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A Review on Software Defect Prediction using Artificial Intelligence

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***Abstract*-Faults in software systems continue to be a major problem. A software fault is a defect that causes software failure in an executable product. Knowing the causes of possible defects as well as identifying general software process areas that may need attention from the initialization of a project could save money, time and work. The possibility of early estimating the potential faultiness of software could help on planning, controlling and executing software development activities [3]. This paper surveys literature review of articles for the past many years in order to explore how various prediction methodologies have been developed during this period in order to take care of the issues related to software defect.**

Keywords: Software Defects, RMSE, ANFIS, MDP.

1. Introduction

Faults in software systems continue to be a major problem [4]. Software bug is an error, mistake, flaw, failure, or fault in a computer program that prevents it from behaving as intended (e.g., producing an incorrect result) [5]. A software fault is a defect that causes software failure in an executable product. In software engineering, the non-conformance of software to its requirements is commonly called a bug. Most bugs occur from mistakes and errors made by persons in either a program's design or its source code, a few are caused by compilers producing incorrect code. Knowing the causes of possible defects as well as identifying general software process areas that may need attention from the initialization of a project could save money, time and work. The possibility of early estimating the potential faultiness of software could help on planning, controlling and executing software development activities.

A wide range of prediction models have been proposed. Complexity and size metrics have been used in an attempt to predict the number of defects a system will reveal in operation or testing. Reliability models have been developed to predict failure rates based on the expected
operational usage profile of the system. Information from defect detection and the testing process has been used to predict defects. The maturity of design and testing processes have been advanced as ways of reducing defects. Recently large complex multivariate statistical models have been produced in an attempt to find a single complexity metric that will account for defects. This paper provides a *critical* review of the various work carried out in this field with the purpose of identifying future avenues of research.

2. Review of Literature

Bibi S., Tsoumakas G., Stamelos I., Vlahavas I.(2006) applied a machine learning approach to the problem of estimating the number of defects called Regression via Classification (RvC). To evaluate this approach a comparative experimental study of the effectiveness of several machine learning algorithms in a software dataset was performed. The data was collected by Pekka Forselious and involves applications maintained by a bank of Finland. It was seen that the success of the method is that it provides a framework for discovering potential causes of faults that are not profound like the one that implies that applications for deposit organizations are fault-prone.

Norman Fenton et.al.(1999), have described a probabilistic model for software defect prediction. The aim here is to produce a single model to combine the diverse forms of, often causal, evidence available in software development in a more natural and efficient way than done previously. Here a *critical* review of numerous software metrics and statistical models and the state-of-the art has been carried out. The use of subjective judgements of experienced project managers to build the probability model and use this model to produce forecasts about the software quality throughout the development life cycle has been discussed. This model can not only be used for assessing ongoing projects, but also for exploring the possible effects of a range of software process improvement activities.

Ahmet Okutan, et.al.(2012), proposed a novel method using Bayesian networks to explore the relationships among software metrics and defect proneness. Nine data sets from Promise data repository has been used and show that RFC, LOC, and LOCQ are more effective on defect proneness. In addition to the metrics used in Promise data repository, two more metrics, i.e. NOD for the number of developers and LOCQ for the source code quality has been proposed. At the end of modelling, the usefulness of the marginal defect proneness probability of the whole software system, the set of most effective metrics, and the influential relationships among metrics and defectiveness has been deduced.

Mrinal Singh Rawat et. al.(2012), identified causative factors which in turn suggest the remedies to improve

software quality and productivity. They showed how the various defect prediction models are implemented resulting in reduced magnitude of defects. They presented the use of various machine learning techniques for the software fault prediction problem. The unfussiness, ease in model calibration, user acceptance and prediction accuracy of these quality estimation techniques demonstrate its practical and applicative magnetism. These modeling systems can be used to achieve timely fault predictions for software components presently under development, providing valuable insights into their quality. The software quality assurance team can then utilize the predictions to use available resources for obtaining cost effective reliability enhancements.

Supreet Kaur, et.al. (2012), studied the performance of the Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is evaluated for Fault prediction in Java based Object Oriented Software systems and C++ language based software components. Here, the metric based approach is used for prediction. In case of Java based dataset named as
KC3, first, thirty nine metrics are used and later the worth of a subset of attributes is calculated and the number of metrics are reduced to eight. When the worth of an attribute by computing the value of the chi-squared statistic with respect to the class is evaluated, it was seen that that the BRANCH_COUNT and maxHALSTEAD_VOLUME are highest rank metrics for fault prediction in case of Java and C++ based fault prediction dataset respectively.

Xiao-dong Mu et. al.,(2012), in their work to improve the accuracy of software defect prediction, a coevolutionary algorithm based on the competitive organization is put forward for software defect prediction. During this algorithm, firstly, competition mechanism is introduced to organization coevolutionary algorithm. Then, three evolution operators which are reduced operator, allied operators and disturbed operators are developed for evolution of population. And competition is considered for calculate the fitness function. When the algorithm applied into software defect prediction, it improves the accuracy of software prediction through increases the diversity of population.

N Fenton, et. al. (2008), in their work reviewed the use of Bayesian networks (BNs) in predicting software defects and software reliability. The approach allows analysts to incorporate causal process factors as well as combine qualitative and quantitative measures, hence overcoming some of the wellknown limitations of traditional software metrics methods. Using such 'dynamic discretization' algorithms results in significantly improved accuracy for defects and reliability prediction type models.

