A platform floating algorithm based on fuzzy PID with nonlinear feedback

Haochen Hong \(^1\), Shunqi Yang \(^{1,2}\), Guannan Shi \(^1\), Gang Liu \(^3\), Guohua Xu \(^1\)

\(^1\) School of Naval Architecture and Ocean Engineering, Huazhong University of Science and Technology, Wuhan, Hubei, China
\(^2\) Kunming Shipborne Equipment Research & Test Center, Kunming, Yunnan, China
\(^3\) No.2 research Department, Wuhan Second Ship Design and Research Institute, Wuhan, Hubei, China

ABSTRACT

This paper proposes a new algorithm for the floating of the underwater platform. To eliminate the effect of the disturbance and improve the safety of the floating process, a fuzzy PID algorithm with a nonlinear feedback technique is used to control the underwater platform. Compared with the traditional PID algorithm and fuzzy PID algorithm, the proposed algorithm can keep the underwater platform within a smaller angle. In addition, the output of the winches is more smooth compared with the output of the traditional algorithm. The proposed algorithm is more in line with the requirements of the underwater platform floating algorithm.

KEY WORDS: Underwater platform; Nonlinear feedback; Fuzzy PID; Floating algorithm; anti-interference capability;

INTRODUCTION

With the rapid development of modern science and technology, the field of ship and ocean engineering has played an irreplaceable role in all aspects of modern society. With the increasing depletion of land resources, ocean exploration, as an important subject, has been growing steadily in the past two decades (Fossen, 2011). Among them, the underwater tension leg platform is a very important part. Because the underwater tension leg platform can enter the water while maintaining a large system, it can complete some large-scale experiments and projects. The underwater tension leg platform has a very broad application prospect in resource exploration and crude oil collection. However, the underwater tension leg platform system is huge and involves many systems, so it is difficult to establish a high-precision mathematical model. In addition, in the complex underwater environment, many disturbances need to be overcome in the control process, and the problems of actuator failure and communication failure need to be overcome in the control process. Therefore, the control core of the underwater tension leg platform is still facing huge challenges.

In recent years, there are many types of research on the control methods of underwater tension leg platforms. Xia et al. (2018) designed a three-layer sliding mode controller using the uncertainty prediction ability of a neural network and proposed a winch synchronization control strategy. The algorithm makes the motion of TLP more stable and has a stronger anti-interference ability; Zhang and Yang (2016) used the fuzzy PID control method to control the underwater platform, which has a good control effect in angle control and floating control of the platform; Zhang et al. (2014) proposed an observer-based optimal error tolerance control method for offshore steel jacket platforms, which realized real-time observation of hard to observe state variables and improved the reliability and work efficiency of offshore platforms. Nourisola et al. (2015) designed several types of sliding mode controllers to solve the control problem for an offshore steel jacket platform. The new method is very useful to deal with the nonlinear wave force.

Based on the above research, we can summarize the control core issues of the underwater tension leg platform as follows. First, in the process of platform movement, reduce the output time and eliminate overshoot of the system while keeping the speed of the platform. Second, during the simulation, considering the real working environment of the platform is necessary; Third, improving the anti-interference capability of the platform controller is essential. In addition, the current control problems of the underwater tension leg platform are mostly focused on the process of the platform's diving, and there are few controllers designed for the platform's floating. Therefore, the following works have been done to solve the above four problems,

1. Firstly, a fuzzy PID controller is designed for underwater tension leg platform floating. Under the disturbance, compared with the traditional PID controller, the proposed controller can eliminate most of the overshoot of the system while maintaining the platform speed, and the control curve is smooth.
2. Secondly, the nonlinear feedback technique is used to improve the anti-interference capability of the controller. With the usage of nonlinear feedback technology, the angle of the fuzzy PID controller under interference is less than that of the fuzzy PID controller.
3. Third, a speed limit function is designed for the speed output to make the winch output more in line with the actual situation. According to real situations, the movement of the platform is divided into the acceleration floating stage, uniform speed floating stage, and deceleration floating stage.

The remainder of this article is structured as follows. The platform model proposed controller design process, nonlinear feedback