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# Application of Inclusion Measures in the Field of Cultivation of Crops

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ABSTRACT
In this paper, the inclusion measure to a multi attribute decision making problem in the field of cultivation of crops is presented to show effectiveness of proposed inclusion measure based on various distance measures, and results obtained are discussed. Though having a simple measure for calculation, the inclusion measure presents a new approach for handling the interval neutrosophic information. Finally the best distance measures among the various distance measures was discussed.
**Keywords :** Single Valued Neutrosophic Set (SVNS), Interval Neutrosophic Set (INS).

## I. INTRODUCTION

The concept of the neutrosophic set developed by Smarandache [12] is a set model which generalizes the classic set, fuzzy set [21], interval fuzzy set [14] intuitionistic fuzzy set [1] and interval valued intuitionistic fuzzy set [2]. In contrast to intuitionistic fuzzy sets and also interval valued intuitionistic fuzzy sets, indeterminacy degree of an element in a universe of discourse is expressed explicitly in the neutrosophic set. There are three membership functions such that truth membership, indeterminacy membership and falsity membership in a neutrosophic set, and they are independent. However, the neutrosophic set generalizes the above mentioned sets from philosophical point of view and its functions $T_A(x)$ , $I_A(x)$ and $F_A(x)$ are real standard or nonstandard subsets of $]0^-,1^+[$ and are defined by $T_A(x): X \to ]0^-,1^+[$ , $I_A(x): X \to ]0^-,1^+[$ and $F_A(x): X \to ]0^-,1^+[$ . That is, its components $T_A(x), I_A(x), \mathrm{F}_A(\mathrm{x})$ are non-standard subsets included in the unitary nonstandard interval $]0^-,1^+[$ or standard subsets included in the unitary standard interval $[0,1]$ as in the intuitionistic fuzzy set.

## II. DISTANCE MEASURES FOR INTERVAL NEUTROSOPHIC SET

Let

$$A=\left\{\left\langle x,\left[u_A^L(x),u_A^U(x)\right],\left[p_A^L(x),p_A^U(x)\right],\left[v_A^L(x),v_A^U(x)\right]\right\rangle : x\in X\right\}$$

$$B=\left\{\left\langle x,\left[u_B^L(x),u_B^U(x)\right],\left[p_B^L(x),p_B^U(x)\right],\left[v_B^L(x),v_B^U(x)\right]\right\rangle : x\in X\right\}$$

be two INS in X.

**Definition 2.1 [23]**

The Hamming distance measure

$$d_H(A,B)=\frac{1}{6}\sum_{i=1}^{n}\left\{\begin{array}{l}\left|u_A^L(x_i)-u_B^L(x_i)\right|+\left|p_A^L(x_i)-p_B^L(x_i)\right|+\\ \left|v_A^L(x_i)-v_B^L(x_i)\right|+\left|u_A^U(x_i)-u_B^U(x_i)\right|+\\ \left|p_A^U(x_i)-p_B^U(x_i)\right|+\left|v_A^U(x_i)-v_B^U(x_i)\right|\end{array}\right\}$$

Definition 2.2 [23]

The Euclidean distance measure

$$d_E(A,B)=\sqrt{\frac{1}{6}\sum_{i=1}^{n}\left\{\begin{array}{l}\left(u_A^L(x_i)-u_B^L(x_i)\right)^2+\left(p_A^L(x_i)-p_B^L(x_i)\right)^2+\\ \left(v_A^L(x_i)-v_B^L(x_i)\right)^2+\left(u_A^U(x_i)-u_B^U(x_i)\right)^2+\\ \left(p_A^U(x_i)-p_B^U(x_i)\right)^2+\left(v_A^U(x_i)-v_B^U(x_i)\right)^2\end{array}\right\}}$$

Definition 2.3 [23]

The normalized Hamming distance measure

$$d_{nH}(A,B)=\frac{1}{6n}\sum_{i=1}^{n}\left\{\begin{array}{l}\left|u_A^L(x_i)-u_B^L(x_i)\right|+\left|p_A^L(x_i)-p_B^L(x_i)\right|+\\ \left|v_A^L(x_i)-v_B^L(x_i)\right|+\left|u_A^U(x_i)-u_B^U(x_i)\right|+\\ \left|p_A^U(x_i)-p_B^U(x_i)\right|+\left|v_A^U(x_i)-v_B^U(x_i)\right|\end{array}\right\}$$

Definition 2.4 [23]

The normalized Euclidean distance measure

$$d_{nE}(A,B)=\sqrt{\frac{1}{6n}\sum_{i=1}^{n}\left\{\begin{array}{l}\left(u_A^L(x_i)-u_B^L(x_i)\right)^2+\left(p_A^L(x_i)-p_B^L(x_i)\right)^2+\\ \left(v_A^L(x_i)-v_B^L(x_i)\right)^2+\left(u_A^U(x_i)-u_B^U(x_i)\right)^2+\\ \left(p_A^U(x_i)-p_B^U(x_i)\right)^2+\left(v_A^U(x_i)-v_B^U(x_i)\right)^2\end{array}\right\}}$$

Definition 2.5 [25]

The Geometric distance measure

$$d_r(A,B)=\sum_{i=1}^{n}\left|\left\{\begin{array}{l}\left(u_A^L(x_i)-u_B^L(x_i)\right)^r+\left(p_A^L(x_i)-p_B^L(x_i)\right)^r+\\ \left(v_A^L(x_i)-v_B^L(x_i)\right)^r+\left(u_A^U(x_i)-u_B^U(x_i)\right)^r+\\ \left(p_A^U(x_i)-p_B^U(x_i)\right)^r+\left(v_A^U(x_i)-v_B^U(x_i)\right)^r\end{array}\right\}\right|^{1/r}$$

Definition 2.6 [26]

