Automation Diagnosis of Skin

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Automation Diagnosis of Skin Disease in Humans using Dempster-Shafer Method

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Abstract. Skin disease is an infectious disease that is common in people of all ages. Disorders of the skin often occur because there are factors, among others, are climate, environment, shelter, unhealthy living habits, allergies and others. Skin diseases in Indonesia are mostly caused by bacterial, fungal, parasitic, and allergies. The objective of the research is to diagnose skin diseases in humans by using the method of making decision tree then performing the search by forward chaining and calculating the probability value of Dempster-Shafer method. The results of research in the form of an automated system that can resemble an expert in diagnosing skin disease accurately and can help in overcoming the problem of skin diseases.

1 Introduction

The skin is the organ that lies outside and limits it from the human environment. The skin is an essential and vital organ and is a mirror of health and life. The skin is also very complex, elastic and sensitive, varying in climatic conditions, age, gender, race and also highly dependent on the location of the body [1].

Skin diseases in Indonesia are mostly caused by bacterial infections, fungi, parasites, and allergic basic diseases. This is different from Western countries that are more influenced by degenerative factors. Besides the difference in causes, other factors such as climate, habits and the environment also contributed to differences in clinical images of skin diseases [2].

Epidemiology data show that superficial dermatomycosis is a skin disease common in all societies, both rural and urban, not only in developing countries but also in developed countries. Although the disease is not fatal, but because it is often chronic, and not a few are resistant to anti-fungal drugs, the disease can cause disruption of comfort and reduce quality of life for the sufferer [3].

The Dempster-Shafer method is the representation, combination and propagation of uncertainty, in which this theory has some characteristics that are institutive in accordance with the way an expert thinks, but is based on a strong mathematical [4].

2 Uncertainties in Expert System

The construction of expert and other intelligent computer systems requires to be sophisticated mechanism for representing and reasoning with uncertain information. At least three forms of uncertainty can be identified as playing a significant role in these types of systems. The first of these possibility and uncertainty appears in situations where the value of a variable can only be narrowed down to a set of values one of which is the actual value of the variable. The second kind of uncertainty is related to situations in which there exists uncertainty as to satisfaction of a predicate by an element. This is manifested by concepts which have imprecise or gray boundaries. A very powerful tool for handling this type of uncertainty which also handles the first type of uncertainty is the fuzzy set. The third type of uncertainty is related to situations in which the value of a variable assumes can be modeled by the performance of a random experiment. [5]

3 Dempster-Shafer Method

The Dempster-Shafer method was first introduced by Dempster [6], which attempts to model th uncertainty with range probabilities rather than as a single probability. Then in 1976 Shafer published the Dempster theory in a book called Mathematical Theory Of Evident [7]. Dempster-Sahfer Theory of Evidence, suggests a way to give the weight of confidence according to the facts collected. In theory it can distinguish uncertainty and ignorance. The Dempster-Shafer Theory is a representation, combination and propagation of uncertainty, in which this theory has some characteristics that are institutive in accordance with the way an expert thinks, but a st g mathematical basis [4].

In general Dempster-Shafer theory is written in an interval: [*Belief, Plausibility*]. *Belief* (Bel) is a measure of the strength of evidence in favor of a set of propositions. If the value of 0 then indicates that there is no evidence, and if the value of 1 indicates a certainty. *Plausibility* (Pls) will reduce the level of certainty of the evidence. Plausibility is 0 to 1. If it is sure of X ', then it

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can be said that Bell (X') = 1, so the above formula valu is from Pls (X) = 0.

