

M5 LINEAR CONTROL OF THE YAW AND RUDDER LIMITATIONS FOR CORMORAN AUV

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Abstract

This work presents a detailed situation about the linear control design for the yaw in the Cormoran autonomous underwater vehicle (auv). The development includes the physical limitations of the rudder that involve more constraints for the control. The whole system is simulated in simulink and three different controls (P, PD, PID) are compared.

Keywords—auv; cormoran; linear control; rudder limitations

I. INTRODUCTION

The Cormoran is a low cost oceanic observation vehicle, which combines the characteristics of the ASVs and AUVs because its principle of motion [1]. This principle is based on the navigation at the surface level, where the vehicle has to follow a predefined path in the mission. The path is defined by a series of waypoints, in which the vehicles stops, dives and emerge vertically in order to obtain a profile of a water column.

This task leads to the need of a control system for the yaw which be fast and stable, but at the same time that take into account the physical constraints of the rudder, like saturation and reaction time. This work addresses this control using different linear controls (P, PD and PID) and comparing them with a root locus analysis that includes these constraints.

For this, it is organized as follows: section II shows a dynamic model of the vehicle in 3DoF with the rudder limitations; section III shows its linearization around a constant velocity; section IV presents the linear control designs and their implications according to the constraints; finally, section V shows the results and conclusions.

II. DYNAMIC MODEL

The dynamic model has been derived from the Fossen equations [2], and it was simplified to 3 degrees of freedom: surge (x), sway (y) and yaw (ψ). This model includes two terms that influences the turns, which are $Y_{uuf}U^2\delta_r$ and $N_{uuf}U^2\delta_r$, in where δ_r represents the action of the rudder, and its action is limited in the range $\pm 20^\circ$.

III. LINEARIZATION

In order to design a control system of the yaw it is necessary to obtain a linearization of the dynamic model. This linearization assumes that the surge velocity (u) is bigger compared with the other sway (v) and yaw (r) velocities that are smaller and taken zero. The resulting transfer function of the yaw (ψ) respect the rudder (δ_r) has the form: $G(s) = -b/(s(s+a))$, where a and b depends in the velocity of linearization u_0 .

IV. LINEAR CONTROL DESIGN

The transfer function $G(s)$ implies that while the gain loop is bigger, the control will be faster and exact in a step response. However, the gain loop affects directly the action of the rudder, which has a significant constraint. For this reason, in the control design is taken as definition that the gain loop cannot be bigger than the maximum rudder angle, i.e. 0.35 radians in order to not saturate the step response.

Figure 1 shows a root locus for a PD-control in where the gain loop has been limited and the zero is the varying variable (the final paper will extend to the other controls).

V. RESULTS AND CONCLUSIONS

The results show that due the rudder constraints the system has its own time responses depending of the forward velocity. For this reason, the margin for action of the linear control design is limited. As future work will be studied this design regarding different step sizes in order to have more margin with the gain loop.

REFERENCES

- [1] D. Roig Broman, M. Martínez Ledesma, B. Garau Pujol, A. Alvarez Díaz, J. Tintoré Subirana. "A Low-Cost Autonomous Vehicles For Coastal Sea Monitoring". Mediterranean Institute of Advanced Studies (CSIC – UIB). Autumn 2005.
- [2] Fossen, T. I. (2002). "Marine Control Systems: Guidance, Navigation and Control of Ships, Rigs and Underwater Vehicles", Marine Cybernetics AS, Trondheim. ISBN 82-92356-00-2.

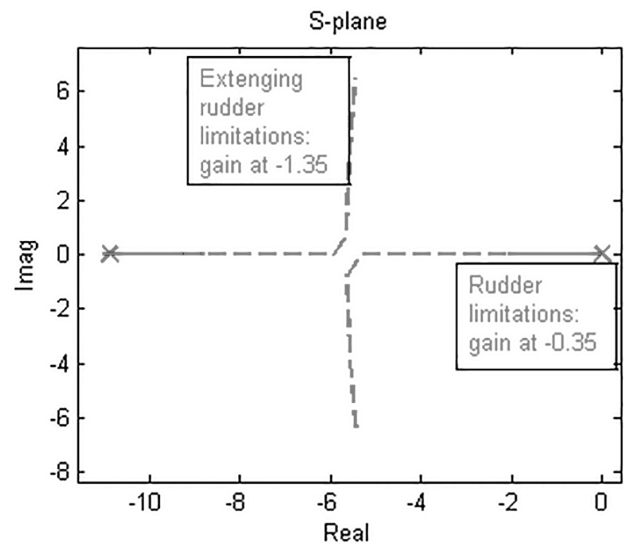


Fig. 1. Fig.1. Root locus for PD-control design