# Design and Development of Android Based Teeth and Mouth Disease Detection Expert System Using Dempster-Shafer Method

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*Abstract*—Teeth and mouth disease is a disease that affects many people in Indonesia. Teeth and mouth disease can interfere with human activities and also some other scientific findings indicate a link between oral health to overall body health including diabetes, heart disease, pregnancy problems, and memory loss. The quick detection of teeth and mouth disease would help people to quickly recover from teeth and mouth disease. This research was conducted with the aim to help detect teeth and mouth disease suffered by the user. In this research, the determination of the results of teeth and mouth disease detection was conducted using Dempster-Shafer method. This method is used because this method combines belief values of experts, resulting in an accurate level of confidence that the data is taken from the entire value of the trust that is available. This application was developed for android devices. This application was tested using ten kinds of cases designed by a doctor. Based on test cases conducted as many as ten kinds of cases, the results given by this application correspond 100% with the results that have been validated by drg. Lanny Widjaja.

*Index Terms: Android, Dempster-Shafer, expert system, teeth and mouth disease*

## I. INTRODUCTION

In modern times, the development and distribution of information technology has been unable to be stopped. Everything can be done easily and quickly. Many things in this world have been facilitated with the help of technology. One of the technology implementations that can be encountered during this period is an expert system that has been developed by many researchers in various fields respectively. However, the expert system is more commonly found in the field of health. This expert system can perform detection of disease symptoms exist. This expert system can be useful as a tool for people to make the detection of various diseases, so the presence of this expert System will enable people to detect diseases that happened as early as possible. In addition, the expert system can also be used as a consultation complementary facility with a doctor. The system built in this research is the teeth and mouth diseases detection expert system.

Teeth and mouth diseases chosen because this disease is one of many diseases that has complained by Indonesian society [1]. This is due to a low awareness of teeth and mouth health in the community. In fact, teeth and mouth health is very important. Thar must be maintained because the mouth is the first gate entry of all kinds of food and also bacteria and even viruses that can harm other organs in our body. Another thing behind choosing this teeth and mouth disease is the national prevalence of teeth and mouth problems which show figures of 25.9% and also the ability to get dental care from medical personnel that only amounted to 8.1% [2].

Now, some of the scientific findings indicate a link between oral health with overall body health including diabetes, heart disease, pregnancy problem, and memory loss [3].

In general, to determine the dental and oral diseases suffered, the patient should consult directly with the dentist. It is certainly rather difficult due to various limitations. Therefore we needed an effective breakthrough in accordance with the times to help overcome this problem. Hopefully, by the presence of teeth and mouth disease detection expert system, it can be used by many people, so it can help provide useful information for a variety of issues regarding teeth and mouth diseases.

## AI. THEORIES

### A. Expert System

Expert system is a system that adopts human knowledge and applies it to the computer so that the computer can resolve the problem as was done by experts. Expert system can solve a problem by imitating the work of experts [4]. Good expert system must meet the following characteristics [4].
1. Having reliable information facilities
2. Easily modified
3. Can be used in many different types of

computers
4. Have the ability to learn to adapt

On the other side, there are also many advantages from expert systems [4].
1. Allows layman can do the work of the experts
2. Can the process be repeated automatically
3. Save the knowledge and expertise of the experts
4. Increase the output and productivity
5. Improving the quality
6. Being able to take and preserve the skills of experts (notably including the rare skill)
7. Able to operate in hazardous environments
8. Having the ability to access knowledge
9. Having reliability
10. Increase the capability of computer systems
11. Have the ability to work with incomplete information and uncertainty
12. As a complement to the training media
13. Increase the capability to solve problems
14. Save time in making decisions

In addition to having many advantages, expert systems also still have some weaknesses [4].
1. The cost required to create and maintain application of expert systems is very expensive
2. Difficult to developing. It is of course closely related to the availability of experts in the field
3. Expert systems are not 100% true worth

From the explanation of the expert system, another thing that is necessary and important to know is the creating of expert system is not to replace the expert itself but can be used as a very experienced assistant [4].

