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The special issue on the 100th anniversary of Lotfi A. Zadeh (1921–2017)
"Applications of Fuzzy Technology in Civil Engineering and Construction Management"

Editorial

APPLICATIONS OF FUZZY TECHNOLOGY IN CIVIL ENGINEERING AND CONSTRUCTION MANAGEMENT: THE SPECIAL ISSUE IN THE 100th ANNIVERSARY OF LOTFI ZADEH

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Abstract. In papers published in *Journal of Civil Engineering and Management*, many applications of fuzzy logic can be found. To commemorate the contributions of the fuzzy set theory proposed by Professor Lotfi Zadeh to the fields of civil engineering and construction management, seven papers were selected for this special issue. These papers combined fuzzy set theory with appropriate methods to solve specialized problems in the fields of civil engineering and construction management, and provided good insights for the applications of fuzzy technology in solving problems related to civil engineering and construction management.

Keywords: civil engineering, construction management, fuzzy set, multiple criteria decision making, Lotfi Zadeh.

Introduction

As the social environment becomes more and more complex, the expression of various kinds of information becomes more and more ambiguous. Civil engineering, as a field involving a large amount of information and knowledge, has more or less uncertainty and fuzziness (Corotis, 2015). In this respect, the fuzzy set theory (Zadeh, 1965) enables uncertain and fuzzy information to be dealt with mathematically. To facilitate the applications of the fuzzy set theory, Bellman and Zadeh (1970) further integrated the fuzzy set theory into general decision-making problems. Afterwards, many fuzzy decision-making methods were proposed to be implemented in different fields including civil engineering and construction management (Liu & Liao, 2017). To commemorate the contributions of the fuzzy set theory proposed by Professor Lotfi Zadeh, many journals, such as *Technological and Economic Development of Economy* (Xu & Herrera-Viedma, 2021), *International Journal of Computers Communications & Control* (Dzitac, 2021), *Mathematical Problems in Engineering* (Antucheviciene et al., 2015), *Sustainability* (Zavadskas et al., 2017), organized special issues about the applications of the fuzzy set theory to specific fields.

At present, scholars have used fuzzy technology to solve various problems in the fields of civil engineering and construction management, for instance, for construction contractor prequalification, supplier/subcontractor selection, construction project risk assessment, evaluating alternative construction technologies, developing construction schedules, cost calculation and many others. Several survey papers about the fuzzy approaches to civil engineering, structural engineering and other related areas from different perspectives can be found (Antucheviciene et al., 2015; Corotis, 2015; Zavadskas et al., 2017; Falcone et al., 2020; Chen & Pan, 2021).

In papers published in *Journal of Civil Engineering and Management*, many applications of fuzzy logic can be found (Shoar & Banaitis, 2019; Yazdani et al., 2019; Yin et al., 2019; Fallahpour et al., 2020; Huang et al., 2020; Mohandes et al., 2020). To further commemorate the contributions of the fuzzy set theory proposed by Professor Lotfi Zadeh to the fields of civil engineering and construction management, seven papers were selected for the special issue of *Journal of Civil Engineering and Management* entitled "*Applications of Fuzzy Technology in Civil Engineer-*

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ing and Construction Management: The Special Issue in the 100th Anniversary of Lotfi Zadeh". These papers combined fuzzy set theory with appropriate methods to solve specialized problems in the fields of civil engineering and construction management, and provided good insights for the applications of fuzzy technology in solving problems related to civil engineering and construction management.

Description about the selected papers

Among the seven selected papers, the first three are the summary of the applications of the fuzzy set theory and multiple criteria decision making (MCDM) methods in the fields of civil engineering and construction management, and the last four are the applications of fuzzy technology in specific problems related to civil engineering and construction management.

The first paper, "Applications of fuzzy multiple criteria decision making methods in civil engineering: A state-of-the-art survey", written by Zhi Wen, Huchang Liao, Edmundas Kazimieras Zavadskas, and Jurgita Antuchevicience, reviews the journal papers on the applications of fuzzy MCDM models (the combination of fuzzy set theory and MCDM methods) in civil engineering. The MCDM problems in civil engineering are classified, and individual fuzzy MCDM models and hybrid fuzzy MCDM models used in civil engineering are reviewed, respectively. The research challenges of fuzzy MCDM models in the civil engineering field and corresponding suggestions for future research directions are put forward for researchers and practitioners.

