

A SYSTEMATIC LITERATURE REVIEW ON THE DEVELOPMENT OF MULTI-GRANULAR LINGUISTIC (MGL) TERMS SET IN THE DECISION-MAKING AREA

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ABSTRACT

The usage of Multi-Granular Linguistics (MGL) in today's decision-making problem among decision-makers is an active area of research. This study was a Systematic Literature Review (SLR) using the PRISMA model to identify various appropriate and relevant kinds of literature to identify the development of MGL in the decision-making area. Data search was carried out using criteria determined by researchers from various search engines such as Scopus, Web of Science and others. In total, 60 articles were retrieved, and only 15 articles were relevant to this study. Furthermore, the data were analysed using a qualitative approach to describing the research findings. The results showed that three main research themes had been found, that are the purpose of the study, MGL category and unification/aggregation processes. Outline, the analysis results of these articles stated that the implementation of MGL in the decision-making area is still developing. These results are anticipated to provide researchers with ideas for further research in developing a better MGL method to reduce complexity, which is crucial for decision-making and used in other fields to validate their applicability and effectiveness further. The findings of SLR provided insight into the field's primary contributions, gaps, and chances, which created a conversation about essential research areas in the future.

Keywords: Multi-Granular, Multi-Granular Linguistic Term Sets, development

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1. Introduction

To understand the Multi-Granular Linguistic (MGL) term set in the decision-making domain and its evolution, this paper will analyse, assess, and categorise the relevant literature. This Systematic Literature Review (SLR) examines research patterns, along with similar study goals, MGL categories, theoretical and conceptual frameworks, and research unification and aggregation processes. The themes of this study are shown in Table 1.

Table 1. Themes of This Study

No	Themes of This Study
1	Purpose of the Study
2	MGL Category
3	Unification/Aggregation Processes



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Several decision-makers have stated that group decision-making (GDM) is utilised to find the best solution(s) for a problem. Even though each decision maker (expert) may approach the decision-making process differently, they all desire to come at the best option possible (Morente-Molinera, J. A., et al., 2015). The advancement of information technology has made it possible for people to post reviews of goods and activities online. Most of the time, linguistic information offers online reviews in complex contexts, including dynamic social networks, heterogeneous and large-scale decision environments. Therefore, developing a new algorithm of MGL for GDM can help decision-makers in decision-making as the reducible differences among the experts have been narrowed, and the final solution is the aggregation of all opinions (Dong, Q., Zhou, X., & Martínez, L., 2019).

2. Literature Review

According to (Jiang et al., 2008), in practical group decision-making problems, the experts have different cultural, educational backgrounds, experiences, and knowledge. Thus, each decision-maker may have a different preference regarding the number of linguistic term sets. Multi-granular linguistic term sets give flexibility to the decision-makers to set their own linguistic set. Some decision maker prefers to have two linguistic term sets (good and bad), and some prefer five linguistic term sets (none, good, average, bad and very bad) in evaluating the criteria of the problem. Footnotes are not permitted. If your paper contains footnotes, move the information into the main text or the reference list, depending on the content.

The first researchers incorporated multi-granular linguistic term sets into decision-making problems (F Herrera & Martinez, 1999). In the later year, (F. Herrera et al., 2000) introduced the first fusion method to handle multi-granular linguistic information using fuzzy set theory. Based on their method, all the pre-established linguistic term sets are transformed into fuzzy sets defined in the basic linguistic term set using transformation functions.

3. Methodology

This study used the SLR method to collect, identify, analyse, and synthesize various studies on developing MGL term sets in decision-making. An SLR is a methodologically rigorous evaluation of research findings conducted by an expert employing ad hoc literature selection. An SLR's objective is to promote the creation of evidence-based guidance for practitioners, not only to compile all the data already available on a particular research subject (Kitchenham, B., et al., 2009). The systematic analysis of the relevant literature for this review followed procedures based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) process. The PRISMA method intends to provide a checklist tool for creating systematic reviews of quality literature (Angelini, G., 2023). These stages are identification, screening, eligibility, and inclusion. The following Figure 1 shows the methodical approach to answering this research question. Furthermore, based on the data search results, as illustrated in the chart above, 15 articles were further analysed. The identity of the articles is summarized in Table 2.

