Fish Disease Diagnose System using Case-based Reasoning with Euclidean Distance

Michel Farrel Tomatala, Rillya Arundaa and Handri Damodalag
Information Technology Department, STMIK Multicom Bolaang Mongondow, North-Sulawesi, Indonesia

Keywords: Case-based Reasoning, Nile Tilapia, Euclidean Distance, Fish Disease.

Abstract: Nile Tilapia fish disease has concerned the fish farmers. The farmers still lacked knowledge and information for finding the appropriate solution to prevent or cure the disease, and this situation caused the deficiency of Nile Tilapia fish harvest, which caused financial loss. Thus, it is necessary to find a suitable application as a medium of consultancy to diagnose the disease symptoms that affect Nile Tilapia fishes. Case-Based Reasoning (CBR) is one of the methods that can solve the problem by making a new Decision Support System (DCS) by referring to the old cases which have similarities or even the same cases like the new DCS. The system which is made in this study is the CBR system to diagnose Nile Tilapia disease by using *Euclidean Distance Method.* The number of based-cases which are used for this study is 40 old cases that are analyzed by using 40 new cases. System testing has been done three times by using Threshold 1, 2, and 3. The Threshold testing 1, 2, and 3 fell in the scores of 100%, 100% and 100% respectively. As a result, this study provides a useful application for Nile Tilapia fish farmers to prevent and cure fish disease.

1 INTRODUCTION

Nile Tilapia is freshwater fish which is said to be originally coming from East Africa around 1969. Its lateen name is *Oreochromis Niloticus.* Nile Tilapia is commonly consumed by people around the world (Kottelat et al., 1993). Nile Tilapia can be affected by the fish disease, and if this disease is not treated appropriately, the effect could be fatal such as causing the fish to die and make the fish farmers suffer significant financial loss due to deficiency of the fish harvest. The issue was when those Nile Tilapia fishes were affected by the disease, most of the fish farmers still did not know how to find appropriate information in order to find a proper solution to cure the disease. If the fish farmers were going to find and meet the Nile Tilapia experts directly in order to consult the fish disease, their Nile Tilapia fishes which were already affected might die at the time they were consulting. This habit caused more time and even gave a worse outcome (Chitmanat et al., 2016).

Fortunately, the fish farmers could use the technology to find proper information about how to prevent and cure the Nile Tilapia fish disease. Information medium is necessary in order to help the process of consultancy which are based on the dependable expert system. By using Case-Based Reasoning (CBR) application that uses the *Euclidean Distance Method*, this study is expected to give a proper and beneficial solution for the fish farmers in preventing and curing the Nile Tilapia fish disease.

2 LITERATURE REVIEW

Case-Based Reasoning (CBR) is one of the most successful techniques among knowledge-based systems in various types of problem domains. CBR previously came from researches which are related to cognitive science. In 1997, Schank and Abelson proposed CBR for the first time. They proposed that human's general knowledge about a particular situation is recorded in the brain as a script that allows us to set up an expectation and perform inference (Watson, 1997). CBR is highly regarded as a plausible high-level model for cognitive processing. It was focused on problems such as how people learn a new skill and how they generate hypotheses about a new situation based on their past experiences (Pal and Shiu, 2003). According to Aamodt et al. (1994), CBR consisted of four stages. They are *Retrieve, Reuse, Revise* and *Retain*. There is case representation in a

Farrel Tomatala, M., Arundaa, R. and Damodalag, H.
Fish Disease Diagnose System using Case-based Reasoning with Euclidean Distance.
DOI: 10.5220/0010622500002967
In *Proceedings of the 4th International Conference of Vocational Higher Education (ICVHE 2019) - Empowering Human Capital Towards Sustainable 4.0 Industry*, pages 215-221
ISBN: 978-989-758-530-2; ISSN: 2184-9870

CBR system which aims to describe the problems and the solutions to solve the problems. In a CBR system, the new case is compared to the old case which was saved in a database system. Then, the system will calculate the level of appropriateness or agreement between the old case and the new case (Aamodt and Plaza, 1994). The particular attributes that will be used as a standard of comparison are the information of every case, whether it is the old or new case (Ji et al., 2010). The information can be the symptoms and types of disease. This information is taken from the database to count the proximity or distance value. This calculation is to measure the similarity between the data-items and the distance between the two objects. *Euclidean distance* is an approach which is commonly used for measuring two vectors (Merigo and Casanovas, 2011). This study measures the distance proximity value between the new and old cases which were previously happened by using *Euclidean Distance*.

