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EXPERIMENTAL EVALUATION OF FUZZY- BASED FUNCTION POINT ANALYSIS FOR SOFTWARE EFFORT ESTIMATION

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ABSTRACT

Accurate Effort Estimation is a significant task in software development, which is helpful in the scheduling and tracking of the project. A number of estimation models are available for effort calculation. However, a lot of newer models are still being proposed to obtain more accurate estimation .This paper attempts to propose a hybrid technique which incorporates both quality factors and fuzzy based technique in function Point Analysis. Fuzzy logic has the capability of tackle the uncertainty issues in the estimation. The goal of this paper is to evaluate the accuracy of fuzzy analysis for software effort estimation. In this approach, fuzzy logic is used to control the uncertainty in the software size with the help of a triangular fuzzy set, and de-fuzzification through the weighted average method. The experimentation is done with different project data on the proposed model, and the results are tabulated. The measured effort of the proposed model is compared with that of the existing model, and finally, the performance evaluation is done based on parameters in terms of MMRE and VAF.

Keywords: *Effort Estimation, Function Point, Fuzzy-based Function Point, Triangular Fuzzy Set, Accuracy.*

1. INTRODUCTION

In most of the existing research on effort estimation, the function point analysis method is used to estimate the effort, but not the non-functional characteristics and quality factors of the project. The previous research of the authors showed that the non-functional characteristics mainly help in the improvement of the accuracy [1]. The accurate and reliable effort and cost of the software are very important for project head in planning and scheduling, particularly in the early stages of the software development life cycle [2].So, a reliable and accurate software development effort prediction in software engineering is an important issue in Project Management [3]. If the estimation is not properly done, it may result in the failure of the software project [4]. Controlling the expenses of software development efficiently is another important issue in today's competitive world [5].

Any improvement in the accuracy of predicting the development effort can significantly reduce the cost arising from errors. Existing algorithmic models such as COCOMO and SLIM have limitations in handling uncertainty [6].New postulates offer alternatives to estimate the effort, in particular Fuzzy Logic that exploits the mechanisms of fuzzy systems that try to behave parts of the brain with a rule base.

This work intends the utilization of concepts and attributes taken from fuzzy logic, in order to extend the traditional function Point analysis to a Fuzzy- based Function Point Analysis with performance metrics. The Function Point Analysis is a widely used estimation method for measuring software effort, which can be further used to estimate the cost required to design the software. However, fuzzy sets play an important role in making software effort estimation models more user- friendly. Fuzzy logic may be a convenient tool for software development effort estimation [7]. Fuzzy logic as the name implies, describes the mode of reasoning to be approximate rather than exact.

This paper suggests a new approach that combines fuzzy rules with domain specific knowledge to improve the estimation accuracy.

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This new approach solves problems like uncertainty in input values, barriers in choosing the non-functional characteristics, and poor effort estimation accuracy.

The Fuzzy-based Function Point Analysis starts with the splitting of a project or application into its data and transactional functions [8].

2. MATERIALS AND METHODS

In the past few years, many methods have been presented the area of software effort estimation to improve accuracy.

Gray and MacDonnell [9] compared popular techniques in software effort estimation such as regression techniques, function point analysis (FPA), fuzzy logic and Neural Network. Their results showed that the fuzzy logic model achieved good accuracy.

Martin and Stefan [10] proposed an improved analogy-based approach based on extensive dimension weighting. Their results empirically evaluated the accuracy and reliability improvements of the project efforts.

Sunia Juneja and Rana [11] presented the fuzzification concept in the function point analysis, which can emulate the imprecision of human knowledge.

Harish Mittal and Pradeep Bhatia [12] used fuzzy logic to find the fuzzy functional point, and then, the results were defuzzified to get the functional points which were transferred into size estimation in person/month.

Researchers had also tried to combine fuzzy logic with neural network and Artificial Intelligence. There is still much uncertainty in predicting the software effort estimation. It is also difficult to make decisions in choosing the performance metrics for improving accuracy [13].

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3. PROPOSED METHOD

This research develops an optimized Fuzzy-based Function Point Analysis framework to handle the imprecision and ambiguity present in the data of the project to estimate the effort more accurately. The Proposed procedures include four major steps: Calculating the precision Value, Fuzzification, Inference Fuzzy rules and defuzzification. The Overall framework of the proposed method is given in figure 1 which clearly shows all the steps in this method.

