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The Massive Implementation of Artificial Intelligence and Computational Methods Across Various Sectors

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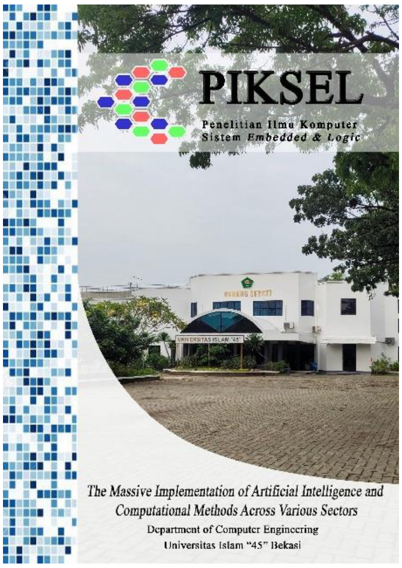

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From Editor-in-Chief

Rahmadya, Ph.D.
Editor-in-Chief

السَّلَامُ عَلَيْكُمْ وَرَحْمَةُ اللهِ وَبَرَكَاتُهُ

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Best wishes to all the members of Editorial Board, Reviewers Panel, Authors and Readers of PIKSEL for a very happy, and stay healthy.

The World Health Organization declares an end to the Covid-19 global health emergency; hence, society has started to return to normal activities. This edition of articles extensively explores computational methods in fields such as education, finance, taxation, industry, and agriculture.

This edition introduces the use of IoT in bandwidth management, Random Forest and Genetic Algorithms in energy consumption prediction, clustering analysis in taxation, EfficientNetV2M for detecting tomato plant diseases, Apriori and Eclat algorithms in sales pattern detection, multi-objective optimization in selecting the best customers, decision support system for determining final project topics, sentiment analysis with pre-trained BERT models, Fuzzy Use Case Points for estimation and classification using learning vector quantization, and Hebbian learning and Self-Organizing Maps that have the potential to improve current models.

Several other research studies help monitor the effectiveness of a system, such as analyzing factors that influence the relationship between majors and graduation rates, evaluating user experience performance of products.

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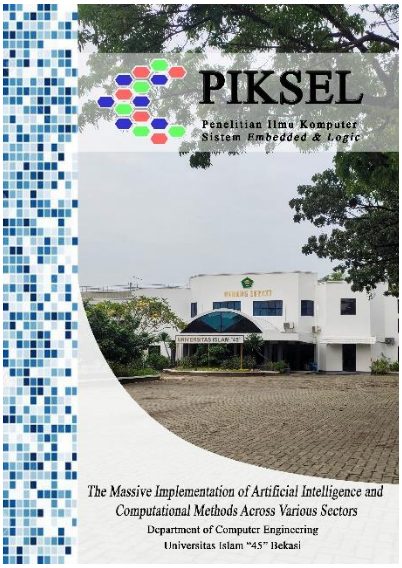

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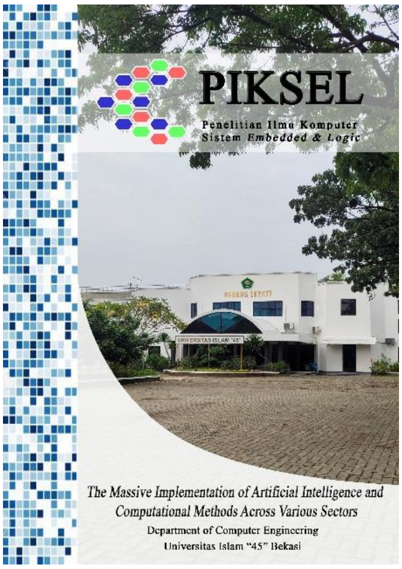

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Fuzzy Use Case Points as a Basis for Effort Estimation