*B. Dempster-Shafer*

Dempster-Shafer is a method of proof based on the function of trust and sensible thinking. This method is used to combine pieces of information (evidence) separate to be calculated in order to get the results in the form of the possibility of an event. Dempster-Shafer theory is the representation and combination of uncertainties. This theory has some characteristics in accordance with the way of thinking of a master, but with a strong mathematical basis [5]. This method was originally introduced by Arthur P. Dempster were then developed further by Glenn Shafer.

In general, Dempster-Shafer method is written in the [Belief, plausibility] interval. Belief

(Bel) is a measure of the strength of evidence (symptoms) in favor of a subset. If the value is 0 then it indicates that there is no evidence, and if the value of 1 indicates certainty. Plausibility (Pls) will reduce the degree of certainty of the evidence. Plausibility worth 0 to 1. If you believe would be X ', it can be said that Bel (X') = 1, so for the above formula the value of Pls (X) = 0. Belief and plausibility functions can be formulated and denoted in the following equation [5].

$$Bel(X) = \sum m(Y), Y \subseteq X \qquad ...(1)$$
$$Pls(X) = 1 - Bel(X) \qquad ...(2)$$

where:
$Bel(X) = Belief(X)$
$Pls(X) = Plausibility(X)$
$m(Y) = mass\ function\ of\ (Y)$

On the Dempster-Shafer method known term frame of discernment which is denoted by θ and the mass function is denoted by m. This frame is a universe of discourse of a set of hypotheses, so called Environment shown in the following equation [5].

$$\theta = \{\theta 1, \theta 2, ..., \theta N\} \qquad ...(3)$$

where:
$\theta$ = frame of discernment or environment
θ1,...,θN = elements

Environment contains elements that describe the possibility of an answer, and the only one that will suit the required answers. The possibility of the Dempster-Shafer theory called the power set and is denoted by , every element in this power set interval value between 0 and 1.

$$m : P(\theta) \rightarrow [0, 1]$$

So it can be formulated in the following equation [5].

$$\sum m(X) = 1, X \epsilon P(\theta) \qquad ...(4)$$

where:
$P(\theta)$ = power set
$m(X)$ = mass function $(X)$

Mass Function (m) is the level of trust of a measure that evidence is denoted by m. The aim is to link the size of the trust elements θ. Not all evidence directly supports each element, so it requires the probability density function (m). M value not only defining the elements of θ alone, but also all its subsets, so if θ contains n elements, then the subset θ is 2n. The sum of all the subset θ m equals 1. In the absence of any information to select the hypothesis, then the value of:

$$m\{\theta\} = 1,0$$

If known that X is a subset of θ, with m1 as

a function of its density, and Y is also a subset of θ by m2 as a function of its density, it can be formed of a combination of function between m3 m1 and m2 as shown in the following equation [5].

$$m3(Z) = \frac{\sum_{X \cap Y = Z} m1(X).m2(Y)}{1 - \sum_{X \cap Y = \emptyset} m1(X).m2(Y)} \quad ...(5)$$

where :

m3(Z) = *mass function* from *evidence* (Z)
m1(X) = *mass function* from *evidence* (X), obtained from a confidence value is multiplied by the value of disbelief evidence of such evidence.
m2(Y) = *mass function* from *evidence* (Y), obtained from a confidence value is multiplied by the value of disbelief evidence of such evidence.
$\sum_{X \cap Y = Z} m1(X).m2(Y)$ = the Z value of the strength of evidence obtained from a combination of the value of a set of beliefs evidence.

## C. *Teeth and Mouth Disease*

Disease is a medical disorder that is caused by bacteria, viruses, or physiology or tissue system abnormalities in organs (in living organisms) [6]. Teeth are hard parts present in the mouth used for chewing food. Gear consists of three main parts: email, dentin, and pulp. If there is one part is broken, it can be said as a teeth and mouth disease. Thus teeth and mouth diseases can be defined as health problems that are caused by bacteria, viruses, or physiology or tissue system disorders of the teeth and mouth. Teeth and mouth diseases that will be discussed in this study are as follows [7].

