Certainty factor and dempster-shafer method analysis for early detection of final year student depression

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Abstract. Academic loads in writing a thesis cause difficulties to students to complete their studies. This problem can be solved with the application of an expert system with early detection of depressive final-year students that compares Certainty Factor method and Dempster-Shafer method. Certainty Factor method used to measure facts certainty or rules in defining the level of expert confidence, while the Dempster-Shafer method combines uncertainty that has characteristics according to the way of thinking of experts but has a mathematical basis. The purpose of comparing these methods is to get the most appropriate and best method for early detection of depression. The methodology used in this study is a comparative test between two methods, with a mechanism (1) Collecting data related to the depression of final year students; (2) Data acquisition and weighting of confidence values; (3) Calculate formulations from both methods; (4) Perform a comparative test to obtain conclusions. Certainty Factor method is the most appropriate and the best model in early detection of depression, because Certainty Factor method revealed that the more symptoms are given, the higher the probability of detection of depression.

1. Introduction
Final year students who are working on thesis experience various psychological problems. Some of the symptoms that are seen are irregular heartbeat, dizziness, chills or fever, irregular eating patterns, and irregular sleep-wake syndrome. Symptoms of psychological problems arise because of the difficulty of students in finding literature books, meeting with a supervisor who inhibits the completion of a thesis as well as a lack of knowledge about a study and also difficulty in analyzing data [1]. If students who are depressed do not know the depression they are experiencing, it can delay the completion of the final thesis, even not completed the thesis until the deadline.

Depression is a disorder of mood characterized by moodiness and deep and ongoing sadness so they loss the excitement of life and no disturbances in evaluating reality (Reality Testing Ability / RTA), personality remains intact (do not experience personal cracking / splitting of personality) behavior can be disrupted but within normal limits [2]. Depression is a mental health problem.

Expert systems are computer-based applications that are used to solve problems as thought by experts. Psychologists are able to diagnose the mental processes suffered by a person and can provide treatment for these mental states. Academic loads in writing a thesis cause difficulties to students to complete their studies. This problem can be solved with the application of an expert system with early detection of depressive final-year students that compares Certainty Factor method and Dempster-Shafer method. Certainty Factor method used to measure facts certainty or rules in defining the level of expert
confidence, while the Dempster-Shafer method combines uncertainty that has characteristics according to the way of thinking of experts but has a mathematical basis. The purpose of comparing these methods is to get the most appropriate and best method for early detection of depression.

2. Method

2.1. Certainty factor

Certainty Factor Method is a technique to overcome uncertainty in decision making. This method is suitable for use in expert systems that diagnose something uncertain [3]. The following general formula Certainty Factor: $\text{CF}[h,e] = \text{MB}[h,e] - \text{MD}[h,e]$

Where:

$\text{CF} [H, E]$: Certainty Factor with hypothesis H that is affected by the symptoms E. The CF value has range from -1 to 1. A value of -1 means the absolute distrust, while the value of 1 means absolute trust.

$\text{MB} [H, E]$: the value of increased confidence in hypothesis H that is influenced by the symptoms E.

$\text{MD} [H, E]$: the increased value of disbelief in hypothesis H that are affected by the symptoms E. The following formula Certainty Factor combination with more than one premise:

$\text{CF combine} [\text{CF1},\text{CF2}] = \text{CF1} + \text{CF2} \times (1 - \text{CF1})$

2.2. Dempster-shafer

Dempster-Shafer Theory (DST) is a mathematical theory of evidence [4]. Dempster-Shafer method was introduced by Arthur P. Dempster, to give weight to the belief of uncertain information. Dempster-Shafer's proof theory can express the uncertainty of a hypothesis by assigning different belief values to hypothesis that contain different elements through the function of establishing basic beliefs [5]. Dempster-Shafer is written in the interval [Belief, Plausibility]. Where:

Belief (Bel): a collection of belief values in the form of a matrix. A value of 0 means that there are no symptoms. A value of 1 means certainty.

Plausibility (Pl (s)): Things that can reduce the degree of certainty of symptoms.

