Domain Protection Guidance of Multiple Autonomous Surface Vehicles based on Differential Game and Control Barrier Functions

1st Fangyuan Xu
School of Marine Electrical Engineering
Dalian Maritime University
Dalian, China
xufangyuan34@dlmu.edu.cn

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

3rd Zhouhua Peng
School of Marine Electrical Engineering
Dalian Maritime University
Dalian, China
zhpeng@dlmu.edu.cn

4th Dan Wang
School of Marine Electrical Engineering
Dalian Maritime University
Dalian, China
dwangdl@gmail.com

***Abstract*—The problem of game countermeasure of autonomous surface vehicles (ASVs) at sea is a hot topic nowadays. In adversarial operations, it is a challenging task to formulate effective game strategies to deal with the movement state of the target and possible countermeasures. Domain protection is a typical confrontation game scenario between two opposing groups, in which the goal of the evaders is to reach the domain target, while the pursuers are to intercept and protect the target domain. In this paper, an optimal safety game guidance method is proposed for two groups of ASVs to realize the antagonistic game under the domain protection task. Specifically, a time-evolving optimal game strategy for the evaders and the pursuers is constructed based on the idea of differential game, to ensure the optimal game result for each team under any circumstances. Then, the quadratic programming problem based on control barrier functions (CBFs) is designed to further ensure the security in the game confrontation. Finally, the optimal safety game guidance strategy for the ASV players is designed based on the auxiliary variable method, so that the pursuers can successfully intercept the evaders and complete the task of protecting the domain target when both teams use the optimal strategy. By using the Hamilton-Jacobi-Isaacs (HJI) equation, it is proven that the proposed optimal game strategy is reliable. Simulation results show that the adaptability of the proposed method in the domain protection game countermeasure task.**

***Index Terms*—Autonomous surface vehicles, domain protection, differential game, control barrier functions, optimal safety game guidance.**