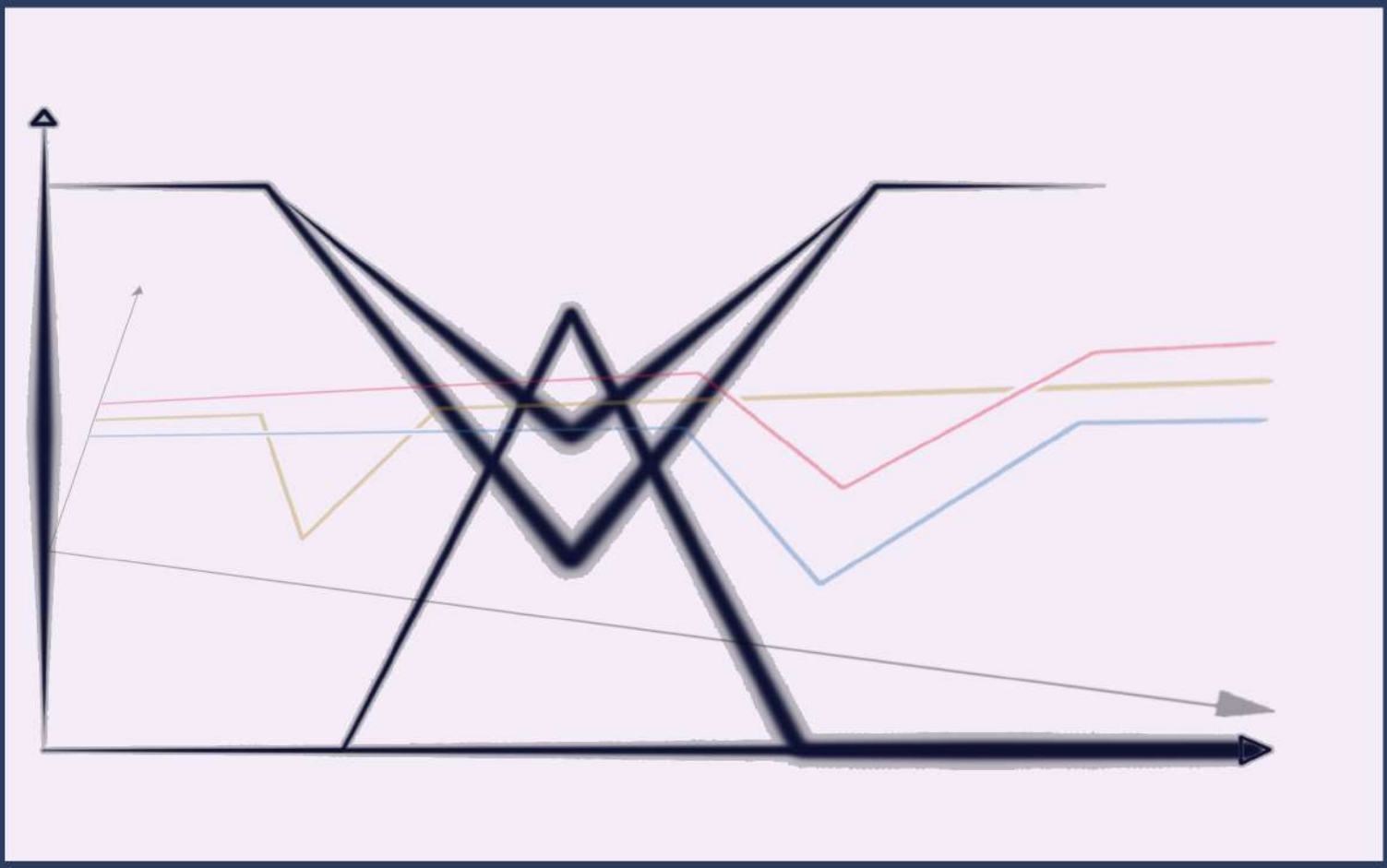
Journal of Fuzzy Extension & Applications
www.journal-fea.com



Journal of Fuzzy Extension & Applications

Print ISSN: 2783-1442
Online ISSN: 2717-3453

J. Fuzzy. Ext. Appl

J. Fuzzy. Ext. Appl

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 81–138.

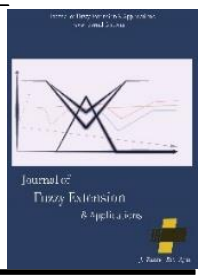


TABLE OF CONTENTS

E-ISSN: 2717-3453 | P-ISSN: 2783-1442

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 81–83.

Paper Type: Short Communication

Generalizations and Alternatives of Classical Algebraic Structures to NeutroAlgebraic Structures and AntiAlgebraic Structures

Florentin Smarandache*

University of New Mexico, 705 Gurley Ave., Gallup, New Mexico 87301, USA; fsmarandache@gmail.com.

Citation:

Smarandache, F. (2020). Generalizations and alternatives of classical algebraic structures to neutroalgebraic structures and antialgebraic structures. *Journal of fuzzy extension and application, 1* (2), 81-83.

Received: 17/12/2019 Reviewed: 22/01/2020 Revised: 20/02/2020 Accept: 20/04/2020

Abstract

In this paper we present the development from paradoxism to neutrosophy, which gave birth to neutrosophic set and logic and especially to NeutroAlgebraic Structures (or NeutroAlgebras) and AntiAlgebraic Structures (or AntiAlgebras) that are generalizations and alternatives of the classical algebraic structures.

Keywords: NeutroAlgebra, NeutroAxiom, NeutroOperation, NeutroTheorem, AntiAlgebra, AntiAxiom, AntiOperation.

1 | From Paradoxism to Neutrosophy

Licensee Journal of Fuzzy Extension and Applications. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0).

1.1| Paradoxism

Paradoxism is an international movement in science and culture, founded by Smarandache in 1980s, based on excessive use of antitheses, oxymoron, contradictions, and paradoxes in science, literature, and arts. During three decades (1980-2020) hundreds of authors from tens of countries around the globe contributed papers in various languages to 15 international paradoxist anthologies.

1.2| Neutrosophy

In 1995, the author extended the paradoxism (based on opposites) to a new branch of philosophy called neutrosophy (based on opposites and their neutral) that gave birth to many scientific branches, such as neutrosophic logic, neutrosophic set, neutrosophic probability and statistics, neutrosophic

Corresponding Author: fsmarandache@gmail.com

http://dx.doi.org/10.22105/jfea.2020.248816.1008

algebraic structures, and so on with multiple applications in engineering, computer science, administrative work, medical research, biology, psychology, social sciences etc.

1.3| Extensions

Neutrosophy is also an extension of Dialectics (characterized by the dynamics of opposites in philosophy), and of Yin-Yang Ancient Chinese philosophy (based also on opposites: male/female, good/bad, sky/earth, etc.) that was founded and studied two and half millennia ahead of Hegel's and Marx's Dialectics.

2| From Classical Algebras to NeutroAlgebras and AntiAlgebras

2.1| Operation, NeutroOperation, and AntiOperation

When we define an operation on a given set, it does not automatically mean that the operation is well-defined. There are three possibilities:

The operation is well-defined (or inner-defined) for all set's elements (as in classical algebraic structures; this is classical *Operation*).

The operation if well-defined for some elements, indeterminate for other elements, and outer-defined for others elements (this is *NeutroOperation*).

The operation is outer-defined for all set's elements (this is *AntiOperation*).

2.2| Axiom, NeutroAxiom, and AntiAxiom

Similarly for an axiom defined on a given set endowed with some operation(s). When we define an axiom on a given set, it does not automatically mean that the axiom is true for all set's elements. We have three possibilities:

The axiom is true for all set's elements [totally true] (as in classical algebraic structures; this is classical *Axiom*).

The axiom if true for some elements, indeterminate for other elements, and false for other elements (this is *NeutroAxiom*).

The axiom is false for all set's elements (this is *AntiAxiom*).

Similarly for any statement, theorem, lemma, algorithm, property, etc. For example: Classical *Theorem* (which is true for all space's elements), *NeutroTheorem* (which is partially true, partially indeterminate, and partially false), and *AntiTheorem* (which is false for all space's elements).

2.3| Algebra, NeutroAlgebra, and AntiAlgebra

An algebraic structure who's all operations are well-defined and all axioms are totally true is called Classical Algebraic Structure (or Algebra). An algebraic structure that has at least one NeutroOperation or one NeutroAxiom (and no AntiOperation and no AntiAxiom) is called NeutroAlgebraic Structure (or NeutroAlgebra).

An algebraic structure that has at least one AntiOperation or Anti Axiom is called AntiAlgebraic Structure (or AntiAlgebra). Therefore, a neutrosophic triplet structure is formed Algebra, NeutroAlgebra, and AntiAlgebra.

"Algebra" can be any classical algebraic structure, such as: groupoid, semigroup, monoid, group, commutative group, ring, field, vector space, BCK-Algebra, BCI-Algebra, etc.

3| Foundation of NeutroAlgebra and AntiAlgebra

The classical algebraic structures were generalized in 2019 and 2020 by Smarandache [1, 2, 3] to NeutroAlgebraic Structures (or NeutroAlgebras) whose operations and axioms are partially true, partially indeterminate, and partially false as extensions of partial algebra, and to AntiAlgebraic Structures (or AntiAlgebras) whose operations and axioms are totally false.

4| Foundation of NeutroStructures and AntiStructures

And in general, we extended any classical Structure, which is a space characterized by some properties, ideas, laws, shapes, hierarchy, etc., in no matter what field of knowledge, to a NeutroStructure and an AntiStructure.So, we formed a general neutrosophic triplet: Structure, NeutroStructure, and AntiStructure.

Acknowledgement

The author thanks Dr. S. A. Edalatpanah for his opinions and comments on this small paper.

References

[1] Smarandache, F. (2020). *NeutroAlgebra is a generalization of partial algebra*. Infinite Study.
[2] Smarandache, F. (2019*). Introduction to neutroalgebraic structures and antialgebraic structures (revisited)*. Infinite Study.
[3] Smarandache, F. (2019). *Introduction to neutroalgebraic structures and antialgebraic structures (revisited)*. Infinite Study.

E-ISSN: 2717-3453 | P-ISSN: 2783-1442

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 84–97.

Paper Type: Research Paper

Analyzing the Barriers of Organizational Transformation by Using Fuzzy SWARA

Iman Ghasemian Sahebi [1,*], Alireza Arab[2], Seyed Pendar Toufighi[1]

[1] Department of Candidate of Production and Operation Management at University of Tehran, Tehran, Iran; iman.ghasemian@ut.ac.ir; toufighi.p@ut.ac.ir.

[2] Department of Candidate of Operations Research at University of Tehran, Tehran, Iran; alireza.arab@ut.ac.ir.

Citation:

Ghasemian Sahebi, I., Arab, A., & Pendar Toufighi, S. (2020). Analyzing the barriers of organizational transformation by using fuzzy SWARA. *Journal of fuzzy extension and application, 1* (2), 84-97.

Received: 20/01/2020 Reviewed: 17/02/2020 Revised: 22/03/2020 Accept: 16/05/2020

Abstract

The crucial role of bureaucracy in the economic, political, socio-cultural and political structures, and its impact in achieving the goals of organization is so important that in order to achieve the development, change directions consists of purifying and modernization of the administrative system in Iran also seems necessary. An important part of the transportation industry in each country, is the airports. So, dealing with the bureaucracy airports to implement better practices and removing unnecessary processes is the most issues. Hence, it can be stated that the aim of this study is to identify barriers of transformation in the organization administrative and then prioritizing these barriers in Mehrabad airport. For this purpose, the grounded theory and Fuzzy SWARA methods was used to identifying the barriers and prioritizing them. Grounded theory results showed that cognitive barriers, structural barriers, participation barriers, economic and income barriers, legal barriers, strategic barriers, and management barriers are the barriers of the transformation in the Mehrabad airport administrative system. The Fuzzy SWARA method used to prioritize these barriers, which according to the results, the structural barriers were the important barriers. Then cognitive and legal barriers were placed in the next rank. At the end, some solutions have been presented for overcoming these barriers in the Mehrabad airport.

Keywords: Barriers, Organizational transformation, Grounded theory, Fuzzy SWARA.

1 | Introduction

Licensee **Journal of Fuzzy Extension and Applications**. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0).

The present world is the world of changes and transformations [1]. In this regard, Drucker says: 'the first step for preparing ourselves in the present era is to forget yesterday' [2]. In the business world of today, organizations face with important conditions such as global competition, reduced cycle of technology innovation, universal and timely access to information, and also extensive changes in cultural, social and political environments, which have challenged stable competitive advantage, and more importantly, their survival [3]. So, in such turbulent conditions, organizations for their survival are compelled to coordinate themselves with this accelerating and unprecedented changes, and in parallel with hardware changes update their manpower and software, too [4].

Corresponding Author: alireza.arab@ut.ac.ir

http://dx.doi.org/10.22105/jfea.2020.249191.1010

The development of each country is closely connected to the administrative system and its effectiveness. The determinant role of administrative system in economic, political, social and cultural structures and its effect in realizing objectives of socio-political systems is very important. Therefore, administrative system because of association with other structures and affecting them has been of great importance. It is obvious that the efficiency of administrative system reform as a tool for managing and governing, a tool for providing sensitive and essential services to the community, a tool for dealing with necessary and special conditions, and finally a context for achieving economic and social growth and development is not only feasible by focusing on personnel issues, organization, paperwork, eliminating, merging, and dissolving departments, but also the traditional structure introverted and inflexible of administrative system with its hierarchical infrastructure in which task is completely separated of process requires profound changes and sometimes surface changes at different levels of the administrative system of each country which is possible by government's effective and accurate planning [5]. Administrative reform follows several processes such as employees' public participation, reforming administrative structures, appropriateness of duties and authorities, empowering employees and managers, authorities' responsibility against citizens, monitoring administrative system, and development of information practices [6].

The transportation industry isn't considered as the only factor in the development of a country and there are many other factors causing economic growth and development, but it should be noted that transportation is one of the key elements in economic development. The economic impacts of transportation can be observed in all economic activities such as agriculture industry, services, tourism, etc. One of the most important parts of transportation industry in each country is its airports. In the present century aviation industry has an important role in the relations among different countries around the world, culture exchange, showing economic and military powers and acceleration of critical affairs. Airports because of having various potentials in countries' economic growth and contributing in creating stable development play important role [7]. The value and importance of airports in today's world is to the extent that some experts describe airports as economic locomotive of each country and believe that the existence of efficient and prosperous airports is a factor of economic growth and stable development. Therefore, attention to the administrative system of airports for better implementation of activities and elimination of unnecessary processes are of the most obvious issues and the most important mission of the International Airports Union is to integrate airports' activities, determine policies and policy makings and improve its administrative system for faster workflow of works. Hence, paying attention to changes in the administrative system of airports is very essential to gain an appropriate and worthy position in the region.

Before starting change process, the organization must try to identify executive barriers for implementation of change and transformation and prepare itself to deal them properly and reasonably. Therefore, since there are many barriers in changing the administrative system of any organization, so the questions arising in this study are: "What are the main executive barriers in changing administrative system of country's airports company? Among these barriers, which has a greater priority than others and exacerbates other barriers and generally cause the failure of the project creation of change and transformation in administrative system of country's airports company?"

According to what was said, it can be stated that the goal of this research is to identify barriers of organizational transformation and then prioritize them. The highlights of this research as follows:

- *This study proposes an integrated method to barriers of organizational transformation in aviation industry.*
- *Using the grounded theory as a powerful qualitative technique identifying the barriers.*
- *SWARA method extended with fuzzy numbers to obtain the weights of barriers.*
- *We apply Fuzzy Sets theory to handle the imprecise information in the real-world problems.*

2| Research Background

2.1| Why Transformation?

Organizations are always subject to change and transformation and since these changes are caused by human, so it is necessary to assess change's contexts in him, both as the acceptor of change and as the creator of change. Most of rapid and accelerated changes cause unstable and transient behaviors and temporary improvement in organizations and this is due to this fact that human resources under subtle perception of organization's new situation and managers' expectations, act to cosmetic change in his behavior. Hence, we can conclude that organizational change and improvement is a function of the staff's behavioral changes and particularly managers. Therefore, as long as the senior management of an organization hasn't thought about the idea of change and improvement in the organization, it can't be expected to change and improve the organization [8].

The companies usually change to become global and people's thoughts and spirits, individually or as a group, are mobilized to reach the goals of all interest groups including: customers, employees and shareholders and anyway humans are the productive force and impetus for changing systems, structures and organizations. Usually it may that organizational change and transformation is created to transit from one stage of development to another one, organizations become mature by transition from different stages of development. Before making a decision about which of the aspects of the organization needs to be improved, the strengths and weaknesses of the organization must be analyzed. In this regard, needs assessment is of particular importance [9].

Organizational change firstly requires examining and diagnosing problem. Identifying problem and providing real problem is half of the change. If managers of changes scenario make mistake in defining problems, they will pay exorbitant costs, because it will direct organization and its resources towards the goals that haven't been designed towards the actual needs of the organization and can't be responsible for problems. Change management more than anything should examine and identify strategies for problem solving and its dimensions [10]. The message of most successful and unsuccessful administrative reforms in the world has been that transformation is rarely by chance. The success of administrative reform is guaranteed if people are responsible for its management and governance who have serious determination and clear and acceptable view about the future and reform path [11]. The responsible organization for management of administrative system reform, i.e. country's management and planning organization has summarized the main barriers to change country's administrative system as follows [3]:

- *Resistance of groups affected by the reforms.*
- *Political basic Cost-Benefit measurement that concluded from Administrative revolution.*
- *Disagreement in goals, view and desirable future of country's administrative system.*
- *Disagreement in policies and strategies of administrative reform.*
- *Turbulent political environment.*
- *Little communication and connection with international environment.*

Regardless of overcoming political attitude in identifying barriers to change country's administrative system and ignoring structural existing realities and quantity and quality of government employees among the barriers of administrative reform in this report had already been expressed as globalization and its requirements and expectations as one of the threats and weaknesses of administrative system [12], if globalization and its requirements and expectations are considered as a threat and weaknesses for administrative system, therefore how little communication and connection with international environment has been considered as an barrier to change administrative system [13]. *Table 1*, shows the background of some important studies:

Table 1. The background of studies.

N	Definition	Authors
1	Organizational revolution is a respond to changes in the organizational beliefs, attitudes, values and structure, so that these factors can be adjusted aligned with technologies, markets, and challenges in the light of the speed of change.	[14]
2	Organizational revolution can be defined as a programmed and stabilized activity for applying behavioral sciences in improvement of systems via analytical and research methods.	[15]
3	Organizational revolution includes planned process of changes covering organizational culture which institutionalizes collective activities.	[10]
4	Organizational revolution aims at promoting compatibility of structures, processes, strategies, individuals, organization culture that tries to propose new and creative solutions and welcomes renovation.	[16]
5	Organizational revolution is meant changes in processes in all levels of an organization that fulfillment of goals are realized.	[7]
6	It has plans for changing the organization culture according to theories, research and behavioral sciences techniques.	[17]

Literature review results about change in the administrative system and barriers showed that none of the previous researchers have provided a general framework for this purpose, showing all the barriers in the way of implementing the change in the administrative system. Also as yet, no studies have examined these barriers in country's airports company. For this purpose, in this study the researchers tried to provide an overall and comprehensive framework.

2.2| Why Grounded Theory?

The aim of this study is to develop a comprehensive model, which can identify the administrative barriers to change the administrative system of the Mehrabad airport. In order to develop this paradigmatic model, the grounded theory and Fuzzy SWARA were used. In fact, this study tries to investigate administrative barriers to create changes in the administrative system of country's airports company in actual mode and obtain an in-depth and comprehensive explanation of this phenomenon by making a model based on the experiences and attitudes of experts. In order to achieve this goal and based on the data-based theory approach, two secondary objectives were chosen for this study which include the following:

– *Introducing the approach of data-based theory as efficient way to identify executive barriers.*
– *Assess and prioritize identified barriers and determine their importance.*

Above objectives are proportional to identify executive barriers in creating changes in administrative system. The realization of these objectives requires the application of appropriate research design and methodology, which will be discussed in this section.

2.3| Fuzzy Sets Theory

Fuzzy set theory, which was introduced to deal with problems in which a source of vagueness is involved, has been utilized for incorporating imprecise data into the decision framework. A fuzzy set $\widetilde{M}$, can be defined mathematically by a membership function $\mu_{\widetilde{M}}(x)$, which assigns each element x in the universe of discourse X a real number in the interval [0, 1]. The higher the value of $\mu_{\widetilde{M}}(x)$, the higher the degree of membership of x in $\widetilde{M}$ [18].

Triangular and trapezoidal fuzzy numbers are the most common used fuzzy numbers both in theory and practice. Triangular fuzzy numbers are more practical in application because of their calculation easiness and features [19]. So, triangular fuzzy numbers are preferred for representing the linguistic variables in this study.

Let $\widetilde{M} = (l, m, u)$ is a triangular fuzzy number where l, m and u represent the smallest possible value, the most promising value, and the largest possible value, respectively and can be defined as *Eq. (1)*:

$$\mu_{\widetilde{M}}(x) = \begin{cases} 0, & x\langle l \text{ and } x\rangle u \\ (x-l)/(m-l) & l \le x \le m \\ (x-u)/(m-u) & m \le x \le u \end{cases}. \quad (1)$$

Some algebraic operations of the triangular fuzzy numbers ($\widetilde{M_1} = (l_1, m_1, u_1)$ *and* $\widetilde{M_2} = (l_2, m_2, u_2)$) can be expressed as follows [19]-[21]:

$$\widetilde{M}_1 \oplus \widetilde{M}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2). \quad (2)$$

$$\widetilde{M}_1 \ominus \widetilde{M}_2 = (l_1 - u_2, m_1 - m_2, u_1 - l_2). \quad (3)$$

$$\widetilde{M}_1 \otimes \widetilde{M}_2 = (l_1 l_2, m_1 m_2, u_1 u_2). \quad (4)$$

$$\lambda \otimes \widetilde{M}_1 = (\lambda l_1, \lambda m_1, \lambda u_1)\ (\lambda > 0, \lambda \in R). \quad (5)$$

$$\widetilde{M}_1{}^{\lambda} = \left(l_1{}^{\lambda}, m_1{}^{\lambda}, u_1{}^{\lambda}\right)\ (\lambda > 0, \lambda \in R). \quad (6)$$

$$\widetilde{M}_1{}^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right). \quad (7)$$

$$\widetilde{M}_1 \phi \widetilde{M}_2 = \left(\frac{l_1}{u_2}, \frac{m_1}{m_2}, \frac{u_1}{l_2}\right). \quad (8)$$

$$d(\widetilde{M}_1, \widetilde{M}_2) = \sqrt{\frac{1}{3}[(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2]}. \quad (9)$$

2.4| Fuzzy SWARA

SWARA is a method where experts used their own knowledge. In addition, it is not considered to be complicated and time-consuming [22]. The main feature of the SWARA method is the possibility to estimate opinions of experts or stakeholder groups regarding the significance ratio of the attribute in the process of their weight determination [23]. The experts determine the most considerable attribute by the highest rank, the least considerable attribute by the lowest rank, and then estimate the overall ranks from the average value of ranks.

