Fuzzy Logic and ANFIS Model Based Fresh Water Control System and Fish Health Detection in Aquaculture

Jithin V A

[1]Assistant Professor Adhoc, Department of Mechanical Engineering, NSS College of Engineering, Palakkad, Kerala, India
Email: *jithinmtm[at]email.com*

Abstract: ***Fuzzy logic is an innovative technology to design solutions for multi parameter and non-linear control problems. One of the greatest advantages of fuzzy control is that it uses human experience and process information obtained from operator rather than a mathematical model for the definition of a control strategy. As a result, it often delivers solutions faster than conventional control design techniques. The proposed system is an attempt to apply fuzzy logic techniques to predict the stress factor on the fish, based on line data and rule base generated using domain expert. The proposed work includes a use of Data acquisition system, an interfacing device for on line parameter acquisition and analysis, fuzzy logic controller (FLC) for inferring the stress factor. The system takes stress parameters on the fish as inputs, fuzzified by using FLC with knowledge base rules and finally provides single output. All the parameters are controlled and calibrated by the fuzzy logic toolbox and MATLAB programming. The fish's diseases occurred due to change in parameters i.e. dissolved oxygen, ammonia, nitrogen, carbon dioxide, calcium, ozone, hydrogen sulphide, pH present into the water. If these parameters vary abruptly changes, the fishes get affected by the several diseases. It is well known that fish have a low food conversion rate and feeding represents the most important expenditure, approximately 40% of total production cost.***

Keywords: Fuzzy Logic Controller, Stress Parameter, Dissolved Oxygen, MATLAB Simulink

1. Introduction

The proposed system "Fuzzy logic based fresh water aquaculture control system" takes three stress parameters variables temperature, dissolve oxygen (DO) and conductivity as inputs in crisp form and converts these variables into single fuzzified output. Fuzzy logic controller system, control these input stress parameters and get output as a % health of fish which work as display effect of deflection in temperature, dissolve oxygen and conductivity on health of fish. This fuzzy logic system uses fuzzy toolbox in MATLAB and program has been written in MATLAB to implement the system.

2. Input-Output Frame Work

Fuzzy inference system (FIS) performance is evaluated by using the Fuzzy Logic Controller block in a Simulink model of system. The Fuzzy Logic Controller block automatically generates a hierarchical block for fuzzy inference systems. This representation uses only built-in Simulink blocks, enabling efficient code generation using Real-Time Workshop which is available separately.

3. Stress Parametrs and Various Ranges

Here the various parameters for fresh water aquaculture are temperature of the water, content of dissolved oxygen and conductivity of water. Each factor have their own desirable range and acceptable range. This acceptable range implies the range of values in which fish can withstand to the respective parameters. Under this acceptable range, the fish health is optimum and crisis free. Beyond the acceptable range, the health of fish life is questionable. The acceptable ranges of stress factor membership parameters are divided into three catogories – low, medium and high

Table 1: The stress parameter ranges for fresh water aquaculture

Parameters	Desirable Range	Acceptable Range
Temperature	20°C–35°C	0°C–50°C
Dissolved oxygen	5–8 ppm	0–20 ppm
Conductivity	500–1500 µS/cm	100–2000 µS/cm

Table 2: The ranges of various stress factor membership functions

Stress Parameters	Low	Medium	High
Temperature	0-20	10-30	20-50
Dissolved Oxygen	2-10	4-15	10-20
Conductivity	0-2	1-4	2-6

The output effect of percentage of fish health is categorised under various values – bad, average and good. Fish health is actively good if the percentage of fish health is under good category- 40-100%. Like that the fish health percentage is 0-40% then the condition is bad.

Table 3: The output effect on fish

Percentage of Fish Health	Bad	Average	Good
	0-40%	20-60%	40-100%

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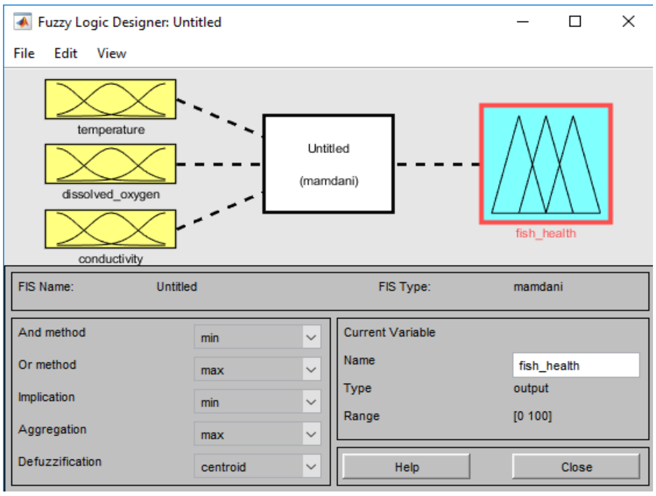

