The Implementation Of An Expert System In Diagnosing Skin Diseases Using The Dempster-Shafer Method

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Abstract. In this study we will describe the types of diseases that often attack the skin. The skin is a very sensitive organ of the body and susceptible to disease. This study uses a dempster-shafer method that is used to diagnose symptoms of skin disease. The dempster-shafer method in this study uses rule based obtained from dermatologists. The results of this study were able to produce an accurate diagnosis of 68.8% using trial sample data. The dempster-shafer method can be applied in the diagnosis of skin diseases.

1. Introduction

Expert system is one branch of Artificial intelligence. The implementation of expert systems is widely used for commercial purposes because expert systems are seen as one concept that is capable of storing knowledge from experts in certain fields into a computer program so that it can be used as a decision making and providing information from the results of reasoning[1] [2] .

The influence of the application of artificial intelligence, as we know it, has found many recent innovations, especially in the field of science. the application of artificial intelligence is one part of the results of computer science computing that makes machines (computers) able to do a good job of cultivating intelligence done by humans. Artificial intelligence technology is always developed in various fields, such as: robotics, computer vision (computers vision), artificial neural networks, natural languages processing, speech recognition, and expert systems [3] .

The Dempster-Shafer method was introduced by someone named Dempster. Dempster conducts research in the form of an uncertainty model experiment that has probabilities and not as the only single probability. In 1976 a man named Shafer published a new theory called Dempst's theory in a book called mathematical theory evident. then The theory called Dempst-Shafer provides a new method of weighting according to the facts collected. The latest theory can distinguish between uncertainty and ignorance. Dempst-Shafer Theory is a combination, propagation of uncertainty and representation, in which this theory has several intuitive characteristics according to the way of thinking of an expert, but has a strong mathematical knowledge base [4] .

The skin is a part of the human body that is quite sensitive to various diseases. Skin diseases are caused by many factors including environmental factors and daily living habits. Skin disease is the
most common infectious disease, occurring in people of all ages. Most treatments for skin infections take a long time to point to the healing effect. Skin disease is a disease that attacks the skin surface of the body caused by various causes. In this study, we tried to apply the method of dementia-shafer to diagnose skin disease so that it is expected to be useful in the medical world, and able to be earlier in preventing skin diseases by knowing the symptoms that are experienced. Based on the exposure of science and knowledge that the authors conveyed in the case of diagnosis of skin diseases in by Dempster-Shafer method.

2. Related Work
Dempster-Shafers (DS) can diagnose based on input data from the knowledge base obtained by experts in agriculture, especially vegetable crops. There is a calculation of belief and reasoning functions that are used to combine separate information (evidence) to calculate probability functions. This method has been done on vegetable plants, and the results of testing accuracy reached 90% [5]*. DS has also been used in diagnosing fever which is often considered common by the public.

This study aims to assist in making decisions, so that the diagnostic process can be done quickly. This study uses three criteria in fever, namely Typhoid Fever, Dengue Fever, and Measles [6]*. Sembiring, et al., applied DS in the field of expert systems on a calculation of the emergence of possible diseases caused by the bacterium Salmonella Typhi which causes typhus, and Salmonella Shigella which causes dysentery and diarrhea. This method can make a diagnosis with high accuracy[7]*.

3. Research Method
In 1976 the shafer published a theory entitled the Mathematical Theory of Evident which was published in a book. Shafer published this theory to perfect the theory of dempster. Dempster is a figure who introduced the dempster-shafer method. A theory that moves in the field of expert systems by applying a model of uncertainty with a single probability trial. The latest theory within Shafer can distinguish between the value of uncertainty and ignorance. This theory is able to provide the right combination, clear representation and is able to provide the exact value of uncertainty. This theory still requires experts to be able to instill the thinking of experts into the method of dempster-shafer [8]*. Generally Dempster-Shafer Theory is written in an interval:

\[
[\text{Believe}_X, \text{Plausibility}_X]
\]

