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Corresponding author: ZHANG Xin
e-mail of corresponding author: zhangxin2019@nuaa.edu.cn
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### Title

# Robust Adaptive Switching Control of Hypersonic Reentry Vehicle based on Q-learning

### Authors

*Xin ZHANG [1]*, Jiyuan SUN [1], Shushi WANG [1]*

** Corresponding author*
[1] *Academy of Astronautics, Nanjing University of Aeronautics and Astronautics, Nanjing, 211106, China*,
*zhangxin2019@nuaa.edu.cn*

### Abstract

This paper proposes a robust adaptive switching control strategy for the hypersonic vehicle during its reentry phase based on Q-learning. First, the kinematics and dynamic models of the hypersonic reentry vehicle (HRV) are established, apart from the system uncertainties and external disturbances, and the traditional PID controller is presented for this basic model. However, during the reentry phase, the strong coupling effects, high angle of attack, large disturbances, sharp changes of atmosphere environment, and system uncertainties inevitably depreciates the performance of the PID controller. To further improve the control performance, the Q-leaning algorithm is devised in the presence of unknown system matrices and disturbances. Therefore, the designed control scheme in this paper consists of two controller, PID and Q-learning, and an adaptive switching strategy is generated by the attitude tracking error and other performance evaluation factors based on the analytic hierarchy process method. Thus, the controller switching occurs mainly based on the value of the attitude tracking error and the better controller between PID and Q-learning. Normally, when the attitude tracking error converges to a small value, the controller currently in use will switch from PID to Q-learning. Finally, this proposed switching control system's stability analysis is conducted by the average dwell time method, while its feasibility, robustness and control performance are demonstrated by comparative simulations.

### References

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