Figure 1: Fuzzy control view with inputs and outputs

This is the fuzzy control with inputs and outputs. Stress parameters are chosen as input and fish health are chosen as output. For each input stress parameter, membership plots are created in fuzzy inference system. While inputs are plotted in the membership function plots, acceptable range should also be mentioned

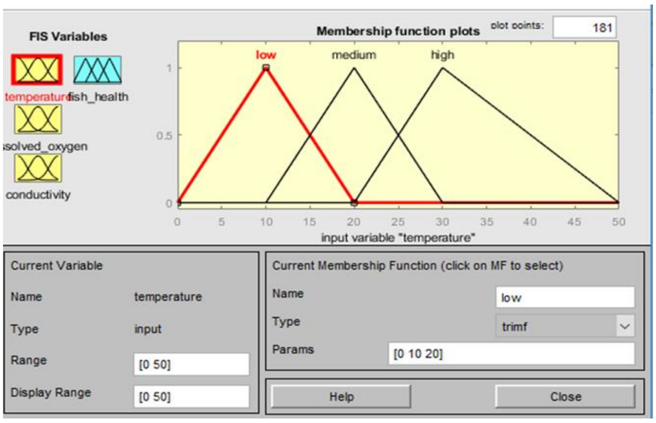

Figure 2: Membership Function Plots for Inputs 'Temperature'

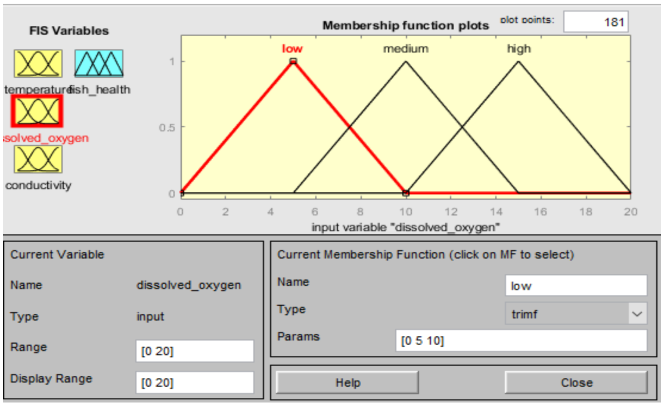

Figure 3: Membership Function Plots for Inputs 'dissolved oxygen'.

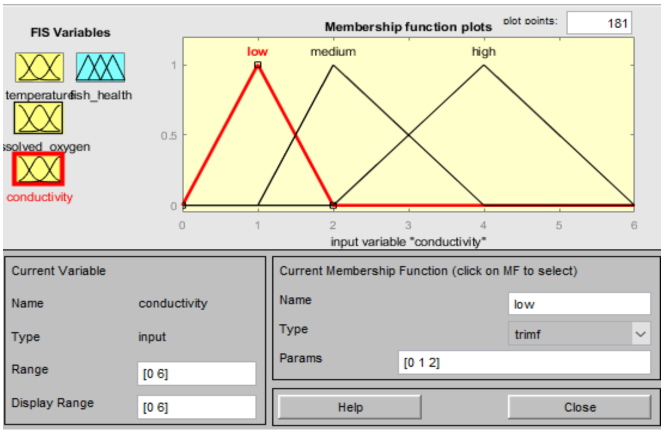

Figure 4: Membership Function Plots for Inputs 'conductivity'.

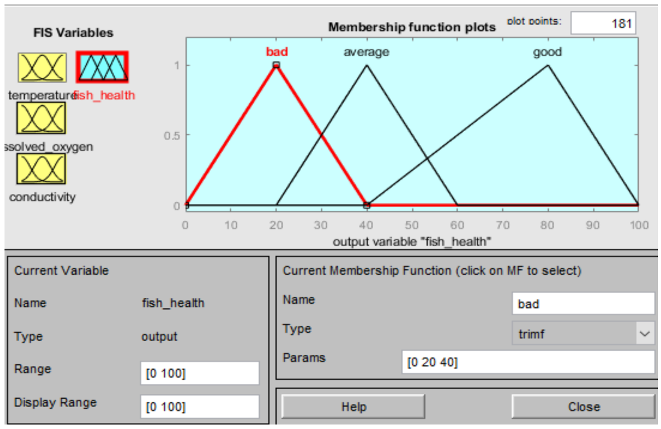

Figure 5: Membership Function Plots for output 'fish health'