1. The tooth abscess
   Tooth abscess is an infection that occurs on the inside of the tooth that causes pus. Collection of pus from a tooth spread to surrounding tissue.
2. Halitosis (Bad Breath)
   Bad breath is foul smell coming out of the oral cavity. Bad breath can be caused by many things such as tartar, lack of oral hygiene, stress, ulcers, and others.
3. Gingivitis
   Gingivitis is an inflammation of the gums. Gingivitis can occur anytime. Gingivitis usually occurs due to negligence when brushing teeth, so there remains plaque along the gum line.
4. Dentin hypersensitivity
   Dentin hypersensitivity is a condition where the toothache within a short period and was sharply due to the open dentin is exposed outside stimuli. Usually this happens because of the food or beverage to be consumed cold or sour, so the food is thus to be avoided.
5. Tartar
   Tartar is plaque and calcium that sticks to the teeth. Tartar commonly found on the surface of the teeth and the bottom teeth in the gums. On the surface of the tooth, usually yellowish-white coral, while on the bottom teeth are covered by black gums.
6. Dental caries
   Dental caries are cavities that are divided into three levels of damage. The first is the damage to the enamel. Then, the damage is in the dentin. Then the damage occurred until the third or deepest part of the pulp. If the coating is exposed enamel layer, then the sense of pain that is felt just felt a little bit. Then, if the layer is already at the dentin, the pain started to feel a lot of pain. Finally, when it is up to the pulp layer, then the perceived pain is pain that is incredible.
7. Mucocele
   Mucocele is soft tissue lesions in the mouth caused by the rupture of the salivary gland duct and mucin secretion into the surrounding soft tissue. Usually there will be a lump that does not hurt. Mucocele usually goes away by itself.
8. Periodontitis
   Periodontitis is an inflammation of the tissues supporting the teeth. Patients with periodontitis, usually already inflamed periodontal tissues.
9. Pulpitis
   Pulpitis is an inflammation of the dental pulp or nerve. Regular pulpitis caused by caries has reached the pulp, causing inflammation of the pulp.
10. Mouth ulcer
    Mouth ulcer is a wound that is limited to the mucosa or soft tissues of the oral cavity. Mouth ulcer is intermittent. Mouth ulcer can grow around the lips, tongue, or palate. Mouth ulcer usually occurs due to biting, stress, or lack of vitamin c.

## D. *Android*

Android is the most popular and widely used mobile operating system in the world today with a very rapid growth. Android has been used in hundreds of millions of mobile phones in more than 190 countries around the world [8]. Android is an operating system made by Google. Android was developed using the Java programming language. The fast growing of Android will make applications such as expert system is easy to use by users. Android has now reached version 5.0 (Lollipop) and will continue to be developed for the future.

## BI. RESEARCH METHODS

The methods used in this study are as follows.

1. Literature study

   This method is used to find the theories related to the topics covered in this study, both on the Dempster-Shafer, and diseases of the teeth and mouth. References used in the analysis of literature sourced from books, articles, scientific journals, and other sources.

2. Expert interview

   A search for information by providing direct questions to the experts so that, obtained a lot of information needed from the answers given by the experts. In this study, the expert in question is a dentist who is experienced. He was drg. Lanny Widjaja. He practices in his own dental clinic in West Jakarta Puri Indah area. Interviews were conducted to obtain the value of the trust experts or belief value of existing symptoms.

3. System Analysis

   Systems analysis is the stage where the various needs required in the construction of the system is analyzed. Those analyses are system development platform, database used, as well as system design.

4. System Design

   The design that is done at this stage is the design of the display or application user interface and what features will be provided in this application.

5. System Programming

   After the previous process passed, then the next step is system programming. Programming the system is the realization or manufacture of systems that have been designed previously.

6. Test and Evaluation

   Once the system programming process is completed, the next process is carried out tests on the application made. In addition it also made an evaluation of the results of these trials.

7. Reports Writing

   Writing the report is intended as documentation of a study that has been conducted so as to provide similar information for the Study.

*A. System Analysis*

The system is designed as an auxiliary system of the patient in the detection of teeth and mouth diseases suffered by the patient. In practice, the system is applied to the android device because it is constituted by the large number of android users in the present.

