Application of Fuzzy Quality on Dempster-shafer for Pest and Disease Diagnosing of Chili (Case Study on Tidal Swamp Land)

Application of Fuzzy Quality on Dempster-shafer for Pest and Disease Diagnosing of Chili (Case Study on Tidal Swamp Land)

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Abstract. Expert systems are usually used only to help get the results of a diagnosis faster. In the expert system, a method usually used to support a diagnosis process. In this research using the method of Fuzzy and Dempster-Shafer. Fuzzy methods used to find the scale of values belief a fact with fuzzyfication process, while the Dempster-Shafer method used to combine pieces of the facts to calculate the likelihood of an event. The purpose of this study was to determine whether the method of Fuzzy and Dempster-Shafer can be applied to the expert system to provide disease diagnosis chili. Where the results of the expert system will produce a presentation about the likelihood of diagnosis of plant diseases chili. Fuzzy weights obtained are Low 0.15, Medium 0.4 and High 0.65.

1. Introduction

Expert system is a system that try to adopt human knowledge to computer, so that computer can solve problems as is usually done by an expert. A good expert system is designed to solve certain problems by imitating the work of experts. With expert system, can solve complex problems that usually can only be solved with the help of experts.

In designing an expert system, an appropriate method is needed to support the expertise of the expert system. The information provided by the expert system designed is in the form of pests, chili plant diseases and solutions to their prevention. Weighting calculations are needed to get accurate results related to information provided later. Therefore, the Fuzzy and Dempster-Shafer methods are chosen as problem solving methods [1]. The Dempster-Shafer theory is representation, combination and propagation of uncertainty. This theory has several characteristics that are instinctively in accordance with the way of thinking of an expert.

In this research, the Fuzzy method is used to find the weight of the belief value of a fact with the fuzzyfication process, while the Dempster-Shafer method is used to combine fact pieces to calculate the probability of an event [2].

2. Research Method

The method used in this research is the Dempster-Shafer method, but for determining the weight of trust using the fuzzy method. There are several steps that must be done in the dempster-shafer method [3]:

1. Determine the value of density

For the value of belief obtained from the Fuzzy method with the function of the degree of membership of the triangular curve representation to find the initial value for each fuzzy variable, the symptoms obtained from the interviews with experts. By obtaining the value of the fuzzy set, it calculates the initial value of a symptom to get the value of belief by representing the triangular curve which can be seen in Figure 1.

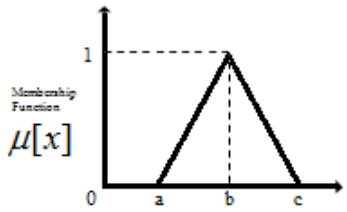

Figure 1. Graph representation of triangular curves

The initial value is x or as a membership value, then it will be processed into a decision if $x \leq aataux \geq c$ then the membership function μ (x) = 0, if $a \leq x \leq b$ then the membership function is calculated using the formula μ (x) = b-xb-a, if $b \leq x \leq c$, then the degree of membership is calculated using the formula μ (x) = c-xc-b.

$$\mu[x]=\begin{cases} 0 & ; \ x \leq a \ \ or \ \ x \geq c \\ \dfrac{(x-a)}{b-a} & ; \ a \leq x \leq b \\ \dfrac{(c-x)}{c-b} & ; \ b \leq x \leq c \end{cases} \qquad (1)$$

Information:
x = The weight of the value specified in each selected symptom
a = Minimum value limit for each symptom
b = Middle value of the minimum and maximum limits
c = Maximum value limit for each symptom
The Flowchart of the triangular curve representation can be seen in this following Figure 2.

2. Calculating the Plausibility Value

Plausibility (Pls) will reduce the level of certainty from evidence. Plausibility is 0 to 1. Formula Plausibility: Pl (s) = 1 -Bel (-s). If the value (-s) is sure, then it can be said that Bel (-s) = 1, so the formula above the value of Pls (-s) = 0.

3. Calculating Value of Mass Function (m)

Mass function (m) in the theory of Dempster-Shafer is the level of confidence of an evidence (symptom), often referred to as evidence measure so that it is denoted by (m). The aim is to link the size of the elements of trust θ. Not all evidence directly supports each element. For this reason, it is necessary to have a probability density function (m). The (m) value not only defines the element θ, but also all the subsets. So if θ contains n elements, then a subset of θ is 2n. The sum of all m in a subset of θ is equal to 1. For example θ = {P2, P3, P4}, with P2 = Bacterial Wilt, P3 = Fusarium Wilt P4 = Rotten Phytophtora. Suppose there is no information whatsoever to choose the three hypotheses, the value of: m {θ} = 1.0. If it is known that X is a subset of θ where m1 is the function of dentity, and Y

is also a subset of θ with m2 as its density function, then a combination function of m1 and m2 can be formed as m3.

