COMPARISON APPROACH TO INTERVAL VALUED VAGUE SET IN DIAGNOSIS OF PLANT DISEASE USING DISTANCE MEASURES

[1]C.Jenita Nancy & [2]A.Arokia Lancy
[1]Research Scholar,[2]Assistant Professor
[1]Department of Mathematics, Nirmala College For Women, Coimbatore,India.

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ABSTRACT: *This paper is a study of the mathematical model which takes its base in the theory of interval valued vague set. The vague information from symptoms constituting the aggregation is defined from the interval valued vague weighted arithmetic average operators and measures of distance is calculated for diagnosis.*

Key Words: *Interval valued vague sets, Hamming distance, Euclidean distance, Normalized Euclidean distance.*

I. Introduction

Out of several higher order fuzzy sets, vague sets have been found to be highly useful to deal with vagueness. Zadeh[6] introduced fuzzy sets as a tool of mathematics to solve the problems with vagueness in everyday life. W.L.Gau and D.J.Buehrer[1] defined vague sets out of several generalizations of fuzzy set theory for various objectives. Sharma[4] introduced the Interval valued vague sets to measure the similarities using multiple criteria decision making. Yao J.F and Yao J.S[5] introduced fuzzy decision making for the diagnosis in medicine based on fuzzy number. In this paper, we have extended the work of L.MariaPresenti and Arockia Rani[3] to develop some distance of measures of Interval valued vague sets and also we compare the result of all measures for the same numerical data.

The work of an agricultural counselor is to find the plant's disease. The diagnosis in the agriculture is considered as the label given by the consultant to describe and evaluate the present scenario of the plant's disease. We apply this method to a plant, as an approach to find the disease.Inspection is done for the Fungal, Bacterial and viral diseases that affect several level of the plants and evaluations are done by several steps.

II. Preliminaries

DEFINITION 2.1: [5]

Let X be an non-empty set. A fuzzy set A drawn from X is defined as $A = \{\langle x, \mu_A(X)\rangle : x \in X\}$ where $\mu_A : X \to [0,1]$ is the membership function of the fuzzy set A.

DEFINITION 2.2: [2]

Let $[I]$ be the set of all closed sub intervals of the interval $[0,1]$ and $\mu = [\mu_L, \mu_U] \in [I]$, where mu_L and mu_U are lower extreme and the upper extreme respectively. For a set X, an IVFS A is given by the equation $A = \{\langle x, \mu_A(X)\rangle : x \in X\}$ where $\mu_A : X \to [0,1]$ defines the degree of membership of an element x to A and $\mu_A(x) = [\mu_{AL}(x), \mu_{AU}(x)]$ is called an interval valued fuzzy number.

DEFINITION 2.3: [1]

A vague set A in the universe of discourse U is characterized by two membership functions given by:

(i) A true membership function $t_A : U \to [0,1]$ and

(ii) A false membership function $f_A : U \to [0,1]$ where t_A is the lower bound on the grade of membership of x derived from the "evidence for x", f_A is the lower bound on the negation of x derived from the "evidence against x", and $t_A + f_A \leq 1$. Thus the grade of membership of μ is the vague set A is bounded by a subinterval $[t_A, 1 - f_A]$ of $[0,1]$. This indicates that if the grade of membership of xis $\mu(x)$ then, $t_A(x) \leq \mu(x) \leq 1 - f_A(x)$

DEFINITION 2.4: [4]

An interval valued vague sets $\widetilde{A^V}$ over a universe of discourse X is defined as an object of the form $\widetilde{A^V}$=$\{\langle x_i, [T_{\widetilde{A^V}}(x_i), [f_{\widetilde{A^V}}(x_i)]\rangle x_i \in X\}$ where $T_{\widetilde{A^V}} : X \to D[0,1]$ and $f_{\widetilde{A^V}} : X \to D[0,1]$ are called "truth membership function" and "false membership function" respectively where D[0,1]is the set of all the intervals within [0,1] or in other words an interval valued vague sets can be represented by

$$\widetilde{A^V} = \langle [\ (x_i), [\mu_1, \mu_2], [\gamma_1, \gamma_2]\ ] \rangle : x_i \in X$$

where $0 \leq \mu_1 \leq \mu_2 \leq 1$ and $0 \leq \gamma_1 \leq \gamma_2 \leq 1$. For each interval valued vague set $\widetilde{A^V}$, $\pi_{\widetilde{1A^V}}(x_i) = 1 - \mu_{\widetilde{1A}}v(x_i) - \gamma_{\widetilde{1A}}v(x_i)$ are called degree of hesitancy of x_i in $\widetilde{A^V}$ respectively.

