ISSN 2085-4552

Application of the Dempster-Shafer Method in Developing a Web-Based Expert System for Diagnosing Dental and Oral Diseases

Yoseph P.K Kelen
Department of Information Technology, Faculty of Agriculture, Universitas Timor, Kefamenanu, Indonesia
yosepkelen@unimor.ac.id

Accepted 19 December 2025
Approved 07 January 2026

***Abstract*— An expert system is a problem-solving system that captures human knowledge into a system similar to what experts typically do. Expert systems allow humans to solve problems usually handled by specialists, even when performed by non-experts. They can also assist experts in completing their tasks or serve as reliable assistants in addressing problems without requiring direct consultation with professionals. This study aims to develop an expert system for diagnosing dental diseases using the Dempster–Shafer method to identify dental and oral conditions based on the highest probability of symptoms experienced. The expert system is implemented on a computer using a web-based programming language with PHP and a MySQL database. The results of this expert system are expected to make it easier for users to conduct consultations and obtain accurate diagnoses of dental diseases they experience, as well as receive appropriate treatment recommendations using the Dempster–Shafer algorithm.**

Index Terms*— *Expert System; Dempster-Shafer; Dental Disease; Oral Disease.

I. INTRODUCTION

One of the branches of computer science widely utilized by humans to assist their work is the expert system, which is a subfield of artificial intelligence [1]. Artificial Intelligence (AI) is a field of computer science that plays an important role in the present and future eras. AI encompasses a broad range of areas, from general to highly specialized domains. From learning to perception, AI is considered a universal discipline [2].

The concept of expert systems is based on the assumption that expert knowledge can be stored and applied in a computer, then utilized by others when needed. One of the applications of expert systems is in the field of medicine or healthcare. The implementation of expert systems in healthcare may include disease diagnosis, health maintenance consultations, and the provision of recommendations based on existing diagnoses. Health is indeed a valuable aspect of human life; therefore, personal awareness is needed to maintain it. One of the body organs that is often neglected is the teeth and mouth. This is evidenced by data from the Directorate General of Health Services (2001), which shows that dental and oral diseases are among the ten most prevalent diseases in Indonesia [3].

Based on a survey conducted by the Dental Health Foundation (2003) on children, 70% were found to suffer from dental caries and gingivitis, while among adults, 73% were reported to have dental caries. Furthermore, according to Indonesia's Basic Health Research (Riskesdas) in 2013, 25.9% of the Indonesian population has dental and oral health problems. The lack of knowledge and limited sources of information regarding dental and oral health contribute to the low public awareness of maintaining oral hygiene. Among those affected, 31.1% received care from dental health professionals—such as dental nurses, dentists, or dental specialists—while the remaining 68.9% did not seek any treatment [4].

The ideal ratio of dentists to the population in Indonesia is 1 to 9,000. However, due to the still limited number of dentists in the country, this ratio has increased to 1 to 24,000. This ideal ratio is far from the standard set by the World Health Organization (WHO), which is 1 to 2,000 people. This concerning situation is further worsened by the unequal distribution of dentists in Indonesia, with 70% of them concentrated on the island of Java. The conditions described above highlight the need for a system that can serve as an initial consultation platform before seeking further treatment from a dentist. Therefore, the author is motivated to develop an "Expert System for Diagnosing Dental and Oral Diseases." This system is intended to assist dental practitioners by improving the speed and accuracy of diagnosing diseases and providing appropriate solutions.

II. METHOD

2.1 Teeth

Teeth are the hardest tissues in the human body. Their structure consists of multiple layers, starting from the extremely hard enamel, followed by dentin, and the pulp, which contains blood vessels, nerves, and other components that strengthen the tooth. However, teeth are also among the body tissues most susceptible to damage. This occurs when the teeth do not receive proper care [5]

Teeth are the hard parts located within the mouth that function to chew food. Each tooth consists of several parts, as illustrated in the figure below:

2.2 Types of Dental Diseases

Based on the *Dental Disease Module* by Kristiani et al. (2010), several types of dental and oral diseases are described as follows:

