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Development of An Expert System for Identifying Dental Diseases Using Certainty Factor Method (Case Study: UPT Puskesmas Parmaksian)

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Abstract

Purpose: Dental health is a critical aspect of human well-being, yet awareness of its significance remains alarmingly low. This study endeavors to bridge this awareness gap by proposing the development of an expert system designed to identify dental diseases, and it employs the Certainty Factor method for this purpose.

Methods/Study design/approach: The Certainty Factor method is a valuable tool that enables the system to express the level of certainty in expert statements, thus facilitating a more personalized approach. The expert system, when fully developed, will calculate Certainty Factor values for each symptom presented by patients. Preliminary tests indicate that the system achieved an impressive 83% accuracy rate in identifying dental diseases. These tests were conducted with a substantial sample size, comprising 47 out of 56 cases.

Result/Findings: The potential impact of this research on the field of dental health is significant. The implementation of such an expert system can serve as a powerful and effective tool for the early identification of dental diseases. This, in turn, not only enhances awareness about the importance of dental health but also has practical applications that can significantly improve oral health care.

Novelty/Originality/Value: In summary, the development of an expert system based on the Certainty Factor method promises to be a breakthrough in dental health. With its high accuracy rate, it can play a pivotal role in early disease detection and, consequently, in raising awareness and improving practical oral health applications.

Keyword: *Expert System, Dental Identification, Certainty Factor Method, Dental Disease, Level of Accuracy.*

I. INTRODUCTION

Teeth are vital organs in the human body, and maintaining dental health has an important impact on a person's well-being. However, people often neglect the importance of dental care until they experience ongoing pain [1]. Awareness of dental care and regular check-ups is often overlooked, even though dental disease can interfere with well-being and appearance [2]. Limited knowledge about dental health and a limited number of dentists have led to low public awareness of the importance of dental health [3]. This can result in expensive treatment when toothache is already severe [4].

Dental problems are a common health issue in Indonesia, with low levels of awareness and a limited number of dentists [5]. Oral health is a global problem, affecting nearly half of the world's population (The Global Burden of Disease 2016). The results of the RISKESDAS survey in 2018 also showed significant dental problems in Indonesia [6]. Data on visits to the Parmaksian Health Center recorded that the total population treated reached 12,223 people, with a total of 3,190 households. In 2022, there were 11,634 people who came for treatment, while in 2023 until July 14, 2023, the number of patient visits reached 10,650 people. Especially for the dental clinic at the Parmaksian Health Center, there were 372 people who came in 2022. Then, in 2023 until July 14, 2023, there were 49 people who came for treatment at the dental clinic. This visit data confirms that the level of patient visits for dental check-ups at Puskesmas is still not reaching optimal numbers. This is in line with the finding that public awareness of the importance of preventive dental care is still low. Patients tend to come to the health center after experiencing severe dental pain.

This research will use the certainty factor (CF) method in making an expert system for identifying dental diseases. It is hoped that this research can help raise awareness about the importance of dental care, reduce treatment costs, and improve people's quality of life in caring for dental health.

II. METHODS

A. Type of Research

This research is a type of quantitative research. Due to this research the data obtained is analyzed quantitatively using methods for expert system performance. method for expert system performance.

B. Data Collection

a. Observation

Observation is carried out by the author to collect data from experts to obtain facts for research purposes. From experts to obtain facts for research purposes. Observation conducted in January at UPT Puskesmas Parmaksian.

b. Literature Study

In this phase, the author collects related studies from various sources with similar topics to become references in the research proposal that is being carried out at UPT Puskesmas Parmaksian.

c. Interview

In this phase, the author conducts interviews with experts by asking questions about dental disease information, symptoms, and expert beliefs that will be used for the knowledge base. That will be used for the knowledge base

