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Software Quality Improvement and Cost Estimation using Fuzzy Logic Technique

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Abstract

Now the current scenario software quality and cost estimation are the most challenging or more important activities in software development organizations. Software companies are focused on minimizing software error, producing good quality software products within the estimated budget. In this article, the fuzzy based methods to improve the software quality as well as minimizing the internal or external failure cost. Fuzzy based methodology the values of the failure cost parameter are improve the effectiveness of the software product and enhancing the cost of software quality. Cost of quality is the most challenging activities is measure by quantifies the cost of conformance and the cost of failure of non-conformance. The results are analysed by different software metrics with their different technique tools and the accuracy level is enhanced significantly. In this paper, the proposed method are implements the technique using MATLAB's fuzzy logic control Method.

Keywords: cost of quality, effort estimation, fuzzy logic, fuzzy triangular membership function, software defects, software quality.

INTRODUCTION

Software cost estimation is very challenging activities in software engineering. Most of the researchers are deals with skyrocketing estimation of software development effort estimation [1]. Cost based estimation product one of the most critical area of researcher due to the monetary aspect involved. The total costs incurred on quality performance and issues, often split into prevention costs, appraisal costs, internal failure costs and external failure costs [2]. Software quality can achieve higher levels of quality by changing their development process or by product assessment where multitudes of different strategies are available [3][4]. Every decision has its own cost implications that must also be taken into account. By reconciliation the challenging objectives of improve software quality and cost reduction, a quality of cost methods approach provides as a useful framework for comparing available software development process and estimation alternatives [5]. The cost of quality strategies in software development and confirmation process re-inspect through statistical cost of quality model explored analytically using a sample data set of fundamental mathematical formulation models [6]. Fuzzy logic is the one of best technique to optimize the software quality and cost estimation. The paper deals, fuzzy logic application to improve the software quality and reduction cost of software products. In this tough researcher have using different techniques and implemented different software metric to improving the software quality and optimizing the estimated cost. However, the Software development lifecycle (SDLC) phases are applied to predict the estimation of effort for singleton life cycle stages. Defect removal effectiveness is a direct indicator of the capability of a software development process in removing defects before the software is delivered [7]. It is one of few, perchance the only, method indicators that bear a direct association with the quality of the software's field performance [8]. The paper deals several aspects of defect removal effectiveness as well as overall effectiveness, going over effectiveness, test effectiveness, phase precise effectiveness and the part of the defect removal effectiveness under quality planning [9]. Quality software is a error-less product, it maintain the defect-less software products to produce expected output and proper shipping time within the limited estimated cost. It might be maintainable with lesser amount of interferences. The software products are maintainable, dependable, understandable and efficient. It increased competitiveness in today's business world. However the mathematical methodological analysis of historical project data is required the software quality development. It changes the business world for competitiveness requirement [10].The bug frame is based on analyzing the error to facilitate the injected from different level of software phases. Defects are injected due to lack of time and proper management or planning during development. In this article, researchers are finding the root cause to analyzing the cause of defects at different level of software improvement [5]. The paper deals, fuzzy logic is popular in software quality prediction or cost estimation technique by using the MATLAB Fuzzy tool. In this tool it

implemented fuzzy logic membership function (MF) to predict or estimated the software products. The cost model and statistical methods to predict the potential cost savings and defect reduction expected. The quality of software should have as few defects as possible [6]. It is accepts that defects will be injected and the objective is to deliver software with few defects within the estimated budget [3].

The paper is organized as follows: Next section describes the detail literature review and related work, follow by the proposed framework in Next section. In this section, discusses the conceptual economic model and follow by the experimental result and detail discussion. Next section are concludes the manuscript and follow by the references.

LITERATURE SURVEY

Software cost of quality is the most challenging topic in software engineering [1]. There are several studies conducted by different researchers for producing high quality software and minimizing the estimated cost [3][5]. In this dimension, most of the studies and research works are done in fuzzy logic controlled methodology.