The normalized Geometric distance measure

$$d_{nr}(A,B)=\frac{1}{4}\sum_{j=1}^{4}\frac{1}{6}\sum_{i=1}^{6}\sqrt{\left\{\begin{array}{l}\left(u_A^L(x_i)-u_B^L(x_i)\right)^2+\left(p_A^L(x_i)-p_B^L(x_i)\right)^2+\\ \left(v_A^L(x_i)-v_B^L(x_i)\right)^2+\left(u_A^U(x_i)-u_B^U(x_i)\right)^2+\\ \left(p_A^U(x_i)-p_B^U(x_i)\right)^2+\left(v_A^U(x_i)-v_B^U(x_i)\right)^2\end{array}\right\}}$$

Definition 2.7 [26]

The Hausdorff distance measure

$$d_q(A,B)=\frac{1}{4}\sum_{j=1}^{4}\frac{1}{3}\sum_{i=1}^{3}\max\begin{Bmatrix}\left|u_A^L(x_i)-u_B^L(x_i)\right|,\left|u_A^U(x_i)-u_B^U(x_i)\right|+\\ \left|v_A^L(x_i)-v_B^L(x_i)\right|,\left|v_A^U(x_i)-v_B^U(x_i)\right|+\\ \left|p_A^L(x_i)-p_B^L(x_i)\right|,\left|p_A^U(x_i)-p_B^U(x_i)\right|\end{Bmatrix}$$

Inclusion measures for interval neutrosophic sets

Definition 2.8 [18]

Inclusion measures based on the distance measure

Assume that $d: INS(X)\times INS(X)\rightarrow R^{+}\cup\{0\}$ is a distance between interval neutro-sophic sets in X. To establish the inclusion indicator expressing the degree to which A belongs to B, we use the distance between interval neutrosophic sets A and $A\cap B$ . If it is considered the inclusion measure based on distance measure, we have the formal given by

$$I_d(A,B)=1-d(A,A\cap B)$$

## III. APPLICATION OF INCLUSION MEASURE IN THE FIELD OF CULTIVATION OF CROPS

Pathinathan.T and Johnson Savarimuthu.S [24] have been studying the problems faced by the farmers, who were planting the cash crops. In this paper we have extended our research work by analysing the rain fed cultivation in the same locality. It has been observed that the farmers of Villupuram district are planting rain fed crops like Kambu, Cholam, Ulundudal, Thinai,etc.

Rain fed cultivation depends on seasonal monsoon, water resources like rivers, tanks and irrigation wells. The water resources of this district have become dry. Even in borewells the water level have gone down so low. Farmers depend on electricity to pump water and electricity supply is very erratic. Hence farmers have to use diesel engines and as the cost of fuel goes up regularly beyond their debt increases.

A. Experts (from Villupuram District)

We collected the overall information regarding agriculture problems from the following five Experts in Villupuram District.

DM1. Mr. P. Ravi, farmer who owns a land, Kallakurichi.

DM2. Mr.S.Rajesh, farmer who is doing share cropping (Kuthagai), Sankarapuram.

DM3. Mr.Arockiaraj, Private Agricultural Officer, Viriyur.

DM4. Mr. A. Anand, Moongilthuraipattu

DM5. Mr.Kirubanithu, Farmer, ThiyagaDurgan

**B. Alternatives**

The following are the major rain fed crops which are cultivated in Villupuram district. We took these crops as our alternatives.

A1. Kambu(Millet)

A2. Cholam(Maize)

A3. Ulundudal(Black gram)

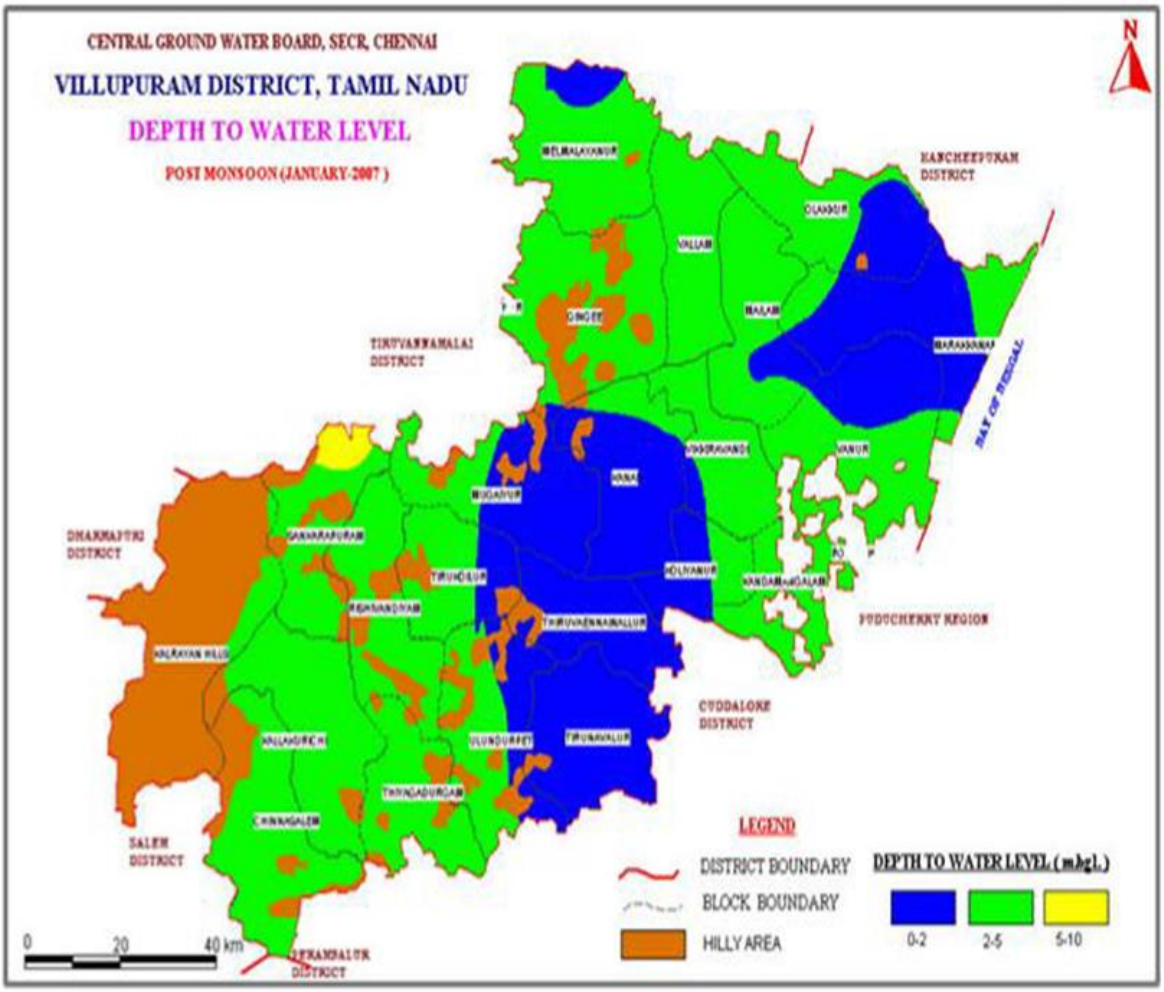
A4. Thinai(Fox tail millet)

