Design of Tracking System and Disturbance Rejection using Neural Networks for Autonomous Underwater Vehicle (AUV)

Abdul Muis Prasetia[1], Trihastuti Agustinah[1], Joko Susila[1]

Abstract - Autonomous Underwater Vehicle (AUV) is under-actuated system with highly nonlinear dynamic and Multi Input Multi Output (MIMO). AUV has stability problem due to external disturbance. These characteristics cause the AUV is difficult to be controlled and to track the reference signal automatically. Based on these problems, this paper present tracking control design and disturbance rejection using Neural Networks for AUV with 6 Degree of Freedom (DOF). The proposed control system is used to generate control signals to overcome the nonlinear dynamics of AUV. The reference signal is processed using Line of Sight (LOS) method to obtain the desired yaw of AUV. Simulation results show that the AUV is able to track the reference signal even in the presence of ocean current disturbance.

Term Index - Autonomous Underwater Vehicle, Neural Networks, Line of Sight, ocean current, disturbance rejection.

INTRODUCTION

In this paper, we use AUV torpedo models with three actuators, the rudder, stern and propeller. Although the AUV has a simple structure, but the motion control is not easy because of the system characteristics (under-actuated system with strong nonlinear, and MIMO system) [1]. More specific cases are 3-axis motion control through the body [2,3].

In addition to the issue of tracking control, the AUV also has problems in stability caused by external disturbances, such as wave and ocean currents, and other disturbances in the form of solids. These disturbances are not only affect the AUV stability, but also on the performance and maneuverability AUV [1].

METHOD

Based on the obtained AUV model [4,5], the control stategy using Single Input Single Output (SISO) for roll, pitch, and yaw is selected (see Figure 1). The proposed control system is desired to provide good performance with fast response and minimum tracking error. Therefore, the neural network controller with 2 layers is used for each controller.

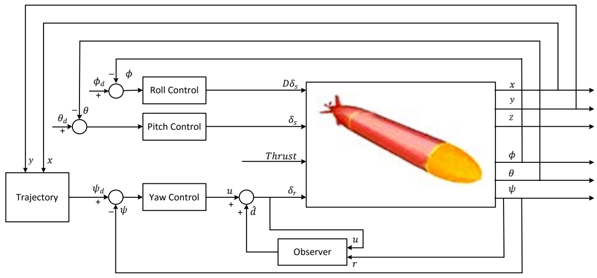

Figure 1. Control strategy

In this paper, disturbance rejection is done by using the observer. The observer design requires inverse models of the AUV system. It is difficult to obtain the inverse model of the AUV, because of the nonlinearity property. Therefore, the inverse model for yaw is approximated by a discrete model as shown in (1).

$$\frac{y(z)}{u(z)} = \frac{b_0 z + b_1 z^{-1} + \cdots + b_n z^{-n}}{a_0 z + a_1 z^{-1} + \cdots + a_n z^{-n}} \quad (1)$$

Equation (1) is the basic structure of the observer that will be converted into the form of Inverse Neural Network with weights $a_0, a_1, \ldots, a_n, b_1, \ldots, b_n$.

RESULT AND DISCUSSION

The trajectory used in simulation is as shown in Figure 2, with desired depth -10m. Simulation results show that the AUV movement can track the trajectory as depicted in Figure 3.

