Dempster Shafer Algorithm For Expert System
Early Detection of Anxiety Disorders

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Abstract

Anxiety is an excessive anxiety disorder that is often found in psychology. Some people generally do not realize that they may have symptoms of this anxiety disorder. If ignored and continued continuously, it can interfere with one's activities, reduce academic achievement, and disrupt psychological conditions that affect their lives. This expert system for early detection of anxiety disorders is carried out using forward chaining tracing techniques to explore the knowledge base, and the inference motor is the Dempster Shafer algorithm. Dempster Shafer calculation is done by combining symptom pieces to calculate the possibility of the anxiety disorder. This anxiety disorder detection system is built on the web. Then the test is carried out by comparing the value generated by the system with the value generated by two experts. The test results prove that the value generated by the system has a similarity of 85% to the value produced by the two experts. It can be concluded that implementing the Dempster Shafer algorithm for this expert system in the early detection of anxiety disorders is feasible.

Keywords: Anxiety Disorders, Expert System, Dempster-Shafer, Foward Chaining

1. Introduction

At this time, so many people, in general, do not realize that they may have symptoms of anxiety disorders so that if ignored and sustained continuously, can interfere with one's activities [1], can reduce academic achievement, and disrupt psychological conditions that result in a standard of living that person [2].

To overcome the various problems that occur, it takes a diagnosis of anxiety disorders to solve the disorder. Diagnosing anxiety disorders requires a person's expertise. A psychologist can only have this expertise. This diagnosis is carried out by transferring the knowledge possessed by a psychologist, which is realized into an Expert System. This is not to replace the role of humans as experts but to transfer human knowledge into a system form so that it can be used by other people who need it as a tool to check whether the person has an anxiety disorder or not, without having to see a psychologist again.

Artificial intelligence is one part of computer science that makes machines (computers) able to do work as well as humans [3]. An expert system application is one component of artificial intelligence that has a knowledge base in a particular field and uses inference reasoning to solve problems initiated on a computer device. The expert system can be used in several fields such as health, government, and any field that utilizes decision-making to obtain the desired results [4].

One of the expert systems that can perform early detection of anxiety disorders is the Dempster-Shafer algorithm. The name of this algorithm is taken from its inventors, namely Arthur P. Dempster and Glenn Shafer. This algorithm serves to find evidence-based belief and thought functions, then combines pieces of information to calculate the probability of an anxiety symptom. The symptoms used are derived from the information provided in the form of symptoms of anxiety disorders [5].

Several cases that have applied the Dempster-Shafer method, among others, prove that the contribution of the Dempster Shafer theory has proven to be a good decision-making tool for early diagnosis of gastric disease [6] and can diagnose disease in toddlers aged 0-60 months [7]. In addition, the Dempster-Shafer method has succeeded in providing disease information on chili plants [8]. Then the damage to the motorcycle can also be diagnosed early with this expert system of the Dempster Shafer algorithm [9].

2. Research Methods

2.1. Dempster Shafer Algorithm

Dempster Shafer Algorithm is a mathematical theory to find proofs based on belief functions and rational thinking. This algorithm serves to unite separate pieces of information by calculating all the possibilities of a phenomenon. In general, this algorithm is stated as follows [10]:

$$[Belief, Plausibility]$$

Belief (Bel) is the possibility of information supporting a set of propositions. If it is 0, it shows no evidence, and if it is 1, it shows certainty. Plausibility (Pl) is stated as follows : [11]:

$$Pl(s) = 1 - Bel (\sim s) \tag{1}$$

Explanation :
Pl   : *plausibility*
Bel   : *belief*

Plausibility can also be worth 0 to 1. In this Dempster Shafer algorithm, there is a frame of discrement, namely the universe of conversation from a set of hypotheses. This frame is denoted by θ (theta). Furthermore, m3, which is a combined function of m1 and m2, can be expressed as follows [12]:

$$m_3 = \frac{\Sigma\, X \cap Y = Z m1(X).m2(Y)}{1 - \Sigma\, X \cap Y = \theta m1\,(X).m2(Y)} \tag{2}$$

Explanation :
m_1 : probability density 1
m_2 : probability density 2
m_3 : probability density 3
$X \cap Y$: disease X slice disease Y
θ : *frame of discrement*

