Fish Diseases Diagnose System Using Case-Based Reasoning with Euclidean Distance

*Michel* Farrel Tomatala1, *Rillya* Arundaa2, *Handri* Damodalag3

1Department of Information Technology, STMIK Multicom Bolaang Mongondow

2Department of Information System, STMIK Multicom Bolaang Mongondow

3Department of Information Technology, STMIK Multicom Bolaang Mongondow

email: michel@stmikmulticom.ac.id1), rill@stmikmulticom.ac.id2), handridamodalag@stmikmulticom.ac.id3)

**Abstract.** Nile Tilapia fish disease has concerned the fish farmers. The farmers were still lacking 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 lost. 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 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 CBR system to diagnose Nile Tilapia disease by using *Euclidean Distance Method.* The number of based-cases which are used for this study are 40 old cases that are analyzed by using 40 new cases. The system testing have been done three times by using Threshold 1, 2, and 3. All Thresholds testing 1, 2, and 3 fell in the score 100%. As a result, this study provides useful application for Nile Tilapia fish farmers to prevent and cure the fish disease.

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

1. **Introduction**

Nile Tilapia is fresh water fish which is said to be originally came from east Africa around 1969. Its lateen name is *Oreochromis Niloticus.* Nile Tilapia is commonly consumed by people around the world [1]. Nile Tilapia can be affected by fish disease and if this disease is not treated appropriately, the effect could be fatale such as causing the fish to die and make the fish farmers suffer significant financial lost due to deficiency of the fish harvest. The issue is 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 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 in time they were consulting. This habit caused more time and even gave worse outcome [2]. 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 *Euclidean Distance Method*, this study is expected to give proper and beneficial solution for the fish farmers in preventing and curing the Nile Tilapia fish disease. That is why this study aims to design and develop an appropriate CBR application by using *Euclidean Distance Method* to diagnose the disease of Nile Tilapia fish.

1. **Literature Review**

Case-Based Reasoning (CBR) is one of 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 1977, Schank and Abelson proposed about CBR for the first time. They proposed that human’s general knowledge about a particular situation is recorded in the brain as script that allows us to set up expectation and perform inference [3]. 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 new situation based on their past experiences [4]. According to Aamodt et al (1994) CBR consisted of four stages. They are *Retrieve, Reuse, Revise* and *Retain*. There is case representation in CBR system which aims to describe the problems and the solutions to solve the problems. In CBR system, the new case is compared to 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 [5]. The particular attributes that will be used as standard of comparison are the information of every case, whether it is old or new case [6]. The information can be the symptoms and types of disease which are taken from the database to count the proximity or distance value in order to measure the similarity or regularity among the data-items and the distance between the two objects. *Euclidean distance* is an approach which is commonly used for measuring two vectors [7]. This study measures the distance proximity value between the new and old cases which were previously happened by using *Euclidean Distance*.

1. **Research Method**

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

* 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:

*3.1.1 Formatting author names and author affiliations*

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

*3.1.2 Document Study*

This method was done by gathering and researching the documents such as published journals and books which have correlation with the topic of this study.

* 1. **Case Representation**

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 application and the *users* are the Nile Tilapia fish farmers. The *users* are the parties who diagnose the disease by inputting the symptoms into application.

*3.2.1 Experts Measurement*

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 which were inputted on the department’s data base from 2017 to 2018. The examples of the data are presented below on the **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 city. This data shows that there are five types of diseases. The next data is the symptoms which are appeared in the Nile Tilapia fish. The data is showed below in **Table 2**.

**Table 2.** Data of the 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 breath 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 | The fish’ fin becomes folded |
| S15 | There are red spots on the fish’ skin |

**Table 2** shows the symptoms of disease which is usually affected by Nile Tilapia fishes. The case representation of every disease and symptom which are shown in the **Table 1** and **Table 2** are clarified in the **Table 3** below.

**Table 3.** Case-Based Data

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

**Table 4.** New Case-Based Data

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

*3.2.2. Euclidean Distance Method*

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

(1)

*Notes*:

DistXY = dissimilarity degree

m = numbers of vectors

Xjk = input vector

Xik = output vector

K = the attribute which represents each vector Xjk and Xik

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 very important role in clustering techniques. The numerous methods are available for clustering techniques. Normally, the task is to define a function similarity (X, Y), where X and Y are two objects or sets of a certain 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 [8].

*d(i,j)=* (2)

*Notes*:

*d(i,j) = Euclidean Distance*

*Xi =* value point 1

*Xj =* 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 algorithm cluster is measuring 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 grouping the similar data [9].