ILLUSTRATION 2.5 [3]

We introduce the approach for the test of diagnosis for the diseased plant. The four steps for the approach is as follows :

Let $S = \{S_1, S_2, S_m\}$, $D = \{D_1, D_2, D_n\}$ and $P = \{P_1, P_2, P_q\}$ be the sets regarding symptoms disease and plants. The relation of two vague sets Q and R is stated by

$$Q = \{\langle (p,s), t_Q(p,s), 1 - f_Q(p,s) \rangle\ /\ (p,s) \in P \times S\}$$
$$R = \{\langle (s,d), t_R(s,d), 1 - f_R(s,d) \rangle\ /\ (s,d) \in S \times D\}$$

$t_Q(p,s), 1 - f_Q(p,s)$ are the degree of symptoms of plants.

$t_R(s,d), 1 - f_R(s,d)$ are the relation between symptoms and disease. It is necessary to note that Q is defined on the set $P \times S$and Ron $S \times D$. $T = Q \circ R$ shows the plant's state in terms of disease as a vague relation from P to D followed by truth and false membership.

$$t_T(p,d) = \max\{\min[t_Q(p,s), t_R(s,d)]\}$$
$$1 - f_T(p,d) = \max\{min[1 - f_Q(p,s), 1 - f_R(s,d)]\}\ \forall\, p \in P\ and\ d \in D$$

Step 1:

Develop an Interview chart along with interval valued vague degree on the basis of the relation between symptoms and diseases.

Step 2:

A disease has various symptoms. Hence it is needful for aggregation of symptoms.

Step 3:

Using the interval valued vague weighted average operator, we get the vague information from the symptoms.

Step 4:

Apply a measure of distance for the Disease- diagnosis .

DEFINITION 2.6[3]

A is the collection of IVV values . Then

$$IVWAA(A) = \left(\left[1 - \prod_{i=1}^{n}\left(1 - t_{AL}(x_i)\right)^{w_i}, 1 - \prod_{i=1}^{n}\left(1 - t_{AU}(x_i)\right)^{w_i}\right], \left[1 - \prod_{i=1}^{n}\left(f_{AL}(x_i)\right)^{w_i}, 1 - \prod_{i=1}^{n}\left(f_{AU}(x_i)\right)^{w_i}\right]\right)$$

Where $w = (w_1, w_2 \cdots\cdots, w_n)^T$, the weight vectors of A. Also $w_i > 0$ and $\sum_{i=1}^{n} w_i$ =1.

III. Hamming ,Euclidean and Normalized Euclidean Distances In Interval Valued Vague Set

DEFINITION 3.1

For any two IVVS , the vague Hamming distance, Euclidean and Normalized Euclidean distance measures are calculated including the hesitant part stating,

$$h(A,B) = \frac{1}{4}\sum_{i=1}^{n}[|t_{AL}(x_i) - t_{BL}(x_i)| + |t_{AU}(x_i) - t_{BU}(x_i)| + |(1 - F_{AL}(x_i)) - (1 - F_{BL}(x_i))|$$
$$+ |(1 - F_{AU}(x_i)) - ((1 - F_{BU}(x_i))| + |H_{AL}(x_i) - H_{BL}(x_i)| + |H_{AU}(x_i) - H_{BU}(x_i)|]$$

where $H_A = 1 - (t_A + f_A)$

$$e\ (A,B) = \left\{\frac{1}{4}\left[\sum_{i=1}^{n}(t_{AL}\ (x_i) - t_{BL}\ (x_i)]^2 + [t_{AU}(x_i)\ -\ t_{BU}(x_i)]^2 + [\left(1 - F_{AL}(x_i)\right) - \ (1 -\ F_{BL}(x_i))]^2\right.\right.$$
$$\left.\left. + [(1\ -\ F_{AU}(x_i))\ - (1 - F_{BU}(x_i))]^2 +\ [H_{AL}(x_i)\ -\ H_{BL}(x_i)]^2 +\ [H_{AU}(x_i)\ -\ H_{BU}(x_i)^2\right]\right\}^{1/4}$$

$$n_e(A,B) = \left\{\frac{1}{4n}\left[\sum_{i=1}^{n}(t_{AL}(x_i) - t_{BL}(x_i)]^2 + [t_{AU}(x_i) - t_{BU}(x_i)]^2 + [(1 - F_{AL}(x_i)) - (1 - F_{BL}(x_i))]^2 + [(1 - F_{AU}(x_i)) - (1 - F_{BU}(x_i))]^2 + [H_{AL}(x_i) - H_{BL}(x_i)]^2 + [H_{AU}(x_i) - H_{BU}(x_i)^2\right]\right\}^{1/4}$$