2.2. Anxiety Disorder

Anxiety is a state of tension which is an impulse like hunger, only it does not arise from tissue conditions in the body but is originally caused by external causes. When anxiety arises, it will motivate the person to do something [13]. Anxiety is a human character in the form of tension or shock to something that threatens accompanied by physiological changes [14]. There are several anxiety disorders, namely [15] :

    a. Panic Attack (R1)
    b. Agoraphobia (R2)
    c. Specific Phobia (R3)
    d. Social Phobia (R4)
    e. Obsessive-Compulsive Disorder (R5)
    f. Post Traumatic Stress Disorder (R6)
    g. Acute Stress Disorder (R7)
    h. Generalized Anxiety Disorder (R8)

Before implementing, we must first design the rules in this Expert System [16]; one of them is with a decision tree. The design of the decision tree in this Expert System is shown in Figure 1 below.
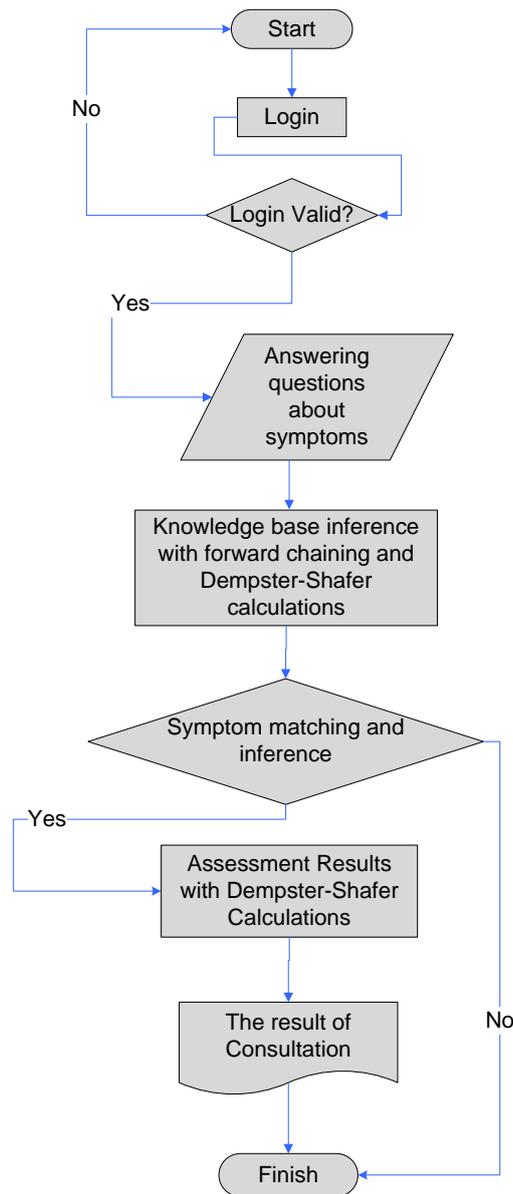
Figure 1. Decision tree

In Figure 1, the decision tree shows that there are 54 symptoms with eight types of anxiety disorders. Each symptom has its density value obtained from the expert. After designing the decision tree, the next step is to design an inference engine. The preparation of the inference motor in this Expert System uses the Forward Chaining tracing technique. The reasoning starts from the facts to test the truth of the hypothesis and the Dempster Shafer algorithm, namely by matching the facts in the knowledge base with the accumulation of probability density symptoms. The inference engine design is shown in Figure 2 below.

Figure 2. Inference Engine Design

3. Result and Discussion

3.1. Implementation of the Dempster Shafer Algorithm

To further analyze the Dempster Shafer Algorithm, manual calculations with the following symptoms of anxiety disorders can be done. The following symptoms are taken by one of the sufferers :

K1   : Excessive anxiety (R1, R2, R3, R4, R5, R6, R7, R8)
K4   : Heart pounding (R1, R2, R3, R4, R5, R6, R7, R8)
K6   : Difficult to concentrate (R1, R2, R3, R4, R5, R6, R7, R8)
K8   : Often feel worried and uncomfortable (R1, R2, R3, R4, R5, R6, R7, R8)
K7   : Excessive sweating (R2, R3, R4)
K2   : Fear of losing control (R2, R3, R4)
K23   : Have you ever admitted that your fear is unwarranted (R3, R4)
K25   : Experiencing fear for more than six months (R3, R4)
K22   : Fear of particular objects (R3)

