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IoT-Based Guppy Aquaculture Monitoring System Using C 4.5 Method on Thingspeak Platform

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ABSTRACT

Monitoring water media in Guppy fish farming is a major problem that must be solved. Monitoring is carried out to obtain a decision whether the media is suitable or not suitable for getting good guppy fish. This study aims to extract knowledge in order to make decisions on the quality of Guppy fish water media through data obtained from the IoT system. The main contribution of this research is the effort to obtain new knowledge from data collected through IoT systems. New knowledge is obtained from water quality parameter data acquired by sensors of temperature, water level and water pH. data from the sensor is sent to the Thingspeak cloud application via the microcontroller module. Data from the cloud is extracted into new knowledge in the form of decision-making rules for the quality of Guppy fish water media. To validate the method used, an analysis was performed using a confusion matrix in the rapidminer application. tested for the C 4.5 method and the Naive Bayes method The results obtained the same high accuracy of 100 percent. It is possible that this IoT system can be applied in a larger scope, for example monitoring the aquariums of various Guppy fish farming communities in a city, so that real time data on the quality of Guppy fish is obtained within the scope of Smart City.

I. Introduction.

There are about 650 Indonesian marine ornamental fish species, of which 480 species have been identified, and around 200 are traded. Indonesian marine ornamental fish species have a high selling value in the international market. Indonesia's maritime ornamental fish market share is 20 percent of the global world market share, of which 95 percent are caught, and only 5 percent result from community cultivation[1]. The number of Indonesian freshwater ornamental fish species is estimated at around 36 percent of ornamental fish species worldwide, as many as 400 species, favorite ornamental fish commodities from Indonesia include Arowana (Schleropages formosus sp) especially the exceptional pink Arowana species and the Red Banjar species. , Botia (Botia macrochaeta sp), and Betta (Beta splendens), Indonesia has succeeded in domesticating imported ornamental fish such as koi (Cyprinus carpio), goldfish (Carassius auratus), discus (Symphysodon discus), and guppies (Poecilia reticulata)[1]. Guppy fish is a species of freshwater fish that is popular in Indonesia. It turns out that guppy fish originate from the Fernando de Noronha archipelago, off the coast of northeastern Brazil[2]. Guppy fish is a fish that grows well in water areas, especially in fresh water, and is widespread in the tropics[3].

The entry of Guppies to Indonesia was initially to eradicate mosquito larvae that cause malaria. Around the 1920s, although the size of the guppy was too small, it was ultimately less than optimal in the mission of preying on mosquito larvae. Initially, the Guppy were kept in aquariums after being released into the wild. Guppy breeding is relatively rapid, spreading to many areas of free water. In 1929, it was noted that Guppy fish can be found in almost all waters of West Java, especially in ponds and ditches, and has even spread in almost all waters of the archipelago, such as Java and Bali, including the species whose existence is the most abundant and abundant[4].

There has been an increase in the number of hobbyists, lovers, and cultivators of Guppy Fish in Indonesia. It is recorded that the Guppy Fish community has reached more than 50 communities from 34 provinces throughout Indonesia, with the ability to produce Guppy Fish of 110,000 pairs in 6 months. The Indonesian Guppy Popularized Association (IGPA), as one of the largest Guppy fish communities in Indonesia, is very optimistic that Indonesia can become a barometer of world Guppy fish production, with a wealth of environmental potential that is very supportive of Guppy fish cultivation, Indonesia's potential is very large in terms of economic value in the world Guppy fish market, when calculated with the ability to scale production with world market selling value of 100 US dollars for one pair of Guppy Fish, the national economic value of Guppy Fish can reach 162 billion Rupiah for only six months[5].

Considering the economic potential and cultivation of guppy fish, optimizing the monitoring of the Guppy fish farming system is necessary. By research[6], water quality parameters are observed: temperature, pH, and Dissolved Oxygen (DO) in ensuring the quality of Guppy fish water. The tools used are a thermometer to measure temperature, a pH meter to measure pH, and a DO meter to measure the content of dissolved oxygen in the water. In this study, monitoring is carried out using an information technology-based system in the form of an Internet of Things (IoT) system. A Guppy fish monitoring system based on the Internet of Things allows us to monitor the habitat of Guppy fish in real-time. The system can be integrated into the internet system, cloud applications in the form of an Internet of Things platform, and even functional integration as part of a smart city.

Some of the problems related to guppy fish include the need to stop exports to transit countries[7]. Another problem in Guppy fish farming is water quality and disease[8]. The factors that significantly influence the production of ornamental Guppy fish are worm feed, pellet feed, labor, and the type of maintenance site[9]. The need for technology to be able to guarantee the quality of fish ordered by consumers at home and abroad, of course, by monitoring the condition of the fish and taking quick action if there are indicators that threaten the death or quality of the fish. Water quality and disease can be monitored using an IT system in the form of an IoT-based system and monitoring feed and maintenance areas in general.