3 RESEARCH METHOD

This section aims to elaborate on several methods which are used to solve the research problems of this study. Those methods are explained below:

3.1 Data Gathering Techniques

The data findings are obtained directly from the research objects and the available references. The approaches which are used to gather the data are:

This method was done by directly visiting the research field, which was the office of the Department of Fisheries and Marine at Kotamobagu and consulting with the Nile Tilapia fish experts.

3.1.1 Library Study

This study was done by gathering and researching documents such as published journals and books. The included reference have correlations with the topic of this study.

3.2 Data Collection Method

The financial lost which had been often faced by the fish farmers were mostly caused by the lack of information related to Nile Tilapia fish disease. This problem could be solved by having a consultation system which is specifically designed to help the fish farmers to gain more reliable information related to Nile Tilapia fish disease. The system which is made for this study aims to diagnose and give useful suggestion to treat the Nile Tilapia fishes, which are infected by the disease. The *admin* of the system plays a role as the one who inputs the master data into the application, and the *users* are the Nile Tilapia fish farmers. The *users* are the parties who diagnose the disease by inputting the symptoms into the application.

3.2.1 Document Study

This study data is the data of Nile Tilapia fish disease which were listed and given by the Nile Tilapia fish experts who works at the Department of Fisheries and Marine of Kotamobagu city. The data has been specified and taken from all of the documents. Next, they were inputted on the department's database from 2017 to 2018. The examples of the data are presented below in Table 1.

Table 1: Fish Disease.

Disease Code	Disease Name
D01	Trichodina spp
D02	Epistylis spp
D03	Saprolegniasis
D04	Red Stain
D05	Notonecta

Table 1 proposes the data which was gotten from the Department of Fisheries and Marine of Kotamobagu. This data shows that there are five types of diseases. The following data is the symptoms which are appeared in the Nile Tilapia fish. The data is shown below in Table 2.

Table 2: Data of Symptoms

Symptom Code	Symptom Name
S01	Scars in the area which are infected
S02	White yarns are found on the fish' skin
S03	The fish' gill becomes brownish red
S04	The fish seems to breathe hardly
S05	The fish' movement becomes slower than usual
S06	The fish experiences stunted growth
S07	There is bleeding in the fish' skin
S08	The fish' scales are peeling off
S09	The fish' stomach becomes bloated
S10	There are ulcers on the fish' skin
S11	The fish looks weak
S12	The fish is often seen on the surface of the pond
S13	There are white spots like rice on the fish' skin
S14	There are white yarns around the fish' body
S15	There are red spots on the fish' skin

Table 2 shows the symptoms of the disease, which usually affect Nile Tilapia Fishes. The case representation of every disease and symptom are shown in Table 1 and Table 2. They are clarified in Table 3 below.

Table 3: Case-Based Data.

C	D	S				
		1	2	3	4	5
C1	D1	1	1	0	0	0
C2	D2	0	1	1	1	1
C3	D3	0	0	0	0	0
C4	D4	0	0	0	0	0
C5	D5	0	0	0	0	0
C6	D1	0	1	0	0	0
C7	D2	0	0	0	1	1
C8	D3	0	0	0	0	0
C9	D4	0	0	0	0	0
C10	D5	0	0	1	0	0
C	D	S				
		6	7	8	9	10
C1	D1	0	0	0	0	0
C2	D2	0	0	0	0	0
C3	D3	1	1	1	1	0
C4	D4	0	0	0	0	0
C5	D5	0	0	0	0	0
C6	D1	0	0	0	0	0
C7	D2	0	0	0	0	0
C8	D3	0	1	0	0	1
C9	D4	0	1	1	0	0
C10	D5	0	0	0	0	0
C	D	S				
		11	12	13	14	15
C1	D1	0	0	0	0	0
C2	D2	0	0	0	0	0
C3	D3	0	0	0	0	0
C4	D4	1	1	0	0	1
C5	D5	0	0	1	1	0
C6	D1	0	0	0	0	0
C7	D2	0	0	0	0	0
C8	D3	0	0	0	0	0
C9	D4	1	1	0	0	0
C10	D5	0	0	1	0	0

Notes: S=Symptoms, C=Case, D=Disease

Table 3 has shown the ten cases which are taken as the case-based for CBR in the process of diagnosing the Nile Tilapia fish disease. Next, this section provides new case-based data that will be measured by measuring its proximity value with the old case-based data. The data is shown in Table 4 below.