### C. Attributes

We collected a few major problems faced by the farmers and we interviewed them to filter out four major attributes .

(i) Benefit Type (Qualitative in nature)

(ii) Cost Type (Quantitative in nature).




X1. Crop failure (Benefit Type) – Due to reduction in crop yield, nutritional need of the people is not met. Failure of the crop means drying crop and inability to save the standing crop.

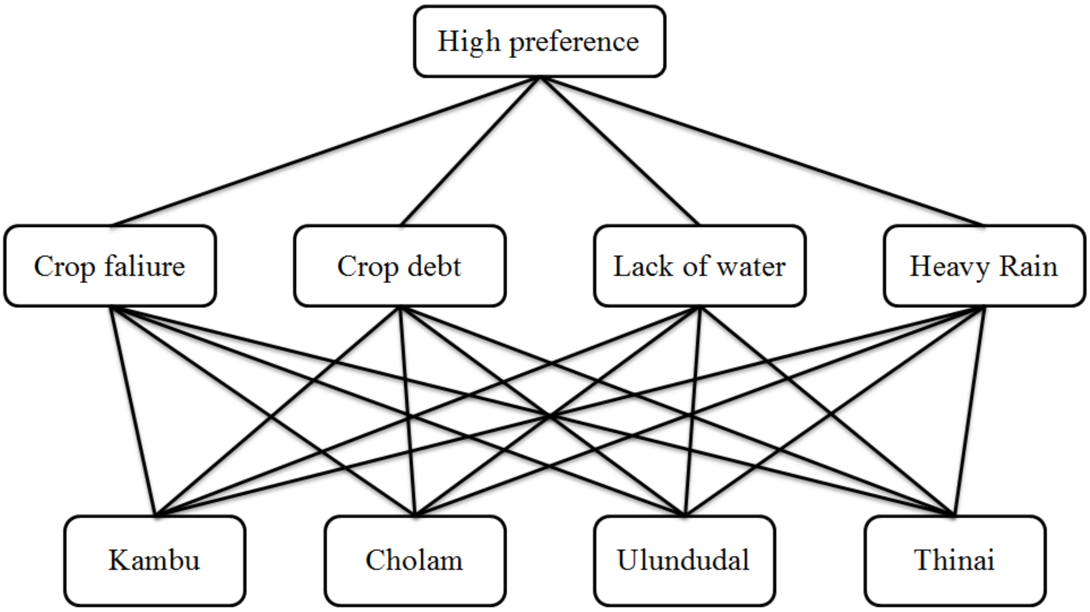
X2. Crop debt (Cost Type) – Borrowing of money from private money lenders, agriculture debt to meet the expenses increases the interest.

X3. Lack of water (Benefit Type) - Water scarcity in Gamukha, Sathanur Dam and truant monsoon.

X4. Heavy rain and Cyclone (Nilam) (Benefit Type) – Soil erosion, loss of soil fertility is caused; livelihood and farming lands have been destroyed by Nilamcyclone in the recent year across the Villupuram District.

### D. Hierarchical Structure

The hierarchical structure of this decision making problem is shown from the below diagram;




### E. ADAPTATION AND DESCRIPTION OF THE PROBLEM

The patterns are denoted by the following INSs as

$$A_1 = \begin{Bmatrix} \langle x_1,[0.4,0.6],[0.2,0.3],[0.1,0.3]\rangle,\langle x_2,[0.6,0.7],[0.2,0.3],[0.1,0.2]\rangle, \\ \langle x_3,[0.5,0.6],[0.2,0.4],[0.6,0.4]\rangle,\langle x_4,[0.5,0.7],[0.1,0.2],[0.4,0.5]\rangle \end{Bmatrix}$$

$$A_2 = \begin{Bmatrix} \langle x_1,[0.5,0.6],[0.1,0.3],[0.2,0.3]\rangle,\langle x_2,[0.6,0.7],[0.2,0.5],[0.2,0.3]\rangle, \\ \langle x_3,[0.5,0.6],[0.1,0.3],[0.3,0.4]\rangle,\langle x_4,[0.4,0.7],[0.1,0.3],[0.1,0.2]\rangle \end{Bmatrix}$$

$$A_3 = \begin{Bmatrix} \langle x_1,[0.3,0.5],[0.3,0.5],[0.3,0.4]\rangle,\langle x_2,[0.1,0.3],[0.4,0.2],[0.5,0.6]\rangle, \\ \langle x_3,[0.2,0.5],[0.1,0.2],[0.4,0.5]\rangle,\langle x_4,[0.2,0.3],[0.3,0.4],[0.4,0.6]\rangle \end{Bmatrix}$$

$$A_4 = \begin{Bmatrix} \langle x_1,[0.3,0.4],[0.3,0.4],[0.3,0.4]\rangle,\langle x_2,[0.4,0.7],[0.1,0.3],[0.1,0.2]\rangle, \\ \langle x_3,[0.4,0.5],[0.2,0.3],[0.3,0.4]\rangle,\langle x_4,[0.4,0.6],[0.1,0.3],[0.2,0.4]\rangle \end{Bmatrix}$$

