# APPLICATION OF AN EXPERT SYSTEM TO DIAGNOSE EYE DISEASES USING THE WEB-BASED CERTAINTY FACTOR METHOD

**João Baptista De Carvalho Gama [1], Joseph Dedy Irawan [2], Yosep Agus Pranoto [3]**
[1,2,3] Informatics Engineering, National Institute of Technology Malang
*1818002@scholar.itn.ac.id*

**ABSTRACT**

Eye examinations in the community still face several obstacles, primarily due to their reliance on manual methods that require in-person visits to health facilities. Furthermore, the lack of easy access to medical information is also a significant issue. Therefore, this study aims to create a web-based expert system that can accelerate and simplify the accurate diagnosis of eye diseases. This system uses the Certainty Factor method, which allows the system to mimic the decision-making process of an expert based on symptoms reported by the user. The system was built using PHP and the CodeIgniter framework, with MySQL as its database. Test results showed that all system features functioned as expected, with 79% of respondents stating the system was easy to use, 11% found it quite easy, and 0% found it difficult. Expert testing of 13 cases showed a diagnostic accuracy rate of 76%. With this system, it is hoped that the public will be able to more quickly recognize early symptoms of eye disease and receive appropriate treatment advice.

***Keywords :*** *Eye Disease, certainty factor, expert system*

## 1. INTRODUCTION

Eye health problems are quite common, leading to a continued increase in cases. However, the availability of ophthalmologists in some hospitals remains limited. This results in a less efficient and time-consuming diagnostic process. Furthermore, the use of manual medical record systems in some healthcare facilities also complicates the effective and structured management of patient information [1].

An expert system is a computer system developed by integrating knowledge into existing information systems, enabling it to intelligently and effectively solve problems in a specific field. This system is designed to mimic the analytical and decision-making capabilities typically possessed by experts. In the medical field, expert systems are used to help treat various diseases that require the specialized expertise of specialist doctors [2].

According to David McAllister, the Certainty Factor method measures the level of confidence in a fact, whether it can be considered certain or whether it remains uncertain. The Certainty Factor is expressed as a metric and has been widely applied in expert systems. This method is particularly suitable for use in diagnostic systems, especially when the condition being addressed is not entirely clear or certain [3].

Based on the previous description, it can be concluded that expert systems have the potential to be used in the process of diagnosing eye diseases. Therefore, researchers designed an innovation by developing research that integrates a web-based expert system to diagnose eye diseases using the Certainty Factor method. This system is expected to facilitate user access to services via the website and assist medical personnel in making diagnoses more quickly and accurately.

The problem formulation, based on the previous problem description, is as follows: How to build an expert system for diagnosing eye diseases that can be accessed via a web platform? Can the Certainty Factor method be used to diagnose eye diseases web-based?

To focus and direct the research, the problem limitations applied in developing this system are as follows: The system was developed using the PHP programming language and MySQL version 3.3.2 database.

The discussion in this system is limited to eye diseases and does not cover other vision disorders. The issues addressed in this system include symptoms, diseases, treatments, and solutions or suggestions for eye disease sufferers. The expert system was developed by referring to common symptoms frequently experienced by eye disease sufferers. The confidence level in the Certainty Factor method diagnostic process was applied by referring to the symptoms inputted by the user.

## 2. LITERATURE REVIEW

The use of the Certainty Factor method as a basis for developing expert systems has been widely discussed in various previous studies. One such study, titled "Implementation of the Certainty Factor Method for an Expert System for Diagnosing Damage in Daihatsu Vehicles," focused on the development of an online vehicle damage diagnosis system. The primary goal of this system is to assist vehicle owners in identifying damage and obtaining appropriate repair recommendations. This web-based system allows users to input damage symptoms, which are then analyzed using the Certainty Factor method to determine the level of certainty of the diagnosis [4].