Table 4: New Case-Based Data.

C	1	2	3	4	5
B1	0	0	0	0	0
B2	1	0	0	0	0
B3	0	1	0	0	0
B4	0	0	1	0	0
B5	0	0	0	1	0
B6	0	0	0	0	0
B7	0	0	0	0	1
B8	0	0	0	0	1
B9	0	0	0	0	0
B10	0	0	0	0	0
C	6	7	8	9	10
B1	0	0	0	0	0
B2	0	0	0	0	0
B3	0	0	0	0	0
B4	0	0	0	0	0
B5	0	0	0	0	0
B6	0	0	0	0	1
B7	0	0	0	0	0
B8	0	0	0	0	0
B9	0	0	0	0	0
B10	0	0	0	0	0
C	11	12	13	14	15
B1	0	0	0	0	1
B2	0	0	0	0	0
B3	0	0	0	0	0
B4	0	0	0	0	0
B5	0	0	0	0	0
B6	0	0	0	0	0
B7	0	0	0	0	0
B8	0	0	0	0	0
B9	0	1	0	0	0
B10	1	1	0	0	0

3.2.2 Euclidean Distance Method

Euclidean distance is a method that computes the root of the square difference between the coordinates of a pair of objects.

$$Dist_{XY} = \sqrt{\sum_{k=1}^{m}(X_{ik} - X_{jk})^2} \quad (1)$$

Notes:

$Dist_{XY}$ = dissimilarity degree
m = numbers of vectors
X_{jk} = input vector
X_{ik} = output vector
k = the attribute which represents each vector X_{jk} and X_{ik}

A metric function or distance function is a function which defines a distance between elements/objects of a set. A set with a metric is known as metric space. This distance metric plays a vital role in clustering techniques. The numerous methods are available for clustering techniques. Typically, the task is to define a function similarity (X, Y), where X and Y are two objects or sets of a particular class, and the value of function represents the degree of "similarity" between the two. Formally, a distance function is a function with positive real values, defined on the Cartesian product X x X of a set X (Goncalves et al., 2014).

$$d(i,j)=\sqrt{|X_{i1}-X_{j1}|^2+|X_{i2}-X_{j2}|^2+\cdots+|X_{ip}-X_{jp}|^2} \quad (2)$$

Notes:
d(i,j) = *Euclidean Distance*
X_i = value point 1
X_j = value point 2

When we use the function of *Euclidean Distance* for comparing the distance, it is unnecessary to calculate the second root because the distance is always positive numbers. An important component in the algorithm cluster measures the distance among each data point. If the data component is a part of the same unit, the simple *Euclidean Distance* only is capable enough for similar grouping data (Singh et al., 2013).

3.2.3 Accuracy Measurement

In this study, the testing is done by comparing the measurement result manually by using the *Euclidean Distance Method* with the measurement result, which used CBR application through accuracy measurement. Accuracy value describes true presentation from the total of cases which are tested (Baratloo et al., 2015). The accuracy measurement can be seen in Equation (3).

$$\text{Accuracy} = \frac{Jumlah\ Kasus\ Sesuai}{Jumlah\ Keseluruhan\ Kasus}\ \text{X } 100\% \quad (3)$$

3.2.4 Measurement by using Euclidean Distance Algorithm

The detail of the CBR mechanism system by using Euclidean distance can be seen in Figure 1 below.

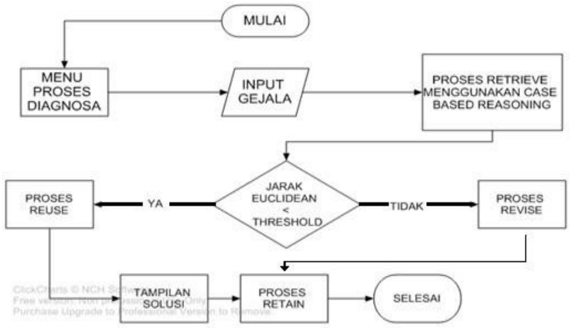

Figure 1: CBR Mechanism System by using Euclidean Distance.

