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Expert System of Diagnosis of Human Dental Diseases Using The Naïve Bayes Method

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ABSTRACT

Teeth are important in the process of breaking down food, but many people do not pay attention to dental health. Unfortunately, most people especially in Indonesia are unconscious and don't really care about the dental health they experience. The main factor is the pattern of consumption of sweet foods and the high cost of consultation with the dentist. Therefore an expert system is needed which is expected to be a solution to diagnose dental disease. The present study applies the Naïve Bayes method because it is based on looking at the probabilities that exist in dental disease data through several perceived symptoms. The diagnosis process is carried out by inputting symptoms of the disease then the probability value of each class is calculated then the final result is the disease class that has the highest probability. The test results in this study involved testing data that were able to produce an accuracy of 93% so that the system could be applied to dental disease

1. Introduction

In 2019 BKGN, Research: 80 Percent of Indonesian Communities Have Cavities with Tooth Problems (Liputan6, 2019). This problem can occur due to lifestyle changes that lead to the consumption of foods containing soda and sugar, this is supported by a lack of education and high consultation costs for dentists. By seeing the importance of this problem, the authors take some research into expert systems that can help reduce the percentage of dental diseases in Indonesia.

Of the various problems, there are systems that can solve problems and find solutions. a system that can provide problem-solving options as well as communication skills for problems with semi-structured and unstructured conditions.

Expert systems, systems that can resemble human knowledge applied to computers that are made specifically to have the ability to solve problems like an expert. With this expert system made, ordinary people can solve the problem without the need to come directly to experts in their respective fields or just looking for the information needed. This system can also be an assistant to experienced experts in working on their activities.

To diagnose an expert system disease requires a method of resolution, one of which is the naïve Bayes method. The naïve bayes method has the advantages of being easy to understand, fast and efficient and faster in the calculation.

The results of this study aim to create and develop web-based applications for diagnosing dental diseases in humans that have the feature of studying the reasons and solutions of a user's disease as well as studying the large probability statistics of users using the disease using Naïve Bayes. Other objectives of this study can provide information, solutions, and recommendations for the resolution of human dental diseases

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2. Study Literature

An expert system to diagnose dental diseases using the naïve bayes method produces a system that can provide information, education, and information about dental diseases to the public and makes it easy to conduct real-time consultations without visiting a dentist [1]. Dental and oral disease expert system using the naïve bayes method produces information about dental health and treatment that can be done in related diseases. by using 100% blackbox testing [2]. The asthma classification system uses the naïve bayes algorithm method because many patients experience complaints but cannot recognize the symptoms of asthma. Therefore this system was made aiming to create a system that produces solutions based on the knowledge of an expert that can be used if the community without having to meet an expert. The results of this study the naïve bayes method is effective and efficient for classifying the severity of asthma [3]. The expert system of early detection of tuberculosis with Bayes method produces a system that allows users to conduct consultations and be able to produce answers with valid calculation results [4]. The expert system of early detection of the expert system of eye disease diagnosis using the naïve bayes method, the authors chose this title because the comparison of population and medical staff was far from the ideal standard so that the lack of understanding of the eye disease suffered. From a trial system that uses data from 12 patients with eye disease, the diagnosis result from an expert is 83% of the suitability of the diagnosis. lack of understanding of eye diseases suffered. The trial system that uses data of 12 patients with eye disease resulted in an actual diagnosis from an expert 83% percentage of the suitability of the diagnosis [5]. The classification system for diagnosing the liver disease can predict the presence or absence of heart disease in patients achieving promising results [6]. Comparative Analysis of Expert Systems Diagnosis of Cattle Disease using Bayesian Network and the Dempster-Shafer Method can diagnose cow disease with the Bayesian method with 75.3% accuracy results [7]. Comparison of Naïve Bayes Method and Certainty Factors for Expert Systems of Corn Disease can detect diseases and symptoms that indicate certain diseases. the symptoms used are 46 which can indicate one of the 15 types of diseases in maize shows an accuracy of up to 80% [8].