The idea was proposed by Lotfi Zadeh et al. 1965 suggested that set membership is the key to decision making when faced with uncertainty [11]. The notion of a fuzzy set provides a suitable point of different approach for the construction of a conceptual framework which parallels in many respects the framework used in the case of ordinary sets, but is more general than the latter and, potentially, may prove to have a much wider scope of applicability, predominantly in the fields of pattern classification and information processing [12]. Essentially, such a framework provides a natural way of dealing with problems in which the source of imprecision is the absence of sharply defined criteria of class membership rather than the presence of random variables.Most of the researcher worked on cost estimation and software quality. Dizaji and Gharehchopogh propose the unique technique of ant colony optimization, his research work to optimize the ant colony algorithms as compared to COCOMO effort estimation models [13]. Shivakumar discover the nuero-fuzzy method to estimate the software development effort. But, the proposed technique is not suitable for higher dataset [14]. Sharma and Verma use the Gaussian MFs and compared other software metrics and produce very excellent results. Quality control and minimizing the estimated cost through the function point and defects injection into the requirement phase [15]. Wolverton et al 1974 module estimated the cost of development of software products, in this module he focus on historical cost data and analysis between new observer cost data [16]. The project estimation model modifies and re-created, cost estimated the models Kemerer et al. 1987. The models focused on function point, SLIM, COCOMO, and ESTIMACS. In this models it analysis of large (average of 200 KLOC) software products, Knafl et al 1986 and Kafura et al. 1987 both are in-lighted software metrics and function points. Boehm et al. 1981 cost model and calculation of effort estimation for software life cycle development process [17]. Mohanty et al. 1981 and Conte both are focus on software effort estimation and cost of quality. In this research Mohanty has proposed cost model, estimation of project size, project development time, and the cost of development has been an insightful process [18]. David Binkley et al. 1995 focused on cost effectiveness of the regression testing, in this process improving the software quality and cost effectiveness. Cost model, in this methods finding the root cause analysis and improving the software quality. Ganapathy et al. 2014 has proposed cost of quality, in this approach software cost failure rate observed and finding the root cause defects analysis [19]. The proposed method provides the approach for minimization of cost and poor quality of software products. There are several studies conducted by different researchers for producing high quality software and reducing the estimated cost, A. Schiffaucrova and V. Thomson et al 2006 propose quality cost models, in this model practical use of cost of quality suggests that even though quality is consider an important issue. Dale and Wan et al. 2002, it focuses on quality costing method policies for industrial level. Most of the researcher only focuses on finding the defects on software developing process for these study Fang Chengbin (2008) was introduce a tool called bug tracing system (BTS), for defect tracing, has the advantage of popularity and low cost, and also improves the accurate tracking and identify the defects where it is located on software developing lifecycle (SDLC) phases. Bhatnagar and Ghose propose a new method for linear Regression neural network; it has minimizing the MMRE out of the other existing models. Kad and Chopra work on to build the soft computing to overcome the issues of uncertainty [20]. Kumar and Chopra proposed, comparatively analysis between the neural network and fuzzy logic. Ansish Mittal has proposed cost effort estimation and compare to other software cost model. He has implemented the KLOC using the fuzzy logic technique [1]. Yadav et al. has to develop phase-wise defect prediction using fuzzy logic technique and comparer the results to other fault prediction model. Pankaj Jalote et a.l and Naresh Agarwal et al. 2007 stressed on how analysis of defects found in first iteration, letter on how to retrieve the feedback for defect prevention to next iterations, leading to quality and productivity improvement [21]. To Improving, the quality of software can be approaches using the same basic principles support by quality leads to W. Edwards Deming, Philip B, Crosby, and Harold F. Dodge. Show that, it will be possible to predict the potential cost savings and defect reduction expected [22]. The processes which can provide to managers/ practitioners to devote effort in minimization of failure cost and optimize the prevention cost. Liang-Hsuan chen, Ming-Chu Weng et al 2002, proposed a fuzzy method is introduced in cost of quality, Liang and Weng suggested the quality of control to

preventing the defect ratio and lower the failure cost [21][22]. In this methodology is applies and developed by Ming-Chu et al. 2010, Lin Zhang et al. 2010 extended quality function deployment (QFD) approach to assess quality cost. The behavioral method of various cost categories are studies by chopra et al. 2013. The quality of software is heavily influence by proper attention to every phase of development. However, high quality software should have as few defects as possible. It is accepts that defects will be injected and the objective is to deliver software with few defects within the estimated budget. Cost models the specific equations of the model are given and are use subsequently in estimating the cost of an imaginary software system [23].