According to Giarratano and Riley the Belief function can be formulated and shown in the equation:

$$Bel\ (X) = \sum_{Y \subseteq X} m(Y) \quad (1)$$

And Plausibility is denoted in the equation:

$$Pls\ (X) = 1 - Bel\ (X) = 1 - \sum_{Y \subseteq X} m(X) \quad (2)$$

Where:
Bel (X) : Belief (X)
Pls (X) : Plausibility (X)
m(X) : Mass function from (X)
m(Y) : Mass function from (Y)

The Dempster-Shafer theory states the existence of a frame of discrement denoted by a symbol (θ). Frame of discrement is the universe of speech of a set of hypotheses so often called the environment shown simultaneously: θ = {01, 02, … 0N}
Where:
θ : Frame of discernment
01, 02, … 0N : Elements in the environment

The environment contains elements that describe the possibility of an answer, and there is only one that will correspond to the required answer. This possibility in Dempster-Shafer theory is called the power set and denoted by P (θ), each element in this power set has an interval value of 0 to 1.

$$m : P(\theta) \rightarrow [0,1]$$

So it can be formulated in equations with:

$$\sum_{X \in P(\theta)} m(X) = 1 \quad (3)$$

Where:
P(θ) : Power set
m (X) : Mass function (X)

The mass function (m) in Dempster-shafer theory is the degree of confidence of an evidence, often called an evidence measure so that it is denoted by (m). The goal is to relate the trust size of the elements θ. Not all evidences directly support each element. For that we need probability density function (m). The m value not only defines the elements θ only, but also all the subset. So if θ contains n elements, then the subset θ is 2n. The number of sems in a subset θ equals 1. If there is no information whatsoever to select the hypothesis, then the value: m{θ} = 1,0

If X is a subset of θ, with m1 as its density function, and Y is also a subset of θ with m2 as its density function, a function of combinations m1 and m2 as m3 can be formed as shown in equation:

$$m_3(Z) = \frac{\sum_{X \cap Y = Z} m_1(X).m_2(Y)}{1 - \sum_{X \cap Y = \Phi} m_1(X).m_2(Y)} \quad (4)$$

Where:
$m_3(Z)$: mass function from evidence (Z)
$m_1(X)$: mass function from evidence (X), which is obtained from the confidence value of an evidence multiplied by the disbelief value of the evidence.
$m_2(Y)$: mass function from evidence (Y), which is obtained from the confidence value of an evidence multiplied by the disbelief value of the evidence.
$\sum_{X \cap Y = Z} m_1(X).m_2(Y)$: is a strength value from the evidence Z obtained from a combination of confidence values set of evidence.

4. Research Method

4.1 Knowledge Acquisition

Initial identification process to obtain initial data and understanding for specific determination of the problem then conducted an interview with a skin specialist. Preliminary data and understanding obtained data of symptoms and illness then illustrated in a decision tree diagram. In the decision tree diagram of the skin disease diagnosis expert system, the symptoms are grouped and denoted by a combination of numeric and letter codes, then disease (diagnosis) and handling (solution) are denoted by numeric and letter codes. The decision tree is illustrated in Figure 1.

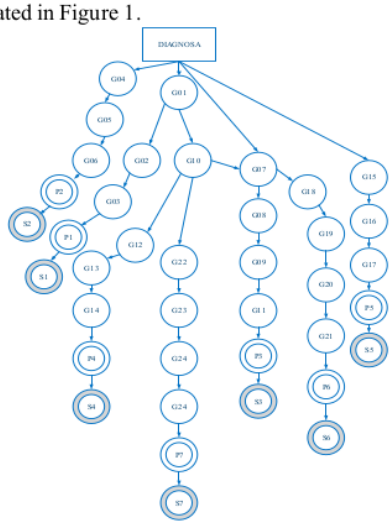

Fig.1. *Decision Tree* for Diagnosis of Skin Disease in Humans

Table 1 and Table 2 show the symptoms and illnesses of the decision tree in Figure 1.

Table 1. Description of the Symptom Code

Code	Symptoms
G01	Reddish patches on the skin
G02	The presence of plaques (skin lesions whose surface is elevated and flat top)
G03	Symptoms occur koebner phenomenon (skin disorder, where if healthy skin exposed to trauma / scratched, healthy skin will also be a disorder)
G04	The presence of a papula (solid protrusion bordered on a skin surface of <1 cm in diameter) of a small needle-sized head
G05	Papula grows prominent
G06	The surface of the skin becomes darker and hyperkeratosis (the skin becomes thick rough)
G07	Fever
G08	Rashes appear that become small bumps then turn into nodules with fluid
G09	Limp
G10	Itchy
G11	Appetite is gone
G12	The skin feels dry
G13	Skin thickened
G14	Skin scab
G15	The presence of macula hipopigmentasi (skin disorder where the white color is not rising flat compared to surrounding healthy skin) on the asymptomatic skin
G16	The appearance of white fine spots on the skin is not scaly
G17	Skin looks white and slippery
G18	Shivering
G19	Out of breath
G20	Pain joint joints in one part of the body
G21	The appearance of reddish spots on the skin that eventually form a bubble of liquid
G22	Skin blisters
G23	Appears a red bump on the itchy part
G24	Itching is more intense especially at night
G25	Thickening and wrinkles on the skin are covered by yellowish-gray crust