Similar research was conducted by Lola Fida Putri in her work, "Design of an Expert System Application for Diagnosing Roseola Disease Using the Certainty Factor Method." The expert system designed in this study utilized the knowledge of doctors to assist in the diagnosis of Roseola [5].

Her study, titled "Expert System for Diagnosing Watermelon Plant Diseases Using the Certainty Factor Method," demonstrated how expert beliefs regarding the relationship between symptoms and disease can be modeled to help farmers recognize the disease early [6].

Then, Putra and Yunus (2021), through their research entitled "Expert System for Analyzing Mental Disorders Using the Certainty Factor Method," developed a web-based expert system for diagnosing mental disorders. This system helps users identify mental disorders based on their symptoms, utilizing the Certainty Factor method to calculate the level of certainty of the diagnostic results obtained [7].

### 2.1. Expert System

An expert system is a branch of artificial intelligence that aims to mimic the thinking and problem-solving skills of an expert. These systems operate by utilizing the knowledge contained in a database to generate decisions or conclusions. A crucial step in an expert system is how the expert's knowledge is transferred to a computer system and used to aid in informed decision-making [8].

### 2.2. Eye Diseases

Eye health problems can start as mild conditions and progress to more serious conditions. If not treated promptly, these problems can progress further and ultimately lead to blindness [9].

### 2.3. Certainty Factor

The Certainty Factor method was developed to address uncertainty in the reasoning process. This method allows experts to express their level of confidence in a phenomenon using terms such as “highly likely” or “almost certain.” This confidence value is then calculated using a mathematical formula to produce a certainty value for a particular hypothesis [9].

The Certainty Factor is defined as follows:

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

Where:
CF(H,E): Certainty Factor value
MB(H,E): A measure of the increase in confidence in hypothesis H when evidence E is considered (values range from 0 to 1).
MD(H,E): A measure of the increase in distrust in hypothesis H when evidence E is considered (values range from 0 to 1).

The following explains how to combine Certainty Factor values under various conditions:

a. Certainty Factor with one premise:
$CF(H,E) = CF(E) \times CF(rule) = CF(user) \times CF(expert)$ (2)
b. Certainty Factor with multiple premises:
$CF(A \cap B) = Min(CF(A), CF(B)) \times CF(rule)$ (3)
c. Certainty Factor for rule combination:
$CFcombined(CF1 \cup CF2) = (CF1 + CF2) \times (1 - CF1)$ (4)

## 3. METHOD

### 3.1. Table of Eye Diseases

Table 1 explains the disease codes and names.

Table 1. Eye Diseases

| No | Disease Code | Name of Disease |
|---|---|---|
| 1 | P01 | Cataract |
| 2 | P02 | Refraction Error |
| 3 | P03 | Hordeolum |
| 4 | P04 | Pterygium |
| 5 | P05 | Conjunctivitis |
| 6 | P06 | Glaucoma |
| 7 | P02 | Diabetic retinopathy |
| 8 | P08 | Dry Eyes |

### 3.2. Symptom Table

The symptom table explains the symptom codes and names.

Table 2. Symptom table

| No | Symptom Code | Symptom Name |
|---|---|---|
| 1 | G1 | Blurred vision |
| 2 | G2 | Difficult to drive at night |
| 3 | G3 | Vision is impaired during the day |
| 4 | G4 | Cannot identify objects clearly |
| 5 | G5 | Blurred vision at long distances |
| 6 | G6 | Blurred vision at close range |
| 7 | G7 | Blurred vision in old age |
| 8 | G8 | Swelling of the skin around the eyes |
| 9 | G9 | Sore eyes |
| 10 | G10 | Red eye |
| 11 | G11 | Watery eyes |
| 12 | G12 | Discomfort in the eyes |
| 13 | G13 | Hydrophobic vision |
| 14 | G14 | Sticky secretions in the eyes in the morning |
| 15 | G15 | Itchy eyes |
| 16 | G16 | Increased eye pressure |
| 17 | G17 | Narrow field of view |
| 18 | G18 | Blurred vision for distance/near |
| 19 | G19 | Central vision is impaired especially for reading and seeing. |
| 20 | G20 | Object is unclear |
| 21 | G21 | Discomfort in the eyes |

### 3.3. MB Value Table

Table 3 explains the weight values obtained from experts to measure the increase in confidence in symptoms.