Given an unknown sample (i.e., the positive ideal solution of decision)

$$A^+ = \begin{Bmatrix} \langle x_1,[0.5,0.6],[0.1,0.3],[0.1,0.3]\rangle,\langle x_2,[0.6,0.7],[0.1,0.3],[0.1,0.2]\rangle, \\ \langle x_3,[0.5,0.6],[0.1,0.2],[0.3,0.4]\rangle,\langle x_4,[0.5,0.7],[0.1,0.2],[0.4,0.7]\rangle \end{Bmatrix}$$

Our aim is to classify pattern $A^+$ to one of the decision alternatives $A_1, A_2, A_3,$ and $A_4$.

First we have to find $A^+ \bigcap_{i=1}^{4} A_i$ as follows:

$$A^{+}\bigcap A_1=\left\{\begin{array}{l}\left\langle\begin{array}{l}x_1,\left[\min\{0.4,0.5\},\min\{0.6,0.6\}\right],\\ \left[\max\{0.2,0.1\},\max\{0.3,0.3\}\right],\\ \left[\max\{0.1,0.1\},\max\{0.3,0.3\}\right]\end{array}\right\rangle,\left\langle\begin{array}{l}x_2,\left[\min\{0.6,0.6\},\min\{0.7,0.7\}\right],\\ \left[\max\{0.2,0.1\},\max\{0.3,0.3\}\right],\\ \left[\max\{0.1,0.1\},\max\{0.2,0.2\}\right]\end{array}\right\rangle\\ \left\langle\begin{array}{l}x_3,\left[\min\{0.5,0.5\},\min\{0.6,0.6\}\right],\\ \left[\max\{0.2,0.1\},\max\{0.4,0.2\}\right],\\ \left[\max\{0.6,0.3\},\max\{0.4,0.4\}\right]\end{array}\right\rangle,\left\langle\begin{array}{l}x_4,\left[\min\{0.5,0.5\},\min\{0.7,0.7\}\right],\\ \left[\max\{0.1,0.1\},\max\{0.2,0.2\}\right],\\ \left[\max\{0.4,0.4\},\max\{0.5,0.7\}\right]\end{array}\right\rangle\end{array}\right\}$$

$$A^{+}\cap A_1=\left\{\begin{array}{l}\langle x_1,[0.4,0.6],[0.2,0.3],[0.1,0.3]\rangle,\langle x_2,[0.6,0.7],[0.2,0.3],[0.1,0.2]\rangle,\\ \langle x_3,[0.5,0.6],[0.2,0.4],[0.6,0.4]\rangle,\langle x_4,[0.5,0.7],[0.1,0.2],[0.4,0.7]\rangle\end{array}\right\},$$

Similarly we compute

$$A^{+}\cap A_2=\left\{\begin{array}{l}\langle x_1,[0.5,0.6],[0.1,0.3],[0.2,0.3]\rangle,\langle x_2,[0.6,0.7],[0.2,0.5],[0.2,0.3]\rangle,\\ \langle x_3,[0.5,0.6],[0.1,0.3],[0.3,0.4]\rangle,\langle x_4,[0.4,0.7],[0.1,0.3],[0.4,0.7]\rangle\end{array}\right\},$$

$$A^{+}\cap A_3=\left\{\begin{array}{l}\langle x_1,[0.3,0.5],[0.3,0.5],[0.3,0.4]\rangle,\langle x_2,[0.1,0.3],[0.4,0.3],[0.5,0.6]\rangle,\\ \langle x_3,[0.2,0.5],[0.1,0.2],[0.4,0.5]\rangle,\langle x_4,[0.2,0.3],[0.3,0.4],[0.4,0.7]\rangle\end{array}\right\},$$

and

$$A^{+}\cap A_4=\left\{\begin{array}{l}\langle x_1,[0.3,0.4],[0.3,0.4],[0.3,0.4]\rangle,\langle x_2,[0.4,0.7],[0.1,0.3],[0.1,0.2]\rangle,\\ \langle x_3,[0.4,0.5],[0.2,0.3],[0.3,0.4]\rangle,\langle x_4,[0.4,0.6],[0.1,0.3],[0.4,0.7]\rangle\end{array}\right\},$$

Using the above mentioned various distance measures we can compute the inclusion measure for INSs as follows:

3.1.Based on Hamming distance measure:

$$d_H(A,B)=\frac{1}{6}\sum_{i=1}^{n}\left\{\begin{array}{l}\left|u_A^L(x_i)-u_B^L(x_i)\right|+\left|p_A^L(x_i)-p_B^L(x_i)\right|+\\ \left|v_A^L(x_i)-v_B^L(x_i)\right|+\left|u_A^U(x_i)-u_B^U(x_i)\right|+\\ \left|p_A^U(x_i)-p_B^U(x_i)\right|+\left|v_A^U(x_i)-v_B^U(x_i)\right|\end{array}\right\}$$