C. Analysis System

At this stage, an analysis is performed on the reasoning that is that will be used in the inference engine. This research uses certainty factor reasoning technique:

a. Certainty Factor Method

Certainty factor is a method used to prove a certain or uncertain fact which is formed from metrics commonly used in expert systems. The certainty factor method is very suitable for expert systems in diagnosing something that is uncertain. In stating the level of confidence, it is represented by a number called the certainty factor to calculate the level of confidence of an expert in the context of facts. Below is the basic formula for the confidence factor value [7] :

$$CF(H,e) = CF(E,e) * CF(H,E) \quad (1)$$

$$CF[H, E] = CF[E] * CF[Expert] \quad (2)$$

$$CFcombine = CFold + CFgejala * (1 - CFold) \quad (3)$$

The three equations above are used to calculate probability in different contexts. The first equation relates the conditional probability H to E and e. The second equation relates the probability of H to E based on the probability of E and expert knowledge. The third equation combines the probabilities of the old situation (CFold) and the new phenomenon (CFsymptom). All these equations help in calculating probabilities for analysis based on conditions and available information. Table 1 shows how CF values are determined for various levels of uncertainty, which are used in conjunction with this equation for precise calculations.

Table 1. The Rule Of CF

Uncertain Term	The expert's CF value
Not at All	0
Not Sure	0.2
Somewhat Sure	0.4
Probably	0.6
Sure	0.8
Very Sure	1

b. Design System

System design involves modeling with UML (Unified Modeling Language) diagrams such as use cases, sequences, and activity diagram to describe the steps and processes in the system. The goal is to provide a clear picture of the functionality and workflow of the system under development.

1. Use case diagram

The use case diagram in Figure 1 illustrates two user interactions with the system: the user can initiate identification by registering and inputting symptoms, which will be stored in the database. Next, the system calculates the Certainty Factor (CF) value based on the inputted symptoms and converts it into a percentage. The identification result contains the CF percentage for the disease that may be experienced by the user.

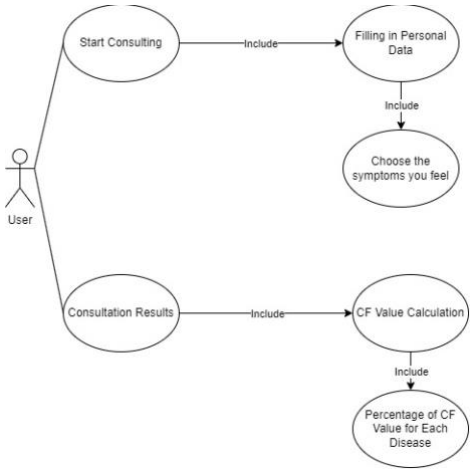

Figure 1. Use case diagram application

2. Sequence Diagram

The sequence diagram shown in Figure 2 illustrates the interaction between objects in the system through messages that are passed and obtained, arranged according to the order in the use case diagram.

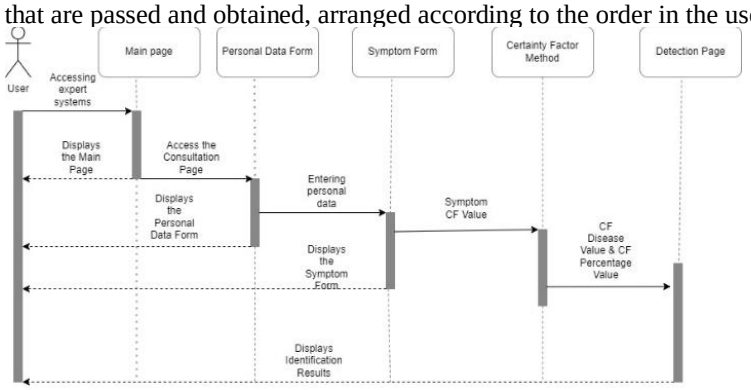

Figure 2. Sequence Diagram

3. Activity Diagram

An activity diagram is a visual representation that depicts the sequence of activities in the system. Figure 3 shows the steps of the system in sequence.

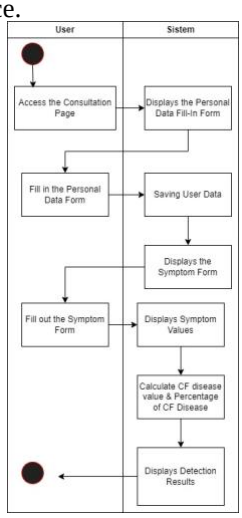

Figure 3. Activity Diagram

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III. RESULT AND DISCUSSION

A. Certainty Factor Analysis

Table 2 contains information about dental diseases, related symptoms, and the confidence value (CF) of experts in dental disease identification. This data is used as a reference to facilitate the identification of dental diseases with higher effectiveness and accuracy thanks to the structure and systematization of the information in the table.This is the identification result obtained from one of the patients who experienced dental problems at UPT Puskesmas Parmaksian.