Tabel 3. Tabel gejala

| Disease | Code | Symptom | MB |
|---|---|---|---|
| Cataract | G1 | Blurred vision | 0,8 |
| | G2 | Difficult to drive at night | 0,6 |
| | G3 | Vision is impaired during the day | 0,6 |
| | G4 | Cannot identify objects clearly | 0,6 |
| Refraction Error | G1 | Blurred vision | 0,6 |
| | G5 | Blurred vision at long distances | 0,4 |
| | G6 | Blurred vision at close range | 0,4 |
| | G7 | Blurred vision in old age | 0,8 |
| Hordeolum | G8 | Swelling of the skin around the eyes | 0,6 |
| | G9 | Sore eyes | 0,4 |
| Pterygium | G10 | Red eye | 0,6 |
| | G11 | Watery eyes | 0,6 |
| | G12 | Discomfort in the eyes | 0,6 |
| | G13 | Hydrophobic vision | 0,6 |
| Conjunctivitis | G10 | Red eye | 1 |
| | G11 | Watery eyes | 1 |
| | G14 | Sticky secretions in the eyes in the morning | 0,6 |
| | G15 | Itchy eyes | 0,4 |
| Glaucoma | G16 | Increased eye pressure | 0,8 |
| | G9 | Sore eyes | 1 |
| | G17 | Narrow field of view | 1 |
| Diabetic retinopathy | G18 | Blurred vision for distance/near | 0,8 |
| | G19 | Central vision is impaired especially for reading and seeing. | 0,6 |
| | G20 | Object is unclear | 0,4 |
| Dry Eyes | G13 | Hydrophobic vision | 0,4 |
| | G21 | Discomfort in the eyes | 0,8 |
| | G9 | Sore eyes | 0,6 |

### 3.4. Use Case Diagram

Explanation Figure 1 shows the access flow in the system. On the login page, the admin can directly enter the system, while users are required to register an account first before being able to log in. On the dashboard page, both admins and users can view the displayed information. On the officer page, only admins have access rights to view and manage officer data. Meanwhile, on the user page, admins have the authority to add, delete, and edit user data. On the symptoms page, admins can also add, delete, and edit symptom data. Features on the disease page allow admins to modify and delete data. Meanwhile, on the detection page, access is given to admins and users to add, edit, and delete symptom data.

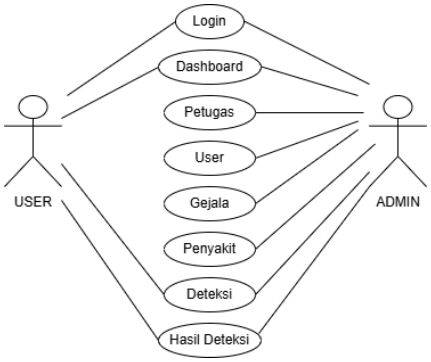


Figure 1. Use case diagram

### 3.5. Menu Structure

The menu structure on the admin page includes several key features. The Dashboard menu allows admins to monitor the number of diagnostic data, symptoms, diseases, and active staff. The Staff menu allows admins to view complete information about staff registered in the system. In the Diseases section, admins can add, edit, and delete disease data. The Symptoms menu also allows admins to input new data, edit data, and delete symptom data. Meanwhile, the Detection Results menu allows admins to print reports on the system's detection results.

