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Article

Water Quality Modelling (WQM) Using Machine Learning (ML) For Surface Modelling of Shrimp Pond Vehicles Using Smart Water Optimization (SWO)

Prawidya Destarianto[1*], Ariesia Ayuning Gemaputri[2], Denny Wijanarko[3], Ely Mulyadi[4]

[1] Department of Information Technology, Politeknik Negeri Jember; prawidya@polije.ac.id
[2] Department of Agribusiness Management, Politeknik Negeri Jember; ariesia@polije.ac.id
[3] Department of Information Technology, Politeknik Negeri Jember; denny_wijanarko@polije.ac.id
[4] Department of Information Technology, Politeknik Negeri Jember; elymulyadi@polije.ac.id

* Correspondence: prawidya@polije.ac.id

Abstract: Indonesia is one of global major aquaculture producer. White leg shrimp is considered a superior commodity due to its growth resilience. Therefore, annual white leg production is increasing from 2018 at 932,698 tons. In regard to these findings, the shrimp farming sector appears to hold great promise. But the quality of the water, which constantly fluctuates, is a key factor in shrimp farming success. However, in line with united nation (UN) sustainable development goals (SDGs) 12 in which requiring optimization on food production. The farming environment such as temperature, pH, and the availability of phytoplankton—a natural source of shrimp food—all have an impact on the water quality. To guarantee ideal circumstances, these parameters have to stay inside predetermined bounds. Automated water quality control is critical to improve shrimp production efficiency. The main goal of this research is to apply a fuzzy algorithm to create surface modelling vehicle for shrimp ponds (SMV-SP) where utilize the same sensor as autonomous surface vehicles (ASVs), but instead of classifying the sensors based on coral reef monitoring, the reference is optimal water condition to support shrimp growth. A 92% accuracy rate is indicated by the test finding. The result confirms ReSMeV-SP is able to improve water quality thus enabling more efficient and enhanced yield of shrimp production.

Keywords: IoT; Shrimp; Machine Learning

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1. Introduction

Indonesia is global major aquaculture producer with 14.61 million tons aquatic organism were cultivated or harvested [1]. In 2001, Indonesian Ministry of Marine Affairs and Fisheries introduces vannamei or white leg shrimp (*Litopenaeus vannamei*) as a superior variety [2]. White leg shrimp has excellent resilient in brackish water and can be cultivated at high density scenario, more than double of tiger shrimp. Therefore, white leg shrimp become more popular dan widely farmed throughout Indonesia. Annual total shrimp production is increasing since 2009 (338,060 tons) until 2018 at 932,698 tons and expected to grows continuously [2]. In line with UN concern about sustainable consumption and production patterns (SDGs 12), where food production needs to be optimized [3]. These results point to a potential future for the shrimp farming sector, although water quality has a significant impact on the industry [4].

The water quality used in shrimp aquaculture is always fluctuating [4], [5]. There are several factors that might create variations in water quality. These include the following: temperature, pH, dissolved oxygen content, biomass status of shrimp, and the presence of phytoplankton, which is a natural food source for shrimp [4], [5]. These water-related parameters ought to fall inside the typical border rank. Therefore,

maintaining shrimp requires careful attention to regulating the water's quality every hour of every day. Pool management procedures are appropriate only when the quality of the water in the pools is controlled. The production of shrimp that are harvested is mostly dependent on proper water quality control.

Shrimp farm in Kencong, Jember Regency has been raising white leg shrimp super-intensive maintenance of sixteen shrimp ponds. Pool controls are operated by a technician with assistance from twenty field personnel. the company uses several manual tools. Inaccurate water quality control is caused by lack of workforce's tool proficiency. It frequently fails to obtain precise data, requiring a second inspection, which takes longer time and increasing costs. Therefore, we require a contemporary, precise, efficient, and mobile water quality management tool for shrimp farming. In order to support the sector that produces high-quality shrimp, meet worldwide criteria for shrimp size, maximise output, and increase the amount of shrimp that are exported, The development of cutting-edge engineering technologies that can inform shrimp biomass is vital. The industry need a shrimp biomass information system in order to establish the most accurate and efficient way to handle shrimp farming.