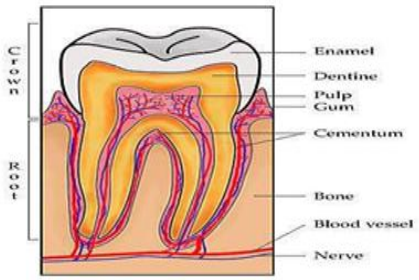
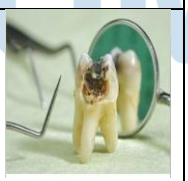


Figure 2.2 Structure of the Tooth

Table 2.2. Types of Dental and Oral Diseases

No	Disease Name	Description	Illustration
1	**Dental Caries**	Dental caries is an infectious disease that damages the hard structure of the teeth. It is characterized by cavities.	
2	**Dental Abscess**	A dental abscess is a pus-filled swelling or lump that forms in the tooth due to bacterial infection.	
3	**Gingivitis**	Gingivitis is a bacterial infection that causes the gums to become inflamed, red, and swollen.	
4	**Pulpitis**	Pulpitis is a condition caused by inflammation of the pulp—the central part of the tooth containing tissues and tooth-forming cells.	
5	**Periodontitis**	Periodontitis is a gum infection that damages the soft tissue and bone supporting the teeth. This condition requires prompt treatment as it may lead to tooth loss.	
6	**Pericoronitis**	Pericoronitis is an inflammation of the gum tissue surrounding the wisdom teeth, which are the last molars to emerge and are located at the back of the mouth.	

2.3 Expert System

An expert system is a computer system designed to replicate the abilities or expertise of a human specialist in a specific domain. It is implemented as a computer program presented in a way that non-expert users can easily understand and utilize. This enables users without expert knowledge to make decisions or draw conclusions similar to those made by experts [6].

The reasoning ability of an expert system depends on the knowledge base encoded within the system. The effectiveness of such a system in solving problems is directly related to the amount and quality of expert knowledge stored. The larger and more accurate the knowledge base, the more capable the expert system becomes [7].

The user interface serves as the communication bridge between the user and the system. It allows users to input data and receive information in return. Expert systems differ from conventional systems primarily in their knowledge-based foundation. According to Adriani (2016:13–14), the distinguishing characteristic of an expert system lies in how it utilizes stored expert knowledge to perform reasoning and provide conclusions based on that knowledge.

2.4 Dempster-Shafer Method

The Dempster-Shafer theory is a mathematical framework for reasoning under uncertainty, based on *belief functions* and *plausible reasoning*. It is used to combine separate pieces of evidence to calculate the probability of an event [8]. The theory was developed

by Arthur P. Dempster and Glenn Shafer. Generally, the Dempster-Shafer theory is represented within an interval:
Belief,PlausibilityBelief,
PlausibilityBelief,Plausibility

Belief(Bel)
Belief represents the strength of evidence supporting a particular hypothesis. A value of 0 indicates no evidence, while a value of 1 represents complete certainty [9].

Plausibility(Pl)
Plausibility measures how much the evidence does *not* refute a hypothesis and is calculated as: Pl(s)=1−Bel(¬s)Pl(s) = 1 - Bel(¬s)Pl(s)=1−Bel(¬s) Plausibility values range from 0 to 1. If we are certain of ¬s (not s), then Bel(¬s) = 1 and Pl(¬s) = 0. Thus, plausibility reduces the degree of belief in the evidence.

In Dempster-Shafer theory, there exists a **frame of discernment**, denoted as θ, which represents the universal set of all possible hypotheses, and a **mass function (m)**, which denotes the degree of belief assigned to a subset of hypotheses[10].

Let:
θ = {A, B, C, D, E, F, G}

Where:
A=DentalCaries
B=Pulpitis
C=Gingivitis
D=DentalAbscess
E=Malocclusion
F=CrowdedTeeth
G = Impaction

MassFunction(m) The mass function in Dempster-Shafer theory quantifies the degree of belief in a given piece of evidence. To combine multiple pieces of evidence, the Dempster's Rule of Combination is applied: If $m_1(X)$ and $m_2(Y)$ are two mass functions representing different evidences, the combined mass function $m_3(Z)$ is calculated by applying the rule to aggregate the evidences and compute the resulting belief.

III. Result and Discussions

3.1 Implementation of the Dempster-Shafer Method

1. Dental and Oral Disease Data

Dental and oral disease data is data in the system presented in table 3.1.

