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Research Paper

Hesitant Fuzzy Linguistic Term Sets with Fuzzy Grid Partition in Determining the Best Lecturer

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Abstract

Decision-making on conditions that involve many alternatives, many criteria, and many judgments is a difficult thing to do. The difficulty is coupled with assessors who sometimes make decisions in hesitant, unclear, and inconsistent circumstances and each person can provide different judgments. One of the methods that can be used is Hesitant Fuzzy Linguistic Term Sets which is the development of Fuzzy Sets that can make decisions by using Hesitant Fuzzy Sets. Hesitant linguistic term has been introduced for capturing the human way of reasoning using linguistic expressions involving different levels of precision. The integration of Hesitant Fuzzy Linguistic Term Sets with Fuzzy Grid Partition will enhance the ability in the decision making process. This research will discuss the use of Hesitant Fuzzy Linguistic Term Sets method and Fuzzy Grid Partition for best lecturers determination.

Keywords: *Decision-Making, Hesitant Fuzzy Sets, Fuzzy Sets, Hesitant Fuzzy Linguistic Term Sets*

1. Introduction

Fuzzy Linguistic is often used as an approach to taking solutions to qualitative decision making. In the traditional framework the concept of linguistic expression used is often wetted on several terms that have been applied. Hesitant Fuzzy Linguistic Term Sets (HFLTS), which can combine multiple linguistic expressions, have been proposed for the convenience of using multiple terms at the same time and accommodating uncertainty and doubt in the use of human language judgments[1]. On the other hand, in some judgments and decision-making need to pay attention to efficiency[2] and The consequences of the decision-making process have been assessed in terms of efficiency using several methods[3]. In the Fuzzy Linguistic Term Sets there is usually a number of Linguistic Decision Making (LDM) which is the set of linguistic terms used as a model to overcome the uncertainty and obscurity that exist. Experts express their opinions and preferences by selecting appropriate terms in LDM [4].

However, in the problem of using LDM classification it is necessary to note the problem of frequent accuracy when it occurs within the problem that may cause a term to be used more frequently than another term that causes an imbalance[5] and also need to pay attention to the diversity that exists [6] and also their accuracy and sensitivity[7]. In some processes this is required to process the productivity and this applies also in the decision-making process [8]. The determination of the best lecturers at universities is also intended to improve the satisfaction of all stakeholders [9] and this directly affects student satisfaction[10]. The linguistic approach is an approximate technique that represents the aspect of linguistic value expressed through linguistic variables. This variable has a value that is not expressed in terms of numbers but in the form of words or sentences in the form of natural or artificial language[11]. In Indonesia, the lecturer's assessment is based on teaching activities, research, and community service. This aspect is considered in the selection of the best lecturers [12]. The use of fuzzy-based methods has been widely used by a number of researchers for decision-making, but the best method of qualitative decision making is the Hesitant Fuzzy Linguistic Term Sets method[13][14].

Initially, linguistic models based on expansive principles [15] and symbolic linguistic models [16] are often regarded as counting with linguistic information. To make computational results interpretable, these models require an approximate process to find the nearest linguistic term. This process is usually criticized by the loss of information. The integration of Hesitant Fuzzy Linguistic Term Sets with Fuzzy Grid Partition will enhance the ability in the decision making process [17]. This research will discuss the use of Hesitant Fuzzy Linguistic Term Sets Method and Fuzzy Grid Partition for best lecturers determination.

2. Related Works

The good performance of linguistic computing associated with uncertainty has led to the spread of its use in various types of deci-

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sion-based applications [18] [19]. However, in the above linguistic computational model, decision makers are limited to express their opinions with a single and simple linguistic term. In most situations, it is difficult for the decision maker to use a single linguistic term to express his opinion when dealing with the complex decision issues under uncertainty. Decision makers may hesitate between different linguistic terms and require a richer expression to express their knowledge more accurately[20]. For this reason, Rodríguez et al. [21] proposed the concept of fuzzy linguistic term (HFLTS) to provide a linguistic and computational basis for increasing the wealth of linguistic elicitation based on fuzzy linguistic approaches and the use of context-free grammar using the term comparison. The fuzzy grid partition can determine the number of fuzzy rules that consist of the underlying model as well. In the Fuzzy Grid Partition, we can create multiple variable labels that can be linked to generate rules that can be linked[17].

3. Methodology

The data used in this research is the lecturer's performance data in each university that includes: education and teaching, research, and community service.