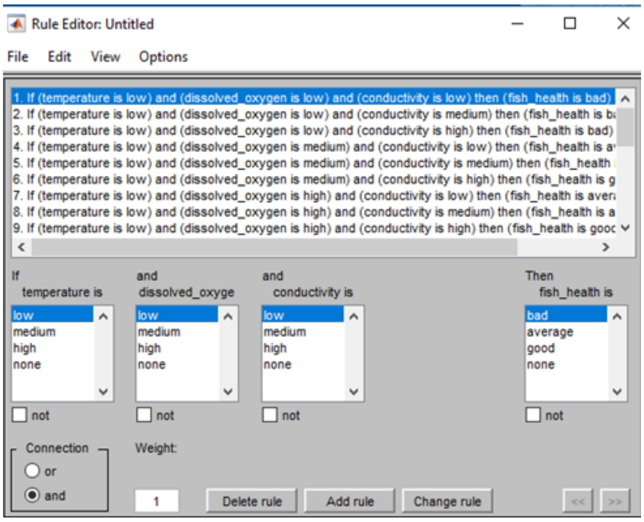

Figure 6 : Rule Editor showing 26 set of rules.

After plotting the input and output membership functions, various set of rules are created according to the various categories of stress parameters. Its simply like the permutation and combination of parameters joined together to showcase the fish health. For example, if temperature of water is low, dissolved oxygen content of water is low, conductivity of water is low where these parameters are combined by 'and' connection then the output parameter fish health is bad implies the percentage of fish health stands within 0 and 40 percentage. Like that if temperature of water is high, dissolved oxygen content of water is high, conductivity of water is high where these parameters are combined by 'and' connection then the output parameter fish health is good implies the percentage of fish health stands within 60 and 100 percentage. Total 26 set of rules are implemented.

4. Matlab Implementation

Fuzzy Controller Model for fish health aquaculture is given. fuzzy logic controller is created by using matlab Simulink. Output is displayed in the display.

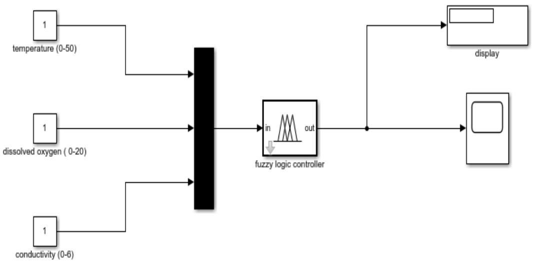

Figure 7: Fuzzy Controller Model for fish health aquaculture

5. Findings

With Fuzzy controller Model , we can observe fish health in aquaculture if we provide definite values for parameters like dissolved oxygen , conductivity and temperature .fuzzy logic control system controls input stress parameters such as temperature ,dissolved oxygen and conductivity and get output display as a % health of fish . Thus by implementing the FLC in the MATLAB with the help of fuzzy logic toolbox and MATLAB programming can be utilized to control the various stress factors on the fish. Developed system presents a display that show deflection in temperature, dissolve oxygen and conductivity on health of fish as output. This manuscript considers only three input parameters dissolved oxygen, temperature and conductivity.

