A Selection based on Seller’s Perspectives of insect detection techniques in stored grains by using weighted correlation coefficient under intuitionistic fuzzy environment

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Abstract. Grains have enacted a supreme role in human history and grain agriculture. Cereal grains are the world’s most substantial origin of food energy. The loss of grains can occur in three stages which are Pre-harvest, harvest and Post-harvest stages. Post-harvest losses take place during the time of harvest and the stage of human consumption. The losses can occur at the process of transportation, processing, storage and also by insects attack. In many developing countries the post-harvest losses are normal. In grain storage, several methods are being used to detect insects. But methods which are efficient and also time saving are very much needed. So, researchers have advanced many detection techniques to find insects in the stored grains. The weighted correlation coefficient using entropy weights give more enlightenment to solve many prevailing problem in real life. The encouragement of this research work is to interpret the sellers perspectives of insect detection technique for stored grains.

1. INTRODUCTION

In 1965, Fuzzy set theory was established by Professor Lofti Aliaskerzadeh at the University of California which is very practicable to deal with real life events. In 1983, Krassimir Atanassov advanced the concept of intuitionistic fuzzy sets as a continuation of Zadehs conception of fuzzy set, which itself developed the idea of classical set theory [1][3]. In real life phenomena, there is no optimal solution for a complex problem. Therefore, multi-criteria decision making is considered here as an effective tool to make the decision correctly. Multi-criteria decision making (MCDM) is to uphold decision-makers challenging such delinquent situation.

In this paper, a multi-criteria fuzzy decision-making is suggested method in accordance with the weighted correlation coefficient utilizing entropy weights under intuitionistic fuzzy environment. By using fuzzy entropy, the degree of intuitionism of a set can be measured [2]. An entropy weight model is constructed to determine the criteria weights. The criteria values are obtained in the form of intuitionistic fuzzy number. An estimation formula of the weighted correlation coefficient between an alternative and the ideal alternative are clarified. Based on the weighted correlation coefficients the most acceptable alternative can be selected. This paper is structured as follows: section 2 consists of the definitions of intuitionistic fuzzy sets, section 3 includes the fuzzy decision-making method, section 4 interprets the case study, section 5
describes the problem description and suggests fuzzy decision-making method with an example and the closure of the paper takes in the final section.

2. Preliminaries

Definition 2.1 Let A be an intuitionistic fuzzy set in the universal set X which is formulated by,

\[ A = \{(x, \mu_A(x), \nu_A(x)) | x \in X\} \]

where \( \mu_A(x) : X \to [0, 1] \) and \( \nu_A(x) : X \to [0, 1] \) that satisfies the condition, 

\[ 0 \leq \mu_A(x) + \nu_A(x) \leq 1. \]

Here the membership degree and non-membership degree for each element to the set A is described by \( \mu_A(x) \) and \( \nu_A(x) \), respectively [1][9].

Definition 2.2 Let A be an intuitionistic fuzzy set which is determined on X. Then the indeterminacy degree of every \( x \) to A is denoted as follows,

\[ \pi_A(x) = 1 - \mu_A(x) - \nu_A(x), x \in A, \]

with the condition, \( 0 \leq \pi_A(x) \leq 1, x \in X \)[1][9]

Definition 2.3 Let X be the universe of discourse. Let A and B be two intuitionistic fuzzy sets. Then the correlation coefficient of A and B is defined by,

\[ K(A, B) = C(A, B) \sqrt{(T(A), T(B))} \]

where \( C(A, B) = \sum_{i=1}^{n} (\mu_A(x_i) \mu_B(x_i) + \nu_A(x_i) \nu_B(x_i)) \) is the correlation of two intuitionistic fuzzy sets A and B [5]. The informational intuitionistic energies of two IFSs A and B are shown by \( T(A) = \sum_{i=1}^{n} (\mu_A^2(x_i) + \nu_A^2(x_i)) \) and \( T(B) = \sum_{i=1}^{n} (\mu_B^2(x_i) + \nu_B^2(x_i)) \) respectively [4]. The correlation coefficient of two IFSs A and B satisfies the succeeding aspects:

(i) \( 0 \leq K(A, B) \leq 1 \), (ii) \( K(A, B) = K(B, A) \), (iii) \( K(A, B) = 1 \) if \( A = B \).

