"Variations of Fuzzy Techniques on Software Effort Estimation: A Review"

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***Abstract*— The development of the successful software mostly depends upon its effort estimation. From the era of the SDLC, the accurate software effort estimation is the biggest worry of the software management team. There has been a lot of model that are developing for this purpose only and they are still trying to find better solution. When the fuzzy logic comes to light, it opens a new path to predict. It gives a way to be more accurately present the problems with respect to the real world. Software effort estimators also found it more feasible and started to apply it. It also shows better result on different project. This paper mainly focuses on the effort estimation methods using fuzzy techniques and its variations. It is review of some of the models that implemented fuzzy logic and got better results.**

***Keywords*— Software development effort (SDE), software testing effort (STE), lines of code (LOC), fuzzy logic, defuzzification, test effort drivers (TEDs).**

I. INTRODUCTION

To control the development of the software project, it is very important to estimate the effort. There has been a lot of research those are trying to find it more accurately and at early stage too. There have been a lot of models to estimation the effort [4, 10]. Some of these are:

A. *Algorithmic cost Modeling*
B. *Expert Judgment*
C. *Estimation by analogy*
D. *Parkinson's Law*
E. *Pricing to win*

The above estimation techniques are attempted to calculate effort estimation in a way so that it can further converted into the time or man-hour. As effort and cost are related very closely, there is lot of parameter that effect on the values of one or another. So many different techniques were developed as the industry grows.

II. FUNCTION POINT ANALYSIS

Function point method was fisted proposed by Albrecht in 1979. It is based on 5 user identifiable logical "functions" which are divided into 2 data function types and 3 transactional function types :

- External Inputs (EIs)
- External Outputs (Eos)
- External Inquiries (EIs)
- Internal Logical Files (ILFs)
- External Interface Files (EIFs)

Function point are calculated by multiplying these factors by their weightage using following formula :

$$\textbf{FP = count total x [0.65 + 0.01 x } \sum(F_i)\textbf{]}$$

III. COCOMO II Model

Barry boehm[4] introduced an ordered arrangement of estimation model with name COCOMO which stands for Constructive Cost Model. It further became more comprehensive model, called COCOMO II [6, 13].

COCOMO model requires software size for information in terms of object point, function point and line of source code. Objects point is computed by counting the numbers ofscreen reports and components. Then these are classified according to their complexity level as suggested by Boehm. Then obect point is calculated by multiplying the instaces with their weightage factor. Object point is adjused using the formula:

NOP = (objects point) x [100 - %reuse]/100]
Where NOP is new object points.

PROD = NOP/ person-month

Estinated effort = NOP/PROD

II. FUZZY LOGIC

In 1965, Prof. LoftiZadeh introduced fuzzy set theory that can handle the imprecise and incomplete data. It gives a way to represent the linguistic value such as low, medium etc. it gives better way to relate realistic situation in terms of some values and measure it. The fuzzy set has two elements. One element is considered as x and other element is the membership of x with the universe of discourse of A.

The membership is defined in the term of the membership function. It is mapping between x i.e. a

number and the universe of the discourse i.e. A. This membership function may be Gaussian function or trapezoidal function or triangular function etc.

III. LITERATURE REVIEW

Batra and Trivedi [9] Software effort estimation is a backbone of the software project management. The more accurately the estimation increases the chances to software to be successful software. It is the most crucial and difficult hurdle in the software development life cycle. This paper applies Gaussian Membership Function (GMF) instead of Trapezodial Membership Function (TMF) on the cost divers of the model. And it produced better results than the existing models.

Manoj et al. [22] shows that there is a lot of model that calculate effort estimation of the software. But, still there is a lot of ways to decreases the difference between the estimated effort and the actual effort. Accurate estimation gives a hope towards the right way to develop the software. This paper proposed the fuzzy logic on the well known ubiquitous model. For e.g. doty, Harish model etc. it adjust the parameters of the models and evaluate the impact on accuracy using MARE and VARE evaluation criteria.

