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Finite-time path following control of a sailboat with actuator failure and unknown sideslip angle

Key words:

Sideslip angle observation, Line-of-sight guidance, Finite-time control, Sailboat, Path following

Problem description

Guidance

- Sailboats can slip sideways while sailing, affecting guidance accuracy

Control

- There are unmodeled dynamics in the mathematical model of a sailboat
- The sailboat actuator may fail

Sailboat path following

■Innovative points of this paper

To solve the above problems, the control scheme proposed in this paper has the following innovations:

- The DFSO devised in this paper can observe the time-varying sideslip angle.
- The fault model of the unmanned sailboat is considered , and a non-singular terminal sliding mode with adaptive parameter adjustment is designed to enhance the robustness of the system and prevent the system from leaving the equilibrium state when the actuator suddenly fails.

- The RBF neural network minimum parameter estimation method is utilized to compensate for the uncertainty part of the unmanned sailboat model.

Sailboat path following

■**Schematic of the variables and path tracking of a sailboat**

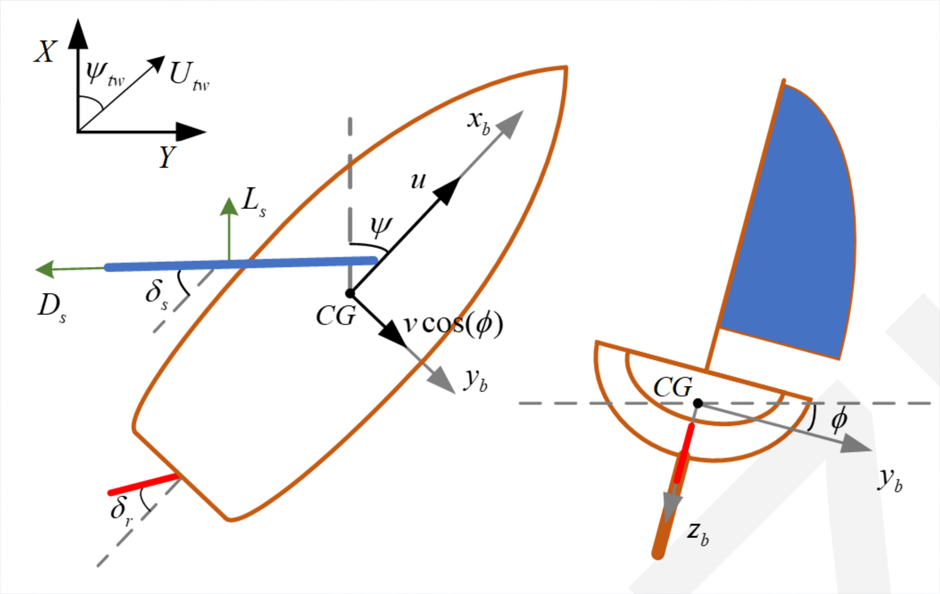


Fig. 1 Sailboat different in coordinates

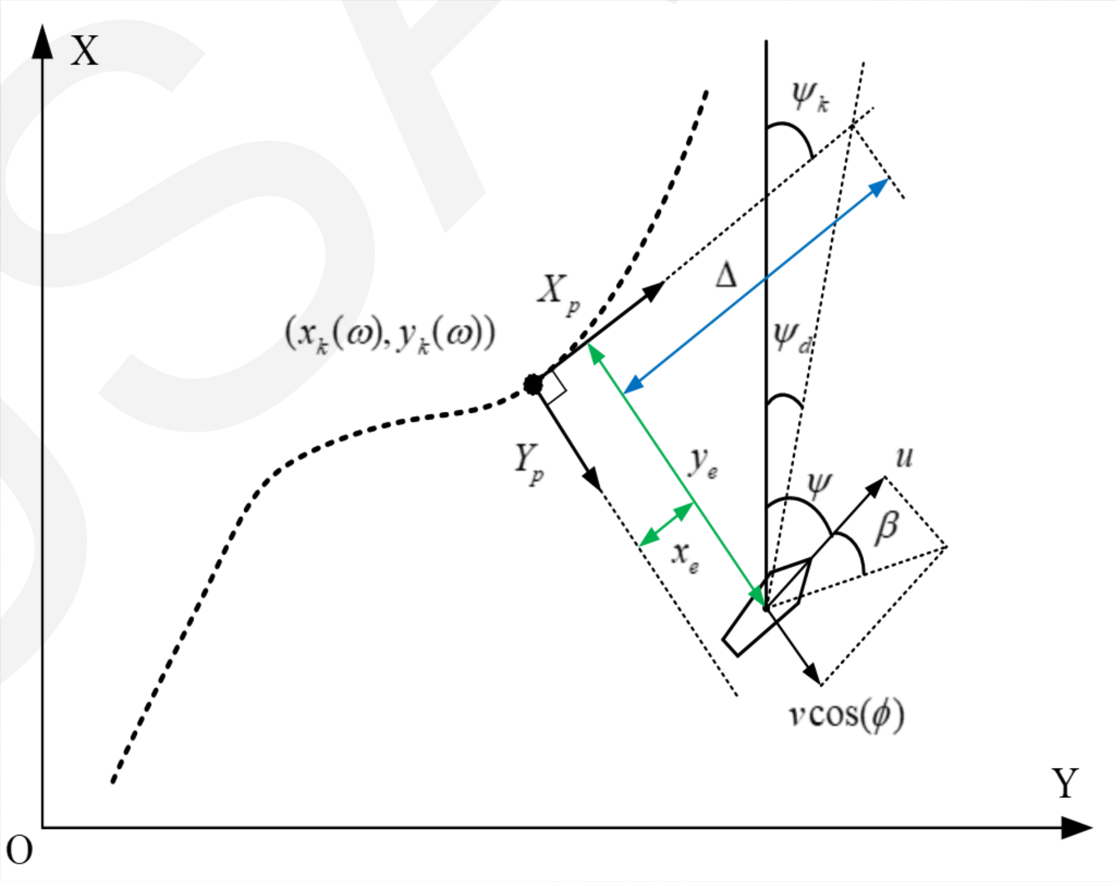
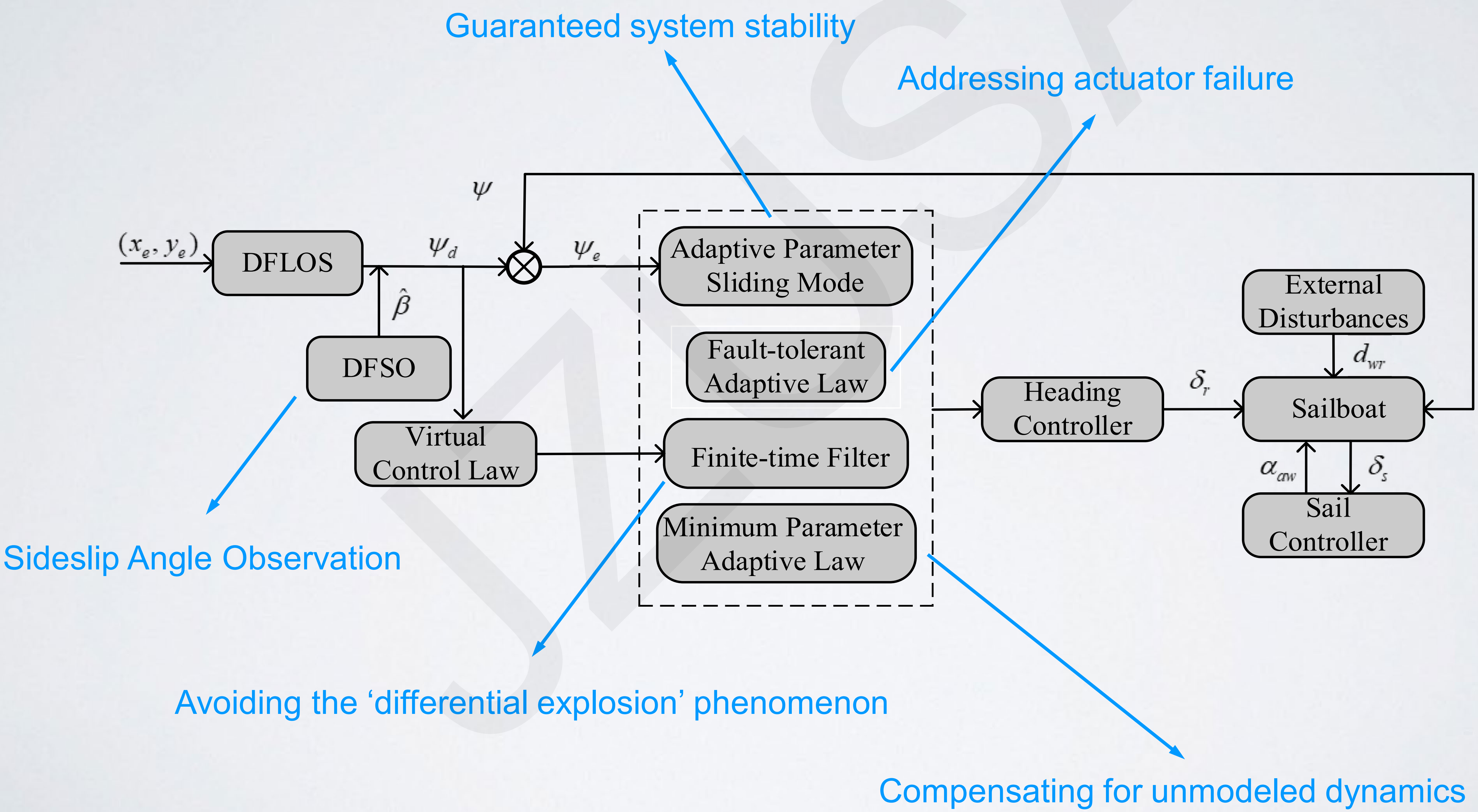


Fig. 2 Path following control geometry of a sailboat

Sailboat path following

■Framework of sailboat control



Research Priorities

Research Priorities:

