Digital-twin modeling and ship-shore collaborative control of fully-actuated maritime autonomous surface ships

1st Jiaxue Xu
School of Marine Electrical Engineering
Dalian Maritime University
Dalian, Liaoning
xujiaxue1995@dlmu.edu.cn

2nd Nan Gu
School of Marine Electrical Engineering
Dalian Maritime University
Dalian, Liaoning
ngu@dlmu.edu.cn

3rd Dan Wang
School of Marine Electrical Engineering
Dalian Maritime University
Dalian, Liaoning
dwangdl@dlmu.edu.cn

4th Zhouhua Peng
School of Marine Electrical Engineering
Dalian Maritime University
Dalian, Liaoning
zhpeng@dlmu.edu.cn

***Abstract*—Maritime autonomous surface ships (MASSs) are the complex cyber-physical system that integrates computing, communication, and control. Unlike traditional trajectory tracking methods that lack bidirectional data flow, this paper investigates the ship-shore collaborative control problem of fully-actuated maritime autonomous surface ships. By integrating parallel intelligence technique into the ship motion control framework, a parallel dynamic control method is proposed, which extends the actual trajectory tracking problem to virtual space processing. Specifically, a high-order learning extended state observer is introduced to construct an artificial MASS system, enabling precise depiction of the motion characteristics of the actual MASS system. Next, a dipolar guiding vector field is designed to provide the reference orientation for the MASS, ensuring smooth tracking of the desired trajectory. Finally, based on the unknown total disturbance learned by the artificial MASS system and reference orientation generated by the dipolar guiding vector field, a parallel dynamic control law is designed to guide MASS to achieve the trajectory tracking task. Simulation results verify the effectiveness of the designed parallel dynamic control scheme for MASS.**

***Index Terms*—maritime autonomous surface ship, high-order learning extended state observer, dipolar guiding vector field, parallel dynamic control**