PROPOSED FRAMEWORK

Conceptual Economic Model:

In this section paper, describe a cost of quality model introducing the risk level and the time to remove errors. The cost model formulated the mathematical formulas to minimize the expected total software cost and enhancing the software quality. An appropriate measure of the economic impact of an inadequate infrastructure for software testing is the profit differences of developers and users between conditions with the current testing infrastructure and conditions with the counterfactual infrastructure. This can be expressed by summing over all developers and users as follows

$$\Delta \text{ CQM} = \sum\Delta \text{ Conformance Cost} + \sum\Delta \text{ Non-Conformance Cost} \quad (1)$$

Cost of Quality (COQ) is a measure that quantities the cost of control/conformance and the cost of failure of control/non-conformance. In this model the cost related to prevention and detection of defects and the costs due to occurrences of software defects.

$$\Delta\text{COQ} = \sum\Delta \text{ Cost of Control} + \sum\Delta \text{ Cost of Failure Contr} \quad (2)$$

Where,

$$\text{Cost of Control} = \text{Prevention Cost} + \text{Appraisal Cost} \quad (3)$$

And

$$\text{Cost of Failure Control} = \text{internal Failure Cost} + \text{External Failure Cost} \quad (4)$$

From equation (3) and equation (4),

Cost of Quality (COQ) = Cost of Control (Prevention Cost + Appraisal Cost) + Cost of Failure Control (Internal failure cost + External Failure Cost) (5)

The Cost Quality Model is high risk due to the failure cost. If the non-conformance cost's is low the expected total cost of software development is minimize. So the internal failure or external failure cost due to the effort of rework or unidentified defects or bugs into the software. These occur it calculates and formulated the mathematical formulas are as follows:

Cost of Failure (COF) = [{pre-delivery rework effort ($\sum\Delta$ applicable phase) + Post-delivery rework effort ($\sum\Delta$ applicable phase)} x 100] / ($\sum\Delta$ Actual Effort) (6)

COQ = [(cost of Appraisal) + (cost of Prevention) + (cost of Failure)] x Effort (7)

Where, COA and COP are

COA = [{(Review effort + Testing Effort +UAT Effort)} x 100] / ($\sum\Delta$ Actual Effort)

COP = [{(PQA effort +DP Effort + Training Effort+ KT Effort)} x100] / ($\sum\Delta$ Actual Effort)

Fuzzy Effort Estimation:

Fuzzy based cost estimation technique anticipated finding keys to the annoyed dilemmas away from the domain of quantitative conception in view of the inherent details, and it always toes the line of fuzzy set theory [24]. Fuzzy based general approach as follows.

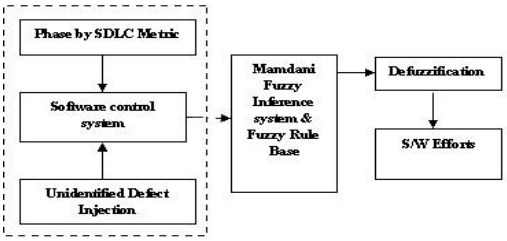

Figure1. Fuzzy Cost Estimation Model

Step1: *Define the membership function for each input and output metrics.*

Step2: *Define the crisp input fuzzification using Membership Function (MF).*

Step3: *Fuzzy rules and collect the expert's opinion for the consequential part of each rule.*

Step4: *Aggregate all the individual fuzzy sets for various rules and find out a crisp value by defuzzifying the aggregated fuzzy set.*

In the fuzzy cost estimation model, software cost drivers are affected the software control system. All the software development metrics are incorporated into this section [25]. This proposed work is based on fuzzy logic technique to indicate the effectiveness of the software quality cost predictions. In this methodology fuzzy based rule is effectively to accurate estimation of the software development

cost. First all the input parameter of fuzzy membership functions (crisp set) and fuzzification by the fuzzy control system then it converted the fuzzy rule based technique and the final processed, it is Defuzzification. Figure 1 show that the proposed fuzzy Architecture model used for estimation based fuzzy rules. The fuzzy model essential five input parameters like Complexity, Data, Tool, Loc, skills and one output parameter is estimate effort [26]. The fuzzy parameters are fuzzyfied using membership functions. In table 1 show input and out linguistic variables are represented.

Table 1. Fuzzy Membership functions

Input/output parameter	Linguistic variables used
Complexity	Less, Medium, High,
Data	Low, Average, High
Tool	Low, Medium, High
Loc	Bare, Average, Very High
Skills	Novice, Good, Expert
Estimate	Low, Medium, High,

The above linguistic variables are used fuzzy MATLAB tool are represented at graphically as shown below [25][26].

