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Picture Fuzzy Set with Disaster Management & Decision Making by Measures

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Abstract:
Picture fuzzy sets are extension of intuitionistic fuzzy sets. One method to ascertain the relationship between two picture fuzzy sets is to use the correlation coefficient of those sets. In this research, we introduce the refusal membership grade for picture fuzzy sets in the implementation of similarity measure, correlation coefficient and Distance based Similarity Measure in the application of disaster management. We will get the accurate value while considering refusal value in the utilization of picture fuzzy set. It has universal applications in numerous disciplines such pattern recognition, clustering analysis, and disaster management, among others. A picture fuzzy set can be used to convey the character of a decision-making problem, both positively and negatively and comparative study also made with the help of Distance measure, Similarity measure and Correlation coefficient.

Keywords: Picture fuzzy set, Distance Measure, Similarity Measure, Correlation coefficient, Disaster management, picture fuzzy operations.

1. Introduction

In 1965, Zadeh[34] presented the fuzzy set (FS) theory. Following that, FSs and their applications have drawn the attention of other authors, including Chen and Jong (1997)[8], Manoj et al. (1998) [21], and Singh et al. (2019, 2020) [28] [29]. The non-membership degree is automatically regarded as one-minus membership degree in the FS theory, which only takes an element's membership degree into account. As a result, knowing the membership degree of an element may undoubtedly be used to determine its non-membership degree. However since they are aware of the membership degree in real life, a researcher might not be as positive about the non-membership degree (Deschrijver and Kerre 2003) [11]. Atanassov (1986)[3] developed the idea of intuitionistic fuzzy sets (IFSs) employing membership and non-membership functions. In such a scenario, it is desirable to have both an independent non-membership function and a membership function.

Even though IFSs have been applied to many different fields, there are still some situations in daily life that they are not able to handle, such as voting, medical diagnosis, feature selection, personal selection, etc. Cuong and Kreinovich (2013)[6] introduced the concept of picture fuzzy set (PFS) to address these situations. It is an exact extension of Atanassov's (1986)[3] IFSs and Zadeh's (1965)[33] FSs. Every element in a PFS has three degrees: neutrality, non-membership, and membership.

On the other hand, the correlation coefficient is a commonly employed statistical instrument that holds significance in various domains such as data analysis, classification, pattern recognition, decision-making, and so on. As an illustration, the correlation coefficients of Atanassov's IFSs [3,4] were first presented by Gerstenkorn and Manko [16]. In recent years, some weight determining procedures based on distance measures, entropy measures, similarity measures and discrimination measures have been presented [22,30]. Dinh and Thao[12] presented some similarty measures between picture fuzzy sets to deal with MADM problem.

Even with all of the preparation and mitigation work completed, disasters still happen and do harm. The entirety of the measures that individuals and organizations take in the face of a disaster is referred to as the disaster response. Disaster response is to minimize the impacts of a disaster, restore control, and protect people and property immediately. The response phase starts as soon as it appears that a hazard event is likely to occur and continues until the situation is deemed to be resolved (Coppola, 2006) [10]. Predictions and alerts are part of the disaster response process.

Among the pertinent literature, the following research are particularly important: In response to the urgent relief demands, Shen (2007) [25] offers a hybrid fuzzy clustering-optimization solution for emergency logistics co-distribution operations. During the critical time of the rescue, use fuzzy set theory to make decisions on emergency shelter allocation in a geographic information system. In order to improve the decision-making process for spatial water resources, Simonovic and Nirupama (2005) [26] developed a novel technique that led to a quantifiable improvement in flood control.

The remainder of the document is structured as follows:

In Section 2, several fundamental ideas about picture fuzzy sets and correlation coefficients for operations on picture fuzzy sets (PFS) are reviewed. In Section 3, we examine disaster management in order to apply the fuzzy picture set. The fuzzy set theory is used in the research on disaster management in section 4 to describe the process for determining the affected area survey and the quantitative reaction to deal with such imprecision or uncertainty and the application of a real-world case is covered. Result and Discussion were made in section 5. The conclusion is presented in section 6.