First we have to compute the distance between $A^{+}$ and $A\bigcap_{i=1}^{4}A_i$ based on the Hamming distance measure as follows:

$$d_H\left(A^{+},A^{+}\cap A_1\right)=\frac{1}{6}\left\{\begin{array}{l}|0.5-0.4|+|0.6-0.6|+|0.1-0.2|+|0.3-0.3|+|0.1-0.1|+|0.3-0.3|+\\ |0.6-0.6|+|0.7-0.7|+|0.1-0.2|+|0.3-0.3|+|0.1-0.1|+|0.2-0.2|+\\ |0.5-0.5|+|0.6-0.6|+|0.1-0.2|+|0.2-0.4|+|0.3-0.6|+|0.4-0.4|+\\ |0.5-0.5|+|0.7-0.7|+|0.1-0.1|+|0.2-0.2|+|0.4-0.4|+|0.7-0.7|\end{array}\right\}$$

$$d_H\left(A^{+},A^{+}\cap A_1\right)=\frac{1}{6}\{0.1+0.1+0.1+0.1+0.2+0.3\}$$

$$d_H\left(A^{+},A^{+}\cap A_1\right)=0.15$$

$I\left(A^{+}, A_{1}\right)=1-0.15=0.85$

Similarly we can compute

$$\left.\begin{array}{l} I\left(A^{+}, A_{1}\right)=0.85 \\ I\left(A^{+}, A_{2}\right)=0.85 \end{array}\right\} \text{Same result}$$

$I\left(A^{+}, A_{3}\right)=0.21667$

$I\left(A^{+}, A_{4}\right)=0.68333$

Thus we rank the crops according to inclusion measure based on the Hamming distance measure as

$$A_{2}=A_{1} \succ A_{4} \succ A_{3}$$

3.2.Based on Euclidean distance measure:

$$d_{E}(A, B)=\sqrt{\frac{1}{6} \sum_{i=1}^{n}\left\{\begin{array}{l} \left(u_{A}^{L}\left(x_{i}\right)-u_{B}^{L}\left(x_{i}\right)\right)^{2}+\left(p_{A}^{L}\left(x_{i}\right)-p_{B}^{L}\left(x_{i}\right)\right)^{2}+ \\ \left(v_{A}^{L}\left(x_{i}\right)-v_{B}^{L}\left(x_{i}\right)\right)^{2}+\left(u_{A}^{U}\left(x_{i}\right)-u_{B}^{U}\left(x_{i}\right)\right)^{2}+ \\ \left(p_{A}^{U}\left(x_{i}\right)-p_{B}^{U}\left(x_{i}\right)\right)^{2}+\left(v_{A}^{U}\left(x_{i}\right)-v_{B}^{U}\left(x_{i}\right)\right)^{2} \end{array}\right\}}$$

First we have to compute the distance between $A^{+}$ and $A \bigcap_{i=1}^{4} A_{i}$ based on the Euclidean distance measure as follows:

$$d_{E}\left(A^{+}, A^{+} \cap A_{1}\right)=\sqrt{\frac{1}{6}\left\{\begin{array}{l} |0.5-0.4|^{2}+|0.6-0.6|^{2}+|0.1-0.2|^{2}+|0.3-0.3|^{2}+|0.1-0.1|^{2}+|0.3-0.3|^{2}+ \\ |0.6-0.6|^{2}+|0.7-0.7|^{2}+|0.1-0.2|^{2}+|0.3-0.3|^{2}+|0.1-0.1|^{2}+|0.2-0.2|^{2}+ \\ |0.5-0.5|^{2}+|0.6-0.6|^{2}+|0.1-0.2|^{2}+|0.2-0.4|^{2}+|0.3-0.6|^{2}+|0.4-0.4|^{2}+ \\ |0.5-0.5|^{2}+|0.7-0.7|^{2}+|0.1-0.1|^{2}+|0.2-0.2|^{2}+|0.4-0.4|^{2}+|0.7-0.7|^{2} \end{array}\right\}}$$

$$d_{E}\left(A^{+}, A^{+} \cap A_{1}\right)=\sqrt{\frac{1}{6}\left\{0.1^{2}+0.1^{2}+0.1^{2}+0.1^{2}+0.2^{2}+0.3^{2}\right\}}$$

$$d_{E}\left(A^{+}, A^{+} \cap A_{1}\right)=0.16833$$

$$I\left(A^{+}, A_{1}\right)=1-0.16833=0.83167$$

Similarly we can compute

$I\left(A^{+}, A_{1}\right)=0.83167$

$I\left(A^{+}, A_{2}\right)=0.86460$

$I\left(A^{+}, A_{3}\right)=0.50840$

$I\left(A^{+}, A_{4}\right)=0.78015$

Thus we rank the crops according to inclusion measure based on the Euclidean distance measure as

$A_{2} \succ A_{1} \succ A_{4} \succ A_{3}$

3.3.Based on normalized Hamming distance measure:

$$d_{nH}(A,B)=\frac{1}{6n}\sum_{i=1}^{n}\begin{Bmatrix}\left|u_A^L(x_i)-u_B^L(x_i)\right|+\left|p_A^L(x_i)-p_B^L(x_i)\right|+\\ \left|v_A^L(x_i)-v_B^L(x_i)\right|+\left|u_A^U(x_i)-u_B^U(x_i)\right|+\\ \left|p_A^U(x_i)-p_B^U(x_i)\right|+\left|v_A^U(x_i)-v_B^U(x_i)\right|\end{Bmatrix}$$