Table 2. Decription of the Disease Code

Code	Disease
P1	Psoriasis
P2	Verruca
P3	Varicella
P4	Eczema
P5	Vitiligo
P6	Herpes
P7	Scabies

4.2 Knowledge Base

After the acquisition of knowledge then afterwards done representation of knowledge by making model of rule.

a. For example, for the first rule (R01) is:

IF G1
AND G2
AND G3
THEN Psoriasis

with the weighting value of each of the following symptoms:

G01 = 0.5 = P1 and P4
G02 = 0.8 = P1
G03 = 0.8 = P1

from the value of the symptom weights above, then determined initial density (m) value consisting of belief and plausibility.

Symptom 1: Reddish spots on the skin, then obtained :
$m_1\{P1,P4\} = 0.5$
The plausibility value of the formula is then determined
Pl=1 – Bel
$m_1\{P1,P4\} = 1 - 0.5 = 0.5$

Symptom 2: The presence of a plaque (skin lesions that surface is raised and flat top), then obtained: $m_1\{P1\} = 0.8$
The plausibility value of the formula is then determined
Pl=1 – Bel
$m_1\{P1\} = 1 - 0.8 = 0.2$

Based on the initial density determination on symptoms 1 and 2, the initial density of the next symptoms can be seen in Table 3.

Table 3. Determination of Initial Density (m)

No	Symptoms	Disease	Density (m)	
			Belief	Plausibility
1	Reddish patches on the skin	P1, P4	0.5	0.5
2	The presence of plaques (skin lesions whose surface is elevated and flat top)	P1	0.8	0.2
3	Symptoms occur koebner phenomenon (skin disorder, where if healthy skin exposed to trauma / scratched, healthy skin will also be a disorder)	P1	0.8	0.2

From Table 3 we can calculate the new density (m) value by creating a combination rule table first. Then the resulting combination will be used when indicating a new symptom.

Table 4. Combination Rule for m_3

Density 2 / Density 1	$m_2\{P1\}$ 0,8	$m_2\{\theta\}$ 0.2
$m_1\{P1,P4\}$ 0.5	{P1} 0.4	{P1,P4} 0.1
$m_1\{\theta\}$ 0.5	{P1} 0.4	{θ} 0.1

Then calculated :

a) $m_3\{P1\} = \frac{0.4 + 0.4}{1 - 0} = 0.8$

b) $m_3\{P1,P4\} = \frac{0.1}{1 - 0} = 0.1$

c) $m_3\{\theta\} = \frac{0.1}{1 - 0} = 0.1$

Symptom 3: Symptoms of koebner phenomenon (skin disorder, where if healthy skin is affected by trauma / scratches, healthy skin will also be a disorder).

Based on the decision tree and the density value of the symptoms of the disease it is obtained: $m_4\{P1\} = 0,8$
Then plausibility value: $m_4\{\theta\} = 0,2$

Table 5. Combination Rule for m_5

Density 3 \ Density 4	m_4 {P1} 0,8	m_4 {θ} 0,2
m_3 {P1} 0.8	{P1} 0.64	{P1} 0.16
m_3 {P1,P4} 0.1	{P1} 0.08	{P1,P4} 0.02
m_3 {θ}0.1	{P1} 0.08	{θ} 0.02

Then calculated :

a) m_5 {P1}= $\frac{0.64+0.16+0.08+0.08}{1-0} = 0.96$

b) m_5 {P1,P4} = $\frac{0.02}{1-0} = 0.02$

c) m_5 {θ} = $\frac{0.02}{1-0} = 0.02$

Then the magnitude of the possibility of users affected by Psoriasis disease is 96%.

b. For example, the rule for the second rule (R02) is:

IF G1
AND G10
AND G12
AND G13
AND G14
THEN Eczema

with the weighting value of each of the following symptoms:

G01 = 0,5 = P1 and P4
G10 = 0,5 = P3, P4 and P7
G12 = 0,7 = P4
G13 = 0,6 = P4
G14 = 0,6 = P4

from the value of the symptom weights above, then determined initial density (m) value consisting of belief and plausibility.

