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Dempster Shafer Analysis in Mental and Emotional Health Monitoring

Asyahri Hadi Nasyuha[1], Dini Fakta Sari[2], Azanuddin[3], Muhammad Hafidz Ady Khoiri[4]

[1,4] Information Systems, Faculty of Information Technology, Universitas Teknologi Digital Indonesia, Yogyakarta, Indonesia
[3]Department of Computer Engineering, Faculty of Computer Engineering and Informatics, Politeknik Negeri Medan, Medan, Indonesia
[2]Informatics, Faculty of Information Technology, Universitas Teknologi Digital Indonesia, Yogyakarta, Indonesia

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ABSTRACT

Monitoring and diagnosing mental and emotional health are a significant challenge in the healthcare field due to its complex and subjective nature. This research aims to develop an expert system using the Dempster-Shafer method in monitoring and diagnosing mental and emotional health conditions. The Dempster-Shafer method was chosen because of its ability to handle uncertainty and combine various evidence from different information sources. This analysis is designed to identify seven types of mental and emotional illness by considering twenty-four related symptoms. The results of the analysis show that this expert system can provide a more accurate and comprehensive assessment compared to conventional methods. It is hoped that the implementation of this expert system can be an effective tool for medical personnel in making diagnoses and determining appropriate treatment steps for patients with mental and emotional health conditions. The results of this analysis show that the expert system, using the Dempster-Shafer method, achieved a diagnostic accuracy rate of over 85% when tested on real patient data. In particular, the system was effective in accurately identifying conditions such as anxiety and depression with a high degree of confidence. The system also successfully handled overlapping symptoms across mental health conditions, offering precise diagnoses for complex cases involving multiple symptoms. This study also highlights the potential of the Dempster-Shafer method in other applications that require evidence-based analysis under uncertainty.

Corresponding Author:

Asyahri Hadi Nasyuha,
Faculty of Information Technology, Information Systems
Universitas Teknologi Digital Indonesia,
Jl. Raya Janti Karang Jambe No. 143 Yogyakarta 55198, Indonesia,
Email: asyahrihadi@gmail.com

INTRODUCTION

Mental health plays a crucial role in overall well-being, influencing how individuals think, feel, and behave(Das et al., 2020). With rising awareness of mental health issues globally, the need for efficient monitoring and diagnosis has become increasingly urgent(Abdullah & Choudhury, 2018). Mental health disorders, including depression, anxiety, and other emotional conditions, often manifest in complex and subjective ways, making diagnosis and treatment challenging for healthcare providers. Traditional diagnostic methods rely heavily on patient reporting and clinical judgment, which may not always capture the full scope of a patient's mental health condition(Campbell et al., 2019). Thus, there is a growing need for more objective, technology-driven solutions. Mental and emotional health are important aspects of human well-being. However, monitoring mental health conditions is often a challenge, especially in the context of everyday life(Anggriani, 2023). Advancements in technology have revolutionized various aspects of healthcare, offering

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new tools for the monitoring and diagnosis of mental health. These tools can collect data continuously, analyze trends, and provide insights that may be overlooked in traditional healthcare settings. In particular, expert systems have gained prominence for their ability to analyze complex data and support decision-making processes. Expert systems use artificial intelligence (AI) to simulate the decision-making ability of a human expert, making them valuable in fields where decisions are based on interpreting large volumes of data, such as mental health diagnostics. On the other hand, expert systems have been proven to be efficient in dealing with uncertainty and complexity in data analysis, so that it can be a solid foundation for the development of a more sophisticated expert system for monitoring mental health(Erwis et al., 2022). With the urgency of research looking at increasing mental stress and the pressures of modern life, the problem of mental stress continues to become widespread, creating an urgency in developing a more effective mental health monitoring system (Nurhafiyah & Marcos, 2023). With so many Android users, this research is very suitable for supporting community welfare which can be carried out independently(Wahyuni & Winarso, 2021).

