

EXTENSIONS OF AHP/ANP AT INTERNATIONAL CONFERENCES: EXAMPLES FROM ISAHP AND INFUS CONFERENCES

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ABSTRACT

Fuzzy sets have been used to extend both Analytical hierarchy process and analytical network processes in the literature. In this study we focus on the potential usage of fuzzy extensions of AHP / ANP and analyze the conferences publishing AHP papers and provide insight about the trends as a result of an extended literature review.

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

1. Introduction

Fuzzy sets proposed by Zadeh (1965) provides mathematical tools that facilitate the construction of useful conceptual frameworks for understanding complexity, solving engineering problems and representing human decision-making. By using fuzzy sets decision making problems can be handled even if the information is incomplete or uncertain. Fuzzy set theory has been used to model decision making problems that are hard to define precisely.

Ordinary fuzzy sets use the term membership value to represent the grade of membership of an element to a set. In order to provide a better representation of imprecision and vagueness, novel extension of fuzzy sets have been proposed in the literature. 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), Neutrosophic sets (Smarandache, 1998), Picture fuzzy sets (Coung, 2015) and Spherical fuzzy sets (Kahraman and Kutlu Gündoğdu, 2019) are the most popular extensions of ordinary fuzzy.

Fuzzy sets and its extensions have been widely used to extend existing crisp decision making methods. As AHP/ANP are among the most popular decision making techniques, fuzzy extensions of AHP and ANP have been in the focus of academic studies.

Academic conferences are events during which researchers present their most recent studies work to each other. Academic conferences are important for scientific improvement since researchers get feedback on early version of their work, they can get to know other people in the field, and observe the latest work of other academicians. For this reason, we focus on a brief literature survey on AHP/ANP at international conferences.

In this study, we try to examine the trends about fuzzy Extensions of AHP and ANP at international conferences. To this end, fuzzy extensions of AHP/ANP are briefly summarized in second section. In the third section, top international conferences which publish AHP/ANP papers are listed. In section four, a literature review on fuzzy extensions of AHP/ ANP is provided. In section five, conclusions and future study suggestions are given.

2. Fuzzy Extensions of AHP and ANP a brief explanation

Ordinary fuzzy sets are represented with a grade of membership, μ and a grade of non-membership which is the complement of membership, $1-\mu$. To deal with the weaknesses of ordinary fuzzy sets, they have been extended to several new types by various researchers that describe membership functions in much more detail. Type-2 fuzzy sets to handle the vagueness in membership functions as an extension of ordinary fuzzy sets. Intuitionistic fuzzy sets (IFSs) were introduced by Atanassov (1985), which are composed of a degree of membership and a degree of non-membership whose sum is not necessarily equal to 1. Their objective is to take the hesitancy of experts into consideration. Hesitant fuzzy sets (HFSs) introduced by Torra (2010) have been used to handle the potential membership grades of an element in a fuzzy set. After intuitionistic type-2 fuzzy sets (IFS2) are proposed by Atanassov (1989), Yager (2013) called them as Pythagorean fuzzy sets (PFSs) represented with a larger domain area for membership and non-membership grades. q-rung orthopair fuzzy sets (Q-ROFSs) developed by Yager (2017) are the generalization of IFSs and PFSs. Neutrosophic sets developed by Smarandache (1998) involve degrees of truthiness, indeterminacy, and falsity for each element in the universe. The sum of these independent three grades can be at most equal to 3. Picture fuzzy sets and spherical fuzzy sets characterized by the grades of membership, non-membership, and hesitancy for each element in a set have been introduced by Coung (2015) and by Kahraman and Kutlu Gündoğdu (2018).

3. Conferences that publish AHP/ANP and fuzzy AHP/ANP

In order to see the trends about AHP and fuzzy AHP, a literature review using Scopus database is executed. The number of conference papers using AHP and fuzzy AHP are shown in Fig. 1. The results show that AHP paper (without fuzzy sets) are published more than fuzzy AHP papers.

