Expert System in Periodontal Diseases Diagnosis Using the Certainty Factor Method

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Abstract. Dental and oral health is sometimes not a priority for some people, even though dental and oral diseases have a serious impact on health in general, because teeth and mouth are a place for germs and bacteria to enter, so they are likely to interfere with the health of other body organs. Periodontal disease is an inflammatory disease caused by bacteria that damage the tissue supporting the teeth and cause tooth loss. Periodontal disease is divided into 2, namely gingivitis and periodontitis. An expert system is a system that tries to implement human knowledge on a computer so that computers can solve problems as experts do. The certainty factor method is used for calculations because the certainty factor method can solve the uncertainty of a problem by measuring a person's belief. The result of this research is an expert system that can produce the name of periodontal disease and the level of certainty for the user's disease. This application has 100% accuracy based on test results on 20 medical record data, it is obtained that the 20 data match with the results of the system diagnosis.

1. Introduction
Dental and oral health is sometimes not a priority for some people, even though dental and oral diseases have a serious impact on health in general because teeth and mouth are the entry point for germs and bacteria so that it is likely to interfere with the health of other body organs [1].

One of the most common examples of oral diseases is periodontal disease. Periodontal disease is an inflammatory bacterial disease that results in progressive damage to the supporting tissues of the teeth and causes tooth loss [2]. Traditionally, periodontal disease has been divided into 2 main categories namely gingivitis and periodontitis. Gingivitis is a mild form of periodontal disease, with the clinical signs of gingiva being red, swollen, and bleeding easily, whereas periodontitis is characterized by loss of attachment and pocket formation caused by the development of pathogenic bacteria and decreased patient defense mechanisms [3].

The Certainty Factor method has been widely used to solve various problems such as Identifying Formalin and Borax in Foods [4], Pest Plant Disease Prevention and Identification System [5], Personality Disorders [6], early diagnosis of meningitis disease [7], Diagnosis of Virus Infection Disease in Children [8], Broiler Diseases [9], Koi’s Fish Disease [10], Sleep disorder diagnosis[11], Diagnosis
Corn Pests And Diseases [12], Farmer's Health Monitoring [13]. Additionally, there are various studies focus on developing automated disease detection using various methods [14].

In this study, the method used is the Certainty Factor method where the Certainty Factor method can provide accurate results by the certainty value provided by users and experts. The experts referred to in this study were Indra Syahfery, drg, Sp.Perio., M.A.P. and Beby Mayasari Miraza, drg.

2. Method
This section will explain how the Certainty Factor method works. In the Certainty Factor method, the input data is the answer from users and experts. Each answer has its weight, the value of which will be combined between user answers (CF User) and expert answers (CF Expert) [5].

2.1. Certainty Factor Calculations
The CF value can be calculated by the following equation:

- For the value of CF1 > 0 and the value of CF2 > 0.
  \[ CF[H, E] = CF1 + (CF2 * (1 - CF1)) \] (1)
- For the value of CF1 < 0 and the value of CF2 < 0.
  \[ CF[H, E] = CF1 + (CF2 * (1 + CF1)) \] (2)
- For the value of CF1 > 0 and the value of CF2 < 0 or the value of CF1 < 0 and the value of CF2 > 0.
  \[ CF[H, E] = \frac{CF1 + CF2}{1 - \min(CF1, CF2)} \] (3)

Information:
CF [H, E] = The certainty factor of the hypothesis (H) which is influenced by the symptoms (E)
CF1 = CF value of symptom 1
CF2 = CF value of symptom 2

2.2. Periodontal Disease Symptom Data
The risk factors and clinical symptoms of periodontal disease are presented in Table 1.

| Symptom id | Symptom Name                                                                 | Gingivitis disease | Periodontitis |
|------------|-------------------------------------------------------------------------------|--------------------|--------------|
| G1         | Gums bleed when brushing teeth                                                | ✓                  | ✓            |
| G2         | Gums are not pink (pink)                                                      | ✓                  | ✓            |
| G3         | Teeth are sensitive to cold, heat, sweetness, and pressure                    | ✓                  | ✓            |
| G4         | Dry mouth                                                                     | ✓                  | ✓            |
| G5         | Don't brush your teeth 2 times a day                                          | ✓                  | ✓            |
| G6         | Never do tartar cleaning                                                      | ✓                  | ✓            |
| G7         | The presence of pain or discomfort in the gums                                | ✓                  | ✓            |
| G8         | There is a history of systemic diseases (hypertension, diabetes, blood disorders) | ✓                  | ✓            |
| G9         | Take certain drugs                                                            | ✓                  | ✓            |
2.3. Designing a Diagnostic Inference Mechanism

Diagnosis will use forward chaining inference mechanisms. The system will show the results of the periodontal disease diagnosis against input data in the form of confidence or absence of a symptom. This data is the user's choice of the symptoms they feel. In diagnosing periodontal disease, certainty factor methods are used. An expert's confidence in determining the diagnosis of a disease will be measured through expressions made by experts, where each expression has its weight. The expressions and weight values obtained can be seen in Table 2.