Crisp SWARA cannot effectively deal with problems with such imprecise information, hence, in this study fuzzy SWARA method has been applied to handle this issue. The process of evaluating the importance weights of attribute using the fuzzy SWARA method described in this section.

Step 1. Each of the Experts *(DM=1,2,...,m)* sort the evaluation attribute *(j=1,2,...,n)* in descending order of importance.

Step 2. According to *Table 2*, the relative importance of the attribute j in relation to the previous *(j−1)* attribute should be determined by each of the experts.

Table 2. Linguistic comparison scale and fuzzy values [24].

Linguistic Scale		Response Scale
Equally important		(1, 1, 1)
Moderately important	Less	(2/3, 1, 3/2)
Less important		(2/5, 1/2, 2/3)
Very less important		(2/7, 1/3, 2/5)
Much less important		(2/9, 1/4, 2/7)

Step 3. Obtain the coefficient $\widetilde{K}_j$:

$$\widetilde{K}_j = \begin{cases} \tilde{1}, j = 1 \\ \tilde{S}_j + \tilde{1}, j > 1 \end{cases}. \quad (10)$$

Step 4. Calculate the fuzzy weight $\tilde{q}_j$:

$$\tilde{q}_j = \begin{cases} \tilde{1}, j = 1 \\ \frac{\tilde{q}_{j-1}}{\widetilde{K}_j}, j > 1 \end{cases}. \quad (11)$$

Step 5. Calculate the relative weights of the evaluation attribute:

$$\widetilde{W}_j = \frac{\tilde{q}_j}{\sum \tilde{q}_j}. \quad (12)$$

Step 6. Calculate the defuzzied weights of the attribute:

$$W = \frac{l + 2m + u}{4}. \quad (13)$$

Step 7. Calculate the normalized weights of the attribute:

$$w_j' = \frac{w_j}{\sum w_j}. \quad (14)$$

Step 8. Calculate the average normalized weights of the attribute:

$$w_j'' = \frac{1}{m} * \sum_{D=1}^{m} w_j'. \quad (15)$$

3| Research Methodology

This study also in terms of philosophical basis of research has interpretive paradigm. This study in terms of orientation, approach, background, goal and type of research is a practical, posteriori, combinatorial, descriptive and library and field research, respectively. In the first section of the study, qualitative method and in the second section semi-quantitative method has been used. The most important reasons for using qualitative method in the first section of this study include:

- *Lack of paradigmatic and systematic view in studies conducted in this field.*
- *Multilateral approach towards executive barriers in creating changes in administrative system and try to identify them in a real manner.*

Therefore, in this study, firstly, paradigmatic model to identify executive barriers in creating changes in administrative system of country's airports company using grounded theory approach and based on data collected with deep interviews, observation and reviewing documents, is provided. In grounded theory approach, data analysis is performed in two main levels: text level and conceptual level. Text level includes segmentation and organization of data files, data encryption and writing notes, while conceptual level emphasizes on making model, including sorting codes, and shaping networks. In the next step, in order to complete the model and assess the identified barriers, fuzzy SWARA method was used which has quantitative approach.

In this study, in order to choose sample size, the snowball sampling has been used. In this method, the process has been started of people who are experts in the field and have necessary criteria and in addition to the research questions, they were asked to introduce other experts in the field. Therefore, except for the first few people who were elected directly by the investigator based on specified criteria, other experts in addition to expertise criteria were chosen by other experts. Finally, 8 expert had choice that details of experts has been provided in the *Table 3*.

Table 3. Expert's panel.

N	Job position	Education	Work Experiences
1	Adviser and expert of aviation industry	Master degree	Dean of the faculty of country's aviation industry, deputy of country's aviation industry, board member and deputy of management and resources of country's airports companies, director of Iran's aviation industries, and deputy of aviation industry research institute.
2	Deputy of management development and resources	Master degree	Deputy of management development and resources of country's airports companies, deputy of company, general manager of procurement, financial controller and director general of finance and income.
3	Chief of expert studies department of managing director's office	PhD	Chief of expert studies department of managing director's office, member of committee of administrative system reforms of country's airports company.
4	Veep (director general's assistant)	Master degree	Administrative and financial assistant of Islamic republic of Iran international exhibitions company, tax administration and income assistant of airports company and member of administrative health committee.
5	Veep (director general's assistant)	Master degree	Assistance of management development and resources of Mehrabad international airport, assistant of general department of finance and revenue.
6	Veep (director general's assistant)	Master degree	Assistant of general department of finance and revenue, member of policy development; administrative and budgetary development committee, inspector of airports company and Iran's air navigation, and deputy of management and resources development of technical and soil mechanics laboratory Co.
7	Assistant of general department of education and human resource development	Master degree	Assistant of general department of education and human resource development, legal general director' deputy.
8	Supervisor of reviewing operational manpower	Master degree	Chief of attracting and recruiting department, member of human resources committee.

In this study, the researcher guided all interviews. The adoption of this procedure caused the researchers can use data from earlier interviews in subsequent interviews. Most of interviews were conducted in the interviewees' offices. Most of interview time was allocated to identify details of each executive barriers and related examples. Researcher in each organizational unit conducted interview, observed behavior and events, and in some cases studied some of documentations. In this study, data collection continued until theoretical saturation of categories and in other words, as far as access to new data was not possible. Form literature review, it can be realized that the subject of changing in administrative system is very diverse and there are great differences in the studied field, discussed issues, used tools, adopted policies

and strategies among different researchers. The flowchart of the proposed MCDM model is shown in *Fig. 1*.

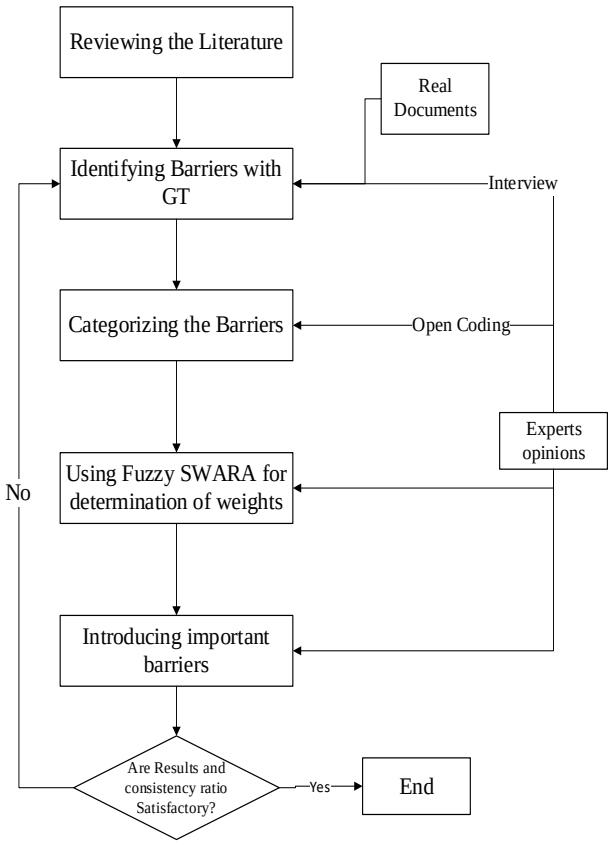


Fig. 1. Flowchart of the proposed MCDM model.

4| Data Analysis

4.1| Open Coding

Open coding is a part of the analysis performed by exact data analysis, naming and categorizing data. In order to classify concepts in categories accurately, each concept must be labeled after separation and raw data must be conceptualized by careful examination of interviews text and context notes. Data collected of Interviewees are encoded to identify their similarities and differences easier. Respondents in response to questions related to each dimension of the model described executive barriers to change and transform in the Mehrabad airport. The initial codes were extracted by analyzing their statements and views. In the next step, common codes and emphasized by all interviewees as well as important codes in researcher's view were identified as the final codes. Interviewees' descriptions in response to questions about the problem finding and causal conditions of executive barriers to create change and transformation in Mehrabad airport led to the identification of codes has been in *Table 4*.

Table 4. Extracted codes related to barriers.

N	Initial Extracted Code	N	Initial Extracted Code
1	Lack of attention to research and development department as an independent unit.	20	Lack of participation by managers of different levels.
2	Lack of attention to successful patterns and benchmarks around the world.	21	Lack of knowledge management system.
3	Lack of strategic planning.	22	Lack of attention to enhance employees' knowledge and skill.
4	Lack of Action Plan (executive actions) and legal and executive projects.	23	Assigning task of changing and transforming only in personnel and administrative affairs unit.
5	Negative attitudes of managers to develop and implement strategic planning.	24	Indifference of other units to administrative change process.
6	Attitudes of managers and officials.	25	Superior rules.
7	Lack of manager's system attitude.	26	Managers' fear of losing position.
8	Macro policies governing the country.	27	Organizational Structure.
9	Political relations governing the organizations' communications.	28	Organization's Funds.
10	The lack of an integrated transformation system.	29	International and global standards and rules.
11	Economic conditions governing the society.	30	Mandatory costs.
12	International Relations and relationship with international organizations.	31	Poor coordination of government's economic and cultural policies.
13	Budget allocated to the change and transformation.	32	Lack of knowledge regarding the identification of weaknesses, power, opportunities and threats.
14	Lack of skill of organizational individual in changing and transforming.	33	Organization employees' low motivation.
15	Fear of losing company reputation.	34	Uncertainty of task aspects.
16	Low level of public participation.	35	Company's activities are professional.
17	Lack of proper operational and non-operational infrastructures.	36	Lack of full access to income sources.
18	Inadequate study of company's comprehensive plan.	37	Lack of coordination in company's macro decision makings.
19	Lack of understanding of the results of the project.		

Investigation of extracted codes of interviewees' responses about the executive barriers to create change and transformation in Mehrabad airports has led to identification of the final. After applying experts' opinions and eliminating repetitious codes the final codes were obtained which showed in *Table 5*.

Table 5. Final codes related to barriers.

N	Final Code	N	Final Code
1	Lack of attention to research and development department as an independent unit.	15	Macro policies governing the country.
2	Lack of attention to successful patterns and benchmarks around the world.	16	Political relations governing the organizations' communications.
3	Lack of strategic planning.	17	The lack of an integrated transformation system.
4	Lack of Action Plan (executive actions) and legal and executive projects.	18	Economic conditions governing the society.
5	Negative attitudes of managers to develop and implement strategic planning.	19	International Relations and relationship with international organizations.
6	Lack of manager's system attitude.	20	Budget allocated to the change and transformation.
7	Superior rules.	21	Lack of skill of organizational individual in changing and transforming.
8	Fear of losing company reputation.	22	Fear of losing company reputation.
9	Organization employees' low motivation.	23	Lack of proper operational and non-operational infrastructures.
10	Inadequate study of company's comprehensive plan.	24	Lack of understanding of the results of the project.
11	Lack of participation by managers of different levels.	25	Managers' fear of losing position.
12	Lack of knowledge management system.	26	International and global standards and rules.
13	Lack of attention to enhance employees' knowledge and skill.	27	Organization employees' low motivation.
14	Assigning task of changing and transforming only in personnel and administrative affairs unit.	28	Mandatory costs.

4.2| Selective Coding

While open coding separates data into different categories, selected coding connects categories and their sub-categories given their characteristics and aspects. To discover how categories are connected to each other, the researcher uses paradigm. Paradigm is an analytic tool that Strauss and Corbin proposed for studying the data. The main components of the paradigm are: conditions, actions/ reactions and consequences. Strauss and Corbin proposed the paradigmatic model because in context theory sub-categories are related to categories in the form of a series of connections indicating casual conditions, phenomenon, context, intervention conditions, action/reaction strategies and results. During selective coding process, the researcher uses analytical tools such as asking question, and theoretical and permanent comparison of categories, sub-categories and their characteristics which have been appeared in open coding to develop relations between categories and sub-categories and form categories proportional to paradigmatic model. Simultaneous with doing open and selective coding a model was made indicating the relationship between the categories and sub-categories. When these relationships were developed, the selective coding procedure is used to facilitate integration of categories and sub-categories which have been identified in open and selective coding in the form of a new theory.

In selective coding the researcher by asking questions about the category which generally characterize a relationship refers to data and examines incidents confirming or rejecting questions. In selective coding process, the researcher is continuously moving between inductive and deductive thinking. It means that when he is working with data suggests their possible relations or properties deductively, and then tries to examine what he has expressed deductively against data. In Table 6, the identified concepts and categories associated with executive barriers to create change in Mehrabad airport has been presented.

As seen in the above table, after conducting interviews with experts and open coding, the axial coding and selective coding were discussed. In axial coding 15 concepts were identified and in the next step according to the selective coding, the identified factors were classified in 7 main barrier groups. In the following, in order to determine the importance and priority level of each of the six main barrier groups, the fuzzy SWARA method was used.

4.3| Prioritizing the Barriers by Using Fuzzy SWARA

At this step, fuzzy which was explained in *Section 2.4* utilized to obtain importance weights of identified barriers. The barrier set is determined on the basis of the GT results as shown in the *Table 6*.

The results of fuzzy SWARA are presented in this section. Because of limitation of space, the method results presented for the first Decision Maker (DM1) and main barriers dimension of this research and showed in *Table 7* for instance. A similar procedure was followed for the other experts and sub-barriers.

Table 6. Identified concepts and categories associated with executive barriers.

Barriers	Sub-Barriers	Final Codes
Management barriers- B1	Managers' poor planning- B11	Lack of coordination in company's macro decision makings.
		Lack of strategic planning.
	Managers' traditional attitude- B12	Negative attitudes of managers to develop and implement strategic planning.
		Attitudes of managers and officials.
		Lack of manager's system attitude.
	Fear of change- B13	Managers' fear of losing position.
		Lack of participation by managers of different levels.
Strategic barriers- B2	Lack of attention to the future- B21	Lack of attention to research and development department as an independent unit.
		Lack of attention to successful patterns and benchmarks around the world.
		Lack of strategic planning.
	Poor knowledge for changing- B22	Lack of knowledge management system.
		Lack of attention to enhance employees' knowledge and skill.
		Lack of knowledge regarding the identification of weaknesses, power, opportunities and threats.
Legal barriers- B3	Intra-organizational rules-B31	Lack of action plan (executive actions) and legal and executive projects.
		Macro policies governing the country.
		Superior rules.
	extra-organizational rules- B32	International relations and relationship with international organizations.
		Political relations governing the organizations' communications.
		International and global standards and rules.
Economic and income barriers- B4	Economic policies- B41	Poor coordination of government's economic and cultural policies.
		Economic conditions governing the society.
	Company's financial constraints- B42	Mandatory costs.
		Budget allocated to the change and transformation.
		Organization's funds.
		Lack of full access to income sources.
Participatory barriers- B5	Lack of inter-sectorial collaboration- B51	Indifference of other units to administrative change process.
		Low level of public participation.
	Making processes professional- B52	Assigning task of changing and transforming only in personnel and administrative affairs unit.
		Company's activities are professional.
Structural barriers- B6	Lack of transparency- B61	Uncertainty of task aspects.
		The lack of an integrated transformation system.
	Poor infrastructure- B62	Lack of proper operational and non-operational infrastructures.
		Organizational structure.
Cognitive barriers- B7	Insufficient knowledge of the change process- B71	Lack of understanding of the results of the project.
		Fear of losing company reputation.
	Employees' poor attitude- B72	Lack of skill of organizational individual in changing and transforming.
		Organization employees' low motivation.

Table 7. Fuzzy SWARA results for DM1 and main barriers dimension.

Barrier	$\tilde{S}_j$	$\widetilde{K}_j$	$\tilde{q}_j$	$\widetilde{w}_j$	w'_j
B6	–	(1, 1, 1)	(1, 1, 1)	(0.3969, 0.4848, 0.5828)	0.46979
B7	(0.6667, 1, 1.5)	(1.6667,2, 2.5)	(0.4, 0.5, 0.6)	(0.1588, 0.2424, 0.3497)	0.23937
B3	(0.6667, 1, 1.5)	(1.6667,2, 2.5)	(0.16, 0.25, 0.36)	(0.0635, 0.1212, 0.2098)	0.12429
B2	(0.4, 0.5, 0.6667)	(1.4, 1.5, 1.6667)	(0.096, 0.1667, 0.2571)	(0.0381, 0.0808, 0.1499)	0.08424
B5	(0.6667, 1, 1.5)	(1.6667,2, 2.5)	(0.0384, 0.08333, 0.1543)	(0.0152, 0.0404, 0.0899)	0.04481
B1	(0.6667, 1, 1.5)	(1.6667,2, 2.5)	(0.0154, 0.0417, 0.0926)	(0.0061, 0.0202, 0.0539)	0.02420
B4	(0.6667, 1, 1.5)	(1.6667,2, 2.5)	(0.0061, 0.0208, 0.0555)	(0.0024, 0.0101, 0.0324)	0.01325

At the final step, the average weights of barriers are calculated and showed in *Table 8*.

Table 8. Transformation barriers weights.

Barriers	Weight	Sub-Barriers	Local Weight	Global Weight	Rank
B1	0.030219283	B11	0.158874095	0.004801061	15
		B12	0.558670388	0.016882619	11
		B13	0.282455518	0.008535603	13
B2	0.089694687	B21	0.35444225	0.031791587	8
		B22	0.64555775	0.0579031	6
B3	0.132160409	B31	0.36443833	0.048164319	7
		B32	0.63556167	0.08399609	5
B4	0.01710169	B41	0.373803176	0.006392666	14
		B42	0.626196824	0.010709024	12
B5	0.050169669	B51	0.60455053	0.0303301	9
		B52	0.39544947	0.019839569	10
B6	0.445636176	B61	0.610242382	0.271946082	1
		B62	0.389757618	0.173690094	2
B7	0.235018085	B71	0.615934235	0.144755684	3
		B72	0.384065765	0.090262401	4

The prioritization of barriers (*Table 8*) explain that the 'structural barriers (B6)', 'cognitive barriers (B7)' and 'legal barriers (B3)' are the most important barriers and, 'economic and income barriers (B4)', 'management barriers (B1)' and 'participatory barriers (B5)' are the least important barriers respectively.

5| Conclusion and Recommendations

In general, any governmental administrative system depicts the government attitude toward administration and management of the country. The administrative system plays an important role in economic, political, socio-cultural structure and its effect in realization of the society macro-systems is of importance; so that the mentioned goals cannot be achieved without an efficient and effective administrative system. In recent years, improvement of administrative system is considered as a prerequisite of growth and its fundamental goal. The quality and efficacy of the administrative system is a determinant factor in implementation of developmental plans and providing welfare. Paying attention to the results, fulfillment of goals, continuous improvement of the quality of the public services and citizens' satisfaction, conducting organizational affairs in meaningful way and making significant changes in management knowledge in recent years, considering administrative system functions and evaluation of this system are essential. Nowadays, the role of management systems as an evaluation system and efficient supervision is obvious in improvement and perfection of organizations. While applying appropriate solutions, it is expected that the administrative system revolution will convert the government vision to service providing attitude which considers customer-oriented principle and customer satisfaction as one of the main indicators of efficacy and development of the system measurement. The components such as speed, accuracy and precision in providing the client services, the quality of performance, transparency and appropriate information dissemination are effective factors in customer satisfaction on services offered by the governmental system which provides the context for public trust as the biggest capital and support for the administrative system. It worthwhile to note that merely application of the revolutionary patterns proposed by different scholars will not be remedial in other organizations and communities that codify the rules and norms based on specific conditions. However, the Mehrabad airport needs for identification the barriers of changes and it should make effort to remove them. The results of fuzzy SWARA showed that the important barrier of changes in the administrative system in the Mehrabad airport is structural barriers. It is recommended this firm to try to remove these barriers. This firm also can identify jobs dimensions by clarification and establishing an integrated revolution system. Also, it should strengthen its infrastructural weak points in order to eliminate structural barriers before revolution.

The second case is cognitive barriers. The Mehrabad airports is recommended to recognize the change process in order to implement it without fear of losing its credibility. This firm also can take an action to change its staff vision on revolution. Legal barriers are considered as the third barrier of change in the administrative system. This firm should pay attention to codification of inter-organization rules; because it does not have authority to compile intra-organization regulations. Revolution is an essential, time-consuming, gradual and difficult process in this firm administrative system. Certainly, realization or non-realization of changes in this sector lies in the implementation of strategies and programs. In contrary to some extent, the firms are unable to approve laws and implement the rules in different contexts. Codification and implementation procedures are interwoven and providing the condition for implementation of a policy is superior to any other plans. Observance of this principle leads to compatibility in the nature of the implemented program and strategy which at the end it will pave the road for realization of the target. As before said, the findings of current research depict inconsistency of the strategy of change with the revolution program nature in the administrative system in the Mehrabad airport, so that it has caused to violation from the goals. Thus, successful implementation coordinated with the revolution program nature will be possible merely when the dependency relations are minimized. In other words, this research emphasizes the decentralization process as the main element and fundamental solution for making changes. However, this firm should take an action to remove its strategic barriers. Following propositions are recommenced:

- *It is recommended to conduct the organizational, technical and political decentralization process in short-term, middle-term and long-term.*
- *It is recommended to pay attention to planning and then implementation and control: If we consider any organizational change as a process, we will have three phases of planning, implementation and control. The governmental organizations put more energy on planning and then pay attention to implementation. Control is also the lost chain of organizational change process. In Iran it is emphasized documentation and strategy.*

The cultural barriers encourages changes and rewards ideas and innovation. We can see this culture rarely in Iranian governmental organizations and what is tangible is habit and uniformity. The findings of this research reveal that slogans and politicized behaviors in the governmental organizations is the biggest barrier before organizational revolution. In such atmosphere seeking organizational revolution programs seems unlikely since some of the management of these organizations prioritize establishing a close relationship and strengthening of their position not development of organization.

The findings of this research propose various research opportunities for researchers. Some of these propositions include:

- *Blocking sub-categories: In this research, blocking was done according to Strauss and Corbin categories paradigmatic model. The current research sub-categories paradigmatic model provides context for innovation and gaining knowledge.*
- *Examining variables and their relationships using survey research and multi-criteria decision making techniques is useful.*

References

[1] Wu, C. R., Lin, C. T., & Tsai, P. H. (2010). Evaluating business performance of wealth management banks. *European journal of operational research*, *207*(2), 971-979.

[2] Drucker, P. (2001). The next society. *The economist*, *1*. DOI: 10.1016/j.semerg.2013.05.004

[3] Zhu, X., & Zhang, Y. (2016). Political mobility and dynamic diffusion of innovation: The spread of municipal pro-business administrative reform in China. *Journal of public administration research and theory*, *26*(3), 535-551.

[4] Bass, B. M., & Riggio, R. E. (2006). *Transformational leadership*. Psychology press.

[5] Youqi, S. H. I. (2014). Legalization of China's administrative restructure reform [J]. *Law review*, *6*. https://en.cnki.com.cn/Article_en/CJFDTotal-FXPL201406002.htm

[6] Stanleigh, M. (2008). Effecting successful change management initiatives. *Industrial and commercial training*, *40*(1), 34-37.

