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Expert System for Diagnosing Diseases in Catfish Using Android-Based Bayesian Probability Method

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Abstract:
In general, many catfish farmers do not know about the diseases that attack their fish. Apart from their lack of knowledge, the difficulty of obtaining consultations with experts in this field is also one of the causes. This condition makes farmers ignore the diseases found in these fish. Based on the existing problems, research was carried out to build an expert system which aims to diagnose catfish disease and treat it early based on the symptoms suffered using the Bayesian probability method. The search technique used is based on an inference engine, namely Forward Chaining, to trace evidence inputted by the user in determining the type of disease in catfish. By achieving an accuracy level of 95%, this expert system can be implemented to draw conclusions based on expert knowledge. Black box testing uses 3 aspects, namely interface 87.2%, performance 86.6%, and initialization/termination 88% resulting in an overall accuracy of 87.2% from 30 respondents who are included in the assessment criteria as strongly agree.

Keyword: catfish farmers, diseases, Forward Chaining.

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1. Introduction

Fish are creatures that live and reproduce in water and breathe using gills [1]. There are different types of farming depending on the type of fish, including freshwater farming and seawater farming. Freshwater cultivation itself is experiencing an increase in demand relative to the current average demand [2]. There are thousands of species of freshwater fish in the world, each with unique and diverse characteristics. Several types of freshwater fish that are commonly found are goldfish, catfish, gourami, tilapia, betta, arowana, catfish, baung and tilapia [3].
Catfish is one of the freshwater fish that is very common and is in demand by the public. There is a lot of public interest in catfish, so it is not uncommon for people to cultivate catfish, from small home ponds to large farmers. Catfish cultivation must be carried out with maximum care to obtain maximum profits. But in cultivating catfish there are definitely problems in the cultivation process, one of which is the disease factor [4].
In general, there are two groups of fish diseases, the first is infectious diseases caused by pathogenic organisms. Second, non-infectious diseases that are influenced by environmental problems, nutritional deficiencies, or genetic abnormalities [5]. The symptoms and indicators of this disease are very little known by farmers, so they often ignore this fish disease. Many fish farmers immediately throw away dead fish [2]. For this reason, quick countermeasures are needed to avoid this [6].
Based on the results of discussions with Mr. Dr. Ir. Muhammad Ikhsan Wamnebo, S.Pi., M.Si. as an expert who studies fisheries, said there are 4 types of catfish diseases that are rarely found in cultivation, namely Gyrodactylus sp., Ichthyophthirius multifiliis, Mycobacteriosis, Aeromonas hydrophila. The Ministry of Maritime

Affairs and Fisheries (KKP) noted that catfish production in Indonesia will reach 1.12 million tons with a value of IDR 22.24 trillion in 2022. The volume is up 5.03% compared to the previous year which reached 1.07 tons worth IDR 18.94 trillion. Problems that are often experienced in cultivating catfish are the emergence of disease and death of fish. Disease disorders in fish farming are a biological risk that must always be anticipated.

Farmers need experts or experts especially to diagnose catfish diseases but it is not easy to bring in experts. Apart from being considered to require quite large costs, it must be addressed as quickly as possible in terms of time to minimize losses. Therefore, there is a need for a system that can help fish farmers understand fish diseases and also how to prevent and treat them. So an expert system can be a solution to solve this problem, because it is computerized and can solve certain problems by resembling the work of experts [7] [2].

The forward chaining method is a search technique that starts with facts and then matches facts or statements starting with IF (if) to test hypotheses [6]. Based on related research which applied the conclusion drawing method using forward chaining to develop an expert system for diagnosing betta fish disease, it resulted in an accuracy rate of 83.3% of the test results of the system functioning as expected [8]. In the process of determining hypothesis results from evidence, mathematical calculation methods can be applied which can produce accuracy values.

With the expert system that will be designed, it can later be used as a service to assist in diagnosis based on the symptoms present in catfish, so that the disease experienced by catfish can be identified quickly and accurately by applying the Bayesian probability method.

The Bayesian probability method is a method used to measure uncertainty values using information and data in the form of probabilities for each alternative faced and will produce values that are the basis for decision making [2]. Research related to the application of the Bayesian method was used to diagnose tilapia disease very well with an accuracy rate of 95.24% based on symptoms and test results [9].