*3.2.3. Accuracy Measurement*

In this study, the testing is done by comparing the measurement result from the experts by using *Euclidean Distance Method* and the measurement result which used CBR application through accuracy measurement. Accuracy value describes true presentation from the total of cases which are tested [10]. The accuracy measurement is shown in the Equation (3).

Accuracy = X 100% (3)

*3.2.3. CBR Mechanism System by Using Euclidean Distance*

As has been previously mentioned in Literature Review section, this study uses CBR system which has four stages. The four stages are *Retrieve, Reuse, Revise* and *Retain. Revise* stage happens when the *Euclidean Distance* value which is resulted from the application is larger than the threshold value. The experts then will revise the cases which are already in *Revise* stage. The rest three stages will be explained more in **Fig. 1** below.

Start

Diagnose Process Menu

Input the Symptoms

The *Retrieve* Stage by using CBR

Euclidean Distance < Threshold

*Reuse* Stage

*Revise* Stage

NO

Solution View

*Retrain* Stage

End

YES

**Fig. 1.** CBR System Mechanism using *Euclidean Distance*

*3.2.5. Measurement by Using Euclidean Distance Algorithm*

Based on the data in **Table 3** and **Table 4,** the measurement by using *Euclidian distance* algorithm for measuring the 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*(B1,C1) =

=

=

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

*d*(B1,C2) =

=

=

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

*d*(B1,C3) =

=

=

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

*d*(B1,C4) =

=

=

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

*d*(B1,C5) =

=

=

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

*d*(B1,C6) =

=

=

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

*d*(B1,C7) =

=

=

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

*d*(B1,C8) =

=

=

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

*d*(B1,C9) =

=

=

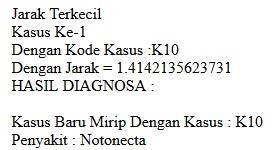
The Measurement of Case B1 with the case C10 is explained below:

*d*(B1,C10) =

=

=

Based on the measurements which are done 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 the **Fig. 2** below.



Smallest distance

Case – 1

With Case Code: C10

With Distance = 1.4142135623731

DIAGNOSE RESULT:

New Case is similar with case: C10

Disease: *Notonecta*

**Fig. 2.** The Result of Diagnose 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 are 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 | 1 | 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 B6 was the only new case which fell in the score 0.

1. **Findings**

The system testing which has been done to know the system accuracy to diagnose the 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 [11]. The system testing is done by checking the diagnosis result system where 40 cases are used as the testing data. Testing process is done by using three different threshold which are 1, 2, and 3.

In accuracy system, 40 appropriate cases are divided by whole 40 cases and then times to 100%. The result showed the accuracy level fell in the 100%. For the comparison between the experts’ measurement and the application by using Threshold 2 could be seen in **Table 6**.