Definition 2.4 Let A be an intuitionistic fuzzy set. Then the intuitionistic entropy of an IFS A is denoted as follows [2]:

\[ E(A) = \sum_{i=1}^{n} (1 - \mu_A(x_i) - \nu_A(x_i)) = \sum_{i=1}^{n} \pi_A(x_i) \]

3. A technique of multicriteria fuzzy decision-making method based on the weighted correlation coefficient

In this part, the decision-making problems with unknown information of criteria weights for alternatives were discussed: Let us consider a known set of alternatives as \( A = \{A_1, A_2, ..., A_m\} \) and a set of criteria as \( C = \{C_1, C_2, ..., C_n\} \). The component of the alternative \( A_i \) is interpreted by the subsequent IFS:

\[ A_i = \{(C_j, \mu_{A_i}(C_j), \nu_{A_i}(C_j)) | C_j \in C\}, \]

where \( 0 \leq \mu_{A_i}(C_j) + \nu_{A_i}(C_j) \leq 1, C_j \in C, j = 1, 2, ..., n \) and \( i = 1, 2, ..., m \) [14]. Here, the information about weight \( w_j \) of the criterion \( C_j(j = 1, 2, ..., n) \) is totally indefinite. So, firstly
there is a need to find the criteria weight, for that an exact model of entropy weights must be initiated [8]:

$$w_j = 1 - H_j n - \sum_{j=1}^{n} H_j$$  \hspace{1cm} (2)$$

where $w_j \in [0, 1]$, $\sum_{j=1}^{n} w_j = 1$,

$$H_j = 1 m E(C_j) = 1 m \sum_{i=1}^{m} (1 - \mu_{A_i}(C_j) - \nu_{A_i}(C_j)) = 1 m \sum_{i=1}^{m} \pi_{A_i}(C_j),$$

$0 \leq H_j \leq 1$, $j = (1, 2, ... n)$ Based on the entropy theory, if the entropy value for every criterion is lesser over alternatives, it must give decision-makers with the effective information. Hence, the criterion must be selected a greater weight; if not, such a criterion must be decided as a very less weight by maximum number of decision-makers. Based on the decision-making problem, the ideal alternative for excellence for the ranking order of the alternatives is given as:

$$A^* = \{\langle C_j, 1, 0 \rangle / C_j \in C\},$$  \hspace{1cm} (3)$$

In 1991, Gerstenkorn and Manko recommended the correlation coefficient between intuitionistic fuzzy sets. By using entropy weights for criteria, the correlation coefficient between an alternative $A_i$ and the ideal alternative $A^*$ is calculated by the weighted correlation coefficient $W_i (i = 1, 2, ... m)$:

$$W_i (A^*, A_i) = C_i (A^*, A_i) \sqrt{T^*(A^*) T_i (A_i)} = \sum_{j=1}^{n} w_j \mu_{A_i}(C_j) \sqrt{\sum_{j=1}^{n} w_j (\mu_{A_i}(C_j) + \nu_{A_i}(C_j))^2}$$  \hspace{1cm} (4)$$

The higher the value of weighted correlation coefficient $W_i$ the more appropriate the alternative $A_i$, when the alternative $A_i$ is nearer to the ideal alternative $A^*$. On the basis of the weighted correlation coefficient all the alternatives are ranked and select the most acceptable one.

4. Case Study

Various studies have shown that people who take food grains can reduce heart disease, diabetes, colon cancer, obesity and have a tendency to be active for a longer period of time. In the current scenario, food borne diseases are caused by some stored food materials because of harmful insects and microorganisms. An Insect detection method helps us to detect insect infestation in the grain samples. The most frequently formed and expanded grains are rice, wheat and maize. Some of the food items like breads, cereals, pasta, muesli, tortillas, oatmeal and also junk food items like pastries and cookies are made from grains. Especially in processed foods, Grain -based products are used to make ingredients. In India, rice and wheat are considered as the staple food grain. So, the seller need to choose one of the best insect detection methods based on certain criteria such as cost, time saving, reliability in detecting insects, convenience to operate and harmless technique. There are so many advanced insect detection methods that are established by the researchers to control the post-harvest losses of grains and also to detect the infested grain. In this paper, an evaluation of three insect detection methods is given as follows which are based on perception of sellers desire.

Grain probes and Insect traps

In grain samples, the insect probe trap is pioneered to diagnose the existence of insects in storage [6]. In this technology the actions of the insects are easily manipulated and also detect
the insect density. The insect traps are very effortless to negotiate. Loschiavo and Atkinson advanced a brass probe trap for noticing several species of insect in stored food grain [4]. By using probe traps thirteen insect species are determined especially, eight types of species were identified with grain samples. The predominant repeated insects obtained in the grain samples are Cryptolestes ferrugineus and Rhyzopertha domincawere [12]. An insect probe trap is made up of the materials namely, the main tube, insect trapping tube and a detachable cone at the bottom. The main tube is constructed by equispaced perforations of 2 mm diameter. The insect trap has to be perpendicularly injected into the grain samples like rice, wheat, etc., with the white plastic cone downside. As the insects enter into the hole and fall into the detachable white cone at the bottom they are captured. Then the captured insects cannot escape and the insects are trapped interminably. There are no chemicals, no maintenance cost and no side effects in this technology to keep it executing [10], [13] and [15].