Based on the problems above, the author conducted research with the title "Expert System for Diagnosing Diseases in Catfish Using the Android-Based Bayesian Probability Method". With this Android-based application, it is hoped that it can help fish farmers in finding information on symptoms of catfish disease before taking further action with treatment by experts or special veterinarians and early treatment.

2. Method

The research stages are as follows:

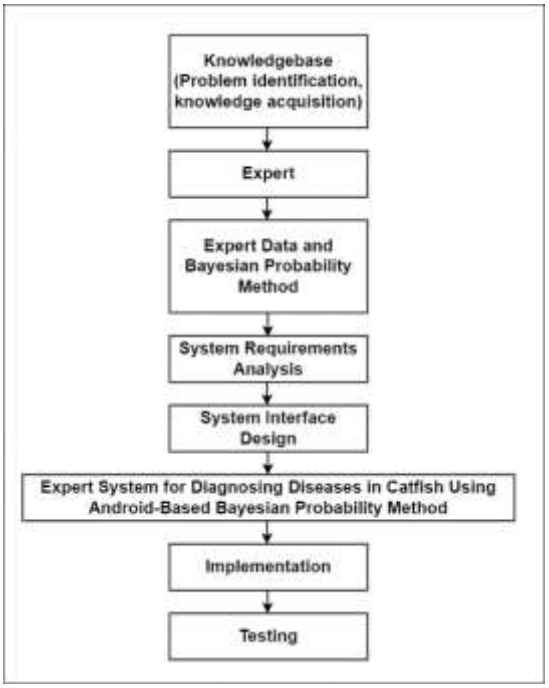

Figure 1. Research stages

1. Knowledge Base

a. Identification of problems

At this stage the author analyzes the problems that occur in people who want to know the type of catfish disease and treat it early without having to consult directly with an expert or specialist veterinarian.

b. Knowledge Acquisition

It is a process to gain knowledge about the problems discussed and will be used as a guide in development efforts. This stage includes studies by holding meetings with experts who study fisheries to discuss aspects of the problems often experienced in catfish farming, namely the emergence of disease and fish death.

2. Expert Data

This stage involves gathering relevant knowledge and information from experts or experts in the related field. This expert data is used as a basis for building an expert system. Where, the data in question is data on disease, symptoms and treatment.

3. Bayesian Probability Method

This method is a statistical approach used to process and analyze expert data that has been collected. The Bayesian Probability Method is useful for calculating the possibility or probability of an event based on available information or data and the next stage is identifying and analyzing the needs needed to build an expert system that is effective and in accordance with the desired goals.

4. System analysis required

At this stage, an analysis of the proposed expert system is carried out, including evaluation of the features, functionality, and potential improvements or modifications required.

5. System Interface Design

This stage includes designing a user interface that is intuitive and easy to use, so that users can interact with the expert system effectively.

6. Implementation

At this stage, the design and design of the expert system that has been created is realized in the form of Java program code or an application that can be run and used.

7. Testing

The final stage is system testing using black box testing which has been implemented to ensure that the system functions properly, provides an accurate diagnosis, and meets user needs.

The system research design for the application is as follows:

1. System Design

a. Flowchart

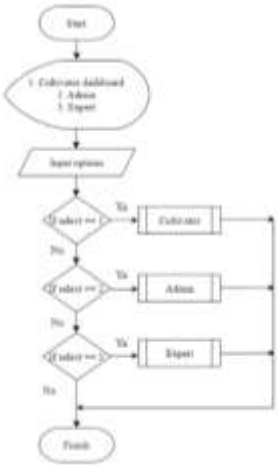

Figure 2. Login Flowchart

Figure 2 is a flowchart that will be carried out when logging in as a cultivator, admin, expert in the catfish expert application.

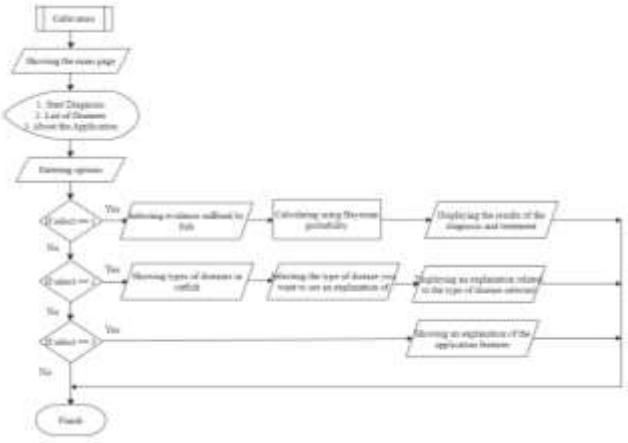

Figure 3. Cultivator Flowchart

Figure 3 is a cultivator flowchart from the catfish expert application. The menus in the application are the start diagnosis menu, the disease list menu and the application menu.