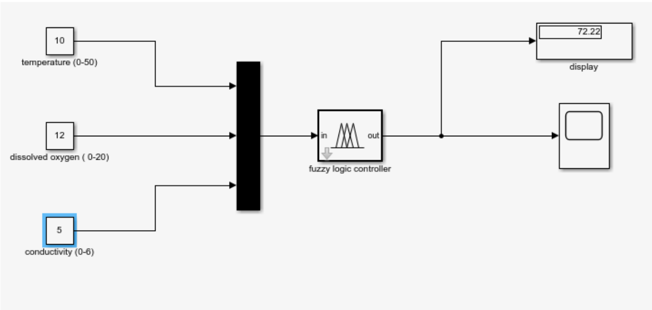

Figure 8 : example result of fish health if particular input is given

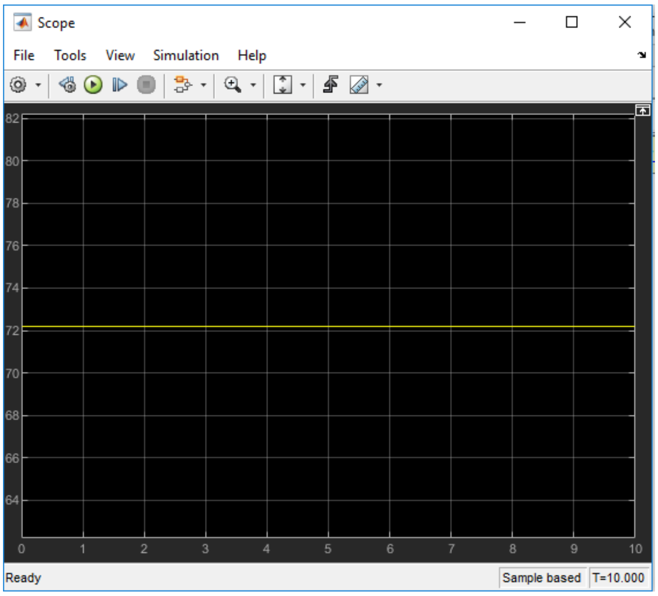

Figure 9 : scope of example result

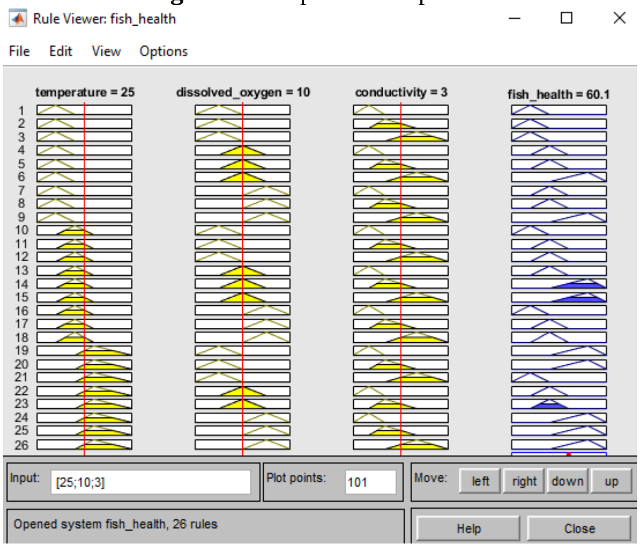

Figure 10 : Rule Viewer

Rule viewer show the set of 26 rules involved in simulation of fish health aquaculture with fish health as the output.

6. Fish Health Detection Based on ANFIS Model - Input Output Frame Work

According to the ranges for conditions of the fish one can predict the health of fish i.e.PH Value and Dissolved Carbondioxide. The main objective of fuzzy based aquaculture is to maintain in good condition for fish, therefore parameters such as PH Value and Dissolved Carbondioxide and condition must be adjusted accordingly. If the value of input variables is not suitable for good health of the fish, then that input variable has to be replaced. There are three membership functions for these parameters i.e., low, medium, and high. Each of these stress factors has different range. The type of membership function selected is triangular..

Table 4: The stress parameter ranges for fresh water aquaculture

Parameters	Desirable Range	Acceptable Range
PH Value	0-14	0-14
Dissolved carbondioxide	5–8 ppm	0–20 ppm

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Table 5: The ranges of various stress factor membership functions

Stress Parameters	Low	Medium	High
PH Value	0-7	4-9	6-14
Dissolved Carbondioxide	2-8	4-14	11-20

Table 6: The output effect on fish

Percentage of Fish Health	Bad	Average	Good
	0-40%	20-60%	40-100%

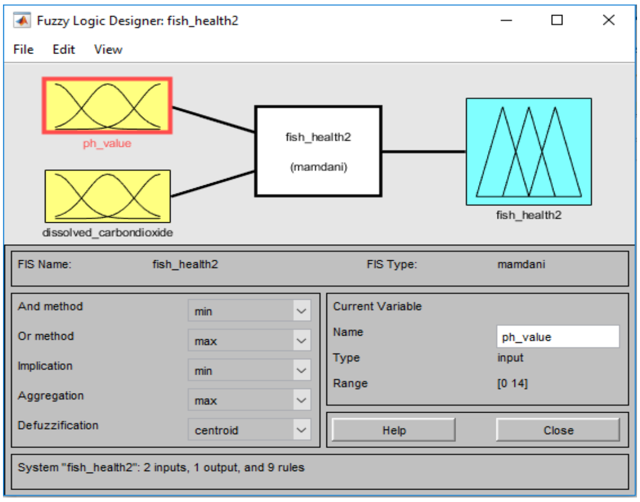

Figure 11: Fuzzy control view with inputs and outputs

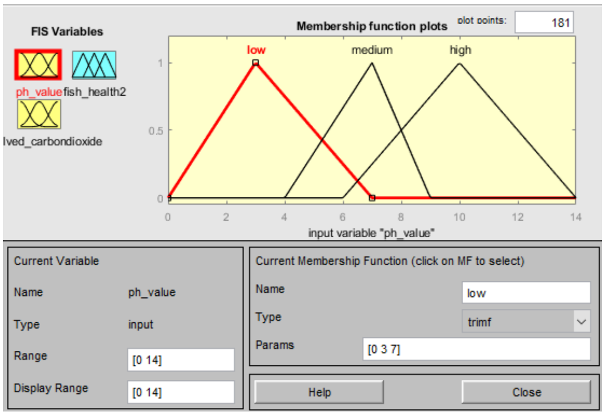

Figure 12: Membership Function Plots for Inputs 'PH Value'

