Studies on fuzzy decision making in Turkish Universities: An overview

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Abstract

Fuzzy sets theory bridges the gap between boolean logic and human logic which is including a high degree of ambiguity. It has been used to accomplish different tasks (to control, to optimize, to make decision etc.) in different areas (education, management, medicine, technical, military etc.). Many fuzzy decision making methods have been proposed over the years. Classification of these methods and their applications can be found in literature. However, most of these studies concern only one method or one specific application area or one certain time interval. From this point of view, this study aims to show the studies on application of fuzzy decision making in Turkish universities. It is expected that this study will help the researchers on working fuzzy decision making as it is beneficial to know the previous studies on their topic, in an organized way and there is no similar study on this area. It mainly surveys the PhD and MSc Theses in Turkey on fuzzy decision making and the unclassified studies are not given to limit the study. Classified studies are summarized, compared and future recommendations are given for new researchers.

Keywords: Fuzzy Decision Making, Review Paper

1. Introduction

The ability to make rational decisions is one of the mankind’s unique attributes. Man has continuously devised ways and means to enlarge his abilities to cope with the growing complexity of his decision problems. A characteristic of most of the formal techniques that have been used for decision making is the selection of the best alternative with respect to a certain figure of merit. However, the nature of many decision problems has changed considerably in recent years, and serious doubts have been raised as to the adequacy of many models and their solution techniques. Having uncertainty in parameters and having several factors affecting decision maker led to fuzziness and multiplicity in decision making situations (Tabucanon, 1988).

It is not surprising to see that uncertainty always exists in the human world. Research that attempts to model uncertainty in to decision analysis is done basically through probability theory and/or fuzzy set theory. The former presents the stochastic nature of decision analysis while the latter captures the subjectivity of human behaviour. It is suggested by Efstathiou (1979) and Dubois and Prade (1985) that a stochastic decision method such as statistical decision analysis does not measure the imprecision in human behaviour; rather, this method is a way to model incomplete knowledge about the external environment surrounding human

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beings. Fuzzy set theory, on the other hand, is a perfect means for modeling uncertainty (or imprecision) arising from mental phenomena which are neither random nor stochastic. Human beings are heavily involved in the process of decision analysis. A rational approach toward decision making should take into account human subjectivity, rather than employing only objective probability measures. This attitude towards the uncertainty of human behavior led to study on fuzzy decision making (Chen and Hwang, 1992).

Pioneering study on fuzzy logic is done by Lotfi Zadeh (1965). The first attempt at applying fuzzy set theory to multi-attribute analysis is done by Bellman and Zadeh (1970), who have outlined one possible route toward fuzzy decision making. Due to the easiness and variety of fuzzy logic applications, studies on this area are quickly spread out. Today, fuzzy logic hasn’t lost its value yet. Each year, thousands of studies are carried out on this field over the world. Turkey also produces its share from these studies. However, there are few or no studies on some areas while studies on the other areas have been increasing because variety of the studies’ contents and application areas has not been investigated. Kentli (2011) has classified the studies on fuzzy logic application but only to control of electrical machines. This study investigates the application areas of fuzzy decision making to fill this gap.

The scope of this study is narrowed to be able to investigate thoroughly due to extensiveness of the application area. Only the studies on fuzzy decision making applications are investigated. In this study, firstly, background information on fuzzy logic and decision making are given. Then, studies in Turkish Universities are summarized and compared. Lastly, recommendations for future studies are given.

2. Background on fuzzy logic

The development of technology has computerized our life and strengthened the problem of man–machine interaction. The man-machine interaction could be understood in a wide sense, not just as an interface but as a problem of establishing a harmony in communication between a computer and a human being on the levels of cooperative thinking, logic and language. We have a computer, operating according to Boolean logic with numerical mathematical models constructed by application researchers, and users who operate with another sort of logic and language including a high degree of ambiguity or fuzziness. Fuzzy set theory aims to bridge this gap.

Over the past few decades, the use of fuzzy set theory, or fuzzy logic, in control systems has gained widespread popularity, especially in Japan. From as early as the mid-1970s, Japanese scientists have been instrumental in transforming the theory of fuzzy logic into a technological realization. Today, fuzzy logic-based control systems, or simply fuzzy logic controllers (FLCs), can be found in a growing number of products, from washing machines to speedboats, from air condition units to hand-held autofocus cameras.

The inference engine is the heart of a fuzzy controller (and any fuzzy rules system) operation. Its actual operation can be divided into three steps (Figure 1):
- Fuzzification – actual inputs are fuzzified and fuzzy inputs are obtained.
- Fuzzy processing – processing fuzzy inputs according to the rules set and producing fuzzy outputs.
- Defuzzification – producing a crisp real value for a fuzzy output.
3. Decision Making Theories

Making decisions is a part of our daily lives. The major concern is that almost all decision problems have multiple, usually conflicting criteria. Research on how to solve such problems has been enormous. Methodologies, as well as their applications, appear in professional journals of different disciplines. Diversified as such problems may be, they are broadly classified into two categories: MADM and MODM. From a practical viewpoint, MADM is associated with problems whose number of alternatives has been predetermined. The Decision Maker (DM) is to select/prioritize/rank a finite number of courses action. On the other hand, MODM is not associated with problems in which alternatives have been predetermined. The DM’s primary concern is to design a “most” promising alternative with respect to limited resources.