2. Preliminaries

In this section refusal value is considered for all the formulae like Distance measure, Similarity Measure and Correlation Measure. We have proposed the formulae with refusal value for Normalized Euclidean Distance and Similarity Measure by picture fuzzy set. Even though it is working for picture fuzzy set with refusal but while applying refusal value the result is more accuracy.

Definition 2.1 [6]: The form of an object in a picture fuzzy set A on a universe T is A = {t, ($\mu_A(t)$, $\eta_A(t)$, $\gamma_A(t)$)}; (t in T)}. Where μ_A (t) in [0.1] is called the degree of positive membership of t in A, $\eta_A(t)$ in [0,1] is called the degree of neutral membership of t in A and $\gamma_A(t)$ in [0,1] is called the degree of negative membership of t in A, and where μ_A, η_A, and γ_A satisfy the following condition:

$(\forall t \text{ in } T)\ (\mu_A(t) + \eta_A(t) + \gamma_A(t) \leq 1)$

Now $\theta_A(t) = (1 - (\mu_A(t) + \eta_A(t) + \gamma_A(t))$ could be called the degree of refusal membership of t in A.

Let PFS (T) denote the set of all the picture fuzzy sets on universe T.

Definition 2.2 [3]: A intuitionistic fuzzy set A on a universe T is an object of the form A = { (t, ($\mu_A(t)$, $\gamma_A(t)$)} | t in T) } Where $\mu_A(t)$ in [0.1] is called the degree membership of t in A, $\gamma_A(t)$ in [0,1] is called the degree of non-membership of t in A, and where μ_A and γ_A satisfy the following condition :

(∀t in T) (μ_A (x) + γ_A (x)≤1)

Definition 2.3 [6]: For every two PFSs A and B, the union, intersection and complement are defined as follows:

- A ⊆ B iff (∀t in T, $\mu_A(t) \le \mu_B(t)$ and $\eta_A(t) \le \eta_B(t)$ and $\gamma_A(t) \ge \gamma_B(t)$)
- A = B iff (A ⊆ B and B ⊆ A)
- A U B = {(t, max(μ_A(t) , μ_B(t)), min(η_A(t) , η_B(t)), min(γ_A(t) , γ_B(t))|t in T}
- A ∩ B = {(t, min(μ_A(t) , μ_B(t)), min(η_A(t) , η_B(t)), max(γ_A(t) , γ_B(t))| t in T)
- co (A) = $\bar{A}$ = {(γ_A(t), η_A(t), μ_A(t)) |t in T}

Definition 2.4:

Let A and B be two picture fuzzy sets in the universe of discourse U. Our proposed similarity measure for a real valued function SM: A X B → [0,1] is

$$SM(A, B) = 1 - \frac{1}{P}$$
$$\sqrt{\sum_{i=1}^{p}\{(\mu A(x_I) - \mu B(x_I))^2 + (\eta A(x_I) - \eta B(x_I))^2 + (\gamma A(x_I) - \gamma B(x_I))^2 + (\theta A(x_I) - \theta B(x_I))^2\}}$$

Where $\theta_P(x_i)$ = 1- { μ_A(x) + η_A(x) + γ_A(x)} is the degree of refusal.

Definition 2.5:

Let A and B be two picture fuzzy sets in the universe of discourse U. Our proposed Normalized Euclidean distance (NED) with similarity measure for two picture fuzzy sets A and B in X = {x_1, x_2. . . ..x_n} is

NED (A,B) =

$$\sqrt{\frac{1}{P}\sum_{i=1}^{p}\{(\mu A(x_I) - \mu B(x_I))^2 + (\eta A(x_I) - \eta B(x_I))^2 + (\gamma A(x_I) - \gamma B(x_I))^2 + (\theta A(x_I) - \theta B(x_I))^2\}}$$

and

$$SM_{(NED)}(A, B) = \frac{1}{1+NED(A,B)}$$

Where $\theta_P(x_i)$ = 1- {μ_A(x) + η_A(x) + γ_A(x)} is the degree of refusal.

