Learning Outcomes Measurement on Image Processing Subject using Self Organizing Map based Fuzzy Logic

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Abstract. Outcome-based Education (OBE)-based learning has been implemented to improve the quality of education. One of the important things is to measure the achievement of PLO. The aim of this study is proposed an alternative method of measuring PLO which is measurement carry out used Self Organizing Map (SOM) based on Fuzzy Logic. The parameters used in SOM are the number of epochs of 500, and the learning rate of 0.5. The implemented fuzzy logic uses a centroid fuzzification parameter with a membership function triangle and fuzzy bisector fuzzification parameter with gaussian membership function. The experimental results show that measurements using a Fuzzy Logic-based Self Organizing Map (SOM) can be used but must go through a simulation process first. This is because the selection of fuzzy and rules-based parameters that are implemented greatly affects the final result.

Keywords: learning outcomes measurement · image processing subject · fuzzy logic

1 Introduction

The teaching and learning process using Outcome Besed Education (OBE) has been implemented at various universities in the world, in various study programs. One of the implementations is applied to the Civil Engineering study program [1]. Industrial Engineering [2], and also Economic Management [3]. The results of the study indicate that the resulting curriculum has met the needs of the industry. Based on other research, the implementation of OBE is very effective, and according to students it makes them more skilled and more enthusiastic because they know the things that need to be prioritized [4]. Another advantage is that it motivates students to learn more, and provides lecturer feedback which is very useful in their learning process [5]. Other research states that OBE is flexible in its application, and empowerment-oriented approach to learning [6].

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The challenges faced in implementing OBE include the process of preparing the curriculum which is a very important process because it is based on all things determined by the university, the challenges of the time required by lecturers in the implementation stage, and the assessment process. In addition, the workload of lecturers becomes higher, and also the infrastructure must support the achievement of the predetermined PLO [7].

The process of preparing the OBE curriculum begins with the preparation of the Program Educational Objective (PEO), which is this preparation must be accordance with the university's vision and mission, the standards applied, and also adapted to the needs of stakeholders. The next stage is the preparation of the Program Leaning Outcome (PLO), curriculum maps, determination of courses, identification of materials, selection of evaluations and creation of rubrics in accordance with Couse Learning Outcomes (CLO) and PLO, and conducting assessments [8] [9] [10].

Important things that need to be considered in determining the PLO are regulatory bodies, institutional philosophy, industry demands that have been obtained from stakeholders, opinions and input from experts, curriculum benchmarks, and applicable learning frameworks [11]. In achieving the Learning Outcomes that have been determined, several researches use several strategies, including using problem based learning [12]. Another strategy to achieve PLO is by applying Design-based Learning (DBL) and Outcome-based Education (OBE) in the learning process [13]. Besides that, as an alternative method, blended learning can also be applied [14].

The assessment process is carried out by assessing the aspects accordance with the Course Learning Outcome (CLO), where the CLO is prepared in accordance with the established PLO and PEO. CLO is divided into aspects that become its derivatives [15]. This assessment is carried out for each course and then combined into an assessment of all courses in the study program. With this assessment, the performance of each PLO determined by the study program will be analyzed.

Currently, the PLO's measurement using artificial intelligence has been implemented. One of the methods of assessment learning outcomes has been using fuzzy logic [16]. The application of the fuzzy method has been able to measure the achievement of PLO in a course. This is supported by several studies that use the fuzzy method in measuring the achievement of PLO in a course [17] [18].

The purpose of this research is to apply Self Organizing Map based Fuzzy Logic in analyzing PLO achievement in image processing courses. This process begins with an analysis of PLO achievement using fuzzy then categorizing student achievement using Self Organizing Map (SOM). Originality when compared to previous research is that in addition to analyzing PLO achievement using Fuzzy Logic, student achievement categorization using SOM is also carried out.

2 Materials and Methods

2.1 Stage of Research

This research phase begins with the determination of the Course Learning Outcome (CLO) originating from the PLO that has been determined by the study program. After that, an element analysis of the assessment was carried out in accordance with the predetermined CLO. The next stage is to carry out a fuzzy design for the analysis of PLO achievement, and continue with the SOM design stage for categorizing the achievements achieved by students based on the results of the PLO achievement analysis.

