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**Title:** Mathematical Fuzzy Logic in the Emerging Fields of Engineering, Finance, and Computer Sciences

**Year:** 2022

**Version:** Published version

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**Please cite the original version:**

Shukla, A. K. (2022). Mathematical Fuzzy Logic in the Emerging Fields of Engineering, Finance, and Computer Sciences. *Axioms*, 11(11), Article 615. <https://doi.org/10.3390/axioms11110615>

## Editorial

# Mathematical Fuzzy Logic in the Emerging Fields of Engineering, Finance, and Computer Sciences

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With more than 50 years of literature, fuzzy logic has gradually progressed from an emerging field to a developed research domain, incorporating the sub-domain of mathematical fuzzy logic (MFL). Primarily, MFL's objective is to formulate a mathematical tool to model uncertainty due to vagueness in real-world scenarios. It specifically targets many-valued logic and has significantly contributed to the logical foundations of fuzzy set theory (FST).

Through the efforts and substantial interest of researchers, the literature on the theory and modeling of MFL has expanded rapidly, improving our understanding of this domain. However, more attention is required from the research community, especially in the current context where data-driven information retrieval and explainability are of great concern with the growth of never-ending data resources. Moving forward, MFL aims to target a wide range of complex problems in many applicative contexts ranging from the medical sciences to finance, commerce, engineering, and computer sciences. Further, it also holds significance when applied to the applications of artificial intelligence and deep learning.

This book presents papers on the cutting-edge contributions of MFL to the emerging fields of engineering, finance, and computer sciences. It comprises a collection of articles in the *Axioms* Special Issue of "Mathematical Fuzzy Logic in the Emerging Fields of Engineering, Finance, and Computer Sciences". The publications in this book target both the theoretical and practical aspects of MFL and FST. Several publications present the formal approaches to applying MFL to address real-world problems.

The volume opens with the theoretical contribution of the paper by Dai et al. [1], where authors extensively studied the properties of overlap and grouping functions concerning operations such as meet, join, convex combination, and  $\otimes$ -composition. The outcome of this work may be utilized as a norm for selecting the generation approach of overlap and grouping functions.

In another significant contribution, the fuzzy logic extension to the Algebraic Routley–Meyer-style (ARM) semantics for basic substructural logic is introduced by Yang [2]. Overcoming the drawbacks of earlier semantics such as Kripke and Urquhart, ARM semantics signifies operations interpreting ternary relations, which eventually followed similar structures as algebraic semantics.

Jiang and Qiu [3] proposed a novel granular division for the division of type-1 fuzzy numbers. The authors first critically analyzed the relationships among the already available gH-division, g-division, and gr-division. Numerical examples were then added, in order to provide young researchers with a comprehensive overview of this domain.

Thanh and Lan [4] targeted the supplier selection problem pertaining to Vietnam's Food Processing industry. They proposed novel hybrid metrics comprising Triple Bottom Line Metrics, the Fuzzy Analytical Hierarchy Process, and the Combined Compromise Solution approach for sustainable supplier selection.

Another case study of Vietnam focused on petroleum supply chain design was conducted by Wang et al. [5]. The authors proposed a methodology comprised of a heuristic-based location-determination algorithm and a fuzzy multi-objective mixed-integer linear



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Received: 2 November 2022

Accepted: 4 November 2022

Published: 5 November 2022

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programming optimization model. The uncertainty parameters in this model, such as cost, demand, capacity import/export quota, and cost, are modeled using fuzzy triangular numbers. Maximizing profits and energy security and minimizing transport emissions are the objectives framed under the fuzzy min-max goal programming model.

Moving to another continent, Martin et al. [6] presented an interesting study that analyzes the key factors needed to identify immigrants in Ecuador. This study is administered on the inputs provided by the immigrants themselves, which first process it using a fuzzy hybrid multi-criteria decision-making method, and then a fuzzy clustering approach is used to study the variations in the main determinants.

Another paper targeting a specific geographical area was composed by Simjanović et al. [7]. The authors explored the criteria for the successful design of an e-commerce platform in the Western Balkans. The involved factors were studied during and after the COVID-19 pandemic and modeled using fuzzy triangular numbers under the framework of a fuzzy analytical hierarchy process.

Another computational study focused on the post-COVID-19 effect is presented by Castillo et al. [8]. A financial forecasting problem is addressed using the fuzzy system aggregation of neural networks. Here, the authors utilize the interval type-3 fuzzy theory for the fuzzy system and propose a novel mathematical formulation. The ensemble of COVID-19 and the Dow Jones time series is used for the experimental analysis.

Indelicato et al. [9] studied the attitude of European countries such as Belgium, Germany, Spain, France, the United Kingdom, and Portugal towards various immigrants using the Fuzzy-Hybrid TOPSIS method. The fuzzy triangular numbers are used to model the uncertain parameters, and the data for this study are extracted from the International Social Survey Program.

With the application to brain tumor classification, Nayak et al. [10] suggested an upgraded dense EfficientNet convolutional neural network (CNN) architecture. This CNN model is fully automatic and follows min-max normalization for the multi-classification of brain tumors. The authors advised that fuzzy logic could be used as a pre-processing step for improving brain images. Further, the proposed architecture may be employed as a decision-making tool.

The application of fuzzy logic for assessing students in education is studied by Doz et al. [11]. It integrates the teacher-assigned student's grades with the Italian national assessment of mathematical knowledge score for the final judgment. The teacher grades include grades on oral and written evaluations.

Mishra et al. [12] explored the area of explainable artificial intelligence (XAI) based on the background of the Explainable Fuzzy AI Challenge 2022. The authors proposed a fully autonomous and optimized XAI algorithm that can play the Python arcade game "Asteroid Smasher". A computationally efficient and explainable solution is presented for an XAI agent to work in this fast-paced environment, using fuzzy inference systems (FIS) such as Mamdani FIS and TSK-based FIS.

Castelló-Sirvent and Meneses-Eraso [13] present a systemic review study that focuses on the ideology and agenda in multiple-criteria decision making (MCDM) with the perspective of the business and management domain. The bibliometric section explores the major thematic clusters, international research collaboration networks, and the bibliographic coupling of the MCDM-related publications.

With such a diverse publication, ranging from several theoretical contributions to applications for solving real-world problems, this book will be of great interest to students, as well as young and established researchers.

**Conflicts of Interest:** The author declares no conflict of interest.

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