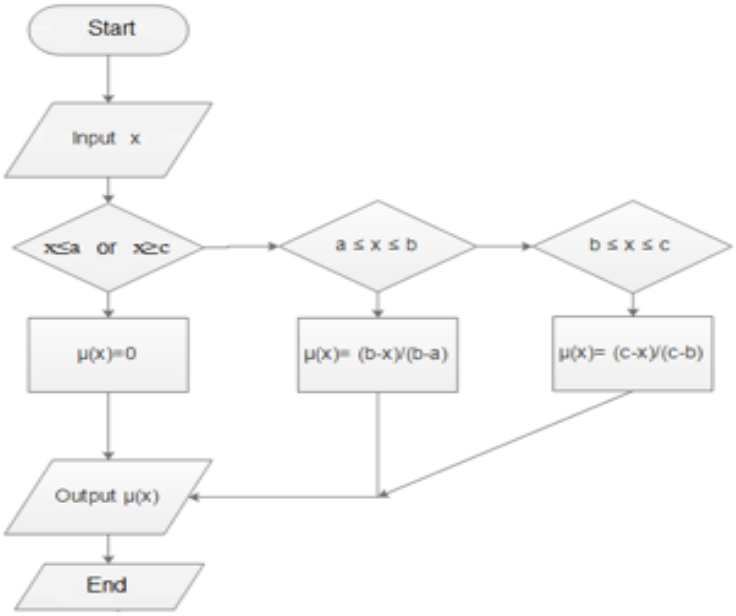

Figure 2. Flowchart of Triangular Curve Representations

According to Giarratano and Riley the Belief function can be formulated [4]:

$$Bel\ (X) = \sum_{Y \in X} m(Y) \tag{2}$$

And Plausibility is notated

$$Pls\ (X) = 1 - Bel\ (X) = \ 1 - \sum_{Y \in X} m(X) \tag{3}$$

Where:

a. Bel (X) = *Belief* (X)
b. Pls (X) = *Plausibility* (X)
c. m (X) = *mass function* from (X)
d. m (Y) = *mass function* from (Y)

The combination function m1 and m2 as m3 is formed with the equation below:

$$m_3(z) = \frac{\sum_{x \cap y = z} m_1(X).m_2(Y)}{1 - \sum_{x \cap y = \theta} m_1(X).m_2(Y)} \tag{4}$$

Where:

a. m3 (Z) = mass function of evidence (Z)
b. m1 (X) = mass function of evidence (X), which is obtained from the confidence value of an evidence multiplied by the value of the disbelief of the evidence.
c. m2 (Y) = mass function of evidence (Y), which is obtained from the confidence value of an evidence multiplied by the value of disbelief and evidence.
d. $\sum_{X \cap Y = Z} m1(X).M2(Y)$ = is the strength value of evidence Z obtained from a combination of confidence values a set of evidence.

3. Results and Discussion

To apply Fuzzy weights to Dempster-Shafer there are several variables that are needed: weighting the value of each symptom, limit the minimum value of each symptom, the maximum value limit of each symptom and the rules that show the symptoms of each disease [5]**.** The following are disease and symptom codes:

Table 1. Disease Code

Disease Code	Name of disease
P1	Damping Off
P2	Bacterial Wilt
P3	Fusarium wilt
P4	Rotten Phytophthora
P5	Flower Bud
P6	Cercospora Leaf Spot
P7	Bacterial Spots
P8	Anthtmcnose
P9	Virus
P10	Powdery mildew

Table 2. Symptom Codes

Symptoms Code	Name of Symptoms
G1	Seeds not germinate
G2	The plant suddenly wilted and fall
G3	The base of the stem is black brown
G4	Wilt on the leaves begins on young leaves
G5	Stems, branches or the base of the stem are split, it will look dark brown and rot
G6	If the part of the plant that is attacked by the disease is cut and put into the water, it will come out with a white liquid resembling smoke
G7	Wilt on the leaves begins with the old leaves and spreads to young leaves and turns yellow
G8	The stems of the affected chili plant are characterized by blackish brown spots and wetness
G9	Plants wither
G10	The leaves of chili plants are attacked like hot water
G11	The affected chili fruit is marked by the wet-brown spots to become blackish brown and soft
G12	Only the stalks, flowers, shoots and twigs of the chili plant are attacked
G13	The branches that are attacked will be blackish brown, spread rapidly so that it turns off the chili shoots, while the other parts are still strong
G14	The presence of small round spots wet, its can expand with a diameter of 0.5 cm, the center of the pale point becomes white with an older colored edge
G15	The leaves of the plants turn yellow and fall
G16	Small wet spots then become brownish necrosis in the middle of the affected plant.
G17	Leaves of chili plants fall
G18	There are white spots surrounded by blackish brown on chili
G19	The chili that is attacked forms a dark brown spot then extends to rotten and soft
G20	Chili becomes dry and wrinkled
G21	In the middle of the spot there is a collection of black dots
G22	On chili is discovered small black spots are curved, these spots on the edges are yellow, enlarged and elongated.
G23	Chili is attacked since green color
G24	In humid temperatures, the fungus will form a pink centered circle
G25	The growth of plants stunted
G26	The leaves become perming and there are yellow spots of wetness
G27	The upper surface of the leaf appears to have yellowish necrosis
G28	Looks like there is a grayish white flour behind the leaves
G29	Leaves become yellow