IoT is today's technology, integrating various intelligent devices, technologies, and applications, bridging multiple technologies to enable new applications by linking physical objects together to support intelligent decision-making[10]. IoT is an ecosystem that contains smart objects in the form of sensors, networks, and processing technologies that are integrated and work together to provide intelligent services, bringing many benefits into people's lives through an environment where intelligent services are provided for every activity, anywhere and anytime. These facilities and services are delivered through various applications carried out in the IoT environment. The most important utility achieved by IoT applications is monitoring and, consequently, immediate decision-making for efficient management[11], even the Internet of Things (IoT) creates a world where intelligent objects and services interact autonomously and can be used for various cases in decision-making, management, and monitoring of the environment in the cloud[12]. Currently, there are billions of devices connected to the Internet of Things, especially with network communication media in the form of Lora, which can connect many devices and cover a wide area[13]. You can imagine the large variety of data from these various devices. These data can be information that is very valuable if it can be extracted using data mining methods and other methods into knowledge for various purposes. Even in 2025, it is estimated that twenty billion devices will be connected to the IoT [14].

There have been several studies related to fish monitoring, including [15] monitoring water quality, using aquarium media, more specifically, monitoring pH and ammonia levels in the water. Research [16] monitored pH and temperature pads and already used visual displays on the IoT platform. Monitoring water level, temperature, and oxygen levels in an IoT-based multilevel aquarium system [17]. An IoT-based intelligent fish aquarium system already uses the IoT platform[18]. This IoT-based system generates warm energy to bring warm conditions to the fish farming system [19]. IoT-based system to monitor fish metabolism by [19]. IoT-based mini aquarium system by[20]. The details are shown in Table 1.

Table 1. Literature Cpmparison

Authors	***Fish***	***Parameters***	***Technology***	***Methods***
[16]	It is not specific type of fish	IoT System Measuring pH and water temperature, temperature	Using connected sensors on parameters and presenting water quality information in real-time, the data obtained is stored in excel format and database, using a google-based cloud application.	It is No specific method mentioned
[17]	It is not specific type of fish	IoT system measures water level, oxygen content and temperature	Vertical water management system for fish farming, using related sensors, not explicitly mentioned cloud application, only ANSYS FLUENT 13.0 software	It is No specific method mentioned
[18]	It is not specific type of fish	IoT system measures water level, light, and temperature	Smart fish tank, with android based app, using IoT platform/cloud app, but not explicitly mentioned	It is No specific method mentioned
[19]	It is not specific type of fish	IoT system measures water level, Oxygen, temperature, and pH	Waste heat energy management system in IoT-based fish farming, including android technology, no mention of the use of cloud applications	It is No specific method mentioned
[21]	It is not specific type of fish	The IoT system measures Temperature, Oxygen, ammonia levels, electrical conductivity, and the total dissolved solids.	The IoT-based system, IoTtalk, monitors water media with connected sensors, as if a fish is talking, with no specific cloud application or an android-based system.	It is No specific method mentioned
[22]	Guppy fish	IoT system measuring pH and salt content in water	The IoT system is used for monitoring related parameters using connected	It is No specific method mentioned

Authors	***Fish***	***Parameters***	***Technology***	***Methods***
			sensors.	
The authors/ in this research	Guppy fish	IoT system measures Temperature, water level and pH	The IoT-based system with related sensors, using the Thingspeak platform, presented in real-time, based on android, extracting knowledge in the form of rules from the data that appears on the platform and exported into excel format analyzed using data mining methods	Data mining method (C 4.5 algorithm) to extract new knowledges

In this study, monitoring PH, temperature, and water level based on IoT are carried out. Only we are trying to gain new knowledge from the data collected by the system as past data, using the C 4.5 algorithm. Considering that Algorithm C 4.5 as a data mining method can extract knowledge in the form of rules [23], the primary purpose of which is to make decisions that Guppy fish culture media is suitable or not suitable. Various types of research on monitoring fish using various technologies are described, monitoring guppy fish in research [22] in particular monitoring the pH and salt content of the water media, and temperature monitoring is recommended for further research based on IoT, but in existing studies, even previous research, has not used any of the following methods: methods for data analysis, do not include the system's ability to extract knowledge. This study seeks to bring newness to the capability of an IoT-based Guppy fish monitoring system that can extract new knowledge from past data on Guppy fish monitoring, as shown in Figure 2.

II. Method

Guppy fish cultivation, in this case, is an experiment in the scope of an aquarium. Experiments were carried out using an IoT-based system. The results are conveyed in real-time on the IoT (Internet of Things) platform using Thingspeak. This study in real-time in the data set from the Guppy fish farming environment. The prototype system in conducting limited monitoring is only carried out within two days and is limited in the amount of data, there were 72 data. The system flowchart is shown in Figure 1. The system architecture chart is shown in Figure 2, visualizing this monitoring system as having a novelty in extracting knowledge from data obtained by an IoT-based system. Knowledge in the form of rules to monitor whether environmental conditions and water quality are suitable or not based on parameters of temperature, water level, and pH of aquarium water. The rules are obtained from the decision tree using the C 4.5 method for testing the confusion matrix. A comparison was made between C 4.5 and Naïve Bayes methods.