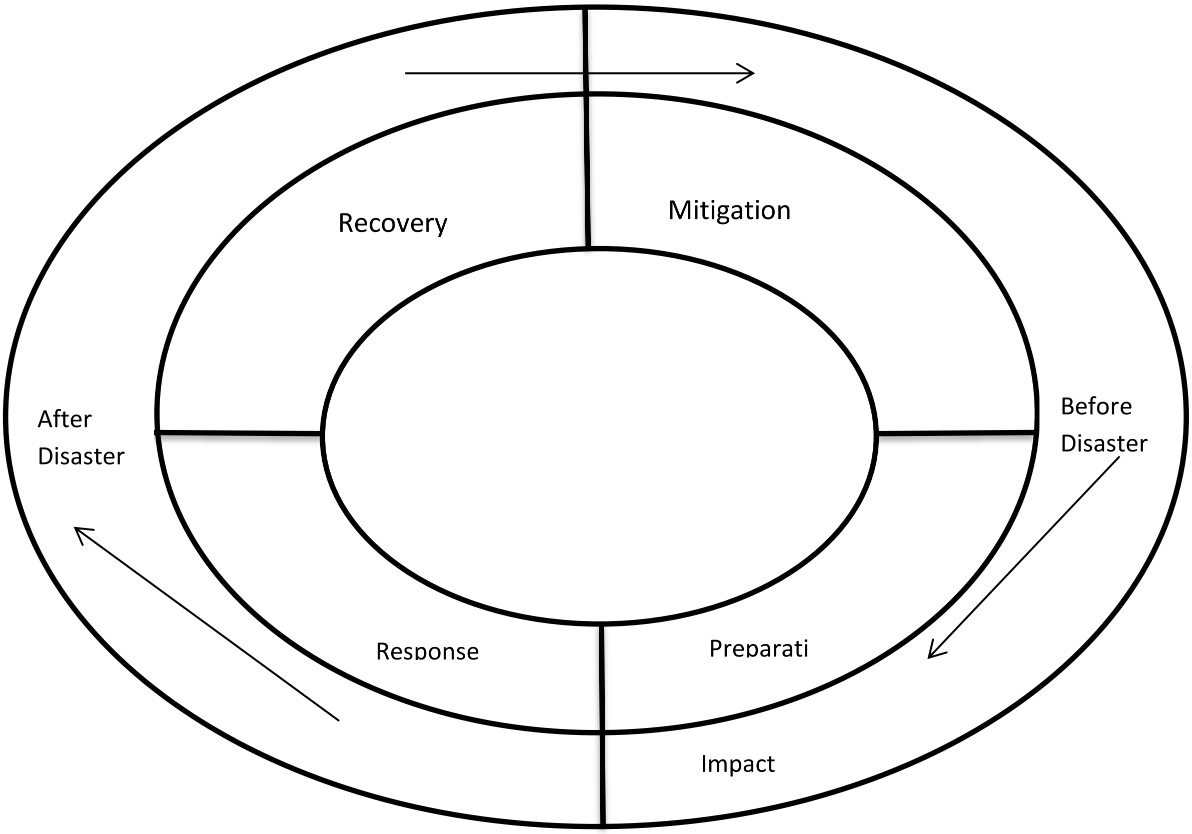
Definition 2.6 [27]: PF Correlation Measure due to Singh(2015) :

$$CM(P,Q) = \frac{\sum_{i=1}^{n}\left\{\mu_P(x_i)\,\mu_Q(x_i)+\eta_P(x_i)\eta_Q(x_i)+\gamma_P(x_i)\gamma_Q(x_i)+\theta_P(x_i)\theta_Q(x_i)\right\}}{\sqrt{\begin{array}{c}\sum_{i=1}^{n}\{(\mu_P(x_i))2+\left(\eta_P(x_i)\right)2+\left(\gamma_P(x_i)\right)2+\left(\theta_P(x_i)\right)2\right\} X \\ \sum_{i=1}^{n}\left\{(\mu_Q(x_i)\right)2+\left(\eta_Q(x_i)\right)2+\left(\gamma_Q(x_i)\right)2+\left(\theta_Q(x_i)\right)2\}\end{array}}}$$

Where $\theta_P(x_i)$ = 1- {μ_A(x) + η_A(x) + γ_A(x)} is the degree of refusal.