Table 2. Knowledge Base

No	Dental Diseases	Symptom Code	Symptom	Expert CF
1	Acute Pulpitis	G02	Cavity	0.8
		G23	Spontaneous pain	0.8
		G05	Swollen gums	0.2
		G19	Migraine	0.8
		G07	Sensitive to cold weather	1
		G29	Pain if food enters	1
2	Radix	G05	Swollen gums	0.2
		G27	Teeth feel sharp	0.4
		G23	Spontaneous pain	0.2
		G01	Fever	0.2
		G26	There are remaining tooth roots	0.8
3	Impacted Teeth	G23	Spontaneous pain	0.4
		G19	Migraine	0.8
		G17	Numbness in the mouth	0.4
		G25	Painful to chew	0.8
		G24	The pain sometimes goes away and then comes and goes	0.8
		G11	Teeth look slanted/not visible at all	1
		G28	Position of buried teeth	1
4	Gingivitis	G05	Swollen gums	0.4
		G16	Gums down	0.8
		G04	Smell of breath	0.8
		G10	Teeth look elongated	0.4
		G13	Itchy gums	0.4
		G15	Gums bleed easily	0.8
		G09	Loose teeth	0.4
		G03	Lots of tartar	0.8
		G14	Purplish gums	0.2
5	Persistence of Deciduous Teeth	G02	Cavity	0.2
		G09	Loose teeth	0.8
		G05	Swollen gums	0.2
		G12	Teeth crushed	0.8
6	Pulp Necrosis / Pulp Gangrene	G02	Cavity	0.8
		G23	Spontaneous pain	0.2
		G05	Swollen gums	0.8
		G19	Migraine	0.8
		G07	Sensitive to cold weather	0.2
		G29	Pain if food enters	0.2
7	Tooth abrasion	G06	Teeth are thinning	0.8

		G02	Teeth sensitive to cold	0.8
		G18	Habit of biting while sleeping	1
		G20	Sensitive when brushed	0.8
8	Abscess	G02	Cavity	0.4
		G08	The tooth hasn't hurt in a long time but it hurt before	0.8
		G05	Swollen gums	0.8
		G21	Gums ooze blood	0.8
		G22	Gums secrete pus	1
		G09	Loose teeth	0.4
		G01	There's a fever	0.4
		G10	Elongated teeth	0.4
		G09	Receding Gums	1
		G17	Numbness in the mouth	0.8

After obtaining values from experts and users, the next step is to calculate the expert's CF value by integrating it with the user's CF value. The next step is the calculation of the combination result which is the result of multiplying each symptom, but this calculation can only be done if there is more than one symptom. The following is Table 3 which contains symptoms and user CF values.

Table 3. Symptoms and Patient Confidence Level

Symptom Code	User Answers	CF value
G-2	Certain	0.8
G-3	Somewhat Sure	0.4
G-4	Sure enough	0.6
G-6	Sure enough	0.6
G-20	Sure enough	0.6
G-22	Sure enough	0.6
G-23	Sure enough	0.6

The CF calculation process will be carried out from symptom G-2. The CF value calculation will use the equation (2) and on the calculation $CF_{combine}$ will use the equation (3).

Disease Acute Pulpitis

G-02 = Cavity

CF[H, E] = CF[E] ∗ CF[Expert]

CF[H, E]= 0.8 * 0.8 = 0.64

G-23 = Spontaneous pain

CF[H, E] = CF[E] ∗ CF[Expert]

CF[H, E]= 0.6 * 0.8 = 0.48

$CF_{combine}$ = CF[H,e]1 + CF[H,E]2 * (1- CF[H,e]1)

= 0.64 + 0.48 * (1- 0.64)

= 0,8128

As a result, the CF of each symptom determined for Acute Pulpitis disease has a probability of 0.8128 or 81.28%.

Abscess

G-02 = Cavity

CF[H, E] = CF[E] ∗ CF[Expert]

CF[H, E]= 0.8 * 0.8 = 0.64

G-23 = Spontaneous pain

CF[H, E] = CF[E] ∗ CF[Expert]

CF[H, E]= 0.6 * 0.4 = 0.24

$CF_{combine}$ = CF[H,e]1 + CF[H,E]2 * (1- CF[H,e]1)

= 0.64 + 0.24 * (1- 0.64)

= 0,7264

As a result, the CF of each symptom determined for Pulpitis disease has a probability of 0.7264 or 2.64%.