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Abstract

Many software development projects encounter problems related to over- or under-estimation of effort. Accurate effort estimation is crucial for successful project management, but it can be challenging when resources are limited, and little is known about the project. The commonly used method for effort estimation is Use Case Points (UCP), which is mainly used for application-based objects and takes use cases as input. However, UCP has weaknesses, particularly in the high variation of weight factor values for Unadjusted Use Case Weight (UUCW). To address this problem, Fuzzy Use Case Points (FUCP), which is a combination of fuzzy logic and use case points, can be used. By applying fuzzy logic to the UUCW category, FUCP derives new weight factor values for UUCW. The implementation of FUCP to calculate effort estimation in ten government-based projects in this research has shown that FUCP yields the closest value to the actual effort required. It has also been demonstrated that FUCP outperforms UCP in terms of accuracy, with an improvement of 6.51%.

***Keywords**: effort, estimation, fuzzy, use case points*

1. Introduction

One of the most important stages in building or developing software is the planning stage. During this stage, effort and resource estimation, human resources, materials, infrastructure, time, and budget must be taken into account (Kurniawan et al., 2013). The problem that is often encountered in software development projects is overestimation or underestimation. Overestimation can lead to unnecessary allocation of resources, while underestimation can indirectly reduce the quality of the product due to lower costs, resulting in software that does not meet standards. Both of these problems indicate that estimation is an important factor that must be carefully considered before starting a software development project (Ziauddin et al., 2013).

Although estimates may not always produce highly accurate results, these inaccuracies can be minimized by using evaluation methods that are tailored to the project being estimated. Effort estimation is an activity that is performed to predict or forecast the number of workers needed and the time it will take to complete the project (Vishal Sharma & Verma, 2010).

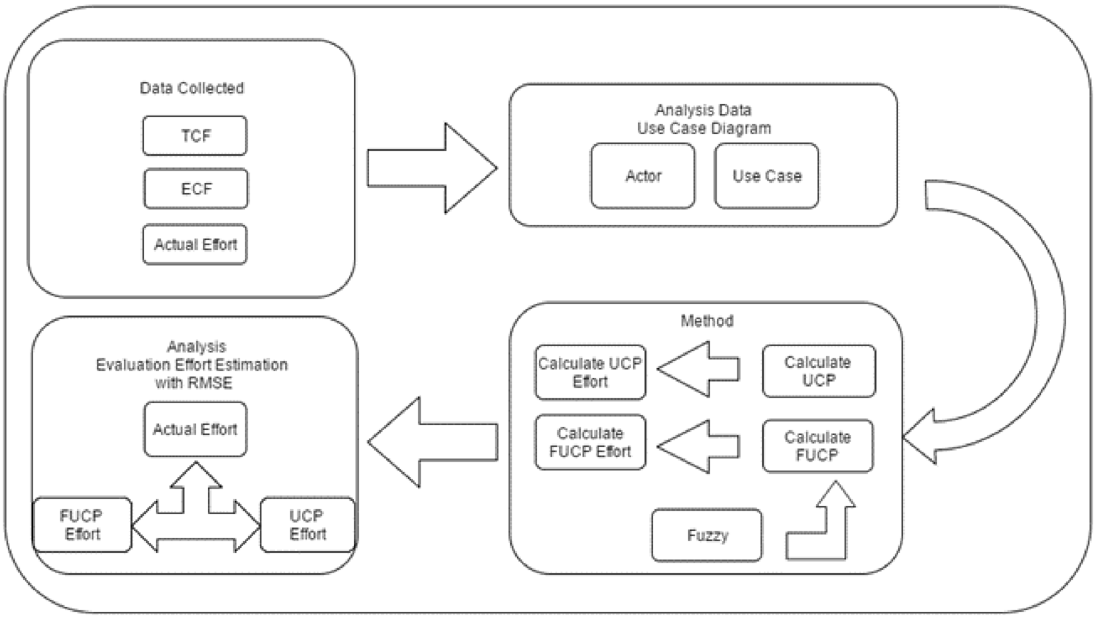
The methods used for effort estimation are Function Points and Use Case Points. The Function Points method has the advantage of not depending on the programming language and can be applied to different types of applications (Sholiq et al., 2019). This approach is also more predictable because its parameters are calculated based on the number of inputs and outputs. The Use Case Points (UCP) method is widely used in object-based applications. Estimating software projects using UCP is easy to use in complex software environments. The UCP method provides an estimate of the effort (person-hours) required to create a project. UCP method is valuable in the context of early size measurement and estimation of effort (Garg et al., 2014).

