architecture for redeeming maintainability modelfor aspect oriented frameworks utilizing officially characterized programming measures.

Dubey and Vern[16] also proposed fuzzy as a modelling point of view.

3.2.1. Analysis of the Literature Review

On the basis of above survey and detailed analysis of the work done by different researchers in predicting maintainability for various application development domains, the following table is summarized:

S. No	*Author*	*Approach*	*Factors/Approach*	*Result*
General Approach				
1.	Riaz et al [3]	Case-based reasoning (CBR)classification and regression trees (CART)	DocQual, QA, ChngLogs, DB Design, UstndApp, Design Rev, ChngPolappDB,DataTypes, Tools, Reqs, CodelInsp, Fversion, Dep Env App	CBRIs slightly better (at 76.8% CART (67.8%).
Soft Computing Approach				
2.	Grover et al [4]	Component Based Systems	Trackability and portability	Extensions self proposed for ISO9126
3.	Ardil et al [5]	Mamdani Using Fuzzy concept of Neuro and Fuzzy Inference System	Mean Absolute Error(MAE), root Mean squared error(RMSE) and Accuracy	Neuro fuzzy gives better results
4.	Kaur et al [6]	Soft Computing Approaches (ANN, Fuzzy Inference Systems, Adaptive Neuro Fuzzy Inference systems	LCOM, DIT, WMC, NOC, RFC, DAC, MPC, NOM,	UIMSANN is 36.85 than GRNN (25.5%)
5.	Kumar et al [7]	Soft Computing, Fuzzy Logic, ANN	Defect Density	ANN is better then Fuzzy Inference System
6.	Sinha et al [8]	Support vector machines (SVM) method and Radial Basis Function (RBF)	Actual Development Time (ADT), Estimated Development Time (EDT)	SVM Gaussian Radial Basis kernel function is better than RBFN.

(*contd...*)

(*Table 1 contd...*)

S. No	*Author*	*Approach*	*Factors/Approach*	*Result*
7.	Dhaka and Aggarwal [9]	Models of Neural Network	Ward Neural Network and Hopfield Neural Network	Hopfield model represents high correlation and high degree.
8.	Sharma & Bhardwaj [10]	Neural Network Based	Complexity and Defect Density	RMSE value for TRINBR is neurons 15 at epoch 24 is maximum
9.	Mewada et al [11]	ANFIS (Adaptive Neuro Fuzzy Inference System)	COCOMO attributes	ANFIS worked better than RMSE error
10.	Tiwari and Sharma [13]	Artificial Neural Network (ANN)	Analytical Hierarchy Process, Functions like trainlm, trainbr is used.	TRAINBR function at 18 neurons with RMSE 0.1317
11.	Kumar [14]	Artificial Neural Network(ANN)	multiple condition count, node count, percentage comments and total lines of code	ANN is good technique with RMSE.
12.	Sheshasaayee and Jose [15]	WOM, RFM, CAE, CDA, CIM, CFA, CBM, LCCO, LOCC	Maintainability framework is proposed for Aspect Oriented system by using existing metrics	No Empirical assessment is proposed.

For maintainability, different researchers have defined traditional and soft computing techniques using different set of Parameters and characteristics to predict maintainability.From the table, it is clear that for maintainability, majority of authors have used soft computing techniques for maintenance prediction. Out of these papers artificial neutral network have been used extensively which gives the possibility to explore various other algorithms of artificial neural Network (ANN) for maintainability prediction.

3.3. Reliability

Software Reliability is imperative component which influences reliability of framework. It really alludes to flawlessness of configuration of software, that having the high intricacy of basic issues with software reliability.This can be isolated into classifications namelyPrediction modeling and Estimation modeling.

- Prediction Model: It utilizes verifiable information, past information investigation and a lit bit of perceptions. It works on the basis of pre-advancement and test stages under normal conditions. Moreover, it perceives the future time also.
- Estimation Model: It works on the basis of present information acquired from the present software development effort and doesn't use the calculated advancement stages.

3.3.1. General Approach

Gokhale [17] provides a reviewonarchitecture-based software reliability.

Dimov and Punnekkat[18]defined a segment based programming design on quality factorssuch as dependability of implanted frameworks which can be legitimately evaluated and ensured utilizing fitting models,thus ensure reusability of models. They proposed another methodology for the dependability estimation of part based programming frameworks, which ventures on a structural model of the framework utilizing Generalized Nets.

Singh et al [19] defined that there are several uncertainty factors which influence the bug tracking system, and proposed stochastic differential model. Which works on using bugdetection framework at sporadic state and for that they proposed a prototype.

Hsu and Huang[20]defined a versatile structure of fusing way testing into reliability estimation for secluded programming frameworks and showed the relationship between dependability and reliability.

Si et al [21] explained a bottom-up structural engineering based reliability estimation system for segment based programming frameworks. The methodology took component based systems and used recurrence of every component into record, and it is general for distinctive structural planning styles. They proposed five fundamental component composition systems and their reliability representation strategies.

Kapur et al [22] presented testing-exertion subordinate Software Reliability Growth Model (SRGM) for disseminated environment. They had utilized logistic learningcapacity for recently created parts with the suspicionthat the expertise of the testinggroup develops as testing advances.

Pasha et al [23] examined software reliability models and its applicability in the field of software engineering.

Singh et al [24] explained a discrete Software reliability growth model in Imperfect Debugging environment and its usage in its operational profile.