Based on the data in previous Table and Table 4, the measurement by using *Euclidean Distance* algorithm for measuring new cases and old cases were begun by measuring the case B1 in Table 4 with all cases in Table 3. The equations below are examples of measurements which used Equation (2):

The Measurement of Case B1 with the case C1 is explained below:

$$d(\text{B1,C1}) = \sqrt{\begin{matrix}(0-1)^2+(0-1)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2\end{matrix}}$$

$$= \sqrt{\begin{matrix}1+1+0+0+\\0+0+0+0+\\0+0+0+0+\\0+0+1\end{matrix}}$$

$$= \sqrt{3} = 1.732$$

The Measurement of Case B1 with the case C2 is explained below:

$$d(\text{B1,C2}) = \sqrt{\begin{matrix}(0-0)^2+(0-0)^2+(0-1)^2+\\(0-1)^2+(0-1)^2+(0-1)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(1-0)^2\end{matrix}}$$

$$= \sqrt{\begin{matrix}0+0+1+1+\\1+1+0+0+\\0+0+0+0+\\0+0+1\end{matrix}}$$

$$= \sqrt{5} = 2.236$$

The Measurement of Case B1 with the case C3 is explained below:

$$d(\text{B1,C3}) = \sqrt{\begin{matrix}(0-0)^2+(0-1)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(1-0)^2\end{matrix}}$$

$$= \sqrt{\begin{matrix}0+1+0+0+\\0+0+0+0+\\0+1+0+0+\\0+0+1\end{matrix}}$$

$$= \sqrt{3} = 1.732$$

The Measurement of Case B1 with the case C4 is explained below:

$$d(\text{B1,C4}) = \sqrt{\begin{array}{l}(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-1)^2+(0-1)^2+(0-1)^2+\\(0-1)^2+(0-1)^2+(0-1)^2+\\(0-0)^2+(0-0)^2+(1-0)^2\end{array}}$$

$$= \sqrt{\begin{array}{l}0+0+0+0+\\0+0+1+1+\\1+1+1+1+\\0+0+1\end{array}}$$

$$= \sqrt{7} = 2.645$$

The Measurement of Case B1 with the case C5 is explained below:

$$d(\text{B1,C5}) = \sqrt{\begin{array}{l}(0-0)^2+(0-0)^2+(0-1)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-1)^2+(0-1)^2+(1-1)^2\end{array}}$$

$$= \sqrt{\begin{array}{l}0+0+1+0+\\0+0+0+0+\\0+0+0+0+\\1+1+0\end{array}}$$

$$= \sqrt{3} = 1.732$$

The Measurement of Case B1 with the case C6 is explained below:

$$d(\text{B1,C6}) = \sqrt{\begin{array}{l}(0-0)^2+(0-1)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(1-0)^2\end{array}}$$

$$= \sqrt{0+1+0+0+0+0+0+0+0+0+0+0+0+0+1}$$

$$= \sqrt{2} = 1.414$$

The Measurement of Case B1 with the case C7 is explained below:

$$d(\text{B1,C7}) = \sqrt{\begin{array}{l}(0-0)^2+(0-0)^2+(0-0)^2+\\(0-1)^2+(0-1)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(1-0)^2\end{array}}$$

$$= \sqrt{\begin{array}{l}0+0+0+1+\\1+0+0+0+\\0+0+0+0+\\0+0+1\end{array}}$$

$$= \sqrt{3} = 1.732$$

The Measurement of Case B1 with the case C8 is explained below:

$$d(\text{B1,C8}) = \sqrt{\begin{array}{l}(0-0)^2+(0-1)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-1)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(1-0)^2\end{array}}$$

$$= \sqrt{\begin{array}{l}0+0+0+0+\\0+0+0+0+\\0+1+0+0+\\0+0+1\end{array}}$$

$$= \sqrt{2} = 1.414$$

The Measurement of Case B1 with the case C9 is explained below:

$$d(\text{B1,C9}) = \sqrt{\begin{array}{l}(0-0)^2+(0-1)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-1)^2+(0-1)^2+(0-1)^2+\\(0-0)^2+(0-1)^2+(0-1)^2+\\(0-0)^2+(0-0)^2+(1-0)^2\end{array}}$$

$$= \sqrt{\begin{array}{l}0+0+0+0+\\0+0+1+1+\\1+0+1+1+\\0+0+1\end{array}}$$

$$= \sqrt{6} = 2.449$$

The Measurement of Case B1 with the case C10 is explained below:

$$d(\text{B1,C10}) = \sqrt{\begin{array}{l}(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-0)^2+(0-0)^2+(0-0)^2+\\(0-1)^2+(0-1)^2+(1-1)^2\end{array}}$$

$$= \sqrt{\begin{array}{l}0+0+0+0+\\0+0+0+0+\\0+0+0+0+\\1+1+0\end{array}}$$

$$= \sqrt{2} = 1.414$$

Based on the measurements which are done manually by using *Euclidean Distance* toward the new cases B1 with the old cases in Table 3 which are C1 to C10, it can be concluded that new cases have similarities with case 1 (C10) with the distance 1.4. It means the available solution for C10 can be reused, and the proper diagnose for Nile Tilapia disease can be acquired. The view of CBR application using *Euclidean Distance* can be seen in Figure 2 below.

