Cooperative Advanced Motion Control of Aerial and Marine Vehicles for Multipurpose Applications

Shahriar Hassan [1]

[1]University of Toulon

MARINE & MARITIME INTELLIGENT ROBOTICS

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Introduction

In today's era of technological advancements, the integration of aerial and marine vehicles has emerged as a pivotal strategy for addressing environmental challenges. This project aims to enhance cooperative Unmanned Surface Vehicle (USV) and Unmanned Aerial Vehicle (UAV) systems for applications such as marine search and rescue and cross-medium operations. Inspired by the natural transition abilities of certain organisms between water and air, the project addresses current limitations like inflexible underwater motion and unstable medium conversion.

Motivation

- Extended surveillance & detailed inspection
- Complementary perspective for mapping & monitoring
- Multimodal sensing & real-time data integration
- Increase operational efficiency, safety and accessibility
- A cquire environmental data in poorly chartered areas

State-of-the-Art

- In [1]a deep learning-based visual navigation and reinforcement learning control system for a cooperative USV-UAV system
- It enhanced motion control positional accuracy, computational efficiency, and USV control under wave disturbances for marine search and rescue.
- In [4], a cooperative problem for multiple USVs and UAVs in a path-following operation, focusing on lower design complexity and constrained was shown
- This paper [2] identified issues such as inflexible underwater motion and unstable medium conversion.
- The article [6] proposes a solution for cooperative control of multiple autonomous vehicles operating under strict spatial and temporal constraints
- The methodology (figure 4) involves three steps: generating feasible spatial paths and speed profiles for each vehicle, and decoupling spatial and temporal assignments.

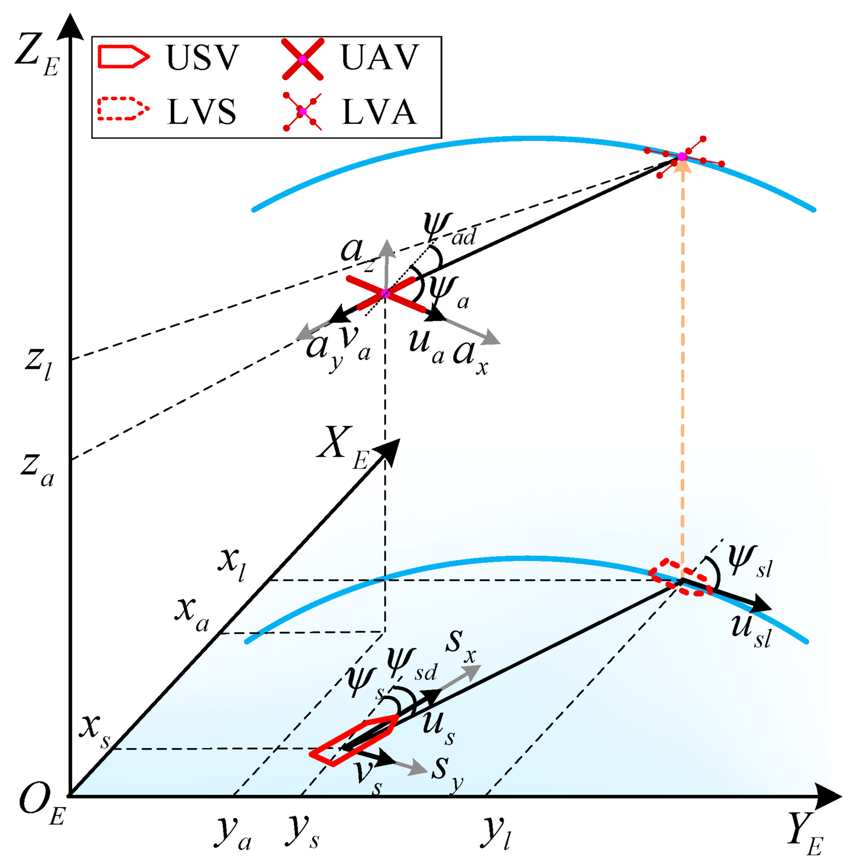

Figure 1. LVS-LVA guidance framework of the USV-UAV system [3]

The LVS-LVA guidance principle represents a sophisticated and collaborative approach to vehicle control, leveraging the strengths of both marine and aerial platforms. The guidance law of the yaw degree for UAV-UAV can be expressed as equation,

$$\psi_{sd} = \frac{1}{2}[1 - \operatorname{sgn}(x_{sl} - x_s)]\operatorname{sgn}(y_{sl} - y_s)\pi + \arctan\left(\frac{y_{sl} - y_s}{x_{sl} - x_s}\right) \quad (1)$$

$$\psi_{ad} = \frac{1}{2}[1 - \operatorname{sgn}(x_{al} - x_a)]\operatorname{sgn}(y_{al} - y_a)\pi + \arctan\left(\frac{y_{al} - y_a}{x_{al} - x_a}\right) \quad (2)$$