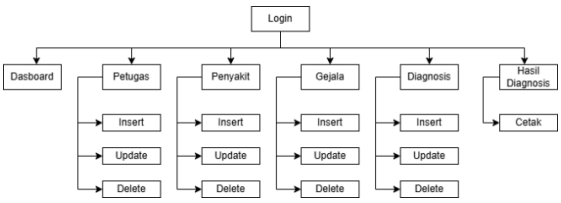


Figure 2. Menu structure

### 3.6. Certainty Factor Flowchart

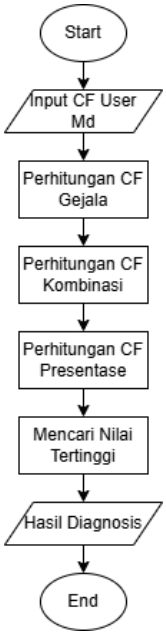


Figure 3. Flowchart of certainty factor

The Certainty Factor flowchart illustrates the system's flow from symptom input to a diagnosis based on the highest CF value. The process begins when the user inputs a confidence level for their symptoms. The system then calculates the CF value for each symptom, combines them into a combined CF, and converts it to a percentage to determine the level of certainty of the diagnosis. From these results, the system selects the highest value representing the greatest likelihood of the disease and displays the diagnosis to the user.

## 4. RESULTS AND DISCUSSION

### 4.1. Testing the Certainty Factor Method

The black box method is used in system testing to assess whether available features are working as intended. Based on the test results, features such as symptom input, Certainty Factor calculation, and diagnostic result presentation performed optimally and as expected.

Case example:

a. Users fill in symptom data based on the conditions they are experiencing, referring to the list of symptoms presented in Table 4..

Table 4. Selected symptoms

| No | Selected Symptoms | MD Value | Information |
|---|---|---|---|
| 1 | Blurred vision | 1 | Often |
| 2 | Difficulty opening eyes when waking | 0,8 | Occasionally |
| 3 | Difficulty driving at night | 0,8 | Rarely |
| 4 | Inability to identify objects clearly | 0,6 | Occasionally |
| 5 | Red eyes | 0,6 | Rarely |

b. The symptoms entered are cataracts and conjunctivitis according to table 5.

Tabel 5. nilai mb

| No | Disease Code | Disease Code | Disease Code | Disease Code | B |
|---|---|---|---|---|---|
| 1 | P1 | Cataract | G1 | Blurred vision | 0,8 |
| 2 | | | G2 | Difficulty driving at night | 0,6 |
| 3 | | | G3 | Dimness in daytime vision | 0,6 |
| 4 | | | G4 | Inability to identify objects clearly | 0,6 |
| 5 | P5 | Conjunctivitis | G5 | Red eyes | 1 |
| 6 | | | G6 | Watery eyes | 1 |
| 7 | | | G7 | Difficulty opening eyes upon waking | 0,4 |
| 8 | | | G8 | Itchy or burning sensation in the eyes | 0,8 |
| 9 | | | G9 | Swollen eyelids | 0,4 |

c. Then calculate the value of C, so that it can produce a value as in table 6.

Table 6. Finding the CF value

| No | Disease Name Uncertainty Value Symptoms | Disease Name Uncertainty Value Symptoms | Disease Name Uncertainty Value Symptoms | MB | MD | CF |
|---|---|---|---|---|---|---|
| 1 | Cataract | CF1 | Blurred vision | 0,8 | 1 | 0,8 |
| 2 | | CF2 | Difficulty driving at night | 0,6 | 0,8 | 0,48 |
| 3 | | CF3 | Difficult daytime vision | 0,6 | 0 | 0 |
| 4 | | CF4 | Inability to identify objects clearly | 0,6 | 0,6 | 0,36 |
| 5 | Conjunctivitis | CF5 | Red eyes | 1 | 0,6 | 0,6 |
| 6 | | CF6 | Watery eyes | 1 | 0 | 0 |
| 7 | | CF7 | Difficulty opening eyes upon waking | 0,4 | 0,8 | 0,32 |
| 8 | | CF8 | Itchy or burning sensation in the eyes | 0,8 | 0 | 0 |
| 9 | | CF9 | Swollen eyelids | 0,4 | 0 | 0 |