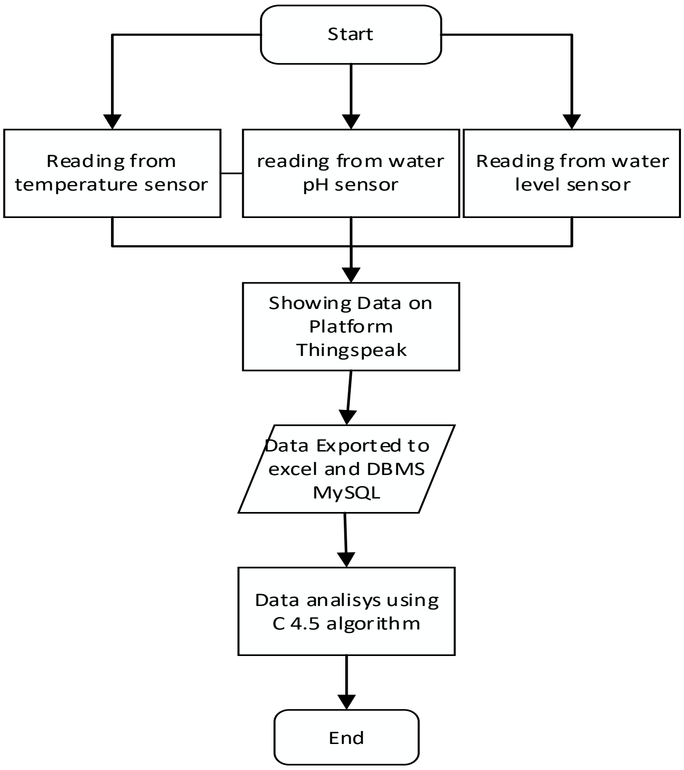

Fig. 1. Flowchart of system

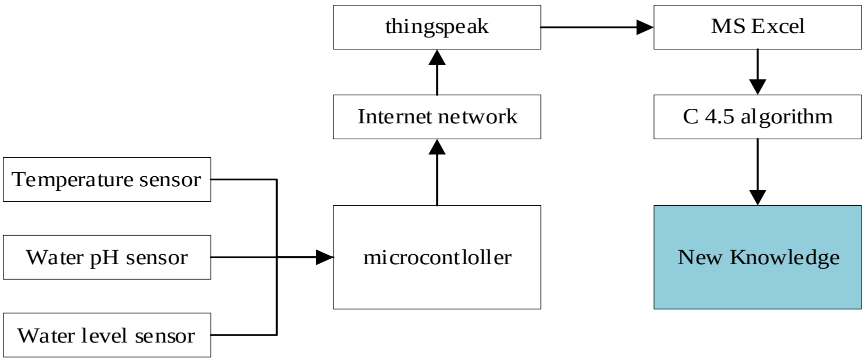

Fig. 2. Architecture system

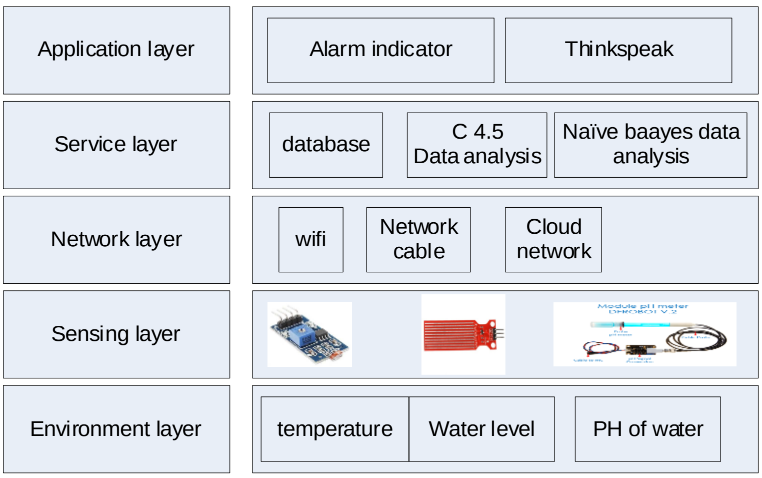

Fig. 3. IoT layers system

Figure 3 corresponds to [23], the layers of the IoT system in the study, as a description of the devices and applications used. For memos following is a tool design or schematic along with sensors of the aquarium water quality monitoring system, as shown in Figure 4.