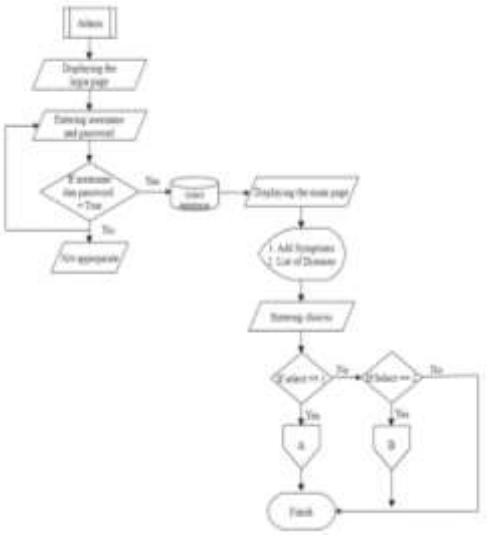

Figure 4. Admin Login Flowchart

Figure 4 is a flowchart when logging in as admin.

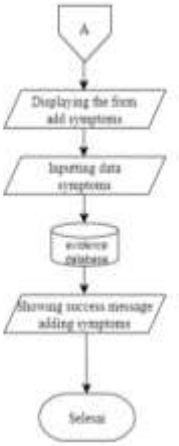

Figure 5. Flowchart for Adding Symptoms

Figure 5 is a flowchart of the process carried out by an admin or expert when they want to add symptom or evidence data.

Figure 6. Flowchart for Adding Diseases

Figure 6 is a flowchart of the process carried out by an admin or expert when they want to add disease data.

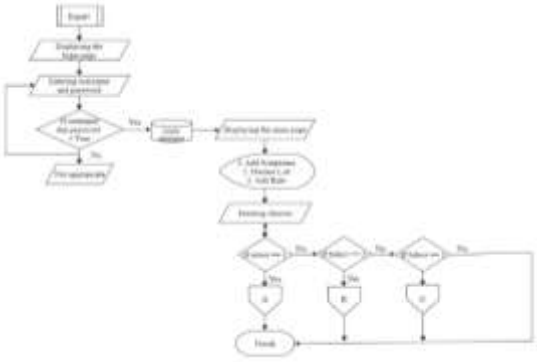

Figure 7. Expert Login Flowchart

Figure 7 is a flowchart when logging in as an expert.

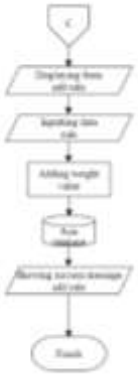

Figure 8. Flowchart for Adding Rules

Figure 8 is a flowchart of the process carried out by experts when they want to add rule data.

b. Use Case Diagrams

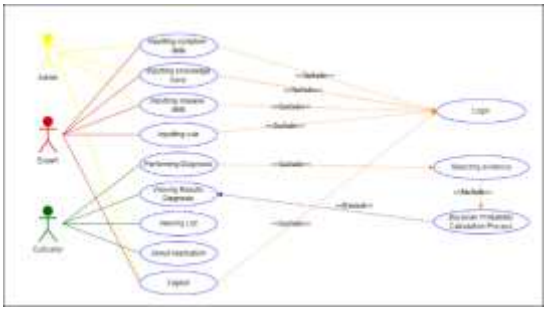

Figure 9. Use Case Diagram

Figure 9 is a use case display that explains the system can be run by 3 actors, namely:

1) Admin, in the system that will be built the admin can manage data.
2) Expert, in this system the expert is an expert who understands fisheries.
3) Users or cultivators, in the system that will be built, users are the general public, especially cultivators who want to diagnose the symptoms suffered by catfish.