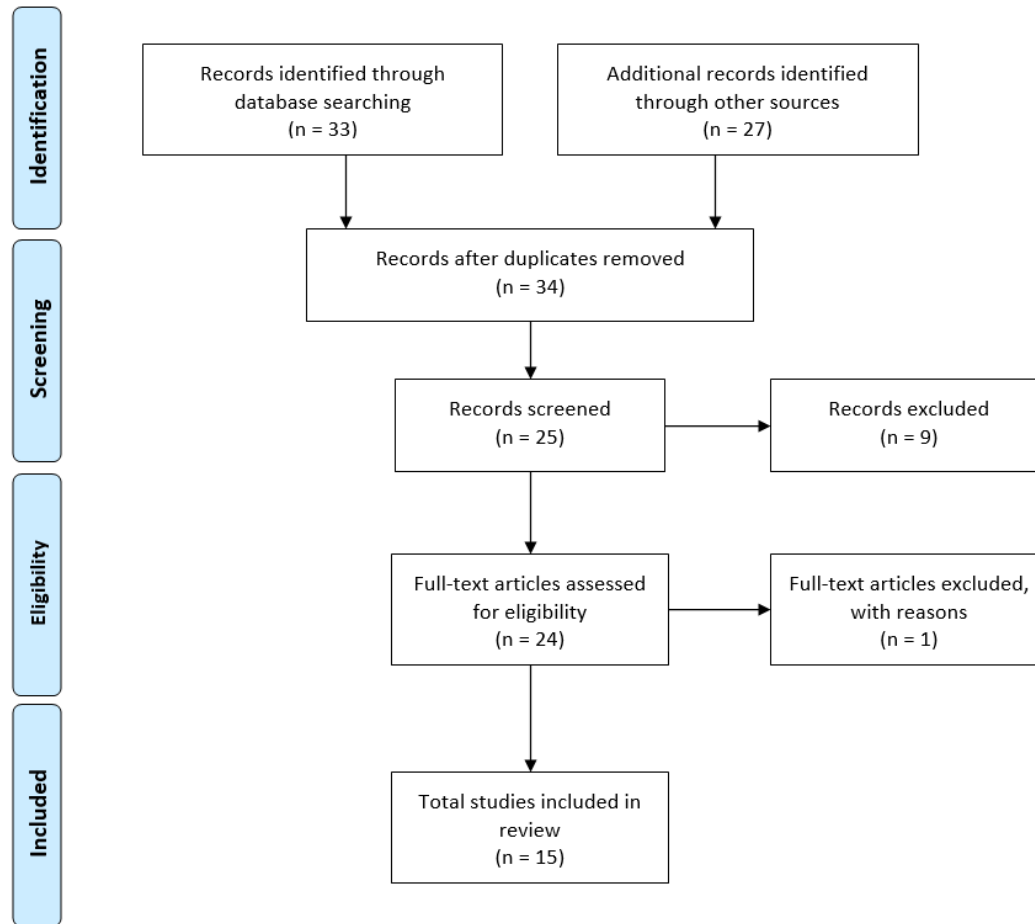


Figure 1. Research Data Search & Selection Flow

Table 2. Identity of the articles to be analyzed further

No	Article Title	Year	Author's Name	Journal Name
1	Supplier selection with different risk preferences and attribute sets: An innovative study based on generalized linguistic term sets	2021	Hui Lin, Jianxin You and Xueyang Zhang	Advanced Engineering Informatics
2	Consensus reaching for group decision making with multi-granular unbalanced linguistic information: A bounded confidence and minimum adjustment-based approach	2021	Zhen Zhang, Zhuolin Li and Yuan Gao	Information Fusion
3	An interpretable knowledge-based decision support system and its applications in pregnancy diagnosis	2021	Kehui Song, Xianyi Zeng, Ying Zhang, Julien De Jonckheere, Xiaojie Yuan and Ludovic Koehl	Knowledge-Based Systems
4	The multiattribute group decision making method based on aggregation operators with interval-valued 2-tuple linguistic information.	2012	Huimin Zhang	Mathematical and Computer Modelling