Pulp Necrosis/Pulp Gangrene

G-02 = Cavity
CF[H, E] = CF[E] ∗ CF[Expert]
CF[H, E]= 0.8 * 0.8 = 0.64
G-23 = Spontaneous pain
CF[H, E] = CF[E] ∗ CF[Pakar]
CF[H, E]= 0.6 * 0.2 = 0.12
$CF_{combine}$ = CF[H,e]1 + CF[H,E]2 * (1- CF[H,e]1)
= 0.64 + 0.12 * (1- 0.64)
= 0,6832
As a result, CF for each symptom defined for Pulp Necrosis/Gangrenous Pulp disease has a probability of 0.6832 or 68.32%.
Gingivitis
G-3 = Cavity
CF[H, E] = CF[E] ∗ CF[Expert]
CF[H, E]= 0.4 * 0.8 = 0.32
G-02 = Cavity
CF[H, E] = CF[E] ∗ CF[Expert]
CF[H, E]= 0.6 * 0.8 = 0.48
$CF_{combine}$ = CF[H,e]1 + CF[H,E]2 * (1- CF[H,e]1)
= 0.32 + 0.48 * (1- 0.32)
= 0,6464
As a result, the CF of each symptom specified for Gingivitis disease has a probability of 0.6464 or 64.34%.
Dental Abrasion Disease
G-20 = Cavity
CF[H, E] = CF[E] ∗ CF[Expert]
CF[H, E]= 0.6 * 1= 0.6
G-23 = Spontaneous pain
CF[H, E] = CF[E] ∗ CF[Expert]
CF[H, E]= 0.6 * 0.8 = 0.48
$CF_{combine}$ = CF[H,e]1 + CF[H,E]2 * (1- CF[H,e]1)
= 0.6 + 0.48 * (1- 0.6)
= 0,792
As a result, the CF of each symptom defined for Dental Pulp Abrasion disease has a probability of 0.792 or 79.2%. The manual calculation results in the highest CF of 81.28%. The same system was used to identify dental diseases, resulting in a CF of 81.28%, as shown in Figure 4.12. This makes identification of dental diseases easier and more accurate, improving the effectiveness of diagnosis and treatment.

B. System Evaluation

To evaluate the system, a comparison is carried out between data from medical records provided by experts/dentists to obtain the identification produced by the system. The system evaluation results are then recorded in Table 4 to facilitate analysis and evaluation of system performance.

Table 4. Table System Evaluation

NO	Patient's	Symptom Code	System Identification	Identify Experts	Evaluation
1	Patient 1	G-5,G-8,G-9	Abscess	Abscess	Suitable
2	Patient 2	G-1,G-2,G-9,G-14	Abscess	Abscess	Suitable
3	Patient 3	G-1, G-2, G-5, G-8, G-14	Abscess	Abscess	Suitable
4	Patient 4	G-1, G-5, G-9, G-15	Abscess	Abscess	Suitable