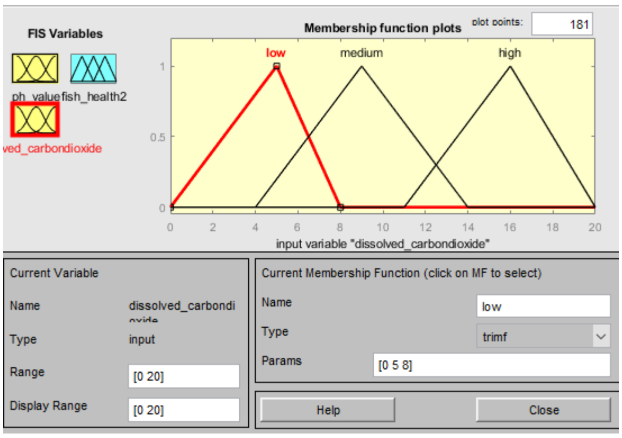

Figure 13: Membership Function Plots for Inputs 'Dissolved Carbondioxide '

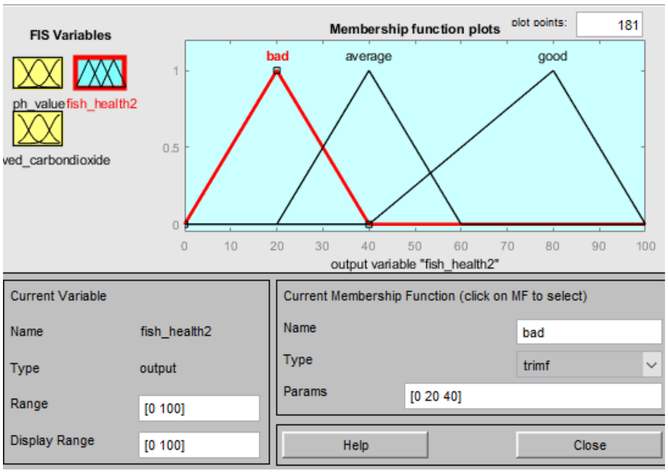

Figure 14: Membership Function Plots for Output Fish Health

7. Matlab Implementation

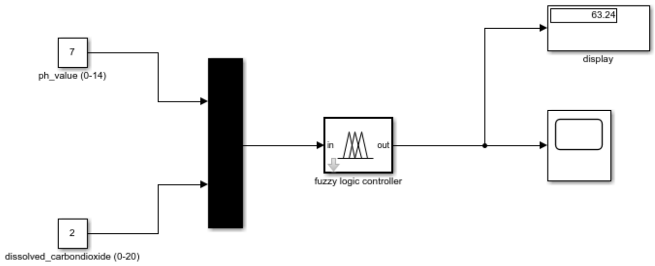

Figure1 5: Fuzzy Controller Model for fish health aquaculture.

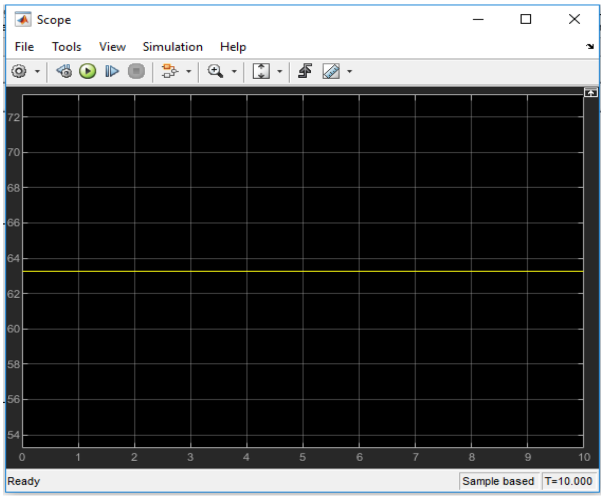

Figure 16 : scope of fuzzy controller model

PH VALUE	C02	FISH HEALTH
7	2	63.24
10	4	40
7	3	65.51
7	4	66.7
7	5	67.11
7	6	63.16
9	14	20
9	18	19
2	7	40
2	13	26.67
13	13	28.78
5	13	29.13
5	4	57.25
5	9	40
5	17	28.2
12	2	40
12	9	40
12	7	40
12	10	40
12	19	20
7	9	40
7	12	33.33
7	15	34.32
7	17	34.21
7	19	30
3	5	40
3	15	20
13	5	40
13	10	40
2	18	40