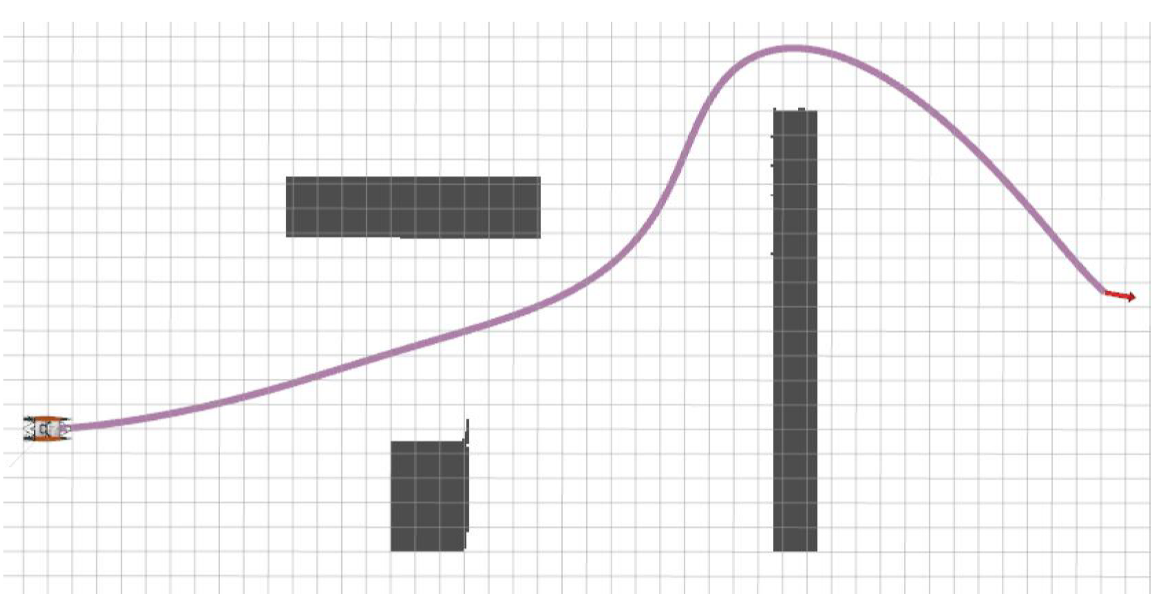

Figure 2. Global trajectory generation performance of the USV-UAV cooperative system. [5]

Here we can see that the generated trajectory not only meets the collision avoidance condition.

Proposal

- To study, design, and evaluate the performance of advanced nonlinear control algorithms
- Aerial/marine vehicle coordination by resorting to theoretical tools
- State-of-the-art control algorithms to explicitly address the dynamics of the vehicles