The Dempster-Shafer method offers an approach that can overcome uncertainty and complexity in data analysis(Aldo, 2020), (Ferdiansyah et al., 2018), so it becomes relevant in efforts to increase the accuracy of diagnosis(Asyahri Hadi Nasyuha et al., 2020). Dempster-Shafer Method or Evidential Reasoning Theory is a mathematical framework used to overcome uncertainty in the process of decision making and information analysis(Rosana et al., 2020), (Kirman et al., 2019), (Ramadhan & Sitorus Pane, 2018) . In the context of mental health monitoring, the Dempster-Shafer method can be applied to manage uncertainty in assessments, assessment of indications, or evaluation of mental states. By using this method, mental health monitoring systems can integrate disparate evidence to provide a more accurate and responsive assessment of people's mental health conditions. In this way, the Dempster-Shafer Method makes a significant contribution in addressing uncertainty and complexity in the analysis of mental health information, which in turn can increase the accuracy and effectiveness in monitoring and assessing mental health conditions(Ramadhani et al., 2017), (Annisa, 2018), (Rizky et al., 2023).

In this paper, the research gap lies in the need for a more effective and reliable system to monitor and diagnose mental and emotional health, especially considering the subjective nature and complexity of these conditions. While previous studies have used various methods for diagnosis, such as traditional probability or rule-based systems, this study overcomes the limitations of these approaches by implementing the Dempster-Shafer method. This method is well suited to handle uncertainty and integrate diverse evidence, thus providing a more accurate and comprehensive diagnostic framework. This study distinguishes itself from similar studies by specifically focusing on the use of this method to analyze 24 symptoms across 7 types of mental and emotional illnesses, which have not been widely explored in the context of mental health monitoring. Furthermore, this study highlights the practical application of the Dempster-Shafer method in creating an Android-based system for community use, emphasizing its relevance for self-diagnosis in everyday life. From the research background above, to having a problem formulation on how to create an Android Health System that is efficient in monitoring mental and emotional health using the Dempster-Shafer method in analyzing information that supports more accurate and reliable mental health monitoring. It is hoped that this research can be part of developing a more effective and efficient mental health monitoring system.

RESEARCH METHOD

Mental and emotional health is a vital aspect of an individual's well-being, which is often overlooked in traditional health systems. Diagnosis and monitoring of this condition is very challenging because symptoms are often subjective and vary between individuals. For this reason, the development of expert systems that are able to handle uncertainty in mental health diagnoses is becoming increasingly important(Sari et al., 2022), (Purwadi & Nasyuha, 2022). The Dempster-Shafer method offers a potential approach to dealing with uncertainty and combining evidence from multiple sources. Expert systems have been used widely in various medical fields to aid diagnosis and decision making(Asyhari Hadi Nasyuha et al., 2023). In the context of mental health, expert systems can help in identifying mental conditions based on symptoms reported by patients. This system works by relying on knowledge from experts in the field and can process data quickly and provide evidence-based diagnosis recommendations.

The Dempster-Shafer (DS) method is a mathematical approach to dealing with uncertainty in decision making. In contrast to traditional probability theory, DS allows combining multiple sources of information and taking into account existing uncertainties(Riansyah et al., 2021). This method uses a belief function to represent evidence and combines various pieces of evidence to produce more accurate decisions(Kirman et al., 2019). The use of DS methods in expert systems can increase diagnostic accuracy by integrating data from various sources and taking into account uncertainty. Implementation of the DS method in an expert system for mental health monitoring involves several stages, including collecting symptom data from patients, processing the data using belief functions, and combining evidence to produce a diagnosis. This system is expected to provide a more comprehensive assessment and help medical personnel make better decisions.

The Dempster-Shafer method offers great potential in improving the accuracy and reliability of expert systems for mental and emotional health monitoring and diagnosis. By combining multiple sources of evidence and dealing with uncertainty effectively, this method can be a very useful tool in the mental health field. Further studies are needed to develop and test this system on a larger scale and in various clinical contexts. To achieve the research objectives related to the development of Mental and Emotional Health Monitoring analysis using the Dempster-Shafer Method, several stages or steps are taken as shown in Figure 1 below:

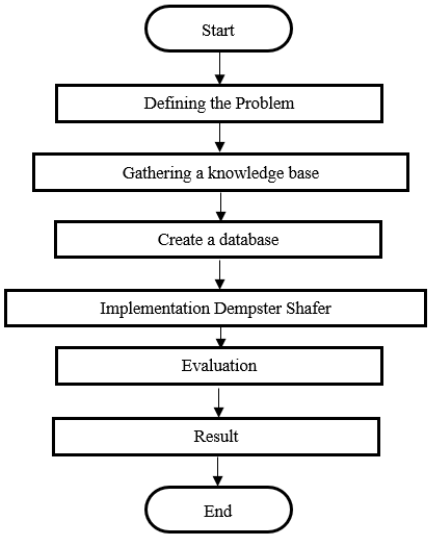

Figure 1. Research Steps Dempster Shafer

1. Determine cases from research into the development of the Android Health System in Monitoring Mental and Emotional Health using the Dempster-Shafer method by providing an in-depth description of the challenges that may be experienced during the system development and implementation process. Like:
   a. Uncertainty in Mental Health Information
   b. Integration with Clinical Practice
   c. Data Security
   d. Validation and Accuracy
   e. Acceptance by User
   f. Conformity to User Needs