UCP estimation does not relate to the estimation of the cost factor, because the UCP has weaknesses, which is high difference among the value of weight factor of UUCW. In order to overcome the abovementioned problem, Fuzzy use case points (FUCP) which is the combination between fuzzy logic and use case points, can be used (Alostad et al., 2017).

This research has contributions to make effort estimation more accurate without increasing the time and money spent and simplifying effort estimation methods without compromising their accuracy.

2. Research Method

The concept of fuzzy use case points is created by expanding the UCP method with Mamdani-type fuzzy logic (Ashita Malik et al., 2013). It is also used for estimating project effort, offering more varied value estimates, and investigating the causal relationship between UCP and FUCP using an evaluation effort estimation model. The research methodology stages are illustrated in Figure 1.



Source: Research Result (2023)

Figure 1. Research Method

Starting from data obtained from data collection techniques, namely technical factors, environmental factors, use case diagrams, and actual effort. The second stage, to analyze the use case diagram, actor and use case become important things that are analyzed in this phase. When analyzing the use case diagram, actor and use case would be the reference for the calculation of effort estimation. Actor and use case analysis can then provides values to variables estimated calculation effort. The third stage calculating effort estimation using UCP and FUCP. When doing calculations using FUCP effort estimation, there is a fuzzy influence on the calculation effort estimation. The final stage is the evaluation of effort estimation methods. Activities such measurements are compared with FUCP and UCP method. Activities such evaluation will produce the best methods that appear to approach the value of actual effort.

2.1. Effort

As the name suggests, ‘effort’ is the number of work units that is vital to complete an activity. In simple terms, it is the number of hours we put in, focused on a particular task, to get a certain job done. Effort has to do with how hard you're trying. If something is easy, it doesn't take much effort. If it's hard, it takes a lot of effort. Effort estimation is predict the real work in completing the project by reviewing the schedule, project size, even the project risk will be borne (Reddy et al., 2011). The common methods used for effort estimation is use case points and fuzzy use case points.

Actual effort is the amount of time needed by programmers in completing the project, starting from the stage of planning, analysis, design to implementation. Column person, working days, and working hours these, three things next will be the reference to get the actual effort of a software development project (Hariyanto & Wahono, 2015). The formula for calculating the actual effort is as follows:

$$Actual\ effort\ = \sum person - \sum working\ days * working\ hours \qquad (1)$$

2.2. Use Case Points

Use Case Points is a method of effort estimation in software development. The concept of UCP is based on the requirements for the system being written using use cases diagram. The UCP concept is based on use case diagrams for the system requirements created. The value of the UCP system is obtained by a person assessing the complexity of the actor. The use case is adjusted to two types of technical factors, namely those that characterize the development environment and the technical complexity of the system being developed (Iraji et al., 2012). The UCP is detailed as follows (Nassif et al., 2011):

a. In UCP, actors are weighted with standard Unadjusted Actor Weights (UAW) values: actors are classified as simple, average, or complex. A weight is assigned to each category as follows:
   1) Simple actors (SA) have a value weight of 1. Actors are usually described as other systems via an API.
   2) The average actor (AA) has a value of 2. Actors are described as systems that interact through a text-based user interface or protocol.
   3) Complex actors (CA) have a value of 3. Complex actors are described as systems that interact through a graphical user interface (GUI).