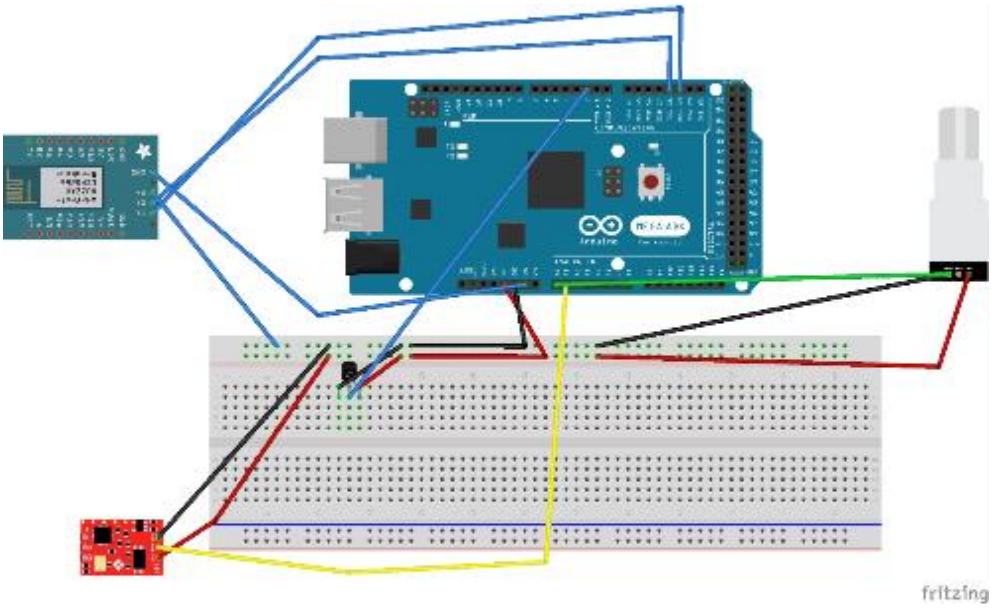

Fig. 4. IoT layers system

Vcc is connected to 5V, and Gnd is connected to GND. The water level sensor has three pins, namely Vcc, Gnd, and S. Connected to the Arduino Mega2560 with pin S (Data) to pin A1. The DS18B20 sensor is connected to pin Data to pin 2. For pH sensor data, it is connected to pin A0. Then to connect to the platform, the author uses the ESP8266 module, as shown in Table 2.

Table 2. Table Styles

ESP8266	Arduino without Serial1	Arduino With Serial1
RX	Pin 7	TX1
TX	Pin 6	RX1
GND	GND	GND
VCC	5V	5V
CH_VD	5V	5V

Categorical data were tabulated, and entropy and gain were calculated until a decision tree was completely obtained as a representation of knowledge. We calculated Total Entropy, Gain, and Entropy Base from categorical data[24][25].

Calculating Total Entropy:

$$\boldsymbol{Entropy\ Total\ (S)} = \sum_{i=1}^{n} -\boldsymbol{Pi} \times \boldsymbol{log_2\ Pi} \tag{1}$$

Calculating Gain Value from parameters:

$$\boldsymbol{Gain\ (S,A)} = \boldsymbol{Entropy(S)} - \sum_{i=1}^{n} \frac{\boldsymbol{Si}}{\boldsymbol{S}} \times \boldsymbol{Entropy\ (Si)} \tag{2}$$

III. Result and Discusion.

The monitoring system uses three sensors, temperature sensors, water level, and pH water. The system is functioning properly and can measure the water level, temperature, and pH. A total of 72 data obtained from the sensor for two days with a duration of 20 minutes, as described in Figure 5, shows the function of temperature, water level, and water pH for Guppy fish.

according to [25] training data is more in number than testing data, producing better results. There were sixten testing data in this research. If data retrieval is carried out in a longer period of time and through communication networks over a wider area, hundreds or even thousands or millions of monitoring points, the number of sensors used is even greater as the various sensors are used by researchers, it is possible to have large data. And a variety of information that is very useful in decision making, of course, is possible to occur in the days ahead.