First we have to compute the distance between $A^+$ and $A\bigcap_{i=1}^{4}A_i$ based on the normalized Hamming distance measure as follows:

$$d_{nH}\left(A^+,A^+\cap A_1\right)=\frac{1}{6\times 4}\begin{Bmatrix}|0.5-0.4|+|0.6-0.6|+|0.1-0.2|+|0.3-0.3|+|0.1-0.1|+|0.3-0.3|+\\ |0.6-0.6|+|0.7-0.7|+|0.1-0.2|+|0.3-0.3|+|0.1-0.1|+|0.2-0.2|+\\ |0.5-0.5|+|0.6-0.6|+|0.1-0.2|+|0.2-0.4|+|0.3-0.6|+|0.4-0.4|+\\ |0.5-0.5|+|0.7-0.7|+|0.1-0.1|+|0.2-0.2|+|0.4-0.4|+|0.7-0.7|\end{Bmatrix}$$

$$d_{nH}\left(A^+,A^+\cap A_1\right)=\frac{1}{6\times 4}\{0.1+0.1+0.1+0.1+0.2+0.3\}$$

$$d_{nH}\left(A^+,A^+\cap A_1\right)=0.0375$$

$$I\left(A^+,A_1\right)=1-0.0375=0.9625$$

Similarly we can compute

$$\left.\begin{aligned}&I\left(A^+,A_1\right)=0.9625\\ &I\left(A^+,A_2\right)=0.9625\end{aligned}\right\}\text{Same result}$$

$$I\left(A^+,A_3\right)=0.8042$$

$$I\left(A^+,A_4\right)=0.9208$$

Thus we rank the crops according to inclusion measure based on the normalized Hamming distance measure as $A_2=A_1\succ A_4\succ A_3$

3.4.Based on normalized Euclidean distance measure:

$$d_{nE}(A,B)=\sqrt{\frac{1}{6n}\sum_{i=1}^{n}\begin{Bmatrix}\left(u_A^L(x_i)-u_B^L(x_i)\right)^2+\left(p_A^L(x_i)-p_B^L(x_i)\right)^2+\\ \left(v_A^L(x_i)-v_B^L(x_i)\right)^2+\left(u_A^U(x_i)-u_B^U(x_i)\right)^2+\\ \left(p_A^U(x_i)-p_B^U(x_i)\right)^2+\left(v_A^U(x_i)-v_B^U(x_i)\right)^2\end{Bmatrix}}$$

First we have to compute the distance between $A^+$ and $A\bigcap_{i=1}^{4}A_i$ based on the normalized Euclidean distance measure as follows:

$$d_{nE}\left(A^{+},A^{+}\cap A_{1}\right)=\sqrt{\frac{1}{6\times 4}\begin{Bmatrix}|0.5-0.4|^2+|0.6-0.6|^2+|0.1-0.2|^2+|0.3-0.3|^2+|0.1-0.1|^2+|0.3-0.3|^2+\\ |0.6-0.6|^2+|0.7-0.7|^2+|0.1-0.2|^2+|0.3-0.3|^2+|0.1-0.1|^2+|0.2-0.2|^2+\\ |0.5-0.5|^2+|0.6-0.6|^2+|0.1-0.2|^2+|0.2-0.4|^2+|0.3-0.6|^2+|0.4-0.4|^2+\\ |0.5-0.5|^2+|0.7-0.7|^2+|0.1-0.1|^2+|0.2-0.2|^2+|0.4-0.4|^2+|0.7-0.7|^2\end{Bmatrix}}$$

$$d_{nE}\left(A^{+},A^{+}\cap A_{1}\right)=\sqrt{\frac{1}{6\times 4}\left\{0.1^2+0.1^2+0.1^2+0.1^2+0.2^2+0.3^2\right\}}$$

$$d_{nE}\left(A^{+},A^{+}\cap A_{1}\right)=0.08416$$

$$I\left(A^{+},A_{1}\right)=1-0.08416=0.91584$$

Similarly we can compute

$$I\left(A^{+},A_{1}\right)=0.91584$$

$$I\left(A^{+},A_{2}\right)=0.93230$$

$$I\left(A^{+},A_{3}\right)=0.75420$$

$$I\left(A^{+},A_{4}\right)=0.89008$$

Thus we rank the crops according to inclusion measure based on the normalized Euclidean distance measure as

$A_2 \succ A_1 \succ A_4 \succ A_3$

3.5.Based on Geometric distance measure:

$$d_r(A,B)=\sum_{i=1}^{n}\left|\begin{Bmatrix}\left(u_A^L(x_i)-u_B^L(x_i)\right)^r+\left(p_A^L(x_i)-p_B^L(x_i)\right)^r+\\ \left(v_A^L(x_i)-v_B^L(x_i)\right)^r+\left(u_A^U(x_i)-u_B^U(x_i)\right)^r+\\ \left(p_A^U(x_i)-p_B^U(x_i)\right)^r+\left(v_A^U(x_i)-v_B^U(x_i)\right)^r\end{Bmatrix}\right|^{1/r}$$

First we have to compute the distance between $A^{+}$ and $A\bigcap_{i=1}^{4} A_i$ based on the Geometric distance measure as follows:

$$d_r\left(A^{+},A^{+}\cap A_{1}\right)=\begin{Bmatrix}|0.5-0.4|^3+|0.6-0.6|^3+|0.1-0.2|^3+|0.3-0.3|^3+|0.1-0.1|^3+|0.3-0.3|^3+\\ |0.6-0.6|^3+|0.7-0.7|^3+|0.1-0.2|^3+|0.3-0.3|^3+|0.1-0.1|^3+|0.2-0.2|^3+\\ |0.5-0.5|^3+|0.6-0.6|^3+|0.1-0.2|^3+|0.2-0.4|^3+|0.3-0.6|^3+|0.4-0.4|^3+\\ |0.5-0.5|^3+|0.7-0.7|^3+|0.1-0.1|^3+|0.2-0.2|^3+|0.4-0.4|^3+|0.7-0.7|^3\end{Bmatrix}^{\frac{1}{3}}$$

$$d_r\left(A^{+},A^{+}\cap A_{1}\right)=\left\{0.1^3+0.1^3+0.1^3+0.1^3+0.2^3+0.3^3\right\}^{\frac{1}{3}}$$

$$d_r\left(A^{+},A^{+}\cap A_{1}\right)=0.33912$$

$$I\left(A^{+},A_{1}\right)=1-0.33912=0.66088$$

Similarly we can compute

$I\left(A^+, A_1\right) = 0.66088$

$I\left(A^+, A_2\right) = 0.75338$

$I\left(A^+, A_3\right) = 0.19844$

$I\left(A^+, A_4\right) = 0.63407$

Thus we rank the crops according to inclusion measure based on the Geometric distance measure as