   The UAW is calculated as:

$$UAW = (\sum SA * 1) + (\sum AA * 2) + (\sum CA * 3) \qquad (2)$$

b. Unadjusted Use Case Weight (UUCW): Use cases have categories based on the number of transactions in the success and alternative scenarios. A weight is assigned to each category as follows :

1) Simple Use Case (SU) Its weight is 5. A use case is classified as Simple if
2) the number of transactions is ≤ 3.
3) Average Use Case (AU) Its weight is 10. A use case is classified as Average if the number of the transactions is between 4 and 7.
4) Complex Use Case (CU) Its weight is 15. A use case is classified as Complex if the number of transactions is more than 7.

   The UUCW is calculated as :

$$UUCW = (\sum SU * 1) + (\sum AU * 2) + (\sum CU * 3) \quad (3)$$

5) The sum of the UAW and UUCW values is the Unadjusted Use Case Points (UUCP) value. This is described as :

$$UUCP = UAW + UUCW \quad (4)$$

c. Technical Complexity Factor (TCF): Factors that influence success and contribute to project complexity. The technical complexity factor (TCF) is calculated as follows:

$$TCF = C_1 + C_2 \sum_{i=1}^{13} TF \quad (5)$$

The TCF weight factor are depicted in Table 1. Where C1 = 0.6, C2 = 0.01 and TF is a factor that takes values between "0" and "5". The value "0" means the factor is irrelevant while the value "5" is essential. The value "3" means that the factor is not very essential, neither irrelevant (average). For instance, if all the factors have a value of "3", the TCF will be 1.

Table 1. Technical Complexity Factor (TCF)

No	Factor contributing to complexity	Weight
T_1	Distributed systems	2
T_2	Response time or through put performance Objectives	1
T_3	End user online efficiency	1
T_4	Complex internal processing	1
T_5	Reusability of code	1
T_6	Easy installation	0.5
T_7	Ease of use	0.5
T_8	Portability	2
T_9	Ease of change	1

No	Factor contributing to complexity	Weight
T_{10}	Concurrency	1
T_{11}	Special security objective includes	1
T_{12}	Direct access for thrid parties	1
T_{13}	Special user training required	1

Source: Research Result (2023)

d. Environmental Complexity Factor (ECF): Factors that affect and contribute to team efficiency and productivity. The environmental factors are presented in Table 2. The environmental complexity factor (ECF) is calculated as follows:

$$ECF = C_1 + C_2 \sum_{i=1}^{8} EF \quad (6)$$

Table 2. Environmental Complexity Factor (ECF)

No	Factor contributing to complexity	Weight
E_1	Familiarity with system development process being used	1.5
E_2	Application experience	0.5
E_3	Object-oriented experience	1.0
E_4	Lead analyst capability	0.5
E_5	Motivation	1.0
E_6	Requirements stability	2.0
E_7	Part time staff	-1.0
E_8	Difficulty of programming language	-1.0

Source: Research Result (2023)

Where C1 = 1.4, C2 = -0.03 and this factor EF environmental has a weight which is equivalent to the EF of the technical factor (i.e. between 0 and 5).

e. Use Case Points (UCP), which is an estimation method for making software and measuring the size of the software using use cases. The value of technical factors such as TCP and technical quality and environmental complexity factor (ECF) of development resources and environmental factors have been obtained, then the UCP can be calculated. UCP is calculated as follows:

$$UCP = UUCP * TCF * ECF \quad (7)$$

if the value of all technical factors is 5, then the maximum value of TCF is 1.3. If a project has high complexity and low team efficiency, then the risk of project failure will be high. Typically, taking technical and environmental factors into account, an adjusted use case (UCP) point value will be 30% more or less than an unadjusted use case points (UUCP).

f. Effort is a technique to change value of UCP into value in the form person man hours (PHM). UCP effort illustrates size of the workforce required in hours. UCP effort can be calculated after UCP results have been obtained. PHM value is influenced by the Environmental Complexity Factor in UCP. Environmental Complexity Factor (ECF) on UCP can be seen in Table 2. Value PHM obtained by the following rules:

$W1 = Total\ weighted\ value\ E1\ to\ E6\ which\ has\ a\ value\ < 3$

$W2 = Total\ weighted\ value\ E7\ to\ E8\ which\ has\ a\ value > 3$

If $W1 + W2 \leq 2$ then $PHM = 20$

If $W1 + W2 = 3\ or\ 4$ then $PHM = 28$

If $W1 + W2 > 4$ then the project should be canceled

UCP effort calculation with the following formula:

$$Effort = UCP * PHM \quad (8)$$

Description :

UCP = Use Case Point

PHM = Person Man Hours

2.3. Fuzzy Inference System

The concept of fuzzy logic was introduced by Lotfi Zadeh, Prof. of University of California at Berkeley in 1965. Fuzzy inference system is computing systems that work on the basis of the principle of fuzzy reasoning (Maleki et al., 2014). Fuzzy inference system can perform reasoning with similar principles such as human reasoning on instinct (Iraji et al., 2012). There are several types of Fuzzy Inference System (FIS) are recognized Mamdani, Sugeno and Tsukamoto. FIS is the easiest to understand. because it suits human instincts (Reddy et al., 2011).

2.4. Fuzzy Use Case Points

The FUCP method is an extension of the UCP method that incorporates Mamdani-type fuzzy logic to calculate project effort estimates. This method allows for a wider range of estimated effort values and can be used to investigate the relationship between UCP and FUCP using an evaluation effort estimation model (Nwaiwu & Oluwadare, 2016).

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Essentially there is no difference in the step of the process calculating the estimate project effort using fuzzy use case points with using use case points, that the difference is the weight factor when looking for value classification UUCW transaction use case. Using the same data that is value UAW, TCF, and ECF use the value obtained by using use case points. Do the calculation of estimated effort using fuzzy use case points. Only one category given the influence of fuzzy logic, namely weighting factor UUCW while other categories of data processed using the appropriate method of use case points.

2.5. Evaluation Effort Estimation

Evaluation effort estimation is a comparison was conducted that predict software effort estimation from use cases which are the UCP and FUCP method (Nassif et al., 2011). Evaluation model effort estimation used to perform analysis of the correlation that is Root Mean Square Error (RMSE), R square, adjusted R square and Spearman’s rank order correlation which is a very common criterion used to evaluate the software effort estimation model (Hariyanto & Wahono, 2015).

When using Root Mean Square Error (RMSE) to evaluation between actual with estimation, good results are shown with a low value. Specifically for R square and adjusted R square to be good models if the indicator measuring goodness of fit models’ high value or closer to 1. If the value of one variable is high, then the value of the other variable will be low and vice versa. In the Spearman rank-order correlation it is called a monotone relationship. In Table 3 shows the evaluation formula was conducted on four different criteria, these include R square, adjusted R square, RMSE and Spearman’s rank-order correlation (Hariyanto & Wahono, 2015).

Table 3. Model Evaluation for Effort Estimation

Model Evaluation	**Formula**
R Square	$R^2 = 1 - \frac{SSR}{SST} = 1 - \frac{\sum(\hat{y}_i - \bar{y})}{\sum(y_i - \bar{y})}$
Adjusted R Square	$Adjusted\ R\ square = 1 - \frac{(1 - R^2) - (N - 1)}{N - M - 1}$
RMSE	$RMSE = \sqrt{\frac{\sum(Actual\ effort - Effort\ estimation)^2}{n}}$

Model Evaluation	**Formula**
Spearman's Rank	$\rho = 1 - \frac{6\sum {d_i}^2}{n(n^2-1)}$ or $\rho = \frac{\sum_i (x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_i (x_i-\bar{x})^2 \sum_i (y_i-\bar{y})^2}}$

Source: Research Result (2023)

3. Results and Analysis

3.1. Use Case Diagram

A use case diagram is composed of use cases and actors, which describe the system's capabilities. This diagram is used to identify the business processes of the system. Once the actors that play a role in the system are identified, the processes that can be performed using the system are determined and illustrated in a use case diagram.