The general architecture of the proposed method used is depicted in Fig. 1

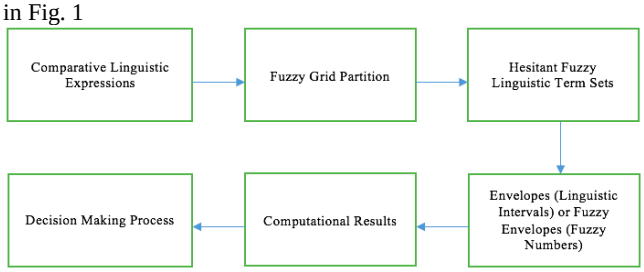


Fig. 1: The General Architecture

3.1. Comparative Linguistic Expressions

The Comparative Linguistic Expressions can be seen in Fig. 2.

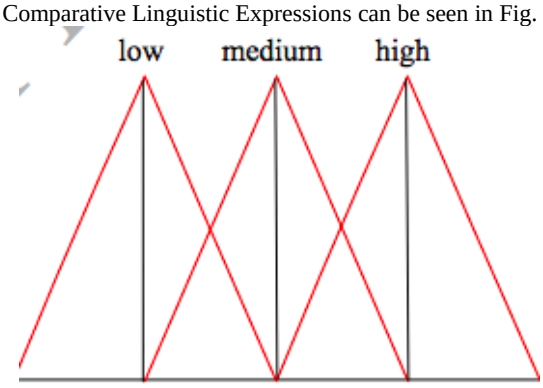


Fig. 2: Comparative Linguistic Expressions

3.2. Fuzzy Grid Partition

There are three types of fuzzy partitions: 1) the grid partition, 2) the tree partition, and 3) the scatter partition [4]. The various method of fuzzy partition can be seen in Figure 3.

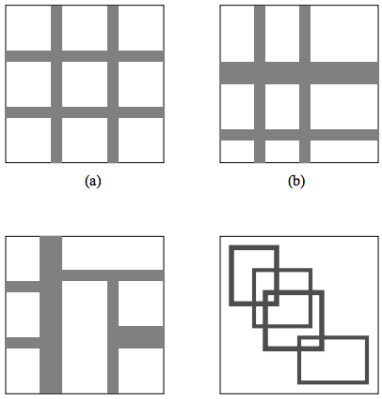


Fig. 3: Fuzzy Partition

Form Fig. 4 we can take some Preliminary Definitions.

Definition 1

Two linguistic labels of an input variable k, $l_{k,a}$ and $l_{k,b}$ with $a < b$, are said to be ***linkable*** when, if there are two rules that differ only in the label of the input k and being this label comprised between the beginning of the support of $l_{k,a}$ and the end of $l_{k,b}$ their consequents are the same. Mathematically, Iff:

$$\nexists\ r_p, r_q \in R \mid \text{if } r_p \equiv (l_{1,s_1}, \ldots, l_{k,i}, \ldots, l_{N,s_N}) \rightarrow c_p \text{ and } r_q \equiv (l_{1,s_1}, \ldots, l_{k,j}, \ldots, l_{N,s_N}) \rightarrow c_q \quad (1)$$

It happens that $c_p \neq c_q$ and $a \leq i \leq j \leq b$

Definition 2

Two rules r_p and r_q :

$$r_p \equiv (l_{1,p_1}, \ldots, l_{k,p_k}, \ldots, l_{N,p_N}) \rightarrow c_p$$

$$r_q \equiv (l_{1,q_1}, \ldots, l_{k,q_k}, \ldots, l_{N,q_N}) \rightarrow c_q \quad (2)$$

Are said to be ***redundant*** iff:

$c_p = c_q$ i and ($l_{k,pi}$ and $l_{k,qk}$) are linkable or equal k

Definition 3

Two linkable labels $l_{k,a}$ and $l_{k,b}$ are said to be ***linked*** or to ***constitute a link*** when they are linked definitively after eliminating a redundant rule.

According to Hesitant Fuzzy Linguistic Terms Sets and Fuzzy Grid Partition, the membership function of Linguistic Term Set can be seen in Fig. 4 [22].

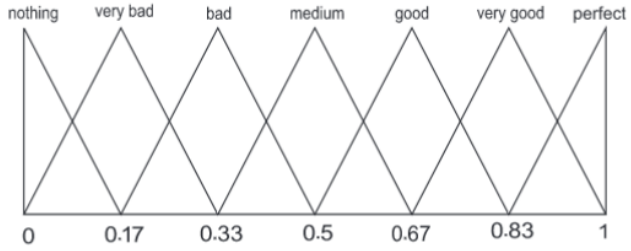


Fig. 4: The Linguistic Term Set

3.3. Hesitant Fuzzy Linguistic Term Sets

The stages of Hesitant Fuzzy Linguistic Term Sets (HFLTS) as proposed by Ashtiani and Asgomi [23] are as follows.