3. Research Method

3.1 Research Flowchart

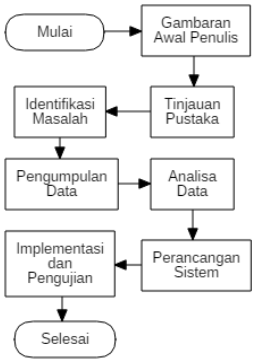

Fig 1. Research Flowchart

In Figure 1 the flowchart above starts from explaining the initial description of the study which explains everything related to the research, what the author wants to convey for the making and development of applications. The second stage is reviewing the literature as obtaining reference information related to research in the form of a journal along with identifying the problem. Then the data was collected from various experts after the data were analyzed using the chosen method, Naïve Bayes. The next stage is the design of the system to be made, what is needed and which needs to be developed, the design uses the PHP programming language and MySQL because the system is web-based. After designing, then to the final stage, it is implemented and tested, if an error occurs or a calculation is lacking, then repairs will be done until completion.

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3.2 Naïve Bayes Method

Naïve Bayes is a classification that calculates a set of probabilities by adding up the frequency and combination of values from a given dataset. The algorithm uses the Bayes theorem and assumes all independent or non-interdependent attributes given by values to class variables (Patil and Sherekar, 2013). The Naive Bayes algorithm predicts future opportunities based on experience so it is known as the Bayes Theorem. The main characteristic of Dr. Naïve Bayes Classifier is a very strong assumption (naive) of independence from each condition/event. This method is suitable for use in a dental disease diagnosis system because it can predict opportunities based on data from experts and their likelihood. Calculation of the Naive Bayes method can be done using the following steps:
1. Finding the Posterior Value of each class that exists using equations.

$$P\ (A|B) = \frac{P(B|A)\,P(A)}{P(B)} \quad (1)$$

Information:
P (A | B) is the probability of event A if hypothesis B.
P (B | A) is the probability of B if a known type of A disease occurs.
P (A) is the probability of occurrence of disease A.
P (B) is the probability of hypothesis B regardless of any event.

3.3 Expert System Application Design

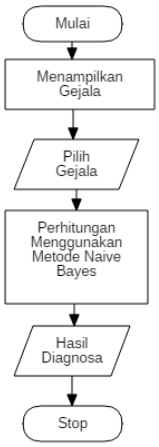

Fig 2. Flowchart application system

In the figure above, the system displays some of the symptoms that exist in each disease. Then the user selects the symptoms that are felt, then the system calculates and the disease diagnosis results will come out based on the user's input.

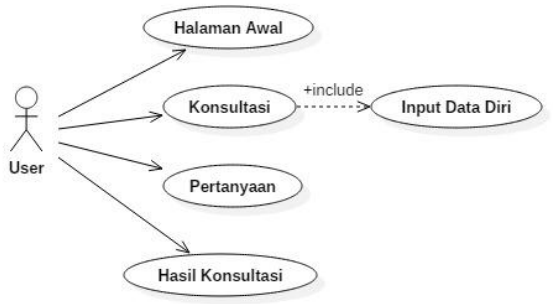

Fig 3. User usecase diagram

In the picture above, the system display figure 3, the system has users who can do consultations, questions, the results of which will appear. Before consulting a disease the user is required to fill in his

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data.ays some of the symptoms that exist in each disease. Then the user selects the symptoms that are felt, then the system calculates and the disease diagnosis results will come out based on the user's input.

4. Result and Discussion

4.1 Naïve Bayes Process

To determine the type of dental disease in the system, it was formulated using Naïve Bayes calculations. The data in the table below is based on the results of interviews with experts to produce six types of diseases, namely gingivitis, pulp, caries, dental abscess, periodontitis, and pericoronitis

TABLE 1
DISEASE NAME

Kode	Penyakit
P01	Pulpa
P02	Gingivitis
P03	Abses Gigi
P04	Karies
P05	Periodontitis
P06	Perikoronitis

Table 1 describes 6 disease data and their codes consisting of dental diseases. Dental disease was chosen only 6 out of 12 because it is a common disease experienced by many people. Disease data were obtained from the Ministry of Health in 2012 [9] [10] [11].

