Case-Based Reasoning for Mortality Prediction of Catfish Farming Based on Water Quality

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Abstract. Catfish (Clarias gariepinus) is a species of freshwater fish that has good prospects for cultivation. This type of fish has a fast growth rate, is able to adapt to a bad environment and is easily cultivated. Water quality is the main element that influences the level of fish life. However, catfish deaths often occur when water quality is in certain conditions. Fish mortality can be predicted using an appropriate system so that it does not greatly affect the cultivation process. This research has succeeded in developing a prediction system for catfish mortality as a result of the water quality used for catfish farming. This system is based on case-based reasoning. The matching process starts by entering water quality condition variables such as Temperature, pH, Ammonia, Nitrite, and Dissolved Oxygen. Features entered by the user will be referred to the knowledge base. The system will look for a base case that has been indexed before. The similarity calculation with the highest value is used as a prediction of the effect of water quality on the mortality rate of catfish farming. The similarity of the test cases shows that the new case has a similarity level of up to 80%.

1. Introduction
Aquaculture is a sector whose growth can continue encouraged, given the potential use of the existing land is still low compared to the area of land which is available. The potential of aquaculture land in Indonesia is estimated to reach 17,744,303 Ha while the total usage has only reached 1,125,597 Ha. Existing conditions of potential pool use recorded at 22.6% [1]. Water quality greatly affects the type of fish and the level of fish life [2]. The water of good quality and in accordance with the nutritional needs of fish will enhance the results of cultivation and vice versa.

Catfish (Clarias gariepinus) is a species of freshwater fish that has good prospects for cultivation. This fish has a fast growth rate, is able to adapt to the environment that is not good and easily cultivated, besides it is popular with the wider community because it has good taste, tasty, soft texture, and has fairly high nutrition. Recently, Clarias Gariepinus has extensively cultivated throughout Indonesia, mainly in Java, Sumatra, Bali, and Kalimantan. Utilization of the catfish in Indonesian aquaculture was initiated in 1985 through the introduction of the species from Taiwan. Its fast-growing performance is well appreciated by fish farmers, led to the rapid development of aquaculture. This species was very popular and locally named as “Lele Dumbo” [3].

The high demand for catfish and the lack of supply of catfish, fish farming is one of the right ways to increase fish supply. Catfish farming is an activity to produce aquatic organisms (organisms) for profit [4]. Hatchery activities begin with the preparation of the hatchery media unit, management, or management of a good parent, spawning, to hatching eggs into seeds or larvae. According to Standard Nasional Indonesia (2000), in rearing nursery 1, namely rearing larvae up to 1-3 cm in size, the survival rate is 60%. This is related to various factors that affect growth and survival, both internal and external factors. Internal factors that influence are genetic, age and parasitic, while external factors are food availability and water quality which includes temperature, dissolved oxygen, carbon dioxide,
water pH, nitrite, and ammonia. The availability of foods that have high nutrition is very needed larvae for the development of organs that are still simple to perfection [6].

Water as the main media for fish farming must have a quantity and quality standard that is in accordance with the fish's living requirements. Water must meet indicators in order to maintain the viability of aquaculture [7]. To predict catfish mortality rates, a case-based reasoning (CBR) system was developed. CBR is one branch of artificial intelligence that uses the knowledge-oriented problem approach of the past to solve current problems [8]. CBR is a methodology for solving a problem that uses previous data or memorized problem situations called cases. The processes of the CBR system proceed in four main steps such as retrieve, reuse, revise, and retain [9]. The new case starts at the top of the stage, where input is entered into the system. The previous case is compared to the new case and start to retrieve step. In a practical CBR system is a comparison between all the cases in the system and a new case, then the result will list the ranking of similar cases [10].

CBR development has been carried out previously, namely to control fish diseases [11]. This research will apply case-based reasoning to help farmers prepare the best water criteria in catfish farming so that the percentage of deaths can be minimized. This system was built using C# programming language as a reliable programming language [12].

