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Expert System for Diagnosing Dental and Mouth Diseases with a Website-Based Certainty Factor (CF) Method

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Abstract—Expert Systems were knowledge-based programs that provided expert quality solutions to problems in a specific domain. The concept of this expert system was a computer program that mimics the thought process and expert knowledge in solving a particular problem. The implementation of expert system was widely used in then health field because the expert system was seen as a way of strong expert knowledge in certain field in a computer program. So that decisions could be given in intelligent reasoning. This work used certainty factor (CF) method implemented in a web-based expert system to diagnose various dental and mouth diseases. The experimental result indicated 99% in accuracy of the testing compared compared to the experts diagnosis.

Keywords—*Diagnosis of diseases, teeth and mouth, expert system, forward chaining, Certainty factor (CF)*

I. INTRODUCTION

Knowledge-based expert systems used human knowledge to solve problems that usually require human intelligence [1]. In the medical world, the aim of the expert system is to support the doctor's diagnosis process. It considered facts and symptoms to provide a diagnosis. This implied that the medical expert system used knowledge about the disease and facts about the patient to suggest a diagnosis [2].

Expert systems were defined as intelligent computer programs that used knowledge and inference procedures to solve problems that were difficult enough to require significant human expertise for the solution [3]. It means, an expert system is a computer system that emulated the decision making ability of a human expert. The term imitate means that the expert system was intended to act in all respects like a human expert.

Oral health played a major role in human nutrition [4]. Oral diseases were some of the diseases found in the oral cavity that caused by several things including food, and vitamins. It was one of the most common diseases in the world and had a serious health and economic burden, greatly reducing the quality of life for those affected [5].

The certainty factor was a compromise, a system based on rules with a certainty factor required experts to produce only a small number of numbers (one for each rule) and will allowed the calculation of fast answers [6]. This approach was only consistent with the axiom of modularity for certainty factors for tree structure inference networks, which rarely applied to practical applications [7].

The certainty factor associated with an expert system was used by many jobs in building disease-based expert systems as in [8-13].

The main objective of this work was to design a web-based expert system to diagnose dental and oral diseases using the certainty factor method.

II. RELATED WORKS

Ghali, et. al. presented a knowledge-based system to diagnose teeth and gums problems by resulting a recommendation for treatment. The system is implemented using SL5 object language [14]. Beside, Setiabudi, et al. performed a dental diagnosis using expert system based on certainty factor method. In the measurement of accuracy, the system tested 20 patients and resulting 95% in accuracy rate [15]. Ali, S.A., et al. introduced a Visual Basic expert system in diagnosing the most common and rare oral ulcers. The result showed 75% in success rate [16]. Moreover, Djamaludin, et al. built dental disease diagnosis expert system using forward chaining method. The result showed that the forward chaining method is appropriate for the diagnosis of dental and oral diseases [17].

Furthermore, Zhang, et al. proposed an expert system for dental disease diagnosis based on DDES knowledge engineering. The experimental result revealed that the DDES is a useful learning and aided diagnosis tool [18]. Naser, et al. presented a SL5 object based expert system for diagnosing mouth problems in infants and children. The system claimed as a simple, fast, and easy to use [19]. Kristian, et al. conducted a detection of teeth and mouth disease using Dempster-Shafer method. The expert system resulted 100% in validity after test case [20]. Maharani, et. al. implemented forward chaining and Bayes theorem in diagnosing teeth and oral diseases for children. The result served good accuracy as an expert system [21].

However, Achmadi, et al. proposed an expert system to diagnose tropical diseases caused by virus infection. Using the certainty factor method, the resulting output uses the possibility of child disease based on calculation of CF method [22]. Beside, Tinuke, et al. developed a coactive neuro-fuzzy expert system model implemented by using C# programming language. This expert system was claimed as a simple and user-friendly desktop application for diagnosing and preventing dental diseases [23].

III. METHOD

Expert systems are computer systems that are intended to mimic all aspects the decision making ability of an expert or the knowledge contained in the expert system. Expert systems optimally utilize the special knowledge of an expert to be able to solve problems.

Shortliffe Buchanan introduced Certainty factor in making of MYCIN [24]. Certainty factor is a clinical

parameter value given by MYCIN to show the magnitude of trust. Certainty factor is defined as the following in Eq. 1.

$$CF(H, E) = MB(H, E) - MD(H, E) \quad (1)$$

CF (Rule) = Certainty factor;

MB(H, E) = Measure of belief (measure of trust) to the H hypothesis, if given evidence E (between 0 and 1);

MD(H, E) = Measure of disbelief (measure of distrust) of evidence H, if given evidence E (between 0 and 1);

P(H) = Probability of the H hypothesis; and

P(H|E) = Pro-balance that H is true because of fact E.

In the system that will be built, identification has been made of the users involved in this expert system. In addition to identifying users or users, the author also describes things that can be done by the user. The system can also describe things that can be done by the admin of this expert system, starting from identifying data input, data processing and data output generated from the built system.