Symptom 1: Reddish patches on the skin, then obtained: m_1{P1,P4} = 0.5
The plausibility value of the formula is then determined
Pl=1 – Bel
m_1{P1,P4} = 1 – 0.5 = 0.5

Symptom 10: Itchy, then obtained: m_1{P3,P4,P7} = 0.5
The plausibility value of the formula is then determined
Pl=1 – Bel
m_1{P1} = 1 – 0.5 = 0.5

Table 6. Determination of Initial Density (m)

No	Symptoms	Disease	Density (m) Belief	Plausibility
1	Reddish patches on the skin	P1, P4	0.5	0.5
2	Itchy	P3, P4, P7	0.5	0.5
3	The skin feels dry	P4	0.7	0.3
4	Skin thickened	P4	0.6	0.4
5	Skin scab	P4	0.6	0.4

Based on the initial density determination on symptoms 1 and 10, the initial density of the next symptoms can be seen in Table 6.

From Table 6 we can calculate the new density (m) value by creating a combination rule table first. Then the resulting combination will be used when indicating a new symptom.

Table 7. Combination Rule for m_3

Density 1 \ Density 2	m_2 {P3,P4,P7} 0.5	m_2 {θ} 0.5
m_1 {P1,P4} 0.5	{P4} 0.25	{P1,P4} 0.25
m_1 {θ} 0.5	{ P3,P4,P7} 0.25	{θ} 0.25

Then calculated :

a) m_3 {P4}= $\frac{0.25}{1-0} = 0.25$

b) m_3 {P1,P4} = $\frac{0.25}{1-0} = 0.25$

c) m_3 {P3,P4,P7}= $\frac{0.25}{1-0} = 0.25$

d) m_3 {θ}= $\frac{0.25}{1-0} = 0.25$

Symptom 12: The skin feels dry

Based on the decision tree and the density value of the symptoms of the disease it is obtained: m_4 {P4} = 0,7
Then plausibility value: m_4 {θ} = 0,3

Table 8. Combination Rule for m_5

Density 3 \ Density 4	m_4 {P4} 0,7	m_4 {θ} 0,3
m_3 {P4} 0,25	{P4} 0,175	{P4} 0,075
m_3 {P1,P4} 0,25	{P4} 0,175	{P1,P4} 0,075
m_3 {P3,P4,P7} 0,25	{P4} 0,175	m_3 {P3,P4,P7} 0,075
m_3 {θ} 0,25	{P4} 0,175	{θ} 0,075

Then calculated:

a. m_5 {P4}= $\frac{0.175+0.175+0.175+0.175+0.175}{1-0} = 0.775$

b. m_5 {P1,P4} = $\frac{0.075}{1-0} = 0.075$

c. m_5 {P3,P4,P7} = $\frac{0.075}{1-0} = 0.075$

d. m_5 {θ} = $\frac{0.075}{1-0} = 0.075$

Symptom 13: Skin thickened

Based on the decision tree and the density value of the symptoms of the disease it is obtained: m_6 {P4} = 0,6
Then plausibility value: m_6 {θ} = 0,4

Table 9. Combination Rule for m_5

Density 5 \ Density 6	m_6 {P4} 0,6	m_6 {θ} 0,4
m_5 {P4} 0,775	{P4} 0,465	{P1} 0,31
m_5 {P1,P4} 0,075	{P4} 0,045	{P1,P4} 0, 03
m_5 {P3,P4,P7} 0,075	{P4} 0,045	{P3,P4,P7} 0,03
m_5 {θ} 0,075	{P4} 0,045	{θ} 0,03