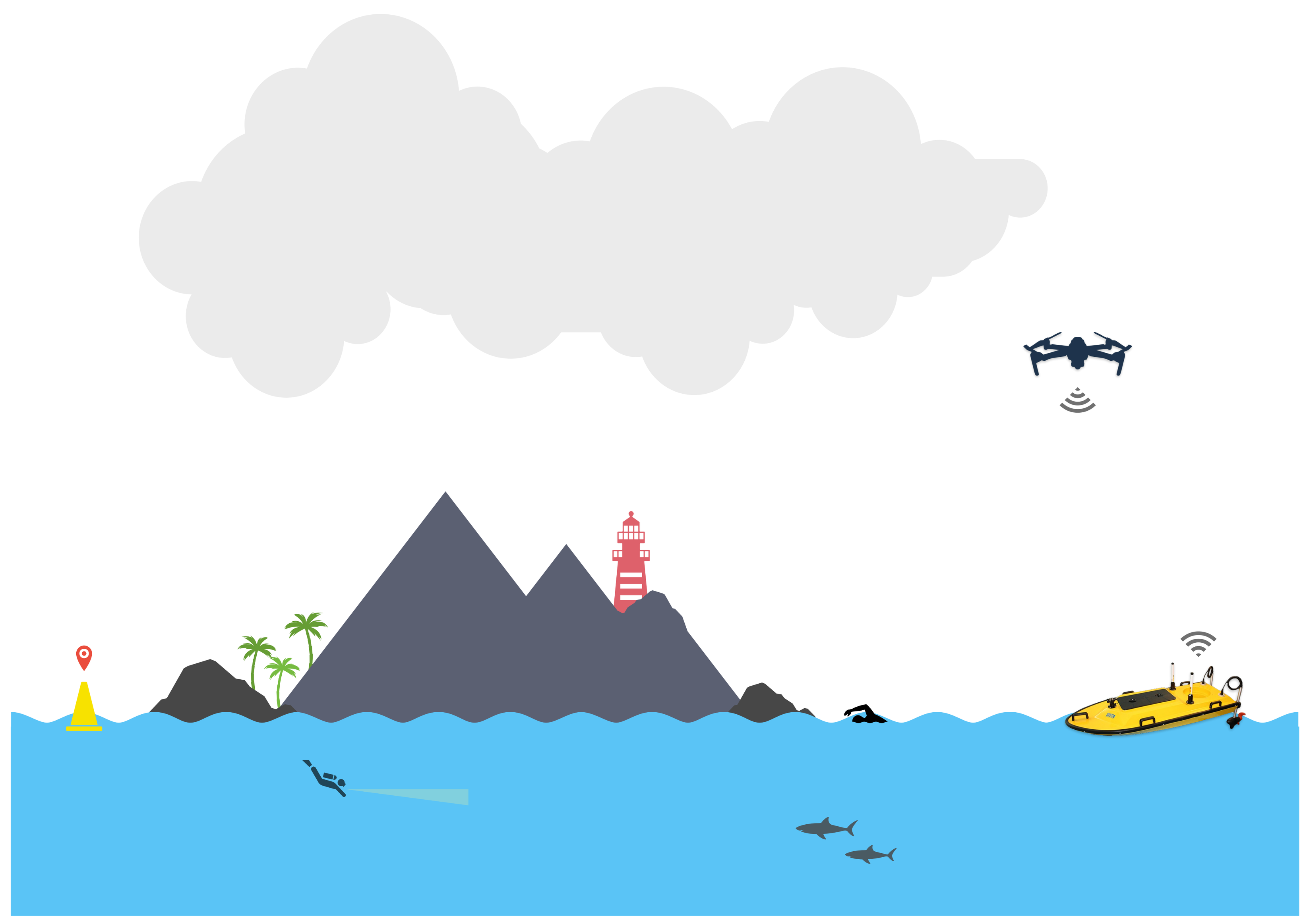

Figure 3. Overview of the Project

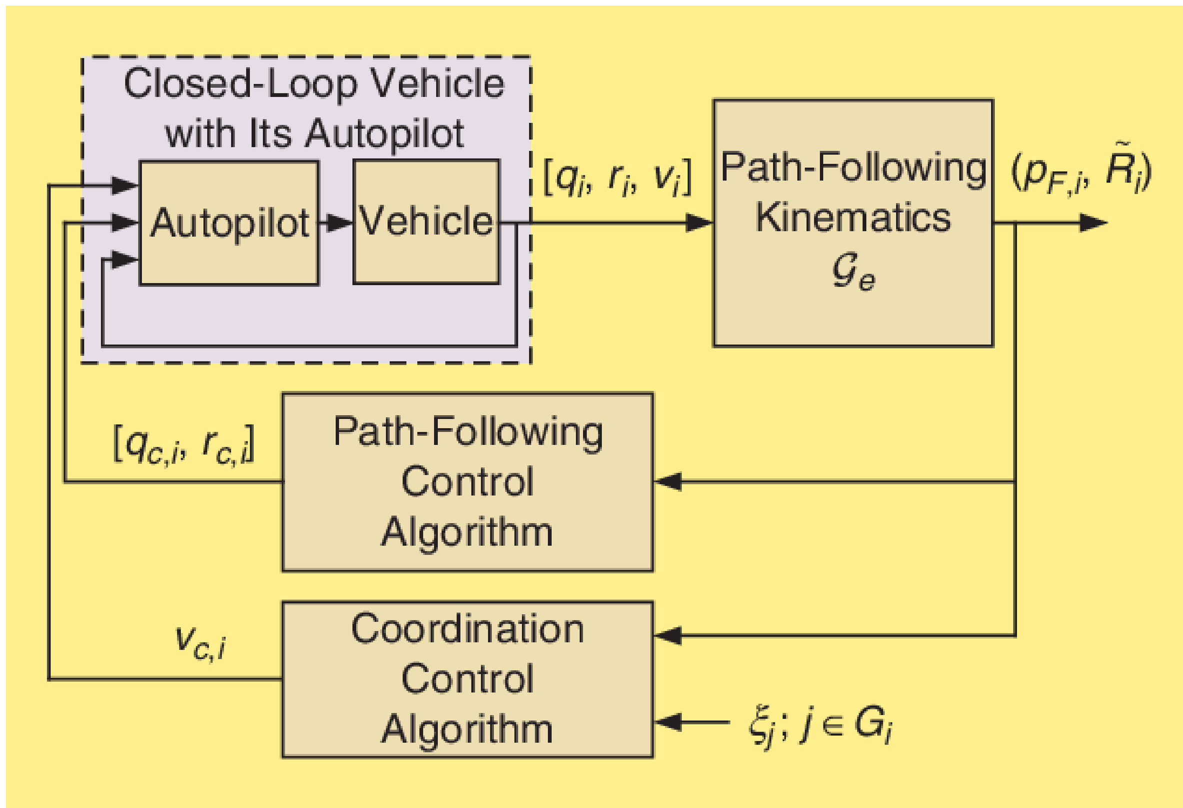

Figure 4. Closed-loop control for cooperative control architecture [6]

Expected thesis contribution

- Designing of cooperative path following and coordinated trajectory tracking
- Implementation and assessment of the performance of the developed algorithms
- Finding the best method by qualitative and quantitative analysis
- Successfully incorporating MPC (Model Predictive Control)

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