2. Research Method
2.1. Data Collection
Water quality data were obtained from the Biofloc Laboratory of Universitas Muhammadiyah Purwokerto.

2.2. Case-Based Reasoning Process
Figure 1 shows the scheme of CBR. New cases can be added according to variables that have been determined by the system. The variables in this system consist of water temperature, water pH, dissolved oxygen nitrite, and ammonia. Retrieve in the system will search into an indexed case base using the C.45 Algorithm. The next retrieval process is to look for closeness between cases within the case base. The similarity calculation has been calculated using Equation 1.

\[ \text{similarity}(e, e_i) = \frac{\text{common}}{\text{common} + \text{different}} \]  

\[ \text{Similarity} (e, e_i) : \text{a degree of similarity between } e \text{ to } e_i. \]
\[ \text{Common} : \text{represents a number of features that have the same feature value between } e \text{ to } e_i. \]
\[ \text{Different} : \text{represent a number of features that have different feature values between } e \text{ to } e_i. \]
Figure 1. Scheme of case-based reasoning

3. Result and Discussion
Water quality is a picture of the fertility of water. Although sometimes catfish can live and grow in minimum quality conditions, some water parameters that can be used as indicators in assessing the quality of water are presented in Table 1. Based on the results of the analysis that has been done, the data requirements include input data and output data can be seen in Table 2 and Table 3.

| Parameter       | Value Range for fish farming | Measurement equipment |
|-----------------|------------------------------|-----------------------|
| **Physical Aspects** |                              |                       |
| Temperature     | 20 – 30 °C                   | Thermometer           |
| Brightness      | > 10 cm                      | Secchi Disc           |
| Turbidity       | 25 - 400 JTU                 | Turbidity meter       |
| Salinity        | Freshwater 0 – 5 °/оо        | Salinometer           |
|                 | Brackish water               |                       |
|                 | 6 – 29 °/оо                  |                       |
|                 | Freshwater                   |                       |
|                 | 30-35 °/оо                   |                       |
| Water discharge | Heavy water 50 l/sec         | Current meter         |
|                 | Calm water 0,5 – 5 l/sec     |                       |
| **Chemical Aspects** |                              |                       |
| Dissolved oxygen| 5 – 6 ppm                    | DO meter/ Winkler Method|
| Carbon dioxide  | Max 25 ppm                   | CO meter/ Titration Method|
| pH              | 6.5 – 8                      | pH meter/ Litmus Paper|
| Alkalinity      | 50 – 500 ppm CaCO₃          |                       |
| Hardness        | 3 – 15 dH                    | dh meter              |
| Ammonia         | < 1,5 ppm                    | Spectrophotometer     |
| H₂S             | < 0,1 ppm                    | Spectrophotometer     |
| Nitrite         | < 0,2 ppm                    | Spectrophotometer     |
| Nitrate         | 0 – 1,5 ppm                  | Spectrophotometer     |
Phosphate < 0.02 ppm

Biological Aspects
- Plankton abundance: As needed (Plankton net)
- Benthos abundance: Haemocytometer
- Periphytons abundance: Ekman Dredge

Table 2. Sample input

| Variable       | Class | Sample input value | Variable | Class | Sample input value |
|----------------|-------|--------------------|----------|-------|--------------------|
| Ammonia        | 1     | 0.01040            | pH       | 1     | 7.5                |
|                | 2     | 0.00980            |          | 2     | 7.4                |
|                | 3     | 0.01490            |          | 3     | 7.3                |
|                | 4     | 0.01420            |          | 4     | 7.2                |
|                |       |                    | Dissolved oxygen | 1 | 7.7 |
|                |       |                    |          | 2 | 7 |
|                |       |                    |          | 3 | 6.4 |
|                |       |                    |          | 4 | 6.2 |

Table 3. Sample output

| Class | Sample output value |
|-------|---------------------|
| 1     | 0%                  |
| 2     | 0.1%                |
| 3     | 0.333667%           |
| 4     | 1.339136257%        |
| ...   | ...                 |
| 49    | 0.299850075%        |

The similarity is calculated based on the new case added by the user. An example of the new case can be seen in Table 4. Before doing the calculation, the system will search for cases with similar criteria in the case-based that can be seen in Table 5. After getting cases with similar criteria, the next process is to calculate the degree of similarity of the new case.