In data processing and decision making diagnosis of dental and mouth diseases, certainty factor has a rule IF E THEN H is as follows in Eq. 2-4. These equations were applied in PHP 7 web-based programming source code using CodeIgniter PHP framework.

$$CF(H, e) = CF(E, e) * CF(H, E) \quad (2)$$

$$CF_{combine}CF[H, E]_{1,2} = CF[H, E]_1 + CF[H, E]_2 * [1 - CF[H, E]_1] \quad (3)$$

$$CF_{combine}CF[H, E]_{old,3} = CF[H, E]_{old} + CF[H, E]_3 * (1 - CF[H, E]_{old}) \quad (4)$$

CF(E,e) = Certainty factor E evidence that is influenced by evidence e

CF(H,E) = Certainty factor hypothesis assuming evidence is known with certainty, namely when CF (E, e) = 1

CF(H,e) = Certainty factor hypothesis that is influenced by evidence e

Fig. 1 depicts the example of CF source code to apply CF equations.

```

15 <H1>ANALISA PENYAKIT</H1>
16 <hr />
17 <H1>Jenis Gejala Penyakit</H1>
18 <?
19 if(!isset($_REQUEST[kodegejala]))
20 {
21     echo "<h1>Gejala Harus dipilih </h1>";
22     return;
23 }
24 $kodepenyakit = $_REQUEST["kodepenyakit"];
25 $sql="Select * from tpenyakit where kodepenyakit = '$kodepenyakit' ";
26 //echo $sql;
27
28 $rs = mysql_query($sql);
29 $fields=mysql_fetch_array($rs);
30 $kodegejala = "";
31 $j=0;
32 foreach($_REQUEST[kodegejala] as $element)
33 {
34     $j=$j+1;
35     $gejala[$j] = $element;
36     $kodegejala = $kodegejala."-".$element;
37 }

```

Fig. 1. Example of CF Source Code in Expert System

Based on the interview with an expert on the symptoms that lead to the emergence of dental disease. The interview acquired 12 symptoms and 5 diseases. Knowledge base inserted into the computer program in order to acts as an

expert were able to identify the symptoms of dental disease. Here are the data tables symptoms from Healthline Media [25] that can be seen in Table I.

TABLE I. LIST OF SYMPTOMS

ID Symptom	Symptom Name
S001	ulcers, sores, or tender areas in the mouth that won't heal after a week or two
S002	bleeding or swollen gums after brushing or flossing
S003	chronic bad breath
S004	sudden sensitivity to hot and cold temperatures or beverages
S005	pain or toothache
S006	loose teeth
S007	receding gums
S008	pain with chewing or biting
S009	swelling of the face and cheek
S010	clicking of the jaw
S011	cracked or broken teeth
S012	frequent dry mouth

Table II lists the types of mouth and dental diseases used in this system.

TABLE II. LIST OF DISEASES

No.	Diseases
D001	Trench Mouth
D002	Periapikal Abses
D003	Simplex Gingivitis
D004	Acute Herpetic Gingivitis
D005	Periodontitis

Furthermore, the base rules is set. The rule base is a rule made to link symptoms with disease. Base rules can be written to the structure of the IF (id_symptoms) THEN (id_disease) CF(x). Here's a rule base table obtained from interview with the dentist with the certainty factor value in Table III:

TABLE III. BASE RULE

No.	IF	THEN	CF
1	S001	D001	0,8
2	S010	D001	0,4
3	S003	D001	0,3
4	S002	D002	0,8
5	S005	D002	0,8
6	S012	D002	0,7
7	S007	D002	0,6
8	S011	D003	0,4
9	S009	D003	0,3
10	S010	D004	0,6
11	S001	D002	0,6
12	S012	D003	0,8
13	S008	D003	0,6
14	S005	D004	0,7
15	S012	D004	0,7
16	S003	D004	0,3
17	S006	D005	0,4
18	S001	D005	0,5
19	S004	D005	0,4
20	S008	D005	0,6

Application testing phase was conducted to test the diagnose application with results that have been calculated manually using certainty factor. Table IV show an example of three symptoms applied with CF.

TABLE IV. USER INPUT

Symptom	CF Trench Mouth	CF Periapikal Abses	Simplex Gingivitis	Acute Herpetic Gingivitis
S001	0,8	0,6	-	-
S010	0,4	0,5	0,5	0,6
S003	0,3	-	-	-

The manual calculation of CF for Trench Mouth can be conducted as follows in Eq. 5:

$$CF \text{ for Trench Mouth} = \frac{0,8}{0,8+0,4+0,3} = 0,5 \quad (5)$$

To build a web-based application, we apply a PHP 7 language implemented in CodeIgniter PHP Framework.

To implement of this assessment, our system requires hardware and software. The hardware and software that will be needed are (i) hardware at least a Pentium 3 microprocessor, a hard drive for where the system operates and as a data storage medium, a minimum of 64 MB memory, super VGA monitor, keyboard, and mouse; and (ii) softwares such as XAMPP, MySQL, Web Browser (IE, Firefox, or Chrome).

