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A space-saving steering method for underwater gliders in lake monitoring

Key words: Underwater glider; Lake monitoring; Space-saving; Steering method; Small pitch angle (SPA); Hydrodynamics

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Motivation

- To enlarge the spacing between different monitoring waypoints in lake monitoring, underwater gliders should have a space-saving steering capacity since lakes always have a limited vertical space.
- Appearance-fixed underwater gliders are more reliable, but may have worse steering capacity compared to the underwater gliders with rotatable rudders.
- A space-saving steering method for appearance-fixed underwater gliders is needed.
- Theoretical analysis tool lacks, since no hydrodynamic model is available for both small and large attack angles

Main idea

- Steering under a small pitch angle (SPA) restricts the increase of axial linear velocity of underwater gliders, which reduces the hydrodynamic drag torque along the steering axis.
- Steering under an SPA could enlarge the attack angle of underwater gliders, thus enhance the hydrodynamic traction torque along the steering axis.
- Steering under an SPA restricts the underwater glider linear velocity that perpendicular to the axial direction, which directly reduces the vertical space occupied by the steering process.

Main method

- To help analyze the steering process under an SPA, a hydrodynamic model available for both small and large attack angles is introduced .
- Steering capacity under different pitch angles are compared to find the relationship between steering ratio and pitch angle.
- Steering capacity under different roll angles and net buoyancy under an SPA are compared to find the optimal roll angle and net buoyancy configuration for steering process.
- Lake trial is conducted to verify the accuracy of the steering process model, and the space-saving capacity of the steering under an SPA.

Main results

- With the amended hydrodynamic model, the accuracy of the steering process model is acceptable.

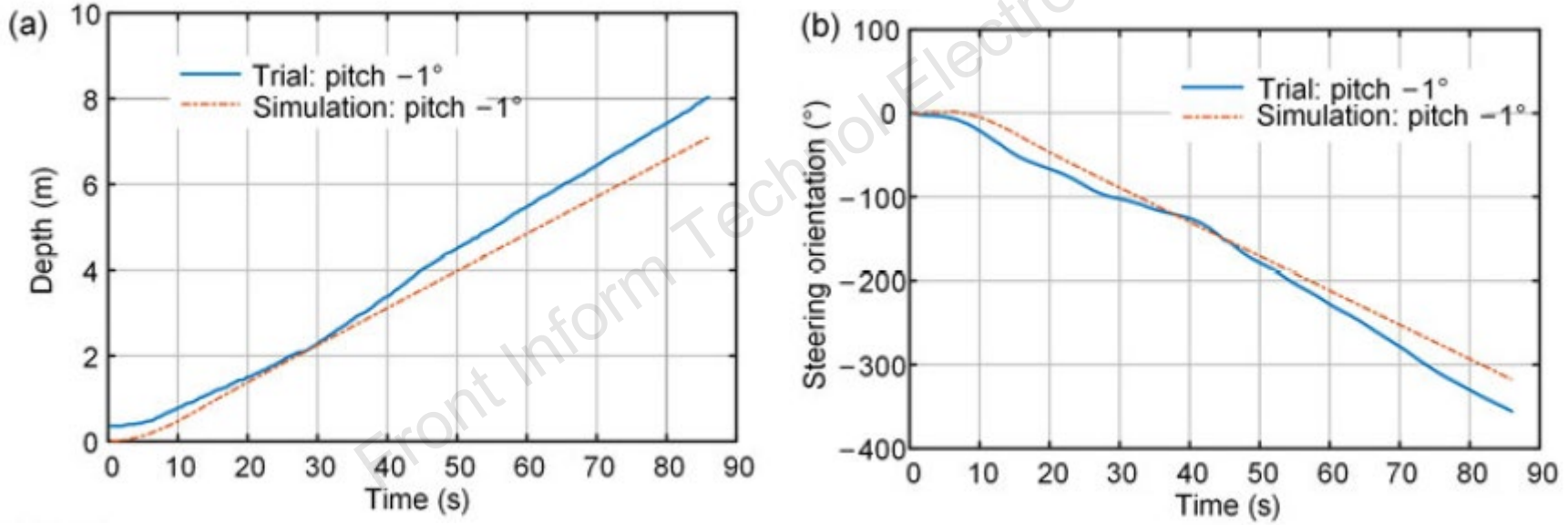
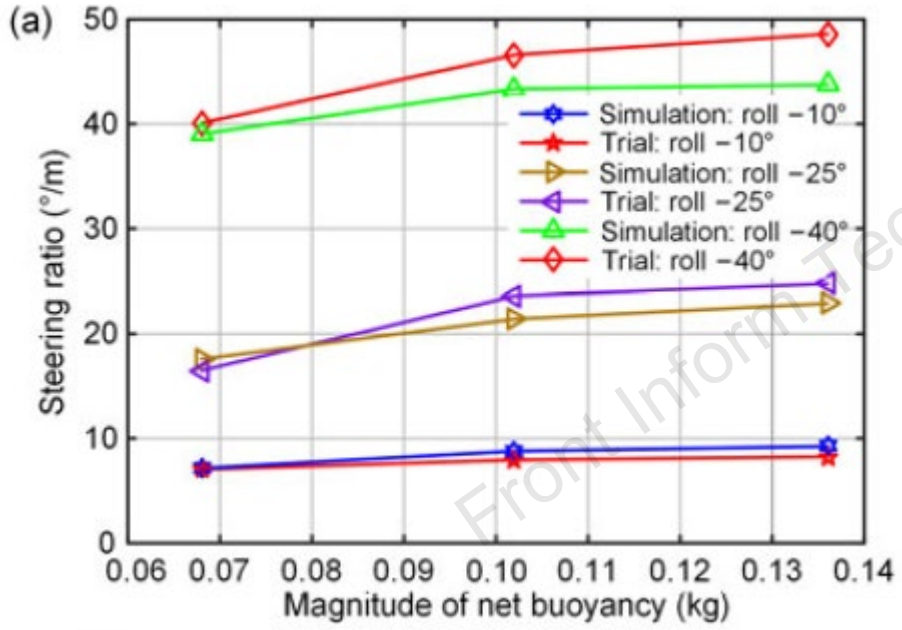