Then calculated:

a. m_7 {P4} = $\frac{0.465+0.045+0.045+0.045+0.031}{1-0} = 0.91$

b. m_7 {P1,P4} = $\frac{0.03}{1-0} = 0.03$

c. $m_7\ \{P3,P4,P7\} = \frac{0.03}{1-0} = 0.03$

d. $m_7\ \{\theta\} = \frac{0.03}{1-0} = 0.03$

Symptom 14: Skin scab

Based on the decision tree and the density value of the symptoms of the disease it is obtained: $m_8\ \{P4\} = 0,6$ Then plausibility value: $m_8\ \{\theta\} = 0,4$

Table 10. Combination Rule for m_5

Density 7 \ Density 8	M_8 {P4 } 0,6	m_8 {θ} 0,4
m_7 {P4 } 0,91	{P4} 0,546	{P4} 0,364
m_7 {P1,P4} 0,03	{P4} 0,018	{P1,P4} 0,012
m_7 {P3,P4,P7} 0,03	{P4} 0,018	{P3,P4,P7} 0,012
m_7 {θ}0,03	{P4} 0,018	{θ} 0,012

Then calculated:

a. $m_9\ \{P4\} = \frac{0.546+0.0364+0.018+0.018+0.18}{1-0} = 0.964$

b. $m_9\ \{P1,P4\} = \frac{0.012}{1-0} = 0.012$

c. $m_9\ \{P3,P4,P7\} = \frac{0.012}{1-0} = 0.012$

d. $m_9\ \{\theta\} = \frac{0.012}{1-0} = 0.012$

Then the magnitude of the possibility of users affected by Eczema disease is 96%.

5. Results and Discussion

This system aims to create a model system that can effectively diagnose skin diseases automatically and work like an expert. Measurement of effectiveness is done by testing the accuracy of diagnostic results by using 20 data samples. Table 11 shows detailed diagnostic accuracy test data.

Table 11. Testing Accuracy of Diagnostic Results

No	Symptoms Suffered		System Diagnostic Results	Expert Diagnosis Results	Accuracy of Comparison Results
1	G08 G12 G17 G20 G21	Rashes appear that become small bumps then turn into nodules with fluid The skin feels dry Skin looks white and slippery Pain or joint joints in one part of the body The appearance of reddish spots on the skin that eventually form a bubble of liquid	Herpes	Herpes	Suitable
2	G01 G04 G07 G10 G13	Reddish patches on the skin The presence of a papula (solid protrusion bordered on a skin surface of <1 cm in diameter) of a small needle-sized head Fever Itchy Skin thickened	Eczema	Eczema	Suitable
3	G02 G03 G04 G05	The presence of plaques (skin lesions whose surface is elevated and flat top) Symptoms occur koebner phenomenon (skin disorder, where if healthy skin exposed to trauma / scratched, healthy skin will also be a disorder) The presence of a papula (solid protrusion bordered on a skin surface of <1 cm in diameter) of a small needle-sized head Papula grows prominent	Psoriasis	Veruca	Not Suitable
4	G06 G08 G09 G15	The surface of the skin becomes darker and hyperkeratosis (the skin becomes thick rough) Rashes appear that become small bumps then turn into nodules with fluid Limp The presence of macula hipopigmentasi (skin disorder where the white color is not rising flat compared to surrounding healthy skin) on the asymptomatic skin	Varicella	Varicella	Suitable
5	G09 G10 G11 G19 G20	Limp Itchy Appetite is gone Out of breath Pain or joint joints in one part of the body	Varicella	Varicella	Suitable
6	G04 G05 G06 G10 G13	The presence of a papula (solid protrusion bordered on a skin surface of <1 cm in diameter) of a small needle-sized head Papula grows prominent The surface of the skin becomes darker and hyperkeratosis (the skin becomes thick rough) Itchy Skin thickened	Veruca	Veruca	Suitable
7	G10 G12 G23 G24 G25	Itchy The skin feels dry Appears a red bump on the itchy part Itching is more intense especially at night Thickening and wrinkles on the skin are covered by yellowish-gray crust	Scabies	Scabies	Suitable