2. Knowledge Representation

a. Disease Data

Table 1. List of Diseases

No	Disease code	Type of disease
1	P01	*Gyrodactylus sp.*
2	P02	*Ichthyophthirius Multifiliis*
3	P03	*Mycobacteriosis*
4	P04	*Aeromonas Hydrophila*

(*Source* : Dr. Ir. Muhammad Ikhsan Wamnebo, S.Pi., M.Si)

b. Data Evidence

Table 2. Evidence Table

No	Kode *Evidence*	Name Evidence
1	G01	Swelling of the gill lamellae
2	G02	Bulging eyes
3	G03	Wounds or ulcers on the body
4	G04	Red patches on the head
5	G05	Paler colored gills
6	G06	Bleeding on scales
7	G07	White spots on the surface of the body
8	G08	Exfoliation of the skin occurs
9	G09	The presence of lumps on the body
10	G10	Swim jerking
11	G11	Rapid or abnormal breathing
12	G12	Fish skin looks not clear
13	G13	Gasping or limp
14	G14	Discoloration of the body to darken
15	G15	Fins swell
16	G16	Fish become thinner

17	G17	Spots of whitish color on the flesh
18	G18	Rubbing the body on the surface of the pool
19	G19	White coating on the body
20	G20	No appetite

(*Source*: Dr. Ir. Muhammad Ikhsan Wamnebo, S.Pi., M.Si)

c. Decision Table

The decision table contains 20 pieces of evidence from 4 types of catfish diseases which are used as a reference in making the decision tree.

Table 3. Decision Table

Symptom code	**Nama *Evidence***	**Disease code**				**Score**			
		P01	**P02**	**P03**	**P04**	**P01**	**P02**	**P03**	**P04**
G01	Swelling of the gill lamellae	√				0,89			
G02	Bulging eyes			√	√			0,89	0,67
G03	Wounds or ulcers on the body			√	√			0,72	0,86
G04	Red patches on the head				√				0,75
G05	Paler colored gills	√			√	0,61			0,82
G06	Bleeding on scales				√				0,89
G07	White spots on the surface of the body		√				0,78		
G08	Exfoliation of the skin occurs		√				0,72		
G09	The presence of lumps on the body			√				0,43	
G10	Swim jerking	√				0,53			
G11	Rapid or abnormal breathing		√				0,84		
G12	Fish skin looks not clear	√				0,76			
G13	Gasping or limp	√				0,79			
G14	Discoloration of the body to darken			√	√			0,76	0,56
G15	Fins swell		√				0,74		
G16	Fish become thinner	√				0,56			
G17	Spots of whitish color on the flesh			√				0,76	
G18	Rubbing the body on the surface of the pool		√				0,56		
G19	White coating on the body	√				0,89			
G20	No appetite	√	√	√	√	0,47	0,65	0,56	0,67

Information:

P = Disease Name

G = Symptom Name

Table 4. Information on Certainty Values [25]

Score	Capacity
0 - 0.30	Sure enough
0.31 - 0.50	Possible
0.51 - 0.70	Almost Sure
0.71 - 0.99	Certain
1.00	Very Certain

d. decision tree

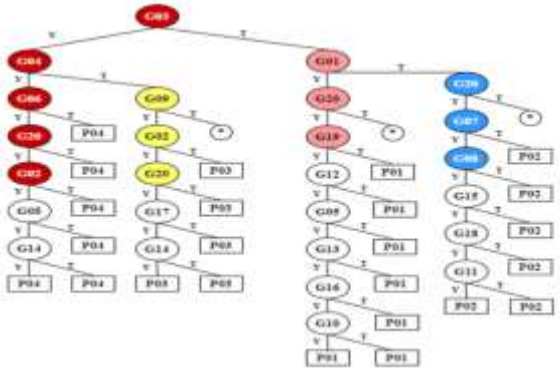

Figure 10. Decision Tree

The diagnosis process is carried out to determine a decision. The system tracks the type of disease with existing evidence based on a decision table. From decision trees that can produce efficient and optimal production rules

Information:

= Main evidence for Gyrodactylus sp.

= The main evidence for Ichthyophthirius Multifiliis disease

= Main evidence for Mycobacteriosis disease

= Main evidence for Aeromonas Hydrophila disease

= Supporting evidence

= Type of disease

e. Production Rules

Production rules are obtained from decision trees that produce rules. By using IF THEN (if then). This statement connects the premise and the conclusion.