Tyagi and Sharma [25] defined that software reliability is characterized as product framework for a predefined timeframe in a predetermined situation. This paper investigates software reliability based on component applications and its association with reliability of programming applications.

Zhang et al [26] stated that dependability and cost are two parameters for Internet framework. Thetransformation system for Markov chain of Internet ware,consists of structural planning, dependability count system which includes the vulnerability of element, and the circulation exactness to acknowledge, that helps improving count calculation.

Hu et a l[27] proposed Modified Adaptive Testing (MAT) is for improving testing techniques.

Xie et al [28] introduced CBS (Component-Based Software), time-invariant, SRGM (Software Reliability Growth Model. They also worked on flows and depict genuine, testing procedure to overcome the issue.

3.3.2. Soft Computing Approach

Madsen et.al [29] predicts software reliability by using the soft computing techniques for optimization purpose. Thisalso supports fuzzy logic, evolutionary computing and data mining.

Kapur et al[30][31]explained various reliability models with numerical example. They use the concept of ANN and compare it with other NHPP model after applying the twofeatures of disappointment information that sets to the referred software development projects. In another work they used another computational approach for computing versatile approaches of ANN for improving the accuracy of complex architectures.

Tyagi and Sharma[32] concentrated on four components namely component dependency, application complexity, reusability and the operational profile for determining CBSS reliability. These four factors recognized as most significant features for improving accuracy. Authors have also [33]proposed a model for assessing CBSS reliability, utilizing a bio-propelled calculation, ant colony optimization (ACO).

Shahzad et.al [34] suggested that Incorporation of various components found in different component based project repositories are involved in software development. They explained the applicability of fuzzy analytic network process for evaluation purposes. It is checked by quality measure defined in ISO/IEC. The study shows that the ANP approach is insufficient for modeling the component projects because of the reason that usually the weights derived from the expert’s opinion give rise to an ambiguous and certain situation.

Tyagi and Sharma[35] discussed about part based software systems of reusable parts which are replaceable elements. The reliability of a Component-based application relies on the dependability of these parts and

on their past code. Every part has an alternate use recurrence and does not contribute similarly to the dependability of a segment based application; subsequently the dependability of a Component-based application relies on the use recurrence of every segment. In this paper they positioned the parts by utilizing a Fuzzy method for request inclination by simulating for perfect arrangement (TOPSIS).

S. No	*Author*	*Approach/Factors*	*Discussion*
Traditional Approaches			
1.	Gokhale [17]	Architecture Based software Reliability	Only theoretically discussed.No experimental work is done.
2.	Dimov [18]	Dependability	Part based programming framework using generalized nets.
3.	Singh et.al [19]	O type stochastic equation	(SRGM)Software reliability growth model with inclusion of irregular functions
4	Hsu and Huang [20]	Reproduction and Affectability	Versatile system framework is propose and validated for exactness and connection
5	Si et al [21]	Recurrence based systems	Bottom-up structural engineering based reliability model.
6	Kapur et al [22]	Software Reliability Growth Model	Distinctive investigating time salck capacity for recently created segments for disseminated environment
7	Pasha et al[23]	Quantity of leftover flaws, programming disappointment rate,programming reliability	Analyze the existing Software Reliability Growth Model (SRGM) methods to give discriminating investigation of the basic suspicion.
8	Singh et al[24]	Dependability of programming item	Discrete programming dependability development approach for multi-up degrees.
9	Tyagi and Sharma [25]	Reusability, Operational Profile, Portability, Functionality, Failure Rate, Application Complexity, Component Dependency, Flexibility, Repair Rate, Fault, Mean Time before Failure, Security	Only factors influencing software reliability have been discussed without only measuring aspect.
10	Zhang et al [26]	Structural planning, dependability count system, dependability capacity	Markov chain based approach for internet dependability is used.
Soft Computing Approach			
11	Madsen et al [29]	Software Fault Diagnosis, Reliability optimization	Fuzzy Modeling, Neural Networks, Evolutionary Computing may be used for reliability optimization
12	Kapuret al [30]	Artificial Neural Networks	Enhanced integrity of-fit for programming failure/fault removal data.
13	Kapur et al [31]	Artificial neural-network (ANN) data driven based models	Promising results while forecasting software reliability rather than individual neural-network based models.
14	Tyagi and Sharma [32]	Additive Models State-based Approach and Path based method	These 4 factors provides accurate estimation.
15	Tyagi and Sharma [33]	Ant Colony Optimization	Ant Colony Optimization(ACO) is used for reliability measurement of CBS.
16	Shahzad et al [34]	FANP(Fuzzy Analytic Network Process)	ISO model is considered for evaluation. FANP is found to be better than ANP
17	Tyagi and Sharma [35]	TOPSIS	Ranking of components based on reliability is measured.

3.3. Analysis (Reliability)

In today's era every researcher chases the reliability anyhow. In this paper, the authors used various optimization techniques such as genetic algorithms,Ant colony optimization and many more for measuring the reliability of software applications however the hybrid approaches may also be applied to get better software reliability estimation.The major findings of the discussed research work in various papers have been summarized in the following table:

4. CONCLUSION

Maintenance and Reliability are two very important aspects for any software development. In the present paper we have conducted a detailed literature review on both the aspects & found that various soft computing techniques & optimization techniques have been used for accessing these two parameters. However a more detailed empirical study involving various other techniques including Hybrid soft computing techniques such as Neuro Fuzzy, Fuzzy AHHP, Fuzzy ANP,Fuzzy Genetic & Neuro Genetic etc. could be applied for better accuracy.

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