[7] Pinborough-Zimmerman, J., Bakian, A. V., Fombonne, E., Bilder, D., Taylor, J., & McMahon, W. M. (2012). Changes in the administrative prevalence of autism spectrum disorders: contribution of special education and health from 2002–2008. *Journal of autism and developmental disorders*, *42*(4), 521-530.

[8] Wessel, L., Baiyere, A., Ologeanu-Taddei, R., Cha, J., & Jensen, T. (2020). Unpacking the difference between digital transformation and IT-enabled organizational transformation. *Journal of association of information systems*. Retrieved from file:///C:/Users/jpour/Downloads/tina_blegind_jensen_et_al_unpacking_the_difference_between_digital_transformation_acceptedversion%20(1).pdf

[9] Niemi, E., & Pekkola, S. (2019). The benefits of enterprise architecture in organizational transformation. *Business & information systems engineering*, 1-13. https://doi.org/10.1007/s12599-019-00605-3

[10] Arukhe, J., Abdullah, E., & Al-Ghamdi, S. (2020, January). Knowledge management and organizational transformation-a quantitative study. *International petroleum technology conference*. Dhahran, Kingdom of Saudi Arabia: International Petroleum Technology Conference.

[11] Bowornwathana, B. (1994). Administrative reform and regime shifts: Reflections on the Thai polity. *Asian journal of public administration*, *16*(2), 152-164.

[12] Jin, L. (2013). Study on economical organization construction under the background of administrative system reform. *Journal of Henan radio & TV University*, *2*.

[13] Kim, D. B. (2014). The Russian health care reforms and changes of its administrative systems in the era of post communism. *Korean comparative government journal*, *18*(2), 109-134.

[14] Bezes, P., & Parrado, S. (2013). Trajectories of administrative reform: Institutions, timing and choices in France and Spain. *West european politics*, *36*(1), 22-50.

[15] Deshpande, T., & Daim, T. (2020). Organizational transformation: semiconductors. *Digital transformation: evaluating emerging technologies*, *6*, 445.

[16] Ghasemi, R., & Beykzad, J. (2019). The study of organizational transformation acceptance and its impact on corporate employee commitment towards organizational change in Shohada Hospital in Tabriz. *Depiction of health*, *6*(2), 26-32.

[17] Simon, H. a. (1989). Bounded rationality and organizational learning. *The artificial intelligence and psychology project*, 1–14.

[18] Baležentis, A., Baležentis, T., & Brauers, W. K. (2012). Personnel selection based on computing with words and fuzzy MULTIMOORA. *Expert systems with applications*, *39*(9), 7961-7967.

[19] Liu, H. C., Wu, J., & Li, P. (2013). Assessment of health-care waste disposal methods using a VIKOR-based fuzzy multi-criteria decision making method. *Waste management*, *33*(12), 2744-2751.

[20] Dursun, M., Karsak, E. E., & Karadayi, M. A. (2011). A fuzzy multi-criteria group decision making framework for evaluating health-care waste disposal alternatives. *Expert systems with applications*, *38*(9), 11453-11462.

[21] Çebi, F., & Otay, İ. (2016). A two-stage fuzzy approach for supplier evaluation and order allocation problem with quantity discounts and lead time. *Information sciences*, *339*, 143-157.

[22] Mardani, A., Nilashi, M., Zakuan, N., Loganathan, N., Soheilirad, S., Saman, M. Z. M., & Ibrahim, O. (2017). A systematic review and meta-Analysis of SWARA and WASPAS methods: Theory and applications with recent fuzzy developments. *Applied soft computing*, *57*, 265-292.

[23] Keršuliene, V., Zavadskas, E. K., & Turskis, Z. (2010). Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA). *Journal of business economics and management*, *11*(2), 243-258.

[24] Mavi, R. K., Goh, M., & Zarbakhshnia, N. (2017). Sustainable third-party reverse logistic provider selection with fuzzy SWARA and fuzzy MOORA in plastic industry. *The international journal of advanced manufacturing technology*, *91*(5-8), 2401-2418.

E-ISSN: 2717-3453 | P-ISSN: 2783-1442

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 98–107.

Paper Type: Research Paper

Prediction of Pakistan Super League-2020 Using TOPSIS and Fuzzy TOPSIS Methods

Muhammad Jafar[1,*], Faizullah Khan[1], Amir Naveed[1]

[1] Department of Mathematics, Faculty of Basic Sciences Lahore Garrison University, Lahore, Pakistan; naveedjafar@lgu.edu.pk; mailto:kfaizullah520@gmail.com; raoaamir432@gmail.com.

Citation:

Jafar, M., Arab, A., Khan, F., Naveed, A. (2020). Prediction of Pakistan super league-2020 using TOPSIS and fuzzy TOPSIS methods. *Journal of fuzzy extension and application, 1* (2), 98-107.

Received: 21/01/2020 Reviewed: 29/02/2020 Revised: 05/03/2020 Accept: 30/04/2020

Abstract

We lived in uncertain word and prediction in this uncertain word is a major issue. Prediction in cricket is very complex because there are many factors which are effecting on results. Weather, pitch, Conditions, Home grounds are some of these factors. In this article it is aimed to predict the results of PSL-2020 by using TOPSIS and Fuzzy TOPSIS methods. It will be interesting because first time in PSL history it is going to be held in Pakistan. But we use some serious factor to predict the winner of PSL-2020.

Keywords: PSL, TOPSIS, Prediction, Cricket.

1 | Introduction

Licensee Journal of Fuzzy Extension and Applications. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0).

Pakistan Super League (PSL) is a professional Twenty20 cricket league in Pakistan contested during February and March every year, with each team play matches in double round robin format. The league is founded by the Pakistan Cricket Board (PCB) in Lahore on 9 September 2015 with initial participation of 5 teams but now there are 6 teams represented by 6 major cities 0f Pakistan including Islamabad, Lahore, Multan, Karachi, Peshawar and Quetta.

The commercial rights to the initial franchises were sold for US$93 million for a ten-years period while the 6th franchise was originally formed in 2017 bought by Schone properties in US$5.2 million per annum for 8 years contract means the total contract for that team was worth US$41.6 million that makes it the most expensive team of PSL but unfortunately the contract was terminated by the PCB just after one year due to the non-payment of annual fee by the franchise. Ali Khan Tareen and Taimoor Malik are the new owners of the 6th team as they won the bid for US$6.2 million per annum for 7 years period.

The 1st edition of the PSL was entirely played in UAE due to security reasons, Islamabad United was the 1st champions, Peshawar Zalmi were the 2017 PSL champions, Islamabad were again won the title in 2018 while Quetta Gladiators are the current champions of the HBL PSL.The PSL 2020 season is now going to be held entirely in Pakistan for the 1st time as by the directions of Pakistani Prime

Corresponding Author: naveedjafar@lgu.edu.pk

http://dx.doi.org/10.22105/jfea.2020.249363.1011

Minister. The tournament will be played from February 20, 2020 to March 22, 2020. Four venues including Lahore, Karachi, Multan and Rawalpindi will host whole the tournament.

Cricket is said to be a game of uncertainties, if we talk about the T20 game then it's really a difficult task to predict about the Twenty20 game as it's the limited overs game and a single player can overcome on the situation [2] and changed the whole map of the game in just few minutes [3]. The combination of key players (Batsmen with good average and bowlers with good economy rates) also plays an important role in match winning [4] for this purpose these 3 factors (batting, bowling, key players) [1] are strongly recommended to add in the stats to help in prediction because more the key players will have the more chances to win the match.

The stats in this article are based on the upcoming edition of the PSL 2020. About 90% data in stats is taken from the website cicinfo.com that's considered to be the most authentic and most visiting website in all over the world for cricket's updates and stats. The 9 important attributes which are considered to be the most important in match wining or lost with names C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9,C_{10} and C_{11} are taken out with 6 teams named as T_1 , T_2 , T_3, T_4, T_5 and T_6.

2| Material and Methods

The 5th edition of the HBL PSL is going to start from February 20, 2020 in Pakistan. The best players from all over the world are taking part with their relative franchises with 6 of the following teams:

T_1= Quetta Gladiators.
T_2= Islamabad United.
T_3= Karachi Kings.
T_4= Peshawar Zalmi.
T_5= Multan Sultan.
T_6= Lahore Qalandars.

Attributes. Some important attributes that plays important role in match wining are as follows with explanation of each one separately.

C1	**C2**	**C3**	**C4**	**C5**	**C6**
Fifties	Chased	Matches won	Matches lost	Win percentage	Lost percentage
C7	**C8**	**C9**	**C10**	**C11**	
2QA		Batting average>24	Bowling S.R	Economy rate	

C1–fifties. Fifties plays an important role in T20 cricket. It also helps to see the overall performance by whole the team, More the fifties maker in the team will have the more chances to adopt the pressure. The data shows the performance regarding fifties of all the teams in last 4 editions of the PSL.

C_2–chased. Chasing is a slightly a difficult task in T20 cricket if the opposite team makes a good total in 1st inning. So the team having good chasing skills will definitely have chances to win the match as well as to adopt the pressure in every situation. In stats the previous record is collected from last 4 editions which clearly shows the chasing abilities by a specific team.

C3–match won. It also an important factor to encourage the teams expectations and moral values. Winning matches shown the previous performance of the team and likely to have to perform well in future on the basis of previous record except of that the pitches, venues and some players are changed for upcoming PSL.

C_4–match lost. It shows the bad performance of the team. The team with most of the lost matches definitely will be considered as the weak team at all but restricted till the expectation as its T20 game and we can't predict with more confidently regarding the strongest and weakest team.

C_5–Win % AGE. Clearly shows the teams combined performance in last 4 editions. As the percentage mostly lies in decimal but in stats it's taken as exact numeric value i.e. instead of taking 58.69%. More the winning percentage shows the team's overall performance in last 4 editions of the PSL.

C_6–lost percentage. Lost percentage shows the weakness of the team. The team with more percentage in matches lost is likely to be consider as the weakest side of the tournament but except of that mostly players are changed or replaced every year so it's not the 100% surety to claim about its performance by just seeing previous record of the weakest team.

C_7–all out. It shows the team's confidence regarding to adopt the pressure in critical situations and also the consistency of the players in difficult situations. More the all outs shows the previous record about their performance in limited overs cricket.

C_8–key players. Key players also plays an important role in match winning .The team with more key players probably have the more chances to win the match or even title. Key players in stats are included with best batting, bowling averages and best economy rates.

C_9–best batting averages. Good batting line up is also a key factor for the team, batting averages taken in stats is >24 means no of best batsmen in a team. More the players with average >24 will increase the chances of winning the match or create a big total on board that helps to win the matches.

C_9 –bowling strike rate. Bowling strike rate is the average number of balls bowled per wicket taken, lower the strike rate means more effective a baller is taking wickets quickly. In stats just those players are taken out who have the best strike rates that is consider to be as <19.

C_{11}–economy rate. Economy rate is the average number of runs conceded for each over bowled. A lower economy rate is preferable. In stats just those bowlers are to be choose out to whom economy rates are less than 8.

Table 1 shows the statistical behavior of the teams performances. The data is collected up to 4 editions of the PSL.

Table 1. Statically behavior of the collected data that is take up to 4 editions of the PSL.

Teams/ Attributes	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
T_1	31	20	26	16	62	38	6	6	5	2	2
T_2	31	18	25	18	58	42	5	6	6	4	4
T_3	27	8	17	23	43	57	4	6	6	3	3
T_4	36	15	27	19	59	41	4	4	6	2	2
T_5	12	5	7	12	37	63	6	4	4	1	4
T_6	24	5	10	24	31	69	7	4	4	2	3

3| Calculations

TOPSIS technique is used to calculate an MCDM problem. So the weights are assigned according to the importance of each of the attribute.

Weight	0.15	0.08	0.12	0.03	0.09	0.08	0.02	0.17	0.16	0.08	0.02
Attributes	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11

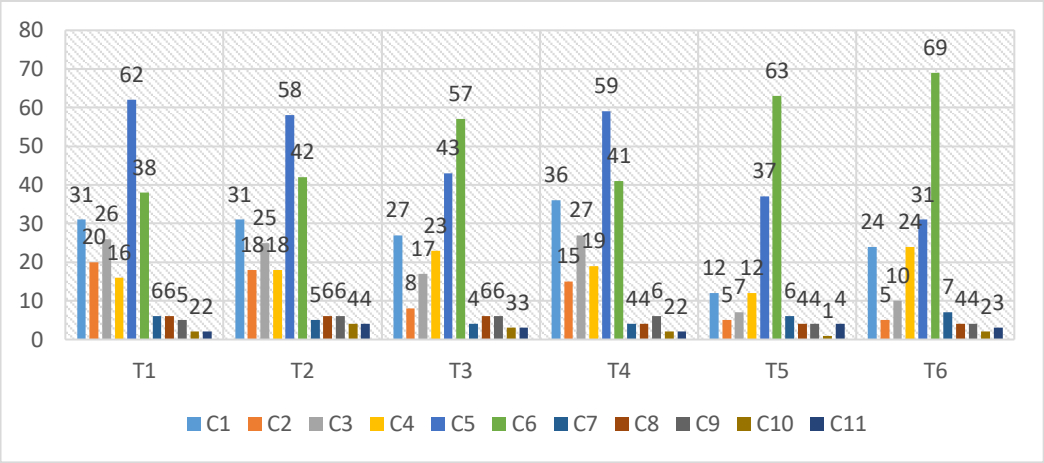


Fig. 1. Graphical representation of the above mentioned data.

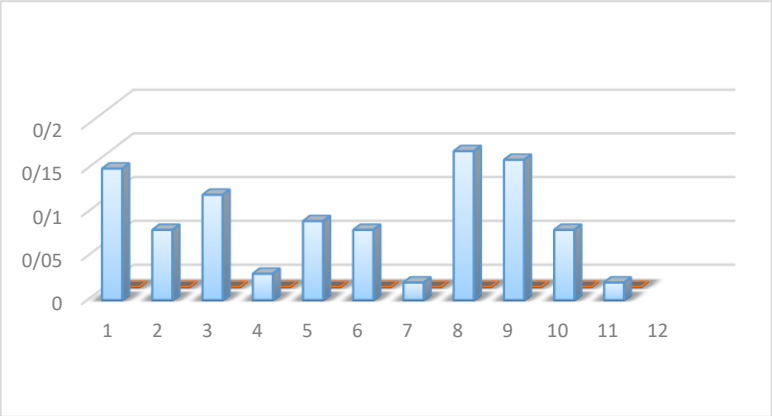


Fig. 2. Graphical behavior of the above mentioned weights to the attributes.

There is a great demand of game prediction for that many of the mathematical formulas are to be used for prediction by using MCDM techniques that is used to choose the best one amongst multiple criteria's.

3.1| TOPSIS Prediction

TOPSIS, Technique for order of preference by similarity to ideal solution, a tool for calculating the best one from the collected data. TOPSIS technique is applied to calculate the weights by given data that is collected up to 4 editions of the PSL which is easily available on "www.cricinfo.com" that is considered to be one of the best cricketing website in the world. To apply the technique some important attributes that are considered to play an important role in match or title winning including Fifties, chased, matches won, matches lost, win percentage, lost percentage, best batting average, best bowling strike rate, best economy rate with 6 teams T_1, T_2, T_3, T_4, T_5, and T_6 as decision makers are taken.

Step 1. Calculate normalized matrix.

$$X_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=1}^{n} x^2_{ij}}}.$$

Weight	0.15	0.08	0.12	0.03	0.09
T/C	C_1	C_2	C_3	C_4	C_5
T1	0.453777	0.613428	0.523360293	0.341899075	0.508470092
T2	0.453777	0.552085	0.503231051	0.384636459	0.47566557
T3	0.395225	0.245371	0.342197115	0.49147992	0.352648612
T4	0.526967	0.460071	0.543489536	0.406005151	0.483866701
T5	0.175656	0.153357	0.140904694	0.256424306	0.303441829
T6	0.351311	0.153357	0.201292421	0.512848612	0.254235046
0.08	**0.02**	**0.17**	**0.16**	**0.08**	**0.02**
C_6	C_7	C_8	C_9	C_{10}	C_{11}
0.292584827	0.449719013	0.480384461	0.389249472	0.324442842	0.262612866
0.32338323	0.374765844	0.480384461	0.467099366	0.648885685	0.525225731
0.43887724	0.299812676	0.480384461	0.467099366	0.486664263	0.393919299
0.315683629	0.299812676	0.320256308	0.467099366	0.324442842	0.262612866
0.485074845	0.449719013	0.320256308	0.311399578	0.162221421	0.525225731
0.531272449	0.524672182	0.320256308	0.311399578	0.324442842	0.393919299

Step 2. Calculate the weighted normalized matrix.

$$V_{ij} = X_{ij} \times W_j.$$

Weight	0.15	0.08	0.12	0.03	0.09
T/C	C_1	C_2	C_3	C_4	C_5
T1	0.068067	0.049074	0.062803235	0.010256972	0.045762308
T2	0.068067	0.044167	0.060387726	0.011539094	0.042809901
T3	0.059284	0.01963	0.041063654	0.014744398	0.031738375
T4	0.079045	0.036806	0.065218744	0.012180155	0.043548003
T5	0.026348	0.012269	0.016908563	0.007692729	0.027309765
T6	0.052697	0.012269	0.02415509	0.015385458	0.022881154
0.08	**0.02**	**0.17**	**0.16**	**0.08**	**0.02**
C_6	C_7	C_8	C_9	C_{10}	C_{11}
0.023406786	0.00899438	0.081665358	0.062279916	0.025955427	0.005252257
0.025870658	0.007495317	0.081665358	0.074735899	0.051910855	0.010504515
0.035110179	0.005996254	0.081665358	0.074735899	0.038933141	0.007878386
0.02525469	0.005996254	0.054443572	0.074735899	0.025955427	0.005252257
0.038805988	0.00899438	0.054443572	0.049823932	0.012977714	0.010504515
0.042501796	0.010493444	0.054443572	0.049823932	0.025955427	0.007878386

Step 3. Calculate the ideal best and ideal worst values.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
V+	0.079045	0.049074	0.065218744	0.007692729	0.045762308	0.023406786	0.005996254	0.081665358	0.074735899	0.051910855	0.010504515
V-	0.026348	0.012269	0.016908563	0.015385458	0.022881154	0.042501796	0.010493444	0.054443572	0.049823932	0.012977714	0.005252257

Step 4. Calculate the Euclidean distance from the idea best.

$$Si^{+} = \left[\left(\sum_{j=1}^{m} V_{ij} - V_j^{+}\right)^2\right]^{0.5}.$$

Step 5. Calculate the Euclidean distance from the ideal worst.

$$Si^{-} = \left[\left(\sum_{j=1}^{m} V_{ij} - V_j^{-}\right)^2\right]^{0.5}.$$

Step 6. Calculate the performance score.

$$P_i = \frac{Si^{-}}{Si^{+}+Si^{-}}.$$

Teams	Si+	Si-	Pi	Rank
Quetta Gladiators	0.032	0.085	0.728429	2
Islamabad United	0.014	0.091	0.865348	1
Karachi Kings	0.049	0.063	0.560988	4
Peshawar Zalmi	0.04	0.085	0.679043	3
Multan Sultan	0.1	0.011	0.099888	6
Lahore Qalandars	0.082	0.03	0.269933	5

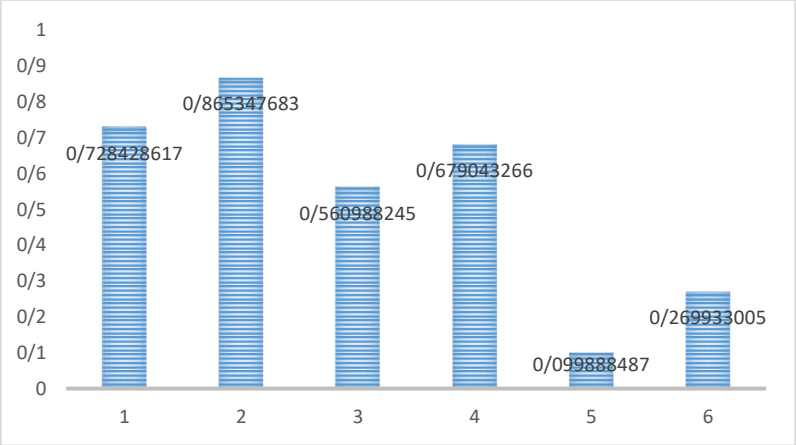


Fig. 3. Graphical representation of the final results against each team.

3.2| Calculations via Fuzzy TOPSIS

Step 1. Assign the fuzzy numbers to the group of decision makers on the basis of attributes regarding each of the criteria.