Important features needed in an teeth and mouth disease detection expert system is a disease detection feature itself is further provided information and solutions about the disease. Then another important feature is the information about the hospital or clinic that can deal with teeth and mouth disease related.

The implementation of this application has six main menu. When the start menu is selected, then the symptoms will be displayed based on diseased organ. Then the symptoms entered by the user input via a checkbox that is displayed by the application. After all inputs included symptoms been chosen, the detection button should pressed by the user. Then, the detection results are displayed by this application. It is based on the calculation method Dempster-Shafer.

The next menu is a glossary. Glossary contains a list of teeth and mouth diseases as well as disease information, solutions, and drawing supporters. The solution obtained from interviews with experts and from teeth and mouth diseases books. Then, the settings menu contains settings which figures on the calculation of Dempster-Shafer want to show or not by the user. Then, help menu that provides guidance on how to use this application. Furthermore, there is the hospital info or clinic menu in which there is a complete list of clinics or hospitals that deal with issues regarding teeth and mouth diseases. Then, the information related to this application can be viewed by the user on the menu about.

*B. System Design*

Before entering into the stage of manufacture or programming, this application should be designed in advance. The design was conducted on the use case diagram, activity diagram, sequence diagram, class diagram and flowchart of Dempster-Shafer method used.

IV. IMPLEMENTATION AND TESTING

*A. Implementation*

Here are some screenshots of the results of the implementation of the teeth and mouth disease detection expert system detection that have been successfully created. Here is the home page of this application. On this page there are six menu buttons that start, glossary, setting, hospital info or clinic info, help, and about.

Then, if the start button is selected then the user can select the symptoms that are felt. Once the symptoms are selected then the detection button must be pressed by the user so that detection results can be displayed by this application.

Figure 1. Application's start page



Figure 2. Start page with symptom choice
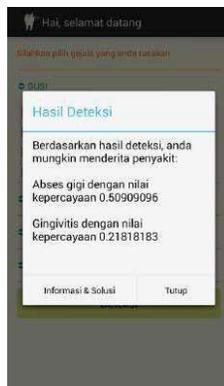


Figure 3. Detection result

## B. Manual Calculation

Manual calculations performed with the aim to test the similarity between the results of calculations done manually by calculations performed by the system. In the manual calculation is also described how the system can provide the calculation results to users based on symptoms given by the user. Calculation on this expert system is using Dempster-Shafer method. Examples of cases discussed in this manual calculation are the user provides input symptoms such as swollen gums. In the data held by this expert system, the symptom of swollen gums is a symptom of the disease, namely the three types of teeth abscess, gingivitis, and periodontitis. Swollen gums on teeth abscesses have a belief value of 0.7. Later, swollen gums in gingivitis belief value of 0.5. Then, swollen gums in periodontitis have a belief value of 0.2. The whole belief value is obtained from the doctor. Here is an explanation of the calculation.

1. Swollen gums on teeth abscesses
$m1$(teeth abscesses) = 0.7
$m1\{\}$ = 1-0,7
$\quad$ = 0.3

2. Swollen gums on gingivitis
$m2$(gingivitis) = 0.5
$m2\{\}$ = 1-0.5
$\quad$ = 0.5

Table 1. Calculation of two symptoms

|  | $m2$(gingivitis) 0.5 | $m2\{\theta\}$ 0.5 |
|---|---|---|
| $m1\{$ teeth abscesses $\}$ 0.7 | ø 0.35 | $\{$ teeth abscesses $\}$ 0.35 |
| $m1\{\theta\}$ 0.3 | {gingivitis} 0.15 | $\theta$ 0.15 |