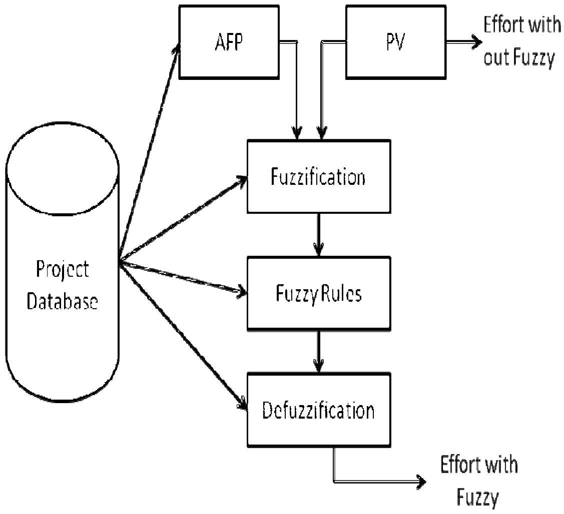

Figure 1. Proposed Framework

3.1. Calculating the Precision Value

Computer performance is characterized by the amount of useful work accomplished by a computer system, compared to the time and resources used. The performance of any computer system can be evaluated in measurable, technical terms, using one or more of the following metrics [1]:

- Speed and latency
- Safety critical
- Precision or accuracy
- Reliability and availability
- Robustness or fault-tolerance
- Capacity
- Scalability or extensibility
- Longevity

The formula to determine the Precision Value is given below

Precision Value (PV) = $0.01 *(\sum^{8}_{i=1} F_i * C_i)$ (1)

Where,

1) F_i = factor of each performance metric
2) C_i = Complexity factor

3.2. Fuzzification

The input terms are transformed into a fuzzy concept. The membership functions are applied to the actual values of variables to determine how much the input values fit the semantic terms [14]. The input size is fuzzified, by

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using the triangular membership function shown in figure 2.
The triangular membership function is defined as TFN (α, m, β), $\alpha \leq m$, $\beta \geq m$, where α, β are left and right side of boundaries, and m is the model value. The membership function is shown below

$$\mu(x) = \begin{cases} 0 \;, x \leq \alpha \quad x \geq \beta \\ \dfrac{x-\alpha}{m-\alpha} \;, \quad \alpha \leq x \leq m \\ \dfrac{\beta - x}{\beta - m} \;, \quad m \leq x \leq \beta \end{cases} \quad (2)$$

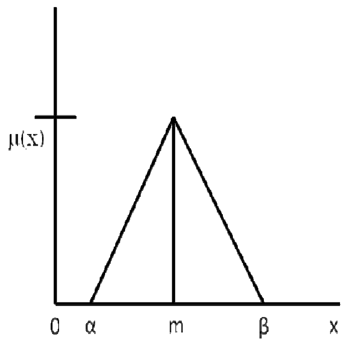

Figure .2 Triangular Fuzzy Numbers

3.3 Inference Fuzzy Rules

The Fuzzy rules are applied to determine the effort equation by applying the basic technique of the Function Point Analysis. The rules are formulated, based on the fuzzy set of complexity and the weight of an unadjusted function point, to estimate the fuzzy function point value.

Three rules are proposed:

IF complexity is LOW and Weight is SMALL
THEN the Fuzzy Function Point is LOW
IF complexity is AVERAGE & Weight is MEDIUM
THEN the Fuzzy Function Point is AVERAGE
IF complexity is HIGH and Weight is BIG
THEN the Fuzzy Function Point is HIGH

3.4. Defuzzification

Once the rules have been composed the solution, as has been seen, is a set of fuzzy rules. However, there is a need for a single action or crisp output for the estimating process. This will be done by the defuzzification of the output set. Defuzzification is the process of converting the fuzzy output into a crisp solution [15]. Finally, fuzzy values are translated into actual output by using the weighted average method, by using the effort equation obtained from the Fuzzy Rules Process. The Defuzzification equation is given below:

$$\text{Output} = \frac{\sum \mathbf{W}_i * \mathbf{V}_i}{\mathbf{W}_i} \quad (3)$$

3.5 Experiment and Results

The Proposed approach has been validated by performing different experiments on the given project data sets. The function point equation has been used to generate fuzzy data sets randomly, for developing Fuzzy-based Effort Estimation. The calculations were made using a software prototype developed with Visual Basic under MS Windows PC environment. Table 1 shows the estimated effort of the Existing model of the given project data sets.

Table 1. *Function Point Analysis-Effort Calculation*

S.No	Data Set	AFP	PV	FP	EFFORT
1	Proj 1	105.3	5.8	111.1	13.8
2	Proj 2	492	6.4	498.4	62.3
3	Proj 3	135	5.6	140.6	17.56
4	Proj 4	226.95	7.2	234.15	29.26

Table 2 shows the estimated effort of the proposed model on the same sets of data, which were applied to existing Function point model.

