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Intuitionistic Fuzzy Sets in Selecting Appropriate Uses of Milk Based on Quality

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Abstract— Intuitionistic fuzzy set (IFS) is a powerful tool to deal with the uncertainty and vagueness involved in the process of decision making. In this paper, we use intuitionistic fuzzy sets (IFSs) in categorizing the raw milk for various products or uses.

Index Terms— fuzzy sets, hesitation degree, intuitionistic fuzzy sets, membership degree, non-membership degree, normalised hamming distance.

I. INTRODUCTION

The concept of fuzzy sets was proposed by L. A. Zadeh [5, 7] in 1965 to handle data which involves non-statistical uncertainty. Fuzzy set has been applied in various fields because of its immense practical importance. It facilitates gradual transitions from membership to non-membership and vice versa. But as far as the real life problems are considered, it may not always be possible that the degree of non-membership of an element in a fuzzy set is the difference between 1 and the membership degree. In many situations, there may arise some hesitation degree also.

The concept of IFS which includes the hesitation degree was first developed by Krassimir T. Atanassov [1, 2]. IFS is a generalized version of fuzzy set. The characteristic feature of IFS is that it assigns to each element a membership degree and a non-membership degree. IFS consider the hesitation margin to express the lack of knowledge involved in the situation. The flexibility of IFSs in handling uncertainty makes it very useful in modeling real life problems. IFS theory is more suitable for classification, pattern recognition, optimization and decision making. The idea of distance between IFSs is widely used in decision making. In the recent years, many distance measures between IFSs have been proposed. Here we use the normalized hamming distance to determine the most suitable purpose for which the milk sample can be used, based on the quality of the milk.

A. Definition 1 [3, 4]

Let X be a non-empty set. An intuitionistic fuzzy set A in X is an object having the form $A = \{\langle x,\ \mu_A(x), \nu_A(x)\rangle : x \in X\}$, where the functions $\mu_A(x), \nu_A(x) : X \to [0,1]$ define respectively, the degree of membership and degree of non-membership of the element $x \in X$ to the set A, which is a subset of X, and for every element $x \in X$, $0 \le \mu_A(x) + \nu_A(x) \le 1$.

B. Definition 2 [3, 4]

Let $A \in X$ be an IFS. Then $\pi_A(x) = 1 - \mu_A(x) - \nu_A(x)$ is called the intuitionistic fuzzy set index or hesitation margin of x in A. $\pi_A(x)$ is the degree of indeterminacy of $x \in X$ to the IFS A and $\pi_A(x) \in [0,1]$.

ie., $\pi_A(x) : X \to [0,1]$ and $0 \le \pi_A \le 1$ for every $x \in X$.

$\pi_A(x)$ expresses the lack of knowledge in knowing whether $x \in X$ belongs to IFS A or not.

II. APPLICATION OF IFS IN DETERMINING THE SUITABLE PURPOSE OF MILK

Milk is an important nutritive food. Besides this, it can be used for various other purposes. It is used in beauty products, fertilizers, cleansing agents and so on. Based on the quality of milk under consideration, it is chosen for consumption. So a proper method should be employed to analyse the quality of milk.

Intuitionistic Fuzzy Set (IFS) theory has become a wide area of research in different fields including medical science, social science, engineering, food processing, computer networks etc. In this paper we use IFS in selecting appropriate uses of milk based on quality.

For example, if the starch contained in the sample is very low and the water content is low, then the milk quality will be good. So definitely it can be used as a health drink. On the other hand, if the starch content is very high it is recommended as fertilizer.

This grading is achieved by finding the normalized Hamming distance between the two IFS's. The equation for calculating the normalized Hamming distance [6] between two intuitionistic fuzzy sets A and B is given by

$$l'_{IFS}(A,B) = \frac{1}{2n}\sum_{i=1}^{n}(|\mu_A(x_i) - \mu_B(x_i)| + |\nu_A(x_i) - \nu_B(x_i)| + |\pi_A(x_i) - \pi_B(x_i)|) \quad (1)$$

Since IFS incorporates the membership degree (ie., the percentage of adulterants present), the non-membership

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degree (ie., the percentage of adulterants not present) and the hesitation degree (ie., the percentage of indeterminacy), it can be used as a tool for grading the milk.