5	Patient 5	G-2, G-5, G-8	Abscess	Abscess	Suitable
6	Patient 6	G-2, G-5, G-14, G-15	Abscess	Abscess	Suitable
7	Patient 7	G-1,G-2, G-5, G-9	Abscess	Abscess	Suitable
8	Patient 8	G-2, G-5, G-7,G-19	Acute Pulpitis	Acute Pulpitis	Suitable
9	Patient 9	G-2, G-5, G-22,G-25	Acute Pulpitis	Acute Pulpitis	Suitable
10	Patient 10	G-2, G-5, G-19,G-22,G-25	Acute Pulpitis	Acute Pulpitis	Suitable
11	Patient 11	G-2, G-5, G-7,G-19,G-22	Acute Pulpitis	Acute Pulpitis	Suitable
12	Patient 12	G-2, G-7,G-19,G-22	Acute Pulpitis	Acute Pulpitis	Suitable
13	Patient 13	G-2, G-7,G-19,G-22	Acute Pulpitis	Acute Pulpitis	Suitable
14	Patient 14	G-2, G-7,G-25	Acute Pulpitis	Acute Pulpitis	Suitable
15	Patient 15	G-6, G-7,G-18,G-20	Tooth abrasion	Tooth abrasion	Suitable
16	Patient 16	G-2,G-3,G-6, G-7,G-20	Tooth abrasion	Tooth abrasion	Suitable
17	Patient 17	G-2,G-6, G-7,G-18	Tooth abrasion	Tooth abrasion	Suitable
18	Patient 18	G-6, G-7,G-18,G-20	Tooth abrasion	Tooth abrasion	Suitable
19	Patient 19	G-2,G-6, G-7,G-20	Tooth abrasion	Tooth abrasion	Suitable
20	Patient 20	G-3,G-4,G-7,G-18	Tooth abrasion	Tooth abrasion	Suitable
21	Patient 21	G-2, G-3,G-6,G-7,G-20	Tooth abrasion	Tooth abrasion	Suitable
22	Patient 22	G-4, G-5,G-10,G-12, G-15, G-16	Gingivitis	Gingivitis	Suitable
23	Patient 23	G-3, G-5,G-13, G-15, G-16	Abscess	Gingivitis	Not suitable
24	Patient 24	G-4, G-5,G-10, G-13, G-15,G-16	Abscess	Gingivitis	Not suitable
25	Patient 25	G-4, G-5,G-10, G-12,	Gingivitis	Gingivitis	Suitable
26	Patient 26	G-3,G-4,G-5,G-9,G-10, G-12, G-16, G-15	Gingivitis	Gingivitis	Suitable
27	Patient 27	G-3,G-4, G-5, G-9,G-10, G-15	Gingivitis	Gingivitis	Suitable
28	Patient 28	G-3,G-4, G-5, G-9,G-10, G-15	Gingivitis	Gingivitis	Suitable
29	Patient 29	G-2,G-5,G-9,G-26	Abscess	Persistence of Deciduous Teeth	Not suitable
30	Patient 30	G-2, G-4,G-9,G-26	Persistence of Deciduous Teeth	Persistence of Deciduous Teeth	Suitable
31	Patient 31	G-2,G-9,G-26	Persistensi Gigi Decidui	Persistensi Gigi Decidui	Suitable
32	Patient 32	G-2,G-4, G-5,G-26	Pulp Necrosis/Pulp Gangrene	Persistence of Deciduous Teeth	Not suitable
33	Patient 33	G-4,G-5,G-9,G-26	Persistence of Deciduous Teeth	Persistence of Deciduous Teeth	Suitable
34	Patient 34	G-2,G-9,G-26,G-5	Abscess	Persistence of Deciduous Teeth	Not suitable

35	Patient 35	G-2,G-3,G-9,G-26	Persistence of Deciduous Teeth	Persistence of Deciduous Teeth	Suitable
36	Patient 36	G-2,G-5,G-7,G-19,G-22	Acute Pulpitis	Pulp Necrosis/Pulp Gangrene	Not suitable
37	Patient 37	G-2,G-5,G-19,G-22	Pulp Necrosis/Pulp Gangrene	Pulp Necrosis/Pulp Gangrene	Suitable
38	Patient 38	G-2,G-5,G-19,G-22,G-25	Acute Pulpitis	Pulp Necrosis/Pulp Gangrene	Not suitable
39	Patient 39	G-2,G-5 ,G-6,G-12,G-19,G-22	Pulp Necrosis/Pulp Gangrene	Pulp Necrosis/Pulp Gangrene	Sesuai
40	Patient 40	G-12,G-2,G-7,G-19,G-22	Acute Pulpitis	Pulp Necrosis/Pulp Gangrene	Not suitable
41	Patient 41	G-2,G-5,G-9,G-19	Pulp Necrosis/Pulp Gangrene	Pulp Necrosis/Pulp Gangrene	Suitable
42	Patient 42	G-2,G-5 ,G-19,G-22	Pulp Necrosis/Pulp Gangrene	Pulp Necrosis/Pulp Gangrene	Suitable
43	Patient 43	G-1,G-5,G-21,G-22,G-28	Radix	Radix	Sesuai
44	Patient 44	G-1,G-5,G-21 ,G-28	Radix	Radix	Suitable
45	Patient 45	G-1,G-5,G-21 ,G-22	Gingivitis	Radix	Not suitable
46	Patient 46	G-5,G-21 ,G-22, G-28	Radix	Radix	Suitable
47	Patient 47	G-1,G-5, G-21,G-22, G-28	Radix	Radix	Suitable
48	Patient 48	G-1,G-5, G-21,G-22, G-28	Radix	Radix	Suitable
49	Patient 49	G-1,G-5, G-21,G-28	Radix	Radix	Suitable
50	Patient 50	G-19,G-22, G-30, G-29	Impacted Teeth	Impacted Teeth	Suitable
51	Patient 51	G-17,G-19,G-22, G-23,	Impacted Teeth	Impacted Teeth	Suitable
52	Patient 52	G-11,G-19,G-22, G-23	Impacted Teeth	Impacted Teeth	Suitable
53	Patient 53	G-11, G-17,G-19,G-22, G-30	Impacted Teeth	Impacted Teeth	Suitable
54	Patient 54	G-11, G-17,G-23, G-30	Impacted Teeth	Impacted Teeth	Suitable
55	Patient 55	G-11, G-17,G-19, G-23, G-30	Impacted Teeth	Impacted Teeth	Suitable
56	Patient 56	G-11 ,G-19, G-22, G-30	Impacted Teeth	Impacted Teeth	Suitable

