MARINE & MARITIME INTELLIGENT ROBOTICS

Takeoff and landing of an UAV on a surface vehicle for sustained presence at sea

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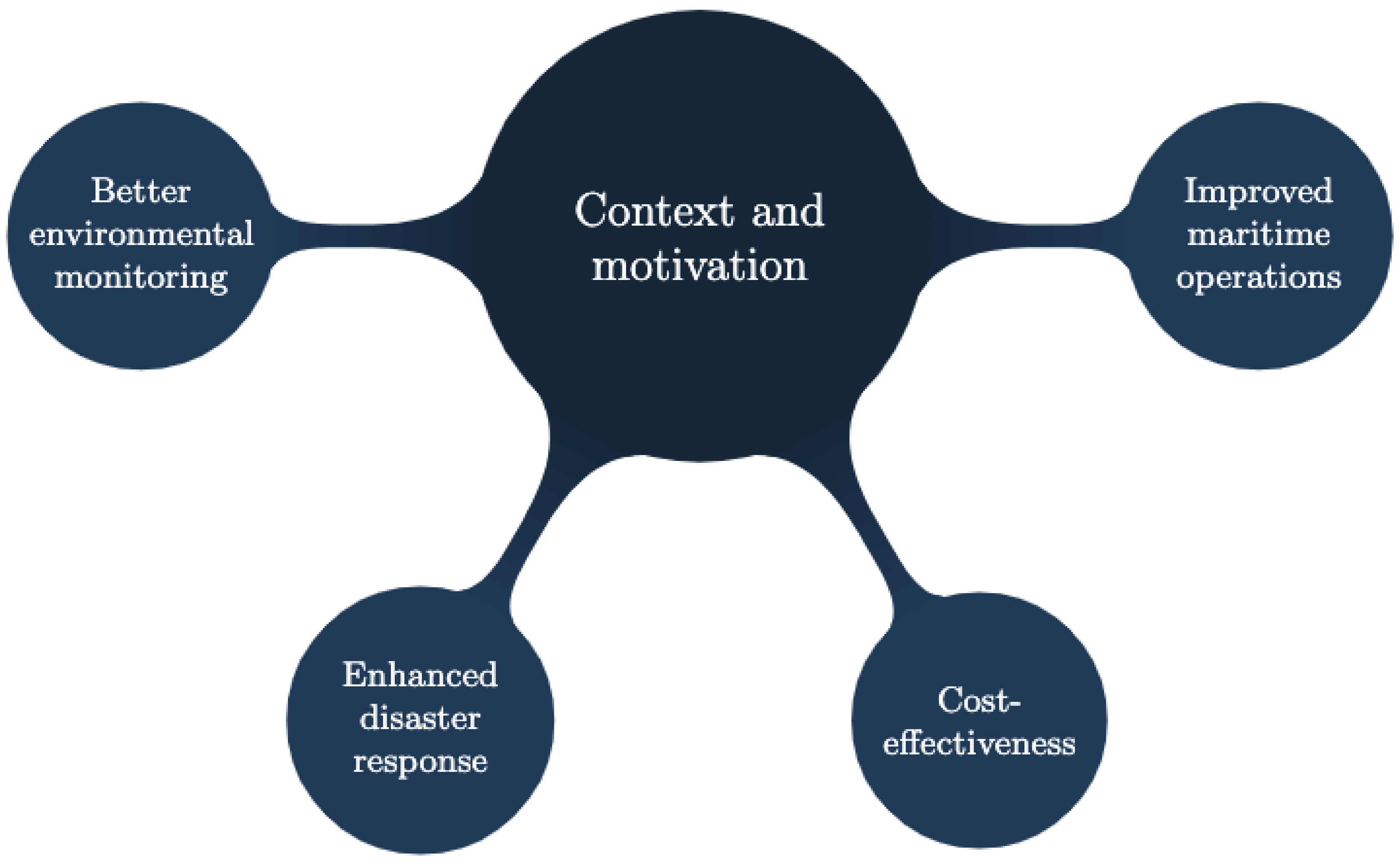


Research objectives

The present study proposes the following objectives:

- Study and develop vision-based control methods for landing an aerial vehicle on a marine vessel and on the ocean surface
- Explore the integration of GNSS (Global Navigation Satellite System) and IMU (Inertial Measurement Unit) data with visual cues to improve landing accuracy and reliability.
- Develop nonlinear adaptive control techniques to enable smooth landings in the presence of wave, current, and wind disturbances.

State-of-the-art

Research on Optimal Landing Trajectory Planning Method between an UAV and a Moving Vessel [3]

- Numerical iterative method to calculate the optimal landing trajectory, introducing an initial lead in the UAV's trajectory calculation to improve accuracy.
- This method overcomes the limitations of variational methods by calculating the optimal turning direction angle for the UAV during landing.