| Table 2. Expressions of Confidence Level |
|----------------------------------------|
| Score  | Expression            |
|--------|-----------------------|
| 1      | Certainly             |
| 0.75   | Almost certain        |
| 0.5    | Most likely           |
| 0.25   | Maybe                 |
| 0      | Do not know           |
| -0.25  | Probably not          |
| -0.5   | Most likely not       |
| -0.75  | Almost certainly not  |
| -1     | Absolutely not        |

The value of expert confidence (CF Expert) on each symptom can be seen in Table 3 below.

| Table 3. CF Expert Value |
|---------------------------|
| Id | Symptoms | CF Expert |
|----|----------|-----------|
| G1 |          | 1         |
| G2 |          | -1        |
| G3 |          | 0.5       |
| G4 |          | 0.5       |
| G5 |          | -0.25     |
| G6 |          | -0.25     |
| G7 |          | 1         |
| G8 |          | 0.25      |
| G9 |          | 0.25      |
| G10|          | 0.25      |
| G11|          | 0.25      |
| G12|          | 0.25      |
| G13|          | 1         |
| G14|          | 1         |
2.4. General Architecture System

Figure 1. General Architecture System

Figure 1. above illustrates the general architecture of the system to be made. First, users access the expert system through a website that can be opened on any device. Before starting a consultation, users must first enter their data. In the consultation session, the user answers questions about the symptoms of periodontal disease, the symptoms of each symptom have their weight. After the user has finished the consultation stage, the CF value percentage calculation is carried out based on the value of the symptom questions answered by the user. Then the user is directed to the diagnosis page to find out the diagnostic results of periodontal disease.

3. Results and Discussion

A case of gingivitis known to patient X aged 24 years who wanted to do a process of diagnosing himself whether he had periodontal disease. She had bleeding gums and sometimes had food stuck between her teeth. The patient had never had a dental examination at the dentist in the last 6 months. There is a buildup of dental plaque on the surface of the teeth and around the gums and the gums are red.

1. The first step is to change the patient's answer into a CF (CF User) value whose weight can be seen in table 2. After that the CF User value is multiplied by the CF expert value which will produce the Final CF value.

| Id | Symptoms | CF User | CF Expert | Final CF |
|----|----------|---------|-----------|----------|
| G1 | 1        | 1       | 1         |          |
| G2 | -0.75    | -1      | 0.75      |          |
| G3 | -0.5     | 0.5     | -0.25     |          |
| G4 | -0.5     | 0.5     | -0.25     |          |
| G5 | 0.75     | -0.25   | -0.1875   |          |
| G6 | -1       | -0.25   | 0.25      |          |
| G7 | -0.75    | 1       | -0.75     |          |
| G8 | -1       | 0.25    | -0.25     |          |
2. The final step is to perform calculations with the certainty factor method.
In the process of calculating the CF value, the value used is the final CF value. The calculation process starts with the symptoms of G1 and G2. The calculation of the CF value uses equation [1] because the weights of G1 and G2 values are greater than 0.

\[ CF = CF_{G1} + (CF_{G2} \times (1 - CF_{G1})) \]
\[ CF = 1 + (0.75 \times (1 - 1)) \]
\[ CF = 1 \]

The calculation process is continued on the G3 symptom. This calculation uses equation [3] because the weight of the initial CF value is greater than 0 and G3 is less than 0.

\[ CF = \frac{CF_{beginning} + CF_{G3}}{1 - (\min\{ CF_{beginning} | CF_{G3} \})} \]
\[ CF = \frac{1 + (-0.25)}{1 + (-0.25)} \]
\[ CF = 1 - (-0.25) \]
\[ CF = 0.75 \]
\[ CF = 1.25 \]
\[ CF = 0.6 \]

The calculation process is continued on the G4 symptom. This calculation uses equation [3] because the weight of the initial CF value is greater than 0 and G4 is less than 0.

\[ CF = \frac{CF_{beginning} + CF_{G4}}{0.6 + (-0.25)} \]
\[ CF = \frac{1 - (\min\{ 0.6 | (-0.25) \})}{0.6 + (-0.25)} \]
\[ CF = \frac{1 - (-0.25)}{(0.35)} \]
\[ CF = \frac{1.25}{0.35} \]
\[ CF = 0.28 \]

The calculation process is continued on the G5 symptom. This calculation uses equation [3] because the weight of the initial CF value is greater than 0 and G5 is less than 0.

\[ CF = \frac{CF_{beginning} + CF_{G5}}{0.28 + (-0.1875)} \]
\[ CF = \frac{1 - (\min\{ 0.28 | (-0.1875) \})}{0.28 + (-0.1875)} \]
\[ CF = \frac{0.28}{0.1875} \]
\[ CF = 0.14 \]
CF = \frac{(0.0925)}{1.1875}
CF = 0.0779

The calculation process is continued on the G6 symptom. This calculation uses equation [1] because the weight of the initial CF value and G6 is greater than 0.