5	Acquiring and Sharing Tacit Knowledge in Failure Diagnosis Analysis Using Intuitionistic and Pythagorean Assessments	2019	Mohammad Yazdi	Journal of Failure Analysis and Prevention
6	Consensus Constructing in Large-Scale Group Decision Making with Multi-Granular Probabilistic 2-Tuple Fuzzy Linguistic Preference Relations	2019	Yong Ming Song and Guang Xu Li	IEEE Access
7	Risk evaluation by FMEA of supercritical water gasification system using multi-granular linguistic distribution assessment	2018	Nie Ru-xin, Tian Zhang-peng, Wang Xiao-kang, Wang Jian-qiang and Wang Tie-li	Knowledge-Based Systems
8	A novel multi-criteria decision making method for assessing health-care waste treatment technologies based on D numbers	2018	Fuyuan Xiao	Engineering Applications of Artificial Intelligence
9	Personalized individual semantics in computing with words for supporting linguistic group decision making. An application on consensus reaching	2017	Cong-Cong Li, Yucheng Dong, Francisco Herrera, Enrique Herrera-Viedma and Luis Martínez	Information Fusion
10	Health-carewaste treatment technology selection using the interval 2-Tuple induced TOPSIS method	2016	Chao Lu, Jian-Xin You, Hu-Chen Liu and Ping Li	International Journal of Environmental Research and Public Health
11	Managing multi-granularity linguistic information in qualitative group decision making: an overview	2016	Zeshui Xu and Hai Wang	Granular Computing
12	The consistency measures of multi-granularity linguistic group decision making	2015	Cai Mei, Gong Zaiwu and Cao Jie	Journal of Intelligent and Fuzzy Systems
13	Consensus-Based Group Decision Making Under Multi-granular Unbalanced 2-Tuple Linguistic Preference Relations	2015	Yucheng Dong, Cong-Cong Li, Yinfeng Xu and Xin Gu	Group Decision and Negotiation
14	A fuzzy multi-granularity linguistic approach under group decision-making for the evaluation of supply chain flexibility	2014	Shian-Jong Chuu	Journal of Industrial and Production Engineering
15	A consensus approach to multi-granular linguistic MCGDM with hesitant fuzzy linguistic information by using projection	2018	Xue-yang Zhang, Jian-qiang Wang and Jun-hua Hu	Journal of Intelligent and Fuzzy Systems

Search for data sources in this research was accessed through various electronic databases such as Scopus and Web of Science. Several keywords are used in data search: Multi-Granular, Multi-Granular Linguistic Term Set and development. In addition, the researchers also used several criteria in analysing data. The researcher developed the analysis criteria in this study by referring to the requirements previously carried out by (Malhotra, T., & Gupta, A., 2020) and (Morente-Molinera, J. A., et al., 2015). These criteria were chosen using the SLR model equation, which is PRISMA. The articles chosen are articles published by reputable scientific journals. Table 3 shows the data collected from the articles included in this study.

Table 3. Data collected from the articles

No	Article Title	Purpose of the Study	MGL Category	Unification/Aggregation Processes
1	Supplier selection with different risk preferences and attribute sets: An innovative study based on generalized linguistic term sets	To develop a method for solving multi-granular linguistic MAGDM problems with risk preferences and several attribute sets, which is further applied to supplier selection.	Traditional multi-granular FLM based on fuzzy membership.	Multi-granular generalized linguistic term sets (GLTSs).
2	Consensus reaching for group decision making with multi-granular unbalanced linguistic information: A bounded confidence and minimum adjustment-based approach	Revise Herrera's unbalanced linguistic term sets and propose a simplified linguistic computational model to fuse multi-granular unbalanced linguistic terms. Next, develop two optimization models to generate adjustment advice for decision makers who have to change his/her opinions in consensus reaching process, which considers both the bounded confidence levels and minimum adjustment of decision makers' linguistic assessments.	Ordinal multi-granular FLM based on 2-tuple FLM.	Multi-granular unbalanced linguistic terms.
3	An interpretable knowledge-based decision support system and its applications in pregnancy diagnosis	To propose an interpretable knowledge-based decision support system (IKBDSS) that will assist physicians in predicting the risk level of a disease by developing the system.	Ordinal multi-granular FLM based on 2-tuple FLM.	Adaptive Neuro-Based Fuzzy Inference System (ANFIS) and Bayesian Network (BN)
4	The multiattribute	Develops the aggregation	Ordinal multi-granular	Interval-valued 2-tuple