The second paper, "Application of multiple criteria decision making methods in construction: A systematic literature review", authored by Xingyu Zhu, Xianhai Meng, and Min Zhang, discusses the developments of popular MCDM methods and their applications in construction. Authors divide the applications of MCDM methods in construction into seven aspects based on a systematic literature review, represent the research trend through bibliometric analysis, and analyze the potential challenges of existing researches. In addition, the future development directions are explored to promote the construction management of related research and practice.

The third paper, "Time, cost and risk in construction with using of fuzzy logic", presented by Edyta Plebankiewicz, Krzysztof Zima, and Damian Wieczorek, reviews the applications of fuzzy logic in construction investment planning. This paper puts forward three fuzzy models related to construction, which improves the accuracy of fuzzy information calculation in the process of construction investment. The examples given in this paper prove the effectiveness of fuzzy logic in solving the construction problem with incomplete and imprecise information.

The fourth paper, "q-indeterminate correlation coefficient between simplified neutrosophic indeterminate sets and its multicriteria decision making method", written by Shigui Du, Jun Ye, Rui Yong, and Fangwei Zhang, develops a simplified neutrosophic indeterminate set (SNIS) to describe the uncertainty degree of uncertain information. Based on the q-indeterminate correlation coefficient of SNISs, this paper considers the risk attitude of decision makers to construct a simplified neutrosophic indeterminate MCDM method. Additionally, this paper takes the selection of architectural design scheme as an example, and the practicability and flexibility of the constructed decision-making method are illustrated.

The fifth paper, "Exploring negative impacts of rural roads using fuzzy multicriteria approach", authored by Vineet Tirth, Makrand Wagale, Ajit Pratap Singh, Ashoke Kumar Sarkar, Ram Karan Singh, Ali Algahtani, and Saiful Islam, introduces an MCDM method which improves fuzzy weighted average aggregation approach and combines it with the fuzzy TOPSIS method. The introduced MCDM method is used to evaluate the negative impact of rural highway construction on the natural environment and social environment.

Serious games together with the gamified and the game-based surveys offer an engaging way to increase citizens participation into the urban planning projects. However, there is always the risk that some of the participants are not motivated to take the GBS seriously. These issues are addressed in the sixth article, "Participant trustworthiness analysis in the game-based urban planning processes by PROMETHEE-MGQNN approach" by Romualdas Bausys, Ingrida Lescauskiene and Rokas Semenas. The novel MCDM approach PROMETHEE under m-generalised q-Neutrosophic environment (PROMETHEE-MGQNN) is proposed as a solution to the problem of the identification of the non-reliable participants. The game-based survey "Parkis" and five criteria that might be valued automatically from the game database are proposed for the analysis of the untrustworthy respondents. Practical experiments show that the proposed solutions can detect the behavioural tendencies of the GBS players.

The seventh paper, "Expert panel on in-situ visual inspections for masonry churches maintenance stage" by Manuel Carpio, Jesús Ortega and Andrés J. Prieto, presents the application of an innovative digital management system using artificial intelligence that can support the maintenance management of buildings and minimize human error in data collection. Analyses carried out show slight differences between the members of the expert panel during the in-situ visual inspection; nevertheless, the proposed digital method helps minimize the uncertainty in the results. The paper highlights input variables, which present high dispersion (load state modification, fire and occupancy), and input parameters which present low dispersion (preservation, roof design and overloads). The study concerns churches emplaced in Chile, yet the results can prove beneficial to stakeholders of various heritage building during the inspection, diagnosis and evaluation stages.

These seven papers demonstrate the universality and effectiveness of fuzzy technology and its decision model

combined with MCDM methods in the fields of civil engineering and construction management. It is hoped that these papers can enlighten and help the readers of *Journal of Civil Engineering and Management*.

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