Table 3.1. Dental and Oral Disease Data

No	Code	Disease
1	P1	Pulpitis
2	P2	Gingivitis
3	P3	Dental Abscess
4	P4	Dental Caries
5	P5	Periodontitis
6	P6	Pericoronitis

2. Symptoms of Dental and Oral Diseases

Data on symptoms of dental and oral disease are symptoms that can cause dental and oral disease, which are presented in Table 3.2.

Table 3.2. Symptoms of Dental and Oral Diseases

No	Code	Symptom
1	G1	Presence of soft tissue growth in a decayed tooth
2	G2	Tooth pain or sensitivity when chewing
3	G3	Pain around the tooth
4	G4	Swollen or easily bleeding gums
5	G5	Unpleasant mouth odor (halitosis)
6	G6	Lesions between the gums and teeth
7	G7	Lump around the head, neck, or jaw
8	G8	Fever
9	G9	Pain while swallowing food
10	G10	Swollen gums
11	G11	Pain when opening the mouth
12	G12	Swelling of lymph nodes in the neck
13	G13	Pain when pressure is applied to the tooth by food
14	G14	Pain in the gums and mouth
15	G15	Swelling of the cheeks
16	G16	Brown, black, or white spots on the tooth surface
17	G17	Presence of holes or cavities in teeth
18	G18	Toothache when exposed to cold water or when food enters
19	G19	Gums feel soft when touched
20	G20	Tooth appears taller than usual
21	G21	Gaps between teeth become wider
22	G22	Gums swollen and appear reddish or purplish
23	G23	Pus discharge from infected gums
24	G24	Limited and sometimes painful jaw movement
25	G25	Pain or difficulty when swallowing

3.2 Calculation Using the Dempster-Shafer Method

To assume the level of certainty of an expert that has been adopted as the system's confidence level in providing a diagnosis of a data, this concept is then formulated into a production rule which is usually written in the form of If-Then (IF-THEN). This production rule can be said to be a two-part implication relationship, namely the premise (If) and the conclusion (Then) as in Table 3.3 below:

Table 3.3. Production Rules

Rule	Symptoms	Conclusion (Disease)
1	IF G1 AND G2 AND G3 AND G4	THEN P1
2	IF G4 AND G5 AND G6 AND G7 AND G8	THEN P2
3	IF G2 AND G9 AND G10 AND G11 AND G12 AND G13 AND G14 AND G23	THEN P3
4	IF G2 AND G15 AND G16 AND G17 AND G18 AND G23	THEN P4
5	IF G2 AND G5 AND G19 AND G20 AND G21 AND G22	THEN P5
6	IF G4 AND G23 AND G24 AND G25	THEN P6

The first step in calculating the system's confidence level is to break down rules with multiple premises (characteristics) into rules with single premises (characteristics). In the first test, several symptoms experienced by the community are given, including the following:

No	Symptom Code	Disease						Knowledge Base	
		P1	P2	P3	P4	P5	P6	Belief Values	Plausibility Value
1	G1	X						0,8	0,2
2	G2	X		X	X	X		0,6	0,4
3	G3	X						0,7	0,3
4	G4	X	X				X	0,4	0,6
5	G5		X			X		0,6	0,4
6	G6		X					0,7	0,3
7	G7		X					0,6	0,4
8	G8		X					0,7	0,3
9	G9			X				0,7	0,3
10	G10			X				0,8	0,2
11	G11			X				0,8	0,2
12	G12			X				0,8	0,2
13	G13			X				0,4	0,6
14	G14			X				0,6	0,4
15	G15				X			0,4	0,6
16	G16				X			0,8	0,2
17	G17				X			0,4	0,6
18	G18				X			0,6	0,4
19	G19					X		0,4	0,6
20	G20					X		0,6	0,4
21	G21					X		0,6	0,4
22	G22					X		0,6	0,4
23	G23			X	X		X	0,4	0,6
24	G24						X	0,8	0,2
25	G25						X	0,6	0,4

In the first test, several symptoms are given and the patient chooses the symptoms based on what they experience, then several selected symptoms appear as in the following table:

Table 3.5. Selected Symptoms

No	Code	Symptom
1	G1	Presence of soft tissue growth in a decayed tooth
2	G2	Tooth pain or sensitivity when chewing
3	G3	Pain around the tooth

From the consultation results, a total of 3 symptoms were selected, so to obtain a confidence value using Dempster's rule of combination of the selected symptoms.