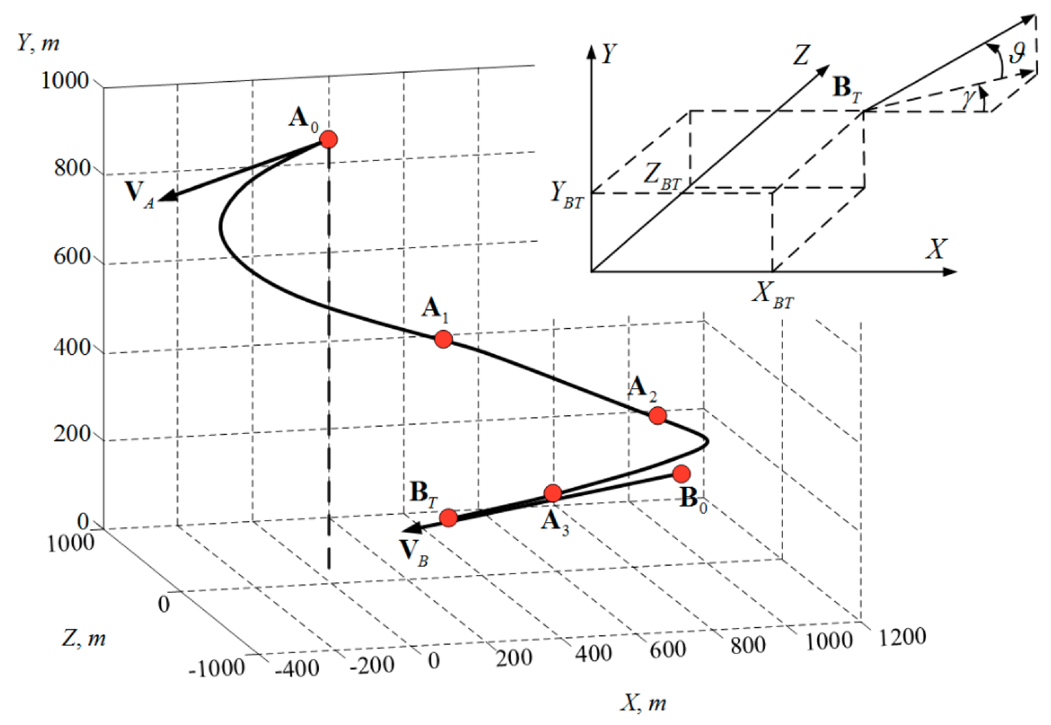


Figure 1. Approach trajectory between an UAV and a vessel

- It concludes that the method can compensate for the UAV's inertia and improve the efficiency of the landing trajectory.

Autonomous UAV Landing on a Moving Vessel: Localization Challenges and Implementation Framework [1]

- Gauss-Newton method-based localization system that reduces reliance on GPS, enabling accurate landing on vessels despite their motion.

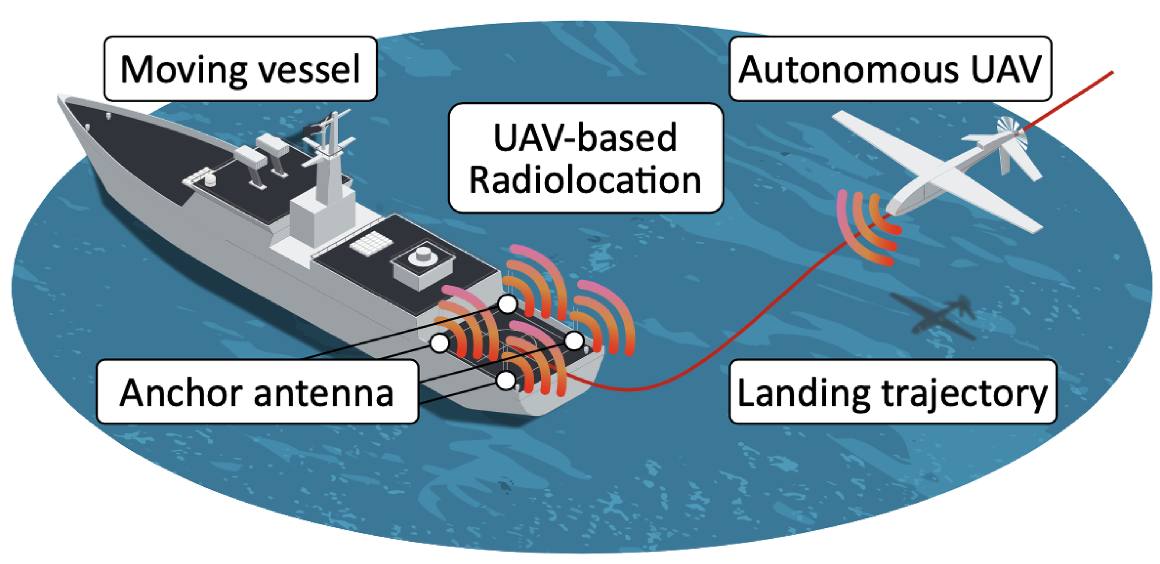


Figure 2. Concept of the vessel-UAV landing.