Table 5. Production Rules

Rule	Production rules
R1	**IF** G03 **AND** G04 **AND** G06 **THEN** P04
R2	**IF** G03 **AND** G04 **AND** G06 **AND** G20 **THEN** P04
R3	**IF** G03 **AND** G04 **AND** G06 **AND** G20 **AND** G02 **THEN** P04
R4	**IF** G03 **AND** G04 **AND** G06 **AND** G20 **AND** G02 **AND** G05 **THEN** P04
R5	**IF** G03 **AND** G04 **AND** G06 **AND** G20 **AND** G02 **AND** G05 **AND** G14 **THEN** P04
R6	**IF** G03 **AND** G09 **AND** G02 **THEN** P03
R7	**IF** G03 **AND** G09 **AND** G02 **AND** G20 **THEN** P03
R8	**IF** G03 **AND** G09 **AND** G02 **AND** G20 **AND** G17 **THEN** P03

R9	**IF** G03 **AND** G09 **AND** G02 **AND** G20 **AND** G17 **AND** G14 **THEN** P03
R10	**IF** G01 **AND** G20 **AND** G19 **THEN** P01
R11	**IF** G01 **AND** G20 **AND** G19 **AND** G12 **THEN** P01
R12	**IF** G01 **AND** G20 **AND** G19 **AND** G12 **AND** G05 **THEN** P01
R13	**IF** G01 **AND** G20 **AND** G19 **AND** G12 **AND** G05 **AND** G13 **THEN** P01
R14	**IF** G01 **AND** G20 **AND** G19 **AND** G12 **AND** G05 **AND** G13 **AND** G16 **THEN** P01
R15	**IF** G01 **AND** G20 **AND** G19 **AND** G12 **AND** G05 **AND** G13 **AND** G16 **AND** G10 **THEN** P01
R16	**IF** G20 **AND** G07 **AND** G08 **THEN** P02
R17	**IF** G20 **AND** G07 **AND** G08 **AND** G15 **THEN** P02
R18	**IF** G20 **AND** G07 **AND** G08 **AND** G15 **AND** G18 **THEN** P02
R19	**IF** G20 **AND** G07 **AND** G08 **AND** G15 **AND** G18 **AND** G11 **THEN** P02

3. Results and Discussion

A. Research Results

Research that has been carried out for approximately 5 months has resulted in an Android-based expert system application for diagnosing disease in catfish using the Forward Chaining search technique to trace types of catfish disease from symptoms input by the public or farmers (users). The following is the appearance of an Android-based expert system for diagnosing diseases in catfish that has been created:

1. Display for Users (cultivators)

Figure 11. Main Menu Display

Figure 11 is a display of the main menu page for users. There is a start menu for diagnosis, a list of diseases, and about the application.

Figure 12. Display of Diagnostic Form

Figure 12 is a display of the diagnosis form when the user wants to carry out a diagnosis by selecting symptoms according to what the fish is suffering from.

Figure 13. Display of Diagnostic Results

Figure 13 is a display of diagnosis results based on the symptoms selected by the user.

Figure 14. Disease List Menu Display

Figure 14 displays information related to the types of diseases in catfish that can be detected by the system.

2. Display for Admin

Figure 17. Login Page Display

Figure 15. Display of Explanation of Disease Types

Figure 15 is an explanatory display regarding the meaning, symptoms and treatment of each type of disease in catfish.

Figure 16. Application Information Display

Figure 16 is a display of information related to the features in the application.

Figure 17 is the login there is a form that must be filled in with a username and password which functions for secure access.

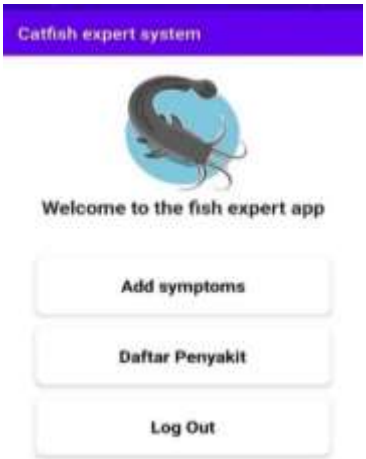

Figure 18. Main Menu Display

Figure 18 there are 2 menus, namely adding symptoms and a list of diseases.

Figure 19. Display of the Add Symptom Form

Figure 19 is a display to add data on disease symptoms in fish which can be done by the admin.

Figure 20. Disease List Display

Figure 20 displays information regarding the types of diseases in catfish that can be detected by the system.

Figure 21. Display of the Add Disease Form

Figure 21 is a display to add to the list of diseases that can be carried out by the admin.