- By observing the sideslip angle of the sailboat, the accuracy of LOS guidance can be improved.
- Ensure the accuracy of the sailboat model and improve path following accuracy.
- Design an efficient control law that allows the system to converge quickly and stabilize in a short period of time.
- Sailboats have the ability to continue to perform tasks in the event of partial failure of the actuator.

Conclusions

In this study, an IDFLOS-FC scheme was designed to solve the problem of controlling the path following of a USV in the case of actuator failure and under the influence of a time-varying sideslip angle and unknown external disturbance. With the help of DFSO, the time-varying sideslip angle is accurately observed. A sliding model with adaptive parameter adjustment was designed. The sum of fault torque and disturbance force is estimated by an adaptive method, and the uncertain part of the model is estimated by a minimum parameter estimation method. Combining the backstepping method with finite-time theory, a finite-time controller based on DFLOS was established to stabilize the path following error and heading following error in finite-time. In addition, the Lyapunov method strictly guarantees the finite-time stability of the integrated guidance and control system. The proposed IDFLOS-FC scheme can achieve accurate path following of an unmanned sailboat under the condition of actuator failure, time-varying sideslip angle and unknown external disturbance, and can accurately track the desired path when adding faults. These results demonstrate the reliability and superiority of the IDFLOS-FC scheme.