T/C	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
T_1	8,6,7	9,7,8	8,6,7	8,6,7	9,7,8	2,3,5	6,5,4	9,7,8	8,6,7	8,6,7	8,6,7
T_2	8,6,7	8,6,7	6,5,4	6,5,4	8,6,7	6,5,4	2,3,5	6,5,4	6,5,4	6,5,4	8,6,7
T_3	6,5,4	2,3,5	6,5,4	2,3,5	2,3,5	6,5,4	2,3,5	9,7,8	8,6,7	6,5,4	6,5,4
T_4	9,7,8	6,5,4	9,7,8	6,5,4	8,6,7	2,3,5	2,3,5	6,5,4	8,6,7	2,3,5	2,3,5
T_5	1,1,2	1,1,2	2,3,5	2,3,5	2,3,5	8,6,7	8,6,7	6,5,4	2,3,5	1,1,2	8,6,7
T_6	2,3,5	1,1,2	1,1,2	1,1,2	1,1,2	9,7,8	9,7,8	6,5,4	2,3,5	2,3,5	6,5,4

Decision Maker 2.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
T_1	9,7,8	9,7,8	8,6,7	8,6,7	9,7,8	1,1,2	6,5,4	9,7,8	9,7,8	9,7,8	8,6,7
T_2	8,6,7	8,6,7	6,5,4	6,5,4	8,6,7	2,3,5	1,1,2	6,5,4	8,6,7	8,6,7	6,5,4
T_3	6,5,4	1,1,2	6,5,4	2,3,5	2,3,5	6,5,4	2,3,5	9,7,8	8,6,7	8,6,7	6,5,4
T_4	8,6,7	6,5,4	8,6,7	6,5,4	8,6,7	2,3,5	2,3,5	6,5,4	6,5,4	2,3,5	2,3,5
T_5	1,1,2	1,1,2	2,3,5	6,5,4	2,3,5	8,6,7	8,6,7	6,5,4	2,3,5	1,1,2	8,6,7
T_6	2,3,5	1,1,2	1,1,2	6,5,4	1,1,2	8,6,7	9,7,8	6,5,4	2,3,5	2,3,5	8,6,7

Step 2. Construct the combined decision matrix by using the following formula.

$$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}) \quad \text{where } a_{ij} = {}^{min}_{k}\{a_{ij}{}^{k}\}, \quad b_{ij} = \frac{1}{k}\sum_{k=1}^{k} b_{ij}{}^{k}, \quad c_{ij} = {}^{max}_{k}\{c_{ij}{}^{k}\}.$$

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
T_1	8,6.33,8	8,6.66,8	8,3,7	8,6.33,8	8,6.66,8	1,1.66,5	2,4.33,5	9,7,8	8,6.66,8	8,6.33,8	6,5.66,7
T_2	8,6,7	8,6,7	6,5,4	6,5.33,7	8,6,7	2,3.66,5	1,1.66,5	6,5.33,7	6,5.33,7	6,5.66,7	6,5.66,7
T_3	6,3,4	1,2.33,5	6,5,4	2,3,5	2,3,5	6,5,4	2,3,5	9,7,8	8,6.33,7	6,5.33,7	6,5,4
T_4	8,6.66,8	6,5,4	8,6.66,8	6,5,4	8,6,7	2,3,5	2,3,5	6,5,4	6,5.66,7	2,3,5	2,3,5
T_5	1,1.66,5	1,2.33,4	2,3,5	2,3.66,5	2,3,5	8,6,7	8,6,7	6,5,4	2,3,5	1,1,2	8,6,7
T_6	1,2.33,5	1,1.66,5	1,1,2	1,4.33,8	1,1,2	8,7,8	9,7,8	6,5,4	2,3,5	2,3,5	6,5.33,7

Step 3. Compute the normalized fuzzy decision matrix by using formulae.

$$r_{ij} = \left(\frac{a_{ij}}{c_j^{+}}, \frac{b_{ij}}{c_j^{+}}, \frac{c_{ij}}{c_j^{+}}\right) \text{ and } c_j^{+} = {}^{max}_{i}\{c_{ij}\} \text{ (Beneficial criteria).}$$

$$r_{ij} = \left(\frac{a_j^{-}}{c_{ij}}, \frac{a_j^{-}}{b_{ij}}, \frac{a_j^{-}}{a_{ij}}\right) \text{ and } a_j^{-} = {}^{min}_{i}\{a_{ij}\} \text{ (Non beneficial criteria).}$$

	Bnf	**Bnf**	**Bnf**	**Non Bnf**	**Bnf**
Wght	**8,6,9**	**6,5,4**	**7,5,8**	**6,5,4**	**6,3,5**
T/C	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**
T1	1,0.79125,1	1,0.8325,1	1,0.375,0.875	0.125,0.1579,0.125	1,0.8325,1
T2	1,0.75,1	1,0.75,0.875	0.75,0.625,0.5	0.1428,0.1876,0.166	1,0.75,0.875
T3	0.75,0.375,0.5	0.125,0.291,0.625	0.75,0.625,0.5	0.2,0.33,0.5	0.25,0.375,0.625
T4	1,0.8325,1	0.75,0.626,0.5	1,0.8325,1	0.25,0.2,0.166	1,0.75,0.875
T5	0.125,0.2075,0.625	0.125,0.291,0.5	0.25,0.375,0.625	0.2,0.27,0.166	0.25,0.375,0.625
T6	0.125,0.291,0.625	0.125,0.2075,0.625	0.125,0.125,0.25	0.125,0.230,1	0.125,0.125,0.25
Non Bnf	**Non Bnf**	**Bnf**	**Bnf**	**Bnf**	**Bnf**
3,4,7	**4,5,6**	**9,7,9**	**9,6,8**	**6,5,7**	**7,6,8**
C_6	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**
0.2,0.602,1	0.2,0.230,0.5	1.125,0.875,1	1,0.8325,1	1,0.791,1	0.8571,0.8085,1
0.2,0.2732,0.5	0.2,0.6024,1	0.75,0.666,0.875	0.75,0.666,0.875	0.75,0.7075,0.875	0.8571,0.8085,1
0.25,0.22,0.166	0.2,0.33,0.5	1.125,0.875,1	0.75,0.666,0.875	0.75,0.666,0.875	0.8571,0.7142,0.5715
0.2,0.33,0.5	0.2,0.33,0.5	0.75,0.625,0.5	0.75,0.7075,0.875	0.25,0.375,0.625	0.285,0.4285,0.7142
0.1425,0.166,0.12	0.1425,0.166,0.125	0.75,0.625,0.5	0.25,0.375,0.625	0.125,0.125,0.25	1.1428,0.8571,1
0.125,0.1425,0.125	0.12,0.14,0.111	0.75,0.625,0.5	0.25,0.375,0.625	0.25,0.375,0.625	0.8571,0.7614,1

Step 4. Calculate weighted normalized fuzzy decision matrix.

$$v_{ij} = r_{ij} \times w_{j.}$$

Such that A1 ⊗A2 = (a1,b1,c1) ⊗ (a2,b2,c2) = (a1 ×a2 ,b1× b2,c1 ×c2).

	Bnf	Bnf	Bnf	Non Bnf	Bnf
Wght	**8,6,9**	**6,5,4**	**7,5,8**	**6,5,4**	**6,3,5**
T/C	**C_1**	**C_2**	**C_3**	**C_4**	**C_5**
T1	8,4.7475,9	6,4.1625,4	7,1.87,6.7	0.75,0.7895,0.5	6,2.49755,5
T2	8,4.5,9	6,3.75,3.5	5.25,3.125,4	0.8568,0.938,0.664	6,2.25,4.375
T3	6,2.25,4.5	0.75,1.4575,2.5	5.25,3.125,4	1.2,1.65,2	1.5,1.125,3.1285
T4	8,4.995,9	4.5,3.125,2	7,4.1625,8	1.5,1,0.64	6,2.25,4.125
T5	1,1.245,5.626	0.75,1.4550,2	1.75,1.875,5	1.2,1.35,2	1.5,1.125,3.125
T6	1,1.7475,5.625	0.75,1.037,2.5	0.875,0.625,2	0.75,1.15,4	0.75,0.375,1.25
Non Bnf	**Non Bnf**	**Bnf**	**Bnf**	**Bnf**	**Bnf**
3,4,7	**4,5,6**	**9,7,9**	**9,6,8**	**6,5,7**	**7,6,8**
C_6	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**
0.6,2.408,7	0.8,1.15,3	10.125,6.125,9	9,4.995,8	6,3.955,7	5.99,4.851,8
0.6,1.092,3.5	0.8,3.012,6	6.75,4.662,7.875	6.75,3.996,7	4.5,3.5375,6.125	5.99,4.851,8
0.75,0.88,1.162	0.8,1.65,3	9,5.39,7.92	9,4.74,7	4.5,3.3,6.125	5.25,3.75,4
0.6,1.32,3.5	0.8,1.65,3	5.94,3.85,3.96	5.58,4.62,7	1.5,1.875,4.37	1.75,2.25,5
0.42,0.64,0.84	0.56,0.80,0.72	5.94,3.85,3.96	2.25,2.25,5	0.75,0.625,1.75	7,4.5,7
0.36,0.57,0.84	0.48,0.70,0.66	5.94,3.85,3.96	2.25,2.25,5	1.5,1.875,4.375	5.25,3.96,7

Step 5. Compute the Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) by given formula.

$A^+ = (v_1^+, v_2^+ \ldots . . v_n^+)$ where $v_j^+ = {}^{\max}_{i}\{v_{ij3}\}$.

$A^- = (v_1^-, v_2^- \ldots . . v_n^-)$ where $v_j^- = {}^{\min}_{i}\{v_{ij1}\}$.

	C 1	C2	C3	C4	C5	C6	C 7	C8	C9	C10	C11
FPIS = A+	8,4.995,9	6,4.1625,4	7,4.1625,8	0.75,1.15,4	6,2.49755,5	0.6,2.408,7	0.8,3.012,6	10.125,6.125,9	9,4.995,8	6,3.955,7	5.99,4.851,8
FNIS = A-	1,1.245,5.626	0.75,1.037,2.5	0.875,0.625,2	0.75,1.15,4	0.75,0.375,1.25	0.36,0.57,0.84	0.48,0.70,0.66	5.94,3.85,3.96	2.25,2.25,5	0.75,0.625,1.75	1.75,2.25,5

Step 6. Calculate the distance from each alternative to the FPIS and then FNIS by using distance formula as mentioned below.

$$d(x,y) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]}.$$

Distance from FPIS.

T/C	C_1	C_2	C_3	C_4	C_5
T1	0.142894192	0	1.521573336	2.0314166	0
T2	0.285788383	0.37423533	2.5909397	1.967769485	0.388107051
T3	3.25499744	3.830831348	2.5909397	1.2232095	2.916048
T4	0	1.562733	0	1.9887454	0.505181
T5	4.981511685	3.711749374	3.73252176	1.1913192	2.924003035
T6	4.862676946	3.632320207	5.355045323	0	3.912826
C_6	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**
0	2.03854883	0	0	0	0
2.158846606	0	2.220857117	1.53411223	1.031169441	0
3.485184261	1.902195574	0.995364255	0.595825758	1.071548723	2.433091381
2.116108378	1.902195574	4.003808603	2.068576403	3.24002572	3.353744226
3.70152329	3.308017735	4.003808603	4.549634601	4.698010217	0.84524178
3.714002513	3.364686414	4.003808603	4.549634601	3.24002572	0.883455526

Distance from FNIS.

T/C	C_1	C_2	C_3	C_4	C_5
T1	4.921090064	3.63232	4.514999077	2.0314166	3.92131859
T2	4.864116946	3.70463	3.12999	1.967769485	3.664666
T3	3.015399	0.241188	3.12999	1.2232095	1.245493
T4	4.98048	2.49481	5.355045323	1.9887454	3.6214
T5	0	0.376364	1.942133	1.1913192	1.243734
T6	0.29011	0	0	0	0
C_6	**C_7**	**C_8**	**C_9**	**C_{10}**	**C_{11}**
3.724002513	1.388104223	4.003808603	4.549634601	4.698010217	3.353744226
2.424574464	3.364686414	2.355325101	3.016538634	3.727634695	3.494042
0.34248309	1.46975	3.023066875	4.311326169	3.667821788	2.273030283
1.60163582	1.46975	0	2.627153085	1.731030522	0
0.053229	0.081649658	0	0	0	3.494042549
0	0	0	0	1.733553052	2.52811524

Step 7. Calculate the di^+ and di^- by using the formula mentioned below.

$$di^+ = \sum_{j=1}^{n} d(v_{ij}, v_j^+) \quad di^- = \sum_{j=1}^{n} d\left(v_{ij}, v_j^-\right).$$

Step 8. Calculate the Closeness Coefficient (CCi) for each alternative.

$$CCi = di^-/(di^+ + di^-).$$

Teams	di+	di-	Cci	RANK
Quetta Gladiators	5.734432958	40.73844871	0.8766069	1
Islamabad United	12.55182534	35.71397374	0.739943695	2
Karachi Kings	24.29923594	23.9427577	0.496305312	4
Peshawar Zalmi	20.7411183	25.87005015	0.555018272	3
Multan Sultan	37.64734128	8.382471407	0.182109614	5
Lahore Qalandars	37.51848185	4.551778292	0.108194679	6

So T_1 (Quetta Gladiator) has the most chances to win PSL-2020.

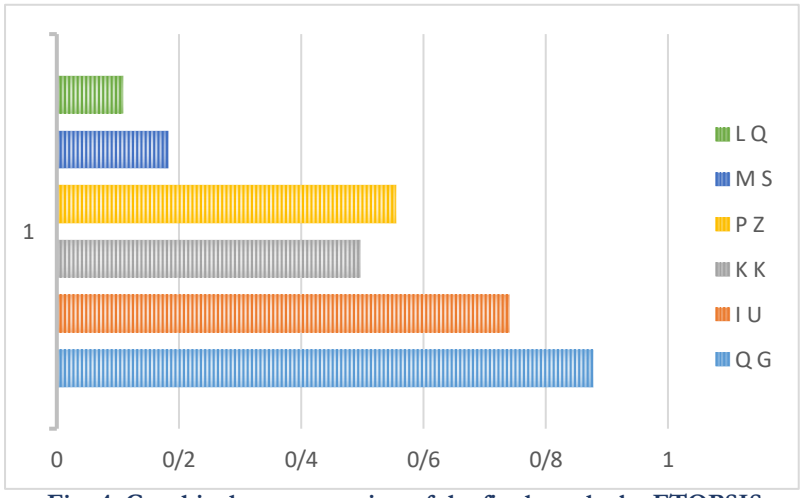


Fig. 4. Graphical representation of the final results by FTOPSIS.

4| Conclusion

The purpose of this research is to predict about the expected winner of PSL-5-2020.Although it's really a problematic task to predict about the game like this especially when we talk about limited overs cricket. Many of the factors including pitch ,weather conditions, availability of the key players directly impacts on the game, except of all that this research paper is based on the previous records of all the teams as well as availability of the key players for the upcoming edition of the PSL. So by collected records and mathematically point of view the results shows that team Islamabad United probably have the more chances to win the PSL-2020 by TOPSIS technique but fuzzy TOPSIS shows slightly different results with wining chances of another strongest and well deserved winning team Quetta Gladiators as well as the teams Multan Sultans and Lahore Qalandars have the lowest chances to win the title.

References

[1] Ahmed, F., Deb, K., & Jindal, A. (2013). Multi-objective optimization and decision making approaches to cricket team selection. *Applied soft computing, 13*(1), 402-414.

[2] Bhattacharya, R., Gill, P. S., & Swartz, T. B. (2011). Duckworth–Lewis and twenty20 cricket. *Journal of the operational research society, 62*(11), 1951-1957.

[3] Davis, J., Perera, H., & Swartz, T. B. (2015). Player evaluation in Twenty20 cricket. *Journal of sports analytics, 1*(1), 19-31.

[4] Perera, H. P., & Swartz, T. B. (2013). Resource estimation in T20 cricket. *IMA journal of management mathematics, 24*(3), 337-3

E-ISSN: 2717-3453 | P-ISSN: 2783-1442

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 108–111.

Paper Type: Review Paper

Application of Fuzzy Logic in Portfolio Management: Evidence from Iranian Researches

Meysam Kaviani[1,*], Seyed Fakhreddin Fakhrehosseini[2]

[1] Department of Financial Management, Tonekabon Branch, Islamic Azad University, Iran; meysamkaviani@gmail.com;

[2] Department of Business Management, Tonekabon Branch, Islamic Azad University, Iran; f_fkm21@yahoo.com.

Citation:

Kaviani, M., & Fakhrehosseini, S. F. (2020). Application of fuzzy logic in portfolio management: evidence from iranian researches. *Journal of fuzzy extension and application, 1* (2), 108-111.

Received: 21/01/2020 Reviewed: 08/03/2020 Revised: 29/03/2020 Accept: 17/05/2020

Abstract

Over the past decades, financial researchers have proposed different methods in portfolio selection, so that, Markwotiz [1] introduced risk and return criteria for a portfolio selection. Since it is difficult how to select an adequate stock portfolio, fuzzy models have been able to help researchers by considering uncertainty. In this research, we surveyed a portfolio management by reviewing the relevant literature of fuzzy model in financial management. The results showed that a fuzzy model can to determine an optimal portfolio.

Keywords: Fuzzy Logic, Portfolio, Optimization.

1 | Introduction

Licensee Journal of Fuzzy Extension and Applications. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0).

Portfolio is important because it is related to profitability and can lead to higher profits by providing a better model for portfolio selection. The first model for the portfolio problem was proposed by Markwotiz [1]. He stated that a rational investor not only focus on maximizing portfolio returns but also focuses on returns and risk [2]. Our decisions are made in conditions of uncertainty because investment environments are uncertain and financial markets are often accompanied by incomplete information. Fuzzy collections are one of the powerful tools to deal with uncertainly financial markets and predict investor's behavior. One of the most important features of these models, like humans, is the ability to intelligently design patterns to process qualitative information. These models, in fact, while creating flexibility in the model, take into account factors in the model such as knowledge, experience and human judgment and provide fully practical answers [3]. In recent years, with development of theories of using fuzzy logic in financial researches, we have seen the development of use of this model in domestic researches. Therefore, this article intends to refer to some of these researches in order to better understand the fuzzy models in investment decisions under portfolio management branch. Therefore, this article consists of three sections: Introduction to fuzzy logic, portfolio management, and the function of fuzzy model in portfolio management with research approach.

Corresponding Author: meysamkaviani@gmail.com

http://dx.doi.org/10.22105/jfea.2020.249372.1012

2| Fuzzy Logic

The theory of fuzzy sub-sets constitutes a very wide context in which to situate multivalent logic. Their origin can be found in the works, which in 1965 were developed by Zadeh [4], professor at the University of California, and today constitutes a mathematical theory constructed in all rigor that allows for the treatment of subjectivity and/or uncertainty. Its development has brought up an epistemological problem in the sense that is it better to use a certain model, which is unlikely to represent reality, or a fuzzy model that constitutes a valid reflection. In our understanding, it is necessary to observe economic and financial phenomena and determine their nature. It will be when they are presented in a fuzzy, vague manner, with limits that it will be necessary to use fuzzy mathematics. But we should not fall into the temptation of converting into fuzzy that which is not, but neither should we qualify as certain that which appears as fuzzy. Knowledge of the fact, persons and things is situated at different levels the specification of which is difficult. Between perfect knowledge of a phenomenon and total ignorance, knowledge that is more or less imprecise can be found.

3| Portfolio Management

Investment management includes two main topics: Securities analysis and portfolio management. Securities analysis includes to estimate each investment portfolio's benefits; while portfolio management includes to survey investments composition and investments management maintenance. Over the past decade, stock selection methods in investment topics have been shifted to portfolio management [5].

One of the most important issues in financial sciences is optimal portfolio selection, in which to achieve specific goals, are distributed a specific capital among the assets. In traditionally portfolio selection approach, when an investor invests in securities with the highest expected return that his aim to be obtain the highest expected return. But in 1952, this view was challenged by Markwotiz [1]. In his view, it is irrational when an investor just pays attention to stock returns. Because in addition to maximizing stock return, the investor must be sure that it will be realize. On the other hand, if investors are only looking to maximize their returns, then they should only invest in a specific type of asset with the highest returns. According to Markwotiz, investors should pay attention to both phenomena of risk and return at the same time. Accordingly, investors are faced two conflicting goals that they must balance them against each other [6]. In today's world, however, investment challenges are uncertainty in the future. What will be happened in the future about investment environment and what will be impacted these events? The traditional approach to uncertainty is to consider the return on assets as a stochastic factor. But this approach will impose unrealistic assumptions on optimal portfolio selection and will lead to many problems about finding the random distribution and related parameters. But we can done modeling more simply and efficiently this uncertainty by fuzzy logic. Experts' opinion is easily included in the model using fuzzy logic. Due to the fuzzy logic efficiency to take into account expert opinions and uncertainty in financial markets, one of the useful solutions for modeling return on assets in portfolio problem is using that approach. So, researchers have concluded that fuzzy logic can be useful, in which returns are considered as a fuzzy number. In next section, function of this model in portfolio management is discussed.

4| Fuzzy Logic and Portfolio Management

There is a lot of research on portfolio optimization. Given uncertainty in financial data, fuzzy logic tools help us to have a more accurate estimate in the future. Hence in our country as well, in this field various researches have been done that the results are remarkable. For example, Shams Lahroudi et al. [3] dealt with affecting factors to selection of optimal portfolio by integrated fuzzy MCDM techniques. Didehkhani [7] showed the multiobjective portfolio rebalancing model with fuzzy parameters is solved by fuzzy goal programming and a hybrid intelligent algorithm that combines fuzzy simulation with a genetic algorithm. The results in their paper demonstrated the effectiveness of the solution approach and efficiency of the model in practical applications of rebalancing an existing portfolio.

Khanjarpanah et al. [2] expressed portfolio selection always has been one of the interesting subjects in financial problems and markets. In this paper, the proposed model for evaluating, performance testing and logicality approved, is applied to some monthly return of company's stock of Tehran Stock Exchange and the results is reported. The results showed that in lower values of confidence level in proposed portfolio problem, it's possible to obtain a higher profit with low risk.

Ghehi et al. [8] remarked the multi-period models running by MOPSO algorithm indicated for the models Mean-AVaR, Mean-Semi Entropy, and Mean-VaR, respectively, performed better, in terms of Sharpe and Treynor measures.

Jafaria and Dezfouli Khajehzadeh [6] explained investment portfolio selection as one of the most important issues raised in the area of financial engineering Mean-Variance model revolutionized portfolio selection problems. They showed a multi-objective portfolio selection model is considered including the uncertainty data. In particular, the aim of their paper presented a robust-fuzzy multi-objective model for portfolio selection. After presenting multi- objective optimization approach, robust optimization approach and fuzzy optimization approach, fuzzy-robust multi-objective model for portfolio selection is expressed. Finally, using real data to solve the proposed mode. Behnamian and Moshrefi [9] considered fuzzy concepts in the discussion of portfolio selection optimization in order to pursue this uncertainty. Then by using Bonison method, they determined priority and preference among the portfolios so that the investor can decide without confusion and finally through introducing combined metaheuristic algorithm for variable neighborhood search and genetics, can optimize the resulting model of previous process and comparing it with other solving algorithms. Fallahpoor et al. [5] showed that there is a significant difference between the mean of monthly sharpe ratio of 3, 5 and 50 shares portfolios obtained from the proposed model and Markwotiz model. However, there is no a significant difference between the mean of monthly sharpe ratio of 10 shares portfolio obtained from the proposed model and Markwotiz model. Nabizade and Behzadi [10] indicated that the proposed approach is well-suited, especially for portfolio models with higher moments. Conclusion: The findings showed that using entropy as a diversification index cannot cause any significant decrease in optimized values for other goals. Using Shannon entropy and Gini-Simpson entropy models can lead to an increase in return and Shannon entropy model can yield more diversification compared to Gini-Simpson entropy model Nabavi Chashmi and Yousefi Kerchangi [11] explained regarding to exerting the model in two unique investment companies during the years 2008 through 2009, research results represent that model application can provide a particular position for better and more precision adjustment recognition of investment companies portfolio in order for easier decision making of investors.

5 | Conclusion

Portfolio selection is one of the fascinating issues in uncertainty planning. In recent years, we have seen studies in finance's field, in which extensive research has been done in portfolio selection and various methods have been presented for stock selection. One of these models has been using fuzzy approaches, which indicates its function in increasingly portfolio management efficiency. Therefore, it is expected that mutual funds managers will achieve to desirable return in the least risk and the shortest time by recognizing this application.

References

[1] Markwotiz, H. (1952). Portfolio selection. *Journal of finance, 7*, 77-91.

[2] Khanjarpanah, H., Pishvaee, M. S., & Jabbarzadeh, A. (2017). Optimizing a flexible constrained portfolio in stock exchange with fuzzy programming. *Journal of operational research and its applications (journal of applied mathematics), 13*(4), 39-54.

[3] Shams Lahroudi, S. H., Ahmadi, H., & Fekrvand Lilabadi, M. (1397). Provide a ranking model of effective factors in selecting the optimal portfolio by investors with integrated fuzzy MCDM techniques. *New research approaches in management and accounting, 8*(2), 87-100.