Automation of mobile information on shrimp biomass is required due to the industry's high production efficiency. The Jember State Polytechnic's science, technology, and information technology outcomes are delivered downstream in the form of an ASV water quality control system, which is how the automation is implemented [6]. An ASV is a device or vehicle that can function on the water's surface without a crew. The ASV tool has demonstrated its capacity to generate precise data on temperature, PH, DO (Dissolved Oxygen), turbidity, and carbon dioxide. This is made possible by the sensors that are included in the ASV application, which include PH, temperature, turbidity, DO, and carbon dioxide sensors. The system uses the fuzzy algorithm to process the data received from the sensor. A class model system is then used to process the data that were gathered from the sensor readings that were stored in the ASV. For every sensor indicator, class modelling is separated into three categories: Good, Medium, and Dangerous. An information system based on the Web is used to distribute class information.

Research on the use of IoT has been developed, particularly with regard to its potential to assist people in all of their activities, one of which is in the context of the environment. Study carried out by [7], [8], [9], [10], [11]. However, the relevant research published in IEEE [12], [13] indicates that there is still a deficiency in the application of WQM especially for the primary aquaculture of white leg shrimp.

The goal of this project is to create the SMV-SP using Fuzzy Algorithm, which is based on [4], [5], [12]. The research is no longer referring to coral reef standards; instead, the instrument developed by this study (SMV-SP) will use the same sensor as ASV [6] but with a different class classification. The ideal water conditions for growth and development are now the point of reference in this study, rather than the guidelines for coral reefs. It is expected that the research's instruments would enable precision white leg shrimp cultivation, leading to higher shrimp yields and improved production efficiency.

2. Materials and Methods

Shrimp farming pond water quality is typically affected by periodic fluctuations [4], [5]. Numerous elements, such as temperature, pH, and the amount of dissolved oxygen, can affect variations in the quality of water [4], [5]. To produce high-quality shrimp, these components need to be in accordance with guidelines for shrimp culture. As a result,

maintaining the water quality in shrimp is very concerned with doing so every hour of every day (in real-time). The suitability of pool management techniques is determined by pool water quality control. The production of shrimp that are harvested is mostly dependent on proper upkeep. Thus, we require an appropriate, cutting-edge, accurate, and effective method of managing the Internet of Things (IoT) water quality for shrimp farming. This is to support the industry that produces high-quality shrimp. achieving the size of shrimp required by international standards, optimizing output, and increasing exported shrimp quantity.



Figure 1. ASV

IoT application has been the subject of research, particularly regarding its potential to assist people in all their projects, including environmental context-based activities. Study carried out by [7], [8], [9], [10], [11]. However, the relevant research published in IEEE [12], [13] indicates that there is still a deficiency in the application of WQM especially for the primary aquaculture of white leg Shrimp.

The Real-time Surface Modelling Vehicle Development for Shrimp Farms (SMV-SP) Using Fuzzy Algorithm is the goal of this project, which is based on [4], [5], [12]. The sensor used by ASV [6] in Figure 1 will be used by the tool developed in this study (SMV-SP), but it will be classified differently. Coral reef criteria are no longer used in research; instead, the ideal water conditions for white leg shrimp growth and development are the focus of this study. It is expected that the research's devices would enable precision white leg shrimp cultivation, leading to higher shrimp yields and improved production efficiency.

The literature review, which is the first step in this research method and is depicted in Figure 2, is crucial for ensuring the State of the Art (research position) [14], [15], [16]. The research position found will be compared with issues that come up in the field, and the issues that need to be identified and resolved are those that are related to the study's goal. Creating boundary condition or rules is the next research step; these rules will be applied to the fuzzy process on many sensors [6].