C. Implement System

1. Home

The homepage is the first view when a user accesses the expert system through the website. It also contains general information about the system and has an "Identification" menu for user registration. The display of the home page can be seen in Figure 4.

Figure 4. Home

2. Registration Page

Certainly, in the interaction between the user and the expert system, the initial stage involves the user providing their personal information. This is achieved through the presentation of a registration page that features a form for inputting the user's personal details. Subsequently, this data is stored in a MySQL database. You can observe the appearance of the registration page in Figure 5.

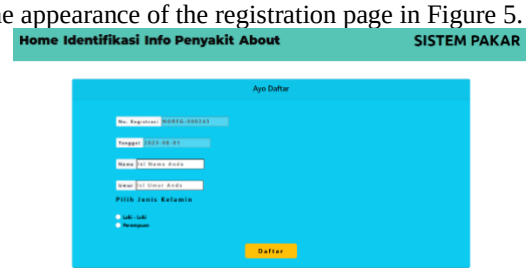

Figure 5. Registration Page

3. Symptom Page

After successfully registering on the registration page, the next step is to be directed to the symptoms page. The display of the symptoms page can be seen in Figure 6. On this page the system will display a list of symptoms in the MySQL database, and the user is asked to select the symptoms they are experiencing.

Figure 6. Symptom Page

4. Identification Result Page

After users select their symptoms and confidence levels on the symptoms page, the system will display the identification results page. Here, the system will calculate based on the weight of the symptoms specified by the user. As a result, the system will display the user's and expert's confidence level in the form of a Certainty Factor (CF) percentage on the identification result page. The display of identification results from the system can be seen in Figure 7.

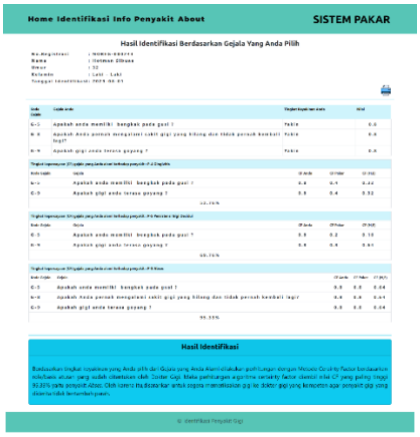

Figure 7. Identification Result Page

IV. CONCLUSION

Based on the results of tests conducted on the expert system for the identification of dental diseases using the certainty factor method, the conclusion can be drawn is that the dental disease identification expert system developed using the certainty factor method can identify 8 dental diseases, namely acute pulpitis, radix, tooth impaction, gingivitis, decidui tooth persistence, pulp necrosis, tooth abrasion, and abscess. tests performed on the dental disease identification expert system are Black Box and White Box testing. The next test is system evaluation, namely by using 56 medical record data, it was found that the method has an accuracy rate of 83.92%. Of the 56 cases tested, 47 cases were found to be in accordance with the identification made by the system, but there were 9 cases that were not appropriate.

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