The Assessment Library Website development project is used as an example in this study. Figure 2 shows the main page of the Assessment Library Website, while Figure 3 displays the use case diagrams of the website.

Source: Research Result (2023)

Figure 2. Main Page Assesment Library Website

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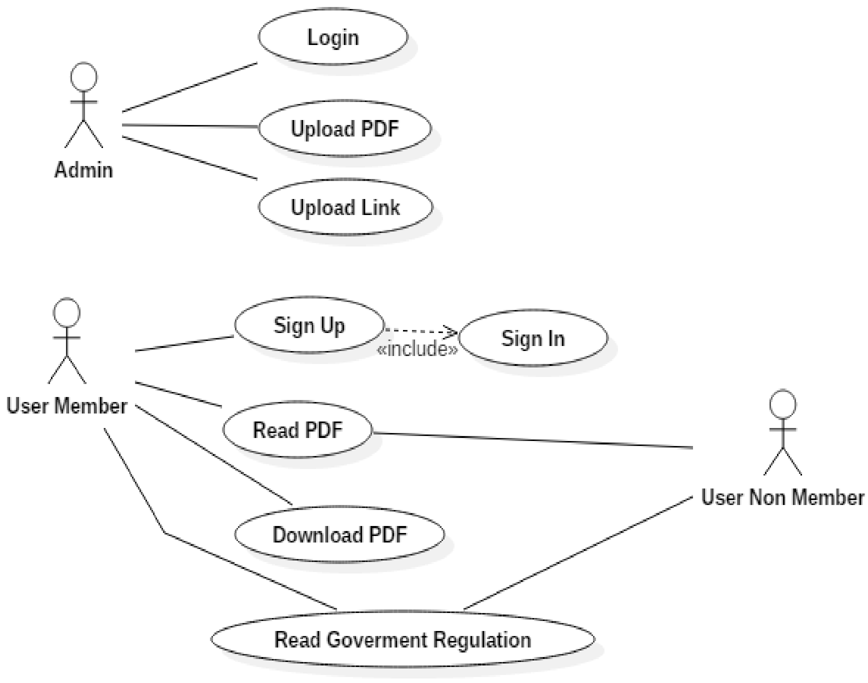


Source: Research Result (2023)

Figure 3. Use Case Diagram Assesment Library Website

3.2. Use Case Points

Based on Figure 3, the use case diagram for the Assessment Library Website consists of three actors and eight use cases. The actors on the use case diagram will be used as the variable Unadjusted Actor Weight (UAW), and the UAW for the Assessment Library Website is shown in Table 4. Similarly, the use cases on the use case diagram will be used as the variable Unadjusted Use Case Weight (UUCW), and the UUCW for the Assessment Library Website is shown in Table 5.

Table 4. UAW Value Assesment Library Website

Actor Type	**Description**	**Weighting Factor**	**Number**	**Result**
Simple	External System with well-defined API	1	0	0
Average	External system using a protocol based interface	2	0	0
Complex	Human	3	3	9
Unadjusted Actor Weight (UAW)				9

Source: Research Result (2023)

Table 5 shows the UUCW values for the Assesment Library Website project, including the actor type, description, weighting factor, number, and resulting value.

Table 5. UUCW Value Assesment Library Website

Actor Type	Description	Weighting Factor	Number	Result
Simple	1-3 transaction	5	5	25
Average	4-7 transaction	10	2	20
Complex	> 7 transaction	15	1	15
Total				60

Source: Research Result (2023)

Unadjusted Use Case Points (UUCP) value is the result of the UAW value added by UUCW. Based on formula number 4, UUCP value of Assesment Library Website is 69. Calculating the value of technical factors to obtain the value of TCP. Based on formula number 5, TCF value of Assesment Library Website is 1.17. Calculating the value of environment factors to obtain the value of Environment Complexity Factor (ECF). Based on formula number 6, ECF value of Assesment Library Website is 0,67.