The frame of discernment contains elements that describe Several possible answers, and only one will match the answer needed. This possibility in the Dempster-Shafer theory is called the power set and is notated with P (θ), each element in the power set has a value between 0 to 1. So, the Dempster-Shafer has the following functions:

$m_{12}(A) = 1/(1-k) \sum_{B \cap C = A \neq 0} [(m_1(B) \times m_2(C)]$

$k = \sum_{B \cap C} [(m_1(B) \times m_2(C)]$

2.3. Knowledge acquisition

Based on Milton, the knowledge acquisition takes knowledge from expert or other sources of knowledge into computer systems to build a knowledge base [6]. It consists of three aspects in the field knowledge, namely:

- Knowledge capture: The technique used to capture expert knowledge is literature study and direct interview with expert, in this case psychology at Medan State University.
- Knowledge analysis: Knowledge engineer identify the concepts and relationship of knowledge from the knowledge capture process. The results of the identification process was obtained types of diseases, symptoms of the disease and the relationship between disease and symptoms.
- Knowledge modelling: This stage knowledge engineer perform an analysis to build a knowledge base which is then translated into a model like a tree, binder and matrix. The knowledge base helps get advice in solving problem.
3. Result and discussions

3.1. Problem analysis

Usually depression in the young adult population ranges around 10%, of the 10% there are 20% of the student population who are depressed. Some things that trigger depression symptoms of university students are: academic stress, meeting new people and experiencing life as an adult [6]. The levels of depression experienced by final year students are categorized as mild depression, moderate depression, and severe depression [7].

The symptoms of depression experienced by the final year students are irregular sleep, irregular eating, headache, restless, easily tired, depressed, easy heated, difficult to concentrate, pessimistic, doubtful [1].

Expert system is part of artificial intelligence. Expert system focus on building and implementing computer programs that can duplicate human activities that require gathering some skills and experience from human knowledge [8]. Expert system is built from a set of rules, the rules can be obtained from the interaction of rules / symptoms. Thus to characterize the system, it requires a method [9]. The right method in detecting early depression in final year students requires processing an expert's knowledge base in diagnosing depression levels based on symptoms. Knowledge Management Process is a comprehensive scientific discipline, the need for knowledge acquisition, storage, transmission, and sharing of comprehensive analysis and design, or which is an obstacle in knowledge management [10]. The following are certainty factor value provisions used in research:

| No | Uncertain Term     | CF | No | Uncertain Term | CF |
|----|-------------------|----|----|----------------|----|
| 1  | Certainly not     | -0.1| 6  | Maybe          | 0.4|
| 2  | Almost certainly not | -0.8| 7  | Most likely    | 0.6|
| 3  | Most likely not   | -0.6| 8  | Almost certain | 0.8|
| 4  | Probably not      | -0.4| 9  | Certainly      | 1.0|
| 5  | Do not know       | -0.2 to 0.2 | | |

Based on table 1, The following are the expertise values from the processing of knowledge obtained from a campus environmental psychiatrist expert.

| No | Depression Symptoms        | Value of Certainty Factor |
|----|-----------------------------|---------------------------|
|    | Mild Depression             | Moderate Depression       | Severe depression        |
| 1  | Irregular Sleep             | 0.8                      |                           |
| 2  | Irregular Eating            | 1.0                      |                           |
| 3  | Headache                    | 0.8                      |                           |
| 4  | Not interested in around    |                           | 0.8                      |
| 5  | Restless                    |                           | 0.8                      |
| 6  | Easily tired                |                           | 0.2                      |
| 7  | Depressed                   |                           |                           |
| 8  | Easy to get angry           | 0.8                      |                           |
| 9  | Difficult to Concentrate    |                           | 0.4                      |
| 10 | Excuse me                   | 0.2                      |                           |
| 11 | Doubtful                    | 0.6                      |                           |

Furthermore, the rule base is based on the value of expertise that has been obtained previously. The following is the rule base from table 2 for early detection of final year student depression.
Rule 1: IF irregular eating = Yes AND pessimistic = Yes THEN detection = mild depression.
Rule 2: IF irregular sleep = Yes AND headache = Yes AND restless = Yes AND easily tired = Yes AND irritable = Yes AND difficult to concentrate = Yes AND doubtful = Yes THEN detection = moderate depression.
Rule 3: IF not interested in around = Yes AND depressed = Yes THEN detection = severe depression.

3.2. Application of the certainty factor method

3.2.1. Student Case 1: "I feel dizzy, I had never slept all night to work on my thesis and in the morning, I would go to consultations, really dizzy on my head, just when we walked like someone daydreaming, my throat was hoarse from lack of sleep" [1].

3.2.1.1. Apply the forward-chaining method to the rule base: From these cases, the symptoms felt by students, namely: irregular sleep, headaches, and difficult to concentrate. These three symptoms in the rules are:
   Rule 2: IF irregular sleep = Yes AND headache = Yes AND restless = Yes AND easily tired = Yes AND irritable = Yes AND difficult to concentrate = Yes AND doubtful = Yes THEN detection = moderate depression.
   From the basis of rules, students detected moderate depression.