- The system's performance is validated through simulations for both fixed-wing and multi-rotor UAVs, showing near-perfect accuracy in the final meters of the landing trajectory.

Vision-Based Control For Landing an Aerial Vehicle on a Marine Vessel[2]

- Mathematical model for the quadrotor UAV and design of an inner-loop control system.
- Exploits image features on a textured target plane to derive a vision-based control law.
- The system uses the image of the spherical centroid of landmarks for position measurement and translational optical flow for velocity measurement.
- The proposed control law ensures convergence and maintains a positive distance between the UAV and the target, preventing collisions.

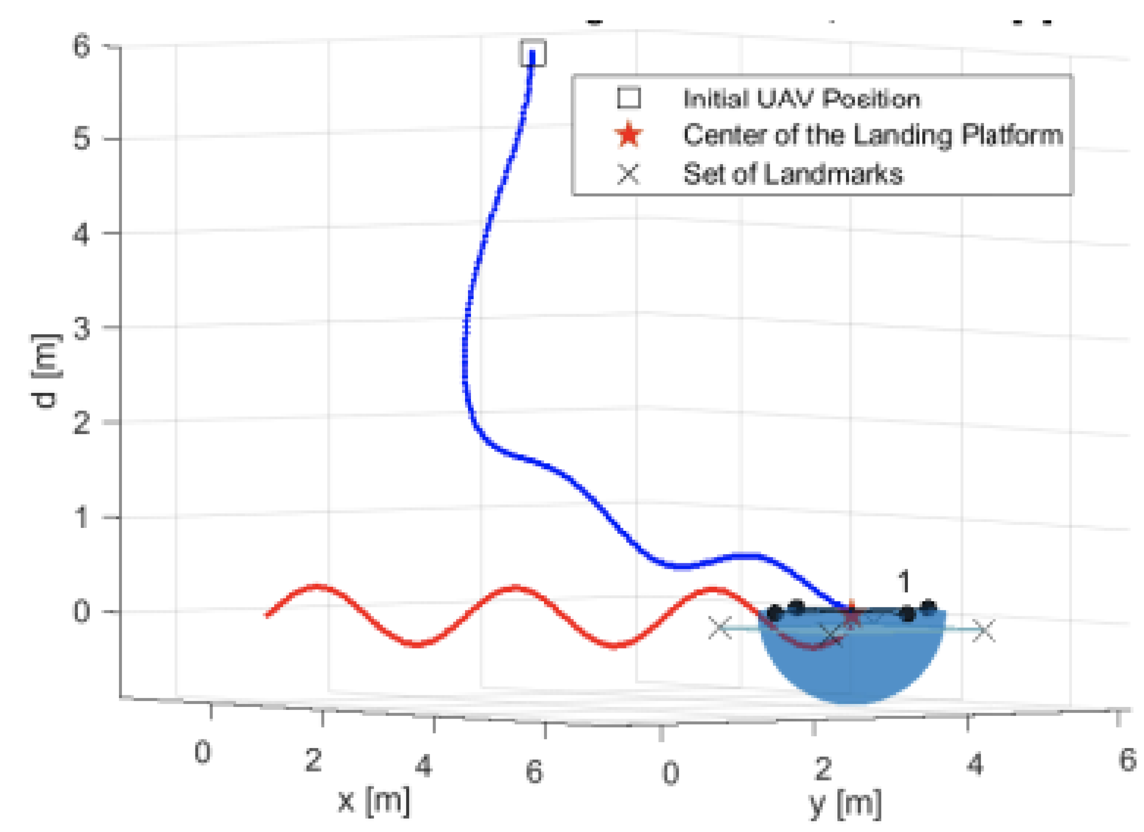
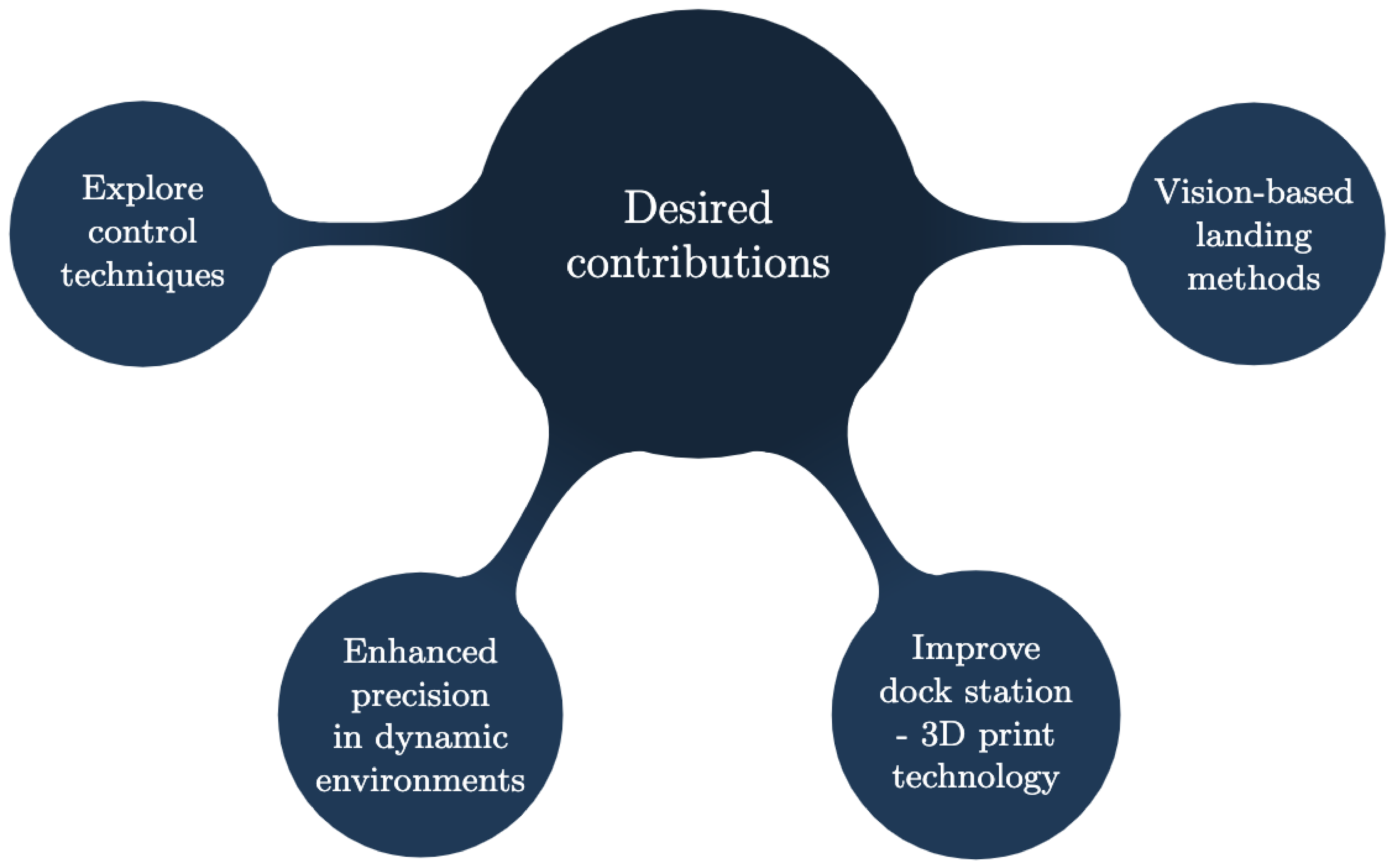