Fig. 11 Trialed and simulated gliding states for case B-1: (a) depth; (b) steering orientation

Main results

- Steering under an SPA enhances the steering ratio, which enhances the space-saving capacity .



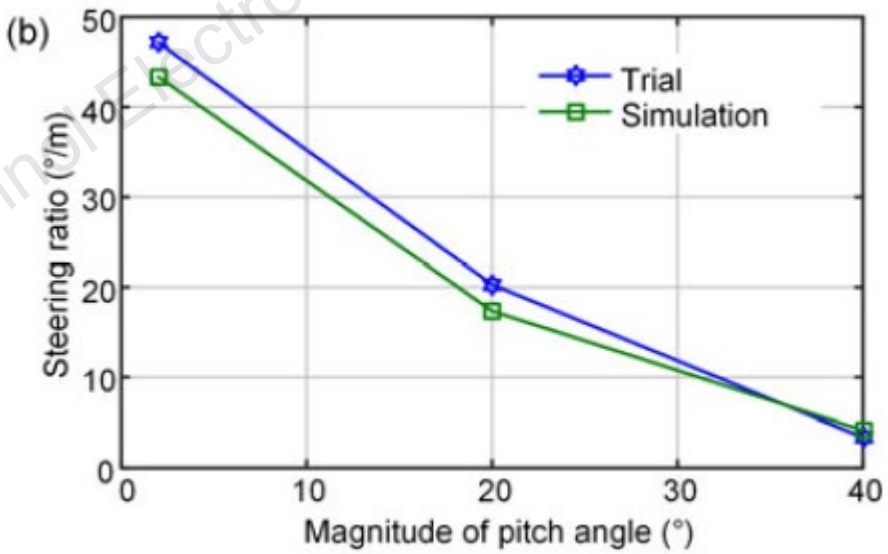


Fig. 12 Steering ratio for simulation and trial of cases A-1–A-9 (a) and cases B-1–B-3 (b)

Main results

- Steering under an SPA helps the underwater glider to cover a larger horizontal displacement than the control group.

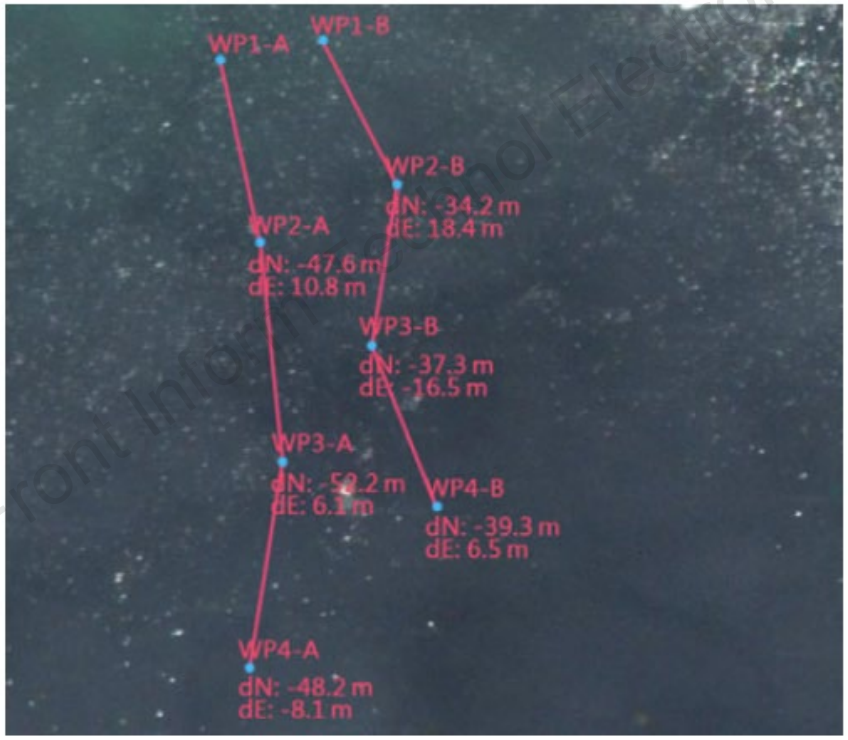


Fig.14 Waypoints with GPS handle (WP-A: under an SPA; WP-B: control group)

Conclusions

- The amended hydrodynamic model is available for analyzing the steering process under an SPA.
- Steering under an SPA enhances the steering ratio, which enhances the space-saving capacity. The steering ratio increases with the magnitude of net buoyancy and roll angle.
- Steering under an SPA enlarges the spacing between different waypoints covered by underwater gliders in lake monitoring.