3.2.1.2. The process of calculating certainty factor method and determining certainty value of symptoms: Detection moderate depression:
   Irregular sleep and headaches = 0.8+0.8(1-0.8) = 0.96 (CFkom)
   CFkom and difficult to concentrate = 0.96+0.4(1-0.96) = 0.97 (CFend)
   Then, certainty value of symptoms obtained for the detection of moderate depression is 0.97 or 97%.

3.2.2. Student Case 2: "I am not interested in contributing with friends and family and when communicating out of focus” [1].

3.2.2.1. Apply the forward-chaining method to the rule base: From these cases, the symptoms felt by students, namely: not interested in around and difficult to concentrate. These two symptoms in the rules are:
   Rule 2: IF irregular sleep = Yes AND headache = Yes AND restless = Yes AND easily tired = Yes AND irritable = Yes AND difficult to concentrate = Yes AND doubtful = Yes THEN detection = moderate depression.
   Rule 3: IF not interested in around = Yes AND depressed = Yes THEN detection = severe depression.
   Judging from the rule base, students detected moderate and severe depression.

3.2.2.2. The process of calculating certainty factor method and determining certainty value of symptoms: Detection moderate depression:
   Difficult to concentrate = 0.4+0(1-0.4) = 0.4 (CFend)
   Detection severe depression:
   Not interested in around = 0.8+0(1-0.8)=0.8(CFend)
   Then, the certainty value of symptoms for the detection of moderate depression is 0.4 or 40% and the certainty value of symptoms for detection of severe depression is 0.8 or 80%. For the case of the second student, the detection value given is the highest detection certainty, namely detection of major depression with a probability value of 80%.
3.3. Application of the dempster-shafer method

To get the Dempster-Shafer (DS) certainty from depression, a predetermined believe value is used for each symptom. Pl(\Theta) = 1 – Bel, Where the value of bel (believe) is the weight value inputted by the expert.

3.3.1. Student Case 1: "I feel dizzy, I had never slept all night to work on my thesis and in the morning, I would go to consultations, really dizzy on my head, just when we walked like someone daydreaming, my throat was hoarse from lack of sleep" [1].

From these cases, the symptoms felt by students, namely: irregular sleep, headaches, and difficult to concentrate.

3.3.1.1. Calculate the value of believe

Symptom 1: Irregular sleep, so \( m_1 \{R,S,B\} = 0.8 \rightarrow \Theta = 1 - 0.8 = 0.2 \)

Symptom 2: headache, so \( m_2 \{S\} = 0.8 \rightarrow \Theta = 1 - 0.8 = 0.2 \)

After getting the value of 2 symptoms, then do the calculations with the Dempster-Shafer equation to get a new density value with several combinations (m3). By the rules of the slices to m3 as follows:

| Combination | \{S\} | \Theta |
|-------------|-------|-------|
| \{R,S,B\}   | (0.8) | (0.16)|
| \Theta      | (0.2) |       |

The left column is the value of symptom 1 (m1). And the right column of the first row is the value of symptom 2 (m2). The new density value (m3) is obtained from the product of matrix m1 x m2.

Based on table 3, new density value with several combination (m3):

\[
\begin{align*}
\text{m3}\{S\} &= 0.64 + 0.16 = 0.83 \\
\text{m3}\{R,S,B\} &= 0.16 / (1 - 0.04) = 0.17 \\
\text{m3}\{\Theta\} &= 0.04 / (1 - 0.04) = 0.04
\end{align*}
\]

The results of the density value of m3 with some combination of the above, indicate that the value of \{S\} is higher than the value of the other combinations, with a density value of 0.83.

Symptom 3: difficult to concentrate, so \( m_4 \{R,S\} = 0.4 \rightarrow m_4 \{\Theta\} = 1 - 0.4 = 0.6 \)

Furthermore, doing calculations with a combination of m3 to get a new density value m5. With the rules for m5 as follows:

| Combination | \{R,S\} | \Theta |
|-------------|---------|-------|
| {S}         | (0.83)  | (0.6) |
| {R,S,B}     | (0.17)  |       |
| \Theta      | (0.04)  |       |

The left column is the value m3. And the right column of the first row is the value of symptom 3 (m4). The new density value (m5) is obtained from product of matrix m3 x m4.