The Value of Belief (Bel) is a measure of value to provide proportional supporting evidence. If the value of belief is 0, the value (Bel) cannot provide the right evidence, and if the value of confidence is 1, it can be concluded that it can provide certainty. Plausibility (Pls) will reduce the value of the evidence level. If plausibility is 0 to 1. If you believe X', it can be said that Bel (X') = 1, so the formula above has a value of Pls (X) = 0 [9]*. The confidence function can be shown by the formula in equations (1) and (2):

\[
\text{Bel}(X) = \sum_{Y \in \mathbb{X}} m(Y)
\]

\[
\text{Pls}(X) = 1 - \text{Bel}(X) = 1 - \sum_{Y \in \mathbb{X}} m(Y)
\]
Plausibility is also worth 0 to 1, if sure of X ‘then Belief (X ’) can be said = 1 so that from the formula value Pls (X) = 0. Several possible ranges between Belief and Plausibility can be seen in Table 1.

Table 1. Rule based system with believe value.

| Possibility     | Explanation               |
|-----------------|---------------------------|
| [1,1]           | Everything is correct     |
| [0,0]           | All wrong                 |
| [0,1]           | Uncertainty               |
| [Bel,1] where 0 < Bel < 1 | Tend to support          |
| [0,Pls] where 0 < Pls < 1 | Tend to reject          |
| [Bel,Pls] where 0 < Bel ≤ Pls | Tend to support and reject |
| Pls < 1         |                           |

In the Dempster-Shafer theory there is a frame of discrement (FOD) model that has a symbol in the form of \( \Theta \). The FOD framework is a universe of conversation obtained from a set of hypotheses from the object under study. The purpose of using this FOD is to connect the level of confidence in the element \( \Theta \). All evidence in this model cannot directly support each element \( \Theta \). Then there are several possibilities for a density function of the symbol \( m \). The value of \( m \) is not only used to define the element value \( \Theta \) only, but also all parts of the element \( \Theta \). So if element \( \Theta \) contains \( n \) elements, then the subset of element \( \Theta \) is worth \( 2^n \). The sum of all \( m \) values in the subset of elements \( \Theta \) must be equal to 1. but if there is no information on the hypothesis chosen, then the value is:

\[
\Theta = \{\theta_1, \theta_2, \ldots, \theta_n\} \tag{4}
\]

where

\( \Theta = \text{FOD or environment} \)

\( \theta_1, \ldots, \theta_n = \text{Elemental parts in the environment} \)

Environment contains elements which describes the possibilities as answer and there is only one that will suit with that answer needed. Possible in Dempster-Shafer theory called a power set and notated with \( P(\Theta) \), each element in this power set has an interval value of 0 to 1.

\[
m = (\Theta) \rightarrow [0,1] \tag{5}
\]

then it can be formulated like Equation 5:

\[
\sum_{X \in P(\Theta)} m(x) = 1 \tag{6}
\]
where
\( P(\Theta) = \text{Power Set} \)
\( m(X) = \text{Mass function} \)

The function of mass value (m) in Dempster-shafer (DS) theory is a level of confidence to measure a proof, and this evidence is often referred to as a measure of action so by the symbol (m). The purpose of the mass value function is to connect the element \( \Theta \). But not all evidence of a measure of trust can directly support each element \( \Theta \). So in this case it is possible that there is a density of mass (m). The value of the m function not only defines the element value \( \Theta \), but also is able to define all sets in the sect elements, then subset element \( \Theta \) is \( 2^n \). The number of all functions m in equal to 1. If there is no additional information to choose a hypothesis, 1.0. to calculate the value of the Combination Function \( m(Z) \). that is if elements \( \Theta \), with the value m1 as its density function, and the value of with the value of m2 as its density function, the function combination of functions m1 and the m2 function can be formed as M3 functions, and can also be formed as show:

\[
M_3(Z) = \frac{\varphi}{1-\varphi}
\]

where
\( m_3(Z) = \text{function of the mass value of evidence(Z)} \)
\( m_1(X) = \text{function of the mass value of evidence (X), obtained from evidence multiplied by the disbelief value of the evidence.} \)
\( m_2(Y) = \text{function of the mass value of evidence (Y), obtained from evidence multiplied by the disbelief value of the evidence.} \)

\[
\sum x f y = zm_1(x), zm_2(y) = \text{is a measure of strength from evidence} \ z \ \text{de combination of} \ m.
\]