The PLO determined by the study program is as follows:

1. Able to apply knowledge of mathematics, natural sciences, information technology, and electrical engineering to gain a thorough understanding of engineering principles.
2. Able to design system components or processes to be applied in the field of electrical engineering.
3. Able to design and carry out experiments in the laboratory/field as well as analyze and interpret data to strengthen technical assessment.
4. Able to apply engineering principles, identify, formulate, and analyze data/information to solve problems in the field of electric power systems, electronics, regulatory systems, telecommunications and intelligent computing.
5. Able to apply modern electrical engineering methods and skills needed to solve engineering problems.
6. Able to communicate effectively both orally and in writing.
7. Able to plan, complete and evaluate tasks related to electrical engineering.
8. Able to work in cross-disciplinary and cultural arts teams.
9. Able to be responsible to the community by complying with religious norms, professional ethics and being responsible for solving electrical engineering problems.
10. Able to understand the need for lifelong learning in the field of electrical engineering related to relevant contemporary issues.

2.2 Design of Research

This course contributes to PLO 3, PLO 5, and PLO 7. Assessment to measure the achievement of PLO 3 is carried out by written tests, performance performance when designing experiments, and design presentations. PLO assessment 5 written test (knowledge), the process of completing the project, and presenting the results of the projects that have been carried out. While the measurement of the achievement of PLO 7 is carried out by evaluating the results of the analysis of the projects that have been carried out (in the form of reports) and presentation of the results of the analysis. The design of this assessment is illustrated in Table 1.

Table 1. Selection of Input and Output Variables

No.	Measurement	Assessment	Assessed aspects
1	PLO 3	Paper based examination	Cognitive
		Demonstrate performance when designing experiments	Psychomotor
		Presentation of project results (designing experiments to solve problems)	Psychomotor, Affective
2	PLO 5	Paper based examination	Cognitive
		The process of completing the project	Psychomotor, Affective
		Presenting the results of projects that have been carried out	Cognitive, Affective
3	PLO 7	Reports on the results of the analysis of projects that have been carried out (in the form of reports)	Cognitive
		Presentation of analysis results.	Cognitive, Affective

In order to be solved using SOM based Fuzzy Logic, it is necessary to design the input and output systems. The illustration of the input output system is described in Table 2. The research process was carried out with several measurements, namely the measurement of the achievement of PLO 3, PLO 5, and PLO 7, this process used the fuzzy logic method. As for the process of classifying the overall results using SOM.

Furthermore, a fuzzy design is carried out to measure the achievement of PLO 1, PLO 2, and PLO3. The assessment in Table 2 is carried out by giving assignments, mid-semester exams, and final semester exams. The fuzzy design of this study is depicted in Fig. 1.

The SOM method has been used in various fields including robotics [19], Clustering Research Papers [20], and many other applications. In this research, the overall assessment used the SOM method.

The number of clusters in this study is 5 clusters, namely excellent, good, satisfy, fair, and fail. The data is learned from the previous data representing each cluster. Then learning is done, the resulting weight is used for the trial process. The parameters used are the number of epochs of 500, and the learning rate of 0.5.

Table 2. System Input/Output system illustration

Input	Aspect	Output (PLO)	Final output
Result of paper based examination (knowledge) (a1)	Cognitive	Able to design and carry out experiments in the laboratory/field as well as analyze and interpret data to strengthen technical assessment.	Overall Performance
Performance assessment results when designing experiments (a2)	Psychomotor		
Presentation of project results (designing experiments to solve problems) (a3)	Psychomotor		
Communication, Group work (a4)	Affective		
Result of paper based examination (b1)	Cognitive	Able to apply modern electrical engineering	
The results of the assessment of the process of completing the project (b2)	Psychomotor	methods and skills needed to solve engineering problems.	
The results of the assessment present the results of the projects that have been carried out (b3)	Psychomotor		
Communication, Group work (b4)	Affective		
Reports on the results of the analysis of projects that have been carried out (in the form of reports) (c1)	Cognitive	Able to plan, complete and evaluate tasks related to electrical engineering.	
Presentation of analysis results (c2)	Psychomotor		
Communication (c3)	Affective		