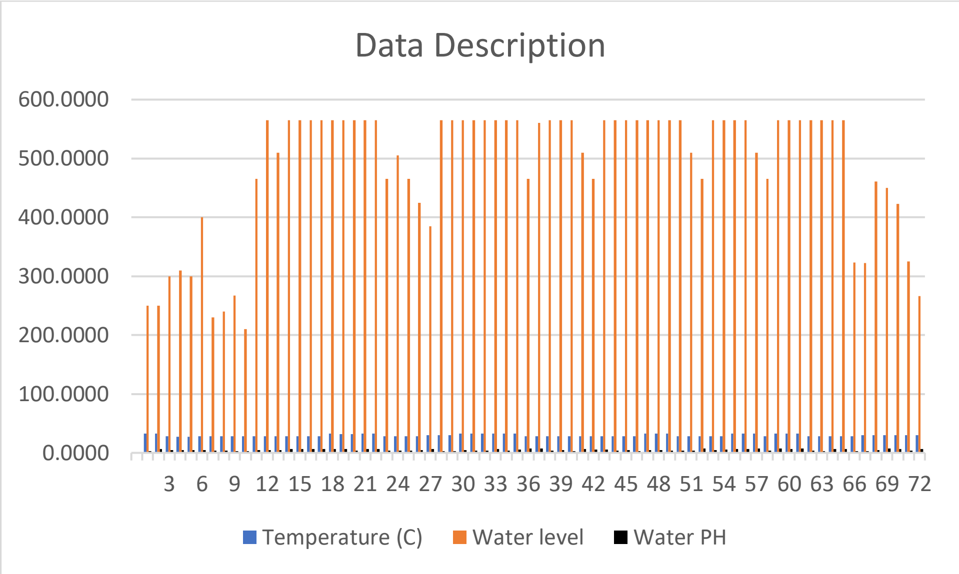

Fig. 5. Temperature, water level, pH of water function graph against time.

Table 3. Upper and lower limits of parameters Temperature, water level and water pH

Level	***Temperature***	***Level water***	***Water pH***
Lowest	27.1	210	3.0
highest	32.9	565	7.8

Table 4. The magnitude of the categories obtained to convert the data in Table 2

Temperature	High	> 30,04
	In between	28 - 30,04
	low	< 28
Water level	Full	>387
	Not full	< 387
Water pH	base	>5,4
	Normal	4 -5,5
	Acid	< 4
class	Suitable	
	Not suitable	

Table 5. The pieces of data from the conversion of numeric to categorical quantities

No	**Temperature**	**Water level**	**Water pH**	**Class**
1	high	Not full	Acid	Not suitable
2	high	Not full	Base	Not suitable
3	low	Not full	Normal	Not suitable

No	Temperature	Water level	Water pH	Class
4	low	Not full	Normal	Not suitable
5	low	Not full	Normal	Not suitable
6	In between	Full	Normal	Suitable
7	In Between	Not full	Acid	Not suitable
8	In Between	Not full	Acid	Not suitable
9	In Between	Not full	Acid	Not suitable
10	In Between	Not full	Acid	Not suitable

The summary of the results of the Entropy and Gain calculations to determine the root is in Table 6. The pH parameter becomes the root because it has the largest Gain value compared to the gain from temperature parameters and aquarium water level parameters. The results of the manual analysis are the same as those using the rapidminer tool. The root in the decision tree in Figure 12 is the pH of the water.

Table 6. Entropy and gain calculation results

Node 1	Calculation for Node 1		Entropy	Gain
1.0	Total		0,710676854	
	Temperature			0,142437879
		high	0,182662636	
		In between	0,784992089	
		low	0	
	Water Level			0,062904886
		full	0,790501384	
		Not full	0	
	Water pH			0,551940578
		Base	0	
		Normal	0,672294817	
		Acid	0	

Figure 6 The following is a prototype system that has been assembled based on the design that the author made earlier. Figure 7 is a complete prototype with a guppy fish experimental environment in the form of an aquarium.

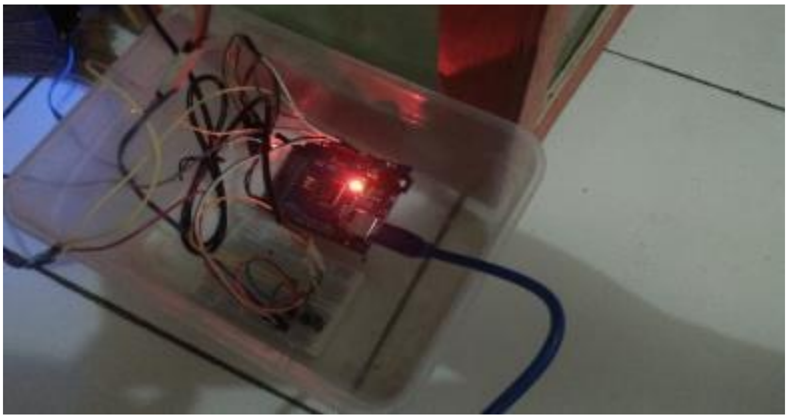

Fig. 6. Prototype system.

Fig. 7. System testing.

Figure 8 is the source code of the Arduino interface, as well as the test results.