3. Disaster Management Cycle (Alexander, 2002)[1]

Disaster response contain other forms of protective measures included in disaster response include those that are done before, during, and right away after a hazard event with the goal of minimizing harm, fatalities, and destruction to property and the environment. One of the hardest and most significant issues with Altay and Green's management is uncertainty (2006) [2]. More than half of the works examined by Altay and Green (2006) [2]. Consider uncertainty through the use of operations research techniques such simulation, probability, fuzzy sets, queueing theory, and stochastic programming. One of the least advised approaches in disaster management is the use of fuzzy sets.



3.1 Disaster Response System

The short-term efforts performed immediately following or immediately prior to a disaster are known as disaster response activities. The following is a list of typical response phase activities, according Altay and Green (2006) [2]:

1. Turning on the emergency operation system
2. Making the emergency operations center operational
3. Threatened populations' evacuation
4. Starting shelters and offering general medical care
5. Emergency medical attention and rescue
6. Fighting fires
7. Search and rescue in urban areas
8. Lifeline service recovery and safeguarding of emergency infrastructure
9. The handling of fatalities

The actions mentioned above are intended to protect people's lives, property, the environment, and the social, political, and economic fabric of the community by using emergency protocols and resources in accordance with plans (Altay and Green, 2006) [2].

Pre-disaster and post-disaster activities are the two categories into which the functions of the disaster response system can be divided. If advanced warning systems are in place and accurately predict the impending crisis, pre-disaster operations could prove to be effective (Coppola, 2006) [10].

1. Warnings: These are plans in place to quickly notify the public and government authorities about impending disaster dangers (Syed, 2009) [32].
2. Evacuation: This is the process of moving people to a safer area from areas where a disaster is expected to occur soon.
3. Resources and supply logistics: Thanks to early warning of the disaster, officials can get supplies into the afflicted area before the effects and danger circumstances make such movement more challenging (Coppola, 2006) [10].
4. Last-minute preparation and mitigation: Planning and preparation are most successful when done well in advance of a disaster. But often, decisions are made in the hours or days leading up to a calamity.

The primary objective when responding to a disaster is to save lives. Search and rescue, first aid, and evacuation are examples of emergency operations that directly contribute to saving lives; however, additional supporting actions can be required depending on the nature of the disaster. The following are the post-disaster activities:

1. Search and rescue: This is the procedure of locating potential isolated or trapped disaster victims and transporting them to a safe area with medical assistance.
2. First Aid Medical Care: Following a tragedy, there may be so many victims that local clinics or hospitals are unable to provide care for them all. In such cases, it is important to identify the injured parties, administer first aid to stabilise their health, and then transfer them to a facility where they can get the life-saving medical care (Coppola, 2006) [10].
3. Evacuation: Relocating people away from hazards and their effects can lessen the impact of many disasters.
4. Disaster Assessment: When a disaster strikes, response officials must start gathering information as soon as possible. This information is then turned into information that will help with the response. It is essential to know at all times or at short intervals what is happening, where it is happening, what is needed to address those needs, and what resources are available.
5. Logistics and Supply: In order to deliver emergency relief, logistical facilities and capacity will be needed. Handling, storing, and distributing relief supplies will require a well-organized supply service.
6. Safety and Security: During the catastrophe response phase, the afflicted area's social order is disturbed. The main concern of local authorities is handling the fallout from the hazard. The survivors' needs for protection and security, however, are greater than usual and must be met.
7. Health and Sanitation: During disasters, there is a greater chance of disease and injury than in everyday life. Health facilities, however, can be overcrowded or damaged, thus facilities for emergency medical operations must be ready to meet the population's medical demands. Achieving appropriate sanitation is one of the most crucial problems.

In this paper, we have discussed about floods that happen when water from bodies of water—like rivers, lakes, or the ocean—overflows. In this case, the impact by PFS has been analysed using the following criteria.

i) Predicting the future and issuing an alert: a thorough examination and analysis of the data at hand to project the past into the future.
ii) First Communication: In-the-moment expert knowledge and opinion sharing to warn the public.
iii) Identify and Rescue: locating the impacted individuals and transporting them to a more secure location.
iv) Logistics and Supply: To meet the demands of the impacted population or of the individuals themselves. It guarantees the impacted people's safe living environment.