	group decision making method based on aggregation operators with interval-valued 2-tuple linguistic information	operators of interval-valued 2-tuples and introduces their properties	FLM based on 2-tuple FLM	linguistic variable
5	Acquiring and Sharing Tacit Knowledge in Failure Diagnosis Analysis Using Intuitionistic and Pythagorean Assessments	To provide a novel framework to improve knowledge acquisition for analyzing fault diagnosis in a FT (Developing Fault Tree Analysis) and comparing the results with listing of approaches.	Ordinal multi-granular FLM based on 2-tuple FLM.	2-tuple intuitionistic fuzzy numbers (IFNs)
6	Consensus Constructing in Large-Scale Group Decision Making with Multi-Granular Probabilistic 2-Tuple Fuzzy Linguistic Preference Relations	To construct a multi-granular linguistic-based consensus model in large-scale group decision making (LGDM) and establish simultaneously an automatic iteration CRP	Ordinal multi-granular FLM based on 2-tuple FLM.	Probabilistic linguistic term set (PLTS) with 2-tuple linguistic, probabilistic linguistic preference relation (PLPR)
7	Risk evaluation by FMEA of supercritical water gasification system using multi-granular linguistic distribution assessment	To develop a hybrid risk evaluation model to match the supercritical water gasification SCWG system circumstances and remedy the limitations in classical failure mode and effects analysis (FMEA).	Ordinal multi-granular FLM based on 2-tuple FLM.	Proportional 2-tuple linguistic model
8	A novel multi-criteria decision making method for assessing health-care waste treatment technologies based on D numbers	The proposed HCW treatment assessment approach which considers multiple and hierarchical evaluation criteria in HCW management is developed for multi-granularity linguistic information environment.	Traditional multi-granular FLM based on fuzzy membership.	Normalized numerical weight
9	Personalized individual semantics in computing with words for supporting linguistic group decision making. An application on consensus reaching	To develop a new model to represent PIS and a framework for Computing with Words (CW) dealing with personalized individual semantics (PIS), based on the 2-tuple linguistic model including personalized 2-tuple linguistic operators are proposed,	Ordinal multi-granular FLM based on 2-tuple FLM.	Numerical scale to extend the 2-tuple linguistic model

10	Health-carewaste treatment technology selection using the interval 2-Tuple induced TOPSIS method	To develop a new hybrid decision making approach based on interval 2-tuple linguistic variables and a modified TOPSIS method to select the best disposal technology for Health-care waste (HCW) management.	Ordinal multi-granular FLM based on 2-tuple FLM.	Interval 2-tuple induced TOPSIS (ITI-TOPSIS)
11	Managing multi-granularity linguistic information in qualitative group decision making: an overview	Developments of multi-granularity linguistic term sets by several perspectives	Ordinal multi-granular FLM based on hierarchical trees.	Multi-granularity Qualitative Group Decision Making
12	The consistency measures of multi-granularity linguistic group decision making	To present a consistency index of multi-granularity linguistic preference relations, and develop a more flexible consistency measure method.	Traditional multi-granular FLM based on fuzzy membership.	Uncertain linguistic variables and combination of linguistic computational model with statistics methods
13	Consensus-Based Group Decision Making Under Multi-granular Unbalanced 2-Tuple Linguistic Preference Relations	To develop a group decision making (GDM) model based on multi-granular unbalanced 2-tuple linguistic preference relations,	Ordinal multi-granular FLM based on 2-tuple FLM.	Multi-granular unbalanced 2-tuple linguistic preference relations
14	A fuzzy multi-granularity linguistic approach under group decision-making for the evaluation of supply chain flexibility	To establish a useful heterogeneous group decision-making model with multi-granularity linguistic information using a new fuzzy linguistic approach to evaluating supply chain flexibility (SCF).	Ordinal multi-granular FLM based on a basic linguistic term set (LTS).	Modified linguistic hybrid geometric averaging (LHGA)
15	A consensus approach to multi-granular linguistic MCGDM with hesitant fuzzy linguistic information by using projection	To make an extension of the induced ordered weighted averaging operator, develop a multi-granular hesitant 2-tuple induced ordered weighted averaging operator.	Ordinal multi-granular FLM based on 2-tuple FLM.	Hesitant 2-tuple sets and hesitant fuzzy linguistic term set (HFLTTS)

4. Result and Discussion

This section discussed on the analysis of the selected article in Table 3 based on 3 themes that are purpose of the study, MGL category, and unification/aggregation processes.