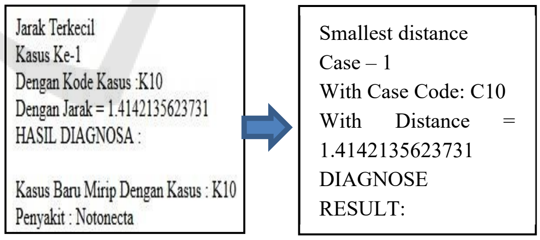

Figure 2:Diagnose result using CBR Euclidean Distance.

From the example of measurement method using *Euclidean Distance* towards the new case B1, the new case B2 to B10 could be measured as well. The final measurement, which shows each proximity value of new cases, is shown in Table 5 below.

Table 5: Result of Case B1 to B10

No	B	Distance	Similarity (Proximity Value) with Old Cases
1	B1	1.4	C10
2	B2	1	C1
3	B3	0	C6
4	B4	1.4	C6
5	B5	1	C7
6	B6	0	C8
7	B7	1	C7
8	B8	1.4	C6
9	B9	1.4	C6
10	B10	1.7	C6

The data in Table 5 shows new cases B1 to B10, where the smallest distance in new cases B3 and B6 fell in score 0.

4 FINDINGS

System testing has been done to know the system accuracy to diagnose fish disease. It also aims to test and check whether the work process of the system is already suitable with the master design or not (Koo et al., 2010). The system testing is done by checking the diagnosis result system where 40 cases are used as the testing data. The testing process is done by using three different thresholds which are 1, 2, and 3.

In the accuracy system, 38 appropriate cases are divided by whole 40 cases. Then, the result showed that the accuracy level fell by 95%. For the comparison between the expert measurement and the application by using Threshold 2 could be seen in Table 6.

Table 6: The Comparison between the Manual and Application Diagnose Result.

No	Symptoms	Diagnose Result (Expert)	Diagnose Result (Application)	Note
1	S15	Red Spot	Red Spot	Suitable
2	S1	Trichodina spp	Tricodina spp	Suitable
3	S2	Tricodina spp	Tricodina spp	Suitable
4	S3	Nononecta	Nononecta	Suitable
5	S4	Nononecta	Nononecta	Suitable
6	S10	Saprolegnia sis	Saprolegniasi s	Suitable
7	S5	Epistylis spp	Epistylis spp	Suitable
8	S6	Notonecta	Notonecta	Suitable
9	S12	Notonecta	Notonecta	Suitable
10	S11 and S12	Notonecta	Notonecta	Suitable
11	S3	Epistylis spp	Epistylis spp	Suitable
12	S5	Epistylis spp	Epistylis spp	Suitable
13	S9	Red Spot	Red Spot	Suitable
14	S11	Red Spot	Red Spot	Suitable
15	S10	Saprolegnia sis	Saprolegniasi s	Suitable
16	S1	Trichodina spp	Trichodina spp	Suitable
17	S13	Notonecta	Notonecta	Suitable
18	S14	Notonecta	Notonecta	Suitable
19	S15	Red Spot	Red Spot	Suitable
20	S2	Trichodina spp	Notonecta	Unsuitab le
21	S6	Epistylis spp	Epistylis spp	Suitable
22	S8	Red Spot	Red Spot	Suitable
23	S9	Red Spot	Red Spot	Suitable
24	S12	Red Spot	Red Spot	Suitable
25	S13	Notonecta	Notonecta	Suitable
26	S6	Epistylis spp	Epistylis spp	Suitable
27	S5	Epistylis spp	Epistylis spp	Suitable
28	S10	Notonecta	Notonecta	Suitable
29	S15	Epistylis spp	Epistylis spp	Suitable
30	S3	Trichodina spp	Trichodina spp	Suitable
31	S1	Trichodina spp	Trichodina spp	Suitable
32	S2	Trichodina spp	Trichodina spp	Suitable
33	S10	Saprolegnia sis	Saprolegniasi s	Suitable
34	S11	Red Spot	Red Spot	Suitable
35	S12	Red Spot	Red Spot	Suitable
36	S13	Notonecta	Notonecta	Suitable
37	S2	Trichodina spp	Notonecta	Unsuitab le
38	S4	Notonecta	Notonecta	Suitable
39	S8	Red Spot	Red Spot	Suitable
40	S12	Red Spot	Red Spot	Suitable