3.2 Algorithm

Step 1: Determine the area affected by the disaster and turn it into a picture fuzzy set with the variables falling under the specified range for n zones.
Step 2: In X = {x1, x2,....... n}, let {F_1, F_2,......... Fn} be a collection of picture fuzzy sets. Transform and formulate as a real-world problem to help you make better choices.
Step 3: Use def 2.4 to 2.6 to compute the measures with the refusal values for each picture fuzzy set.
Step 4: To assess the disaster response, compare the impacted area with the current affected area.
Step 5: Sort the zones based on the similarity measure values, deciding which picture fuzzy set is the severely damaged zone and assigning it with the highest range of the calculated value.

4. An Application

This section presents the application of PFS to a decision-making problem. Assuming that there are four affected zones—CUDDALORE, TIRUNELVELI, CHENNAI and SALEM—let's looks at zones F_1, F_2, F_3, and F_4. For {x_1, x_2, x_3, x_4} ∈ X, there are four set criteria: forecasting and alerting, first communication, identification and rescue and logistics and supply. PFS has been given greater degrees of freedom to handle real-world scenarios in each of these criteria. By using the correlation coefficient, these impacted zones were compared to the known, previously examined zone, especially "E." from the previous analysis.

Step 2:
F_1 = {(X_1, 0.6, 0.1, 0.2), (X_2, 0.7, 0.0, 0.1), (X_3, 0.5, 0.0, 0.4), (X_4, 0.6, 0.0, 0.4)}
F_2 = {(X_1, 0.5, 0.0, 0.3), (X_2, 0.7, 0.0, 0.3), (X_3, 0.4, 0.1, 0.5), (X_4, 0.6, 0.0, 0.3)}
F_3 = {(X_1, 0.4, 0.0, 0.3), (X_2, 0.6, 0.1, 0.2), (X_3, 0.4, 0.0, 0.5), (X_4, 0.6, 0.0, 0.3)}
F_4 = {(X_1, 0.5, 0.1, 0.4), (X_2, 0.7, 0.0, 0.2), (X_3, 0.5, 0.0, 0.2), (X_4, 0.4, 0.0, 0.6}
E = {(X_1, 0.4, 0.1, 0.2), (X_2, 0.8, 0.0, 0.1), (X_3, 0.2, 0.0, 0.5), (X_4, 0.7, 0.1, 0.2)}
and
F_1 = {(X_1, 0.6, 0.1, 0.2, 0.1), (X_2, 0.7, 0.0, 0.1, 0.2), (X_3, 0.5, 0.0, 0.4, 0.1), (X_4, 0.6, 0.0, 0.4, 0)}
F_2 = {(X_1, 0.5, 0.0, 0.3, 0.2), (X_2, 0.7, 0.0, 0.3, 0), (X_3, 0.4, 0.1, 0.5, 0), (X_4, 0.6, 0.0, 0.3, 0.1)}
F_3 = {(X_1, 0.4, 0.0, 0.3, 0.3), (X_2, 0.6, 0.1, 0.2, 0.1), (X_3, 0.4, 0.0, 0.5, 0.1), (X_4, 0.6, 0.0, 0.3, 0.1)}
F_4 = {(X_1, 0.5, 0.1, 0.4, 0), (X_2, 0.7, 0.0, 0.2, 0.1), (X_3, 0.5, 0.0, 0.2, 0.3), (X_4, 0.4, 0.0, 0.6, 0)}
E = {(X_1, 0.4, 0.1, 0.2, 0.3), (X_2, 0.8, 0.0, 0.1, 0.1), (X_3, 0.2, 0.0, 0.5, 0.3), (X_4, 0.7, 0.1, 0.2, 0)}

Step 3: To Find SM(F_i,E):

SM (F_1, E) = $1 - \frac{1}{4}\sqrt{0.08 + 0.02 + 0.14 + 0.06}$ = 0.8633

SM (F_2, E) = $1 - \frac{1}{4}\sqrt{0.04 + 0.06 + 0.09 + 0.04}$ = 0.8801

SM (F_3, E) = $1 - \frac{1}{4}\sqrt{0.02 + 0.06 + 0.08 + 0.04}$ = 0.8882

SM (F_4, E) = $1 - \frac{1}{4}\sqrt{0.14 + 0.02 + 0.18 + 0.168}$ = 0.8218

To Find SM_{NED}(F_i,E) by NED(F_i,E):