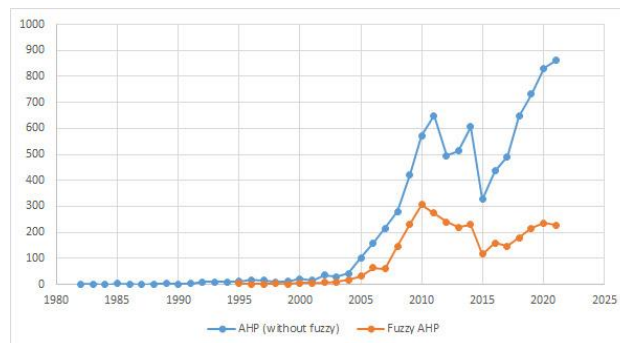


Fig. 1: Comparison of AHP and Fuzzy AHP papers published in Conferences.

The conferences which publish AHP and Fuzzy AHP papers investigated. Table 1 shows the top 10 fuzzy AHP publishing conferences and Table 2 shows the top 5 AHP publishing conferences.

Conference	Papers
INFUS (<i>International Conference on Intelligent and Fuzzy Systems</i>)	68
IEEM (<i>IEEE International Conference on Industrial Engineering and Engineering Management</i>)	67
FSKD (<i>International Conference on Fuzzy Systems and Knowledge Discovery</i>)	65
FUZZ-IEEE (<i>IEEE International Conference on Fuzzy Systems</i>)	41
MASS (<i>International Conference on Management and Service Science</i>)	38

Table 1: Top 5 conferences publishing Fuzzy AHP papers

Table 1 shows that INFUS, IEEM, FSKF and FUZZ-IEEE are the most “fuzzy AHP” publishing conferences. It is important to underline that three out of these conferences bare the word Fuzzy in their full names. Table 2 shows that ISAHP is the most AHP/ANP publishing conference and the followers have very low number of papers relatively.

Conference	Papers
ISAHP (<i>International Symposium on the Analytic Hierarchy Process</i>)	>150
IEOM (<i>Industrial Engineering and Operations Management Society</i>)	15
ICMSE (<i>International Conference on Materials Science and Engineering Science</i>)	15
ACRS (<i>Asian Conference on Remote Sensing</i>)	15
KES (<i>International Conference on Knowledge-Based and Intelligent Information and Engineering Systems</i>)	14

Table 2: Top 5 conferences publishing Fuzzy AHP papers

The results show that, although the total number of Fuzzy AHP publications is lower than total number AHP publications, total number of Fuzzy AHP papers in top 10 conferences are higher than total number of AHP papers in top 10 conferences (when ISAHP is excluded as an outlier). This result show that Fuzzy AHP methods are used in a limited scientific area, on the other hand AHP has found widespread application in different fields of science. This, can also be interpreted as a potential of Fuzzy AHP to become widespread.

4. Literature review on fuzzy extensions of AHP and ANP in the conferences

AHP and ANP has been widely integrated with fuzzy extensions. Some of the recent studies from various areas. Ilbahar et al. (2022) provide a risk assessment of renewable energy investments using intuitionistic fuzzy AHP. Buran and Ercek (2022) evaluate public transportation business models by using Spherical Fuzzy AHP. Xu et al. propose a model for consensus checking using AHP and q-rung dual hesitant fuzzy preference relations. Gundogdu et al. evaluate public transport service quality by using picture fuzzy AHP.

Oztaysi et al. (2020) provide an advertisement selection process by using Spherical fuzzy AHP. Onar et al. (2020) propose using hesitant Pythagorean fuzzy AHP for evaluation of legal debt collection services. Kahraman et al. (2020) focus on evaluation of outsource manufacturers by using intuitionistic fuzzy AHP.

Fuzzy extensions are broadly used in academic conferences. Figure 2 shows the number of all conference papers which use fuzzy extensions. The results reveal that Intuitionistic fuzzy sets and Type-2 fuzzy sets are the most popular fuzzy extensions.

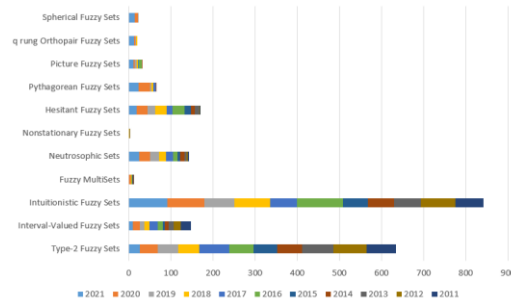


Fig 2: Number of conference papers which use fuzzy extensions

Figure 3 shows the trends about conference papers using fuzzy extensions. The results reveal that Intuitionistic fuzzy sets, spherical fuzzy sets, and q-rung Orthopair fuzzy sets show a positive trend while Type-2 Fuzzy sets shows a negative trend after 2015.