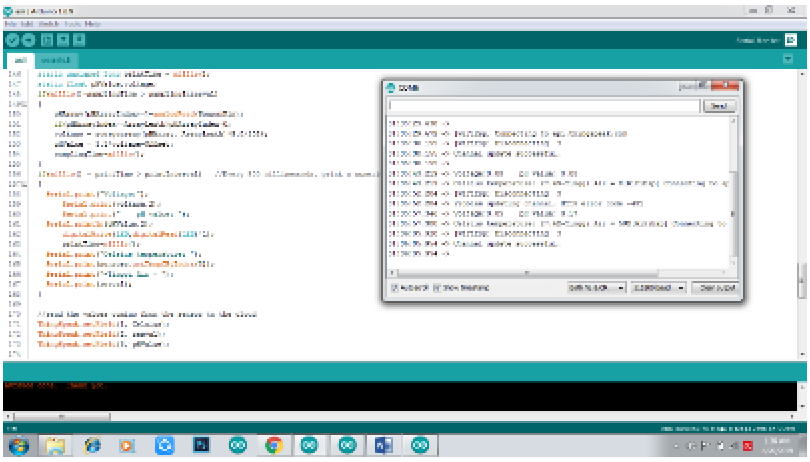

Fig. 8. Source code for interfacing Arduino.

Next is the final testing stage, where in this test, the author does modeling on rapidminer tools using the C 4.5 and Naïve Bayes methods. The data in Table 4 were analyzed using the Naïve Bayes method and C 4.5. the model of the C 4.5 method is shown in Figure 10, and the model using the Naïve Bayes method is shown in Figure 13. The accuracy gain from the C 4.5 method is shown in Figure 11, while the accuracy gain from the Naïve Bayes method is shown in Figure 14. Specifically the decision tree using the C 4.5 method is shown in Figure 12.

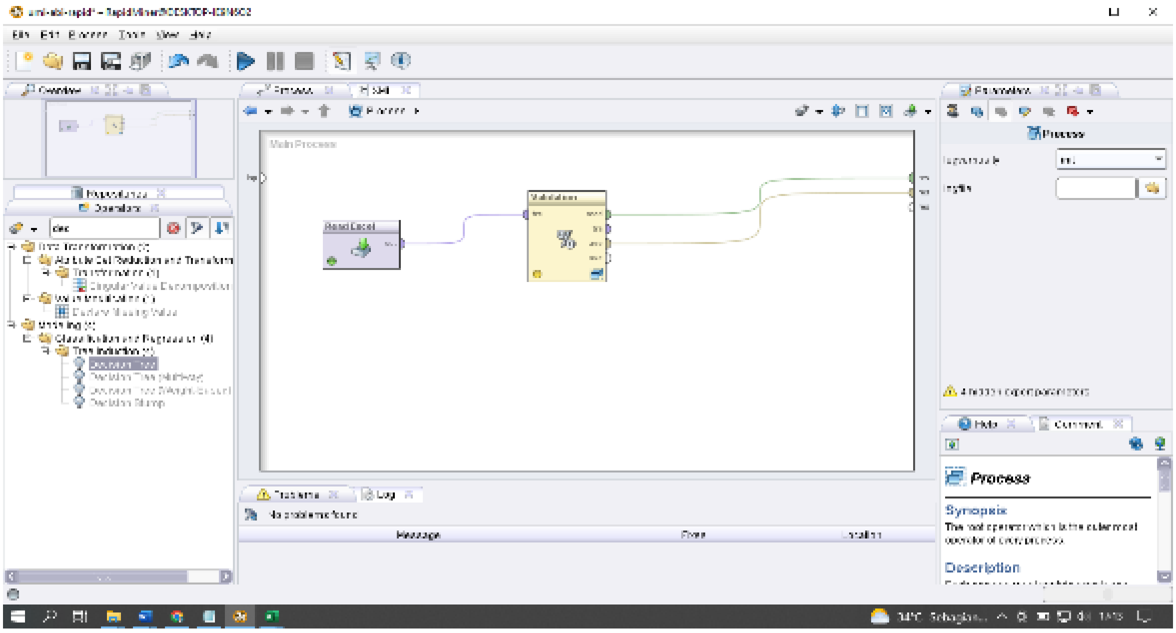

Fig. 9. Model on rapidminer.