Azzeh et al. [15] presented that for decades, the analogy based techniques uses to estimates the effort of the software. It tries to apply fuzzy numbers on the analogy based estimation to improve the estimation. This paper evaluates the different data set of the software projects. It uses Jack knifing method to evaluate the data sets. These are Albrecht, COCOMO, kermemer, desharnais and ISBSG. The result of the study shows that proposed methods performed very well as compared to some existing techniques.

Idri et al. [2] upgrades the COCOMO model using fuzzy logic. The fuzzy logic helps to work with the different categories of data. This approach also helps to account the importance of the attribute into different level that was not possible without fuzzy logic. So, the result comes much better than the intermediate COCOMO model. Fuzzy gives a lot of options in COCOMO model that shows a good impact on the result.

Chawla and Ahlawat [20] used fuzzy logic with mamdani inference system used to get acceptable and consistent effort estimation of software in various cases having data that is imprecise and inaccurate and difficult to calculate precise result.

In the paper, Chawla and Ahlawat [20] proposed a fuzzy logic model that used data from COCOMO dataset i.e. S. G. MacDonell's "FULSOME: Fuzzy Logic for Software Metric Practitioners and Researchers". The input variables are MODE and SIZE and the four membership functions i.e. Triangular-shaped membership function, Generalized bell-shaped membership function, Trapezoidal-shaped membership function and Two-sided Gaussian membership function are used.

Result from the COCOMO model and the four membership functions was analyzed and compared with each other using MMRE metric. The Gaussian2 Membership Function with fuzzy logic was considered best as yielding better estimate very much near to actual effort. Fuzzy logic with Trapezoidal Membership Function produced the best approximate results as compared to other ones [20].

Du et al. [23] proposes a new model of software effort estimation using neuro-fuzzy logic and combines it with SEER-SEM effort estimation algorithm analyzing its prediction performance as compared to estimation of methods that using with SEER-SEM algorithm using MMRE.

The data used in this study from 93 published COCOMO 81 project data points and 6 industrial project data. The first data was transferred from COCOMO 81 to COCOMO II and then to SEER-SEM. then data is processed through it. The model evaluates on the bases of 4 case studies. These cases, which used different datasets from 93 projects, were utilized to perform training on the parameter values [23].

In all four cases, the MMREs of our proposed model are improved over the ones where only SEER-SEM effort estimation model is used, and it shows more than a 20% decrease as compared to SEER-SEM. According to these results, neuro-fuzzy technology improves the prediction accuracy when it is combined with the SEER-SEM effort estimation model, especially when reducing the outliers of MRE >100%. The result analysis showed MMRE from Cases 1 and 4 displays an improvement of no more than 7.15% & MMRE of industrial projects was minimal [23].

Mittal and Bhatia [10] introduced two fuzzy based sizing models that will be calculate the software effort estimation, in this paper, the size is using a triangular fuzzy number instead ofa single fuzzy number.The four criteria are used to test these models on 10 NASA software projects [4] to test the accuracy of software cost estimation model.

The proposed study gives better results as compared to some earlier models. Proposed Model is the best as per the above experimental study, on the basis of VAF, Mean Absolute Relative Error, Variance Absolute Relative error and Pred (25). It is not possible to evolve a method, which can give VAF (%) equal to 100. The effort estimation can be optimized with the adjustment of arbitrary constants [10].

Iraji and Motameni [16] propose a neuro-fuzzy use case size Points Calibration model that incorporates

the learning ability from neural network and the human's ability to confinethe knowledge from fuzzy logic and also validated it in this paper. Use case size point measures the total number of actors, the pre-conditions as well as post-conditions and the scenarios contains in use case models.

After training neural network by ISBSG data, proposed neuro fuzzy system is applied on seven samples of projects. Effort estimation with Adaptive neuro fuzzy Unadjusted Use Case Size Points (ANFUUSP) MMER is less and ANFUUSP accuracy further [16].