UUCP, TCF and ECF value used to calculate UCP. Based on formula number 7, UCP value of Assesment Library Website is 54.0891 ≈ 54.09. Based on ECF of Assesment Library Website, PHM value is 20. UCP effort can be calculated after UCP and PHM results have been obtained. Based on formula number 8, UCP effort value of Assesment Library Website is 1081.79 ≈ 1082 hour.

3.3. Fuzzy Use Case Points

Using the same data from the Assesment Library Website, UAW, TCF, and ECF value use the value obtained by using use case points. Only one category given the influence of fuzzy logic, namely weighting factor UUCW while other categories of data processed using the same method of use case points. UUCW value for the Assesment Library Website using fuzzy logic influence can be seen in Table 6. UUCW value combined with fuzzy called FUUCW.

Table 6. FUUCW Value Assesment Library Website

No	Use Case	Type of Transaction	Weighting Factor	Value
1	Login	3	5,70	5,70
2	Upload PDF	7	10,30	10,30
3	Upload Link	4	6,72	6,72
4	Sign up	10	13,70	13,70
5	Sign in	3	5,70	5,70
6	Read PDF	1	4,79	4,79
7	Upload PDF	1	4,79	4,79
8	Read Government Regulation	1	4,79	4,79
Total				56,49

Source: Research Result (2023)

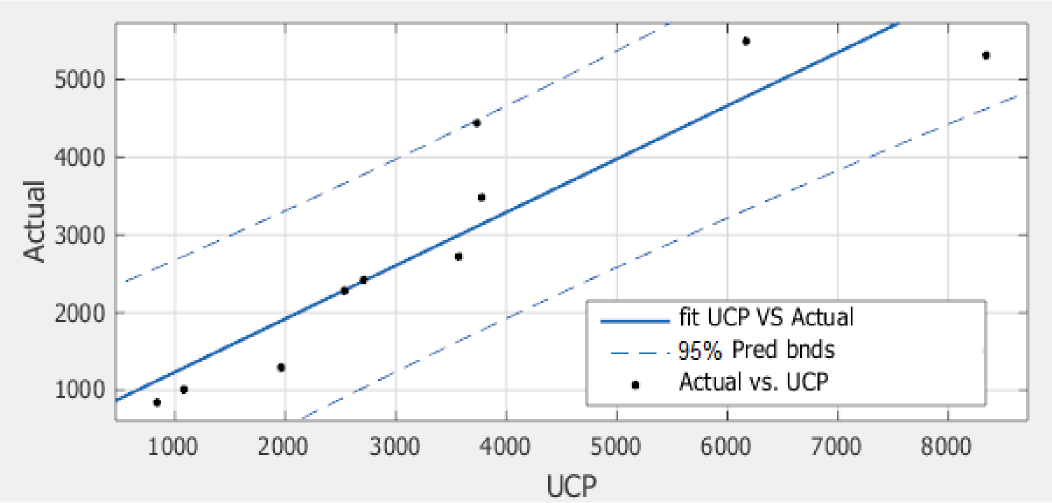
Unadjusted Use Case Points (FUUCP) value is the result of the UAW value added by FUUCW. Based on formula number 4, FUUCP value of Assesment Library Website is 65,49. Using the same data from the value obtained by using use case points, UAW, TCF, and ECF and then value of FUUCP, TCF and ECF value used to calculate FUCP. Based on formula number 7, FUCP value of Assesment Library Website is 51.337611 ≈ 51.34. Based on ECF of Assesment Library Website, PHM value is 20. FUCP effort can be calculated after FUCP and PHM results have been obtained. Based on formula number 8, FUCP effort value of Assesment Library Website is 1026.76 ≈ 1027 hour.

3.4. Actual Effort

Actual effort value is the amount of time required by the programmer in completing the project, starting from the stage of planning, analysis, design to implementation. On the Assesment Library Website has a person is two people, working days Assesment Library Website is 101 days and do the project for five hours each day. Based on formula number 1 actual effort value of Assesment Library Website is 1010 hours.