$A_2 \succ A_1 \succ A_4 \succ A_3$

3.6.Based on normalized Geometric distance measure:

$$d_{nr}\left(A,B\right) = \frac{1}{4}\sum_{j=1}^{4}\frac{1}{2}\sum_{i=1}^{6}\sqrt{\begin{Bmatrix} \left(u_A^L\left(x_i\right)-u_B^L\left(x_i\right)\right)^2 + \left(p_A^L\left(x_i\right)-p_B^L\left(x_i\right)\right)^2 + \\ \left(v_A^L\left(x_i\right)-v_B^L\left(x_i\right)\right)^2 + \left(u_A^U\left(x_i\right)-u_B^U\left(x_i\right)\right)^2 + \\ \left(p_A^U\left(x_i\right)-p_B^U\left(x_i\right)\right)^2 + \left(v_A^U\left(x_i\right)-v_B^U\left(x_i\right)\right)^2 \end{Bmatrix}}$$

First we have to compute the distance between $A^+$ and $A\bigcap_{i=1}^{4} A_i$ based on the Geometric distance measure as follows:

$$d_{nr}\left(A^+, A^+ \cap A_1\right) = \frac{1}{4}\sum_{j=1}^{4}\frac{1}{2}\begin{Bmatrix} \left\{\sqrt{\begin{Bmatrix}(0.5-0.4)^2+(0.6-0.6)^2+(0.1-0.2)^2+ \\ (0.3-0.3)^2+(0.1-0.1)^2+(0.3-0.3)^2\end{Bmatrix}}\right\} \\ \left\{\sqrt{\begin{Bmatrix}(0.6-0.6)^2+(0.7-0.7)^2+(0.1-0.2)^2+ \\ (0.3-0.3)^2+(0.1-0.1)^2+(0.2-0.2)^2\end{Bmatrix}}\right\} \\ \left\{\sqrt{\begin{Bmatrix}(0.5-0.5)^2+(0.6-0.6)^2+(0.1-0.2)^2+ \\ (0.2-0.4)^2+(0.3-0.6)^2+(0.4-0.4)^2\end{Bmatrix}}\right\} \\ \sqrt{\begin{Bmatrix}(0.5-0.5)^2+(0.7-0.7)^2+(0.1-0.1)^2+ \\ (0.2-0.2)^2+(0.4-0.4)^2+(0.7-0.7)^2\end{Bmatrix}} \end{Bmatrix}$$

$$d_{nr}\left(A^+, A^+ \cap A_1\right) = \frac{1}{4}\sum_{j=1}^{4}\frac{1}{2}\begin{Bmatrix} \left\{\sqrt{0.1^2+0+0.1^2+0+0+0}\right\}, \\ \left\{\sqrt{0+0+0.1^2+0+0+0}\right\}, \\ \left\{\sqrt{0+0+0.1^2+0.2^2+0.3^2+0}\right\}, \\ \left\{\sqrt{0+0+0+0+0+0}\right\} \end{Bmatrix}$$

$$d_{nr}\left(A^+, A^+ \cap A_1\right) = \frac{1}{4}\{0.07071+0.05+0.18708+0\}$$

$$d_{nr}\left(A^+, A^+ \cap A_1\right) = 0.07695$$

$$I(A^+, A_1) = 0.92305$$

Similarly we can compute

$$I\left(A^+, A_1\right) = 0.92305$$

$$I\left(A^+, A_2\right) = 0.92425$$

$$I\left(A^+, A_3\right) = 0.71867$$

$$I\left(A^+, A_4\right) = 0.87867$$

Thus we rank the crops according to inclusion measure based on the normalized Geometric distance measure as

$$A_2 \succ A_1 \succ A_4 \succ A_3$$

3.7.Based on Hausdorff distance measure:

$$d_q(A,B) = \frac{1}{4}\sum_{j=1}^{4}\frac{1}{2}\left\{\begin{array}{l}\max\left\{\left|u_A^L(x_i) - u_B^L(x_i)\right|, \left|u_A^U(x_i) - u_B^U(x_i)\right|\right\} + \\ \max\left\{\left|v_A^L(x_i) - v_B^L(x_i)\right|, \left|v_A^U(x_i) - v_B^U(x_i)\right|\right\} + \\ \max\left\{\left|p_A^L(x_i) - p_B^L(x_i)\right|, \left|p_A^U(x_i) - p_B^U(x_i)\right|\right\}\end{array}\right\}$$

First we have to compute the distance between $A^+$ and $A\bigcap_{i=1}^{4} A_i$ based on the Hausdorff distance measure as follows:

$$d_q\left(A^+, A^+ \cap A_1\right) = \frac{1}{4}\sum_{j=1}^{4}\left\{\begin{array}{l}\frac{1}{2}\left\{\begin{array}{l}\max\{|0.5-0.4|, |0.6-0.6|\} + \\ \max\{|0.1-0.2|, |0.3-0.3|\} + \\ \max\{|0.1-0.1|, |0.3-0.3|\}\end{array}\right\}, \\ \frac{1}{2}\left\{\begin{array}{l}\max\{|0.6-0.6|, |0.7-0.7|\} + \\ \max\{|0.1-0.2|, |0.3-0.3|\} + \\ \max\{|0.1-0.1|, |0.2-0.2|\}\end{array}\right\}, \\ \frac{1}{2}\left\{\begin{array}{l}\max\{|0.5-0.5|, |0.6-0.6|\} + \\ \max\{|0.1-0.2|, |0.2-0.4|\} + \\ \max\{|0.3-0.6|, |0.4-0.4|\}\end{array}\right\}, \\ \frac{1}{2}\left\{\begin{array}{l}\max\{|0.5-0.5|, |0.7-0.7|\} + \\ \max\{|0.1-0.1|, |0.2-0.2|\} + \\ \max\{|0.4-0.4|, |0.7-0.7|\}\end{array}\right\}\end{array}\right\}$$