TABLE 2
SYMPTOMS OF DISEASE

Kode	Gejala
G1	Terdapat daging tumbuh pada gigi yang berlubang
G2	Gigi terasa sakit atu nyeri bila mengunyah
G3	Nyeri di sekitar gigi
G4	Gusi bengkak atau mudah berdarah
G5	Bau mulut tidak sedap
G6	Luka antara gusi dan gigi
G7	Benjolan di bagian kepala, leher, atau rahang
G8	Demam
G9	Nyeri pada saat menelan makanan
G10	Bengkak pada gusi
G11	Sakit pada saat membuka mulut
G12	Pembengkakan kelenjar getah bening di leher
G13	Nyeri saat gigi tertekan oleh makanan
G14	Nyeri pada gusi dan mulut
G15	Pipi menjadi membengkak
G16	Terdapat noda berwarna cokelat, hitam, atau putih pada permukaan gigi
G17	Terdapat lubang pada gigi
G18	Timbul rasa sakit jika terkena air dingin, dan kemasukan makanan
G19	Gusi terasa lunak jika disentuh
G20	Ukuran gigi terlihat lebih tinggi dari biasanya
G21	Jarak antara satu gigi dan gigi lainnya terasa renggang.\
G22	Gusi bengkak dan berwarna merah atau keunguan
G23	Keluarnya nanah dari gusi yang terinfeksi
G24	Gerakan membuka dan menutup rahang menjadi terbatas, sekaligus kadang menyakitkan
G25	Sulit dan sakit saat menelan makanan

In Table 2, 25 data on the names of symptoms and the symptoms of dental diseases are obtained from the data of the Ministry of Health in 2012 [9] [10] [11].

TABLE 3
METHOD RULES

IF	THEN
G01, G02, G03, G04	Pulpa
G04, G05, G06, G07, G08	Gingivitis
G02, G09, G10, G11, G12, G13, G14, G23	Abses Gigi
G02, G15, G16, G17, G18, G23	Karies
G02, G05, G19, G20, G21, G22	Periodontitis
G03, G04, G23, G24, G25	Perikoronitis

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For table 3 the rules are used to determine the results of the analysis of dental diseases obtained by experts and the Ministry of Health in 2012 [9] [10] [11].

4.2 Manual Calculation Analysis

For manual calculations, use examples of dental diseases based on direct input from the user.

TABLE 4
SAMPLE CASE

Kode Gejala	Jawaban	Kode Gejala	Jawaban
G1	Ya	G14	Tidak
G2	Ya	G15	Tidak
G3	Ya	G16	Tidak
G4	Ya	G17	Tidak
G5	Tidak	G18	Tidak
G6	Tidak	G19	Tidak
G7	Tidak	G20	Tidak
G8	Tidak	G21	Tidak
G9	Tidak	G22	Tidak
G10	Tidak	G23	Tidak
G11	Tidak	G24	Tidak
G12	Tidak	G25	Tidak
G13	Tidak		

Then the next step from table 4 is the naïve bayes calculation. Then the calculation is as follows:

4.2.1 Calculate the Number of Class P(A)

No	G01	G02	G03	G04	G05	G06	G07	G08	G09	G10	Kategori
1	Ya	Ya	Ya	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Pulpa
2	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Pulpa
3	Ya	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Pulpa
4	Ya	Ya	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Pulpa
5	Tidak	Ya	Ya	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Pulpa
6	Tidak	Tidak	Ya	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Pulpa
7	Tidak	Tidak	Tidak	Ya	Tidak	Tidak	Tidak	Tidak	Tidak	Tidak	Pulpa
8	Tidak	Tidak	Tidak	Tidak	Ya	Ya	Ya	Ya	Ya	Ya	Pulpa

Fig 4. Dataset

In figure 4 there is a partial training data of 25 symptoms and 8 occurrences of pulp disease that are used to calculate the number of classes of disease.