1. Define problems and goals.
2. Determine alternatives, criteria, and appraisers
3. Determine the weight of each criterion
4. Compare the results of the assessment in the form of linguistics
5. Presenting the results of the assessment in the form of envelopes

linguistic.
6. Determine the value of optimistic and pessimistic assessment.
7. Build vector linguistic for each criterion.
8. Determining the Preference Relation Degree for each alternative
criterion.
9. Determine the value of Non Dominance Choice Degree.
Determining Final Ranking.

4. Experimental Process

4.1. Define Problem and Goals

The problem to be discussed in this research is to determine the achievement lecturer.

4.2. Determine alternatives, criteria, and appraisers

In this study there are 3 alternatives, 3 criteria, and 3 assessors. The criteria used in this study are the criteria for the determination of achieving lecturers covering the activities of Tridarma Perguruan Tinggi namely education and teaching, research, and community service.

4.3. Determine the weight of each criterion

The weight of each criterion can be determined directly by the decision maker directly in the form of a fixed value or in the form of linguistic value. If the decision maker gives an answer in the form of linguistic value then the answer can be converted with the following conditions: No effect = 0.1, Very unimportant = 0.2, Unimportant = 0.3, Medium = 0.4, Somewhat important = 0.5, Important = 0.6, and Very important = 0.7

For example in this study, educational and teaching weights = 0.5, research weight = 0.3, and community service weight = 0.2

4.4. Compare the results of the assessment in the form of linguistics

Assessment in linguistic form can be expressed as follows: none = 0, very low = 1, low = 2, medium = 3, high = 4, very high = 5, and absolute = 6. The assessment result by each assessor is expressed in form of pairwise matrix comparison which contains the comparison of importance of each criterion for each alternative.

Suppose a pairwise comparison matrix filled by the 1st assessor can be seen in Table 1, 2, and 3.

Table 1. Comparison Matrices for Education and Teaching Criteria from the 1st Assessor

	Alternative 1	Alternative 2	Alternative 3
Alternative 1	-	Between High and Very High	More than high
Alternative 2	Medium	-	Low
Alternative 3	Low	High	-

Table 2. Comparison Matrices for Research Criteria from the 1st Assessor

	Alternative 1	Alternative 2	Alternative 3
Alternative 1	-	Low	Medium
Alternative 2	High	-	High
Alternative 3	Medium	Low	-

Table 3. Comparison Matrices for Community Service Criteria from the 1st Assessor

	Alternative 1	Alternative 2	Alternative 3
Alternative 1	-	More than High	Very Low
Alternative 2	Low	-	Very Low
Alternative 3	High	Very High	-

The same can be done by the 2nd and 3rd Assessors

4.5. Presenting the results of the assessment in the form of envelopes linguistic.

Suppose that the recaptures of the 1st, 2nd, and 3th Assessors in the form of Envelopes Linguistic can be seen in Table 4.

Table 4. Form of Envelopes Linguistic

Education and Teaching	Research	Community Service
$\begin{bmatrix} - & [T,ST] & [T,A] \\ [M,M] & - & [R,R] \\ [R,R] & [T,T] & - \end{bmatrix}$	$\begin{bmatrix} - & [R,R] & [M,M] \\ [T,T] & - & [T,T] \\ [M,M] & [R,R] & - \end{bmatrix}$	$\begin{bmatrix} - & [T,A] & [SR,SR] \\ [R,R] & - & [SR,SR] \\ [T,T] & [ST,ST]] & - \end{bmatrix}$
$\begin{bmatrix} - & [T,ST] & [T,A] \\ [M,M] & - & [R,R] \\ [R,R] & [T,T] & - \end{bmatrix}$	$\begin{bmatrix} - & [T,A] & [SR,SR] \\ [R,R] & - & [SR,SR] \\ [T,T] & [ST,ST]] & - \end{bmatrix}$	$\begin{bmatrix} - & [R,R] & [M,M] \\ [T,T] & - & [T,T] \\ [M,M] & [R,R] & - \end{bmatrix}$
$\begin{bmatrix} - & [T,A] & [SR,S \\ [R,R] & - & [SR,S \\ [T,T] & [ST,ST]] & - \end{bmatrix}$	$\begin{bmatrix} - & [R,R] & [M,M] \\ [T,T] & - & [T,T] \\ [M,M] & [R,R] & - \end{bmatrix}$	$\begin{bmatrix} - & [T,ST] & [T,A] \\ [M,M] & - & [R,R] \\ [R,R] & [T,T] & - \end{bmatrix}$

4.6. Determine the value of optimistic and pessimistic assessment

The results of the calculation of the optimistic value of the assessment can be seen in Table 5.