   Some of the cases above can formulate appropriate strategies to overcome challenges that arise during the development of the Android Health System in Mental and Emotional Health Monitoring using the Dempster-Shafer Method.
2. Gather a knowledge base from mental and emotional health experts. This knowledge base also uses references from several theoretical sources, such as manuscripts from national journals that discuss mental and emotional health. The data obtained are presented in table 1 in the form of disease data and symptom data.

Table 1. Mental and Emotional Health Illnesses.

No.	Code	Disease	Solution
1	P1	Depression	Counseling or psychological treatment, antidepressant medication, social support, exercise, and maintaining a healthy sleep pattern.
2	P2	Anxiety	Cognitive treatment, meditation, respiratory training, exercise, avoiding stimulants caffeine and alcohol.
3	P3	Schizophrenia	Antipsychotic treatment, social support, cognitive treatment, and long-term care.
4	P4	Bipolar Disorder	Healing mood stabilizer, psychological treatment, family and social support, mental stress management.
5	P5	Eating Disorders	Psychological treatment, nutritional support, family support, group treatment.
6	P6	Post Traumatic	Stress Disorder Trauma treatment, cognitive attitude treatment, social support, anti-anxiety medication or antidepressants.
7	P7	Personality Disorders	Psychological treatment, dialectical attitude treatment, interpersonal treatment, and family support.

The following table provides a list of common symptoms associated with various mental and emotional health conditions. Each symptom is classified and can help healthcare providers assess the severity of a patient's condition and determine appropriate action. Table 2 below provides an organized overview of key symptoms, which are important for clinicians to detect and monitor the development of mental and emotional health disorders, thereby improving the quality of care and treatment outcomes.

Table 2. Symptoms of Mental and Emotional Health Diseases

No	Code	Symptom	Value
1.	G1	Feelings of deep sadness	0,6
2.	G2	loss of interest or pleasure in activities usually enjoyed	0,6
3.	G3	sleep disorders,	0,4
4.	G4	changes in body weight	0,5
5.	G5	fatigue	0,5
6.	G6	Excessive worry	0,7
7.	G7	feeling restless	0,75
8.	G8	muscle tension	0,5
9.	G9	excessive sweating	0,5
10.	G10	Thought disorders	0,7
11.	G11	Delusions	0,65
12.	G12	Hallucinations	0,65
13.	G13	Extreme mood swings between mania and depression	0,7
14.	G14	excessive energy	0,6
15.	G15	Despair	0,75
16.	G16	Unhealthy eating behavior	0,6
17.	G17	obsession with weight	0,5
18.	G18	body dissatisfaction.	0,5
19.	G19	Disturbing traumatic memories	0,65
20.	G20	nightmare	0,6
21.	G21	increased tension	0,6
22.	G22	Thought patterns	0,6
23.	G23	emotion	0,6
24.	G24	unhealthy behavior	0,6

3. Creating a database based on the knowledge base that has been obtained from the research preparation that has been carried out. The contents of the database are in accordance with the disease table and symptom table for Mental and Emotional Health Diseases.
4. In the context of mental and emotional health monitoring, the Dempster-Shafer method helps combine evidence from multiple symptoms to reach a more accurate diagnosis or conclusion about a patient's condition. This process involves several stages, starting from collecting symptom data, assigning probability values, combining evidence, and finally making decisions based on the aggregate data. Each stage plays a critical role in ensuring that the diagnosis or health monitoring process is reliable, even when there is uncertainty or incomplete information. Figure 2 illustrates the step-by-step application of the Dempster-Shafer method to mental and emotional health monitoring. By visualizing these stages, healthcare providers can better understand how this method works and its potential to improve patient care in cases where multiple symptoms need to be evaluated simultaneously:

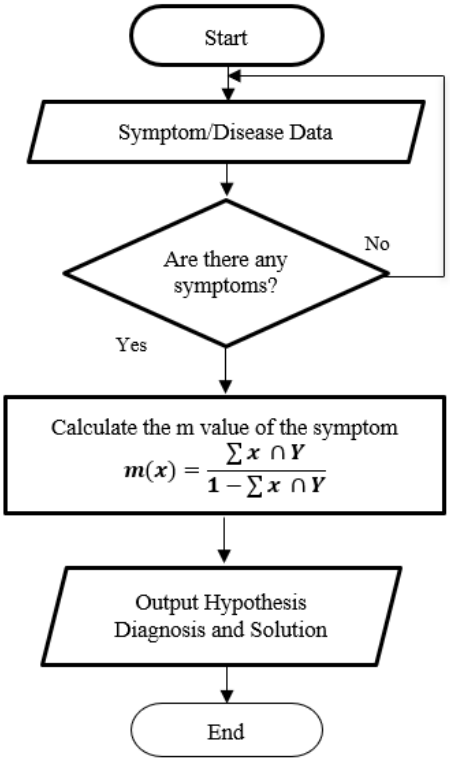

Figure 2. Diagnostic Series using the Dempster Shafer Method

Dempster Shafer's series of methods are used as a reference for solving mental and emotional health problems.

a. Determining diseases and symptoms of mental and emotional health. From the data obtained, there are seven types of disease as seen in table 1.
b. Determine the symptoms experienced, if you have symptoms then the process will continue to determine the m value, if not then input the symptoms again.
c. The process of calculating the m value of the symptom using the following formula:

$$m(x) = \frac{\sum x \cap Y}{1 - \sum x \cap Y} \quad (1)$$

5. This Evaluation phase ensures that the developed system is not only theoretically sound but also practically effective. This phase involves validating the system's performance by testing it in real-world scenarios with actual patient data. The goal is to assess the system's accuracy in diagnosing mental and emotional health conditions, as well as its usability, reliability, and overall user acceptance. During this phase, several key metrics will be

measured, including diagnostic accuracy, user satisfaction, and system responsiveness. The system will be evaluated by medical professionals who will compare the system's diagnosis with conventional methods to measure its effectiveness. Additionally, user feedback will be collected to understand how intuitive and useful the system is for non-expert users. This feedback is important to identify limitations or areas for improvement in the system's design and functionality. By combining these evaluation phases, the research becomes more robust, as it not only develops the system based on the Dempster-Shafer method but also validates its practical application. This ensures that the system can be confidently implemented in clinical or everyday use, thereby increasing the reliability and effectiveness of mental and emotional health monitoring.

6. Obtain results in the form of a diagnosis hypothesis for the disease suffered based on the symptoms experienced and solutions that can be taken as initial steps for treatment

RESULTS AND DISCUSSION

The application of the Dempster-Shafer theory in this study aims to diagnose seven different mental and emotional health conditions based on twenty-four symptoms identified from patient data. Table 3 below explains the knowledge-based rules for the symptoms and diseases experienced:

Table 3. Knowledge Base

	P1	P2	P3	P4	P5	P6	P7
G1	✓						
G2	✓						
G3	✓						
G4	✓				✓		
G5	✓	✓					
G6		✓					
G7		✓					
G8		✓					
G9		✓					
G10			✓				
G11			✓				
G12			✓				
G13				✓			
G14				✓			
G15				✓			
G16					✓		
G17					✓		
G18					✓		
G19						✓	
G20						✓	
G21		✓				✓	
G22							✓
G23			✓				✓
G24							✓

Dempster Shafer is a value given to indicate the amount of trust, so the value (m) of a symptom is input (0-1). The formula used to diagnose coral stone disease is:

$$M3 = \frac{\sum X \cap Y = Zm1(X).M2(Y)}{-\sum X \cap Y = \emptyset m1(X).m\ 2(Y)} \quad (2)$$

Information:
M1 (X): Density for the first symptom
M2 (Y): Density for the second symptom
M3 (Z): Combination of both densities
Ø: universe of discussion from a set of hypotheses (X' and Y')
X and Y: Subset of Z
X' and Y': Subset of Ø

In the context of diagnosing mental health conditions, symptoms are often rated based on their intensity and frequency, which is represented by density values. These values help determine the severity of the symptom and how it may contribute to the patient's overall condition. Table 4 below provides examples of patient cases, which demonstrate different symptoms and their density values. Each case represents a different symptom reported by the patient, which plays a role in diagnosing their mental or emotional condition:

Table 4. Cases experienced by patients

No	Code	Symptom	Density Value
1	G6	Excessive worry	0,7
2	G5	fatigue	0,5
3	G23	emotion	0,6

Symptom 1: G6 Excessive worry
m1{p2} = 0.7
m1{θ} = 1-0.7 = 0.3

Symptom 2: G5 fatigue
m2{p1, p2} = 0.5
m2{θ} = 1-0.7 = 0.5

In this context, m1 and m2 represent two different sources of evidence regarding propositions p1, p2p1, p2, and θ (which represents all possible outcomes or unknown probabilities). The number assigned to each proposition or set of propositions represents the degree of confidence (or mass) that the evidence supports that particular proposition. The table 5 below shows the belief masses for m1 and m2, which will later be combined using Dempster's combination rule to reach a more precise conclusion based on the two pieces of evidence:

Table 5. Basic Probability Assignment (BPA) for m1 and m2

m1	m2	
	{p1, p2} = 0.5	{θ} = 0.5
{p2} = 0.7	{p2} = 0.35	{p2} = 0.35
{θ} = 0.3	{p1, p2} = 0.15	θ = 0.15

$\{p2\} = \frac{0.35+0.35}{1-0} = 0.7$
$\{p1, p2\} = \frac{0.15}{1-0} = 0.15$
$\{\theta\} = \frac{0.15}{1-0} = 0.15$

Symptom 3 : G23 Emotion
m3{p3, p7} = 0.6

m3{θ} = 1-0.7 = 0.4

In this case, m2 and m3 represent two pieces of evidence with their respective probability distributions for different sets of propositions (denoted by p1, p2, p3, p7p1, p2, p3, p7 and θ). Each proposition corresponds to a possible state or outcome related to mental and emotional health. The values assigned to these sets represent the confidence (or mass) that the evidence supports the corresponding proposition or set of propositions.

The table 6. below depicts the various sets of propositions and their associated belief masses under m2 and m3, which will later be combined using Dempster's combination rule to update the overall belief based on multiple sources of evidence. Now, here is the representation of m2 and m3 with their belief masses:

Table 6. Basic Probability Assignment (BPA) for m2 and m3

m2	m3	
	{p3, p7} = 0.6	{θ} = 0.4
{p2} = 0.7	{θ} = 0.42	{p2} = 0.28
{p1, p2} = 0.15	{θ} = 0.09	{p1, p2} = 0.06
{θ}=0.15	{p3, p7} = 0.09	θ = 0.06

$\{p2\} = \frac{0.28}{1-(0.42+0.09)} = 0.57$

$\{p1, p2\} = \frac{0.06}{1-(0.42+0.09)} = 0.12$

$\{p3, p7\} = \frac{0.09}{1-(0.42+0.09)} = 0.18$

$\{\theta\} = \frac{0.06}{1-(0.42+0.09)} = 0.12$

The highest density value is p2: 0.57, the disease experienced is Anxiety disease (P2).

CONCLUSION

The results obtained from the application of Dempster-Shafer theory in mental and emotional health monitoring demonstrate its ability to manage uncertainty and provide a flexible framework for diagnostic reasoning. This discussion explores the implications of these findings, the challenges faced, and potential future directions for research in this area. The high diagnostic accuracy obtained in this study, especially for depression and anxiety, suggests that Dempster-Shafer theory can effectively integrate diverse symptom information to produce reliable diagnostic assessments. The application of Dempster-Shafer theory in mental and emotional health monitoring demonstrates its potential to improve diagnostic accuracy by managing uncertainty and integrating diverse symptom data. The results suggest that the expert system developed in this study can serve as a valuable tool for healthcare professionals, providing a more comprehensive assessment compared to conventional methods. Future research could further improve the system, with scaling the system to larger datasets and more diverse patient populations helping to validate its generalizability and improve its robustness in real-world clinical settings. Incorporating larger datasets will also allow the system to learn from a wider range of cases, improving its diagnostic accuracy for complex or less common mental health conditions. Focus on improving the user interface, particularly by incorporating feedback from clinicians and patients during the pilot study. Usability improvements could make the system more intuitive and accessible, increasing its practical utility in everyday healthcare settings. Exploring the integration of the system into clinical workflows, ensuring that it aligns with existing practices while offering support for decision-making. By focusing on these aspects, the system's real-world effectiveness can be maximized, making it an important tool for mental and emotional health monitoring.

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