NED (F_1, E) = 0.27386

SM_{NED} (F_1, E) = $\frac{1}{1+NED\ (F1,E\ )}$ = 0.785

NED (F_2, E) = 0.2398

SM_{NED} (F_2, E) = 0.8066

NED (F_3, E) = 0.2236

SM_{NED} (F_3, E) = 0.8173

NED (F_4, E) = 0.3564

SM_{NED} (F_4, E) = 0.7372

To Find CM (F_i,E):

CM (F_1, E) = $\frac{0.32+0.59+0.33+0.5}{\sqrt{1.9\ X\ 1.88}} = \frac{1.74}{1.889}$ = 0.9207

CM (F_2, E) = $\frac{0.32+0.59+0.33+0.48}{\sqrt{1.84\ X\ 1.88}} = \frac{1.72}{1.8599}$ = 0.9248

CM (F_3, E) = $\frac{0.31+0.51+0.36+0.48}{\sqrt{1.64\ X\ 1.88}} = \frac{1.66}{1.7559}$ = 0.9454

CM (F_4, E) = $\frac{0.29+0.59+0.29+0.4}{\sqrt{1.86\ X\ 1.88}} = \frac{1.57}{1.8699}$ = 0.8396

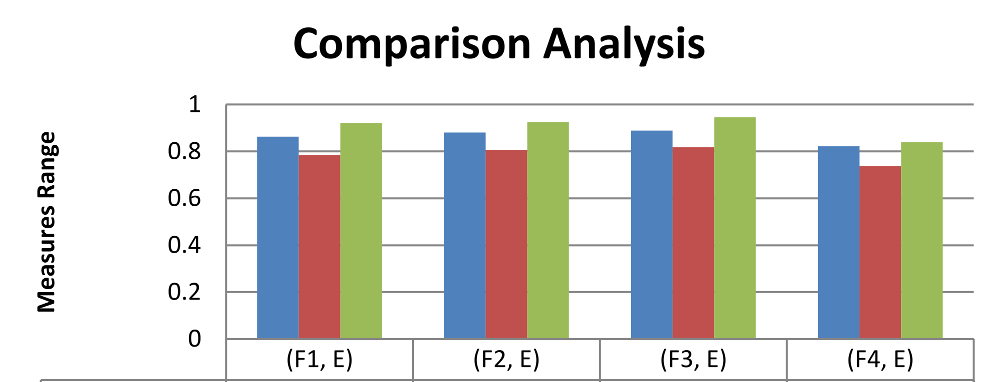
Step 4:

Zones	SM(F_i,E)	SM_{NED}(F_i,E)	CM (F_i, E)	Result
(F_1, E)	0.8633	0.785	0.9207	Medium Affected Zone
(F_2, E)	0.8801	0.8066	0.9248	High Affected Zone
(F_3, E)	0.8882	0.8173	0.9454	Severe Affected Zone
(F_4, E)	0.8218	0.7372	0.8396	Low Affected Zone

Table: 4.1 Calculated value of PFS correlation measure

5. Result and Discussion:

From our proposed method in picture fuzzy sets we deliver that picture fuzzy set is more flexible while comparing any of the real life situation. It helps the decision maker and give more accuracy when we are consider refusal value with picture fuzzy sets. We have compared our proposed method in similarity measure which is based on distance, non distance similarity measure and correlation measure also. All the measures are supporting and providing more accuracy when we are using picture fuzzy set with refusal value.



	(F1, E)	(F2, E)	(F3, E)	(F4, E)
SM(F1, E)	0.8633	0.8801	0.8882	0.8218
SMNED (Fi, E)	0.785	0.8066	0.8173	0.7372
CM(Fi, E)	0.9207	0.9248	0.9454	0.8396

Table 5.1 Graph of PFS with measures

6. Conclusion:

This research discusses the new idea of picture fuzzy sets in disaster management using real-world examples. It focuses in particular on one area hit by flooding and compares it with earlier analysis. When faced with a decision-making challenge involving disaster response, picture fuzzy sets are utilized to address the inherent uncertainties. Our proposed method is give more accuracy result while comparing with any of the previous measures with picture fuzzy sets. Future disaster management measures that are comparable to current ones will be concentrated on improving decision-making.

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