The following will calculate the Dempster Shafer algorithm based on formula (1) to determine the user's probability of an anxiety disorder. The method is as follows.

a. Determine the plausibility value of the first and second symptoms
   K1 : Excessive anxiety

   $$m_1 \{R1, R2, R3, R4, R5, R6, R7, R8\} = 0,2 \quad \text{and} \quad m_1 \{\theta\} = 1 - 0,2 = 0,8$$

   K4 : Heart pounding

   $$m_2 \{R1, R2, R3, R4, R5, R6, R7, R8\} = 0,4 \quad \text{and} \quad m_2 \{\theta\} = 1 - 0,4 = 0,6$$

b. Finding the intersection of the plausibility values and the density values of K1 and K4

   After knowing the density values of K1 and K4, the next step is to find the intersection (m_3) of the plausibility and density values of K1 and K4. The slice intersection table for m_3 can be seen in Table 1 below.

Table 1. Intersection for m_3

		Belief		**Plausibility**	
		{R1,R2,R3,R4,R5,R6,R7,R8} (0,4)		θ (0,6)	
{R1,R2,R3,R4,R5,R6,R7,R8} (0,2)		{R1,R2,R3,R4,R5,R6,R7,R8} (0,08)		{R1,R2,R3,R4,R5,R6,R7,R8} (0,12)	
θ (0,8)		{R1,R2,R3,R4,R5,R6,R7,R8} (0,32)		θ (0,48)	

Based on table 1, the new m_3 value can be calculated based on formula (2). The m_3 value is as follows.

$$m_3 \{R1, R2, R3, R4, R5, R6, R7, R8\} = \frac{(0,2 \; x \; 0,4) + (0,2 \; x \; 0,6) + (0,8 \; x \; 0,4)}{1 - 0}$$

$$= \frac{0,08 + 0,12 + 0,32}{1 - 0}$$

$$= \frac{0,52}{1 - 0} = 0,52$$

$$m_3 \{\theta\} = \frac{0,8 \; x \; 0,6}{1 - 0}$$

$$= \frac{0,48}{1 - 0} = 0,48$$

c. Find the value of plausibility and density of K6 and then slice it with m_3
   K6 : Difficult to concentrate
   $$m_4 \{R1, R2, R3, R4, R5, R6, R7, R8\} = 0,4 \quad \text{dan} \quad m_4 \{\theta\} = 1 - 0,4 = 0,6$$

   After the new m_3 value is obtained, then the m_3 value is then subtracted by m_4. The results of the m_3 and m_4 the intersection is shown in table 2.

Table 2. Intersection for m_5

		Belief		**Plausibility**	
		{R1,R2,R3,R4,R5,R6,R7,R8} (0,4)		θ (0,6)	
{R1,R2,R3,R4,R5,R6,R7,R8} (0,52)		{R1,R2,R3,R4,R5,R6,R7,R8} (0,208)		{R1,R2,R3,R4,R5,R6,R7,R8} (0,312)	
θ (0,48)		{R1,R2,R3,R4,R5,R6,R7,R8} (0,192)		θ (0,288)	

Based on table 2, the results of the intersection of m_3 and m_4 produce m_5, so the new m_5 value can be calculated. The m_5 value is as follows.

$$m_5 \ \{R1, R2, R3, R4, R5, R6, R7, R8\} \ = \frac{(0,52 \ x \ 0,4) + (0,52 \ x \ 0,6) + (0,48 \ x \ 0,4)}{1 - 0}$$

$$= \frac{0,208 + 0,312 + 0,192}{1 - 0} = 0,712$$

$$m_5 \ \{\theta\} \qquad\qquad = \frac{0,48 \ x \ 0,6}{1 - 0}$$

$$= \frac{0,288}{1 - 0} = 0,288$$

d. Look for the plausibility and density values of K8 and then slice them with m_5
   K8 : Often feel worried and uncomfortable
   $m_6 \ \{R1, R2, R3, R4, R5, R6, R7, R8\} \ = \ 0,4$ dan $m_6 \ \{\theta\} \ = \ 1 - 0,4 \ = \ 0,6$

After obtaining the new m_5 value, then the m_5 value is intersection by m_6. The results of the intersection produce m_7 as shown in table 3 below.

