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Tuning of Single Input Fuzzy Logic Controller using Linear Control Surface Approximation for Underwater Remotely Operated Vehicle (ROV) – Depth Control

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ABSTRACT – This paper presents tuning process of single input fuzzy logic controller (SIFLC) using linear control surface method. This method used to tune variable parameter in SIFLC for underwater Remotely Operated Vehicle (ROV) focusing on depth control. The Linear Control Surface (LCS) method will focus on the gradient of a linear equation to give the optimum performances to reduce the percentage of overshoot, faster rise time and settling time in the system response. The variable obtained in Signed Distance method used in SIFLC was tuned by linear equation of the SIFLC parameter slope. The LCS has shown better performances of the control system.

1. INTRODUCTION

This research was nspired by the tuning method used in the single input fuzzy logic controller (SIFLC) to control the depth for underwater Remotely Operated Vehicle (ROV). The SIFLC used Signed Distance method as discussed in [2] to tunethe parameter from the conventional fuzzy logic controller (FLC). An interest to tuning the SIFLC parameter is about to simplified the FLC as discussed by Aras[1]. The conventional FLC is Multiple input Single Output (MISO) simplified to SIFLC as Single Input Single Output (SISO) as discussed in [3]. The Linear Control Surface method will simplify the SISO into slope of linear approximation control. Figure 1 shows the prototype of underwater ROV used at Universiti Teknikal Malaysia Melaka (UTeM) as the experimental uses.

Figure 1: The Prototype of ROV

2. METHODOLOGY

The research was focused to tune the parameter in the SIFLC and simplified the controller in linear control surface approximation to improve the performance of the system response for underwater ROV depth control.

a) Single Input Fuzzy Logic Controller (SIFLC)

The SIFLC is the method of tuning the variable parameter in conventional FLC as in [4] which gives an improvement in terms of reducing the percentage of overshoot and faster rise time. The SIFLC shown in Figure 2 used in the previous research controls the left thruster and right thruster separately.

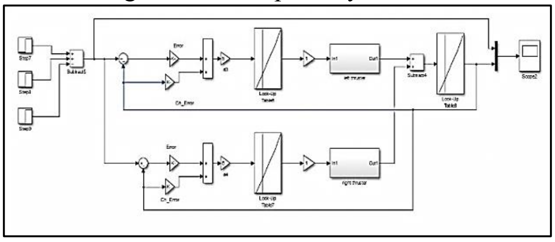

Figure 2: SIFLC controller for two thrusters

b) Linear Control Surface Approximation

The Linear Control Surface method is the tuning process to improve the performances of system response for underwater ROV depth control. In order to improve the performances of system response, the variable parameter in the SIFLC which set in Look-up Table were described in linear equation. The slope of linear line in the look-up table in SIFLC were taken as the linear equation of $y = mx + c$ which $y = 0.35$ and $x = 0.13$ and $m = 4.91$ as shown in Figure 3.

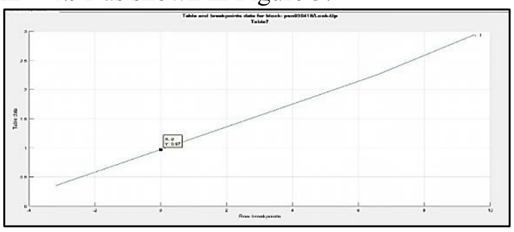

Figure 3: Variable parameter in SIFLC.

The linear control surface approximation described as the product of the gradient parameter and the approximation of point intersection of y axis in the plotted graph of look-up table and described on the simulation as shown in the Figure 4.

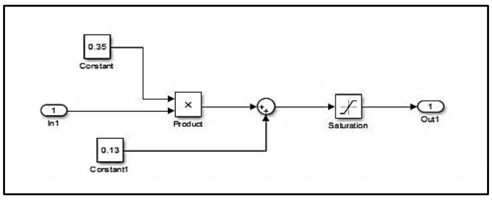

Figure 4: Linear control surface approximation method.