Figure 1. Operation of a fuzzy controller (Reznik, 1997)

Figure 2. Classification of MADM (Hwang & Yoon, 1981)
Methods and applications of MADM and MODM regarding a single decision maker have been thoroughly and critically reviewed and systematically classified by Hwang and Yoon (1981) and Evans (1984), respectively. They based their grouping of techniques according to the stage at which information from the decision maker is needed by the analyst. The classification of MADM (Figure 2) and MODM (Figure 3) is divided into considering articulation of preference information. Detailed explanation on methods given in figures can be found at Hwang and Yoon (1981), Sen and Yang (1998).

4. Studies on Fuzzy Decision Making

This work has aimed to reveal the extent of studies in Turkish Universities done on fuzzy decision making. Scope of the study is limited to MSc and PhD theses. In this section, summarized explanations of the studies are given in order according to their application area. Most of the application areas are diversified as Education, Management, Medicine, Military and Technical. The unclassified studies are given under the topic: Others.

4.1. Education

and thirty five sub criteria are determined and a model of guidance to field in vocational technical schools is developed in this study.

4.2. Management

Applications in this section can be grouped on Supplier Selection, Risk Analysis, Personnel Selection, Location Selection and Portfolio Analysis. Unclassified applications are given at the following paragraph.


4.2.1. Supplier Selection


4.2.2. Risk Analysis

Fazhogullari (2003) has calculated the life cycle cost of a computer classroom project. Tuybsuz (2004) used fuzzy AHP to analysis the risk of a project. Semercioğlu (2005) has performed a fuzzy risk analysis on a major end item project. Han (2005) has estimated cost overrun risk in
international projects. Ünlüyıldız (2007) has evaluated the risk of an ERP implementation project using fuzzy extended AHP. Gürkanlı (2006) has analyzed the risk for occupational safety in construction sites. Kuşan (2009) has evaluated the risks in construction projects. Karabay (1997) has analyzed political risk for international construction sector.

4.2.3. Personnel Selection

4.2.4. Location Selection
Ercan (2006) has evaluated the locational suitability of settlements in Odunpazarı, Eskişehir. Ahlatçuoğlu (2005) has selected the location of a facility. Kodak (2009) has selected the location of the gas station using geographic information systems and fuzzy analytical network process approach. Cengiz (2007) has used fuzzy analytic network to select the location of a dock.

4.2.5. Portfolio Analysis

4.3. Medicine

4.4. Military
Tekeş (2002) has compared the pistols used in Turkish Army Forces by AHP with fuzzy suitability index. Adalı (2003) applied fuzzy decision making to technological intelligence,

4.5. Technical


4.6. Others


5. Observations

There are 936 studies on fuzzy logic in Turkish universities. Among them, 176 studies are on fuzzy decision making (Figure 4). Figure 5 shows the studied areas in detail.
On the other hand, investigated studies are completed in a 16 year time interval. Studies on fuzzy decision making in Turkey have begun at 1994. It is rather late when the history of fuzzy decision making is concerned. However, during last decade, studies are doubled according to the previous decade (Figure 6).
139 studies are MSc theses and 37 studies are PhD theses. Number of PhD theses is more than quarter of that of MSc theses. It is seen that some of these theses are converted into a scientific article (48 of them) or a proceeding (22 of them). 90 articles are published in SCIE indexed journals and 29 articles are published in several journals in different indexes. Also, 89 proceedings are presented in different conferences. In fact, there is more contribution (over 400 articles) to literature when searched for fuzzy decision making. More than half of these studies (260 of 454 articles) are cited at least one time (some of them are cited more than 100 times). Table 1 shows the authors from Turkey and the number of their articles found in literature. The first eleven authors in Table 1 have written the half of all studies.

There are 95 state and 34 private universities and 5 military institutions in Turkey. Investigated studies are done at 32 state universities (Figure 7). Approximately half of studies are done at 4 universities (Istanbul Technical University, Yıldız Technical University, Gazi University and Galatasaray University). Most of the studies are written in Turkish (Figure 8).
Figure 7. Number of studies in each university

Figure 8. Languages of theses

6. Future Recommendations

As a topic, there are few studies on some topics (medicine and education). It is recommended for researchers to study on these topics. As a decision making method, there is only one study which used ELECTRE III or TOPSIS. There could be more study using these methods. Also, there is no study using VIKOR or PROMETHEE. Furthermore, MODM techniques are rarely used. However, there are various applications in literature. They can be used and compared with previous ones, especially evolutionary algorithms. Moreover, it is seen that fuzzy decision making methods have generally been applied to select a candidate or predict the system response but evaluation of a system or performance is also another application area that should be studied.

7. Conclusions and Discussions

This study is aimed to reveal studies on fuzzy decision making in Turkish Universities. Fuzzy decision making studies are given in an organized way. Refereed theses are searched on the website of Turkish Council of Higher Education. This work is a small part of another work
that all fuzzy logic studies at all Turkish universities are searched and then classified. All data belong to the database formed up to the 2010. Even though some studies may be not yet registered to the database; it is believed that their number is few. Obtained results are given as tables and graphs.

It is noted that fuzzy decision making follows fuzzy logic control in interest to study and trend in using fuzzy decision making is getting higher eventhough it has begun to study lately. Number of published articles also proved this fact. The results suggest that more researchers should specialize in this area because most of the studies are done by a few researchers and in a few universities.

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