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# Generalized Parametric Intuitionistic Fuzzy Information Measure

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**ABSTRACT:** In the existing literature of information theory, there is a huge availability of measures of intuitionistic fuzzy entropies each with its own merits and limitations. Keeping in view the flexibility in the system and application areas and by using the concept of intuitionistic fuzzy set we have introduced a new generalized parametric measures of intuitionistic fuzzy entropy and studied there important and interesting properties.

**2020 Mathematics Subject Classification:** 94 D 05

**KEY WORDS:** Intuitionistic Fuzzy Entropy/Uncertainty/Fuzziness/Measures of Information/Shannon Entropy.

## I. INTRODUCTION

Shannon [1] measured the degree of uncertainty in a probability distribution's randomness using a concept known as "entropy." Zadeh [2] established the concept of fuzzy sets as a framework for handling problems that contain inherent uncertainty. Fuzziness is the outcome of ambiguity and is defined as the lack of clear boundaries for set membership when an entity is neither clearly inside a set nor outside of it. De Luca and Termini [3] initially worked on fuzzy entropy. Bhagwan Dass et. al. [4] proposed the generalized exponential measure of fuzzy entropy. Dutta and Banik [5] suggested a new generalized similarity measure having applications to criminal investigations in intuitionistic fuzzy surroundings. Singh and Ganie [6] applied fuzzy information measures to multicriteria decision analysis. A. Munde [7], [8] suggested that fuzzy information measures should be applied to decision-making. Gleb Beliakov, Jian-Zhang Wu, Weiping Ding [9] explained the representation, optimization, and generation of fuzzy measures. Hooda [10] introduced a new measure of fuzzy entropy that corresponds to the non-additive entropy of discrete probability distributions, having a parameter  $\alpha$ , characterized by Sharma and Taneja [11]. The concept of intuitionistic fuzzy set was first time given by K. T. Atanasav [12]. This fuzzy entropy measure involves only one parameter. To enhance this paradigm, a new generalized parametric measure of fuzzy entropy with two parameters  $\alpha$  and  $\beta$  has been introduced. Because of its parameters, the suggested measure has greater applicability in decision analysis. Compared to conventional entropy measures, the two-parameter fuzzy entropy offers a more nuanced assessment of uncertainty and complexity in each of these domains. The entropy measure's parameters generally provide the adjustment of its sensitivity to various elements of the data, hence augmenting its usefulness and efficacy in a wide range of intricate circumstances. In Section 2, we define some terms related to fuzzy set theory, probability theory, and the measurement of fuzzy data. In Section 3, we introduce an innovative fuzzy entropy measure called "parametric measure of fuzzy entropy with parameter  $\alpha$ " and verify its axiomatic validity. The monotonic behaviour of the proposed measure is also presented. The proposed measure and corresponding probabilistic measure are compared in this section. Also some fundamental set properties have been discussed, and finally, we conclude our research in Section 4.

## II. METHODOLOGY

### 2.1 Measure of Information

Assume that in an experiment using the probability distribution  $P=(p_1, p_2, \dots, p_n)$ ,  $X$  is a discrete random variable. The well-known Shannon [1] entropy,  $H(P)=-\sum_{i=1}^n p_i \log p_i$  (2.1.1) provides the information found in this experiment.

### 2.2 Fuzzy Set Theory

Recall that a membership function  $\mu_A:U \rightarrow [0,1]$  characterizes a fuzzy subset  $A$  in  $U$  (collection of speech) and expresses the degree of membership of  $x \in U$  as follows in  $A$ :

$$\mu_A(x)=0 \text{ if } x \notin A, \text{ and there is no uncertainty} \\ =1 \text{ if } x \in A \text{ and there is no uncertainty}$$



=0.5 if there is greatest uncertainty

In actuality,  $\mu_A(x)$  is related to each  $x \in U$  a classification of membership within set A. As the characteristic function of a crisp (i.e. non-fuzzy) set,  $\mu_A(x)$  has a value in  $\{0,1\}$  that is the characteristic function of a crisp (i.e. nonfuzzy) set.

**2.3 Intuitionistic fuzzy set:** - Let a set E be fixed. An intuitionistic fuzzy set (IFs) A of E is an object having the form  $A = \{ \langle x, \mu_A(x), \nu_A(x) \rangle \mid x \in E \}$  where the function  $\mu_A: E \rightarrow [0,1]$  and  $\nu_A: E \rightarrow [0,1]$  define respectively the degree of membership and degree of non membership of the element  $x \in E$  to the set A, which is a subset of E and for every  $x \in E$ ,  $0 \leq \mu_A(x) + \nu_A(x) \leq 1$ .