The structure of linear control surface approximation as shown in Figure 4 was put into sub block which replace the look-up table as shown in Figure 5. The detail of the linear control surface approximation method was discussed by Aras et al (2013). The linear control surface based on the look-up table parameter and also can be gain from the open loop experimental which the result almost the same for this method. This method will create the algorithm for linear control system and simpler to apply to real time controller.

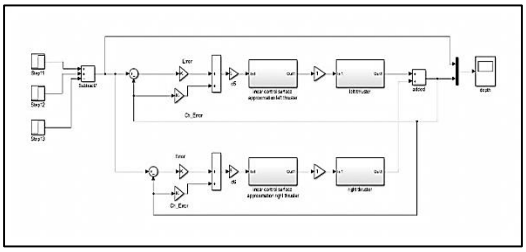

Figure 5: Underwater ROV with two thrusters for depth control.

3. RESULT AND DISCUSSION

The study on the slope of linear equation as the inference engine for FLC using the linear control surface approximation method was shown an improvement and at the same time simplified the SIFLC into linear algorithm equation. The operating conditions for tuning into approximate linear by generalize derives the output equation of linear surface. The system response for the linear control surface approximation method is shown in Figure 6.

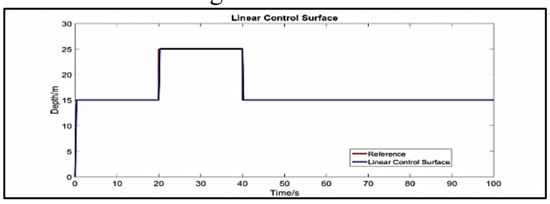

Figure 6: System response for linear control surface approximation.

The linear control surface approximation show the positive response in terms of rise time and settling time which the linear control surface shown the rise time = 23.76ms and settling time =14.25ms and overshoot = 0.51% while the SIFLC show the rise time = 42.73ms and settling time = 30.94ms and overshoot= -0.142% as shown in Table 1.

Table 1 Performances of system response

Controller	Rise Time (ms)	Percent Overshoot (%)	Settling time (ms)
SIFLC	42.73	-0.142	30.94
Linear Control Surface	23.76	0.51	14.25

4. CONCLUSION

According to the result, the linear control surface approximation method achieved the objective to improve the performances in system response in terms of overshoot, rise time and settling time by tuning the variable parameter in the look-up table of SIFLC. This method focused on the slope of the linear equation to give optimum performances for underwater ROV depth control. The method used can be the fastest calculation for SIFLC as fuzzification rule inferences and defuzzification process are reduced. The operation condition to use the linear control surface for tuning the parameter determine the output equation.

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REFERENCES

[1] Aras, M.S.M., Abdullah, S.S., Othman, S.Y.B., Sulaiman, M., Basar, M.F., Zambri, M.K.M. & Kamarudin, M.N. (2016). Fuzzy logic controller for depth control of underwater remotely operated vehicle. *Journal of Theoretical & Applied Information Technology*, 91(2).

[2] Choi, B., Kwak, S., Kim, B. K. (2000). Design and Stability Analysis of Single-Input, 30(2), 303–309

[3] Aras, M. S. M., Kassim, A. M., Khamis, A., Abdullah, S. S., & Aziz, M. A. A. (2013). Tuning factor the single input fuzzy logic controller to improve the performances of depth control for underwater remotely operated vehicle. *UKSim-AMSS 7th European Modelling Symposium on Computer Modelling and Simulation,* 3–7.

[4] Azmi, M.N., Aras, M.S.M., Aripin, M.K., Harun, M.H., Rusli, A.H., Sulaiman, M. & Rizman, Z.I. (2018). An improved of dual single input fuzzy logic controller for underwater remotely operated vehicle (rov)–depth control. *Journal of Fundamental and Applied Sciences*, 10(3s), 951-966

[5] Aras, M., Shahrieel, M., Jaafar, H.I. & Anuar, M.K. (2013). Tuning Process of Single Input Fuzzy Logic Controller Based On Linear Control Surface Approximation Method For Depth Control Of Underwater Remotely Operated Vehicle. *Journal of Engineering and Applied Sciences*, 8(6), 208-214.