3 Result and Discussion

3.1 Measurement of PLO 1 Achievement

The fuzzy logic design for measuring the achievement of PLO 1 is depicted in Fig. 2(a). This measurement consists of 4 inputs as described in Table 2. The implemented fuzzy logic uses a centroid fuzzification parameter with a membership function triangle and fuzzy bisector fuzzi- fication parameter with gaussian membership function. The rule based system is depicted in Fig. 2 (b).

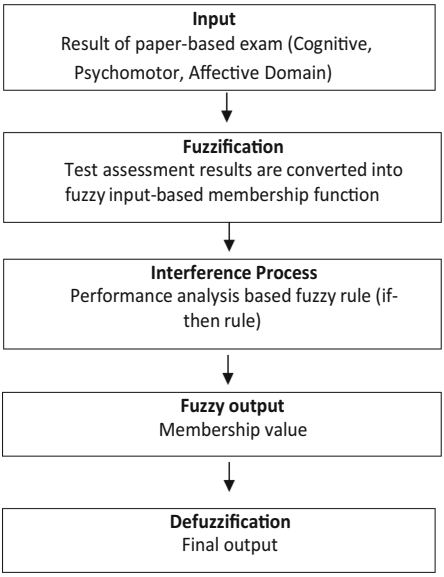
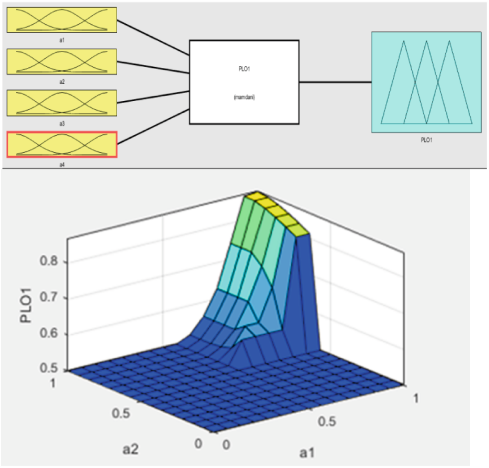


Fig. 1. Design of fuzzy logic system

(a)



(b)

Fig. 2. Assessment of PLO 1 using fuzzy logic (a) Design of fuzzy logic (b) Rule based system on PLO 1

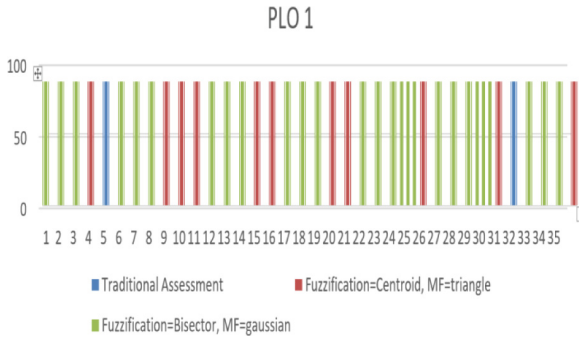


Fig. 3. Assessment results of PLO 1

The results of the PLO 1 measurement using the fuzzy design in Fig. 2 are depicted in Fig. 3. The results of the measurements using the traditional and fuzzy methods are different. Based on Fig. 3 shows that traditional and fuzzy calculations with bisector fuzification parameters and Gaussian membership function obtained almost the same results if the value is more than 80. Meanwhile, if the value is obtained between 60 to 80, the difference is higher.

3.2 Measurement of PLO 2 Achievement

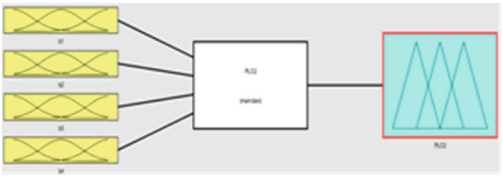
The fuzzy logic design for measuring the achievement of PLO 2 is depicted in Fig. 3(a). This measurement consists of 4 inputs as described in Table 2. The membership function parameter is Gaussian with the fuzzification process using a bisector. The rules-based system used is depicted in Fig. 2 (b).