4.1 Purpose of the Study

In connection with this SLR, the data analysis used in this study is content analysis. The phrase "content analysis" refers to various text analysis techniques. It is a methodical coding and categorising strategy used to covertly examine vast amounts of textual information to identify patterns and trends in words used, their usage frequency, their relationships, and the communication structures and discourses (Vaismoradi, M., Turunen, H., & Bondas, T., 2013). There are three steps taken in analysing data with this technique, namely: (a) purpose analysis, (b) MGL category analysis, and (c) unification/aggregation processes analysis. From Table 3, we can conclude that the purpose of the selected articles is to develop MGL in the decision-making area. Some of the articles focus on the development of the MGL, while most of the articles engage the use of the developed MGL in making decisions in various fields. The developed MGL can resolve linguistic MAGDM difficulties with multiple attribute sets and risk preferences. It can handle difficult real-world decision issues that cannot be solved by linguistic MAGDM techniques now in use (Lin, H., You, J., & Zhang, X., 2021). This result motivates further investigation into the application of MGL in the field of decision-making.

4.2 MGL Category

Table 4. MGL Category in the Study

Themes of This Study	n
Traditional Multi-Granular FLM Based on Fuzzy Membership	3
Ordinal Multi-Granular FLM Based on A Basic Linguistic Term Set (LTS)	1
Ordinal Multi-Granular FLM Based on 2-Tuple FLM	10
Ordinal Multi-Granular FLM Based on Hierarchical Trees	1

The above table shows the studies' 4 out of 6 MGL categories. From the 15 selected articles, one article used ordinal multi-granular FLM based on a basic linguistic term set (LTS) and ordinal multi-granular FLM based on hierarchical trees. While three articles used traditional multi-granular FLM based on fuzzy membership. Most of the articles used ordinal multi-granular FLM based on 2-tuple FLM. From this data, we can conclude that there are readily available mathematics mobile applications for secondary curriculum. Therefore, in the future, more articles should be focused on other MGL categories, which are ordinal multi-granular FLM based on a basic linguistic term set (LTS), ordinal multi-granular FLM based on hierarchical trees and the other two categories not included, which are ordinal multi-granular FLM based on qualitative description spaces and ordinal multi-granular FLM based on discrete fuzzy numbers.

4.3 Unification/Aggregation Processes

From Table 3, we can conclude that each article has different unification or aggregation processes. Unification and aggregation refer to processes that involve combining or bringing together different elements or components to create a cohesive whole. Both unification and aggregation are valuable processes in different fields, as they help make complex systems and data more manageable and comprehensible. The context and goals of the task will dictate which process is appropriate to use. The unification algorithm provides high interpretability with tolerant computational complexity, and the solution of multi-granularity linguistic unification maintains the semantics of the original linguistic information (Wang, H., Xu, Z.,

& Zeng, X. J., 2018). In order to determine an assembly point that best represents the evaluation points, expert evaluation must be gathered (Mengting, Z. O. N. G., Tian, S. H. E. N., & Xi, C. H. E. N., 2019).

5. Conclusion and Recommendation

This study is an SLR on the development of MGL term sets in the decision-making area, which analyses 15 articles that have been published from the year 2012 until the year 2021 in reputable international journals and selected based on predetermined criteria. This article provides a clear picture of the SLR of MGL in decision-making and current trends by identifying, classifying, and synthesizing research results based on research themes. Three main themes are found based on data analysis: the purpose of the study, the MGL category and the unification/aggregation processes. Developing an optimization model to derive the weighting vector of selection criteria objectively can reduce the decision-makers uncertainty as each has their own ideas, attitudes, motivations and personalities. The proposed methods also can be used in other fields to validate their applicability and effectiveness further. One limitation of this review is the relatively small number of articles reviewed or analysed. This is caused by the restrictions set as criteria in capturing various Boolean searches such as “multi-granular AND multi-granular linguistic term sets AND development”. A literature review must be carried out with a broader scope, both in terms of quantity and in producing more comprehensive literature review articles.

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8. Conflict of Interest

The authors have no conflicts of interest to declare.

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