The following is the value of the severity of each symptom and knowledge base obtained from experts

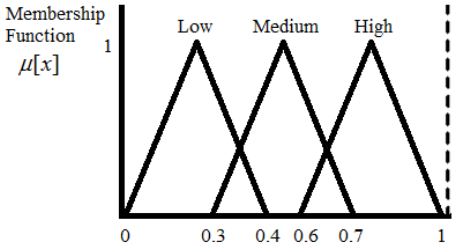

Figure 2. Representation of Severity Value

Table 3. Symptom with membership function

Symptoms	Membership Function			Disease
	Low	Medium	High	
G1	0.15	0,4	0,65	P1
G2	0.15	0,4	0,65	
G3	0.15	0,4	0,65	
G24	0.15	0,4	0,65	
G4	0.15	0,4	0,65	P2
G5	0.15	0,4	0,65	
G6	0.15	0,4	0,65	
G9	0.15	0,4	0,65	
G4	0.15	0,4	0,65	P3
G5	0.15	0,4	0,65	
G6	0.15	0,4	0,65	
G7	0.15	0,4	0,65	
G9	0.15	0,4	0,65	
G11	0.15	0,4	0,65	
G22	0.15	0,4	0,65	
G8	0.15	0,4	0,65	P4
G9	0.15	0,4	0,65	
G10	0.15	0,4	0,65	
G11	0.15	0,4	0,65	
G19	0.15	0,4	0,65	
G20	0.15	0,4	0,65	
G22	0.15	0,4	0,65	
G12	0.15	0,4	0,65	P5
G13	0.15	0,4	0,65	
G11	0.15	0,4	0,65	P6
G14	0.15	0,4	0,65	
G15	0.15	0,4	0,65	
G29	0.15	0,4	0,65	
G16	0.15	0,4	0,65	P7
G17	0.15	0,4	0,65	
G18	0.15	0,4	0,65	
G22	0.15	0,4	0,65	
G18	0.15	0,4	0,65	P8
G11	0.15	0,4	0,65	
G20	0.15	0,4	0,65	
G21	0.15	0,4	0,65	
G22	0.15	0,4	0,65	
G23	0.15	0,4	0,65	
G23	0.15	0,4	0,65	P9
G25	0.15	0,4	0,65	
G26	0.15	0,4	0,65	
G27	0.15	0,4	0,65	P10
G28	0.15	0,4	0,65	

To apply the fuzzy method and dempster shafer can choose the symptoms found in chili plants. here are some symptoms that have been chosen:

Table 4. Selected symptoms

No	Symptoms	Value
1	G23	0,4.
2	G25	0,4
3	G26	0,15
4	G27	0,15

Then the fuzzification process is carried out in accordance with formula 1:

For symptoms 1:

μ[x] = 0; x<0,3 or x>0,7
(x-0,3)/0,2; 0,3<x<0,5
(0,7-x)/0,2; 0,5<x<0,7

Then enter a value of 0.4 for the fuzzification process such as:

X = 0.4, then (0.4-0.3) / 0.2 = 0.5

So the result of symptom 1 with a rather severe level is 0.5

For symptoms 2:

μ[x] = 0; x<0,3 or x>0,7
(x-0,3)/0,2; 0,3<x<0,5
(0,7-x)/0,2; 0,5<x<0,7

Then enter a value of 0.4 for the fuzzification process such as:

X = 0.4, then (0.4-0.3) / 0.2 = 0.5

So the result of symptom 2 with a rather severe level is 0.5

For symptoms 3:

μ[x] = 0; x<0 or x>0,4
(x-0)/0,2;0<x<0,2
(0,4-x)/0,2;x,2<x<0,4

Then enter a value of 0.15 for the fuzzification process such as:

X=0,15, then (0,15-0) / 0,2= 0,75

So the result of symptom 3 with a rather severe level is 0.75

For symptoms 4:

μ[x] = 0; x<0 atau x>0,4
(x-0)/0,2;0<x<0,2
(0,4-x)/0,2;x,2<x<0,4

Then enter a value of 0.15 for the fuzzification process such as:

X=0,15, then (0,15-0) / 0,2= 0,75

So the result of symptom 3 with a rather severe level is 0.75

Then the dempster-shafer calculation is done to get the diagnosis of the symptoms of chili plant disease.