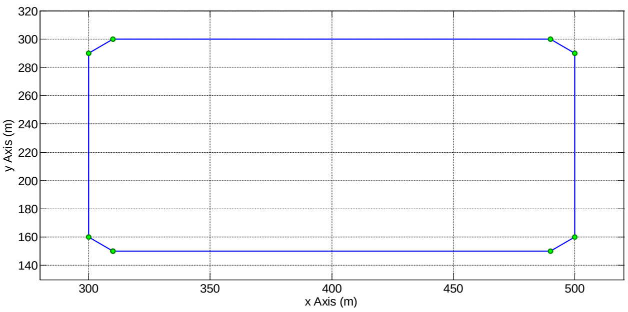

Figure 2. Trajectory

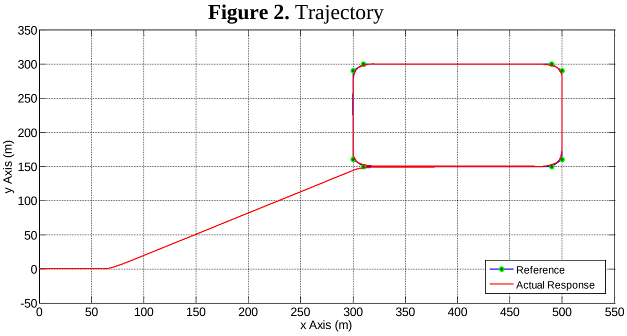

Figure 3. Movement of auv without external disturbance.

The AUV movement without any external disturbances is shown in Figure 3. The average tracking error is 0.19 m. From simulation results, it

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can be said that the proposed control system can work well.

The external disturbances is in the form of 2-dimensional ocean currents as shown in Figure 4. The velocity of the disturbance is ±1.5 m/s on the time interval $58 \leq t \leq 155$. The AUV movement in the trajectory tracking with/without the observer on the control system can be seen in Figure 5 and 6. The average tracking error without observer on the system is 7.17 m; while the average tracking error of the proposed control system is 0.24 m.

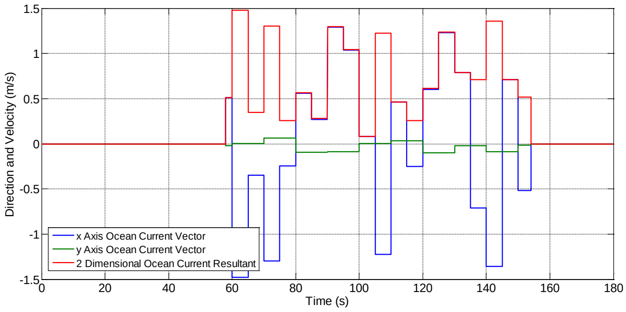

Figure 4. Ocean current disturbance.

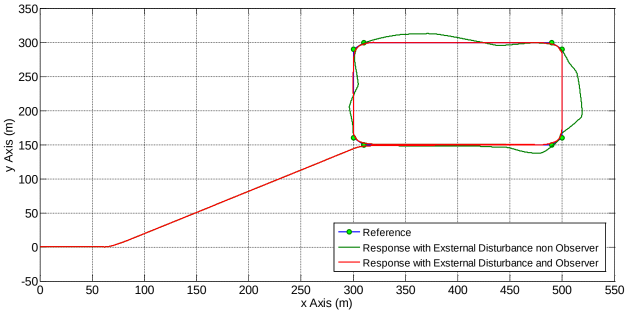

Figure 5. Movement of auv with external disturbance.

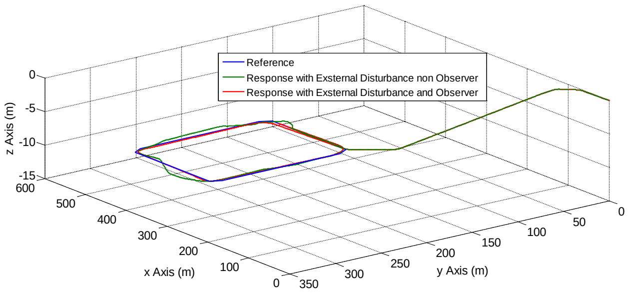

Figure 6. Movement of auv in xyz axis with external disturbance.

CONCLUSION

In this paper we present the tracking system and disturbance rejection design using Neural Network control method for AUV. The proposed control system is able to control the movement of the AUV to track the trajectory with an average tracking error of 0.19 m. If the external disturbance is present, the control system still work well with an average tracking error of 0.24 m.

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