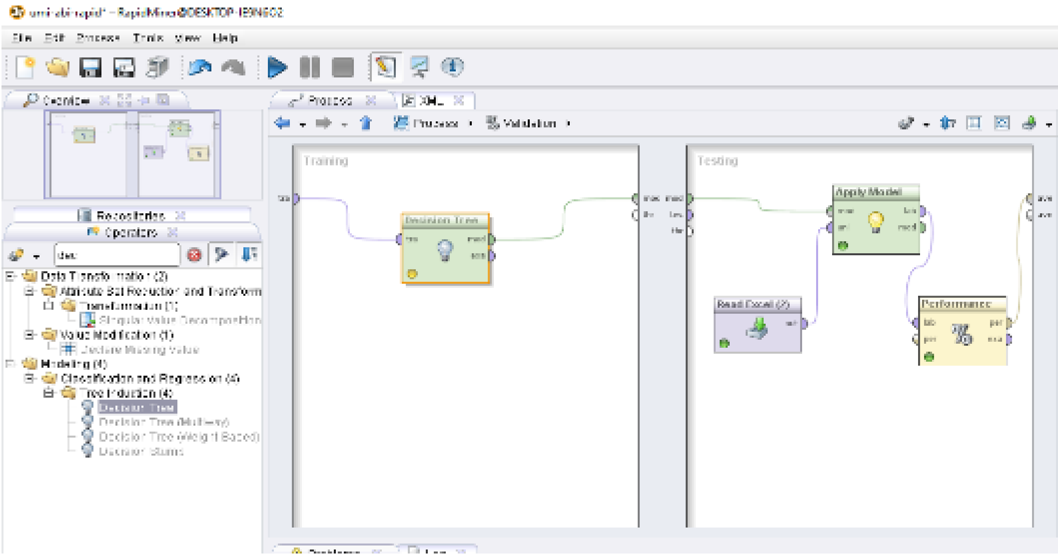

Fig. 10. Model on rapidminer completely with data training

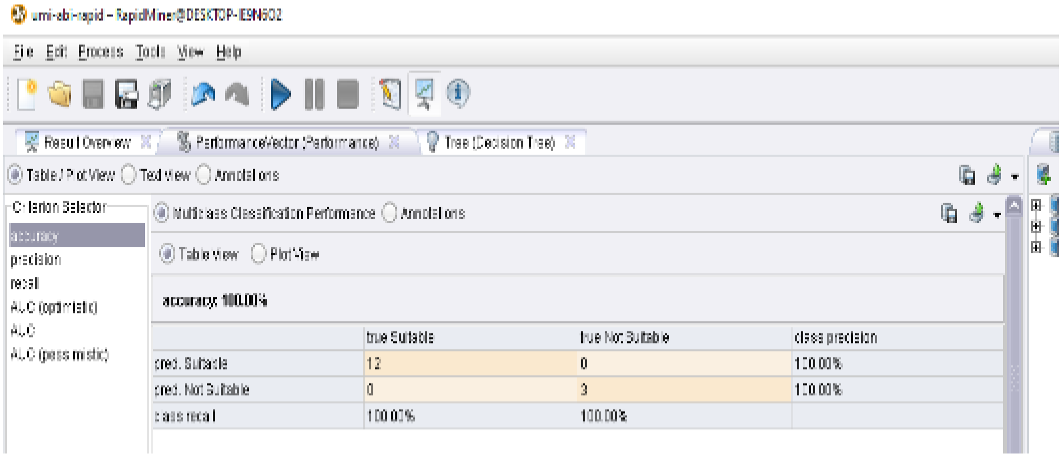

Fig. 11. Model for C 4.5 on rapidminer.

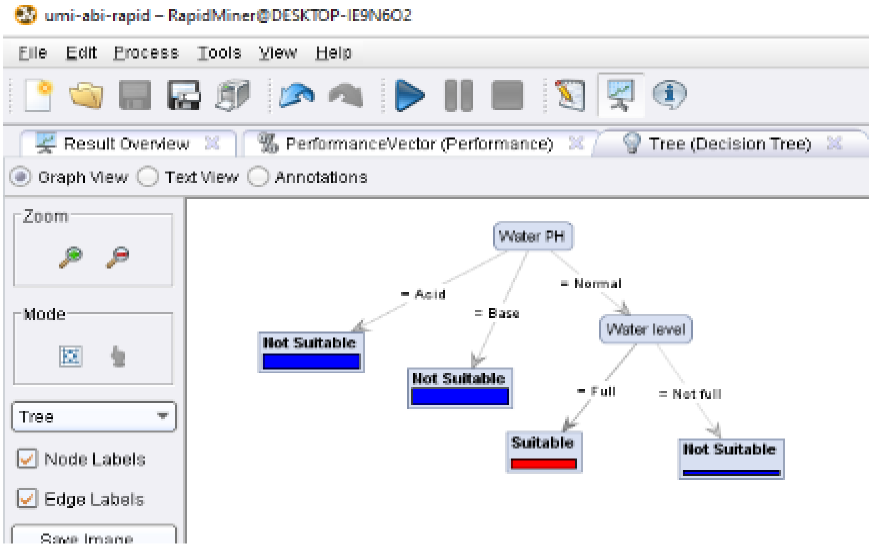

Fig. 12. Decision Three on rapidminer.

From the decision tree in Figure 20, the following rules are obtained:
R1 : IF(water pH =Normal) AND (Water level=Not full) THEN Not suitable
R2 : IF(water pH =Normal) AND (Water Level=full) THEN Suitable
R3 : IF(water pH =Base) THEN Not suitable
R4 : IF(water pH =Acid) THEN Not suitable