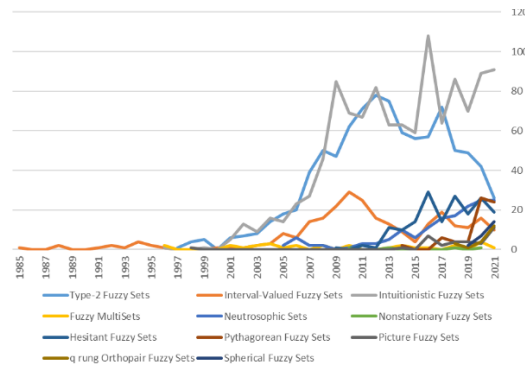


Fig 3: Trends about conference papers using fuzzy extensions

Conference papers which focus on fuzzy extensions with AHP (FEAHP) are analyzed. Figure 4 shows the number of conference papers which use FEAHP. The results reveal that Intuitionistic fuzzy sets and Type-2 fuzzy sets are the most popular fuzzy extensions in the field of FEAHP. However, nonstationary fuzzy sets and fuzzy multisets are not recently used in the field.

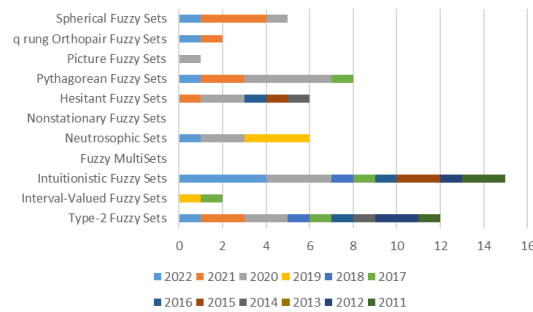


Fig 4: Number of conference papers which use fuzzy extensions and AHP/ANP

In order to provide a better understanding about the trends the percentages of different fuzzy extensions using AHP/ANP are calculated (Fig. 5). The results show that Intuitionistic fuzzy sets has been widely used between 2015 and 2018. Type-2 fuzzy sets had been popular in 2012 but slightly lost the popularity since then. In a similar way Hesitant fuzzy sets have been highly published between 2014 and 2016. Lately, Neutrosophic sets has gained popularity in 2019. In recent years, different fuzzy extensions have been used for conference papers and in 2021 Spherical fuzzy sets have the lead in number of conference papers.

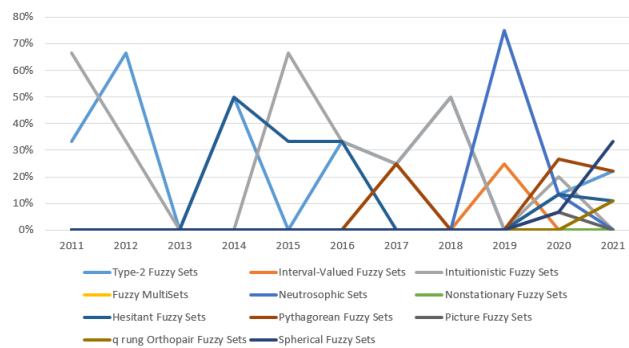


Fig 5: Trends about percentage of conference papers using fuzzy extensions with AHP/ANP

5. Conclusion and Further Suggestions

In this study, we try to provide insight about the potential usage of fuzzy extensions of AHP / ANP. The results reveal some key results. First of all, conference papers using Fuzzy AHP/ANP is less than conference papers which use AHP without fuzzy. Secondly, fuzzy AHP/ANP is generally published in conferences which directly focus on fuzzy sets, however AHP (without fuzzy extensions) are published in a wide range of conferences. Extensions of fuzzy sets are also integrated with AHP/ANP. In this field, intuitionistic fuzzy sets and Type-2 fuzzy sets are the most commonly used fuzzy extension, besides, recently Spherical fuzzy sets are getting more popular.

6. Key References

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