[4] Zadeh, L. A. (1965). Information and control. *Fuzzy sets, 8*(3), 338-353.

[5] Fallahpour, S., Safari, H., & Omrani, N. (2014). Portfolio selection using combination of logarithmic fuzzy preference programming method and PROMETHE. *Journal of financial management strategy, 2*(2), 103-120.

[6] Jafaria, M., & Dezfouli Khajehzadeh, M. (2015). Robust fuzzy multi objective optimization model for portfolio selection. *Journal of decision engineering, 1*(1), 31-56. DOI: 10.22051/JFM.2015.985

[7] Didehkhani, H. (2019). Solving the multiobjective portfolio rebalancing model with fuzzy parameters to develop the expected value by genetic algorithm. *Financial engineering and securities management (portfolio management), 9*(37), 263-298.

[8] Ghehi, A. S., Didehkhani, H., Damghani, K. K., & Saeedi, P. (2017). A comparative study of multi-objective multi-period portfolio optimization models in a fuzzy credibility environment using different risk measures. *Journal of financial management strategy, 5*(18).

[9] Behnamian, J., & Moshrefi, M. (2017). Hybrid meta-heuristic algorithm for multi-objective portfolio optimization by fuzzy programming. *Financial engineering and securities management (portfolio management), 8*(30), 33-53.

[10] Nabizade, A., & Behzadi, A. (2018). Higher moments portfolio optimization with entropy based polynomial goal programming. *Financial research journal*, *20*(2), 193-210.

[11] Nabavi Chashmi, A., Yousefi Kerchangi, R. (2011). Determination of optimal portfolio using fuzzy goal programming technique. *Financial engineering and securities management, 2*(9), 107-134.

E-ISSN: 2717-3453 | P-ISSN: 2783-1442

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 112–121.

Paper Type: Research Paper

A New Decision Making Approach for Winning Strategy Based on Muti Soft Set Logic

Renukadevi Vellapandi [1,*], Sangeetha Gunasekaran[2]

[1] Department of Mathematics, Central University of Tamil Nadu Thiruvarur, India; renu_siva2003@yahoo.com.
[2] Department of Mathematics, Sri Kaliswari College, Sivakasi, India; geethaphd1990@gmail.com.

Citation:

Vellapandi, R., & Gunasekaran, S. (2020). A new decision making approach for winning strategy based on muti soft set logic. *Journal of fuzzy extension and application, 1* (2), 112-121.

Received: 03/02/2020 Reviewed: 30/02/2020 Revised: 28/03/2020 Accept: 29/05/2020

Abstract

We introduce a new concept of certainty and coverage of a parameter of the soft set and present a new decision making approach for the soft set over the universe using the certainty of a parameter. Also, we point out the drawbacks of the reduct definition by pointing out the delusion of Proposition 14 given by Herawan et al. [20] and provide the revised definition of the reduct of the multi soft set.

Keywords: Certainty, Coverage, Flow graph, Decision Making, Multi-Valued information system, Multi soft set.

1 | Introduction

Licensee Journal of Fuzzy Extension and Applications. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0).

Many practical problems involve data that contain uncertainties. These uncertainties may be dealt with existing theories such as fuzzy set theory [1] and rough set theory [2]. In 1999, Molodstov [3] pointed out the difficulties of these theories and he posited the concept of soft set theory. Maji et al. [4] made a theoretical study of soft set in 2003. Soft set theory has rich potential for applications. In [5], Maji et al. presented an application of soft sets in decision making problems and extend the concept into fuzzy soft sets in [6]. In the year 2010, Cagman et al. gave the $uni-int$ decision making algorithm using soft sets [7] and soft matrices [8]. Feng et al. [9] extended Cagman and Enginoglu's $uni-int$ decision making algorithm. They introduced several new soft decision making methods including $uni-int^k$, $uni-int_s^t$ and int^m-int^n decision making methods. Also, Han et al. [10] initiated the pruning method for solving int^m-int^n decision making method. Feng et al. [11] introduced the concept of discernibility matrix in 2014 and using this, they provided a decision making algorithm for soft sets. Also, in the same year, Dauda et al. [12] presented a decision making algorithm of soft sets using AND and OR operations. In 2020, Wang et al. [13] introduced a novel plausible reasoning based on intuitionistic fuzzy propositional logic and Meng et al. [14] proposed an inequality approach with the quasi-ordered set to evaluate the performances of decision making units. Recently many authors studied the concepts of decision making in terms of fuzzy set and intuitionistic fuzzy sets [15]-[18].

Corresponding Author: renu_siva2003@yahoo.com
http://dx.doi.org/10.22105/jfea.2020.249373.1013

In this paper, we define a new definition of certainty of a parameter of the soft set and with the help of this definition, we present a new decision making approach for the soft set over the universe which is a partition of objects. The standard soft set deals with a binary-valued information system. For a multi-valued information system, Herawan et al. [19] introduced a concept of multi soft sets in 2009. Also, they [20] introduced the reduct concept in multi soft sets using the value class of the multi soft matrix. In this paper, we point out the delusion of proposition 14 of [20] and provide the revised definition of the reduct of the multi soft set.

Definition 1. [20]. The idea of multi soft sets is based on a decomposition of a multi-valued information system $S=(U,A,V,f)$ into $|A|$ number of binary valued information systems $S=(U,A,V_{\{0,1\}},f)$ where $|A|$ denotes the cardinality of A. Consequently, the $|A|$ binary valued information systems, define multi soft sets $(F,A_m)=\{(F,a_i)\,/\,1\le i\le|A|\}$.

Definition 2. [20]. Matrix $M_{a_i}, 1\le i\le|A|$ is called matrix representation of the soft set (F,a_i) over universe U. The dimension of matrices is defined by dim $(M_{a_i})=|U|\times|V_{a_i}|$. All entries of $M_{a_i}=[a_{ij}]$ is belong to a set $\{0,1\}$ where $a_{ij}=\begin{cases}0 & if\ f(u,\alpha)\models 0\\ 1 & if\ f(u,\alpha)\models 1\end{cases}$ where $1\le i\le|U|, 1\le j\le|V_{a_i}|, u\in U$ and $\alpha\in V_{a_i}$.

The collection of all matrices representing (F,A_m) is denoted by M_A. That is, $M_A=\{M_{a_i}\mid 1\le i\le|A|\}$.

Definition 3. [20]. Let $M_{a_i}\in M_A$ be a matrix representation of a multi soft set (F,A_m) over U. The value class of M_{a_i}, that is, class of all value sets of M_{a_i}, denoted $C_{M_{a_i}}$ is defined by

$C_{M_{a_i}}=\{\{u\,/\!/\,f(u,\alpha_1)\models 1\},\ldots,\{u\,/\!/\,f(u,\alpha_{|V_{a_i}|})\models 1\}\}, 1\le i\le|V_{a_i}|, u\in U$ and $\alpha\in V_{a_i}$. Clearly, $C_{M_{a_i}}\subseteq\wp(U)$.

Definition 4. [20]. Let $M_{a_i}=[a_{kl}], 1\le k\le|U|, 1\le 1\le|V_{a_i}|$ and $M_{a_j}=[a_{mn}], 1\le m\le|U|, 1\le n\le|V_{a_j}|$ be two matrices in M_A. The AND operation between M_{a_i} and M_{a_j} is defined as M_{a_i} AND $M_{a_j}=M_{a_{ij}}=[a_{pq}]$ with $\dim(M_{a_{ij}})=|U|\times(|V_{a_i}|\times|V_{a_j}|)$ where

$a_{p1}=\min\{a_{k1},a_{m1}\}, a_{p2}=\min\{a_{k1},a_{m2}\},\ldots,a_{p(|V_{a_i}|\times|V_{a_j}|)}=\min\{a_{k|V_{a_i}|},a_{m|V_{a_j}|}\}$.

Proposition 1. Let M_A be a multi soft matrix over U representing multi soft set (F,A_m). A set of attributes B of A is a reduct for A if only if $C_{\underset{b\in B}{AND}M_b}=C_{\underset{a\in A}{AND}M_a}$.

2| Soft Sets

In this section, we define a new definition for soft set over the universe.

Definition 5. Let (F,E) be a soft set over U. Suppose U is partitioned into t classes, namely, $U_1,U_2,\ldots,U_t$. If $U_1=\{u_1,u_2,\ldots,u_i\}, U_2=\{u_{i+1},u_{i+2},\ldots,u_j\},\ldots,U_t=\{u_{k+1},u_{k+2},\ldots,u_n\}$, then the soft set tabular representation of (F,E) as follows.

Table 1. Tabular representation of soft set.

U	e_1	e_2	...	e_m
u_1	$f(u_1,e_1)$	$f(u_1,e_2)$	...	$f(u_1,e_m)$
u_2	$f(u_2,e_1)$	$f(u_2,e_2)$	...	$f(u_2,e_m)$
...	...	...	...	...
u_i	$f(u_i,e_1)$	$f(u_i,e_2)$	...	$f(u_i,e_m)$
u_{i+1}	$f(u_{i+1},e_1)$	$f(u_{i+1},e_2)$	...	$f(u_{i+1},e_m)$
u_{i+2}	$f(u_{i+2},e_1)$	$f(u_{i+2},e_2)$	...	$f(u_{i+2},e_m)$
...	...	...	...	...
u_j	$f(u_j,e_1)$	$f(u_j,e_2)$	...	$f(u_j,e_m)$
...	...	...	...	...
u_{k+1}	$f(u_{k+1},e_1)$	$f(u_{k+1},e_2)$	...	$f(u_{k+1},e_m)$
u_{k+2}	$f(u_{k+2},e_1)$	$f(u_{k+2},e_2)$	...	$f(u_{k+2},e_m)$
...	...	...	...	...
u_n	$f(u_n,e_1)$	$f(u_n,e_2)$	...	$f(u_n,e_m)$

where $f(u_i,e_j)=1$ if $u_i \in F(e_j)$ and $f(u_i,e_j)=0$ otherwise.

Definition 6. Let (F,E) be a soft set over U with the partitions $U_1,U_2,\ldots,U_t$. Then we define the following.

The support of $e \in E$ is defined as $supp(e)=\sum_{U_i \in U} supp_{U_i}(e)$ where $supp_{U_i}(e)=|\{u_j \in U_i \mid f(u_j,e)=1\}|$ and $supp(A_1,A_2)$ is the number of occurrences of A_2 with respect to the parameter A_1.

The coverage of $A_1 \Rightarrow A_2$ is defined by $cov(A_1,A_2)=\dfrac{supp(A_1,A_2)}{|U|}$.

The certainty of $A_1 \Rightarrow A_2$ is defined by $cer(A_1,A_2)=\sum_{U_i \in U} cer(U_i,A_1,A_2)$ where $cer(U_i,A_1,A_2)=\dfrac{supp_{U_i}(A_1,A_2)}{|U_i|}$.

Example 1. Consider the soft set (F,E) over the universe $U=\{U_1,U_2,U_3\}$ where $E=\{e_1,e_2,e_3,e_4,e_5\}, U_1=\{u_1,u_2,u_3\}, U_2=\{v_1,v_2,v_3,v_4\}$ and $U_3=\{w_1,w_2,w_3\}$ whose tabular representation is given below.

Table 2. Tabular representation of (F, E).

U	e_1	e_2	e_3	e_4	e_5
u_1	1	0	1	0	0
u_2	0	1	1	0	1
u_3	0	0	1	1	0
v_1	1	0	1	0	1
v_2	0	1	0	1	1
v_3	1	0	0	0	0
v_4	0	1	1	1	0
w_1	1	0	1	0	1
w_2	0	0	1	1	1
w_3	1	0	0	0	1

Then $cer(U_1,e_1,1)=\frac{1}{3}$ = 0.333, $cer(U_1,e_1,0)=\frac{2}{3}$ = 0.667, $cer(U_2,e_1,1)=\frac{2}{4}$ = 0.5, $cer(U_2,e_1,0)=\frac{2}{4}$ = 0.5, $cer(U_3,e_1,1)=\frac{2}{3}$ = 0.667, $cer(U_3,e_1,0)=\frac{1}{3}$ = 0.333. Hence $cer(e_1,1)$ = 1.5 and $cer(e_1,0)$ = 1.5. And $cer(U_1,e_2,1)=\frac{1}{3}$ = 0.333, $cer(U_1,e_2,0)=\frac{2}{3}$ = 0.667, $cer(U_2,e_2,1)=\frac{2}{4}$ = 0.5, $cer(U_2,e_2,0)=\frac{2}{4}$ = 0.5, $cer(U_3,e_2,1)=\frac{0}{3}$ = 0, $cer(U_3,e_2,0)=\frac{3}{3}$ = 1. Thus, we have $cer(e_2,1)$ = 0.833 and $cer(e_2,0)$ = 2.167. Also, $cer(U_1,e_3,1)=\frac{3}{3}$ = 1, $cer(U_1,e_3,0)=\frac{0}{3}$ = 0, $cer(U_2,e_3,1)=\frac{2}{4}$ = 0.5, $cer(U_2,e_3,0)=\frac{2}{4}$ = 0.5, $cer(U_3,e_3,1)=\frac{2}{3}$ = 0.667, $cer(U_3,e_3,0)=\frac{1}{3}$ = 0.333. Therefore, $cer(e_3,1)$ = 2.167 and $cer(e_3,0)$ = 0.833. Now, $cer(U_1,e_4,1)=\frac{1}{3}$ = 0.333, $cer(U_1,e_4,0)=\frac{2}{3}$ = 0.667, $cer(U_2,e_4,1)=\frac{2}{4}$ = 0.5, $cer(U_2,e_4,0)=\frac{2}{4}$ = 0.5, $cer(U_3,e_4,1)=\frac{1}{3}$ = 0.333, $cer(U_3,e_4,0)=\frac{2}{3}$ = 0.667. Hence $cer(e_4,1)$ = 1.166 and $cer(e_4,0)$ = 1.834. And $cer(U_1,e_5,1)=\frac{1}{3}$ = 0.333, $cer(U_1,e_5,0)=\frac{2}{3}$ = 0.667, $cer(U_2,e_5,1)=\frac{2}{4}$ = 0.5, $cer(U_2,e_5,0)=\frac{2}{4}$ = 0.5, $cer(U_3,e_5,1)=\frac{3}{3}$ = 1, $cer(U_3,e_5,0)=\frac{0}{3}$ = 0. Thus, $cer(e_5,1)$ = 1.833 and $cer(e_5,0)$ = 1.167.

Also, $cov(e_1,1)=\frac{5}{10}$ = 0.5 and $cov(e_1,0)=\frac{5}{10}$ = 0.5, $cov(e_2,1)=\frac{3}{10}$ = 0.3 and $cov(e_2,0)=\frac{7}{10}$ = 0.7, $cov(e_3,1)=\frac{7}{10}$ = 0.7 and $cov(e_3,0)=\frac{3}{10}$ = 0.3, $cov(e_4,1)=\frac{4}{10}$ = 0.4 and $cov(e_4,0)=\frac{6}{10}$ = 0.6, $cov(e_5,1)=\frac{6}{10}$ = 0.6 and $cov(e_5,0)=\frac{4}{10}$ = 0.4. Then the flow graph associated with certainty and coverage is given in the following *Fig. 1*.

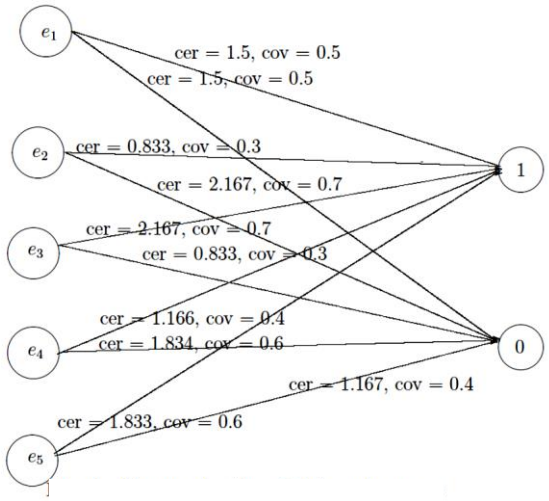


Fig. 1. Flow graph with certainty and coverage.

From the *Fig. 1*, the approximate graph for the flow graph is given as follows.

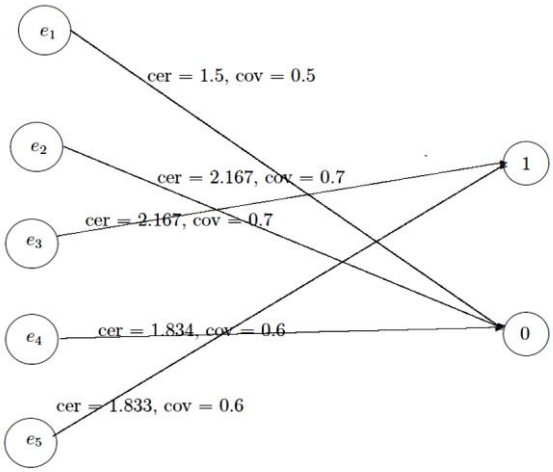


Fig. 2. Approximate graph.

3| Experimental Results

In this section, we illustrate the proposed approach through an example of a data set. Let (F,E) be a soft set over the universe $U=\{U_1,U_2,U_3,U_4\}$ and $E=\{e_1,e_2,e_3,e_4,e_5\}$ where e_1 stands for the Party 'A', e_2 stands for the Party 'B', e_3 stands for the Party 'C', e_4 stands for the Party 'D', e_5 stands for the Party 'E' and $U_1=\{u_1,u_2,u_3,u_4,u_5,u_6,u_7\}$ is the set of people who are politicians, $U_2=\{v_1,v_2,v_3,v_4,v_5,v_6,v_7,v_8,v_9,v_{10}\}$ is the set of formers, $U_3=\{w_1,w_2,w_3,w_4\}$ is the set of government employees and $U_4=\{x_1,x_2,x_3,x_4,x_5,x_6,x_7,x_8\}$ is the set of students.

Table 3. Tabular representation for the given soft set (F, E).

U	e_1	e_2	e_3	e_4	e_5
u_1	0	1	1	0	0
u_2	1	1	0	0	0
u_3	0	1	0	1	0
u_4	1	0	1	1	0
u_5	0	1	0	1	1
u_6	1	1	1	0	0
u_7	0	1	0	1	0
v_1	1	0	1	1	0
v_2	0	1	1	0	0
v_3	1	0	1	0	1
v_4	1	1	0	1	0
v_5	0	0	1	0	1
v_6	1	0	1	1	1
v_7	1	1	0	0	0
v_8	0	1	0	1	0
v_9	1	0	0	1	0
v_{10}	0	0	1	0	0
w_1	0	1	1	0	0
w_2	1	0	1	0	0
w_3	1	1	1	0	0
w_4	0	1	0	1	0
x_1	1	0	0	1	0
x_2	1	1	0	1	0
x_3	1	0	1	0	0
x_4	1	0	0	1	0
x_5	1	1	0	0	0
x_6	1	1	1	0	0
x_7	1	0	1	1	0
x_8	1	1	1	1	0

Then the certainty and coverage of each party is given in the following *Table 4*.

Table 4. Certainty and coverage of parties.

E	Certainty	Coverage
$(e_1,1)$	2.52857	0.65518
$(e_1,0)$	1.47143	0.34483
$(e_2,1)$	2.50714	0.58621
$(e_2,0)$	1.49286	0.41379
$(e_3,1)$	2.27857	0.55173
$(e_3,0)$	1.72143	0.44827
$(e_4,1)$	1.94643	0.51723
$(e_4,0)$	2.05357	0.48276
$(e_5,1)$	0.44286	0.13793
$(e_5,0)$	3.55714	0.86207

From *Fig. 3*, branches of the flow graph represent the parties together with their certainty and coverage factors. For instance, the $(e_1,1)$ has the certainty factor 2.52857 and coverage factor 0.65518.

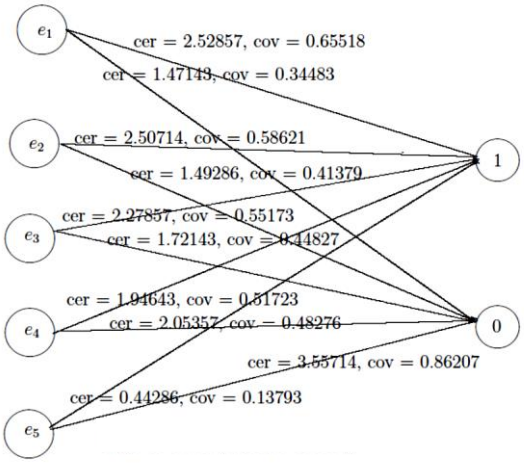


Fig. 3. Flow graph for Table 4.

The flow graph gives a clear insight into the winning strategy of all parties. We can replace flow graph shown in Figure by "approximate" flow graph shown in *Fig. 4*. From the *Fig. 4*, we can conclude that the Parties A, B and C are the winning parameters whose the coverage of 0.65518, 0.58621 and 0.55173, respectively.

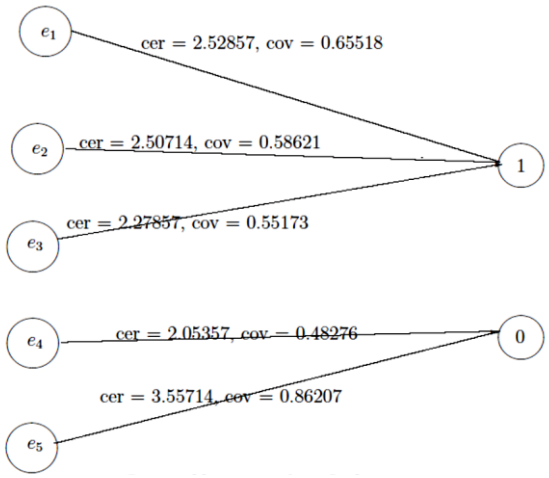


Fig. 4. Approximate flow graph.

4| Erratum

In [10], the authors defined the reduct of a multi soft set and gave a characterization for reduct of a multi soft set. The following Example shows that reduct of a multi soft set under the *Proposition 1* need not be unique.

Example 2. Consider the multi-valued information system given in *Example 15* of [10]. Then the matrices representing the multi soft set (F, A_m) is $M_A = \{M_{a_1}, M_{a_2}, M_{a_3}, M_{a_4}\}$ where

$$M_{a_1} = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ 1 & 0 \end{bmatrix}, M_{a_2} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ 0 & 1 \\ 0 & 1 \end{bmatrix}, M_{a_3} = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 1 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}, M_{a_4} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}.$$

Here M_{a_3} AND $M_{a_4} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix}$ and $C_{\underset{1 \le j \le 4}{AND\, M_{a_j}}} = \{\{1\}, \{2\}, \{3, 4\}, \{5\}\}.$

Now, M_{a_2} AND $(M_{a_3}$ AND $M_{a_4}) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ 0 & 1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{bmatrix}.$

Therefore, $C_{M_{a_2} AND M_{a_3} AND M_{a_4}} = \{\{1\}, \{2\}, \{3, 4\}, \{5\}\}.$

Also, M_{a_1} AND $(M_{a_3}$ AND $M_{a_4}) = \begin{bmatrix} 1 & 0 \\ 1 & 0 \\ 0 & 1 \\ 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \end{bmatrix}$.