TABLE 5
CALCULATION OF THE NUMBER OF CLASSES

Jumlah *Class* (A = Penyakit)	
P(A = Pulpa)	8/68 = 0.117
P(A = Gingivitis)	10/68= 0.147
P(A = Abses Gigi)	16/68= 0.235
P(A = Karies)	12/68= 0.176
P(A = Periodontitis)	12/68= 0.176
P(A = Perikoronitis)	10/68= 0.147

For table 5 it is explained that the calculation in number 1 is P (A = Pulpa) the amount of training data for each disease divided by the total of the training data totaling 68 training data. Example:

$$P(A) = \frac{\text{Number of Occurrences A}}{\text{Overall total possibilities}}$$

$$P(A) = \frac{8}{8+10+16+12+12+10} \quad (2)$$

$$P(A) = \frac{8}{68} = 0.117$$

Informationt:

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Jurnal Mantik
Volume 3 Number 4, February 2020, pp. 373-382 E-ISSN 2685-4236
https://iocscience.org/ejournal/index.php/mantik/index

P (A) is a Chance for Occurrence A (Disease). For calculations on disease number 2 and so on follow calculation on number 1

4.2.2 Calculate the Same Number of Answers in the Same Class as the P(B|A) Formula

TABLE 6
CALCULATION OF EACH CLASS

Terdapat daging tumbuh pada gigi yang berlubang	
G1	P(G01=Ya | A=Pulpa) = 4/8 = 0.5
	P(G01=Ya | A=Gingivitis) =1/10 = 0.1
	P(G01=Ya |A=Abses Gigi)=1/16= 0.0625
	P(G01=Ya | A=Karies) =1/12 = 0.0833
	P(G01=Ya | A=Periodontitis)=1/12= 0.0833
Gigi terasa sakit atu nyeri bila mengunyah	
G2	P(G02=Ya | A=Pulpa) = 4/8 = 0.5
	P(G02=Ya | A=Gingivitis) = 1/10 = 0.1
	P(G02=Ya | A=Abses Gigi) = 1/10 = 0.5
	P(G02=Ya | A=Karies)=11/12 = 0.9166
	P(G02=Ya | A=Periodontitis) = 11/12 =0.9166
Nyeri disekitar gigi	
G3	P(G03=Ya | A=Pulpa) = 4/8 = 0.5
	P(G03=Ya | A=Gingivitis) = 1/10 = 0.1
	P(G03=Ya | A=Abses Gigi) = 1/16 = 0.0625
	P(G03=Ya | A=Karies) = 1/12 = 0.0833
	P(G03=Ya | A=Periodontitis) = 1/12 = 0.0833
Gusi bengkak atau mudah berdarah	
G4	P(G04=Ya | A=Pulpa) = 4/8 = 0.5
	P(G04=Ya | A=Gingivitis) = 5/10 = 0.5
	P(G04=Ya | A=Abses Gigi)=1/16= 0.0625
	P(G04=Ya | A=Karies) = 1/1 = 0.0833
	P(G04=Ya |A=Periodontitis)=1/12= 0.0833
Bau mulut tidak sedap	
G5	P(G05=Tidak | A=Pulpa) = 7/8 = 0.875
	P(G05=Tidak | A=Gingivitis) = 5/10 = 0.5
	P(G05=Tidak|A=AbsesvGigi)=15/16=0.9375
	P(G05=Tidak | A=Karies)=11/12 = 0.9166
	P(G05=Tidak|A=Periodontitis)=6/12= 0.5
Luka antara gusi dan gigi	
G6	P(G06=Tidak | A=Pulpa) = 7/8 =0.875
	P(G06=Tidak | A=Gingivitis) = 5/10 = 0.5
	P(G06=Tidak|A=AbsesGigi)=15/16=0.9375
	P(G06=Tidak | A=Karies)=11/12 = 0.9166
	P(G06=Tidak|A=Periodontitis)=11/12=0.9166
Benjolan di bagian kepala, leher, atau rahang	
G7	P(G07=Tidak | A=Pulpa) = 7/8 = 0.875
	P(G07=Tidak | A=Gingivitis) = 5/10 = 0.5
	P(G07=Tidak |A=Abses Gigi) =15/16=0.9375
	P(G07=Tidak | A=Karies) = 11/12 = 0.9166
	P(G07=Tidak|A=Periodontitis)=11/12=0.9166
Demam	
G8	P(G08=Tidak | A=Pulpa) = 7/8 = 0.875
	P(G08=Tidak | A=Gingivitis) = 5/10 = 0.5
	P(G08=Tidak | A=Abses Gigi) =15/16=0.9375
	P(G08=Tidak|A=Karies) = 11/12 = 0.9166
	P(G08=Tidak|A=Periodontitis)=11/12=0.9166
Nyeri pada saat menelan makanan	
G9	P(G09=Tidak | A=Pulpa) = 7/8 = 0.875
	P(G09=Tidak | A=Gingivitis) = 9/10 = 0.9
	P(G09=Tidak | A=Abses Gigi) = 8/16 = 0.5
	P(G09=Tidak | A=Karies) = 11/12 = 0.9166
	P(G09=Tidak|A=Periodontitis)=11/12=0.9166
Bengkak pada gusi	
G10	P(G10=Tidak | A=Pulpa) = 7/8 = 0.875
	P(G10=Tidak | A=Gingivitis) = 9/10 = 0.9
	P(G10=Tidak | A=Abses Gigi) = 8/16 = 0.5
	P(G10=Tidak | A=Karies) = 11/12 = 0.9166
	P(G10=Tidak|A=Periodontitis)=11/12=0.9166
…….	
Gusi bengkak dan berwarna merah atau keunguan.	
G22	P(G22=Tidak | A=Pulpa) = 7/8 =0.875
	P(G22=Tidak | A=Gingivitis) = 9/10 = 0.9
	P(G22=Tidak | A=Abses Gigi) =15/16=0.9375
	P(G22=Tidak | A=Karies) = 11/12 = 0.9166
	P(G22=Tidak|A=Periodontitis)=6/12 = 0.5
Keluarnya nanah dari gusi yang terinfeksi	
G23	P(G23=Tidak | A=Pulpa) = 7/8 = 0.875
	P(G23=Tidak | A=Gingivitis) = 9/10 = 0.9
	P(G23=Tidak | A=Abses Gigi) =8/16 =0.5
	P(G23=Tidak | A=Karies) = 6/12 = 0.5
	P(G23=Tidak|A=Periodontitis)=11/12=0.9166
Gerakan membuka dan menutup rahang menjadi	