d. Calculations for Cataract Eye Disease:
(MB MD = CF)
0,8 1 = 0,8; 0,6 0,8 = 0,48; 0,6 0 = 0; 0,6 0,6 = 0,36
Combined value A = CF5 + (CF2 (1 - CF1)) = 0,8 + (0,48 (1 – 0,8)) = 0,896
Combined value B = CF3 + (CF(A) (1 – CF3)) = 0 + (0,896 (1 – 0)) = 0,896
Combined value C = CF4 + (CF(B) (1 – CF4)) = 0,36 + (0,896 (1 – 0,436)) = 0,933
Combination percentage = Cfcombine 100% = 0,933 100% = 93,393,3

e. Calculation of conjunctivitis eye disease :
(MB MD = CF) 1 0,6 = 0,6; 1 0 = 0; 0,4 0,8 = 0,32; 0,8 0 = 0; 0,4 0 = 0
Combined value A = CF5 + (CF6 (1 – CF5)) = 0,6 + (0 (1 – 0,6)) = 0,6
Combined value B = CF7 + (CF(A) (1 – CF7)) = 0,32 + (0,6 (1 – 0,32)) = 0,728
Combined value C = CF8 + (CF(B) (1 – CF8)) = 0 + (0,728 (1 – 0)) = 0,728
Nilai gabungan D = CF9 + (CF(C) (1 – CF9)) = 0 + (0,728 (1 – 0)) = 0,728

Combination percentage = Cfcombine 100% = 0,728 100% = 72,8.
From the calculation results above, it is known that Cataract Eye Disease has the highest value with a confidence level of 93%, which indicates that the symptoms experienced by the user indicate the presence of cataract disease.

### 4.2. Dashboard Page

On the dashboard, users can view the total available diagnostic data and the number of recorded symptoms. Additionally, users can review other information displayed on the Disease Count dashboard and view the number of active officers.

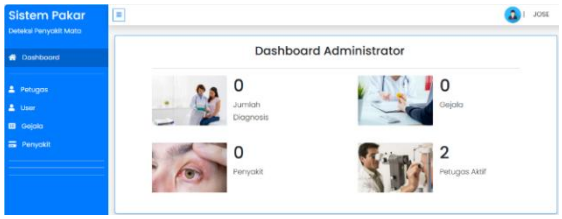


Figure 4. Dashboard view

### 4.3. Detection Page

The detection page displays detection data such as symptom codes, patient names, disease names, and treatment methods. On the detection page, users can add data about their symptoms. On the detection page, users can detect the disease outcome based on the symptoms they input.

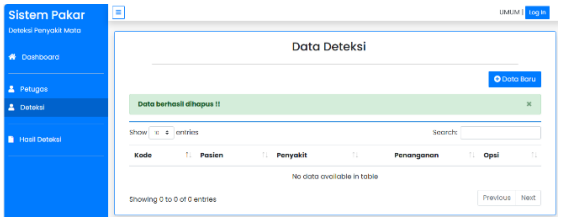


Figure 7. Detection page view

### 4.4. Detection Results Page

In the detection results section, the system will display the output from the diagnostic process that has been obtained. If the detection results have been obtained, the user can print the detection results..

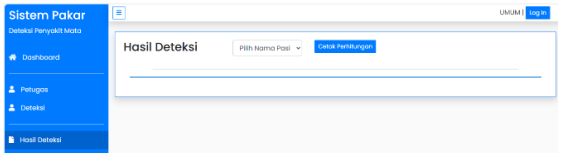


Figure 8. Display of the detection results page

### 4.5. Black Box User Testing

In black box testing, the user cases tested include three pages, namely the dashboard page, the detection page and the detection results page.