4. Implementation and Result
4.1. Data Analysis
Before determining the diagnosis, we must first provide data needed diagnosing common diseases in children is obtained from doctors base expert experience. The following is data a disease that is commonly suffer sample is taken based on the research that has been done, then shown as in:

| No | Disease       | Criteria                        |
|----|---------------|---------------------------------|
| 1  | Tinea Cruris  | - Itching on the skin           |
|    |               | - There is a mushroom element   |
|    |               | - There is macula on skin       |
|    |               | - There is a squama             |
|    |               | - Squama are thicker and more layered |
|    |               | - There is a postula            |
- Appearance of papules / nodules
- The occurrence of erythema

2  Tinea Capitis
- Itching on the skin
- There is a mushroom element
- Red and yellow spots appear
- Hair fall out easily
- Dull colored hair
- Smells bad
- Small ulcers appear on the scalp

3  Tinea Manus
- Itching on the skin
- There is a mushroom element
- There is a squama
- There are vesicles
- The occurrence of erythema

4  Tinea Versicolor
- Itching on the skin
- There are fine scales
- There is macula on skin
- There is a squama

5  Tinea Imbrikata
- Itching on the skin
- Scales resemble a one-edged circle
- There is a squama

6  Tinea barbae
- Itching on the skin
- There is macula on skin
- Reddish spots
- Feeling pain on the skin
- There is pus
- There is edema
- There is a postula
- There is miliar vesicopustula
- Hair fall out easily
- Dull colored hair
- There is an inflammatory reaction in the follicle

No Disease

7  Tinea Nigra Palmaris
- Itching on the skin
- There is macula on skin
- The appearance of brownish black spots
- Muscle pain

8  Candidiasis
- Itching on the skin
- The skin feels hot like burning
- There is a squama
- There are vesicles
- There is a fissure
- Brownish nails
- Appearance of hyperkeratotic
- Appearance of papules / nodules
- The occurrence of erythema

9  Mycetoma
- There are greenish yellow granules
- There is a postula
- There are warts
- The presence of deformities in the legs
- There is swelling or inflammation of the lymph vessels
- There are wart cells
- The appearance of fistula
- The occurrence of erythema

10 Chromomycosis
- Itching on the skin
- There is a mushroom element
- Lesions like cauliflower
- Appearance of papules / nodules

4.2. Presentation Fact and Rules

Based on the results of collecting skin symptoms data obtained from the results of this study so that it can trace the problems in diagnosing skin diseases and provide the expected solutions. To get good results in this research, several search rules must first be made. The following are data on skin disease symptoms that are formed into a code and become a rule.

| Rule (G) | Symptoms | (P1) | (P2) | (P3) | (P4) |
|----------|----------|------|------|------|------|
| G1       | Itching on the skin | ✓ | ✓ | ✓ | ✓ |
| G2       | There is a mushroom element | ✓ | ✓ | ✓ | ✓ |
| G3       | There is a macula on skin color | ✓ | ✓ | ✓ | ✓ |
| G4       | There is a squama | ✓ | ✓ | ✓ | ✓ |
| G5       | Squama are thicker and more layered | ✓ | ✓ | ✓ | ✓ |
| G6       | There is a postula | ✓ | ✓ | ✓ | ✓ |
| G7       | Appearance of papules or nodules | ✓ | ✓ | ✓ | ✓ |
| G8       | The occurrence of erythema | ✓ | ✓ | ✓ | ✓ |
| G9       | Red and yellow spots appear | ✓ | ✓ | ✓ | ✓ |
| G10      | Hair fall out easily | ✓ | ✓ | ✓ | ✓ |
| G11      | Dull colored hair | ✓ | ✓ | ✓ | ✓ |
| G12      | Smells bad | ✓ | ✓ | ✓ | ✓ |
| G13      | Small ulcers appear on the scalp | ✓ | ✓ | ✓ | ✓ |
| G14      | There are vesicles | ✓ | ✓ | ✓ | ✓ |