Figure 17: Training dataset

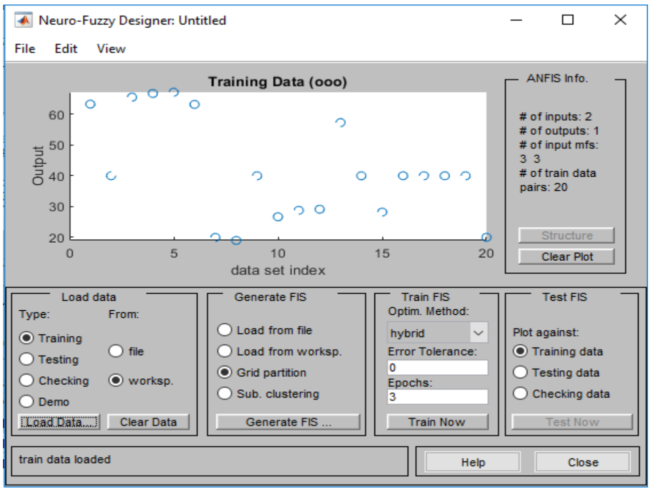

Figure 18: Training data output

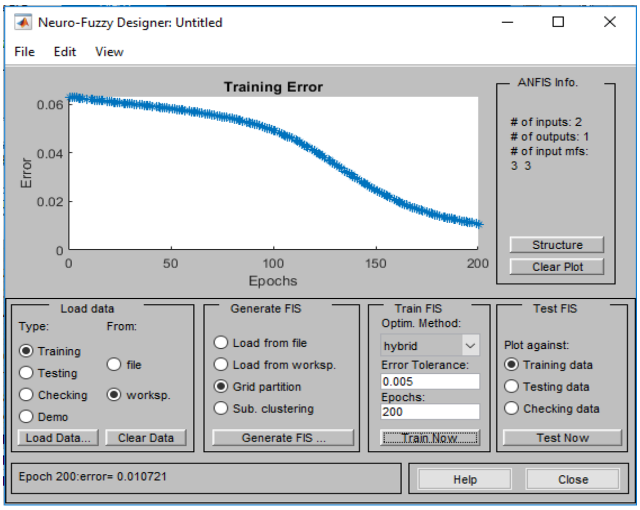

Figure 19: Obtained Training Error

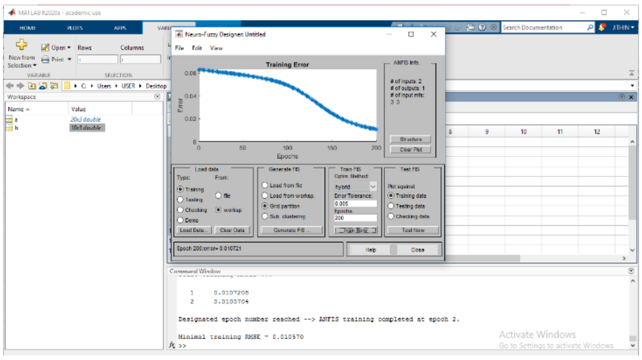

Figure 20: number of epoch and error value

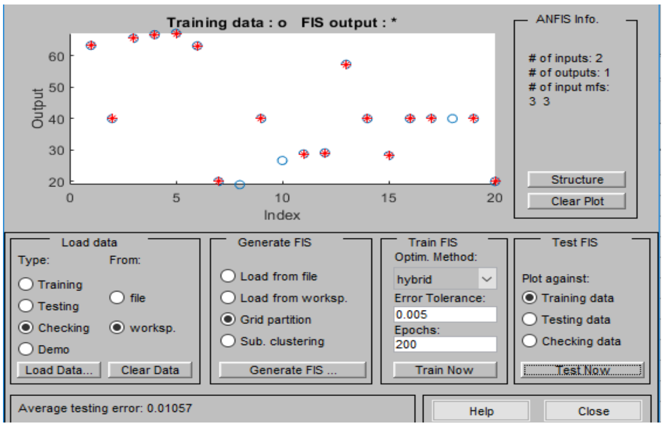

Figure 21: Loading checking data and plot against training data

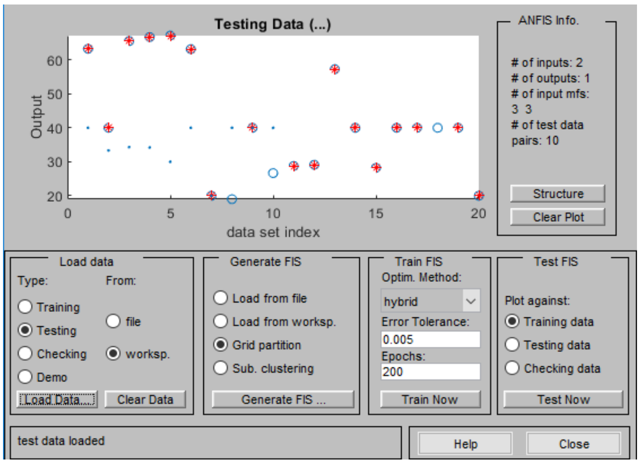

Figure 22: Loading testing data and plot against training data

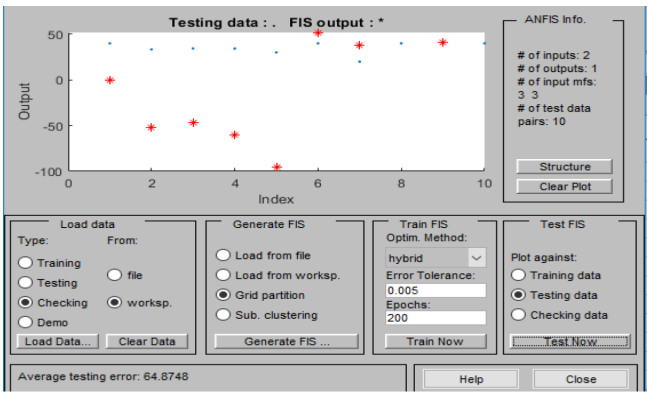

Figure 23: Loading checking data and plot against testing data

8. Result and Discussion

With ANFIS controller Model, we can observe fish health in aquaculture if we provide definite values for parameters like PH value and dissolved Carbondioxide.fuzzy logic control system controls input stress parameters such as PH value and dissolved Carbondioxide and get output display as a % health of fish. Thus by implementing the FLC and ANFIS Model in the MATLAB with the help of fuzzy logic toolbox and MATLAB programming can be utilized to control the various stress factors on the fish. Developed system presents a display that show deflection in temperature, dissolve oxygen and conductivity on health of fish as output. This manuscript considers only three input parameters PH value and dissolved Carbondioxide