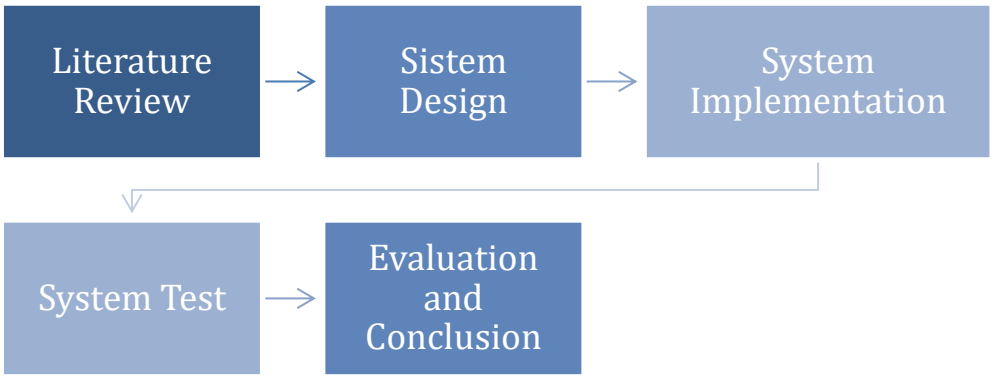


Figure 2. Research Methods

Following that, SMV-SP is updated with the acquired rules. The goal of using the fuzzy approach is to achieve more precise reading. Testing is the next step, which aims to demonstrate sensor readings are accurate [17]. Up to 100 test samples were tested for this study [18], thus the tool's accuracy will also be determined [19]. Following the acquisition of the test results data, processing is done with the intention of assessing the application of the fuzzy algorithm, which is applied based on the outcomes of the SMV-SP water quality reading [14]. The accuracy of the SMV-SP tool's water quality class reading is the ultimate outcome of this research phase. In order to verify the algorithm accuracy, the tool accuracy obtained from data processing is compared with manual calculations [20]. The data obtained at this point will go over the calculated accuracy value influencing variables.

3. Results and Discussion

3.1. SMV-SP Development

Figure 3 depicts an element of the tool that is made up of multiple sensors, including a pH sensor that measures the water's acidity, a temperature sensor that measures the water's degree celcius of water, a DO sensor that measures the oxygen levels in the water, and a turbidity sensor that measures the water's turbidity level. Figure 3 also shows the design of SMV-SP utilized in this study. A web-based monitoring application called SMV-SP shows many sensor values for shrimp ponds, including temperature, turbidity, pH, and DO. The pH sensor is used to measure how acidic water is. Furthermore, this sensor could convert a non-electric quantity—in this example, the pH level—into an electrical quantity—voltage. The purpose of DO sensors is to measure the oxygen content of water. The DO value, which is expressed as a concentration and represents the amount of oxygen (O_2) present in the water, is positively correlated with water quality; on the other hand, lower DO values are indicating lower quality of water.

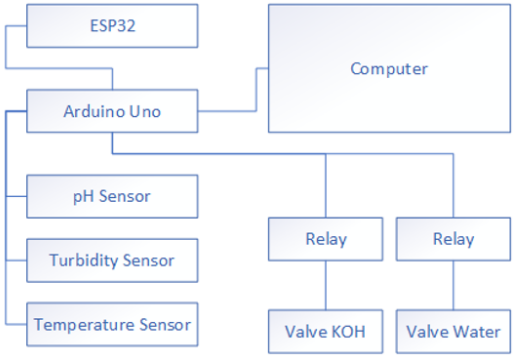


Figure 3. Block Diagram

Subsequently, the temperature sensor measures the water's temperature; the temperature shown will be converted to Celsius, Indonesia's standard unit of measurement for temperature. The term "turbidity assessor" refers to a device which determines the turbidity level of water by translating the infrared light emitted by LED, which then travels through the water and is detected by a phototransistor. The phototransistor's intensity reading is directly correlated with the turbidity level of the water. The data obtained from SMV-SP later compiled using microcontroller.

The Thingspeak application is used to display sensor data or monitoring results. To create graphical data, the findings are reprocessed. This research employs an Arduino Uno, which is also the brain that receives and transmits sensor information and instructs the motor driver to move the propeller (direction of motion) in a water quality reading instrument. MCU nodes are used in this study. MCU nodes serve as bridges for data transfer, connectors, and internet access. Thingspeak application summarize and convert numerical data from four employed sensors with Sugeno fuzzy logic system into graphical diagram for easier reading of water quality

3.2. Fuzzy Calculation

Water quality sensor readings and quadrant data were used as the research's input. This study included DO sensors, temperature, pH, and turbidity sensors. The sensor's output will thereafter be processed as input into Fuzzy, with consideration given to the boundary condition ranges shown in Table 1 that were derived from observations and farmer interviews.

Every sensor is separated into three classes, although the labels associated with each class vary depending on the type of sensor. Table 1 serves as the basis for the research's implementation of the tools that were created.