Table 6 shows the testing system by using threshold two which resulted in 100% similarity while the testing system. The system used threshold 1 and 3 and implemented the same process as threshold 2. All testing of threshold 1, 2 and 3 can be seen in Table 7 as the table, which also shows the measurement result.

Table 7: Measurement Result of Threshold 1, 2 and 3

Threshold	The Total of Cases	The Total of Suitable Cases	Percentage Result
T1	40	39	97,5%
T2	40	38	95%

T3	40	39	97,5%

We can see in Table 7 that the testing system using threshold 1, 2 and 3 are scored 97.5% for threshold 1, 95% for threshold 2, and 97.5 for threshold 3.

5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on this study's finding, which elaborated the application that uses CBR with *Euclidean Distance Method* to diagnose the disease of Nile Tilapia fish, we can conclude that:

1. The system can diagnose the disease by referring to the symptoms and then giving the solution based on the type of disease which is determined by the symptoms.
2. The system gives the diagnosis based on the similarities (proximity level) between old cases and new cases. The diagnoses can be categorized as "similar" if the distance value is ≤ 1.5.
3. The system was tested three times by using threshold 1, 2, and 3. The testing scored 100% for threshold 1, 100% for threshold 2, and 100% for threshold 3.

5.2 Recommendation

The recommendations from this study for further researches are:

1. The CBR system in this study is still an offline application. It is recommended for future researchers to implement this system in their online application. Therefore, this system could be accessed anywhere and anytime.
2. The process of locating the distance can be developed by using *similarity* method, or by combining *Minkowski distance* along with *manhattan distance* and *Euclidean distance* in order to get more complex system.

REFERENCES

Aamodt, A., dan Plaza, E., 1994, Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches, *Journal of AI Communication IOS Press*, 7, 1, 39-59.

Baratloo, A., Hosseini, M., Negida, A., & Ashal, G. E. Part 1: Simple Definition and Calculation of Accuracy, Sensitivity and Specificity. *Emergency* 2015: 2. 48-49.

Chitmanat, C., Lebel, P., Whangchai, C., Promya, J. & Lebel, L. 2016. *Tilapia diseases and management in river-based cage aquaculture in northern Thailand. Journal of Applied Aquaculture*. 28. 9-16. https://doi.org/10.1080/10454438.2015.1104950

Daniel N. S. Goncalves, Carolinne Goncalves, Tassia Assis, Marcelino da Silva. Analysis of the difference between the Euclidean distance and the actual road distance in Brazil. *Transportation Research Procedia 3 (2014) 876-885.*

Ji, Sae-Hyun, Park, Moonseo, Lee, Hyun-Soo and You-Yoon, You-Sang. 2010. The similarity measurement method of case-based reasoning for conceptual cost estimation. *Proceeding of International Conference on Computing in Civil and Building*

Koo, C, Hong, T., Hyun, C., & Koo, K. 2010. A CBR-based hybrid model for predicting a construction duration and cost based on project characteristics in multi-family housing projects. *Canadian Journal of Civil Engineering, 37(5), 739-752. 13-18.*

Kottelat, M., A. J. Whitten, S. N. Kartikasari & S. Wiroatmodjo. 1993. *Freshwater Fishes of Western Indonesia and Sulawesi*. Edisi Dwi Bahasa Inggris Indonesia. Periplus Edition (HK) Ltd. Bekerjasama dengan Kantor Menteri KLH, Jakarta.

Merigo, J. M., & Casanovas, M. A, 2011. New Minkowski Distance based on Induced Aggregation Operators. *International Journal of Computational Intelligence Systems.* 4. (2) 123-135.

Pal, Sankar K. & Shiu, S. C. K. 2003. Foundations of Soft Base Reasoning. 1-27.

Singh, A. Yadav, A. & Rana, A. 2013. K-Means with Three different distance metrics. *International journal of computer applications*. 67 (10).

Watson, I. 1997. *Applying Case-Based Reasoning: Techniques for Enterprise Systems*. San Francisco: Morgan KaufmannPublishers, Inc.