3.5. Evaluation Model for UCP Method

A comparison is performed between UCP method with actual effort. The implementation of UCP to calculate effort estimation in projects used in this research has shown that UCP has RMSE is 699,4. Display train data with a fitted polynomial, degree is one, and 95% prediction bounds intervals. Figure 3 shows the evaluation result of UCP method and actual effort.

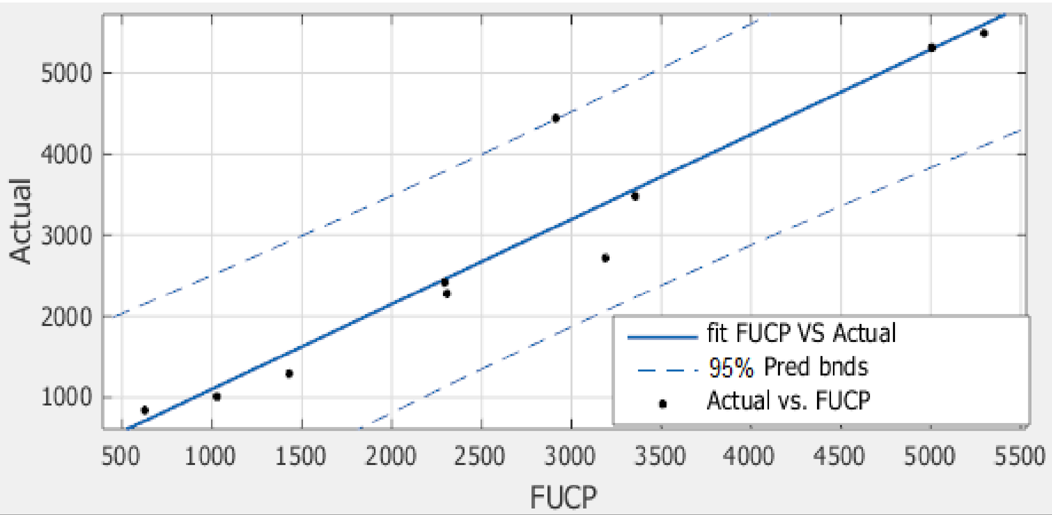


Source: Research Result (2023)

Figure 4. Polynomial Graph UCP Method Versus Actual Effort

3.5. Evaluation Model for FUCP Method

A comparison is performed between FUCP method with actual effort. The implementation of FUCP to calculate effort estimation in projects used in this research has shown that FUCP has RMSE is 547.1. Display train data with a fitted polynomial, degree is one, and 95% prediction bounds intervals. Figure 4 shows the evaluation result of FUCP method and actual effort.



Source: Research Result (2023)

Figure 5. Polynomial Graph FUCP Method Versus Actual Effort

4. Conclusion

In this study that applying fuzzy logic to this use case points in the UUCW category provides a significant improvement in the accuracy of ffort estimation. The implementation of FUCP to calculate effort estimation in ten projects goverment used in this research and it has shown that FUCP has the closest value to the actual effort. It is also demonstrated that FUCP outperforms UCP in terms of accuracy by 6.51 % improvements based on adjusted R square and low value of RMSE the closer to the value actual effort. The correlation calculation effort estimation between UCP and FUCP method with actual effort is FUCP method gives good results for effort estimation in software development projects because FUCP has smaller RMSE is 547.1 than UCP has 699,4. A low value indicates that the effort estimation method approaches the accuracy of the actual value effort.

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Author Contributions

Rakhmi Khalida proposed the topic; Rakhmi Khalida, Tubagus Maulana Kusuma conceived models and designed the experiments; Rakhmi Khalida, Tubagus Maulana Kusuma, and Khairunnisa Fadhilla Ramdhania conceived the optimisation algorithms; Rakhmi Khalida, Tubagus Maulana Kusuma, and Khairunnisa Fadhilla Ramdhania analysed the result.

Conflicts of Interest

The author declare no conflict of interest.

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