Table 2. *Fuzzy Function Point Analysis-Effort Calculation*

S.No	Data Set	AFFP	PV	FFP	EFFORT
1	Proj 1	94.77	5.8	100.57	12.57
2	Proj 2	454.28	6.4	460.68	57.58
3	Proj 3	12.15	5.6	127.1	15.88
4	Proj 4	215.38	7.2	222.58	27.82

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3.6. Performance Evaluation

Parameters such as VAF, MRE are applied to assess as well as to compare the accuracy of the estimated models.

Mean Relative Error

$$= \frac{\text{(Actual Effort-Calculated Effort)}}{\text{Actual Effort}} \quad (4)$$

Variance Account For

$$= \frac{(1 - Var\,(E - E'))}{Var\,(E)} * 100 \quad (5)$$

Where E is the actual effort & E' is the estimated effort.

The Fuzzy-based proposed model with performance metrics can be a powerful technique when tackling the difficulties in optimizing values, and the ambiguity in the input of effort estimation. It can be seen from the resulting output that the proposed model for effort estimation outperforms the existing Function Point Analysis. The computed MRE for the existing and proposed models are shown in table 3.

Table 3. *Comparison of Effort using MRE*

S. No	Data Set	Actual Effort	Effort-FP	Effort-FFP	FP-MRE	FFP-MRE
1	Proj 1	12	13.8	12.57	-0.15	-0.047
2	Proj 2	57	62.3	57.58	-0.09	-0.01
3	Proj 3	27	29.26	27.82	-0.08	-0.03
4	Proj 4	15	17.56	15.88	-0.17	-0.058

The Computed MMRE and VAF for the existing and proposed model are shown in table 4.

Table 4. *Comparison of the Models*

Parameter	FP Analysis	Proposed Technique
MMRE	12.25	3.25
VAF	93.86%	98.7%

4. DISCUSSION

In comparing the proposed model with the existing model,the improvement in accuracy is high, based on the MRE and VAF shown in figure 3.

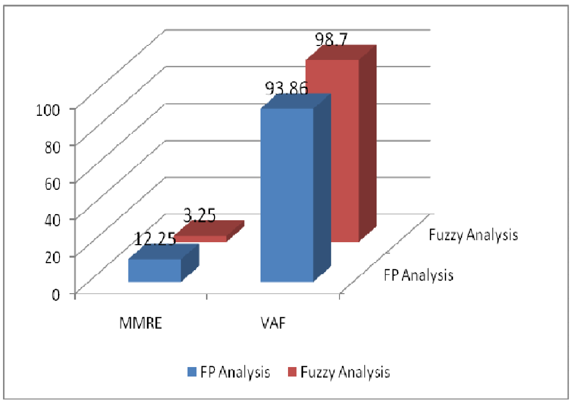

Figure 3.Performance Evaluation

The experimental results show that the proposed Fuzzy Framework shows close proximity with the actual result, whereas the normal function point method gave a result that deviates far from the actual value which is plotted in figure 4, below:

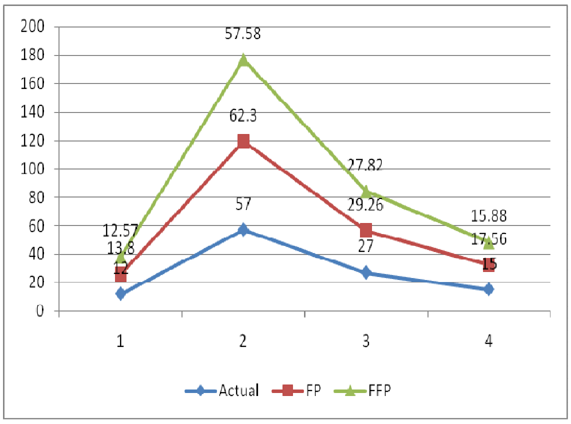

Figure 4.Effort Evaluation Comparison

In summary, fuzzy sets and performance metrics provided a better performance due to better optimization of the input value, avoiding uncertainty and adding the precision value of the non-functional characteristics to the effort.

5. CONCLUSION

This paper focuses on the non-functional characteristics of the project and fuzzy logic metrics for the effort estimation. No model can estimate the effort of software with a high degree of

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accuracy [16]. This paper suggests a transparent and optimized framework for estimating software projects' development effort. The main difference between this work and the existing works, is the, inclusion of the Performance metrics and the newly formulated fuzzy rules in the fuzzy technique .This work is validated with the sample project data collected from the software company. The main advantage of this research is that, it can put together all functional and non-functional characteristics into one general framework, that may have a wide range of usability in effort estimation, and the other benefit of this framework is its good adaptability by using the fuzzy rules.

In future, the same framework can be deployed in different fuzzy membership functions, and analyzed in terms of the feasibility and acceptance in software industries.

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