The results of the PLO 2 measurement using the fuzzy design are depicted in the graph in Fig. 4. The results of the PLO 2 measurement show that using the traditional and fuzzy methods there are differences, the trend is the same as the PLO 1 measurement.

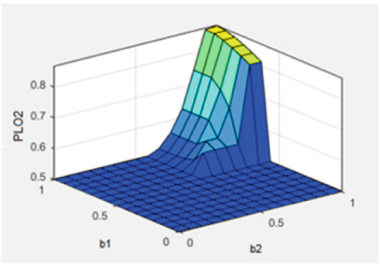
3.3 Measurement of PLO 3 Achievement

The fuzzy logic design for measuring the achievement of PLO 3 is depicted in Fig. 5 (a). This measurement consists of 3 inputs as described in Table 2. Membership function for each variable is depicted in Fig. 6 (b).

The results of PLO 3 measurements using a fuzzy design are depicted in Fig. 7. The results of PLO 3 measurements using a fuzzy design are depicted in Fig. 4. The measurement results also show similar results to PLO 2 and PLO 3. Based on this, it can be concluded that in PLO measurements when using fuzzy results are considered in the selection of parameters. From the fuzzification parameter, the type of membership function, and the number of members in the membership function. It is also important to note that before deciding on the results of the PLO, each student needs to do a simulation for several parameters. This avoids and anticipates discrepancies in the final measurement results.



(a)



(b)

Fig. 4. Assessment of PLO 2 using fuzzy logic (a) Desain fuzzy logic (b) Rule based system of PLO 2

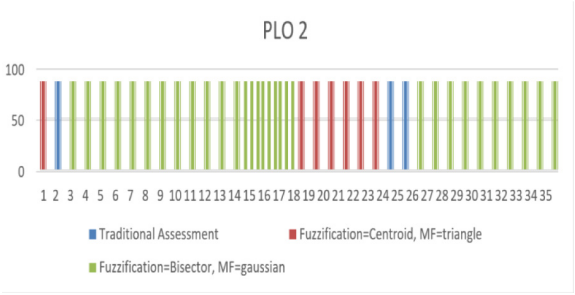
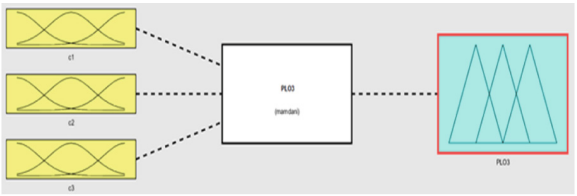


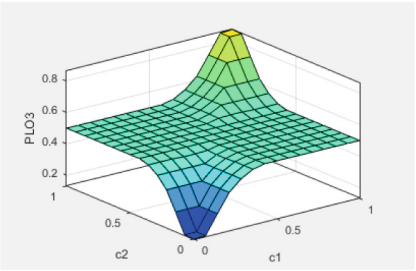
Fig. 5. Assessment Results of PLO 2

The difference in the final results between traditional measurement and centriod fuzzification with membership function triangle, and delta between traditional measurement and bisector fuzzification with gaussian membership function in PLO 1 to PLO 3 is depicted in Fig. 8.

The results of measurements using SOM are shown in Fig. 9. The final results show that the results of calculations using traditional get results that are almost the same as calculations using fuzzy with bisector fuzzyfication parameters with Gaussian membership function.