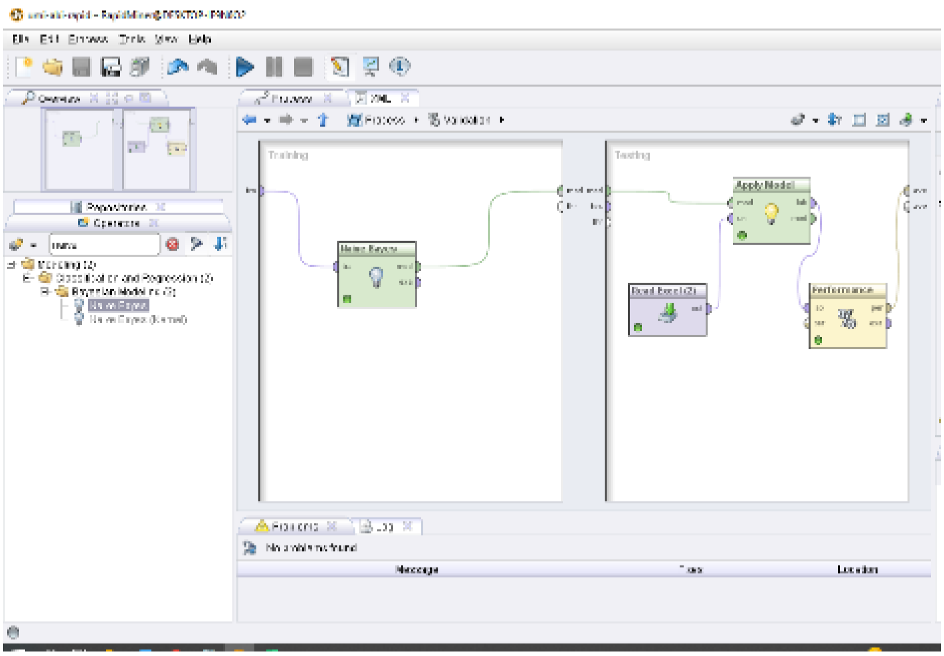

Fig. 13. Model with Naïve Bayes method on rapidminer.

The author makes a comparison using the Naïve Bayes method. The model is shown in Figure 21. The results of the comparison show that both produce high accuracy, which is 100 percent. This shows that the quality of the system can produce data that has very good and reliable suitability.

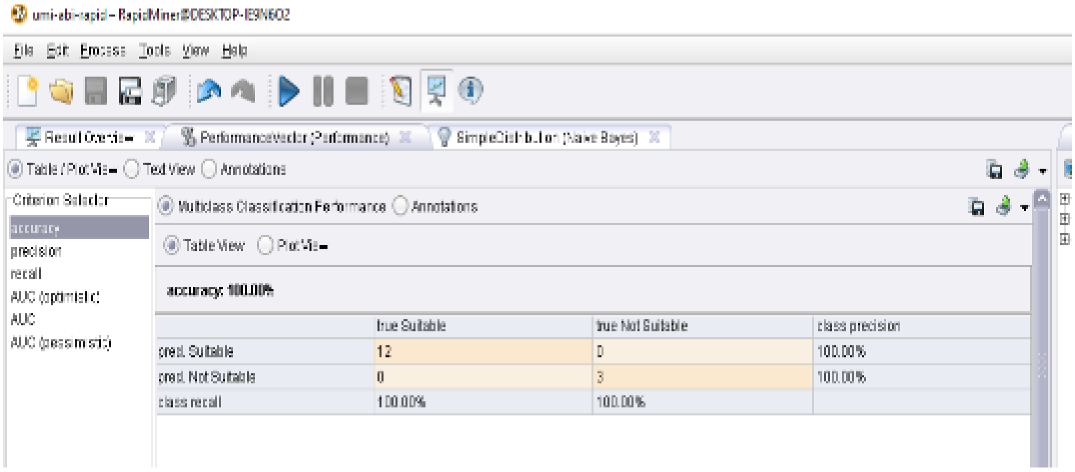

Fig. 14. Accuracy with Naïve Bayes on rapidminer.

IV. Conclusion

An IoT-based system can present monitored parameter information in the form of temperature, water level, and pH water in real-time (real-time) using the IoT platform in the form of Thingspeak. Monitoring is needed to increase aquaculture activities, provide adequate information for consumers in terms of quality that can be accessed in real-time, and allow for easier decision-making on whether the water media is still suitable. The monitoring result data listed on the platform is exported to a spreadsheet format so that it can be analyzed using C 4.5 method to extract knowledge related to monitoring water media in Guppy fish farming, whether it is still suitable or not. The results of the accuracy test on the C 4.5 method and the comparison with the Naïve Bayes method both resulted in an optimal accuracy of 100 percent. Subsequent research can provide a faster measure of time, for example, data retrieval by sensors every 10 minutes and more days, more monitoring points with a broader monitoring area. The system can be integrated with a larger size, for example, using Lora communication technology, monitoring many issues in a sub-district or district level community, and even more broadly and presenting information in a cloud application in the form of an IoT platform that allows consumers to access information on the condition of the media and the quality of the fish they want.

There are several suggestions for future research, namely the environment where data collection is carried out in aquariums of a larger size, even in ponds. Suggestions for more data collection days. A larger data collection environment and longer research data collection time are expected to provide more research data.

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