Table 3. Weight of each symptoms.
G29 There are greenish yellow granules
G30 There are warts
G31 The presence of deformities in the legs
G32 There is swelling or inflammation of the lymph vessels
G33 There are wart cells
G34 The appearance of fistula
G35 Lesions like cauliflower

In the Dempster-Shafer method there is Belief (Bel) and Pausibility (PI) values. On this paper, the Belief (Bel) value is a measure the strength of a symptom to support the system experts when giving conclusions common diseases often suffered by children. While the Plausibility value is obtained from the Belief value (Bell) for each symptom by using equation 2. In fact, a type of disease can have the same symptoms other diseases or in other words a symptom can be a symptom for some skin diseases. For example, symptom 1 (G1) is a symptom of Tinea Crucis (P1), Tinea Capitis (P2), Tinea Manus (P3), Tinea Versicolor (P4), Tinea Imbrikata (P5), Tinea Barbae (P6), Tinea Nigra Palmaris (P7), Tinea Candidasis (P8) and Tinea Chromomycosis (P10), so the density function symbol for symptom 1 this is G1 (P1, P2, P3, P4, P5, P6, P7, P8, P10). Purchase Value (Bell) obtained find the average of the value G1 on Tinea crucis, G1 value on Tinea Capitis, G1 value on Tinea Manus, G1 value on Tinea Versicolor, G1 value on Tinea Imbrikata, G1 value on Tinea Barbae, G1 value on Tinea Nigra Palmaris, G1 value on Tinea Candidasis and G1 value on Tinea Chromomycosis. so it is obtained The bell (G1 (P1, P2, P3, P4, P5, P6, P7, P8, P10)) is 0.189 is the average from the values of weight of each symptom (this value can be seen in table 7). Plausibility value obtained using equation 2, obtained : PI(G1(P1, P2, P3, P4, P5, P6, P7, P8, P10) = 1 - 0.189 = 0.811.

Table 4. Value of Belief and Value of Plausibility.

| Symptoms Code | Name Of Skin Disease | Density Function Symbols | Value Of Belief | Value Of Plausibility |
|---------------|----------------------|--------------------------|----------------|----------------------|
| G1            | {Tinea Cruris, Tinea Capitis, Tinea Manus, Tinea Versicolor, Tinea Imbrikata, Tinea Barbae, Tinea Nigra Palmaris, Tinea Candidasis, Tinea Chromomycosis} | G1(P1,P2,P3,P4,P5,P6,P7,P8,P10) | 0.19            | 0.811               |
| G2            | {Tinea Cruris, Tinea Capitis, Tinea Manus, Tinea Chromomycosis} | G2(P1,P2,P3,P10) | 0.16            | 0.84                |
| G3            | {Tinea Cruris, Tinea Manus, Tinea Versicolor, Tinea Barbae, Tinea Nigra Palmaris} | G3(P1,P3,P4,P6,P7) | 0.18            | 0.82                |
| G4            | {Tinea Cruris, Tinea Manus, Tinea Versicolor, Tinea Imbrikata, Tinea Candidasis} | G4(P1,P3,P4,P5,P8) | 0.2             | 0.8                 |
| G5            | {Tinea Cruris} | G5(P1) | 0.13            | 0.87                |
we tested the Dempster-Shafer method by consulting four symptoms namely:

Itching on the skin (G1)
There is a mushroom element (G2)
There is a postula (G6)
Feeling pain on the skin (G18)

the first step is to calculate G1 and G2.