$$d_q\left(A^+, A^+ \cap A_1\right) = \frac{1}{4}\left\{\begin{array}{l}\frac{1}{2}(0.1+0.1+0)+\frac{1}{2}(0+0.1+0)+ \\ \frac{1}{2}(0+0.2+0.3)+\frac{1}{2}(0+0+0)\end{array}\right\}$$

$$d_q\left(A^+, A^+ \cap A_1\right) = 0.1$$

$$I\left(A^+, A_1\right) = 0.9$$

Similarly we can compute

$$I\left(A^+, A_1\right) = 0.9$$

$$I\left(A^+, A_2\right) = 0.9125$$

$$I\left(A^+, A_3\right) = 0.625$$

$$I\left(A^+, A_4\right) = 0.85$$

Thus we rank the crops according to inclusion measure based on the Hausdorff distance measure as

$$A_2 \succ A_1 \succ A_4 \succ A_3$$

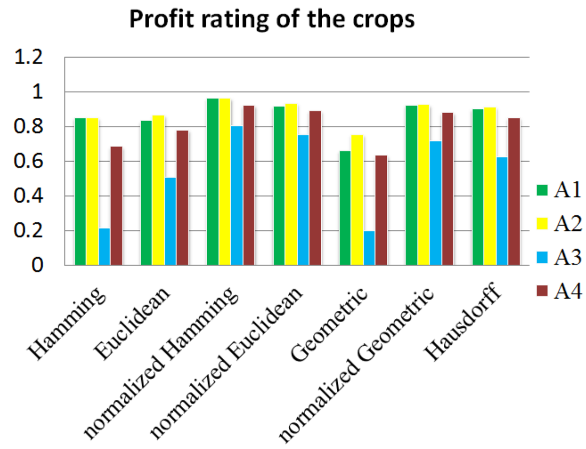
3.8.The table values for the four decision alternatives(crops)

The table values for the four decision alternatives $A_{1,}$ $A_{2,}$ $A_{3,}$ and $A_4$ according to various distance measure is given below

| Distance measures | A1 | A2 | A3 | A4 |
|---|---|---|---|---|
| Hamming | 0.85 | 0.85 | 0.21667 | 0.68333 |
| Euclidean | 0.83167 | 0.8646 | 0.5084 | 0.78015 |
| normalized Hamming | 0.9625 | 0.9625 | 0.8042 | 0.9208 |
| normalized Euclidean | 0.91584 | 0.9323 | 0.7542 | 0.89008 |
| Geometric | 0.66088 | 0.75338 | 0.19844 | 0.63407 |
| normalized Geometric | 0.92305 | 0.92425 | 0.71867 | 0.87867 |
| Hausdorff | 0.9 | 0.9125 | 0.625 | 0.85 |

3.9.The profit rating of the decision alternative

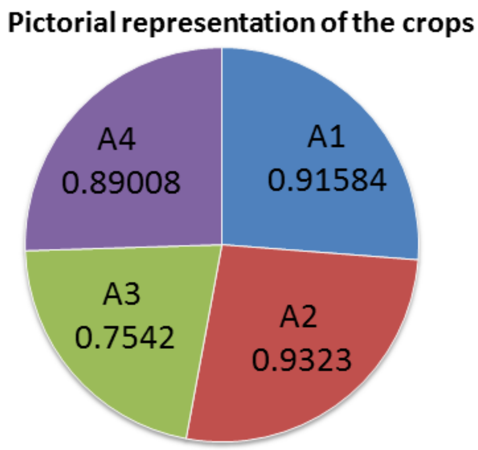
Thus the profit rating of the decision alternative (crops) are given by the following bar diagram as,




Aggregating the opinion from the five Decision makers, we have the preference ranking order relation based on inclusion measure as $A_2 \succ A_1 \succ A_4 \succ A_3$ (i.e.,) Alternative $A_2$ (cholam) and $A_1$ (Kambu) almost shares the same ranking position when compared with the other alternatives. The alternative $A_4$ (Thinai) takes the next ranking position. The alternative $A_3$ (Ulundudal) provide some relief to the former's struggle.

### 3.10.The Pictorial representation of the crops

Thus the Pictorial representation of the crops is given below




Since $I\left(A^{+},A_2\right)=\max_{1\le i\le 4} I\left(A^{+},A_i\right)$ then the pattern $A^{+}$ should be classified to $A_2$ (cholam) according to the principle of inclucion measure between INSs. It means that the decision alternative $A_2$ (cholam) is the optimal alternative which is the closest alternative to positive ideal solution.

## IV. CONCLUSION

In this paper, we introduce an inclusion measure for interval neutrosophic sets. For this purpose, we first give some basic definitions of neutrosophic sets, single neutrosophic sets, interval neutrosophic sets. Moreover, we have proposed a simple and natural inclusion measure based on the various distance measure between interval neutrosophic sets. To analyze its performance, a classification problem in the field cultivation of the crops is established in multi attribute decision making method under interval neutrosophic environment.

In this dissertation, we have investigated the problem in the field cultivation of the crops based on seven distance measures. Though normalized Hamming distance measure gives us the more accurate results but there is a tie between $A_1$ and $A_2$ .The next accurate result for the crops cultivation was given by both normalized Euclidean and normalized Geometric distance measure. Finally the Geometric distance measure gives us the least accurate result.

Thus the best distance measures that gives us the most accurate results for our problem in the field of cultivation of crops were normalized Euclidean and normalized Geometric distance measures.

We hope that the findings in this paper will help the researchers to enhance and promote the further study on inclusion measure to carry out general framework for the applications in practical life.

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