$m3\{$teeth abscesses$\} = \frac{0.35}{1-0.35} = 0.538$

$m3\{$gingivitis$\} = \frac{0.15}{1-0.35} = 0.23$

$m3\{\theta\} = \frac{0.15}{1-0.35} = 0.23$

3. Swollen gums on periodontitis
$m4$(periodontitis) = 0.2
$m4\{\}$ = 1-0.2 = 0.8

Table 2. Calculation of three symptoms

|  | $m4$(periodontitis) 0.2 | $m4\{\theta\}$ 0.8 |
|---|---|---|
| $m3\{$ teeth abscesses $\}$ 0.538 | ø 0.1076 | $\{$ teeth abscesses $\}$ 0.4304 |
| $m3\{$gingivitis$\}$ 0.23 | ø 0.046 | {gingivitis} 0.184 |
| $m3\{\theta\}$ 0.23 | {periodontitis} 0.046 | $\theta$ 0.184 |

$m5\{$teeth abscesses$\} = \frac{0.4304}{1-(0.1076+0.046)} = 0.509$

$m5\{$gingivitis$\} = \frac{0.184}{1-(0.1076+0.046)} = 0.218$

$m5\{$periodontitis$\} = \frac{0.046}{1-(0.1076+0.046)} = 0.054$

$m5\{\theta\} = \frac{0.184}{1-(0.1076+0.046)} = 0.218$

Once the calculation is completed, the results obtained with the largest confidence value against the disease teeth abscess with a value of 0.509 which was followed by gingivitis, θ, and, periodontitis. The manual calculation results are in accordance with the calculation results produced by the system. Results are displayed on a run of three successive detection applications with the highest confidence score, but θ is not shown because θ is the universe of discourse of a set of hypotheses which are used for further calculations if there are other symptoms that should be calculated.

*C.* Test Result

Trials through expert had been done by taking ten examples of cases provided by drg. Lanny Widjaja, with symptoms often suffered by patients.

Table 3. Recapitulation of trials result through expert

| No. | Perceived symptoms | Expert Analysis Results | System Analysis Results |
|-----|--------------------|-----|-----|
| 1. | Swollen gums The gums appear red Gums itch | Teeth Abscesses Tartar Gingivitis | Teeth Abscesses Tartar Gingivitis |
| 2. | Throbbing tooth pain / inflammation in the tooth | Dental caries Teeth Abscesses | Dental caries Teeth Abscesses |
| 3. | Bad breath Bleeding gums | Halitosis Tartar | Halitosis Tartar |
| 4. | Teeth cavity There are patches of white / brown at tooth enamel | Dental caries | Dental caries |
| 5. | Lump in the mouth (lip or palate) Lump in the mouth does not hurt | Mucocele | Mucocele |
| 6. | Gums itch | Gingivitis Tartar | Gingivitis Tartar |
| 7. | Wounds in the oral mucosa Stinging wound while eating, drinking, or touched | Mouth ulcer | Mouth ulcer |
| 8. | Swollen gums Tooth pain when a knock | Teeth Abscesses Periodontitis Gingivitis | Teeth Abscesses Periodontitis Gingivitis |
| 9. | Toothache when exposed to food / beverage cooler / sour | Dentin Hypersensitivity | Dentin Hypersensitivity |
| 10. | Toothache There are patches of white / brown at tooth enamel | Pulpitis Dental caries | Pulpitis Dental caries |

Steps involved in application testing is a comparison between detection results provided by experts with the detection results provided by the system so that it can be seen conformity between the results of the expert results with the results of the system.Based on the comparison results in Table 3 it can be seen that the detection results between expert systems have been corresponding with, so that the application can be said to have passed the test. So, this application can be used to detect teeth and mouth disease.

V.    CONCLUSIONS               AND
       SUGGESTIONS

Android based teeth and mouth disease detection expert system application has been built by using Dempster-Shafer method. Based on the ten examples of cases that were tested, the results provided by the system correspond 100% to the data validation provided by a dentist is drg. Lanny Widjaja. Based on this, the detection result given by the expert system is an accurate and reliable result.

From the research results obtained then, suggestions that can be delivered are as follows

1. Further development of expert systems with additional data of teeth and mouth disease, so it has a more complete knowledge base and in accordance with the newest teeth and mouth diseases.

2. The development of application's user interface to make it more interactive.

3. The source which provides information on the symptoms and the value of belief can be propagated so that the system can be better. The source can either be an expert or doctor, book, or other sources.

4. The test can be performed to more than one doctor to give more accurate test results.

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