Step 1 – Symptom 1 (G1)

Symptom: Presence of soft tissue growth in a decayed tooth
m1{P1}=0.8m_1 \{P1\} = 0.8m1{P1}=0.8, m1(θ)=1−0.8=0.2m_1(θ) = 1 - 0.8 = 0.2m1(θ)=1−0.8=0.2

Step 2 – Symptom 2 (G2)

Symptom: Tooth pain or sensitivity when chewing m2{P1,P3,P4,P5}=0.6m_2 \{P1, P3, P4, P5\} = 0.6m2{P1,P3,P4,P5}=0.6, m2(θ)=1−0.6=0.4m_2(θ) = 1 - 0.6 = 0.4m2(θ)=1−0.6=0.4

By applying the Dempster Combination Rule, we calculate new density values as shown below:

Table 3.6. Combination Rule m3m_3m3

Evidence	Value
{P1} = 0.48	{P1} = 0.32
{P1, P3, P4, P5} = 0.12	{θ} = 0.08

After normalization, the combined mass values indicate the belief in each hypothesis. The highest belief value obtained is **0.6 for P1**, indicating that the disease is most likely *Pulpitis*.

Step 3 – Symptom 3 (G3)

Symptom: Pain around the tooth m4{P1}=0.7m_4 \{P1\} = 0.7m4{P1}=0.7, m4(θ)=0.3m_4(θ) = 0.3m4(θ)=0.3

Table 3.7. Combination Rule m7m_7m7

	m4 {P1} = 0,7	m4{ɵ}= 0.3
{P1} + {P1, P3, P4, P5} = 0,6	{P1} = 0,42	{P1} = 0,18
m3 {P1} = 0,32	{P1} = 0,23	{P1} = 0,10
m3{ɵ}= 0.08	{P1} = 0,06	{ɵ}= 0,24

After combining all three pieces of evidence, the result shows:

m5{P1}=0.76m_5 \{P1\} = 0.76m5{P1}=0.76

Thus, the final belief that the patient suffers from **Pulpitis** is **76%**, based on the Dempster-Shafer calculation

3.4 Interface Design

The system interface represents the interaction between users and the computer system. It involves input (data entry) and output (display of diagnostic results). The main components are described below.

1. Main Menu Interface

This is the first screen displayed after launching the application, consisting of: *Home, About, Info,* and *Login* menus.

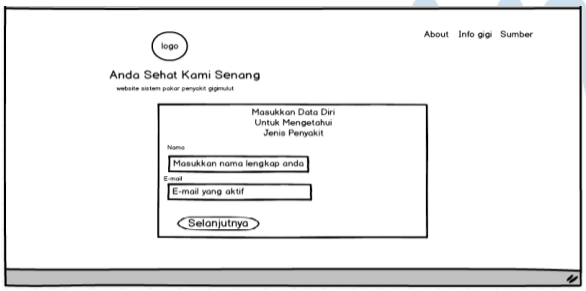


Figure 3.1. Home Interface Design

2. About Interface

Displays the system's vision and mission statement, explaining the purpose and background of the application.

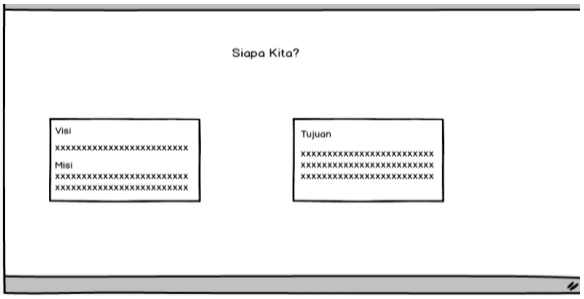


Figure 3.2. About Interface Design

a) 3. Info Interface

Presents information and images related to various dental and oral diseases that may affect users.

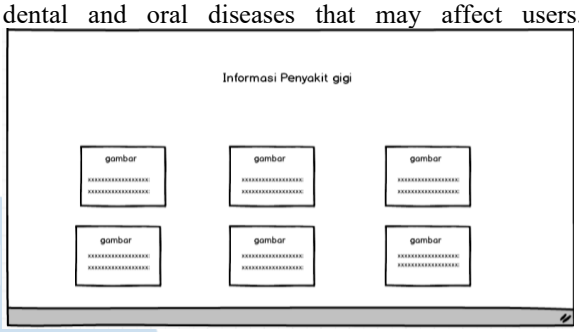


Figure 3.3. Info Interface Design

4. Source Interface

Displays references or information sources regarding the diseases included in the system.