Let $S = \{ S_1, S_2, S_3 \}$ be the set of samples,

$U = \{ health\ drinks, beauty\ products, fertilizers \}$ be the set of uses and $A = \{ starch, water \}$ be the set of adulterants considered.

We consider the above grading in percentage. The following table shows the different categorization of uses based on the amount of adulterants.

Table 1. Different Uses of milk versus Adulterants.

Uses	Starch	Water
Health drinks	(0.1, 0.7, 0.2)	(0.3, 0.5, 0.2)
Beauty products	(0.5, 0.4, 0.1)	(0.6, 0.3, 0.1)
Fertilizers	(0.8, 0.1, 0.1)	(0.7, 0.2, 0.1)

Each sample is described by three numbers, ie., membership, non-membership and hesitation margin. The level of adulterants in each sample is shown in the table given below.

Table 2. Samples versus Adulterants.

Samples	Starch	Water
S_1	(0.8, 0.1, 0.1)	(0.2, 0.7, 0.1)
S_2	(0.3, 0.5, 0.2)	(0.5, 0.3, 0.2)
S_3	(0.1, 0.6, 0.3)	(0.2, 0.6, 0.2)

Using equation (1), we calculate the distance between each sample and each of the prescribed uses with reference to the level of adulterants.

Let A be the IFS representing the level of adulterants contained in the samples under consideration and B be the IFS which represents the level of adulterants present in the different categories of uses of milk. Here we have two adulterants, starch and water. So, n = 2.

For the sample S_1 :

(i) The distance between S_1 and health drinks is given by

$$l'_{IFS} = 1/4\{(|0.8 - 0.1| + |0.1 - 0.7| + |0.1 - 0.2|) + (|0.2 - 0.3| + |0.7 - 0.5| + |0.1 - 0.2|)\} = 0.45$$

(ii) The distance between S_1 and beauty products is given by

$$l'_{IFS} = 1/4\{(|0.8 - 0.5| + |0.1 - 0.4| + |0.1 - 0.1|) + (|0.2 - 0.6| + |0.7 - 0.3| + |0.1 - 0.1|)\} = 0.35$$

(iii) The distance between S_1 and fertilizers is given by

$$l'_{IFS} = 1/4\{(|0.8 - 0.8| + |0.1 - 0.1| + |0.1 - 0.1|) + (|0.2 - 0.7| + |0.7 - 0.2| + |0.1 - 0.1|)\} = 0.25$$

From the above, the shortest distance is 0.25. So, the sample S_1 can be used as a fertilizer. Similarly, the distances are calculated for the samples S_2 and S_3.

The different distances are given in the following table.

Table 3. Samples versus Uses

Samples	Health drinks	Beauty products	Fertilizers
S_1	0.45	0.35	0.25
S_2	0.2	0.15	0.35
S_3	0.1	0.4	0.6

III. RESULTS AND DISCUSSION

From the above table, the shortest distance gives the proper use for which the sample is suitable. Sample S_1 is appropriate for using it as a fertilizer. Similarly, S_2 and S_3 are suitable for beauty products and health drinks respectively.

IV. CONCLUSION

From the analysis based on Intuitionistic Fuzzy Set, the distance between the sample S_1 and health drinks is 0.45. The distance between S_1 and beauty products is 0.35. The distance between S_1 and fertilizers is 0.25. Out of the three distances, 0.25 is the least. It indicates that the sample S_1 is suitable for using it as fertilizer. Similarly, we find the distance between sample S_2 and health drinks, beauty products, fertilizers are 0.2, 0.15 and 0.35 respectively. Among these the smallest distance is 0.15, which is the distance between S_2 and beauty products. Hence the sample S_2 is suitable for beauty products. In case of sample S_3, the distances are 0.1, 0.4 and 0.6 for health drinks, beauty products and fertilizers respectively. So, the sample S_3 is suitable for health drinks.

Intuitionistic Fuzzy Set is an efficient tool in selecting the most appropriate product based on the quantity of adulterants present in milk. So, this can be utilized in the decision making process involved in milk quality analysis. The idea can be implemented in developing quality controllers.

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