Therefore, $C_{M_{a_1} AND M_{a_3} AND M_{a_4}} = \{\{1\},\{2\},\{3,4\},\{5\}\}$. Hence $\{a_1, a_3, a_4\}, \{a_2, a_3, a_4\}$ are reductions of (F, A_m). Also, in [10], the authors determined the reductions of (F, A_m) and gave the reductions as $\{a_1, a_2, a_3\}$ and $\{a_3, a_4\}$. That is, the reductions are not unique.

Based on the *Example 2*, we have the following Lemma.

Lemma 1. Suppose E_1 and E_2 are two members of the value class of $\underset{1 \le i \le n}{AND} M_{a_i}$. Then for any $e_1 \in E_1, e_2 \in E_2, \{e_1, e_2\}$ will not be a subset of any value class of $\underset{1 \le i \le n+1}{AND} M_{a_i}$.

Proof. Suppose $e_1 \in E_1$ and $e_2 \in E_2$. Since $E_1 \neq E_2, e_{1i} = 1$ and $e_{2j} = 1$ for some i and j. Suppose $\{e_1, e_2\} \subseteq F$ where F is a value class of $\underset{1 \le i \le n+1}{AND} M_{a_i}$. Then $e_{1k} = e_{2k} = 1$ for some k. By the definition of "AND" product, $e_{1l} = e_{2l} = 1$ in the matrix $\underset{1 \le i \le n}{AND} M_{a_i}$. That is, e_1 and e_2 belong to the same value class of $\underset{1 \le i \le n}{AND} M_{a_i}$ which is a contradiction.

The following Theorem shows that superset of a reduct set is again a reduct set.

Theorem 1. If B is a reduction of the multi soft set (F, A_m), then $B \cup C$ is also a reduction of (F, A_m) where $C \subseteq A - B$.

Proof. Suppose B is a reduction of (F, A_m). Then $C_{\underset{a_i \in B}{AND} M_{a_i}} = C_{\underset{a_i \in A}{AND} M_{a_i}}$. That is, the number of value classes of $\underset{a_i \in B}{AND} M_{a_i}$ and the number of value classes of $\underset{a_i \in A}{AND} M_{a_i}$ are equal. Also, by the definition of "AND" product, the number of value classes of $\underset{1 \le i \le n}{AND} M_{a_i}$ is less than or equal to the number of value classes of $\underset{1 \le i \le n+1}{AND} M_{a_i}$. Therefore, by *Lemma 1*, for any $C \subseteq A - B$, the value classes of $\underset{a_i \in B}{AND} M_{a_i}$ and the value classes of $\underset{a_i \in B \cup C}{AND} M_{a_i}$ are equal. Hence $C_{\underset{a_i \in B}{AND} M_{a_i}} = C_{\underset{a_i \in B \cup C}{AND} M_{a_i}}$.

By the above Theorem, whenever B is a reduction of the multi soft set (F, A_m), $B \cup C$ is also a reduction of (F, A_m). In *Example 15* of [10], the authors gave reduction of the multi soft set as $\{a_1, a_3, a_4\}, \{a_2, a_3, a_4\}, \{a_1, a_2, a_3\}$ and $\{a_3, a_4\}$. But by *Theorem 1*, any set containing a reduction set is a reduct set and hence the whole set A is a reduct set. Thus, we remove the redundancy, we modify the reduct definition for multi soft set as follows.

Definition 6. Let M_A be a multi soft set over U representing multi soft set (F, A_m). A set of attributes B of A is a reduct for A if B is a minimal subset of A such that $C_{\underset{b \in B}{AND} M_b} = C_{\underset{a \in A}{AND} M_a}$.

Example 3. Consider the multi soft set as in *Example 4.1*. Here $\{a_1, a_2, a_3\}$ and $\{a_3, a_4\}$ are reductions of (F, A_m) but $\{a_1, a_3, a_4\}$ and $\{a_2, a_3, a_4\}$ are not reductions of (F, A_m).

5 | Conclusion

In this paper, we have presented a new decision making approach for the soft set over the universe with partition of objects using the certainty and coverage of a parameter. Also, we have pointed out the misconception of the reduct definition given by Herawan et al. [20].

References

[1] Zadeh, L. A. (1965). Fuzzy set. *Information and control, 8*, 338 - 353.

[2] Pawlak, Z. (1982). Rough sets. *Int. J. Comput. Inform. Sci., 11*, 341 - 356.

[3] Molodtsov, D. (1999). Soft set theory - First results. *Comput. Math. Appl., 37*, 19 - 31.

[4] Maji, P. K., Biswas, R. & Roy, A. R. (2003). Soft set theory. *Comput. Math. Appl., 45*, 555 - 562.

[5] Maji, P. K. & Roy, A. R. (2002). An application of soft sets in a decision making problem. *Comput. Math. Appl., 44*, 1077 - 1083.

[6] Maji, P. K. & Roy, A. R. (2007). A fuzzy soft set theoretic approach to decision making problems. *J. Comput. Appl. Math., 203*, 412 - 418.

[7] Cagman, N. & Enginoglu, S. (2010). Soft set theory and uni-int decision making. *Eur. J. Oper. Res., 207*, 848 - 855.

[8] Cagman, N. & Enginoglu, S. (2010). Soft matrix theory and its decision making. *Comp. Math.Appl., 59*, 3308 - 3314.

[9] Feng, F., Li. Y. & Cagman, N. (2012). Generalized uni-int decision making schemes based on choice value soft sets. *Eur. J. Oper. Res., 220*, 162 - 170.

[10] Han, B. & Geng, S. (2013). Pruning method for optimal solutions of $\text{int}^m - \text{int}^n$ decision making scheme. *Eur. J. Oper. Res., 231*, 779 - 783.

[11] Feng, Q. & Zhou, Y. (2014). Soft discernibility matrix and its applications in decision making. *Appl. Soft Comp., 24*, 749 - 756.

[12] Dauda, M. K., Mamat, M. & Waziri, M. Y. (2015). An application of soft set in decision making. *Jurnal Teknologi (sciences and engineering), 77*(13), 119 -122.

[13] Wang, X., Xu, Z. & Gou, X. (2020). A novel plausible reasoning based on intuitionistic fuzzy propositional logic and its application in decision making. *Fuzzy Optim Decis making, 19*, 251–274. https://doi.org/10.1007/s10700-020-09319-8

[14] Meng, X., Gong, L. & Yao, J. (2020). A fuzzy evaluation approach with the quasi-ordered set: evaluating the efficiency of decision making units. *Fuzzy Optim Decis making, 19*, 297–310. https://doi.org/10.1007/s10700-020-09321-0

[15] Baraka, S., & Dahooei, J. H. (2018). A novel hybrid fuzzy DEA-Fuzzy MADM method for airlines safety evaluation. *Journal of air transport management*, *73*, 134–149.

[16] Mehlawat, M. K., Kumar, A., Yadav, S., & Chen, W. (2018). Data envelopment analysis based fuzzy multi-objective portfolio selection model involving higher moments. *Information sciences*, *460*, 128–150.

[17] Meng, X. L., Shi, F. G., & Yao, J. C. (2018). An inequality approach for evaluating decision making units with a fuzzy output. *Journal of intelligent and fuzzy systems*, *34*, 459–465.

[18] Meng, X. L., Gong, L. T., & Yao, J. C. (2019). A fuzzy inequality evaluation approach for measuring the relative efficiency. *Journal of intelligent and fuzzy systems*, *37*, 6589–6600.

[19] Herawan, T., & Deris, M. M. (2009, September). On multi-soft sets construction in information systems. *International conference on intelligent computing* (pp. 101-110). Springer, Berlin, Heidelberg.

[20] Herawan, T., Deris, M. M., & Abawajy, J. H. (2010, March). Matrices representation of multi soft-sets and its application. *International conference on computational science and its applications* (pp. 201-214). Springer, Berlin, Heidelberg.

E-ISSN: 2717-3453 | P-ISSN: 2783-1442

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 122–132.

Paper Type: Research Paper

Medical Diagnostic Analysis on Some Selected Patients Based on Modified Thao et al.'s Correlation Coefficient of Intuitionistic Fuzzy Sets via an Algorithmic Approach

Paul Augustine Ejegwa[1,*], Idoko Charles Onyeke[2]

[1] Department of Mathematics, Statistics and Computer Science, University of Agriculture, P.M.B. 2327, Makurdi-Nigeria; ocholohi@gmail.com.

[2] Department of Computer Science, University of Agriculture, P.M.B. 2373, Makurdi, Nigeria; onyeke.idoko@uam.edu.ng.

Citation:

Ejegwa, P. A., Onyeke, I. C. (2020). Medical diagnostic analysis on some selected patients based on modified Thao et al.'s correlation coefficient of intuitionistic fuzzy sets via an algorithmic approach. *Journal of fuzzy extension and application, 1* (2), 122-132.

Received: 06/01/2020 Reviewed: 07/03/2020 Revised: 15/05/2020 Accept: 02/06/2020

Abstract

The concept of correlation coefficient of intuitionistic fuzzy sets is a reliable tool in information theory with numerous applications in diverse areas. Correlation coefficients of intuitionistic fuzzy sets have been studied through two-way approach by many researchers. This approach inappropriately discarded the hesitation margins of the concerned intuitionistic fuzzy sets, which makes the results of such experiments unreliable. In this paper, we modified the correlation coefficient of intuitionistic fuzzy sets of Thao et al. [36] in a three-way approach by including the hesitation margins in the computational process to enhance reliable output through an algorithmic method. We show that the modified correlation coefficient of intuitionistic fuzzy sets is more reasonable with precise outputs than correlation coefficient method. In terms of application, we demonstrate an analysis of medical diagnosis on some selected patients via an algorithm of the novel approach coded with JAVA programming language.

Keywords: Algorithmic approach, Correlation coefficient, Fuzzy set, Intuitionistic fuzzy set, Medical diagnostic analysis.

1 | Introduction

Licensee Journal of Fuzzy Extension and Applications. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0).

Uncertainties are huge barrier to reckon with in decision-making processes because many real-life problems are enmeshed with indecisions. The invention of fuzzy sets technology by Zadeh [1] brought an amazing sight of relief to decision-makers, because of the ability of fuzzy model to curb the embedded uncertainties in decision-making. Some decision-making problems could not be properly resolved with fuzzy approach because fuzzy set only considered membership grade whereas, many real-life problems have the component of both membership grade and non-membership grade with the possibility of hesitation. However, with the invention of Intuitionistic Fuzzy Sets (IFSs) [2, 3], such cases can best be addressed. IFS consists of membership grade λ, non-membership grade υ and hesitation margin ϑ whereby their sum is one and $\lambda + \upsilon$ is less than or equal to one. IFS is a special case of fuzzy set with additional conditions and thus has more facility to curb uncertainties more appropriate with higher degree of precision. The concept of IFSs has found massive

Corresponding Author: ocholohi@gmail.com

http://dx.doi.org/10.22105/jfea.2020.250108.1014

applications via measuring tools in myriad areas, namely; medical diagnosis as reported in [3]-[10], pattern recognition as found in [11]-[13], career determination [14]-[16], and group decision-making [17] to mention but a few.

Correlation coefficient proposed by Karl Pearson in 1895 is a vital tool for measuring similarity, interdependency and interrelationship between two variable or data. Statisticians found solace in the instrumentality of correlation analysis because of its vast application potentials. Also, some allied professions like engineering, sciences, among others have applied correlation analysis to resolve their peculiar problems. With the advent of fuzzy sets, some researchers have extended correlation analysis to fuzzy environment to handle fuzzy data [18]-[20]. In the same vein, correlation coefficient has been encapsulated in intuitionistic fuzzy domain and used to solve several Multi-Criteria Decision-Making (MCDM) issues [21]-[26].

The pioneer work on correlation coefficient between IFSs was carried out by Gerstenkorn and Manko [27] by using correlation and informational energies. Hung [28] used statistical approach to study correlation coefficient of IFSs by capturing only the membership and non-membership grades of IFSs. Correlation coefficient of IFSs was proposed based on centroid method in [29]. Park et al. [30] and Szmidt and Kacprzyk [31] improved the approach in [28] by including the hesitation margin of IFS. Liu et al. [32] introduced a new approach of computing correlation coefficient of IFSs with application. Garg and Kumar [33] proposed a novel method of correlation coefficient of IFSs based on set pair analysis and applied the method to solve some MCDM problems. The concept of correlation coefficient and its applications have been stretched to complex intuitionistic fuzzy and intuitionistic multiplicative environments [34], [35]. TOPSIS method based on correlation coefficient was proposed in [36] to solve decision-making problems with intuitionistic fuzzy soft set information. Thao et al. [36] proposed a new method of calculating correlation coefficient of IFSs using mean, variance and covariance with applications. The limitation of this approach is the omission of hesitation margin without minding its influence in the computational output. Also, this approach does not considered time factor in the computation since it was carried out manually with high possibility of errors. Although we cannot doubt the significant of similarity and distance measures as soft computing tools, but the penchant for correlation coefficient measure in information measure theory is because correlation coefficient measure considers both similarity (which is the dual of distance) and interrelationship indexes of IFSs.

The limitations of correlation coefficient measure of Thao et al. [36] motivated us to propose a new technique of estimating correlation coefficient between IFSs by incorporating hesitation margin to the approach in [36], to enhance accuracy and limiting information leakages. The new approach is studied from an algorithmic perspective to enable it to be coded with JAVA programming language and thus, reducing time of computation. The objectives of the work are to: Reiterate the correlation coefficient method in [36] to enable the introduction of a new correlation coefficient method with accuracy and reliability; mathematically justify the new method in corroborating to the axiomatic conditions for correlation coefficient methods, and shows its advantages over the correlation coefficient method in [36]; establish the application of the modified method in medical diagnostic analysis on some selected patients via an algorithmic approach coded with JAVA programming language. The rest of the article is delineated as follow; Section 2 discusses the fundamentals of IFSs and the correlation coefficient of IFSs according to Thao et al. [36]. Section 3 presents the modification of method of measuring correlation coefficient of Thao et al. [36] with some theoretical results and numerical verification. Section 4 demonstrates the application of the modified approach in medical diagnostic analysis on some selected patients via an algorithmic approach coded with JAVA programming language. Section 5 concludes the article with some possible research extensions.

2| Preliminaries

In this section, we present some basic concepts of IFSs and Thao et al.'s correlation coefficient measure of IFSs.

2.1| Concepts of Intuitionistic Fuzzy Sets

Take $\beth$ to be an intuitionistic fuzzy space defined in a non-empty set X.

Definition 1. [2]. Suppose we have an IFS $P \subseteq \beth$. Then we define the construct P by

$$p = \{(\frac{\lambda_p(x), \upsilon_p(x)}{x} | x \in X\} \quad (1)$$

where the functions $\lambda_P(x)$, $\upsilon_P(x) : X \rightarrow [0,1]$ define grades of membership and non-membership of $x \in X$ in which

$$0 \leq \lambda_P(x) + \upsilon_P(x) \leq 1. \quad (2)$$

For any IFS P in X, $\vartheta_P(x) = 1 - \lambda_P(x) - \upsilon_P(x)$ is the IFS index or hesitation margin of P.

Definition 2. [38]. Assume $P, Q \subseteq \beth$, then

(i) $P = Q$ *iff* $\lambda P(x) = \lambda Q(x)$ *and* $\upsilon P(x) = \upsilon Q(x)$ $\forall x \in X$.

(ii) $P \subseteq Q$ *iff* $\lambda P(x) \leq \lambda Q(x)$ *and* $\upsilon P(x) \geq \upsilon Q(x)$ $\forall x \in X$.

(iii) $p = \{(\frac{\lambda_P(x), \upsilon_p(x)}{x} / x \in X\}$.

(iv) $P \cup Q = \{\langle \max(\frac{\lambda_P(x), \lambda_Q(x)}{x}), \min(\frac{\upsilon_P(x), \upsilon_Q(x)}{x}) \rangle | x \in X\}$

(v) $P \cap Q = \{\langle \min(\frac{\lambda_P(x), \lambda_Q(x)}{x}), \max(\frac{\upsilon_P(x), \upsilon_Q(x)}{x}) \rangle | x \in X\}$

Definition 3. [6]. Intuitionistic Fuzzy Values (IFVs) or Intuitionistic Fuzzy Pairs (IFPs) are characterized by the form $< x, y >$ such that $x + y \leq 1$ where $x, y \in [0,1]$. IFVs evaluate the IFS for which the components (x and y) are interpreted as grades of membership and non-membership.

2.2| Correlation Coefficient of Intuitionistic Fuzzy Sets

The concept of correlation coefficient measures the linear relationship between any two arbitrary IFSs. The correlation coefficient indicates positive sign when two intuitionistic fuzzy data sets are directly related, and a negative sign when two intuitionistic fuzzy data sets are inversely related. But whenever the correlation coefficient is zero, it indicates there is no linear relationship, neither positive nor negative. We recall the axiomatic definition of correlation measure of IFSs.

Definition 4. [27]. Suppose $P, Q \subseteq \beth$ and $X = \{x_1, ..., x_n\}$ for $n \in]1, \infty[$. Then the correlation coefficient of P and Q denoted by $\sigma(P,Q)$ satisfies:

(i) $\sigma(P,Q) = \sigma(Q,P)$.

(ii) $\sigma(P,Q) = 1$ *implies* $P = Q$.

(iii) $-1 \leq \sigma(P,Q) \leq 1$.

2.2.1| Thao et al.'s correlation coefficient of intuitionistic fuzzy sets

Definition 5. [37]. The correlation coefficient $\sigma(P,Q)$ is given by

$$\sigma(P,Q)=\frac{\phi(P,Q)}{\sqrt{\psi(P)\psi(Q)}} \tag{3}$$

where $\psi(P)$, $\psi(Q)$ are the variances of P and Q defined by

$$\left.\begin{aligned}\psi(P)&=\frac{1}{n-1}\Sigma_{i=1}^{n}((\lambda_P(x_i)-\overline{\lambda_P})^2+(\upsilon_P(x_i)-\overline{\upsilon_P})^2)\\ \psi(Q)&=\frac{1}{n-1}\Sigma_{i=1}^{n}((\lambda_Q(x_i)-\overline{\lambda_Q})^2+(\upsilon_Q(x_i)-\overline{\upsilon_Q})^2)\end{aligned}\right\} \tag{4}$$

$\varphi(P,Q)$ is the covariance of (P,Q) defined by

$$\phi(P,Q)=\frac{1}{n-1}\Sigma_{i=1}^{n}((\lambda_P(x_i)-\overline{\lambda_P})(\lambda_Q(x_i)-\overline{\lambda_Q})+(\upsilon_P(x_i)-\overline{\upsilon_P})(\upsilon_Q(x_i)-\overline{\upsilon_Q})), \tag{5}$$

for the means

$$\left.\begin{aligned}\overline{\lambda_P},\overline{\lambda_Q}&=\frac{\Sigma_{i=1}^{n}\lambda_P(x_i)}{n},\ \frac{\Sigma_{i=1}^{n}\lambda_Q(x_i)}{n}\\ \overline{\upsilon_P},\overline{\upsilon_Q}&=\frac{\Sigma_{i=1}^{n}\upsilon_P(x_i)}{n},\ \frac{\Sigma_{i=1}^{n}\upsilon_Q(x_i)}{n}\end{aligned}\right\} \tag{6}$$

3| Modified Thao et al.'s Correlation Coefficient of Intuitionistic Fuzzy Sets

In Thao et al.'s correlation coefficient of IFSs, the effect of hesitation margins in the computational procedure is not considered which will of necessity leads to an inaccurate results because hesitation margin is one of the three fundamental parameters of IFS. To remedy this setback, we modified Thao et al.'s correlation coefficient of IFSs by incorporating hesitation margins in the computational procedure.

Definition 6. With the same hypothesis in *Definition 4*, the variances of P and Q are defined by

$$\left.\begin{aligned}\hat{\psi}(P)\frac{1}{n-1}\Sigma_{i=1}^{n}((\lambda_P(x_i)-\overline{\lambda_P})^2+(\upsilon_P(x_i)-\overline{\upsilon_P})^2+(\vartheta_P(x_i)-\overline{\vartheta_P})^2)\\ \hat{\psi}(Q)=\frac{1}{n-1}\Sigma_{i=1}^{n}((\lambda_Q(x_i)-\overline{\lambda_Q})^2+(\upsilon_Q(x_i)-\overline{\upsilon_Q})^2+(\vartheta_Q(x_i)-\overline{\vartheta_Q})^2)\end{aligned}\right\}, \tag{7}$$

and the covariance of (P,Q) is defined by

$$\hat{\phi}(P,Q)=\frac{1}{n-1}\Sigma_{i=1}^{n}\left(\alpha_1\alpha_2+\beta_1\beta_2+\gamma_1\gamma_2\right) \tag{8}$$

for

$$\lambda_P(x_i)-\overline{\lambda_P}=\alpha_1,\ \upsilon_P(x_i)-\overline{\upsilon_P}=\beta_1,\ \vartheta_P(x_i)-\overline{\vartheta_P}=\gamma_1$$
$$\lambda_Q(x_i)-\overline{\lambda_Q}=\alpha_2,\ \upsilon_Q(x_i)-\overline{\upsilon_Q}=\beta_2,\ \vartheta_Q(x_i)-\overline{\vartheta_Q}=\gamma_2$$

where the means of P and Q are defined by

$$\left.\begin{aligned}\overline{\lambda_P},\overline{\lambda_Q}&=\frac{\Sigma_{i=1}^{n}\lambda_P(x_i)}{n},\ \frac{\Sigma_{i=1}^{n}\lambda_Q(x_i)}{n}\\ \overline{\upsilon_P},\overline{\upsilon_Q}&=\frac{\Sigma_{i=1}^{n}\upsilon_P(x_i)}{n},\ \frac{\Sigma_{i=1}^{n}\upsilon_Q(x_i)}{n}\\ \overline{\vartheta_P},\overline{\vartheta Q}&=\frac{\Sigma_{i=1}^{n}\vartheta_P(x_i)}{n},\ \frac{\Sigma_{i=1}^{n}\vartheta_Q(x_i)}{n}\end{aligned}\right\} \tag{9}$$

Definition 7. The modified correlation coefficient $\hat{\sigma}(P,Q)$ is given by

$$\hat{\sigma}(P,Q) = \frac{\hat{\phi}(P,Q)}{\sqrt{\hat{\psi}(P)\hat{\psi}(Q)}} \tag{10}$$

where the components are defined in *Definition 6*.

Certainly, $\hat{\psi}(P) = \hat{\phi}(P,P)$ and $\hat{\psi}(Q) = \hat{\phi}(Q,Q)$. It worthy to note that *Eq. (10)* is more reliable than *Eq. (3)* because it considers grades of membership, non-membership and hesitation margin of the considered IFSs.