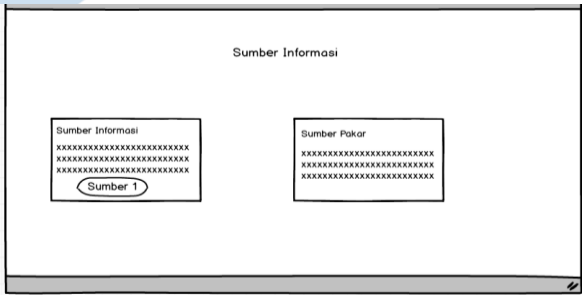


Figure 3.4. Source Interface Design

3.5 Interface Output

This section illustrates how the expert system works in diagnosing dental and oral diseases.

1. Home Page

The home page provides navigation for both admin and user roles, with features tailored to their access rights.

Figure 3.5. Home Page

2. About Page

Displays the vision and mission statement of the system.

Figure 3.6. About Page

3. Info Page

Displays disease information and related illustrations.

Figure 3.7 *Info Page*

4. Source Page

Displays the list of references used as knowledge sources in the system.

Figure 3.8 Source Page

IV. CONCLUSION

The developed expert system is able to represent the role of dentists in assisting patients who experience dental and oral diseases by providing diagnostic results based on the symptoms they select. This web-based system is designed to help and simplify the diagnostic process for general users who may not have access to immediate dental consultations. The system analyzes user-selected symptoms and generates diagnostic recommendations along with appropriate treatment suggestions. The system is capable of producing accurate diagnostic results because it uses the Dempster–Shafer method to calculate probability values by combining diseases, symptoms, and their respective belief values. This method allows the system to deliver reliable diagnostic outcomes.

The system should be further developed by expanding the scope of diagnoses. Currently, the expert system includes only six types of dental and oral diseases. Future development should incorporate additional diseases to enhance the system's comprehensiveness. To improve system performance and maintainability, it is recommended to implement a dynamic database structure. This will make it easier to update information, add new symptoms, and include additional diseases without requiring major system modifications

REFERENCES

[1] H. P. Computing, “Diagnose Expert System Dental Disease In Humans Method Using Dempster,” vol. 2, no. 2, pp. 227–229, 2020.

[2] L. Putu *et al.*, “PERAN ARTIFICIAL INTELLIGENCE (AI) UNTUK MENDUKUNG PEMBELAJARAN DI MASA PANDEMI COVID-19 THE ROLE OF ARTIFICIAL INTELLIGENCE (AI) TO SUPPORT LEARNING,” vol. 1, no. 1, pp. 15–21, 2022.

[3] A. G. Pradana *et al.*, “Expert System for Dental Disease Diagnosis with Forward Chaining Method at Sidoarjo Dental Clinic,” vol. 4, no. 3, pp. 4–7, 2025.

[4] S. 2003, “No Title,” pp. 21–26, 2013.

[5] D. Rubino and E. W. Puspitarini, “GIGI DAN MULUT DENGAN METODE FORWARD CHAINING BERBASIS (STUDI KASUS KLINIK TARUNA MANGGALA GRUP SURABAYA),” vol. 1, no. 1, pp. 29–45, 2016.

[6] C. Factor, “1* , 2 , 3,” pp. 739–748, 2025.

[7] P. Sistem, P. Perbaikan, and D. Metode, “SEMNAS RISTEK 2019 ISSN : 2527-5321,” 2019.

[8] J. Teknologi, “Implementasi metode Dempster-Shafer dalam diagnosa penyakit pada tanaman Cabai Merah Keriting,” vol. 29, no. 1, pp. 13–25, 2019.

[9] M. D. Sinaga, N. Sari, and B. Sembiring, “Penerapan Metode Dempster Shafer Untuk Mendiagnosa Penyakit Dari Akibat Bakteri Salmonella,” pp. 94–107.

[10] N. E. Saragih and R. Adawiyah, “Rancang Bangun Sistem Pakar Mendiagnosa Penyakit Obsessive Compulsive Disorder Dengan Metode Dempster Shafer,” 2020.