Table 5. The Value of Optimistic Assestment

Education and Teaching	Research	Community Service
$\begin{bmatrix} - & [ST,0.2] & [T,0.28] \\ [S,0] & - & [R,0] \\ [R,-0.4] & [S,0] & - \end{bmatrix}$	$\begin{bmatrix} - & [R,-0.1] & [S,-0.17] \\ [SR,0] & - & [R,0.5] \\ [S,0.28] & [S,-0.31] & - \end{bmatrix}$	$\begin{bmatrix} - & [S,-0.4] & [R,0.053] \\ [SR,-0.2] & - & [SR,-0.29] \\ [T,-0.45] & [S,-0.125] & - \end{bmatrix}$

.

The results of the calculation of the Pesimistic value of the assessment can be seen in Table 6.

Table 6. The Value of Pesimistic Assestment

Education and Teaching	Research	Community Service
$\begin{bmatrix} - & [ST,0] & [S,0.429] \\ [TA,0] & - & [SR,0] \\ [SR,0.4] & [S,-0.1] & - \end{bmatrix}$	$\begin{bmatrix} - & [S,0] & [TA,0.33] \\ [SR,0] & - & [SR,-0.33] \\ [S,-0.1] & [R,-0.5] & - \end{bmatrix}$	$\begin{bmatrix} - & [S,0.3] & [R,-0.25] \\ [SR,0] & - & [SR,-0.63] \\ [S,-0.2] & [T,-0.25] & - \end{bmatrix}$

4.7. Build vector linguistic for each criterion

Before building Vector Interval Linguistic for each criterion, we must build Vector Optimistic and Pessimistic for each criterion. In this process, the optimistic and pessimistic values data on the same row in the matrix will be combined.

The results of the formation of Vector Interval Linguistic can be seen in Table 7.

Table 7. Vector Interval Linguistic

Criteria	Interval Linguistic
Education	([(T,0.21),(T,0.74)],[(SR,-0.5),(R,0.5)], [(R,0.15),(R,0.3)]
Research	([(R,-0.34),(R,0.365)],[(SR,-0.17),(R,-0.25)], [(R,0.2),(S,-0.03)]
Community Service	([(R,0.3265),(R,0.5)],[(SR,-0.32),(SR,-0.25)], [R,-0.125) ,(S,0.27)]

4.8. Determining the Preference Relation Degree for each alternative criterion.

To be able to determine the value of Preference Relation Degree for each criterion on the alternative then can be done by using Equation 3.

$$P(A > B) = \frac{\max(0, a_2 - b_1) - \max(0, a_1 - b_2)}{(a_2 - a_1) + (b_2 - b_1)}$$
$$P(B > A) = \frac{\max(0, b_2 - a_1) - \max(0, b_1 - a_2)}{(a_2 - a_1) + (b_2 - b_1)} \quad (3)$$

Preference Relation Degree for education and teaching can be seen in following matrix.

$$\begin{bmatrix} - & 1 & 1 \\ 0 & - & 0.16 \\ 0 & 0.84 & - \end{bmatrix}$$

Preference Relation Degree for research can be seen in following matrix.

$$\begin{bmatrix} - & 0.94 & 0.11 \\ 0.06 & - & 0 \\ 0.89 & 1 & - \end{bmatrix}$$

Preference Relation Degree for community servcie can be seen in following matrix.

$$\begin{bmatrix} - & 1 & 0.4085 \\ 0 & - & 0 \\ 0.5915 & 1 & - \end{bmatrix}$$

4.9. Determine the value of Non Dominance Choice Degree and Determining Final Ranking.

The Non Dominance Choice Degree can be seen in Table 8.

Table 8. Non Dominance Choice Degree

	Alternative 1	Alternative 2	Alternative 3
Education	1	0	0
Research	0.22	0	1
Community Service	0.817	0	1

So based on the result that there is 1st alternative is the best then followed by the 3rd alternative, while the worst result is obtained by the 2nd alternative.

5. Result and Discussion

Based on the results of the research it can be seen that Hesitant Fuzzy Linguistic Term Sets and Fuzzy Grid Partition can be used in decision making to determine best lecturer involving many alternatives, many criteria, and many values and can be used in hesitant and uncertain situations. Future development should be developed to determine criteria weighting by using Hesitant Fuzzy Linguistic Term Sets and Fuzzy Grid Partition concept based on the weight of each sub criterion.

6. Conclusion

The conclusion of this research are as follows. First, Fuzzy Grid Partition can improve the capability of Hesitant Fuzzy Linguistic Term Sets. Second, it is confirmed that Hesitant Fuzzy Linguistic Term Sets and Fuzzy Grid Partition can be used in decision making to determine best lecturer involving many alternatives, many criteria, and many values and can be used in hesitant and uncertain situtations.

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