(a)



(b)

Fig. 6. Assessment of PLO 3 using fuzzy logic (a) Desain fuzzy logic of PLO 3 (b) Rule based sytem of PLO3

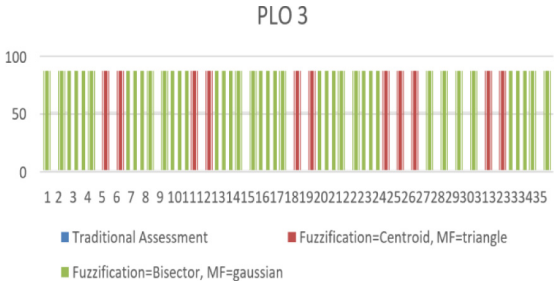


Fig. 7. Assessment Result of PLO 3

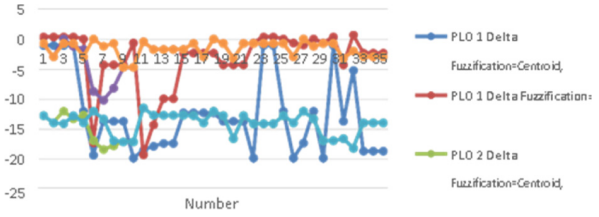


Fig. 8. Comparison between the results of the assessment using fuzzy logic and the current method

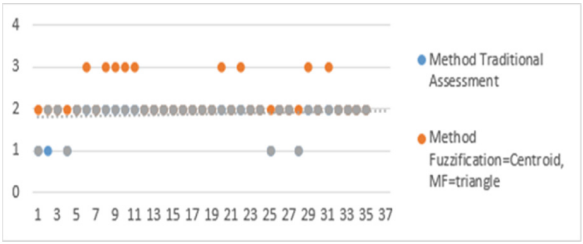


Fig. 9. Final calculation results using SOM

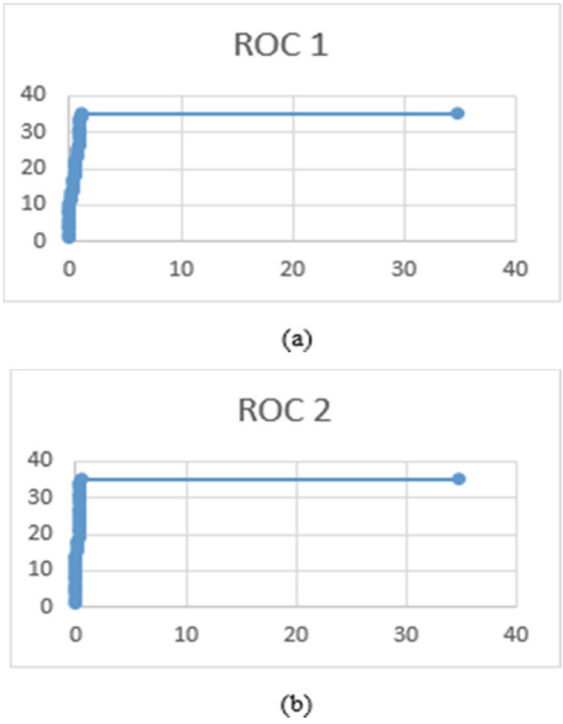


Fig. 10. ROC calculation results (a) ROC 1 comparison between traditional and fuzzy calculations with bisector fuzzification parameters with a Gaussian membership function (b) ROC 2 comparisons between traditional and fuzzy calculations with fuzzification centroid parameters with membership function triangle

Figure 10 is the ROC comparison between traditional and fuzzy calculations with a centroid fuzzification parameter with a membership function triangle and a comparison between traditional and fuzzy calculations with a bisector fuzzification parameter with a Gaussian membership function. Based on the picture, measurements of Are Under the Curve (AUC) were carried out and the results obtained were AUC 1 0.60 while for AUC 2 was 0.97.

4 Conclusion

PLO calculations have been carried out using traditional methods and fuzzy logic with a centroid fuzzification parameter with a membership function triangle and a comparison between traditional and fuzzy calculations with bisector fuzzification parameters with a Gaussian membership function, the experimental results show that calculations using fuzzy logic-based SOM can be done as an alternative method in PLO measurements. The thing that needs to be considered is the selection of parameters used in the fuzzy process, besides that the rules-based system applied must be used with deep consideration (according to real conditions). It is also important to note that during the SOM process, the selection of the gold standard as learning data is very influential on the final result.

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