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Jurnal Mantik
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https://iocscience.org/ejournal/index.php/mantik/index

	terbatas, sekaligus kadang menyakitkan.	Ukuran gigi terlihat lebih tinggi dari biasanya
G24	P(G24=Tidak | A=Pulpa) = 7/8 = 0.875	G25 P(G25=Tidak | A=Pulpa) = 7/8 = 0.875
	P(G24=Tidak | A=Gingivitis) = 9/10 = 0.9	P(G25=Tidak | A=Gingivitis) = 9/10 = 0.9
	P(G24=Tidak | A=Abses Gigi) =15/16=0.9375	P(G25=Tidak | A=Abses Gigi) =15/16=0.9375
	P(G24=Tidak | A=Karies) = 11/12 = 0.9166	P(G25=Tidak | A=Karies) = 11/12 = 0.9166
	P(G24=Tidak|A=Periodontitis)=11/12=0.9166	P(G25=Tidak|A=Periodontitis)=11/12=0.9166

In Table 6 the calculation of each symptom of the disease is explained in comparison with the hypothesis that produces a probability value based on the symptoms chosen. Example:

$$P(B|A) = \frac{P(B \cap A)}{P(A)} \quad (3)$$

Information :
P (B | A) is a chance of event B if A occurs
P (B ∩ A) is an opportunity for B and A to occur together

4.2.3 Probability Results

TABLE 7
PROBABILITY RESULTS

Penyakit	Nilai
Pulpa	0.000445277
Gingivitis	0.000000766
Abses Gigi	0.000000091
Karies	0.000000727
Periodontitis	0.000000727
Perikoronitis	0.000022349

In table 7 this is the final result of the calculation of each symptom per disease multiplied by the result of the results from the number of classes. Based on the results obtained, the probability value (P A = Pulpa) is the largest. From this, it can be concluded that the disease experienced by the user is a pulp disease.

4.3 Display Interface

The design of an expert display system for early mental health detection using the web-based dempster shafer method can be seen from the following explanation.

Fig 5. Home Page

This page contains an initial appearance that shows the website slogan, the consultation form, about the website and dental disease information.

Jurnal Mantik
Volume 3 Number 4, February 2020, pp. 373-382 E-ISSN 2685-4236
https://iocscience.org/ejournal/index.php/mantik/index

Fig 6. About Website

Figure 6 is a display of the website that contains the vision and mission and also the purpose of the system

Figure 7. Disease Information

Figure 7 contains information on each type of dental disease so that the user knows brief information on what types of dental disease.