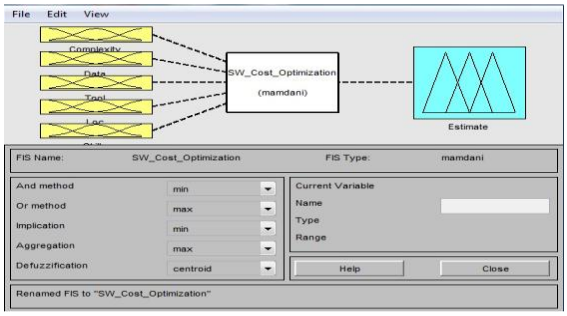

Figure 2. Proposed Mamdani FIS developed is using MATLAB.

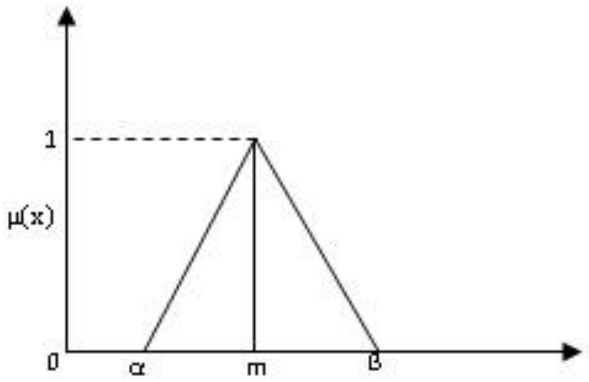

Figure 3. Fuzzy Triangular Membership Function μ(x).

In this approach a triangular Mfs is specified by three parameters A(x) {α, m, β} as follows;

$$A(x) = \begin{cases} 0, & x \le \alpha. \\ \frac{(x-\alpha)}{(m-\alpha)}, & \alpha \le x \le m \\ \frac{(\beta-x)}{(\beta-m)}, & m \le x \le \beta \\ 0, & \beta \le x \end{cases} \quad (8)$$

By using Min and Max, it has an alternative expression the preceding equations:-

$$\Delta(x, \alpha, m, \beta) = \max(\min\left(\frac{(x-\alpha)}{(m-\alpha)}, \frac{(\beta-x)}{(\beta-m)}\right), 0) \quad (9)$$

Where x is size as input, E is effort as output, α, m and β are the parameters of membership function A(x), m is the model value, α and β are the right and left boundaries respectively [27].

Let (m, 0) divides, internally, the base of the triangle in ratio k: 1, where k is real positive number.

$$\text{So that } m = \frac{\alpha + k\beta}{k+1} \quad (10)$$

As by definition of fuzziness

$$F = \frac{\beta-\alpha}{2m}.$$

$$\text{So } \alpha = \left(1 - \frac{2kF}{k+1}\right) \times m \quad (11)$$

$$\text{and } \beta = \left(1 + \frac{2F}{k+1}\right) \times m \quad (12)$$

Similarly, the Triangular Fuzzy Number (TFN) μ(x) is defined as,

$$\mu(\mathbf{E}) = \begin{cases} \mathbf{0}, & \mathbf{E} \le \mathbf{a\alpha^b} \\ \frac{(\frac{E}{a})^{1/b} - \alpha}{m - \alpha}, & \mathbf{a\alpha^b \le E \le am^b} \\ \frac{\beta - (\frac{E}{a})^{1/b}}{\beta - m}, & \mathbf{am^b \le E \le a\beta^b} \\ \mathbf{0}, & \mathbf{E \ge a\beta^b} \end{cases} \quad (13)$$

Table 2, gives values of α and β for F = 0.1, 0.2 and 0.3 for various values of k using equations (11) and (12), where m, size estimate in KLOC [28].

Table 2: Value of α and β for different values of F and k

F	k = 1	k = 2	k = 3
0.1	α = 0.9m β = 1.1m	α =(2.6/3)*m β = (3.2/3)*m	α = 0.85m β = 1.05m
0.2	α = 0.8m β = 1.2m	α =(2.2/3)*m β = (3.4/3)*m	α = 0.7m β = 1.1m
0.3	α = 0.7m β = 1.3m	α = 0.6m β = 1.2m	α = 0.55m β = 1.15m