Theorem 1. The function $\hat{\sigma}(P,Q)$ is a correlation coefficient of IFSs P and Q contain in $-1 \leq \hat{\sigma}(P,Q) \leq 1$.

Proof. We show that $\hat{\sigma}(P,Q) = \hat{\sigma}(Q,P)$, $\hat{\sigma}(P,Q) = 1$ implies $P = Q$ and $-1 \leq \hat{\sigma}(P,Q) \leq 1$. But,

$\hat{\sigma}(P,Q) = \hat{\sigma}(Q,P)$ because

$$\begin{aligned}\hat{\sigma}(P,Q) &= \frac{\hat{\phi}(P,Q)}{\sqrt{\hat{\phi}(P,P)\hat{\phi}(Q,Q)}} = \frac{\hat{\phi}(Q,P)}{\sqrt{\hat{\phi}(Q,Q)\hat{\phi}(P,P)}} \\ &= \hat{\sigma}(Q,P).\end{aligned}$$

Suppose $\hat{\sigma}(P,Q) = 1$, then we have

$$\hat{\sigma}(P,Q) = \frac{\hat{\phi}(P,Q)}{\sqrt{\hat{\phi}(P,P)\hat{\phi}(Q,Q)}} = \frac{\hat{\phi}(P,P)}{\hat{\phi}(P,P)} = 1$$

Hence, $P = Q$.

Again, it is certain that $\hat{\sigma}(P,Q) \geq -1$ because $\hat{\phi}(P,P)$ and $\hat{\phi}(Q,Q)$ are non-negative and $\hat{\phi}(P,Q) \geq -1$. Now, we prove that $\hat{\sigma}(P,Q) \leq 1$ as follows:

$$\begin{aligned}\hat{\sigma}(P,Q) &= \frac{\phi(\hat{P},Q)}{\sqrt{\phi(\hat{P},P)\phi(\hat{Q},Q)}} \\ &= \frac{\frac{1}{n-1}\Sigma_{i=1}^{n}\left(\alpha_1\alpha_2 + \beta_1\beta_2 + \gamma_1\gamma_2\right)}{\sqrt{\frac{1}{n-1}\Sigma_{i=1}^{n}\left(\alpha_1^2 + \beta_1^2 + \gamma_1^2\right)\frac{1}{n-1}\Sigma_{i=1}^{n}\left(\alpha_2^2 + \beta_2^2 + \gamma_2^2\right)}} \\ &= \frac{\Sigma_{i=1}^{n}\left(\alpha_1\alpha_2 + \beta_1\beta_2 + \gamma_1\gamma_2\right)}{\sqrt{\Sigma_{i=1}^{n}\left(\alpha_1^2 + \beta_1^2 + \gamma_1^2\right)\Sigma_{i=1}^{n}\left(\alpha_2^2 + \beta_2^2 + \gamma_2^2\right)}} \\ &= \frac{\Sigma_{i=1}^{n}\alpha_1\alpha_2 + \Sigma_{i=1}^{n}\beta_1\beta_2 + \Sigma_{i=1}^{n}\gamma_1\gamma_2}{\sqrt{\Sigma_{i=1}^{n}\left(\alpha_1^2 + \beta_1^2 + \gamma_1^2\right)\Sigma_{i=1}^{n}\left(\alpha_2^2 + \beta_2^2 + \gamma_2^2\right)}} \\ &\leq \frac{\sqrt{\Sigma_{i=1}^{n}\alpha_1^2\Sigma_{i=1}^{n}\alpha_2^2} + \sqrt{\Sigma_{i=1}^{n}\beta_1^2\Sigma_{i=1}^{n}\beta_2^2} + \sqrt{\Sigma_{i=1}^{n}\gamma_1^2\Sigma_{i=1}^{n}\gamma_2^2}}{\sqrt{\Sigma_{i=1}^{n}\left(\alpha_1^2 + \beta_1^2 + \gamma_1^2\right)\Sigma_{i=1}^{n}\left(\alpha_2^2 + \beta_2^2 + \gamma_2^2\right)}}\end{aligned}$$

Assume that

$$\Delta_1 = \Sigma_{i=1}^{n}\alpha_1^2,\ \Delta_2 = \Sigma_{i=1}^{n}\alpha_2^2,$$

$\Pi_1 = \sum_{i=1}^{n} \beta_1^2$, $\Pi_2 = \sum_{i=1}^{n} \beta_2^2$,

$\Omega_1 = \sum_{i=1}^{n} \gamma_1^2$, $\Omega_2 = \sum_{i=1}^{n} \gamma_2^2$.

Then

$$\hat{\sigma}(P,Q) \leq \frac{\sqrt{\Delta_1\Delta_2} + \sqrt{\Pi_1\Pi_2} + \sqrt{\Omega_1\Omega_2}}{\sqrt{\left(\Delta_1 + \Pi_1 + \Omega_1\right)\left(\Delta_2 + \Pi_2 + \Omega_2\right)}}$$

Consequently,

$$\begin{aligned}\hat{\sigma}^2(P,Q) &\leq \frac{\left(\sqrt{\Delta_1\Delta_2} + \sqrt{\Pi_1\Pi_2} + \sqrt{\Omega_1\Omega_2}\right)^2}{\left(\Delta_1 + \Pi_1 + \Omega_1\right)\left(\Delta_2 + \Pi_2 + \Omega_2\right)} \\ &= \frac{\Delta_1\Delta_2 + \Pi_1\Pi_2 + \Omega_1\Omega_2 + 2\left(\sqrt{\Delta_1\Delta_2\Pi_1\Pi_2} + \sqrt{\Delta_1\Delta_2\Omega_1\Omega_2} + \sqrt{\Pi_1\Pi_2\Omega_1\Omega_2}\right)}{\left(\Delta_1 + \Pi_1 + \Omega_1\right)\left(\Delta_2 + \Pi_2 + \Omega_2\right)}\end{aligned}$$

But

$$\begin{aligned}\hat{\sigma}^2(P,Q) - 1 &= \frac{2\left(\sqrt{\Delta_1\Delta_2\Pi_1\Pi_2} + \sqrt{\Delta_1\Delta_2\Omega_1\Omega_2} + \sqrt{\Pi_1\Pi_2\Omega_1\Omega_2}\right) - \left(\Delta_1(\Pi_2 + \Omega_2) + \Pi_1(\Delta_2 + \Omega_2) + \Omega_1(\Delta_2 + \Pi_2)\right)}{\left(\Delta_1 + \Pi_1 + \Omega_1\right)\left(\Delta_2 + \Pi_2 + \Omega_2\right)} \\ &= -\frac{\left(\Delta_1(\Pi_2 + \Omega_2) + \Pi_1(\Delta_2 + \Omega_2) + \Omega_1(\Delta_2 + \Pi_2)\right) - 2\left(\sqrt{\Delta_1\Delta_2\Pi_1\Pi_2} + \sqrt{\Delta_1\Delta_2\Omega_1\Omega_2} + \sqrt{\Pi_1\Pi_2\Omega_1\Omega_2}\right)}{\left(\Delta_1 + \Pi_1 + \Omega_1\right)\left(\Delta_2 + \Pi_2 + \Omega_2\right)} \\ &\leq 0.\end{aligned}$$

Thus, $\hat{\sigma}^2(P,Q) \leq 1$ implies $\hat{\sigma}(P,Q) \leq 1$. Hence, $-1 \leq \hat{\sigma}(P,Q) \leq 1$. Therefore, $\hat{\sigma}(P,Q)$ is a correlation coefficient of P and Q.

3.1| Numerical Verifications

We experiment the reliability of the Thao et al.'s approach and its modified version with some numerical examples.

3.1.1| Example I

Assume there are two IFSs defined in $X = \{x_1, x_2, x_3, x_4, x_5\}$ by

$$P_1 = \{\langle\frac{0.8, 0.1, 0.1}{x_1}\rangle, \langle\frac{0.6, 0.1, 0.3}{x_2}\rangle, \langle\frac{0.2, 0.8, 0.0}{x_3}\rangle, \langle\frac{0.6, 0.1, 0.3}{x_4}\rangle, \langle\frac{0.1, 0.6, 0.3}{x_5}\rangle\}$$

$$P_2 = \{\langle\frac{0.4, 0.0, 0.6}{x_1}\rangle, \langle\frac{0.3, 0.5, 0.2}{x_2}\rangle, \langle\frac{0.1, 0.7, 0.2}{x_3}\rangle, \langle\frac{0.4, 0.3, 0.3}{x_4}\rangle, \langle\frac{0.1, 0.7, 0.2}{x_5}\rangle\}$$

By using the Thao et al.'s approach, we have $\sigma(P1,P2) = 0.2095$. With the modified version,

$\hat{\sigma}(P1, P2) = 0.1631$. Thao et al.'s approach yields a better correlation index. Certainly, this "so called" advantage cannot be relied upon because Thao et al.'s approach do not take account of the hesitation margins.

3.1.2| Example II

Suppose we have two IFSs defined in $X = \{x_1, x_2, x_3, x_4, x_5\}$ by

$$Q_1 = \{\langle \frac{0.6, 0.1, 0.3}{x_1} \rangle, \langle \frac{0.5, 0.4, 0.1}{x_2} \rangle, \langle \frac{0.3, 0.4, 0.3}{x_3} \rangle, \langle \frac{0.7, 0.2, 0.1}{x_4} \rangle, \langle \frac{0.3, 0.4, 0.3}{x_5} \rangle\}$$

$$Q_2 = \{\langle \frac{0.1, 0.8, 0.1}{x_1} \rangle, \langle \frac{0.0, 0.8, 0.2}{x_2} \rangle, \langle \frac{0.2, 0.8, 0.0}{x_3} \rangle, \langle \frac{0.2, 0.8, 0.0}{x_4} \rangle, \langle \frac{0.8, 0.1, 0.1}{x_5} \rangle\}$$

Computing the correlation coefficient with Thao et al.'s approach, we have $\sigma(Q1,Q2) = -0.3794$. With the modified version, we obtain $\hat{\sigma}(Q1,Q2) = -0.3325$. Here, the modified version shows a better prospect of precision although both approaches indicate negative linear relationship.

It is worthy to note that, both approaches satisfied the conditions in *Definition 4*. In summary, the modified version of Thao et al.'s approach is more reliable, it losses no information due to omission and thus, has a precise output because it incorporates the orthodox parameters of IFSs unlike Thao et al.'s initiative.

4| Medical Diagnostic Analysis of some Selected Patients

Medical diagnosis or diagnosis is the process of deciding which illness or disease describes a patient's signs and symptoms. The information necessary for diagnosis is usually collected from a history and frequently, physical examination of the patient seeking medical attention. Over and over again, one or more diagnosis processes, like medical tests, are also conducted during the procedure.

Diagnosis is time and again thought-provoking, because many signs and symptoms are uncertain. For example, headache by itself, is a sign of numerous diseases and thus does not show the physician what the patient is suffering from. Consequently differential diagnosis, in which some possible explanations are juxtaposed, must be performed, which could be best done by intuitionistic fuzzy approach. This involves correlation of many pieces of information followed by the recognition of patterns via correlation coefficient measures. In fact, the process of medical diagnosis is more challenging when a patient is showing symptoms of some closely related diseases, which also posed a problem to therapeutic process.

4.1| Hypothetical Experiment of Medical Diagnosis

In this section, we present an application of modified Thao et al.'s correlation coefficient to medical diagnostic analysis. In a given hypothetical diagnostic process, assume S is a set of symptoms, P is a set of patients, and D is a set of diseases. Now, we discuss the notion of intuitionistic fuzzy medical diagnosis via the following procedure viz; the determination of symptoms, the formulation of medical knowledge in the intuitionistic fuzzy domain, and the determination of diagnosis based on the greatest correlation coefficient value of the correlation coefficient of patients and diseases.

4.1.1| Example of medical diagnosis

Suppose we have four patients viz; Joe, Lil, Tony, and Tom who visit a medical facility for medical diagnosis. They are observed to possess the following symptoms; temperature, headache, stomach pain, cough, and chest pain. Mathematically, the set of the patients represented by P is $P = \{P_1, P_2, P_3, P_4\}$, where P_1 = Joe, P_2 = Lil, P_3 = Tony, P_4 = Tom, and the set of symptoms S is $S = \{s_1, s_2, s_3, s_4, s_5\}$, in which s_1 = temperature, s_2 = headache, s_3 = stomach pain, s_4 = cough, and s_5 = chest pain.

The patients P_i, $i = 1,2,3,4$ are observed to be showing symptoms of the diseases D_j, $j = 1,2,3,4,5$, given as $D = \{D_1, D_2, D_3, D_4, D_5\}$, where D_1 = viral fever, D_2 = malaria, D_3 = typhoid, D_4 = stomach problem, and D_5 = chest problem.

The intuitionistic fuzzy medical representations of the diseases based on medical knowledge of the diseases are given in *Table 1*. The intuitionistic fuzzy medical representations of the patients after medical examinations are presented hypothetically, in *Table 2*. Both the intuitionistic fuzzy medical representations of the diseases and the intuitionistic fuzzy medical representations of the patients are taken from [7].

Table 1. Intuitionistic fuzzy medical representations I.

Feature Space Diseases	s1	s2	s3	s4	s5
λD1	0.4	0.3	0.1	0.4	0.1
υD1	0.0	0.5	0.7	0.3	0.7
ϑD1	0.6	0.2	0.2	0.3	0.2
λD2	0.7	0.2	0.0	0.7	0.1
υD2	0.0	0.6	0.9	0.0	0.8
ϑD2	0.3	0.2	0.1	0.3	0.1
λD3	0.3	0.6	0.2	0.2	0.1
υD3	0.3	0.1	0.7	0.6	0.9
ϑD3	0.4	0.3	0.1	0.2	0.0
λD4	0.1	0.2	0.8	0.2	0.2
υD4	0.7	0.4	0.0	0.7	0.7
ϑD4	0.2	0.4	0.2	0.1	0.1
λD5	0.1	0.0	0.2	0.2	0.8
υD5	0.8	0.8	0.8	0.8	0.1
ϑD5	0.1	0.2	0.0	0.0	0.1

Table 2. Intuitionistic fuzzy medical representations II.

Feature space Patients	s_1	s_2	s_3	s_4	s_5
λP1	0.8	0.6	0.2	0.6	0.1
υP1	0.1	0.1	0.8	0.1	0.6
ϑP1	0.1	0.3	0.0	0.3	0.3
λP2	0.0	0.4	0.6	0.1	0.1
υP2	0.8	0.4	0.1	0.7	0.8
ϑP2	0.2	0.2	0.3	0.2	0.1
λP3	0.8	0.8	0.0	0.2	0.0
υP3	0.1	0.1	0.6	0.7	0.5
ϑP3	0.1	0.1	0.4	0.1	0.5
λP4	0.6	0.5	0.3	0.7	0.3
υP4	0.1	0.4	0.4	0.2	0.4
ϑP4	0.3	0.1	0.3	0.1	0.3

4.1.2| Algorithm of modified Thao et al.'s correlation coefficient

The algorithm for computing the correlation coefficient between the patients P_i and the diseases D_j using *Eq. (10)* is given as follows.

PRE. lambdaPi[si] is Membership Degrees (MDs) of Patients (Pi), upsilonPi[si] is Non-Membership Degrees (NMDs) of *Pi*, varthetaPi[si] is Hesitation Margins (HMs) of Pi where $i = 1,\ldots,4$; lambdaDi[si] is MDs of Diseases (Dj), upsilonDi[si] is NMDs of Dj, varthetaDj[si] is HMs of Dj where $j = 1,\ldots,5$; $S = \{s_1, s_2, s_3, s_4, s_5\}$, $n = 5$ is the number of feature space.

POST. This algorithm finds the correlation coefficients between *Pi* and *Dj*.

STEPS.

i: Set the value for n
ii: Initialize values for Pi and Dj
iii: Repeat for s = 1 to n
Set sumlambdaPi[si] = sumlambdaPi[si] + Pi[si]
Set sumupsilonPi[si] = sumupsilonPi[si] + Pi[si]
Set sumvarthetaPi[si] = sumvarthetaPi[si] + Pi[si]
End for
iv: Set lambdaPiBar = sumlambdaPi[si]/n; Set upsilonPiBar = sumupsilonPi[si]/n; Set varthetaPiBar = sumvarthetaPi[si]/n
v: Repeat for s = 1 to n
Set sumlambdaDj[si] = sumlambdaDj[si] + Dj[si]
Set sumupsilonDj[si] = sumupsilonDj[si] + Dj[si]
Set sumvarthetaDj[si] = sumvarthetaDj[si] + Dj[si]
End for
vi: Set lambdaDjBar = sumlambdaDj[si]/n; Set upsilonDjBar = sumupsilonDj[si]/n; Set varthetaDjBar = sumvarthetaDj[si]/n
vii: Repeat for s= 1 to n
Set templepi = ((lambdaPi[si]-lambdaPiBar)(lambdaPi[si]-lambdaPiBar) + (upsilonPi[si]-upsilonPiBar)*(upsilonPi[si]-upsilonPiBar) + (varthetaPi[si]-varthetaPiBar)*(varthetaPi[si]-varthetaPiBar))*
Set templedj = ((lambdaDj[si]-lambdaDjBar)(lambdaDj[si]-lambdaDjBar) + (upsilonDj[si]-upsilonDjBar)*(upsilonDj[si]-upsilonDjBar) + (varthetaDj[si]-varthetaDjBar)*(varthetaDj[si]-varthetaDjBar))*
Set templepidj = ((lambdaPi[si]-lambdaPiBar)(lambdaDj[si]-lambdaDjBar) + (upsilonPi[si]-upsilonPiBar)*(upsilonDj[si]-upsilonDjBar) + (varthetaPi[si]varthetaPiBar)*(varthetaDj[si]-varthetaDjBar))*
End for
viii: Set phiPiPi = (1/n-1) ∗ templepi
ix: Set phiDjDj = (1/n-1) ∗ templedj
x: Set phiPiDj = (1/n-1) ∗ templepidj
xi: Set sigmaPiDj = phiPiDj/(sqrt(phiPiPi∗phiDjDj))
xii: Exit .

4.1.3| Medical diagnostic results and discussions

After coding the algorithm for computing the correlation coefficient between patients P_i and diseases D_j via JAVA programming language, we obtain the result in *Table 3*.

Table 3. Results for medical diagnosis.

Diagnosis	Viral Fever	Malaria	Typhoid Fever	Stomach Problem	Chest Problem
Joe	0.1631	0.1572	0.1886	0.0952	−0.3989
Lil	0.1573	0.1399	0.2099	0.1029	−0.2932
Tony	0.0717	0.0791	0.0586	0.0322	−0.2544
Tom	0.1232	0.1226	0.1327	0.0680	−0.3325

From the results above, we obtain the following diagnoses: Joe is diagnosed of typhoid fever with some elements of viral fever and malaria. Lil is diagnosed of typhoid fever and should also be treated for viral fever. Tony has a very negligible symptoms of malaria and viral fever because of the values of the correlation coefficient. In fact, Tony is "near healthy". Finally, Tom has a mere symptoms of typhoid fever, viral fever and malaria; not a sever case at all.

We observe that none of the patients show positive for chest problem. The patients show positive for stomach problem in a very negligible stages. With these diagnoses, a physician can easily prescribe drugs for the patients because the diagnoses show degrees of severity and thus, minimize the possibility of wrong/unnecessary therapies.

5 | Conclusion

In this paper, we have successfully modified the Thao et al.'s method of calculating correlation coefficient because of its limitation. The modified version of Thao et al.'s method remedied the limitation because it incorporated the impact of the hesitation margins of the intuitionistic fuzzy pairs in the computations. We showed that the new method satisfied the axiomatic description of correlation coefficient of IFSs. In addition, we integrated the new method in an algorithm for easy coding to

enhance accuracy and ease of computations. We experimented the applicability of the new method with medical diagnosis conducted hypothetically on some patients and obtained their respective diagnoses with regard to the values of correlation coefficient between each patients and each diseases. Nonetheless, this approach could be extended to cluster algorithm with applications in future research.

References

[1] Zadeh, L. A. (1965). Fuzzy sets. *Information and control*, *8*(3), 338-353.

[2] Atanassov, K. T. (1994). New operations defined over the intuitionistic fuzzy sets. *Fuzzy sets and systems*, *61*(2), 137-142.

[3] Atanassov, K. (1999). Intuitionistic fuzzy sets: theory and applications, physica-verlag, Heidelberg. *International journal of advanced computer science and applications*, 14-17.

[4] Davvaz, B., & Hassani Sadrabadi, E. (2016). An application of intuitionistic fuzzy sets in medicine. *International journal of biomathematics*, *9*(03), 1650037.

[5] De, S. K., Biswas, R., & Roy, A. R. (2001). An application of intuitionistic fuzzy sets in medical diagnosis. *Fuzzy sets and systems*, *117*(2), 209-213.

[6] Ejegwa, P. A., & Onasanya, B. O. (2019). Improved intuitionistic fuzzy composite relation and its application to medical diagnostic process. *Note IFS*, *25*(1), 43-58.

[7] Szmidt, E., & Kacprzyk, J. (2001, October). Intuitionistic fuzzy sets in some medical applications. *International conference on computational intelligence* (pp. 148-151). Springer, Berlin, Heidelberg.

[8] Szmidt, E., & Kacprzyk, J. (2004). Medical diagnostic reasoning using a similarity measure for intuitionistic fuzzy sets. *Note on IFS*, *10*(4), 61-69.

[9] Todorova, L., Atanassov, K., Hadjitodorov, S., & Vassilev, P. (2007). On an intuitionistic fuzzy approach for decision making in medicine: part 1. *International journal bioautomation*, *6*, 92.

[10] Todorova, L., Atanassov, K., Hadjitodorov, S., & Vassilev, P. (2007). On an intuitionistic fuzzy approach for decision making in medicine: part 2. *International journal bioautomation*, *7*, 64-69.

[11] Boran, F. E., & Akay, D. (2014). A biparametric similarity measure on intuitionistic fuzzy sets with applications to pattern recognition. *Information sciences*, *255*, 45-57.

[12] Hatzimichailidis, A. G., Papakostas, G. A., & Kaburlasos, V. G. (2012). A novel distance measure of intuitionistic fuzzy sets and its application to pattern recognition problems. *International journal of intelligent systems*, *27*(4), 396-409.

[13] Wang, W., & Xin, X. (2005). Distance measure between intuitionistic fuzzy sets. *Pattern recognition letters*, *26*(13), 2063-2069.

[14] Ejegwa, P. A., Akubo, A. J., & Joshua, O. M. (2014). Intuitionistic fuzzy set and its application in career determination via normalized Euclidean distance method. *European scientific journal*, *10*(15).

[15] Ejegwa, P. A., Akubo, A. J., & Joshua, O. M. (2014). Intuitionistic fuzzy sets in career determination. *J. of Inform. and Computing Sci*, *9*(4), 285-288.