**First symptoms**: Itching on the skin (G1)

This G1 symptom is a symptoms of Tinea Cruris (P1), Tinea Capitis (P2), Tinea Manus (P3), Tinea Versicolor (P4), Tinea Imbrikata (P5), Tinea Barbae (P6), Tinea Nigra Palmaris (P7), Tinea Candidasis (P8) and Tinea Chromomycosis (P10) with:

\[ m\{G1(P1,P2,P3,P4,P5,P6,P7,P8,P10)\} = 0.811 \]
\[ m\{\emptyset\} = 1 - 0.811 = 0.189 \]

**Second symptoms**: There is a mushroom elements (G2)
This G2 symptom is a symptoms of Tinea Cruris, Tinea Capitis, Tinea Manus and Tinea Chromomycosis with:

\[ m\{G2(P1,P2,P3,P10)\} = 0.84 \]
\[ m\{\emptyset\} = 1 - 0.84 = 0.16 \]

in the deemspte-shafer theory there is a frame of discernment denoted by \( \emptyset \) which aims to associate the measure of trust between elements \( \emptyset \). it is necessary to determine the probability of the density function (m) for each symptom. in the first step we will calculate the relationship between G1 and G2.

| \( m\{G1\} \) | \( m\{G2\} \) | 0.84 | 0 | 0.16 |
|---------------|---------------|------|---|-----|
| \( 0\) | \( 0\) | 0.681 | \( m\{G1\} \) | 0.129 |
| \( 0.189\) | \( m\{G2\} \) | 0.158 | 0 | 0.030 |

then we will calculate the density value for each symptom using equation 4, so that it is obtained:

\[ m_3\{G1(P1,P2,P3,P4,P5,P6,P7,P8,P10)\} = 0.129 / (1 - 0.681) = 0.404 \]
\[ m_3\{G2(P1,P2,P3,P10)\} = 0.158 / (1 - 0.681) = 0.495 \]
\[ m_3\{\emptyset\} = 0.030 / (1 - 0.681) = 0.094 \]

density value for each disease is:

\[ m_3(P1) = 0.404 + 0.495 = 0.899 \]
\[ m_3(P2) = 0.404 + 0.495 = 0.899 \]
\[ m_3(P3) = 0.404 + 0.495 = 0.899 \]
\[ m_3(P4) = 0.404 \]
\[ m_3(P5) = 0.404 \]
\[ m_3(P6) = 0.404 \]
\[ m_3(P7) = 0.404 \]
\[ m_3(P8) = 0.404 \]
\[ m_3(P10) = 0.404 + 0.495 = 0.899 \]

Third symptoms: There is a postula (G6)

This G6 symptom is a symptoms of Tinea Cruris, Tinea Barbae and Tinea Mycetoma with:

\[ m\{G6(P1,P6,P9)\} = 0.89 \]
\[ m\{\emptyset\} = 1 - 0.89 = 0.11 \]

then we insert the set into the table as in the previous step.

| \( m_3\{G1\} \) | 0.404 | \( m\{G6\} \) | 0.89 | 0 | 0.11 |
|----------------|------|---------------|------|---|-----|
| \( m_3\{G2\} \) | 0.495 | \( 0\) | 0.359 | \( m\{G1\} \) | 0.044 |
| \( m_3\{\emptyset\} \) | 0.094 | \( m\{G6\} \) | 0.083 | 0 | 0.010 |

then we will calculate the density value for each symptom using equation 4, so that it is obtained:

\[ m_3\{G1(P1,P2,P3,P4,P5,P6,P7,P8,P10)\} = 0.044 / (1 - (0.359 + 0.440)) = 0.218 \]
\[ m_3\{G2(P1,P2,P3,P10)\} = 0.054 / (1 - (0.359 + 0.440)) = 0.268 \]
\[ m_3\{G6(P1,P6,P9)\} = 0.083 / (1 - (0.359 + 0.440)) = 0.412 \]
\[ m_3\{\emptyset\} = 0.010 / (1 - (0.359 + 0.440)) = 0.049 \]
density value for each disease is:
\[ m_3(P1) = 0.218 + 0.268 + 0.412 = 0.898 \]
\[ m_3(P2) = 0.218 + 0.268 = 0.486 \]
\[ m_3(P3) = 0.218 + 0.268 = 0.486 \]
\[ m_3(P4) = 0.218 \]
\[ m_3(P5) = 0.218 \]
\[ m_3(P6) = 0.218 + 0.412 = 0.63 \]
\[ m_3(P7) = 0.218 \]
\[ m_3(P8) = 0.412 \]
\[ m_3(P9) = 0.412 \]
\[ m_3(P10) = 0.218 + 0.268 = 0.486 \]

**Fourth symptoms:** Feeling pain on the skin (G18)
This G18 symptom is a symptoms of Tinea Barbae with:
\[ m\{G18(P6)\} = 0.91 \]
\[ m\{G1\} = 1 - 0.91 = 0.09 \]

then we insert the set into the table as in the previous step.

Table 7. Matrix 3 : Combination Of G2 and G18.

|       | \( m_3\{G1\} \) | \( m_3\{G18\} \) | \( 0.91 \) | \( 0 \) | \( 0.09 \) |
|-------|-----------------|-------------------|--------|------|--------|
| \( m_3\{G1\} \) | 0.218           | 0                 | 0.198  | \( m_3\{G1\} \) | 0.019  |
| \( m_3\{G2\} \) | 0.268           | 0                 | 0.243  | \( m_3\{G2\} \) | 0.024  |
| \( m_3\{G6\} \) | 0.412           | 0                 | 0.374  | \( m_3\{G6\} \) | 0.037  |
| \( m_3\{\emptyset\} \) | 0.049           | \( m\{G18\} \) | 0.044  | 0     | 0.004  |

then we will calculate the density value for each symptom using equation 4, so that it is obtained:
\[ m_3\{G1(P1,P2,P3,P4,P5,P6,P7,P8,P10)\} = 0.019 / (1 - (0.198 + 0.243 + 0.374)) = 0.102 \]
\[ m_3\{G2(P1,P2,P3,P10)\} = 0.024 / (1 - (0.198 + 0.243 + 0.374)) = 0.129 \]
\[ m_3\{G6(P1,P6,P9)\} = 0.037 / (1 - (0.198 + 0.243 + 0.374)) = 0.2 \]
\[ m_3\{G18(P6)\} = 0.044 / (1 - (0.198 + 0.243 + 0.374)) = 0.237 \]
\[ m_3\{\emptyset\} = 0.004 / (1 - (0.198 + 0.243 + 0.374)) = 0.021 \]

density value for each disease is:
\[ m_3(P1) = 0.102 + 0.129 + 0.2 = 0.883 \]
\[ m_3(P2) = 0.102 + 0.129 = 0.476 \]
\[ m_3(P3) = 0.102 + 0.129 = 0.476 \]
\[ m_3(P4) = 0.102 \]
\[ m_3(P5) = 0.102 \]
\[ m_3(P6) = 0.102 + 0.2 = 0.302 \]
\[ m_3(P7) = 0.102 \]
\[ m_3(P8) = 0.102 \]
\[ m_3(P9) = 0.2 \]
\[ m_3(P10) = 0.102 + 0.129 = 0.476 \]

It can be concluded that the disease suffered is tinea cruris with a value of 0.883 or 68.8%.

5. Conclusion
The implementation of expert systems for diagnosing skin diseases using the dempster-shafer method is generally successfully implemented. The dempster-shafer method can function well in providing the
results of effective skin disease consultation, providing information on the results of disease diagnosis according to the symptoms suffered by the patient. The results of the expert system output manually are in accordance with the rules made.

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