For symptoms 1:

The first step is to calculate the value of belief and plausibility of the symptoms of Chili which is attacked starting from the green chili which is a diagnosis of Antracnose (P8), Fusarium Wilt (P9), then:

m1 {P8,P9} = 0,5

m1 {Ø} = 1 – 0,5 = 0,5

For symptoms 2:

Then if there are new facts, namely the symptoms of the growth of plants that dwarf the diagnosis of Damping Off (P1), Virus (P9), then:

m2{P1,P9} = 0,5

m2 {Ø} = 1 – 0,5 = 0,5

Table 5. Calculation of Belief of the Dempster-Shafer Method of Symptoms 2

		m2{P1,P9}	0.5	m2{ Ø }	0.5
m1{P8,P9}	0.5	{P9}	0.25	{P8,P9}	0.25
m1{ Ø }	0.5	P1,P9}	0.25	{ Ø }	0.25

Next calculate the level of confidence (m3) combine with the formula:

m3 {P9} = 0.25 / (1-0) = 0.25

m3 {P1,P9} = 0.25 / (1-0) = 0.25

m3 {P8,P9} = 0.25 / (1-0) = 0.25

m3 {Ø} = 0.25 / (1-0) = 0.25

The strongest confidence values are against diseases {P9}, {P1, P9} and {P8, P9} that is 0.25.

For symptoms 3:

Next, if new facts are known, namely symptoms, the leaves turn yellow and there are wet-yellow spots that are diagnosis of Virus (P9), then:

m4 {P9} = 0,75

m4 {Ø} = 0,25

Table 6. Calculation of Belief of the Dempster-Shafer Method of Symptoms 3

		m4 {P9}	0.75	m4 {Ø}	0.25
m3 {P9}	0.25	{P9}	0.1875	{P9}	0.0625
m3 {P1,P9}	0.25	{P9}	0.1875	{P1,P9}	0.0625
m3 {P8,P9}	0.25	{P9}	0.1875	{P8,P9}	0.0625
{Ø}	0.25	{P9}	0.1875	{Ø}	0.0625

Next calculate the confidence level of m5:

m5 {P9} = 0.1875 +0.1875 + 0.1875+0.1875+0.0625 / (1-0) = 0.8125

m5 {P1,P9} = 0.0625 / (1-0) = 0.0625

m5 {P8,P9} = 0.0624 / (1-0) = 0.0635

m5 {Ø} = 0.0625 / (1-0) = 0.0625

The strongest confidence value changes to disease (P9), which is 0.8125.

For symptoms 4:

Then, if there is a new fact, the symptoms of the surface of the leaves appear yellowish necrotic spots that are a diagnosis of Powdery mildew disease (P10), then:

m6 {P10} = 0,75

m6 {Ø} = 0,25

Table 7. Calculation of Belief of the Dempster-Shafer Method of Symptoms 4

		m6 {P10}	0.75	m6 {Ø}	0.25
m5 {P9}	0.81	{Ø}	0.6094	{P9}	0.2031
m5 {P1,P9}	0.06	{Ø}	0.0469	{P1,P9}	0.0156
m5 {P8,P9}	0.06	{Ø}	0.0469	{P8,P9 }	0.0156
m5 {Ø}	0.06	{P10}	0.0469	{Ø}	0.0156

Next calculate the level of confidence of m7:
m7 {P9} = 0,2031 / (1-0.6094+ 0.0469+ 0.0469) = 0.68421053
m7 {P1,P9} = 0.0156 / (1-0.6094+ 0.0469+ 0.0469) = 0.05263158
m7 {P8,P9} = 0.0156 / (1-0.6094+ 0.0469+ 0.0469) = 0.05263158
m7 {P10} = 0.0469 / (1-0.6094+ 0.0469+ 0.0469) = 0.15789474
m7 {Ø} = 0.02344 / (1-0.6094+ 0.0469+ 0.0469) = 2.42105263

The strongest belief value against disease (P9} is 0.68421053, thus the diagnosis based on symptoms is a virus.

4. Conclusion

Based on the case study of pests and diseases of chili plants by applying fuzzy weights and dempster-shafer, the following conclusions are obtained as fuzzy weights obtained are Low 0.15, Medium 0.4 and High 0.65. The fuzzy method is used to get the confidence value in the dempster-shafer method and then calculate the combination of confidence values from G23, G25, G26, G27, then obtain the highest confidence value of 0.68421053. The fuzzy and dempster-shafer method can be applied to an expert system for diagnosing chili disease.

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