FUZZY EXTENSIONS OF AHP AND ANP: A STATE OF THE ART LITERATURE REVIEW

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ABSTRACT

Analytical hierarchy process and analytical network processes have been widely used in the literature. Both AHP and ANP have been modified by using fuzzy sets. Especially, extensions of fuzzy sets have been recently used for modifying classical AHP & ANP. In this study, we provide a brief literature review on the usage of AHP & ANP, fuzzy AHP & ANP. We utilize Scopus database for the research.

Keywords: AHP, ANP, fuzzy AHP, fuzzy ANP, extensions of fuzzy sets

1. Introduction

Fuzzy sets introduced by Zadeh (1965) enables dealing with uncertainty caused by imprecision, ambiguity and vagueness. Especially, while dealing with human judgements, the hesitancy and subjectivity in the human decision-making processes can be represented with fuzzy sets. The different types of fuzziness has been represented by using extensions of fuzzy sets such as Type 2 fuzzy sets (Zadeh, 1975), Intuitionistic fuzzy sets (Atanassov 1986), Hesitant fuzzy sets (Torra, 2010), Pythagorean fuzzy sets (Yager, 2013), q-rung orthopair fuzzy sets (Yager, 2017), Picture fuzzy sets (Coung, 2015) and Spherical fuzzy sets (Kahraman and Kutlu Gündoğdu,2019).

Fuzzy sets are very useful for representing subjective judgements in multicriteria decision making processes. Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP) are the most used multi-criteria decision-making processes. Both AHP and ANP enables representing human language. Yet, when the decision makers are hesitant on the decision process and there are great differences among scales, AHP and ANP methods can be used with fuzzy sets. In the literature, both fuzzy AHP and fuzzy ANP methods have been modified by using fuzzy extensions. In this study, we focused on usage of fuzzy AHP and ANP methodologies in the literature. We used the Scopus database for this research and compare the usage of AHP, ANP with fuzzy AHP and fuzzy ANP usage.

The organization of this paper is as follows. In the second section, we give a brief review on the usage of AHP & ANP and fuzzy AHP & ANP in the literature. In the third section, we use summarize extensions of fuzzy AHP and fuzzy ANP studies. In the last section we conclude and give further suggestions.

2. Literature review on fuzzy AHP & ANP

In order to see the usage of AHP&ANP and fuzzy AHP&ANP we conduct a literature review using Scopus database. Keywords "AHP" or "ANP" and not "fuzzy"; "fuzzy" and "AHP" or "ANP" are used for this research. The number of papers using AHP and fuzzy AHP are shown in Fig. 1.
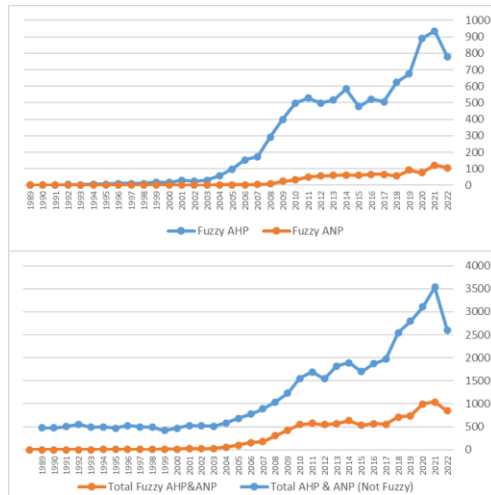
Fig. 1: AHP, ANP, fuzzy AHP and fuzzy ANP papers in the literature

Fig.1 shows us that AHP & ANP methods have been widely used in the literature, whereas the usage of fuzzy AHP and fuzzy ANP is limited. AHP and fuzzy AHP both have been used more frequently when they are compared with ANP. Table 1. shows the publications that frequently publish AHP&ANP and fuzzy AHP&ANP.