[16] Ejegwa, P. A., & Onyeke, I. C. (2018). An object oriented approach to the application of intuitionistic fuzzy sets in competency based test evaluation. *Ann. Commun. Math*, *1*(1), 38-47.

[17] Liu, P., & Chen, S. M. (2016). Group decision making based on Heronian aggregation operators of intuitionistic fuzzy numbers. *IEEE transactions on cybernetics*, *47*(9), 2514-2530.

[18] Chiang, D. A., & Lin, N. P. (1999). Correlation of fuzzy sets. *Fuzzy sets and systems*, *102*(2), 221-226.

[19] Hung, W. L., & Wu, J. W. (2002). Correlation of intuitionistic fuzzy sets by centroid method. *Information sciences*, *144*(1-4), 219-225.

[20] Murthy, C. A., Pal, S. K., & Majumder, D. D. (1985). Correlation between two fuzzy membership functions. *Fuzzy sets and systems*, *17*(1), 23-38.

[21] Ejegwa, P. A. (2020). Modified and generalized correlation coefficient between intuitionistic fuzzy sets with applications. Retrieved from https://www.researchgate.net/profile/Ejegwa_Paul_Augustine/publication/341902780_Modified_and_generalized_correlation_coefficient_between_intuitionistic_fuzzy_sets_with_applications/links/5ed8d821299bf1c67d3bdf10/Modified-and-generalized-correlation-coefficient-between-intuitionistic-fuzzy-sets-with-applications.pdf

[22] Mitchell, H. B. (2004). A correlation coefficient for intuitionistic fuzzy sets. *International journal of intelligent systems*, *19*(5), 483-490.

[23] Xuan Thao, N. (2018). A new correlation coefficient of the intuitionistic fuzzy sets and its application. *Journal of intelligent & fuzzy systems*, *35*(2), 1959-1968.

[24] Xu, Z., Chen, J., & Wu, J. (2008). Clustering algorithm for intuitionistic fuzzy sets. *Information sciences*, *178*(19), 3775-3790.

[25] Hong, D. H., & Hwang, S. Y. (1995). Correlation of intuitionistic fuzzy sets in probability spaces. *Fuzzy sets and systems*, *75*(1), 77-81.

[26] Zeng, W., & Li, H. (2007). Correlation coefficient of intuitionistic fuzzy sets. *Journal of industrial engineering international*, *3*(5), 33-40.

[27] Gerstenkorn, T., & Mańko, J. (1991). Correlation of intuitionistic fuzzy sets. *Fuzzy sets and systems*, *44*(1), 39-43.

[28] Hung, W. L. (2001). Using statistical viewpoint in developing correlation of intuitionistic fuzzy sets. *International journal of uncertainty, fuzziness and knowledge-based systems*, *9*(4), 509-516.

[29] Hung, W. L., & Wu, J. W. (2002). Correlation of intuitionistic fuzzy sets by centroid method. *Information sciences*, *144*(1-4), 219-225.

[30] Park, J. H., Lim, K. M., Park, J. S., & Kwun, Y. C. (2009). Correlation coefficient between intuitionistic fuzzy sets. *Fuzzy information and engineering* Volume 2 (pp. 601-610). Springer, Berlin, Heidelberg.

[31] Bustince, H., & Burillo, P. (1995). Correlation of interval-valued intuitionistic fuzzy sets. *Fuzzy sets and systems*, *74*(2), 237-244.

[32] Liu, B., Shen, Y., Mu, L., Chen, X., & Chen, L. (2016). A new correlation measure of the intuitionistic fuzzy sets. *Journal of intelligent & fuzzy systems*, *30*(2), 1019-1028.

[33] Garg, H., & Kumar, K. (2018). A novel correlation coefficient of intuitionistic fuzzy sets based on the connection number of set pair analysis and its application. *Scientia Iranica. Transaction E, industrial engineering*, *25*(4), 2373-2388.

[34] Garg, H. (2018). Novel correlation coefficients under the intuitionistic multiplicative environment and their applications to decision-making process. *Journal of industrial & management optimization*, *14*(4), 1501.

[35] Garg, H., & Rani, D. (2019). A robust correlation coefficient measure of complex intuitionistic fuzzy sets and their applications in decision-making. *Applied intelligence*, *49*(2), 496-512.

[36] Thao, N. X., Ali, M., & Smarandache, F. (2019). An intuitionistic fuzzy clustering algorithm based on a new correlation coefficient with application in medical diagnosis. *Journal of intelligent & fuzzy systems*, *36*(1), 189-198.

[37] Atanassov, K. T. (1994). New operations defined over the intuitionistic fuzzy sets. *Fuzzy sets and systems*, *61*(2), 137-142.

E-ISSN: 2717-3453 | P-ISSN: 2783-1442

Journal of Fuzzy Extension and Applications

www.journal-fea.com

J. Fuzzy. Ext. Appl. Vol. 1, No. 2 (2020) 133–138.

Paper Type: Short Communication

Computer and Fuzzy Theory Application: Review in Home Appliances

Tim Chen[1], Ilnar Karimov[2], Jcy Chen[3,*], Alexandv Constantinovitc[4]

[1] Faculty of Information Technology, Ton Duc Thang University, Ho Chi Minh City, Vietnam; timchen@tdtu.edu.vn.
[2] Department of Fundamentals of Machine and Mechanism Design, Ufa State Aviation Technical University, Ufa, 450008 Russian Federation, Russia; ikarimov@ugatu.su.
[3] Department of Electronic and Automatic Engineering, Covenant University, 10 Idiroko Road, Canaan Land, Ota, Ogun State, Nigeria; jc343965@gmail.com.
[4] Department of English Language, Moscow City Pedagogical University, Russia; alexandvconstantinovitc@mgpu.ru.

Citation:

Chen, T., Karimov, I., Chen, J., & Constantinovitc, A. (2020). Computer and fuzzy theory application: review in home appliances. *Journal of fuzzy extension and application, 1* (2), 133-138.

Received: 07/01/2020 Reviewed: 03/04/2020 Revised: 14/05/2020 Accept: 04/06/2020

Abstract

Clays have a tendency to this article first introduces the basic concepts of fuzzy theory, including comparisons between fuzzy sets and traditional explicit sets, fuzzy sets basic operations such as the membership function of the set and the colloquial variable, the intersection and union of the fuzzy set, and use the above concepts to guide into the four basic reasoning mechanisms of fuzzy mode and introduce several common types of fuzzy application examples such as fuzzy washing machine and fuzzy control of incinerator plant in China illustrate the application of fuzzy theory in real society.

Keywords: Fuzzy theory, Fuzzy control, Fuzzy set.

1 | Introduction

Licensee Journal of Fuzzy Extension and Applications. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0).

In 1965, Zadeh published a "fuzzy set" Thesis at the University of Califonia at Berkeley in "Information and Control". In this academic journal, the fuzzy theory was born. In this paper, professor Zadeh puts "high temperature", "giant man", "big sets that cannot be clearly defined, such as "number", are based on a new set theory. Representation, called fuzzy set. He specifically pointed out: The fuzzy collection pole suitable for abstract things, such as image recognition, information transmission, etc. These basic behaviors of human thinking that are difficult to express mathematically plus to quantify, and in the form of mathematical theory, to develop these situations. When Professor Zadeh published fuzzy set theory, the reaction of the academic community extremely indifferent, with many criticisms. He was once a "modern cybernetic a member of this rigorous theory has changed 180 degrees to advocate vague concepts, and this has aroused fierce criticism from everyone. Fuzzy theory has been despised since the beginning, but since 1974 British Mamdani announced the application of fuzzy logic to control small steam engines. In 1982, Denmark Ostergaard announced the successful operation of fuzzy logic after being built as a cement kiln factory, the practical potential of fuzzy theory was wide attention. In recent years, the blur has been like a whirlwind, in Europe and China. There are huge manpower in various parts of Japan and Japan. Research boom. Especially

Corresponding Author: jc343965@gmail.com
http://dx.doi.org/10.22105/jfea.2020.251719.1019

Japan, even more with its strong corporate economic to cooperate with the industrial R&D technology that no one can match, and develop vigorously blur product.

Today, as small as the camera' s autofocus device, washing the water flow controller of the clothes machine and the temperature adjustment of the air conditioner are as large as water treatment plant raw water treatment program, subway automatic driving system, the fuzzy trails can be seen everywhere, making the word fuzzy almost synonymous with smart technology. In this article, fuzzy logic develop basic theory, extend its theory to fuzzy control system, and take the fuzzy control system of automatic fuzzy washing machine and incinerator as the example is a simple and clear introduction. There are many applications, for example, see Faber and Stewart [1], Lugeri et al. [4], Markus et al. [5], and Pandey et al. [6]. Other studies have focused on disaster detection and early warning systems [2],[3], and [7].

2| The Basic Concept

The so-called set is composed of some things with common properties. The quality of the organization can be used to summarize a group with the same characteristics tools to sign things. Generally speaking, collection is to express clear things mainly, in order to distinguish, it is customary to use a clear collection (crisp set). Explicit sets have the following common properties: The elements in the set are determined. The elements of the same set have certain identical properties. A whole composed of collective elements, the elements can be distinguished from each other do not. When using a collection to represent a concept, always consider the object restricted to a specific range, this range is called domain (universal of discourse, *U x*). Set A in the universe *U x* has the following two basic representation methods: Enumeration method. If each element in the set can be listed one by one is enumerated, the set can be represented by enumeration. This method can only be used for a limited set of elements. For example Set A of elements, respectively, A1, A2, ..., An, can be expressed as: Descriptive method. If a set defines its elements according to specific properties at that time, this method is called descriptive method.

Common to this method the general formula is as follows: According to this symbol, A is *U x* medium-oriented proposition (proposition) *P (x)* is the set of all elements of truth. For an explicit set A in the universe of *U x*, its element x the relationship with the set can use the characteristic function (characteristic function) to illustrate, its definition is as follows: Definition 1. One of the explicit set A in the universe *U x* , its characteristic function [mu] A to the *U x* of the element x is mapped to a set {0,1} being. Also which is or the above introduced the affiliation between elements and sets. In the set there is also the same definition of affiliation between combination and set, for example: Subset, equal set, etc. About collection the basic operation of, generally refers to intersection, union set, difference set, complement set. It exhibits many properties, such as commutativity, associativity, distributivity, transitivity, and exclusive neutrality law of excluded-middle, etc.

3| Fuzzy Set and Membership Function

Zadeh formally proposed the fuzzy set theory in 1965. Mold the biggest difference between fuzzy sets and explicit sets is that Zadeh proposed replace explicit sets with membership functions the characteristic function in the union. The membership function changes the original non-zero or 1 characteristic the eigen function value is expanded to a real number between 0 and 1. And the set defined by the membership function is called the fuzzy set. For a fuzzy set A in the universe of *U x*, generally as the following definition means: Definition 2. In a fuzzy set A in the universe U x , its membership function several [mu] A to the *U x* map elements to a range of [0,1] in the real number. That is μ A *(x): U x → [0, 1]* or *A (x): U x → [0, 1]* the above two expressions often appear in the literature, in this article the latter is used as the representation of fuzzy sets. In other words, mod the fuzzy set and its membership function are both represented by the same symbol. But use it is written as A (x) when representing the membership function, and there is a specific x value *(x *)* substitute the membership function value into the membership function, then write into *A (x *)*. In practical applications, the

membership function is operated on site personnel, cooperating with experts in the application field, generally the membership function most commonly used in fuzzy logic is segment continuous.

4| The Application of Fuzzy Logic in Home Appliances

Take fuzzy washing machine as an example under the rapidly changing social structure, even the functions of home appliances the orientation has changed a lot. Take washing machines as an example, because small families the emergence of the structure, the proportion of professional women the work is therefore the exclusive work of the housewife. Work shared by the whole family and the flexibility of washing time is improved however, there may be quite extreme differences in the amount of laundry. In this way under the premise, the fuzzy control washing machine set the following development goals and technical issues: When the experienced housewife washes the clothes, computerization of the most appropriate washing method used for total quantity and material. In order to match the operation and use of the whole family, all operations it is best to use a single button, that is, the washer is responsible for pressing the start move the button, the rest are judged by the fuzzy system of the washing machine off.

Fuzzy fully automatic washing machine can be measured by enough sensors the amount of clothing and the quality of the clothing, and can be appropriately blurred control rule base to work out a good washing water volume and washing time, to make the most appropriate control. In order to allow all users to understand the current fuzzy laundry the operating status of the machine, for all expected and completed laundry the process must be clearly displayed to users. The fuzzy washing machine is based on the sophisticated family the housewife considers the problems when washing clothes, such as "do not hurt the cloth material", "strong cleaning power", "shorten washing time", etc. In addition to the theme of cleaning, it also achieves a balance with button operation the effect of control. Fuzzy control provides sensory information and develops sensors for the amount of clothes and fabrics. Based on this principle, developed the most moderate water flow intensity and washing time control technology.

5| Practical Method of Fuzzy Control

In order to make the product practical, the fuzzy control is put into the CPU in the 4 bit CPU, many functions including LCD display. It can realize fuzzy control of saving memory and shortening calculation time. For simplify the sequence and output results from input information to fuzzy control output single, so the possible output combination is fuzzy and real the test results are categorized to divide the range of output combinations and follow 19 practical ways to leave good fuzzy control. It is developed to control the most appropriate water flow, washing time, and dehydration time fuzzy fully automatic washing machine. The application examples of fuzzy automatic washing machines are described above. Needle for problems that are difficult to control by computers until today, fuzzy control can explain the scope of machinery equipment and process control in general industries in the domain, the realization, and home.

6| The Application of Fuzzy Logic in the Manufacturing Industry

Take incinerator control as an example in order to reduce the environmental pollution caused by the landfill method, disposal personnel have racked their brains to design appropriate treatment methods. In addition to the recycling of resources to reduce waste, the incineration method has become the main garbage disposal method adopted by many countries, because this incinerator has also become a very important equipment. But this is equipment that reduces environmental pollution, but it may be exhaust gas exceeds the standard value, which is harmful to the environment. Although discharged gas can use subsequent equipment to reduce pollution, but this is not only time-consuming and also increases the processing cost. So how to control the incinerator can fully burn the contents when burning waste. It has become an important subject of incinerator control. However, because every batch of waste incinerated in the incinerator has different physical and chemical properties, and there is no way before incineration effective screening, so a set of appropriate mathematical models cannot be established. The overall structure of the

incinerator. To describe the incineration process. Therefore, the control encountered in the incineration process the control problem is not easy to solve with traditional control methods. And so, when the incinerator burns incompletely, the operator will often the previous combustion situation and the situation of the incinerator contents determine the future control action. In this case, it can simulate the control actions of human experts fuzzy controller may be more capable than traditional mode control strategy give full play to the effectiveness of its control. Collaboration between scholars in Korea and Samsung Heavy industries, we will try to achieve incinerator control with a fuzzy control architecture aims. The overall structure of the incinerator. The goal of its control is to achieve complete combustion while ensuring keep the evaporation rate and processing energy within the target area. This control system the system is based on the fuzzy controller architecture mentioned in the general literature, then make amendments to meet the needs of incinerator control.

As a whole said, this fuzzy control system is divided into three parts in total. First of all, in addition to the use of general meters to measure the incinerator. In addition to the numerical values of the combustion parameters, the more special part is the designer' s adapt to the characteristics of the incinerator, and especially use the so-called fuzzy measuring device (fuzzy sensor) to capture what cannot be measured by the meter but is the data required for fuzzy control can be used as input variables of the fuzzy controller, the source of the information. Simply put, the so-called fuzzy sensor to collect some data that can be measured by the instrument through fuzzy collection, the calculation of another group of indicators cannot be measured with equipment. The average operator is judging when cutting off the combustion status of the incinerator, it may be the thickness of the waste, the calorific value of the incineration system, the nature of the waste, and the factors such as burning conditions are used as a reference for control and adjustment. But yes for fuzzy controllers, it is really difficult to describe the "burning condition" like this an abstract concept gives a clear definition. So in this system it is convenient to use the pressure drop of the incinerator, the switch state of the feed inlet, combustion bed length, evaporation rate, dry bed length, oxidation carbon concentration, oxygen concentration, etc. Can be measured by measuring equipment to estimate the size of the above indicators. The output of the entire fuzzy measure the relationship between input and output.

7| Fuzzy Decision Maker

Among the fuzzy control systems of the incinerator, the most special one is the so-called fuzzy decision maker (fuzzy decision maker). Actual mode the fuzzy decision maker is the set point of some parameters in the fuzzy controller decision mechanism. In simple terms, the fuzzy decision maker will the nature of furnaces, transmissions and other equipment and control target setting values take them into consideration in order to determine the setting value of the controller. For example in other words, the temperature setting of the combustion air is based on the current temperature and the nature of the waste measured by the fuzzy measurer decided. The decision process is based on the experience of operating experts so that the temperature of the incinerator can be maintained at a target area. Such decision rules generally have the following description: "When discarded, when the nature of the material is not good, if the temperature of the combustion air increases, the temperature of the chemical furnace will tend to stabilize." Another parameter determined by the fuzzy decision maker is the evaporation rate. Rate set point. In the past traditional control, in order to maintain evaporation rate in a certain target area, generally used to regulate waste feed the amount to achieve the goal. But because the ingredients of the feed are always there change, so it is difficult to get the desired effect. In this system, in order to obtain the appropriate evaporation rate set point, the waste and the difference between the current evaporation rate and the current set point, to calculate the next set point.

In this fuzzy controller, mainly use the parameter settings calculated by the aforementioned fuzzy decision maker point, compared with the data currently measured by the fuzzy measurer comparison, using fuzzy control rules constructed by expert knowledge reasoning, and finally get the control actions of each operation. In the output part of this fuzzy controller, you can subdivided into steam calorific value, feed port switch, fuel switch, feed rate, fuel rate, throttle angle, etc. And each output variable

points have not different input parts. Overall, this multiple-input multiple-output fuzzy control can be regarded as the multiple input single output fuzzy controller combination. For example, for the waste and fuel inlet (feeder and stoker ON/OFF) of the switch control part, the input is the difference between the current evaporation rate and its set point, and the rate of change of the difference. The content of its control rules may be as follows narrative: "If the evaporation rate is high, at the same time the evaporation rate will increase the higher the trend, the waste inlet should be opened," or "if the evaporation rate is low, at the same time the evaporation rate tends to be lower and lower when the situation occurs, the waste inlet should be closed. The content of these rules it is accumulated by the experience of on-site control personnel.

8| Extraction of Control Rules

According to the operation of the aforementioned fuzzy controller components look, we can find that the most difficult part is probably the control rules the establishment. For a complex and variable system like an incinerator that said, the establishment of a rule base is particularly difficult. On-site control personnel are average only know the procedures of its on-site operation, but often cannot the accumulated experience is transformed into effective fuzzy control rules. The other party in the same situation, the on-site operators often there are different control strategies. These factors have increased the fuzzy control the complexity of establishing the rules of the device. In constructing this incinerator model when pasting the control system, the designer and multiple on-site operators staff have had many interviews and summed up their control experience reorganize, get rid of the chaos in addition, designers also use the program reaction of the chemical furnace program under normal feeding operation is used as the reference base point.

In addition, when engaging in computer simulations, they also refer to actual control status of the incinerator. Finally, the designers also incinerate the past traditional control strategy used by the furnace is integrated into the rules of the fuzzy controller in the library, to enrich the performance of the controller. In summary, the fuzzy control system of the incinerator is mainly three parts: Fuzzy measurer, fuzzy decision maker and fuzzy controller composition. This control system will be able to be measured by the actual measuring device data, through the fuzzy measurer, is converted to the operator to perform the operating state that is inferred but cannot be measured with instruments. Then profit use the fuzzy decision maker to estimate the set value of each variable, so you can let the control gas setting achieve the purpose of automatic adjustment. And these settings the fixed point is compared with the current value obtained by the measuring instrument, and the Paste the controller to infer the control action of each operating variable to complete into the entire control loop. The above control in the computer simulation, the strategy can be adapted to different incinerator conditions. Enough to get satisfactory control results in a short time.

9| Conclusions and Suggestions

This article is based on basic fuzzy logic theory, a series of discussed fuzzy sets, fuzzy patterns and fuzzy reasoning mechanisms, and use examples in the home appliance industry and factories for verification. But, whether applying fuzzy logic to fuzzy model modeling and fuzzy control above, the integration and implementation of expert knowledge in the entire application of fuzzy theory is very important, and the measurement values obtained by various types of sensors accuracy is the key to whether fuzzy theory can implement expert knowledge factor.

References

[1] Faber, M. H., & Stewart, M. G. (2003). Risk assessment for civil engineering facilities: critical overview and discussion. *Reliability engineering & system safety*, *80*(2), 173-184.

[2] Kanamori, H. (2005). Real-time seismology and earthquake damage mitigation. *Annu. Rev. Earth Planet. Sci.*, *33*, 195-214.

[3] Kanamori, H., Hauksson, E., & Heaton, T. (1997). Real-time seismology and earthquake hazard mitigation. *Nature*, *390*(6659), 461-464.

[4] Lugeri, N., Kundzewicz, Z. W., Genovese, E., Hochrainer, S., & Radziejewski, M. (2010). River flood risk and adaptation in Europe—assessment of the present status. *Mitigation and adaptation strategies for global change*, *15*(7), 621-639.

[5] Markus, A. A., Courage, W. M. G., & Van Mierlo, M. C. L. M. (2010). A computational framework for flood risk assessment in the Netherlands. *Scientific programming*, *18*(2), 93-105.

[6] Pandey, A. C., Singh, S. K., & Nathawat, M. S. (2010). Waterlogging and flood hazards vulnerability and risk assessment in Indo Gangetic plain. *Natural hazards*, *55*(2), 273-289.

[7] Wu, Y. M., Shin, T. C., & Tsai, Y. B. (1998). Quick and reliable determination of magnitude for seismic early warning. *Bulletin of the seismological society of America*, *88*(5), 1254-1259.

Publisher: Ayandegan Institute of Higher Education, Iran.
Director- in-Charge: Seyyed Ahmad Edalatpanah
Editor-in-Chief: Florentin Smarandache

Journal of Fuzzy Extension & Applications (JFEA) is an international scholarly open access, interdisciplinary, fully refereed, and quarterly free of charge journal as a non-commercial publication. The publication start year of JFEA is 2020 and affiliated with Ayandegan Institute of Higher Education. The JFEA Journal has been indexed in the well-known world databases mainly; Directory of Open Access Journals (DOAJ), China Academic Journals (CNKI), WorldCat, Islamic World Science Citation Center (ISC), EBSCO, EuroPub, Google Scholar, Ulrichsweb, and Scientific Information Database (SID). The JFEA has partnered with Publons, the world's leading peer review platform, to officially recognize your peer review contributions. For more information about Publons or to sign up, visit our webpage at Publons. Moreover, JFEA utilizes "Plagiarism Detection Software (iThenticate)" for checking the originality of submitted papers in the reviewing process. This journal respects the ethical rules in publishing and is subject to the rules of the Ethics Committee" for Publication (COPE) and committed to follow the executive regulations of the Law on Prevention and Combating Fraud in Scientific Works.