IV. RESULT AND DISCUSSION

The experimental of expert system diagnose dental and mouth diseases is done by comparing result accurate the types of dental disease that produced by system and expert. This built website can access online at bit.ly/ExpertSystemDentalAndMouth. Table V is a result of testing the accuracy of the system proposed.

TABLE V. RESULT OF ACCURACY TESTING

No.	Symptom	Expert	System	Accuracy
1	S001, S010, S003	D001	D001	Corresponding
2	S001, S004, S006, S008	D005	D005	Corresponding
3	S002, S005, S007, S012	D002	D002	Corresponding
...	...	...	...	...
49	S008, S009, S011, S012	D003	D003	Corresponding
50	S003, S005, S010, S012	D004	D001	Not Corresponding

Testing was conducted on 50 respondents to test the system. Eq. 6 determines the level of accuracy of the system.

$$Result = \frac{\sum \text{case which responding}}{\sum \text{case}} \cdot 100\% \quad (6)$$

In all cases there were 48 cases of corresponding and 2 cases that do not fit. these cases were matched with statements of relevant experts. In can be found that the experimental result indicates 99% in accuracy of the testing.

This design uses a context diagram, this diagram explains the input/output relationship between the system and the outside world, a context diagram always contains only one process that represents the process of the entire system. The system design starts from the most global thing to become the most detailed model. The data flow is sourced from knowledge obtained from experts, entered into the system, and then it will be processed. Patients enter the symptoms that are felt for diagnostic purposes, then the patient gets a diagnosis of the disease. While the admin adds expert data, if

there are new experts in the system. The context diagram of the proposed system is shown in Fig. 2.

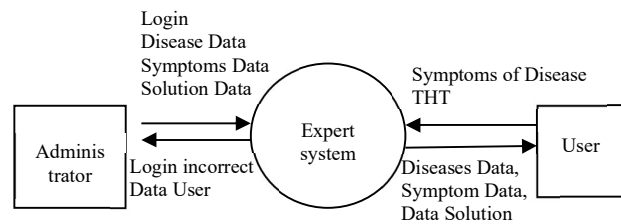


Fig. 2. Context Diagram.

In Fig. 2, an administrator has a privilege to input diseases, symptoms, and solution data into expert system database while the users registered to the system can input the symptoms data they suffered.

Fig. 3 depicts four processes: consultation, expert consultation, expert users, and knowledge update. Administrator manages disease data and rule base to income data while the users manage their condition. In express process of consultation stage, a diagnosing result of consultation displayed to the patients as an advisory treatment.

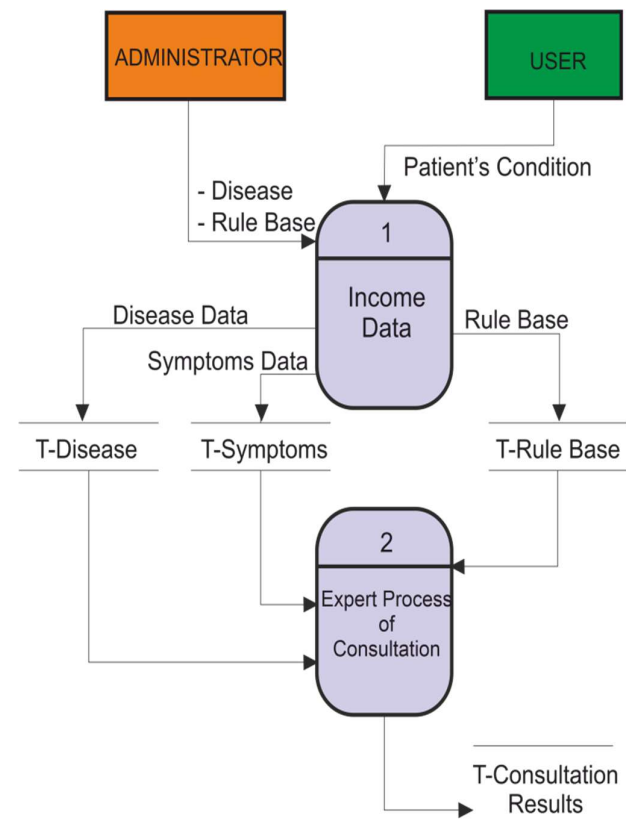


Fig. 3. Data Flow Diagram Level 0.

Fig. 4 displays the web-based user interface for diagnosis form of this expert system. Ensuring the expert systems as user-friendly as possible and avoiding creating a complicated design can attract users to utilize expert systems in their fields. In this system, users must be able to find their problems without being confused or easily frustrated from difficult procedures.



Fig. 4. Web-Based Diagnosis Form.

V. CONCLUSION

The experimental result indicated 99% in accuracy of the testing compared to the experts diagnosis. A knowledge-based expert system can be used to simulate what an expert can do. After designing and applying the proposed web-based system, it can be concluded that the CF inference technique served a high accuracy in detecting dental and mouth diseases from several symptoms.

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