Table 3. Intersection for m_7

	Belief		Plausibility	
	{R1,R2,R3,R4,R5,R6,R7,R8} (0,4)	θ		(0,6)
{R1,R2,R3,R4,R5,R6,R7,R8} (0,712)	{R1,R2,R3,R4,R5,R6,R7,R8} (0,284)		{R1,R2,R3,R4,R5,R6,R7,R8} (0,427)	
θ (0,288)	{R1,R2,R3,R4,R5,R6,R7,R8} (0,115)		θ	(0,172)

Based on table 3. above, the results of the intersection of m_5 and m_6 produce m_7, so the new m_7 value can be calculated. The m_7 value is as follows.

$$m_7 \ \{R1, R2, R3, R4, R5, R6, R7, R8\} \ = \frac{(0,712 \ x \ 0,4) + (0,712 \ x \ 0,6) + (0,288 \ x \ 0,4)}{1 - 0}$$

$$= \frac{0,284 + 0,427 \ + 0,115}{1 - 0} = 0,826$$

$$m_7 \ \{\theta\} \qquad\qquad = \frac{0,288 \ x \ 0,6}{1 - 0}$$

$$= \frac{0,172}{1 - 0} = 0,172$$

After the m9 value is obtained, the next step is to do the same for K7, K2, K23, K25, and K22, so that the results of the Dempster Shafer calculation way can be obtained as follows.

Table 4. Density Value

No.	Symptoms	New Density Value (m)	
		(m) New	Value
1	K1 dan K4	m_3 {R1,R2,R3,R4,R5,R6,R7,R8} m_3 {θ}	0,520 0,480
2	K6	m_5 {R1,R2,R3,R4,R5,R6,R7,R8} m_5 {θ}	0,712 0,288
3	K8	m_7 {R1,R2,R3,R4,R5,R6,R7,R8} m_7 {θ}	0,826 0,172

No.	Symptoms	New Density Value (m)	
		(m) New	Value
4	K7	m_9 {R1,R2,R3,R4,R5,R6,R7,R8}	0,580
		m_9 {R2,R3,R4}	0,300
		m_9 {θ}	0,120
5	K2	m_{11} {R1,R2,R3,R4,R5,R6,R7,R8}	0,464
		m_{11} {R2,R3,R4}	0,440
		m_{11} {θ}	0,096
6	K23	m_{13} {R1,R2,R3,R4,R5,R6,R7,R8}	0,186
		m_{13} {R2,R3,R4}	0,176
		m_{13} {R3,R4}	0,600
		m_{13} {θ}	0,038
7	K25	m_{15} {R1,R2,R3,R4,R5,R6,R7,R8}	0,075
		m_{15} {R2,R3,R4}	0,070
		m_{15} {R3,R4}	0,840
		m_{15} {θ}	0,015
8	K22	m_{17} {R1,R2,R3,R4,R5,R6,R7,R8}	0,014
		m_{17} {R2,R3,R4}	0,014
		m_{17} {R3,R4}	0,168
		m_{17} {R3}	**0,800**
		m_{17} {θ}	0,004

Based on table 4. above, the calculation results of the calculation of the highest probability density value are owned by m_{17} (R3) with a value of 0.800. So the results of the assessment concluded that the user tends to have an anxiety disorder, namely a specific phobia (R3) with a percentage of 80.00%, and can be seen in Figure 5.

3.2. The Implementation of Expert System

The application of the Dempster Shafer algorithm for the Expert System in diagnosing anxiety disorders will result in an assessment that shows the sufferer tends to have an anxiety disorder or not. It is based on "yes" answers to symptom questions provided by the system.