Visual lures
The insects, flies, beetles and moths can easily be attracted by the coloured elements by means of their particular reflectance. A large number of stored grain pests and nearly, hundreds of insect species are engaged to artificial light of various wavelengths. Visual lures is also a common insect detection technique which is also applied in insect manipulation fall into the succeeding classification: lights which magnetizes pests from dark environment (mills, elevators, warehouses). Particularly, in food warehouses and processing plants, insect electrocutors can be very powerful in various scenarios. When compared to dark places, the light is not perceptible. So, the electrocutors are placed in the dark environment. To find seasonal format of insect density and to examine the occupancy of insects, light traps have been used for a number of decades. But this method is not very effective [12].

Acoustical Methods
In 1996, Hagstrum, Webb, and vick observed existence of one infested kernel in a 650 g of grain. In this method, by using insect-feeding sounds one can spontaneously examine both internal and external grain feeding insects. Acoustical methods are useful to detect when the insects are present in the kernals of grain by amplification, filtering of their movement and feeding sounds. The main advantage of this method is to find insects in grain that needs a quantitative knowledge of various physical factors and the biological factors (insect behavior, unfavorable environment and insect inactivity) which damages insect distribution, sound production and detection. The disadvantage of this method is they cannot find infestation by initial larval stages of insects and dead insects in grain [7],[11] and [12].

5. Problem Description
Suppose that the seller needs to buy an insect detection technique to gain the customers satisfaction, the alternatives are taken as Grain probes and traps, Visual lures, and Acoustical methods. Then the seller requirement is to choose one favorable alternative in accordance with the certain set of criteria which are specified as follows: Cost, Time saving, Reliability in detecting insects, Convenience to operate, and Harmless technique. The values of each single alternative along with the certain set of criteria are given by the decision maker. The satisfying and dissatisfying degree of the known set of alternatives $A_i = (i = 1, 2, ...m)$ accompanied by the criteria $C_j = (j = 1, 2, ...n)$ which are taken in the form of intuitionistic fuzzy numbers. To establish the ranking sequence of the alternatives, by using the fuzzy decision-making method for multi-criteria decision making problem with the intuitionistic fuzzy information the most acceptable alternative is selected.
5.1. Methodology
The membership degree and non-membership degree of each alternative $A_i (i = 1, 2, 3)$ along with the criterion $C_j (j = 1, 2, 3, 4, 5)$ are given by the decision maker which is specified as follows:

Alternatives
$A_1 \rightarrow$ Grain probes and insect traps
$A_2 \rightarrow$ Visual lures
$A_3 \rightarrow$ Acoustical methods

Criteria
$C_1 \rightarrow$ Cost
$C_2 \rightarrow$ Time saving
$C_3 \rightarrow$ Reliability in detecting insects
$C_4 \rightarrow$ Convenience to operate
$C_5 \rightarrow$ Harmless technique

Step: 1
By using equation (2), entropy weights are identified for every criterion weight $w_j (j = 1, 2, 3, 4, 5)$ that are given as,

$w_1 = 0.1843,$
$w_2 = 0.2039,$
$w_3 = 0.2000,$
$w_4 = 0.2078,$
$w_5 = 0.2039.$

Step: 2
The weighted correlation coefficient are calculated by utilizing equation (4) which are given as,

$W_1 (A^*, A_1) = 0.9850,$
$W_2 (A^*, A_2) = 0.9734,$
$W_3 (A^*, A_3) = 0.9244.$

Step: 3
In accordance with the weighted correlation coefficient, the ranking order of the alternatives is done as follows $A_1 > A_2 > A_3$
Hence $A_1$ is the most acceptable alternative.

6. Conclusion
In many developing countries, during post-harvest period most of the cereal grains are lost at every year. Furthermore, at the time storage grains are also infected by rodents, birds, insects, microorganisms and mites. But, the customer requirement is insect- free grain. In order to maintain the current state of affairs, an insect detection technique is adopted which helps us to maintain the safety of food grain production. The recommended fuzzy decision-making method is very modest and also accurate to deal with multi-criteria decision-making under intuitionistic fuzzy environment. Finally, in accordance with the entire evaluation of this paper Grain probes and insect traps method is the most acceptable alternative.

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