\[
\begin{align*}
\text{CF} &= \text{CF}_{\text{beginning}} + (\text{CF}_{\text{G6}} \times (1 - \text{CF}_{\text{beginning}})) \\
\text{CF} &= 0.0779 + (0.25 \times (1 - 0.0779)) \\
\text{CF} &= 0.3084
\end{align*}
\]

The calculation process is continued on the G7 symptom. This calculation uses equation [3] because the weight of the initial CF value is greater than 0 and G7 is less than 0.

\[
\begin{align*}
\text{CF} &= \frac{\text{CF}_{\text{beginning}} + \text{CF}_{\text{G7}}}{1 - (\min\{\text{CF}_{\text{beginning}} | \text{CF}_{\text{G7}}\})} \\
&= \frac{0.3084 + (-0.75)}{1 - (\min\{0.3084 | (-0.75)\})} \\
\text{CF} &= \frac{1}{(-0.4416)} \\
\text{CF} &= -0.2523
\end{align*}
\]

The calculation process is continued on the G8 symptom. This calculation uses equation [2] because the weight of the initial value of CF and G8 is smaller than 0.

\[
\begin{align*}
\text{CF} &= \text{CF}_{\text{beginning}} + (\text{CF}_{\text{G8}} \times (1 + \text{CF}_{\text{beginning}})) \\
\text{CF} &= -0.2523 + (-0.25 \times (1 - 0.2523)) \\
\text{CF} &= -0.4392
\end{align*}
\]

The calculation process is continued on the G9 symptom. This calculation uses equation [2] because the weight of the initial value of CF and G9 is smaller than 0.

\[
\begin{align*}
\text{CF} &= \text{CF}_{\text{beginning}} + (\text{CF}_{\text{G9}} \times (1 + \text{CF}_{\text{beginning}})) \\
\text{CF} &= -0.4392 + (-0.25 \times (1 - 0.4392)) \\
\text{CF} &= -0.5794
\end{align*}
\]

The calculation process is continued on the G10 symptom. This calculation uses equation [2] because the weight of the initial value of CF and G10 is smaller than 0.

\[
\begin{align*}
\text{CF} &= \text{CF}_{\text{beginning}} + (\text{CF}_{\text{G10}} \times (1 + \text{CF}_{\text{beginning}})) \\
\text{CF} &= -0.5794 + (-0.25 \times (1 - 0.5794)) \\
\text{CF} &= -0.6845
\end{align*}
\]

The calculation process is continued on the G11 symptom. This calculation uses equation [2] because the weight of the initial value of CF and G11 is smaller than 0.

\[
\begin{align*}
\text{CF} &= \text{CF}_{\text{beginning}} + (\text{CF}_{\text{G11}} \times (1 + \text{CF}_{\text{beginning}})) \\
\text{CF} &= -0.6845 + (-0.25 \times (1 - 0.6845)) \\
\text{CF} &= -0.7634
\end{align*}
\]

The calculation process is continued on the G12 symptom. This calculation uses equation [2] because the weight of the initial value of CF and G12 is smaller than 0.
\[ CF = CF_{\text{beginning}} + (CF_{G12} \times (1 + CF_{\text{beginning}})) \]
\[ CF = -0.7634 + (-0.25 \times (1 - 0.7634)) \]
\[ CF = -0.8225 \]

The calculation process is continued on the G13 symptom. This calculation uses equation [3] because the weight of the initial CF value is less than 0 and G13 is greater than 0.

\[ CF = \frac{CF_{\text{beginning}} + CF_{G13}}{1 - (\min\{ CF_{\text{beginning}} \mid CF_{G13} \})} \]
\[ CF = \frac{-0.8225 + 0.75}{1 - (-0.8225)} \]
\[ CF = \frac{-0.0725}{1.8225} \]
\[ CF = -0.0398 \]

The calculation process is continued on the G14 symptom. This calculation uses equation [3] because the weight of the initial CF value is less than 0 and G14 is greater than 0.

\[ CF = \frac{CF_{\text{beginning}} + CF_{G14}}{1 - (\min\{ CF_{\text{beginning}} \mid CF_{G14} \})} \]
\[ CF = \frac{-0.0398 + 0.25}{1 - (-0.0398)} \]
\[ CF = \frac{0.2102}{1.0398} \]
\[ CF = 0.2021 \approx 0.20 \]

The results obtained from the calculation of the CF value using the certainty factor method is 0.20. The percentage of CF value is the final CF value multiplied by 100% which is 20%. Then the diagnosis result of Patient X is a 20% chance of developing gingivitis (mild periodontal disease).

After the results of the system diagnosis are obtained, testing the accuracy of the system results with medical record data obtained from the dentist as an expert who becomes a reference in making the system.

4. Conclusion
This study concludes that Certainty Factor methods can be used in the expert system for the diagnosis of periodontal disease. The accuracy of the certainty factor method in the diagnosis of periodontal disease is 100%. Based on the test results on 20 medical record data, it was found that the 20 data match with the results of the system diagnosis.

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