Figure 3. Inference Data

Figures 3, 4, and 5 are the page when the user accesses the expert system. The display of the user registration page before consulting the expert system is shown in Figure 3.
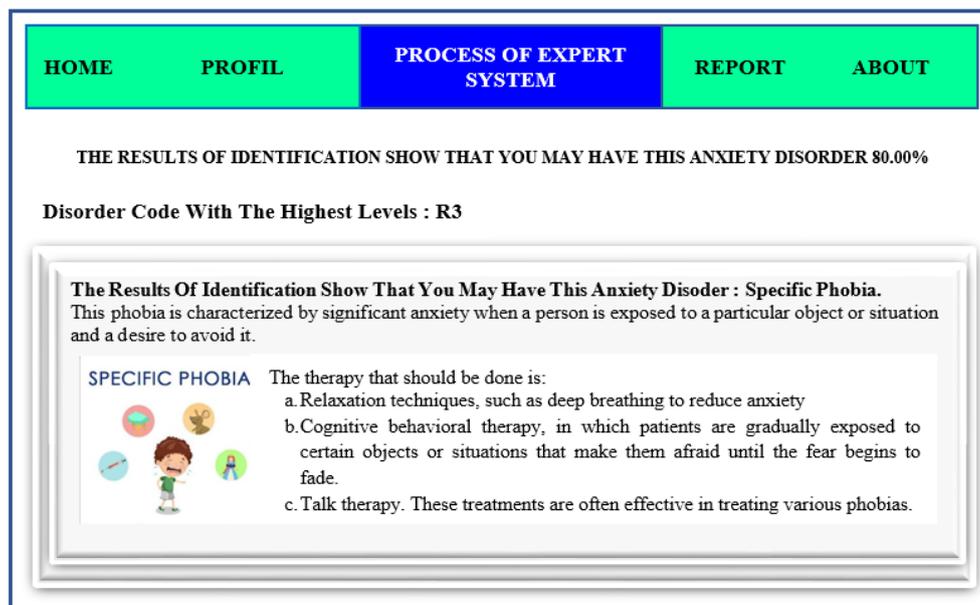
In Figure 3. users can register by filling in their data. After that, the user logs in using the username and password. Then the user can use the consultation menu, such as consulting and expert, in this case, a psychologist. Every user who wants to do early detection of anxiety disorders against himself can choose this menu. Then, the system gives some questions to get the detection results here. In Figure 4. the following is the initial view after the consultation menu is selected.
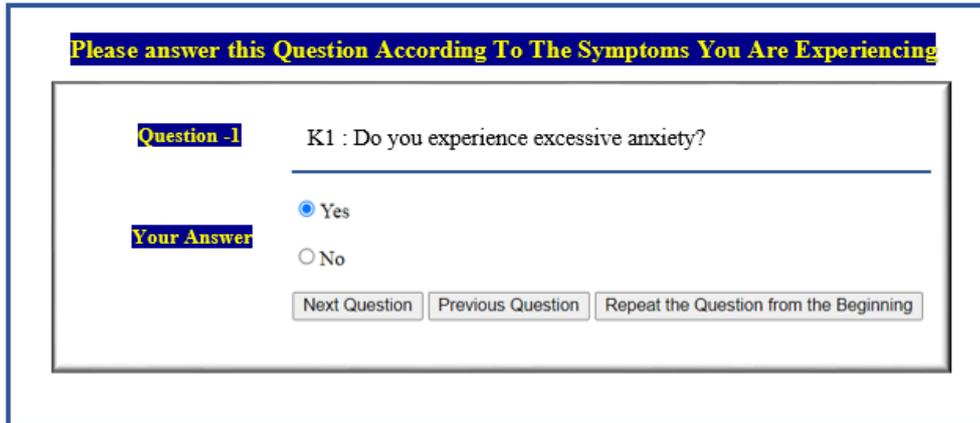
Figure 4. The first question when the user selects the consultation menu

If all questions have been answered, the system will automatically display the early detection results of anxiety disorders and the Dempster Shafer calculation to determine the probability that the patient tends to have anxiety disorders. Then the system will also display the solution, as shown in Figure 5. below.

Figure 5. The Results of Expert System Consultation

In Figure 5, the system displays the results of the Dempster Shafer calculation, which concludes that the patient has a specific phobic anxiety disorder (F3) of 80.00%.

3.1. Testing Expert System Results with Both Experts

After implementation, the two experts tested the results of the expert system as performed in table 5 and table 6 below.