3. Display for Experts

Figure 22. Login Page Display

Figure 22 is the login display in the application, there is a form that must be filled in, namely a username and password which functions for access security.

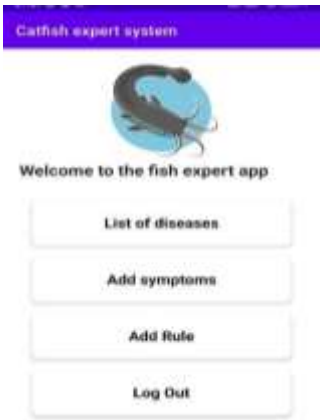

Figure 23. Main Menu Display

Figure 23 is the expert's main menu display, where the expert can add symptoms and a list of diseases.

Figure 24. Disease List Display

Figure 24 displays information regarding the types of diseases in catfish that can be detected by the system.

Figure 25. Display of the Add Disease Form

Figure 25 is a display to add to the list of diseases that can be treated by experts.

Figure 26. Display of the Add Symptom Form

Figure 26 is a display to add data on disease symptoms in fish that can be carried out by experts.

Figure 27. Appearance of the Add Rule Form

Figure 27 is a display for adding rule data by entering disease codes, symptom codes and probability weight values that have been determined by experts.

B. Discussion

Knowledge and information are needed in designing expert systems. Knowledge and information is obtained from several sources, namely from experts, in this case Dr. Ir. Muhammad Ikhsan Wamnebo, S.Pi., M.Si and several books and searches for materials that can be used via the internet. This expert system for diagnosing diseases in catfish can help the public or farmers to recognize the disease they are suffering from by looking at the symptoms caused by the disease. In this expert system, researchers use diseases in catfish to show how the expert system works to diagnose the disease based on symptoms. In making decisions or conclusions from this expert system, researchers use the Bayesian probability method to determine the percentage level and use an inference engine to search for types of disease based on symptoms.

1. Manual Calculation

The discussion in this research will be manual calculations using the Bayesian probability method to be able to determine the diagnosis of disease based on the symptoms suffered by the fish. The symptom data for catfish that will be tested can be seen in the following table:

Table 6. Data Testing

Code *Evidence*	Name *Evidence*
G01	Swelling of the gill lamellae
G12	Fish skin looks not clear
G13	Gasping or limp
G16	Fish become thinner
G20	No appetite

Bayes calculation process using formulas (1) and (2) for catfish disease with the type Gyrodactylus sp., the evidence data belonging to this disease are G01, G12, G13, G16 and G20.

P(Hk) $= \frac{P(E|Hk) \times P(Hk)}{\sum_{i=0}^{n} P(E|Hk)}$

$\sum_{i=0}^{n} P(E|Hk)$ =`G01 + G12 + G13 + G16 + G20

$\sum_{i=0}^{n} P(E|Hk)$ = 0,89 + 0,76 + 0,79 + 0,56 + 0,47

= 3,47

P (H1|G1) $= \frac{G1}{\sum_{i=0}^{n} P(E|Hk)} = \frac{0,89}{3,47} =$ 0,2565

P (H2|G12) $= \frac{G12}{\sum_{i=0}^{n} P(E|Hk)} = \frac{0,76}{3,47} =$ 0,2190

P (H3|G13) $= \frac{G13}{\sum_{i=0}^{n} P(E|Hk)} = \frac{0,79}{3,47} =$ 0,2277

P (H4|G16) $= \frac{G16}{\sum_{i=0}^{n} P(E|Hk)} = \frac{0,56}{3,47} =$ 0,1614

P (H5|G20) $= \frac{G20}{\sum_{i=0}^{n} P(E|Hk)} = \frac{0,47}{3,47} =$ 0,1354

$\sum_{i=0}^{n} (Hk) * P(E|Hk - n)$

= P(H1)*P(G1|H1) + P(H2)*P(G12|H2) + P(H3)*P(G13|H3) + P(H4)*P(G16|H4) + P(H5)*P(G20|H5)

= (0,2565*0,89) + (0,2190*0,76) + (0,2277*0,79) + (0,1614*0,56) + (0,1354*0,47)

= 0,7286

The next step is to find the value of P(Hk|E) or the probability that the hypothesis Hk is true if given evidence E is as follows:

P(Hk) $= \frac{P(E|Hk) \times P(Hk)}{\sum_{i=0}^{n} (E|Hk) * P(Hk)}$

P (H1|G1) $= \frac{0,89 \times 0,2565}{0,7286} =$ 0,3133

P (H2|G12) $= \frac{0,76 \times 0,2190}{0,7286} =$ 0,2285

P (H3|G13) $= \frac{0,79 \times 0,2277}{0,7286} =$ 0,2468

P (H4|G16) $= \frac{0,56 \times 0,1614}{0,7286} =$ 0,1240

P (H5|G20) $= \frac{0,47 \times 0,1354}{0,7286} =$ 0,0874

Once all the P(Hk|E) values are known, then add up all the Bayes values using the following formula:

$\sum_{i=0}^{n} bayes$ = bayes 1 + bayes 2 + bayes 3 + bayes 4 + bayes 5

= (0,89*0,3133) + (0,76*0,2285) + (0,79*2468) + (0,56*0,1240) + (0,47*0,0874

= 0,7580

So the results of calculations using the Bayesian probability method concluded that the catfish was diagnosed with gyrodactylus sp. with a value of 75.80%.

2. Accuracy Testing

Table 7. Accuracy Test Results

TestData	Expert diagnosis results	System diagnostic results	Information
1	Gyrodactylus Sp.	Gyrodactylus Sp. 75.80%	Sesuai
2	Aeromonas Hydrophila	Aeromonas Hydrophila 75.99%	Sesuai
3	Ichthyophthirius Multifiliis	Ichthyophthirius Multifiliis 74.83%	In accordancei
4	Aeromonas Hydrophila	Aeromonas Hydrophila 67%	In accordancei
5	Mycobacteriosis	Mycobacteriosis 78.39%	In accordancei
6	Gyrodactylus Sp.	Aeromonas Hydrophila 75.99%	In accordancei
7	Ichthyophthirius Multifiliis	Ichthyophthirius Multifiliis 74.02%	In accordancei
8	Mycobacteriosis	Mycobacteriosis 74.60%	In accordancei
9	Aeromonas Hydrophila	Aeromonas Hydrophila 74.06%	In accordancei
10	Gyrodactylus Sp.	Gyrodactylus Sp. 86.17%	In accordancei
11	Aeromonas Hydrophila	Aeromonas Hydrophila 85.86%	In accordance
12	Aeromonas Hydrophila	Aeromonas Hydrophila 77.71%	In accordance
13	Ichthyophthirius Multifiliis	Ichthyophthirius Multifiliis 74.02%	In accordance
14	Aeromonas Hydrophila	Aeromonas Hydrophila 75.99%	In accordance
15	Aeromonas Hydrophila	Aeromonas Hydrophila 81.15%	In accordance
16	Ichthyophthirius Multifiliis	Ichthyophthirius Multifiliis 73.68%	In accordance
17	Mycobacteriosis	Mycobacteriosis 74.39%	In accordance
18	Aeromonas Hydrophila	Aeromonas Hydrophila 74.06%	In accordance
19	Mycobacteriosis	Mycobacteriosis 78.39%	In accordance
20	Ichthyophthirius Multifiliis	Ichthyophthirius Multifiliis 68.18%	In accordance

In table 9, based on 20 case examples compared with the expert diagnosis results, there is 1 case that is not suitable and 19 cases that are suitable so that it can be calculated using formula (4), as follows:

$Akurasi = \frac{19}{20} \times 100\% = 95\%$

After calculating the accuracy using the Bayesian probability method, it can be seen that the accuracy value is 95%.

4. Conclusions and recommendations

Based on the process that has been described, this research has succeeded in creating an Android-based disease expert system application for catfish using forward chaining tracing techniques to trace types of disease based on selected evidence with a success rate of 87.2% which is included in the strongly agree assessment criteria. Based on the results of the accuracy level test by comparing manual calculations, the results of expert system diagnosis using the Bayesian probability method and the results of 20 expert diagnoses, the data obtained was 95% in determining the type of disease in catfish using the Bayesian Probability method.

As a suggestion, the author recommends that knowledge about diseases in catfish be enriched by adding data for the type of disease and its symptoms so that the information available will be wider. Using the knowledge of more than one expert in the system, for the purpose of obtaining more accurate results. It is hoped that this application can be developed using other methods such as the depth first search method, dempster shafer, certainty factor.

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