No	Symptoms Suffered		System Diagnostic Results	Expert Diagnosis Results	Accuracy of Comparison Results
8	G12 G13 G15 G16 G17	The skin feels dry Skin thickened The presence of macula hipopigmentasi (skin disorder where the white color is not rising flat compared to surrounding healthy skin) on the asymptomatic skin The appearance of white fine spots on the skin is not scaly Skin looks white and slippery	Vitiligo	Vitiligo	Suitable
9	G07 G08 G10 G23 G25	Fever Rashes appear that become small bumps then turn into nodules with fluid Itchy Appears a red bump on the itchy part Thickening and wrinkles on the skin are covered by yellowish-gray crust	Varicella	Varicella	Suitable
10	G06 G09 G10 G16 G17 G23	The surface of the skin becomes darker and hyperkeratosis (the skin becomes thick rough) Limp Itchy The appearance of white fine spots on the skin is not scaly Skin looks white and slippery Appears a red bump on the itchy part	Vitiligo	Scabies	Not Suitable
11	G01 G02 G03	Reddish patches on the skin The presence of plaques (skin lesions whose surface is elevated and flat top) Symptoms occur koebner phenomenon (skin disorder, where if healthy skin exposed to trauma / scratched, healthy skin will also be a disorder)	Psoriasis	Psoriasis	Suitable
12	G03 G04 G05	Symptoms occur koebner phenomenon (skin disorder, where if healthy skin exposed to trauma / scratched, healthy skin will also be a disorder) The presence of a papula (solid protrusion bordered on a skin surface of <1 cm in diameter) of a small needle-sized head Papula grows prominent	Veruca	Veruca	Suitable
13	G04 G07 G08	The presence of a papula (solid protrusion bordered on a skin surface of <1 cm in diameter) of a small needle-sized head Fever Rashes appear that become small bumps then turn into nodules with fluid	Varicella	Varicella	Suitable
14	G08 G09 G10	Rashes appear that become small bumps then turn into nodules with fluid Limp Itchy	Varicella	Varicella	Suitable
15	G03 G04 G06 G07	Symptoms occur koebner phenomenon (skin disorder, where if healthy skin exposed to trauma / scratched, healthy skin will also be a disorder) The presence of a papula (solid protrusion bordered on a skin surface of <1 cm in diameter) of a small needle-sized head The surface of the skin becomes darker and hyperkeratosis (the skin becomes thick rough) Fever	Veruca	Veruca	Suitable
16	G10 G11 G12 G15	Itchy Appetite is gone The skin feels dry The presence of macula hipopigmentasi (skin disorder where the white color is not rising flat compared to surrounding healthy skin) on the asymptomatic skin	Eczema	Eczema	Suitable
17	G01 G08 G09 G10 G21	Reddish patches on the skin Rashes appear that become small bumps then turn into nodules with fluid Limp Itch The appearance of reddish spots on the skin that eventually form a bubble of liquid	Varicella	Varicella	Suitable
18	G01 G10 G21	Reddish patches on the skin Itch The appearance of reddish spots on the skin that eventually form a bubble of liquid	Varicella	Varicella	Suitable
19	G10 G11 G18 G20 G22	Itchy Appetite is gone Shivering Pain or joint joints in one part of the body Skin blisters	Herpes	Herpes	Suitable
20	G22 G23 G24 G25	Skin blisters Appears a red bump on the itchy part Itching is more intense especially at night Thickening and wrinkles on the skin are covered by yellowish-gray crust	Scabies	Scabies	Suitable

From Table 11 we can calculate the accuracy value based on 20 tested data so that the percentage value obtained by 90% indicates that the accuracy of the diagnosis can work well according to the rules and the specialist skin diagnosis result so that the expert knowledge used has 90% value truth. The value of inaccuracy of 10% is likely due to errors in the assignment of the confidence of symptoms in each disease.

6. Conclusion

Based on the results of research and discussion it can be concluded that the automatic diagnosis of skin disease in humans requires accurate data and model rules are packed in the representation of knowledge as a basis for determining the final diagnosis. The sample simulation trials show that there is a 90% truth score that compares the diagnostic results based on expert knowledge. Value of accuracy results obtained by testing as many as 20 data samples so it can be said the accuracy obtained has a very good accuracy.

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