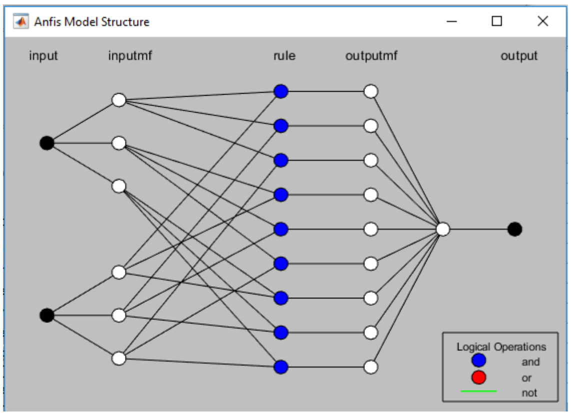

Figure 24: Model System of ANFIS

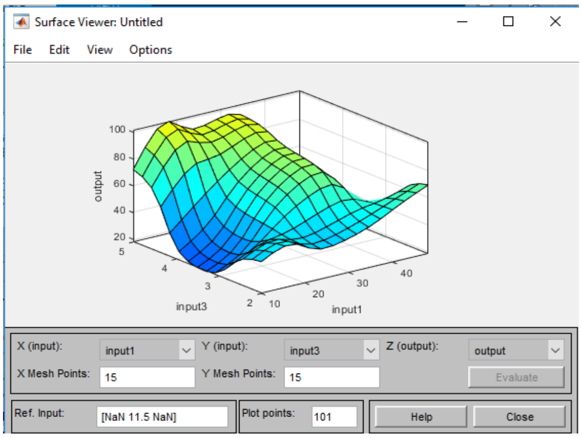

Figure 25: Surface viewer

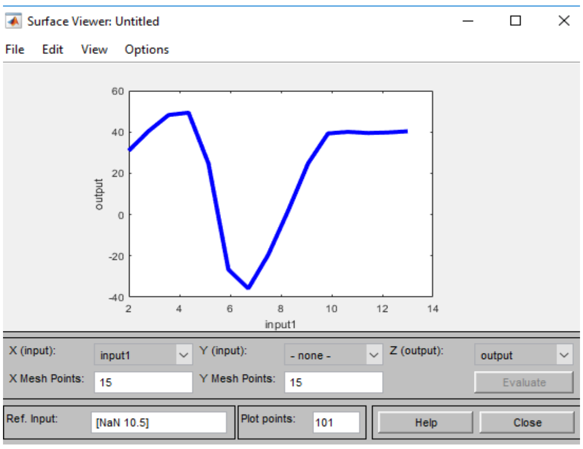

Figure 26: Surface viewer

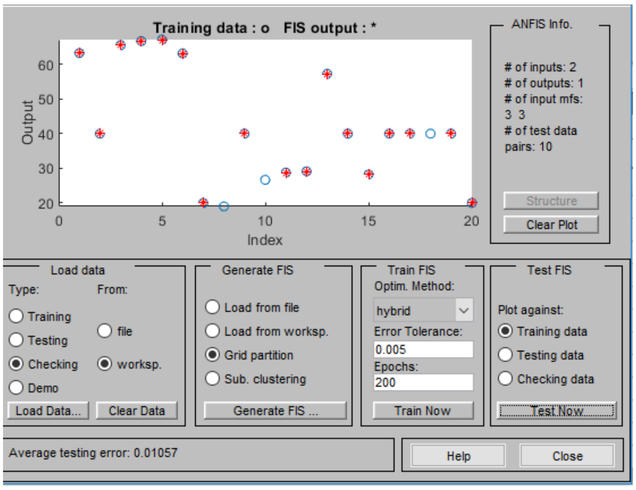

Figure 27: Finding average testing error

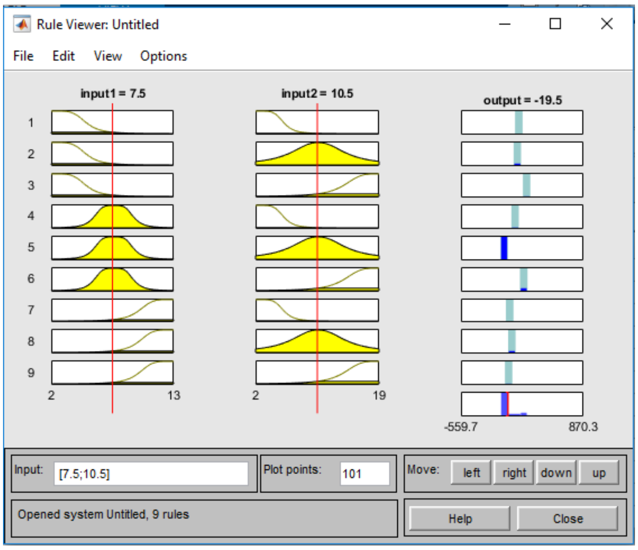

Figure 28: RuleViewer showing 9 set of rules and result obtained

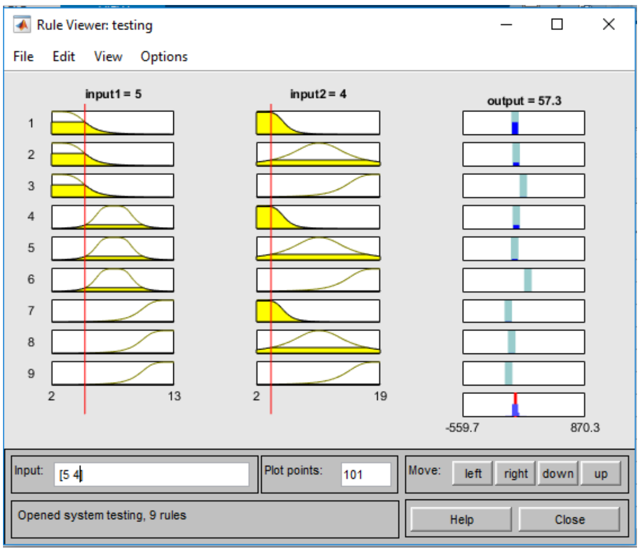

Figure 29: Obtained result for a particular input

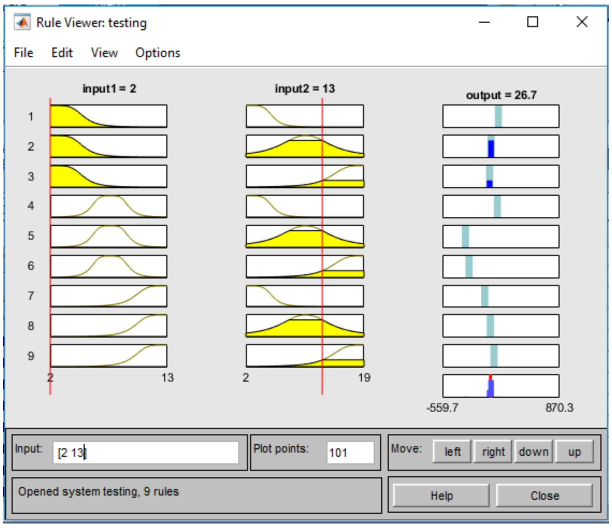

Figure 30: Obtained result for a particular input

9. Conclusion

Fuzzy logic controller (FLC) provides a method to construct controller algorithms in a user-friendly way closer to human thinking and perception which can reduce the controller development time. Here Fuzzy logic proved to be a valuable tool for translating the dive log data into quantitative form. Temperature, salinity, photoperiod, pH, dissolved oxygen, water flow and water level were monitored and controlled in a closed, recirculating seawater raceway.

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Author Profile

Jithin V A Working as Assistant Professor Adhoc, Department of Mechanical Engineering at NSS College of Engineering Palakkad. Received B Tech in Mechanical Engineering from Government Engineering College Bartonhill, Trivandrum (under APJ Abdul KalamTechnological University, Kerala) and M.Tech in Mechatronics from Vellore Institute of Technology VIT University, Tamil Nadu, India.