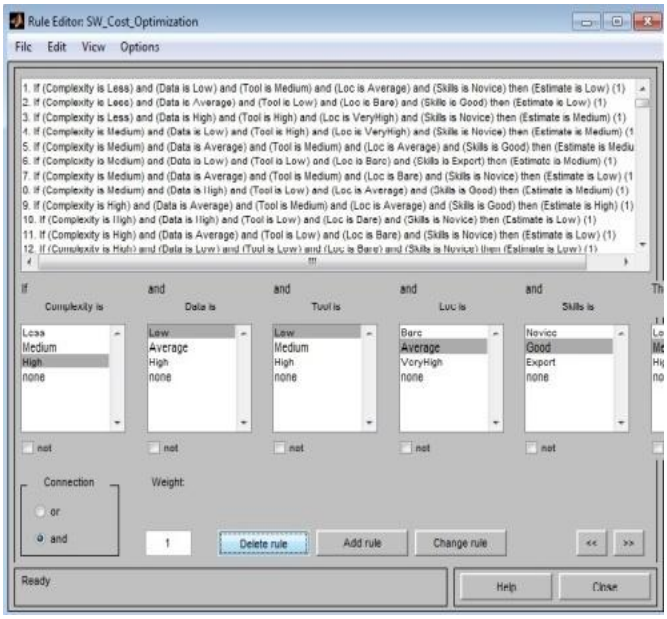

Figure 4. Fuzzy membership functions rules based viewer.

Defuzzification:

The single output, fuzzy estimate of E, can be computed as a weighted average of the optimistic($\mathbf{a\alpha^b}$), most likely ($\mathbf{am^b}$) and pessimistic estimate($\mathbf{a\beta^b}$)

Fuzzy estimate of

$$E = \frac{w_1(\mathbf{a\alpha^b})+\mathbf{w_2}(\mathbf{am^b})+\mathbf{w_3}(\mathbf{a\beta^b})}{w_1+\mathbf{w_2}+\mathbf{w_3}} \qquad (14)$$

Where w_1, w_2 and w_3 are weights of the optimistic, most likely and pessimistic estimate respectively. Maximum weight should be given to the most expected estimate [28].

$$E = \frac{w_1(\mathbf{a\alpha^b})+\mathbf{w_2}(\mathbf{am^b})+\mathbf{w_3}(\mathbf{a\beta^b})}{w_1+\mathbf{w_2}+\mathbf{w_3}},$$

Where a = 6, and b = 0.635 obtained using MATLAB.

m represent the size in KLOC.

$$\alpha = \left(1-\frac{2kF}{k+1}\right)\times m; \beta = \left(1+\frac{2F}{k+1}\right)\times m,$$

k, F, w_1, w_2 and w_3 are arbitrary constants.

The effort is obtained in Man Months (MM). Optimization of effort for an application is done by a suitable choice of arbitrary constants.

RESULT AND DISCUSSION

In this section, the fuzzy model relates the discussed economic factors and other technical factors with the aim to optimize the software cost estimations. The cost of defect amputation are affected the Estimation of the software products [29]. Software cost model incorporating testing coverage and mean value of failure time software. In the earlier traditional cost items such as testing cost, error removal cost, risk cost and failure cost due to potential faults in the unidentified defects are include associated with the number demands from customers [30]. The optimal release policies that minimize the expected total cost subject to the reliability requirements. The optimal software release time that minimizes the expected total software cost. The testing time required to attain the minimum cost is achieve. Thus, the marginal cost for further testing is an increasing the cost of the software.

In the table 3 shows that the comparison of different software estimation models with proposed technique using fuzzy methodology [31]. The results are greatly estimated and comparatively accurate to the other estimated software cost estimation models.

Table 3. Comparison of Effort Estimation Results In MRE

S.No	MRE COCOMO	MRE Bailey-Bsail	MRE Doty	MRE Halstead	**MRE Proposed Model**
1	1.796959	0.583226	5.061133	72.17207	**0.299589**
2	0.417702	0.28542	2.089178	15.24546	**0.239883**
3	0.323778	0.206572	1.863754	43.82836	**0.738711**
4	6.744216	3.314611	15.79051	186.8541	**1.079258**
5	3.357688	1.611792	8.427076	146.5538	**0.139795**
6	0.737203	0.121976	2.782977	20.88664	**0.146572**
7	3.801184	1.657822	9.411791	111.8766	**0.326814**
8	6.937724	3.55046	16.19466	219.2379	**0.882836**
9	0.561337	0.213011	2.402543	16.59008	**0.149658**
10	2.110636	0.761183	5.740837	80.46484	**0.221802**
11	0.705559	0.091055	2.703558	31.87132	**0.433864**
12	2.181342	0.727776	5.90346	66.91395	**0.039009**
13	1.067737	0.125014	3.486674	43.55722	**0.380777**