Table 1. Variable Range

Class	Temp.	Range	pH	Range	Turbidity	Range	DO	Range
1	Low	≤ 26	Acid	≤ 7.5	Low	≤ 250	Low	≤ 4
2	Normal	24-32	Netral	7-9	Normal	200-450	Normal	3-7
3	High	≥ 30	Basa	≥ 8.5	High	≥ 400	High	≥ 6

The pH membership function is displayed in Equation 1. The class used in this investigation is represented by each of the three μ in Equation 1. Three classes are used in pH research: low, neutral, and alkaline. While the pH limit value is obtained from shrimp farmers who use the pH parameter as usual (i.e., no specific limit) in the field, the ideal pH range for white leg shrimp culture is 7.5 to 8.5. Equation 2 illustrates Turbidity Membership.

$$\mu\, low = \begin{cases} 0 & ,x \geq 7.5 \\ \dfrac{(7.5-x)}{(7.5-7)} & ,7 < x < 7.5 \\ 1 & ,x \leq 7.5 \end{cases} \qquad \mu\, netral = \begin{cases} 0 & ,x \leq 7 \; and \; x \geq 9 \\ \dfrac{(x-7.5)}{(7.5-7)} & ,7 < x < 7.5 \\ \dfrac{(9-x)}{(9-8.5)} & ,8.5 < x < 9 \\ 1 & ,7.5 \leq x \leq 8.5 \end{cases} \tag{1}$$

$$\mu\, basa = \begin{cases} 0 & ,x \leq 8.5 \\ \dfrac{(x-8.5)}{(9-8.5)} & ,8.5 < x < 9 \\ 1 & ,x \geq 9 \end{cases}$$

Table 2 depicts the AND procedure for the inference process. For instance, in route number 1, IF Temperature (1 / low) AND pH (1 / acid) AND Turbidity (1 / not hazy) AND DO (1 / little oxygen) THEN Water Quality Very Bad. Or, if the following conditions are met on route 81: Good Water Quality indicated with temperature (3 / high), pH (3 / base), turbidity (3 / hazy), and DO (2 / medium).

One of the route implementation duplications. [R81] Equation 3 indicates that where there are a HIGH oxygen concentration AND alkaline pH AND high turbidity, AND hot temperature, the water quality is sufficient.

Equation 4 illustrates fuzzy Sugeno (Weight Average) defuzzification in this study, for instance in the sample used. where the computational result (Z value) is 0.25.

3.3. SMV-SP Testing

The Black Box testing, which is displayed in Table 3, shows that the tool's development was effective considering every research outcome was successful (100%). The Ground Truth technique was used for the tests in this study, as served in Table 4, where the system's output is compared with the expert perspectives. A difference in the findings will be counted as an error; if they are the same, it will be calculated as accuracy. The study's accuracy value was 92% based on tests conducted on 100 data sets produced by sensors (tools).

Table 2. Functional Tests: *Black Box* (BB)

Num.	Item Test	Function Test	Result Test
1	ESP32	Data Transmit	✓
2	Sensor: Temp.	Reda Temp. Val.	✓
3	Sensor: Turbi.	Read Turbi. Val.	✓
4	Sensor: pH	Read pH Val.	✓
5	Sensor: DO	Read DO Val.	✓

Table 3. *Fuzzy Testing Result*

Num.	Temp. Val.	pH Val.	Turbi. Val.	DO Val.	Class Result	Expert Assessment
1	28	7.18	276	11.30	0.38 (Bad)	Ep: False
2	28	7.52	276	11.21	0.51 (Enough)	Ep: True
...	..	..	..	..	..	
97	27	7.37	276	11.30	0.50 (Enough)	Ep: True
98	28	7.37	275	11.32	0.48 (Bad)	Ep: True
99	28	7.47	276	11.24	0.51 (Enough)	Ep: True
100	28	7.18	276	11.35	0.39 (Bad)	Ep: False

4. Conclusions

A SMV-SP has been developed. Black Box test result that shows 100% system compatibility, or, to put it another way, that every feature functions as intended. However, an accuracy score of 92% was found in the test that used 100 data points. The techniques developed in this study can be applied in shrimp ponds and are expected to improve the precision of shrimp farming, therefore these results serve as a reference.

Supplementary Materials: -

Author Contributions: "Conceptualization, 1st. and 2nd; methodology, 3rd; software, 4th; validation, 3rd; formal analysis, 1st; investigation, 1st; resources, 4th; data curation, 4th; writing—original draft preparation, 3rd; writing—review and editing, 4th; visualization, 3rd; supervision, 2nd; project administration, 2nd; funding acquisition, 1st".

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