Jie Xu, et. al. (2010), used several statistical techniques together with machine learning method verify the effectiveness of software metrics. Moreover, a neuro-fuzzy approach is adopted to improve the accuracy of the estimation model. This procedure is carried out based on data from the ISBSG repository to present its empirical value.

Manu Banga, (2013), here a new computational intelligence sequential hybrid architectures involving Genetic Programming (GP) and Group Method of Data Handling (GMDH) viz. GPGMDH have been discussed. Besides GP and GMDH, a host of techniques on the ISBSG dataset has been tested. The proposed GP- GMDH and GMDH-GP hybrids outperformed all other stand-alone and hybrid techniques. It is concluded that the GPGMDH or GMDH-GP model is the best model among all other techniques for software cost estimation.

Mohamad Mahdi Askari and Vahid Khatibi Bardsiri (2014) used multilayer neural network method in order to improve and increase generalization capability of learning algorithm in predicting software defects. In order to solve the existing problems, a new method is proposed by developing new learning methods based on support vector machine principles and using evolutionary algorithms. The proposed method prevents from overfitting issue and maximizes classification margin. Efficiency of the proposed algorithm has been validated against 11 machine learning models and statistical methods within 3 NASA datasets. Results reveal that the proposed algorithm provides higher accuracy and precision compared to the other models.

Kamaljit Kaur (2012) presented the application of the neural network for the identification of Reusable Software modules in Oriented Software System. Metrics are used for the structural analysis of the different procedures. The values of Metrics will become the input dataset for the neural network systems. Training Algorithm based on Neural Network is experimented and the results are recorded in terms of Accuracy, Mean Absolute Error (MAE) and Root Mean Square Error (RMSE). Hence the proposed model can be used to improve the productivity and quality of software development.

Mrs.Agasta Adline, Ramachandran. M(2014) Predicting the fault-proneness of program modules when the fault labels for modules are unavailable is a challenging task frequently raised in the software industry. They attempted to predict the fault–proneness of a program modules when fault labels for modules are not present. Supervised techniques like Genetic algorithm based software fault prediction approach for classification has been proposed.

Karpagavadivu.K, et.al. (2012) analyzed the performance of various techniques used in software fault prediction. And also described some algorithms and its uses. They found that the aim of the fault prone module prediction using data mining is to improve the quality of software development process. By using this technique, software manager effectively allocate resources. The overall error rates of all techniques are compared and the advantages of all methods were analyzed.

Xiaoxing Yang, et.al. (2014) introduced a learning-to-rank approach to construct software defect prediction models by directly optimizing the ranking performance. They built the model on previous work, and further studied whether the idea of directly optimizing the model performance measure can benefit software defect prediction model construction. The work includes two aspects: one is a novel application of the learning-to-rank approach to real-world data sets for software defect prediction, and the other is a comprehensive evaluation and comparison of the learning-to-rank method against other algorithms that have been used for predicting the order of software modules according to the predicted number of defects. Our empirical studies demonstrate the effectiveness of directly optimizing the model performance measure for the learning-to-rank approach to construct defect prediction models for the ranking task.

Ahmet Okutan1 and Olcay Taner Yıldız, (2013) proposed a new kernel method to predict the number of defects in the software modules (classes or files). The proposed method is based on a pre-computed kernel matrix which is based on the similarities among the modules of the software system. Novel kernel method with existing kernels in the literature (linear and RBF kernels) has been compared and show that it achieves comparable results. Furthermore, the proposed defect prediction method is also comparable with some existing famous defect prediction methods in the literature i.e. linear regression and IBK. It was seen that prior to test phase or maintenance, developers can use the proposed method to easily predict the most defective modules in the software system and focus on them primarily rather than testing each and every module in the system. This can decrease the testing effort and the total project cost automatically.

Yajnaseni Dash, Sanjay Kumar Dubey, (2012) aimed to survey various research methodologies proposed to predict quality of OO metrics by using neural network approach. The application of artificial neural networks is an efficient method to estimate maintainability in object oriented system. It was seen that among the different soft computing techniques ANN possesses advantages of predicting the software maintenance effort by minimal computation. It can be used as a predictive model because of its incredible representation techniques and ability to perform complicated functions.

Ms. Puneet Jai Kaur, Ms. Pallavi, (2013) discussed data mining techniques that are association mining, classification and clustering for software defect prediction. This helps the developers to detect software defects and correct them. Unsupervised techniques may be used for defect prediction in software modules, more so in those cases where defect labels are not available.

3. Conclusion:

This paper presents a literature review of the use of various techniques for software defect prediction. This literature review is very useful, since it brings a better understanding of the field of study, and this is an important contribution of this paper. The main aim is to examine the performance of different techniques in software fault prediction. Fault prediction using these techniques helps in improving the quality of the software. The fault prediction in software is significant because it can help in directing test effort, reducing cost, and increasing quality of software and its reliability. From the literature review it can be concluded that this subject attracts a great deal of interest by researchers.

Further it is concluded that these models heavily depends on the nature ,volume of the defect data and accuracy of classifier and predictors. Most of the researches were carried out with the help of NASA defect data sets.

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