Figure 3. Simulation of a trajectory in 3-D space (x, y, d)

Conclusions

This research advances autonomous aerial vehicle operations by enhancing landing procedures on moving marine vessels and the ocean surface. Integrating vision-based control with GNSS and IMU data improves landing precision and reliability under challenging maritime conditions. Nonlinear adaptive control techniques address environmental disturbances like waves and wind, ensuring smoother and safer landings. These advancements enable more robust and versatile UAV applications in environmental monitoring, commercial inspection, continuous surveillance, and disaster response.



References

[1] Carlos Castillo, Alexander Pyattaev, Jose Villa, Pavel Masek, Dmitri Moltchanov, and Aleksandr Ometov. Autonomous uav landing on a moving vessel: Localization challenges and implementation framework. In *Internet of Things, Smart Spaces, and Next Generation Networks and Systems: 19th International Conference, NEW2AN 2019, and 12th Conference, ruSMART 2019, St. Petersburg, Russia, August 26–28, 2019, Proceedings 19*, pages 342–354. Springer, 2019.

[2] Haohua Dong. Vision-based control for landing an aerial vehicle on a marine vessel. *arXiv preprint arXiv:2404.11336*, 2024.

[3] Liguo Tan, Juncheng Wu, Xiaoyan Yang, and Senmin Song. Research on optimal landing trajectory planning method between an uav and a moving vessel. *Applied Sciences*, 9(18):3708, 2019.