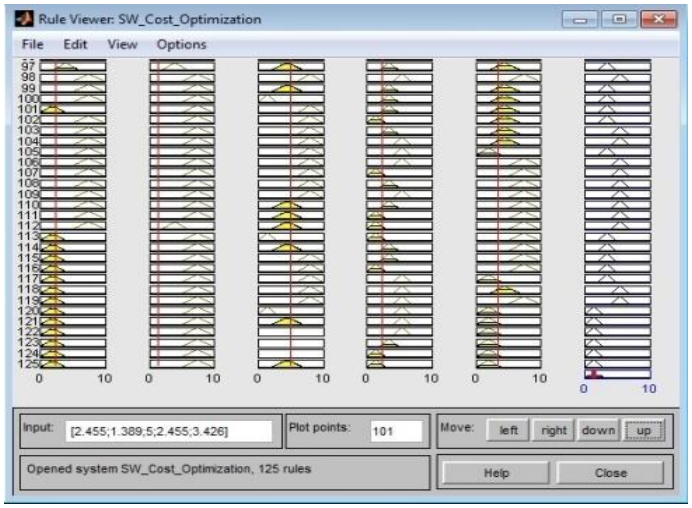

Figure 4: The proposed Method using Fuzzy Tool.

The experimental results are minimizing the estimated cost as compare to other models. The testing coverage at this time is 94% more effectively indicates the reliability analysis.

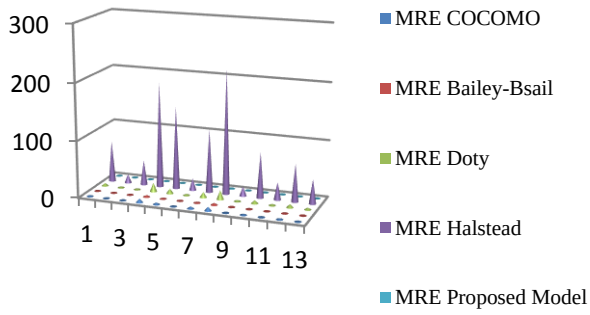

Figure 5. Graphical represented of Effort Estimation Results In MRE

Model Validation

In this subsection, the paper Validate the proposed Fuzzy model commonly used and suggested evaluation measures have been taken as follows.

i. Mean Magnitude of Relative Error (MMRE):

It measures the mean of absolute relative error. It concede the measure of the spread of the variables, where the estimated or Actual values.

$$MMRE = \frac{1}{n}\sum_{i=1}^{n}\frac{|y_i-\hat{y}_i|}{y_i} \qquad (15)$$

Where as y_i is the actual estimate values and $\hat{y}_i$ is the estimate value

ii. Balanced Mean Magnitude of Relative Error (BMMER).

In the above MMER is unbalanced show that the result is underestimates. For this reason, the balanced Mean Magnitude of relative error is measure.

$$BMMRE = \frac{1}{n}\sum_{i=1}^{n}\frac{|y_i-\hat{y}_i|}{Min(y_i,\hat{y}_i)} \qquad (16)$$

In above observation it finding the accurate analyzed result of MMRE and BMMRE for the proposed fuzzy model [26].

Table 4. Comparison the values of model evaluation measures

All Project (n=13)	***COCOMO***	***Bailey-Bsail***	***Doty***	***Halstead***	***Proposed Model***
MMRE	2.364851	1.019224	6.296781	81.2348	**0.390659**
BMMRE	0.00824	0.002243	0.013858	0.046699	**0.001943**

In this article, the above results for 13 numbers of projects which is taken by Promise dataset. It also observed that the measures value of relative error (MMER, BMMER) reduce extensively. The cost model is varying the value of ($a\alpha^b$) and ($a\beta^b$)**.** Show that the proposed model is much closer to actual estimated cost.

CONCLUSION

In this article, fuzzy cost model are minimize and improving the software quality. Fuzzy model are finding the accurate estimation for the development of software products. In this metrics software cost are minimize and improving the quality of software [5][27][28]. The paper presents application of fuzzy method to estimating the software development cost. Fuzzy control process method that captures both cost and quality implications of different development and verification option by measuring all costs associated with different types of software failure cost [26][30]. For the software quality is not only free but leads to shorter development schedules, lower development costs, and significantly reduced costs for maintenance and total costs for ownership. The results of the proposed technique for finding the approximate solution of the statistical mathematical formulation of fuzzy cost estimate model, the proposed model technique encourage or effectiveness to the software companies.

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