Tabel 7. Black box user

| No | Test Case | Expectation Result | Result |
|---|---|---|---|
| **User Dashboard Page** | | | |
| 1 | On the dashboard page there is information on the number of diagnoses, number of diseases, number of symptoms and number of active officers. | Displays information about the number of diagnoses, number of symptoms, number of diseases, and number of active officers. | √ |
| **Detection page** | | | |
| 2 | When a user accesses the Detection page, the system displays information related to the recorded detection data. | Displays the results of the selected symptoms by clicking the diagnosis button. | √ |
| 3 | Select the 'Add New Data' option by clicking the available button.. | Select the 'Add Data' option then you can input the name, symptoms and MB value. | √ |
| **Detection results page** | | | |
| 4 | On the diagnosis results page, users can see the calculation details using the CF method. | The system displays the CF value as the basis for determining the final results of the diagnostic process. | √ |

Based on the available data:
Number of matching results: 4
Number of non-matching results: 0
Total tests performed: 4
From this data, the percentage of results will be calculated using the following formula:

$$\text{Percentage} = \frac{\text{As expected}}{\text{Total testing}} \text{ x } 100\%$$

$$\text{Percentage} = \frac{4}{4} \text{ x } 100\%$$

$$\text{Percentage} = 100\%$$

The test results tested were 4 cases, the number of results according to 4, and the number of results not according to 0, so the calculation states that the device's functionality reached 100%.

### 4.6. Expert Testing

A total of 13 test cases were used in the website testing process. The system's detection results were then compared with expert opinion from Dr. Valerio Andrade.

Table 8. Expert testing

| No | Symptom Code | Disease Detection | |
|---|---|---|---|
| | | Expert | System |
| 1 | G1, G3, G2 ,G5 | P1 | P1 |
| 2 | G8, G9, G1, G5 | P3 | P3 |
| 3 | G1 ,G5, G6, G3 | P2 | P2 |
| 4 | G16, G9, G17, G10, G8 | P6 | P6 |
| 5 | G15, G9, G14, G11, G1,G5 | P5 | P5 |
| 6 | G10, GJ011, GJ012, G9. | P4 | P4 |
| 7 | G18, G19, G20, G11, G17. | P7 | P7 |
| 8 | G7, G6, G5, G11, G20 | P2 | P8 |
| 9 | G9, G15, G3, G5, G10,G11 | P5 | P5 |
| 10 | G13, G9, G21, G7, G10 | P3 | P8 |
| 11 | G1, G14,G16,G24 | P4 | P4 |
| 12 | G10, G2, G14, G | P3 | P4 |
| 13 | G1, G9, G21, 22 | P8 | P8 |

Given:
The total number of valid results is 10.
The total number of invalid results is 3.
The total number of tests is 13.
From this information, the percentage obtained will be calculated as follows:

$$\text{Percentage} = \frac{\text{As expected}}{\text{Total testing}} \text{ x } 100\%$$

$$\text{Percentage} = \frac{10}{13} \text{ x } 100\%$$

$$\text{Percentage} = 76\%$$

The calculated test results stated that the software functionality reached 76%.

## 5. CONCLUSION

The conclusion obtained from the research based on the results of the black box test, all features in the user menu function well, as the author expected. From the results of the user test, it was obtained that 79% of respondents found it easy to understand, 11% were quite easy to understand, and 0% were difficult to understand. According to the expert testing in Table 9, from 13 test cases, it can be concluded that this website successfully detected eye diseases with a success rate of 76% according to interviews with expert, Dr. Valerio Andrade. Based on the results of the website development that has been carried out, there are several recommendations that can be given, such as this site can be further improved by using other methodologies such as Case Based Reasoning, to assess how effective the implementation of the methodology is. Currently, the application development is still focused on the website platform. It is hoped that in the future, development can be continued to the mobile version to expand the user reach..

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