Tabel 5. Comparison of the Test Results of First Expert with the Expert System

Patient	Symptoms	Results with Expert 1	Results with Expert System	Conclusion
1	K8, K9, K5, K14, K10, K3, K13, K15, K16	R1	R1	suitable
2	K8, K9, K5, K14, K10, K3, K48, K49	R8	R8	suitable
3	K8, K9, K7, K2, K18, K23, K25, K22, K24	R3	R3	suitable
4	K8, K9, K5, K14, K10, K3, K48, K49, K50, K51	R8	R8	suitable
5	K8, K9, K7, K28, K29, K30, K31, K32	R5	R5	suitable
6	K8, K9, K5, K14, K10, K3	R1	R8	not suitable
7	K8, K9, K7, K2, K18, K23, K25, K22, K26	R4	R4	suitable
8	K8, K9, K7, K2, K18, K23, K25, K22	R3	R4	not suitable
9	K8, K9, K5, K14, K10, K3, K48, K49, K50, K51, K52, K53	R8	R8	suitable
10	K8, K9, K7, K2, K18, K19, K20	R2	R2	suitable

Based on the tests carried out ten times by the system on the first expert, there are differences in the detection results in the 6th and 8th patients, so it is necessary to calculate the accuracy value, namely the suitability of the system value with the expert. This is because experts understand the patient's typical condition better than the system. The first calculation of the accuracy value is the suitability of the system results with the first expert as follows: (3) [17].

$$Accuracy\ value\ 1 = \frac{\sum suitable\ result\ analysis}{\sum number\ of\ patient} x\ 100\ \% \tag{3}$$

$$Accuracy\ value\ 1 = \frac{8}{10} x\ 100\ \%$$

$$= 80,00\ \%$$

Table 6. Comparison of the Test Results of Second Expert with the Expert System

Patient	Symptoms	Results with Expert 2	Results with Expert System	Conclusion
1	K8, K9, K5, K14, K10, K3, K13, K15, K16	R1	R1	suitable
2	K8, K9, K5, K14, K10, K3, K48, K49	R8	R8	suitable
3	K8, K9, K7, K2, K18, K23, K25, K22, K24	R3	R3	suitable
4	K8, K9, K5, K14, K10, K3, K48, K49, K50, K51	R8	R8	suitable
5	K8, K9, K7, K28, K29, K30, K31, K32	R5	R5	suitable
6	K8, K9, K5, K14, K10, K3	R1	R1	suitable
7	K8, K9, K7, K2, K18, K23, K25, K22, K26	R3	R4	not suitable
8	K8, K9, K7, K2, K18, K23, K25, K22	R4	R4	suitable
9	K8, K9, K5, K14, K10, K3, K48, K49, K50, K51, K52, K53	R8	R8	suitable
10	K8, K9, K7, K2, K18, K19, K20	R2	R2	suitable

Based on table 6. there are differences in the results of the system's detection of the expert on the 7th patient. This is because the expert understands the specifics of the symptoms experienced by the patient more than the system. The second accuracy value calculation results from comparing the values obtained by the system with the second expert. The system accuracy value is obtained by using equation (3) as follows.

$$Accuracy\ value\ 1 = \frac{9}{10}\ x\ 100\ \%$$

$$= 90,00\ \%$$

Setelah didapat perbandingan hasil sistem dengan pakar pertama dan pakar kedua, maka dilakukan perhitungan rerata nilai akurasi kedua pakar tersebut dengan rumus (4) berikut.

$$Average\ accuracy\ value = \frac{Accuracy\ value\ 1 + Accuracy\ value\ 2}{2} \qquad (4)$$

$$Average\ accuracy\ value\ = \frac{80,00\ + 90,00}{2}$$
$$= 85\ \%$$

Based on the average value of accuracy made by the two experts on the Expert System, which showed a result of 85%, it can be concluded that this expert system is acceptable and feasible to use for the early detection of anxiety disorders.

4. Conclusion

After analyzing and testing the implementation of the web-based Dempster Shafer Algorithm for the Expert System for Early Detection of Anxiety Disorders, several inferences can be obtained; namely, Dempster Shafer Algorithm provides the latest breakthroughs in the world of psychology or psychiatry and can assist psychologists in diagnosing anxiety disorders based on the symptoms faced by the patient and can provide solutions to the problems experienced. Then based on the average value of accuracy carried out by the two experts on the Expert System, the result was 85%, which means that this expert system is acceptable and feasible to use for early detection of anxiety disorders.

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