**Table 6.** The Comparison between the Experts and Application Diagnose Result

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No | Symptoms | Diagnose Result (by Experts) | Diagnose Result (by Application) | Note |
| 1 | S15 | Notonecta | Notonecta | Suitable |
| 2 | S1 | Trichodina spp | Trichodina spp | Suitable |
| 3 | S2 and S3 | Trichodina spp | Trichodina spp | Suitable |
| 4 | S3 and S9 | Notonecta | Notonecta | Suitable |
| 5 | S4 and S11 | Notonecta | Notonecta | Suitable |
| 6 | S10 | Saprolegniasis | Saprolegniasis | Suitable |
| 7 | S5 | Epistylis spp | Epistylis spp | Suitable |
| 8 | S6 | Notonecta | Notonecta | Suitable |
| 9 | S12 and S4 | Notonecta | Notonecta | Suitable |
| 10 | S11 and S12 | Notonecta | Notonecta | Suitable |
| 11 | S3 and S12 | Notonecta | Notonecta | Suitable |
| 12 | S5, S1, and S9 | Epistylis spp | Epistylis spp | Suitable |
| 13 | S9 | Red Spot | Red Spot | Suitable |
| 14 | S11 | Red Spot | Red Spot | Suitable |
| 15 | S10 and S9 | Saprolegniasis | Saprolegniasis | Suitable |
| 16 | S1and S3 | Trichodina spp | Trichodina spp | Suitable |
| 17 | S13 and S4 | Notonecta | Notonecta | Suitable |
| 18 | S14 | Notonecta | Notonecta | Suitable |
| 19 | S15 and S1 | Red Spot | Red Spot | Suitable |
| 20 | S2 and S5 | Trichodina spp | Trichodina spp | Suitable |
| 21 | S6 and S2 | Notonecta | Notonecta | Suitable |
| 22 | S8 and S1 | Red Spot | Red Spot | Suitable |
| 23 | S9 | Red Spot | Red Spot | Suitable |
| 24 | S12, S4, and S10 | Notonecta | Notonecta | Suitable |
| 25 | S13 | Notonecta | Notonecta | Suitable |
| 26 | S6 and S10 | Notonecta | Notonecta | Suitable |
| 27 | S5 | Epistylis spp | Epistylis spp | Suitable |
| 28 | S10 | Saprolegniasis | Saprolegniasis | Suitable |
| 29 | S15, S10, and S3 | Epistylis spp | Epistylis spp | Suitable |
| 30 | S3 | Notonecta | Notonecta | Suitable |
| 31 | S1 and S12 | Trichodina spp | Trichodina spp | Suitable |
| 32 | S2 and S8 | Trichodina spp | Trichodina spp | Suitable |
| 33 | S10 and S2 | Saprolegniasis | Saprolegniasis | Suitable |
| 34 | S11 and S9 | Red Spot | Red Spot | Suitable |
| 35 | S12 | Notonecta | Notonecta | Suitable |
| 36 | S13 and S6 | Notonecta | Notonecta | Suitable |
| 37 | S2 | Trichodina spp | Trichodina spp | Suitable |
| 38 | S4 | Notonecta | Notonecta | Suitable |
| 39 | S8 | Trichodina spp | Trichodina spp | Suitable |
| 40 | S12 and S4 | Notonecta | Notonecta | Suitable |

**Table 6** shows the testing system by using threshold 2 which resulted 100% similarity while the testing system which used threshold 1 and 3 are implemented by the same process like 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 | 40 | 100% |
| T2 | 40 | 40 | 100% |
| T3 | 40 | 40 | 100% |

We can see in **Table 7** that the testing system using threshold 1, 2 and 3 scored 100% without failure.

1. **Conclusion and Recommendation**

**5.1. Conclusion**

Based on the finding results 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 “right/true” if the distance value is < 1.5.
3. The system was tested three times by using threshold 1, 2, and 3. The testing showed that all of the thresholds scored 100%.

By referring to three main conclusions above, we find that this study has crucial role as a medium for empowering human capital especially in Industry 4.0. The fish farmers who used to check the fish’s disease traditionally by contacting the experts might be able to use technology only in order to find proper solution to cure the fishes which are infected and even prevent the disease. The CBR application which used *Euclidean Distance* is helpful and useful enough to make fish farmers’ works more simple and flexible. The application will absolutely prevent the fish farmers to experience financial lost. The application facilitate the fish farmers with technology by adopting the real experts’ knowledge into digital application. By having this application, fish farmers’ human capital can be improved by knowing the experts’ knowledge through technology which is CBR application which used *Euclidean Distance.*

**5.2. Recommendation**

The recommendations from this study for further researches are:

1. The CBR system in this study is still an offline application. That is why it is recommended for future researchers to implement this system into online application so that 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**

[1] 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.

[2] Chanagun Chitmanat, Phimphakan Lebel, Niwooti Whangchai, Jongkon Promya & Louis Lebel. Tilapia diseases and management in river-based cage aquaculture in northern Thailand. Journal of Applied Aquaculture. 2016. 28. 9-16. <https://doi.org/10.1080/10454438.2015.1104950>

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

[4] Sankar K. Pal & Simon C. K. Shiu. 2003. Foundations of Soft Base Reasoning. 1-27.

[5] 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.

[6] Sae-Hyun Ji, Moonseo Park, Hyun-Soo Lee, and You-Sang Yoon.

[7] Jose M. Merigo & Montserrat Casanovas. A New Mnkowski Distance based on Induced Aggregation Operators. International Journal of Computational Intelligence Systems. 4. (2) 2011. 123-135.

[8] 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. *Transportaion Research Procedia 3 (2014) 876-885.*

[9] Archana Singh, Avantika Yadav, Ajay Rana. 2013. 67. 10-18. K-Means with Three different distance metrics. International journal of computer applications.

[10] Alireza Baratloo, Mostafa Hosseini, Ahmed Negida, & Gehad El Ashal. Part 1: Simple Definition and Calculation of Accuracy, Sensitivity and Specificity. *Emergency* 2015: 2. 48-49.

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