Based on table 4, new density value with several combination (m5):

\[
\begin{align*}
\text{m5}\{S\} &= (0.33 + 0.498) / (1 - 0.024) = 0.84 \\
\text{m5}\{R,S\} &= (0.068 + 0.016) / (1 - 0.024) = 0.08 \\
\text{m5}\{R,S,B\} &= 0.102 / (1 - 0.024) = 0.10
\end{align*}
\]

The results of the density value of m5 with some of the above combinations, indicate that the value of \{S\}, namely the detection of moderate depression is higher than the value of the other combinations, with a density value of 0.84 or in the percentage of 84%.
3.3.2. Student Case 2: “I am not interested in contributing with friends and family and when communicating out of focus” [1].

From these cases, the symptoms felt by students, namely: not interested in around and difficult to concentrate.

3.3.2.1. Calculate the value of believe

Symptom 1: not interested in around, so: $m1\{B\} = 0.8 \Rightarrow \Theta = 1-0.8 = 0.2$

Symptom 2: difficult to concentrate, so: $m2\{R,S,B\} = 0.4 \Rightarrow \Theta = 1-0.4 = 0.6$

After getting the value of 2 symptoms, then do the calculations with the Dempster-Shafer equation to get a new density value with several combinations (m3). By the rules of the slices to m3 as follows:

| Table 5. New density value with several combinations (m3). |
|-----------------------------------------------------------|
| $\{R,S,B\}$ | (0.4) | $\Theta$ | (0.07) |
| $\Theta$    | (0.6) | $\{B\}$ | (0.32) |
|             |       |         | $\Theta$ | (0.48) |
|             |       |         |         | $\Theta$ | (0.12) |

The left column is the value of symptom 1 (m1). And the right column of the first row is the value of symptom 2 (m2). New density value (m3) is obtained from product of matrix m1 x m2.

Based on table 5, new density value with several combination(m3):

$m3\{B\} = 0.32 + 0.48 = 0.90$

$m3\{R,S,B\} = 0.07 / (1 – 0.12) = 0.08$

$m3\{\Theta\} = 0.12 / (1 – 0.12) = 0.13$

Data have noise so it cannot obtain the maximum belief value. Required, a combination of density values is needed to reduce the effect of noise in the process of getting density values. Otherwise, the belief value of the correct result will be reduced in the final fusion result, even lower than the threshold of the judgment. Then the counterintuitive result appears. So, it is an advantage that maximizes the belief value of the same event supported by most evidences after Dempster-Shafer combination, and can make decisions more reliably [5]. Based on An, the result of the density value of m3 with some combinations of the above, shows that the value of $\{B\}$ is higher than the value of the other combinations, with a density value of 0.90 [5]. These results indicate that these symptoms indicate that patients have detected severe depression with a percentage of 90%.

3.4. Comparative analysis of the certainty factor and dempster-shafer method

After obtaining a certainty value from the use of the Certainty Factor and Dempster Shafer method for cases of the same depressive symptoms, the results of the comparative analysis of the two methods are as follows:

- In the case of symptoms in students, namely: irregular sleep, headaches, and difficult to concentrate. Both methods provide the result of moderate depression detection. The Certainty Factor method gives a certainty value of 0.97 or a probability value of 97%. While the Dempster-Shafer method gives a certainty value of 0.84 or a probability value of 84%.
- In the case of symptoms in students, namely: not interested in the around and difficulty concentrating. Both methods provide the results of detection of major depression. The Certainty Factor method provides a certainty value of 0.8 or a probability value of 80%. While the Dempster-Shafer method provides a certainty value of 0.9 or a probability value of 90%.
- From the results of the previous calculation, Certainty Factor Method with more than two symptom data will give a higher probability value.
- From the results of the previous calculation, Dempster-Shafer method with less than two symptom data will give a higher probability value.
• Certainty factor method provides accurate result from calculation based on the symptoms given, get answers to problem that are uncertain, such as problem diagnosis of disease risk, and has certainty value from expert knowledge [11].

• Dempster-Shafer method is used to get a combination of 2 symptoms to get a higher density value [5].

• From statement Turban and calculation result, certainty factor method in accordance with expertise, the more symptoms are given, the higher the probability of detecting depression [11]. Dempster-Shafer method requires a combination of 2 symptoms to get a good probability value of detecting depression.

4. Conclusion
To detect the depression of final year student we can use the Certainty Factor and the Dempster Shafer method. From two examples of cases with different symptoms as input data, Certainty Factor method with more than two symptom data will give a higher probability value. The Dempster-Shafer method with less than two symptom data will give a higher probability value. It can be concluded that certainty Factor method is the most appropriate and the best model in early detection of depression, because the Certainty Factor method in accordance with the science of expertise revealed that the more symptoms are given, the higher the probability of detection of depression. The Certainty Factor method will be implemented in building an expert system for early detection of depression to assist students in drawing conclusions of the initial diagnosis before conducting an intensive psychological examination.

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