Table 4. New case

| Variable                    | Value       |
|-----------------------------|-------------|
| Ammonia (NH₃)               | 0.01490     |
| Water pH                    | 7.4         |
| Temperature (°C)            | 27          |
| Nitrite (NH₂)               | 0.0400      |
| Dissolved Oxygen (DO)       | 5.4         |
Table 5. Cases that have similar criteria value to the new case

| Case_Id | Ammonia (NH₃) | Water pH | Temperature (°C) | Nitrite (NH₂) | Dissolved Oxygen (DO) | Distance |
|---------|---------------|----------|------------------|--------------|----------------------|----------|
| 6       | 0.01490       | 7.4      | 29               | 0.0400       | 5.4                  | 0.3337   |
| 13      | 0.01490       | 7.2      | 28               | 0.0400       | 5.4                  | 0.3478   |

Table 6. Comparison of new cases with Case_Id = 6

| Variable      | Value    | Similarity | Variable      | Value    |
|---------------|----------|------------|---------------|----------|
| Ammonia (NH₃) | 0.01490  | 1          | Ammonia (NH₃) | 0.01490  |
| Water pH      | 7.4      | 1          | Water pH      | 7.4      |
| Temperature (°C) | 29       | 0          | Temperature (°C) | 27      |
| Nitrite (NH₂) | 0.0400   | 1          | Nitrite (NH₂) | 0.0400   |
| Dissolved Oxygen | 5.4     | 1          | Dissolved Oxygen | 5.4     |

Table 7. Comparison of new cases with Case_Id = 13

| Variable      | Value    | Similarity | Variable      | Value    |
|---------------|----------|------------|---------------|----------|
| Ammonia (NH₃) | 0.01490  | 1          | Ammonia (NH₃) | 0.01490  |
| Water pH      | 7.2      | 0          | Water pH      | 7.4      |
| Temperature (°C) | 28       | 0          | Temperature (°C) | 27      |
| Nitrite (NH₂) | 0.0400   | 1          | Nitrite (NH₂) | 0.0400   |
| Dissolved Oxygen | 5.4     | 1          | Dissolved Oxygen | 5.4     |

Using eq.1, the similarity value of new case based on Case_Id = 6 can be seen as follow:

\[
similarity(e, e_i) = \frac{(1 + 1 + 1 + 1)}{4 + 1} = \frac{4}{5} = 0.8 \times 100\% = 80\%
\]

The similarity value of new case based on Case_Id = 13 can be seen as follow:

\[
similarity(e, e_i) = \frac{(1 + 1 + 1)}{3 + 2} = \frac{3}{5} = 0.6 \times 100\% = 60\%
\]

The comparison of new case values by Case_Id = 6 can be seen in Table 6, while the comparison of new case values by Case_Id = 13 can be seen in Table 7. By using Equation (1) the similarity value of the new case with Case_Id = 6 and Case_Id = 13 respectively obtained similarity values of 80% and 60%. The case that has the highest similarity value will be used as a search solution. This result will help the user in estimating the percentage of catfish mortality.

4. Conclusion

Based on the basis of the case, there are two cases that had similarity criteria with the new case, those cases will be the suggested solution for new cases. The similarity criteria value from each case can be seen that: 1) the similarity criteria of Case_Id = 6 is 0.3337 and 2) the similarity criteria of Case_Id = 13 is 0.3478. The calculation shows that both are respectively obtained similarity values of 80% and 60%.
60%. Therefore, the best result that will be the suggested solution for the new case is using Case_Id = 6 with a similarity value 80%.

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