Kai AN, Zhen-yun GUO, Wei HUANG, Xiao-ping XU, 2022. Leap trajectory tracking control based on sliding mode theory for hypersonic gliding vehicle. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 23(3):188-207. https://doi.org/10.1631/jzus.A2100362

Leap trajectory tracking control based on sliding mode theory for hypersonic gliding vehicle

Key words: Predictor-corrector guidance, Drag tracking, Sliding mode control, Super twisting control

Corresponding author: Wei Huang

E-mail: gladrain2001@163.com

ORCID: https://orcid.org/0000-0001-9805-985X

Main contents

The paper focuses on developing robust tracking control schemes for the three-dimensional leap trajectory of hypersonic gliding vehicles using sliding mode theory. The main contents include following steps:

***Step 1*:** Reference trajectory is obtained by classical predictor-corrector guidance approach because of its incomparable advantages in online rapid trajectory planning.

***Step 2*:** Based on the analysis of drag tracking problem, design the controllers and construct control system using sliding mode theory, adjusting control parameters according to the tracking results.

***Step 3*:** Comparing tracking performance of four controllers (L-SMC, GFT-SMC, ST-SMC, CST-SMC) for the drag reference trajectory, comparing the PID controller and novel controller (CST-SMC), verifying the robustness under the influence of parameter perturbation and initial parameter measurement errors.

Method

A combined super-twisting sliding mode controller (CST-SMC) is proposed to decrease the tracking error and guarantee the tracking performance in the presence of system nonlinearities. The control system feedback loop is shown in the figure below.

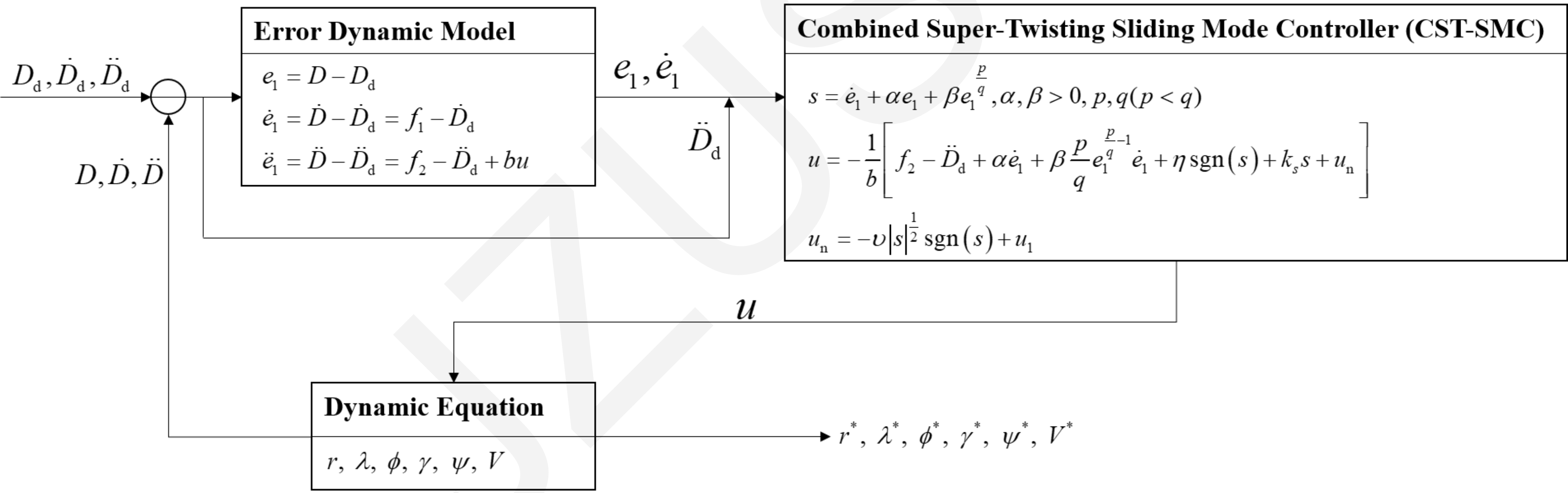

Fig. 2 A block diagram of the drag tracking control problem using CST-SMC

Conclusion

1. The reference trajectory is obtained by the predictor-corrector guidance method, the drag acceleration is chosen as the reference profile to be tracked and the bank angle as the control variable.

2. A CST-SMC based on the terminal sliding mode surface is proposed for guaranteeing the finite-time convergence of the drag tracking error even with parameter perturbation and initial parameter measurement uncertainties.

3. This paper also deduces three traditional sliding mode controllers, the L-SMC, GFT-SMC and ST-SMC, and compares their control performance with CST-SMC in simulations. The results show that the CST-SMC has much better tracking performance than the other three controllers in the presence of various uncertainties, and has great application potential.

Innovation points

1. A dynamic system of drag tracking error with 3-DOF is deduced. Compared with 2-DOF, the coupling of longitudinal and lateral channels is considered.

2. Propose a novel super-twisting sliding mode control approach named CST-SMC to improve tracking performance in the total time series compared with the three traditional sliding mode control methods.

3. Generally, in the process of controller performance verification, the system response under various uncertain disturbances (such as parameter perturbation, state error, and environmental disturbance and so on) can best reflect the quality of the controller design and its anti-interference ability. Thus, we discuss the robustness of CST-SMC under parameter perturbation and initial state measurement errors, and verify its effectiveness.