**2.4 Generalization of Intuitionistic Fuzzy Entropy Measures**

In 1968, Zadeh [2] introduced the concept of fuzzy entropy as a fuzziness measure. Since  $\mu_A(x)$  and  $1 - \mu_A(x)$  yields the similar degree of fuzziness and thus approximates the entropy due to Shannon [1], De Luca and Termini [3] presented the fuzzy entropy measure listed below:

$$H(A) = - \left[ \sum_{i=1}^n \mu_A(x_i) \cdot \log \mu_A(x_i) + \sum_{i=1}^n (1 - \mu_A(x_i)) \cdot \log (1 - \mu_A(x_i)) \right] \tag{2.3.1}$$

A collection of properties presented by De Luca and Termini [3] is commonly used as a standard for establishing new fuzzy entropies. Entropy, a measure of fuzziness in fuzzy set theory, reflects the average degree of ambiguity or having problems recognizing if an element is part of a set or not. Therefore, to be considered legitimate intuitionistic fuzzy entropy, a fuzzy set's average fuzziness measurement needs to satisfy the minimum requirements listed below:

1. It should be defined in the range  $0 \leq \mu_A(x) + \nu_A(x) \leq 1$
2. It should be continuous in this range.
3. It should be zero when  $\mu_A(x) = 0$  and  $\nu_A(x) = 1$ .
4. It should not be changed when  $\mu_A(x)$  changed in to  $\nu_A(x)$ .
5. It should be increasing function of  $\mu_A(x)$  in the range  $0 \leq \mu_A(x) \leq 0.5$  and decreasing function of  $\nu_A(x)$  in the range  $0 \leq \nu_A(x) \leq 0.5$
6. It should be concave function of  $\mu_A(x)$ .

**III. RESULT AND DISCUSSION**

Sharma and Taneja [11] characterize the entropies of discrete probability distributions that are not additive, as follows:

$$H^\beta(P) = \frac{1}{2^{1-\beta}} \left[ 2^{\beta-1} \cdot \sum_{i=1}^n p_i \log p_i \right], \beta > 0 \text{ and } \beta \neq 1 \tag{3.1}$$

And

$$H_\alpha^\beta(P) = \frac{1}{2^{1-\beta}} \left[ \left( \sum_{i=1}^n p_i^\alpha \right)^{\frac{\beta-1}{\alpha-1}} - 1 \right], \alpha \neq \beta, \alpha > 0, \beta > 0 \text{ and } \alpha \neq 1 \tag{3.2}$$

according to (3.1) and (3.2), Hooda [10] proposed the following measure of fuzzy entropy:

$$H^\beta(A) = \frac{1}{1-\beta} \left[ 2^{(\beta-1) \sum_{i=1}^n \{ \mu_A(x_i) \cdot \log \mu_A(x_i) + (1-\mu_A(x_i)) \cdot \log (1-\mu_A(x_i)) \}} - 1 \right], \beta > 0 \text{ and } \beta \neq 1 \tag{3.3}$$

Corresponding to (3.3), we suggest the intuitionistic fuzzy entropy measure listed below:

$$H_\alpha^\beta(A) = \frac{1}{1-\beta} \left[ 2^{(\beta-1) \sum_{i=1}^n \{ \mu_A^\alpha(x_i) \cdot \log \mu_A^\alpha(x_i) + (\nu_A(x_i))^\alpha \cdot \log (\nu_A(x_i))^\alpha \}} - 1 \right], \beta > 0 \text{ and } \beta \neq 1 \tag{3.4}$$

**Theorem:** The intuitionistic fuzzy entropy (3.4) is a valid measure.

**Proof.**  $H_{\alpha}^{\beta}(A)$  is a suitable intuitionistic fuzzy entropy measure if all of the following conditions apply:

$H_{\alpha}^{\beta}(A)=0$  iff  $\mu_A(x_i)=0$  and  $\nu_A(x)=1$ ,  $\forall x_i$  is trivially satisfied.

It should not be changed when  $\mu_A(x)$  changed in to  $\nu_A(x)$  is trivial.

Clearly, It is an increasing function of  $\mu_A(x)$  in the range  $0 \leq \mu_A(x) \leq 0.5$  and decreasing function of  $\nu_A(x)$  in the range  $0 \leq \nu_A(x) \leq 0.5$

Now to show that  $H_{\alpha}^{\beta}(A)$  is a concave function of  $\mu_A(x_i)$

$$\frac{d^2 H_{\alpha}^{\beta}(A)}{d\mu_A(x_i)^2} < 0.$$

Hence  $H_{\alpha}^{\beta}(A)$  is a concave function. It satisfies each and every criterion for intuitionistic fuzzy entropy. Consequently, it is an accurate representation of intuitionistic fuzzy information.

#### IV. CONCLUSION

We have proposed the parametric intuitionistic fuzzy entropy measure in Section 3 and examined its various properties. The proposed measure can be used in soft computing for data aggregation, decision-making, and economics because it satisfies basic set properties.

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