Tarannum et al. [21] compared different software estimation models with each other. The fuzzy logic improved different estimation models such as COCOMO I and COCOMO II. The accuracy of the software projects effort estimations is improves with a significantly. There is lot of scenario that cannot be define on the exact value, but, fuzzy logic increase the number of cases as well as give an approach to relate the data more closely to real worlds. That's why a implementation of the fuzzy logic create an new era in the different areas.

Andreou and Papathrocharous [3] present an approach to provide a tool for automatic software cost estimation by generating Fuzzy Decision Tree (FDT). The data records of approx. 1000 projects selected from the repository of ISBSG and the algorithms i.e. namely chi-square automatic interaction detector (CHAID) and classification and algorithm trees (CART) are applied on empirical software cost data recorded in the ISBSG repository. The instance of fuzzy decision trees generated and the results are evaluated on the basis of predicted accuracy.

The experiments conducted showed that sufficiently accurate cost predictions, close to the actual development costs, can be achieved. The rules extracted promote the linguistic representation of the attributes' associations and provide added value to the whole estimation process with optimized accuracy in relation to other approaches. The results indicated the proposer approach can provide fairly good results [3].

Srivastava et al. [18] are proposing a novel Fuzzy model that comes from the integration of COCOMO, fuzzy logic and weighing techniques, Test Effort Drivers (TEDs) into a one with triangular membership functions with monotonic constraints.

There is some approximation used for STE using intermediate COCOMO model and also for the confidence level. The value of the effort of software development is estimated by integrating confidence level with COCOMO model using fuzzy logic and STE is assessed accordingly. After the test effort driver are identified and thethe approximate values also determined, then it is used to analyze the testing efforts [18].

The results obtained due to this process show promising result. The success of the model depends on the fine-tuning of fuzzy rules that is depends on the experience of the decision maker. This model can be further modified [18].

Chouseinoglou and Aydm [17] proposed a fuzzy estimation model that used ISBSG 11 dataset. It shows that if the uncertainty is properly handled then there is a significant improvement on the result i.e. calculation of effort estimation.

The fuzzy estimation model does provide better result than the other estimation model, if the data is not well defined or imprecise or not clear. It helps to relate data with a better result [17].

Attarzadeh and Ow [12] proposed an approach for estimating software effort estimation using an enhanced fuzzy logic model. this paper used the empirical study done by Lopez- Martin et al. [8] . The effort estimation of 41 modules that are written in Pascal programming language was calculated where the coupling, McCabe Complexity and the number of lines of code was indexed.

The 2-sided Gaussian membership function in fuzzy logic shows much better result as other models.The proposed model shows an significant result and the MMRE is also decrease as compare to the other existed fuzzy logic model [12].

Mittal and Bhatia [11] proposed afuzzy function point analysis that is function point analysis with fuzzy logic. The complexity metrics is represented through triangular fuzzy number. It helps to optimize the result with the variation of the triangular fuzzy numbers.

With the variation of the range of data element type (DET) and trapezoidal shaped fuzzy numbers, the problem of the fuzzy number for the data element type can be resolved to some extent. It also improved the result with significant impact. With the help of the trapezoidal function we can get some variation of function points throughout the rangerepresented by a linguistic term. The proposed study, is sufficiently general and can be applied to other areas of quantitative softwareengineering [11].

Bhatnagar et al. [19] purpose to review the existing studies based on fuzzy logic techniques to that has been used or developed over the years for the estimation of the software development with more precise and accurate estimation. In this paper an observation is being performed and trying to create an fuzzy based novel framework that helps to estimate the efforts at a very early stage.

IV. CONCLUSION AND SCOPE OF FUTURE

There are a lot of variations of fuzzy logic that applied on existing software effort estimation models.

Not only, had it improved the effort estimation but, a way to handle imprecise data. The improvement is increased as per the idea grows. But, if the data is accurate and the model is applied correctly, then the error in estimation also decreases. The neural network and soft computing algorithm are also a good approach. As the ideas are coming to the market, the heterogeneous combination of fuzzy logic, neural network and genetic algorithm are giving the opportunities to decrease the gap between the actual and estimated effort. So we should try to find that combination.

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