Table 1. The publications that frequently publish AHP&ANP and fuzzy AHP&ANP

The publications that frequently publish AHP & ANP	The publications that frequently publish fuzzy AHP & ANP
Sustainability Switzerland	Applied Mechanics And Materials
Advanced Materials Research	Expert Systems With Applications
Applied Mechanics And Materials	Advanced Materials Research
Journal Of Physics Conference Series Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	Advances In Intelligent Systems And Computing
	Sustainability Switzerland
Iop Conference Series Materials Science And Engineering	Journal Of Intelligent And Fuzzy Systems
Journal Of Neurophysiology	Mathematical Problems In Engineering
Advances In Intelligent Systems And Computing	Journal Of Cleaner Production Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics
European Journal Of Operational Research	
Lecture Notes In Electrical Engineering	Iop Conference Series Materials Science And Engineering
Journal Of Cleaner Production	Lecture Notes In Electrical Engineering
Journal Of Physiology	Applied Soft Computing Journal
Expert Systems With Applications	IEEE Access
Environmental Earth Sciences	Lecture Notes In Networks And Systems
Communications In Computer And Information Science	Soft Computing
Energies	Environmental Science And Pollution Research
Water Switzerland	International Journal Of Production Research
Mathematical Problems In Engineering	Communications In Computer And Information Science
Arabian Journal Of Geosciences	Computers And Industrial Engineering
Procedia Engineering	Environmental Earth Sciences

Applied Sciences Switzerland	International Journal Of Advanced Manufacturing Technology
Energy	Journal Of Multiple Valued Logic And Soft Computing
Journal Of Multi Criteria Decision Analysis	Mathematics
Lecture Notes In Mechanical Engineering	Arabian Journal Of Geosciences
Natural Hazards	Energies
International Journal Of The Analytic Hierarchy Process	Technological And Economic Development Of Economy
Environmental Science And Pollution Research	Symmetry
Brain Research	Decision Science Letters
International Journal Of Advanced Manufacturing Technology	Energy
Journal Of Neuroscience	Information Sciences

When we look at Table 1, we see that both AHP &ANP and fuzzy AHP & ANP papers have been published in various fields including energy, sustainability and medical sciences. Yet, fuzzy AHP and ANP have also been published in the computing papers where new versions of fuzzy AHP & ANP are the focus of the study.

3. Literature review on fuzzy extensions of AHP and ANP

In the literature, several studies utilize the extensions of fuzzy sets to modify AHP and ANP. Cevik Onar et al. (2014) use interval type-2 fuzzy AHP for a strategic decision process. Otay et al. (2017) evaluate the healthcare institutions using intuitionistic fuzzy AHP. Bolturk et al. use hesitant fuzzy AHP for warehouse location selection in humanitarian logistics. Kahraman et al. (2018) utilize hesitant fuzzy linguistic AHP for B2C marketplace prioritization. Cevik Onar et al. (2020) evaluation legal debt collection services by using Hesitant Pythagorean (Intuitionistic Type 2) fuzzy AHP. Oztaysi et al. (2020) use spherical fuzzy AHP for location-based advertisement selection. Figure 2 shows the studies that uses most popular fuzzy extensions for modifying AHP and ANP methods.
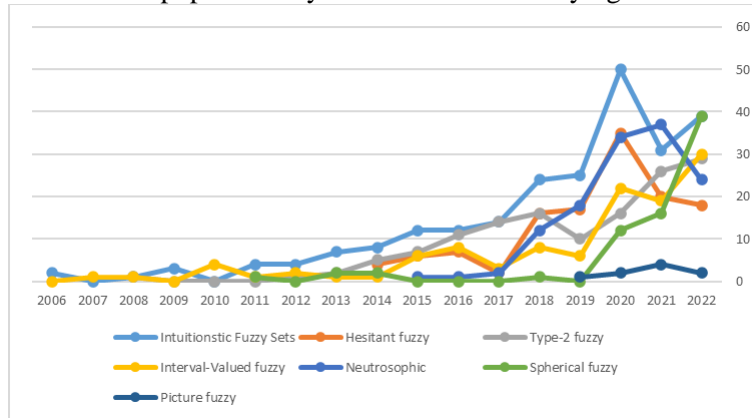

Fig 2: Number of AHP &ANP papers which use fuzzy extensions

4. Conclusion and Further Suggestions

In this study, we develop a brief perception on the usage of AHP & ANP, fuzzy AHP & ANP, extensions of fuzzy AHP & ANP. Both AHP & ANP and fuzzy AHP & ANP methodologies are widely used in the literature and the usage is still increasing in various areas. Although the methodology and computation of classical AHP & ANP is rather

similar, there are many new fuzzy AHP & ANP methodologies in the literature. Especially extensions of fuzzy sets have been used for this objective.

5. Key References

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