Figure 8. Diagnosis Page

In figure 8 there is a questionnaire for the symptoms of each dental disease. Users can fill out a questionnaire by checking the symptoms chosen according to what is felt.

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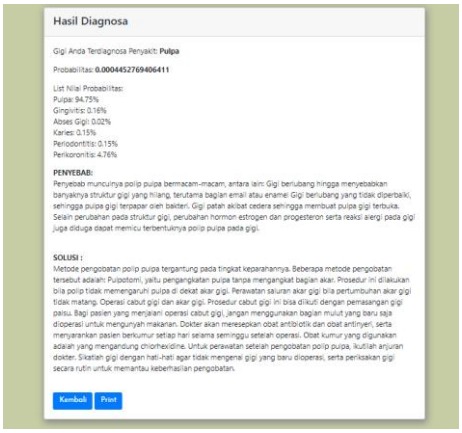

Fig 8. Diagnosis Results

The page in Figure 8 contains the results of the user's disease diagnosis. On this page, there are disease outcomes, probabilities, a list of probability values, causes of disease emergence and solutions for temporary treatment of disease.

4.4 Expert System Accuracy Testing

To determine the level of accuracy in the system that is made it is necessary to do an accurate test that explains the results of the comparison between the system made with experts and book data from the Ministry of Health in 2012 [9] [10] [11].

TABLE 8
SYSTEM ACCURACY TESTING

No.	Gejala	Sistem	Pakar	Hasil
1	G01,G02,G03	PLP	PLP	✓
2	G02,G03	PLP	KRS	x
3	G04,G05,G06,G07	GVT	GVT	✓
4	G02,G09,G10	AG	AG	✓
5	G11,G12,G13	AG	AG	✓
6	G02,G15,G16	KRS	KRS	✓
7	G14,G23	AG	AG	✓
8	G17,G18,G23	KRS	KRS	✓
9	G03,G04	PRK	GVT	x
10	G02,G05	PRD	PRD	✓
11	G19,G20,G21,G22	PRD	PRD	✓
12	G03,G04	PRK	PRK	✓
13	G23,G24,G25	PRK	PRK	✓
14	G09,G12	AG	AG	✓
15	G20,G21,G22	PRD	PRD	✓
16	G04,G05,G09,G10	AG	AG	✓
17	G13,G14,G18,	AG	AG	✓
18	G19,G22,G23	AG	AG	✓
19	G01,G03,G07,G23	PRK	PRK	✓
20	G01,G04,G05,G11	PLP	PLP	✓
21	G04,G05,G12,G13	GVT	GVT	✓
22	G12,G17,G23,G25	AG	AG	✓
23	G07,G15,G16	KRS	KRS	✓
24	G06,G07,G08,G17	GVT	GVT	✓
25	G06,G07,G08	GVT	GVT	✓
26	G14,G15,G16	GVT	GVT	✓
27	G04,G05,G06	GVT	GVT	✓
28	G13,G14,G15	GVT	GVT	✓
29	G08,G09,G14,G15	GVT	GVT	✓
30	G16,G17,G19,G21	KRS	KRS	✓

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*Information :

PLP	= Pulpa	KRS	= Karies
GVT	= Gingivitis	PRD	= Periodontitis
AG	= Abses Gigi	PRK	= Perikoronitis

$$\text{Accuracy} = \frac{Amount\ of\ Correct\ Data}{Amount\ of\ Test\ Data} x100\%$$
$$= \frac{28}{30} x100\% = 93\%$$

From 30 test data, there were 28 that matched from the system and experts. Based on calculations obtained 93% accuracy. It can be concluded that the naïve bayes method has a good degree of accuracy.

5. Conclucion

From the results of research and discussion of the expert system of diagnosing dental diseases using the Naive Bayes method, conclusions have been made:

a. With this application, will be able to assist the community in conducting prevention / first aid with action as early as possible before they come directly to the dentist.
b. Besides being able to run well the application is also accurate because there are 68 training data obtained from experts.
c. The application has passed the accuracy testing of which of the 30 test data 28 data are corresponding to produce an accuracy of 93%.

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