EXAMPLE 3.2[3]

Considering P_1 as the diseased plant acquiring symptoms (F_1,F_3) of fungal disease in leaf , (B_3,B_5) of bacterial disease and (V_1,V_3) of viral diseased leaf from [3], we apply the new distance measures to confirm the disease of the plant.

TABLE 1:Degree of plant P_1

Symptoms	F_1	F_3	B_3	B_5	V_1	V_3
t_Q	[0.3,0.4]	[0.2,0.3]	[0.2,0.4]	[0.1,0.2]	[0.1,0.2]	[0.2,0.3]
$1 - f_Q$	[0.4,0.5]	[0.5,0.6]	[0.4,0.6]	[0.5,0.6]	[0.5,0.7]	[0.6,0.7]

TABLE 2: Confirmability degrees

Symptoms	Fungal Disease	Bacterial Disease	Viral disease
S	$[t_R, 1 - f_R]$	$[t_R, 1 - f_R]$	$[t_R, 1 - f_R]$
F_1	[0.3,0.4] , [0.4,0.6]	[0.2,0.3] , [0.3,0.6]	[0.1,0.4] , [0.2,0.5]
F_3	[0.1,0.4] , [0.3,0.4]	[0.3,0.4] , [0.4,0.5]	[0.3,0.5] , [0.3,0.5]
B_3	[0.2,0.3] , [0.4,0.5]	[0.2,0.4] , [0.3,0.5]	[0.1,0.3] , [0.2,0.6]
B_5	[0.1,0.4] , [0.3,0.5]	[0.1,0.2] , [0.3,0.5]	[0.2,0.4] , [0.3,0.4]
V_1	[0.0.0.1] , [0.3,0.9]	[0.3,0.4] , [0.3,0.4]	[0.2,0.4] , [0.3,0.5]
V_3	[0.3,0.4] , [0.4,0.4]	[0.2,0.3] , [0.3,0.5]	[0.1,0.3] , [0.2,0.4]

TABLE 3:Diseased plant's degree (IVWAA)

Q	Symptoms F	Symptoms B	Symptoms V
$P_1: t_Q$	[0.25,0.35]	[0.15,0.30]	[0.15,0.25]
$1 - f_Q$	[0.45,0.55]	[0.45,0.6]	[0.55,0.70]
π_Q	[0.2,0.2]	[0.3,0.3]	[0.4,0.45]

TABLE 4: Degrees of confirmability

Q	Fungal Disease	Bacterial Disease	Viral disease
Symptom F	[0.20,0.39], [0.35,0.51]	[0.25,0.35], [0.35,0.55]	[0.20,0.45] [0.25,0.5]
Symptom B	[0.15,0.35], [0.35,0.50]	[0.15,0.30], [0.3,0.5]	[0.15,0.35] [0.25,0.49]
Symptom V	[0.16,0.26],[0.35,0.6]	[0.25,0.35] ,[0.3,0.45]	[0.15,0.35] [0.25,0.45]
π_F	[0.15,0.12]	[0.1,0.2]	[0.05,0.05]
π_B	[0.2,0.15]	[0.15,0.2]	[0.34,0.14]
π_V	[0.19,0.34]	[0.05,0.1]	[0.1,0.1]

TABLE 5: Hamming distance for symptoms and diseases

T	Fungal Disease	Bacterial Disease	Viral disease
P_1	0.37	0.53	0.64

TABLE 6: Euclidean distance for symptoms and diseases

T	Fungal Disease	Bacterial Disease	Viral disease
P_1	0.43	0.58	0.61

TABLE 7:Normalized Euclidean distance for symptoms and diseases

T	Fungal Disease	Bacterial Disease	Viral disease
P_1	0.33	0.44	0.46

IV. Conclusion

From Table 5 ,the least value is 0.37.From Table 6 and 7 ,the least values are 0.43 and 0.33 which confirms that the plant P_1 suffers from the fungal disease. We have made an comparison approach to confirm the disease of plant using Hamming distance, Euclidean distance and Normalized Euclidean distance using interval valued vague sets.

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