Accepted Manuscript

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PII: S1270-9638(16)30799-4
DOI: http://dx.doi.org/10.1016/j.ast.2016.10.001
Reference: AESCTE 3787

To appear in: *Aerospace Science and Technology*

Received date: 22 April 2016
Revised date: 2 September 2016
Accepted date: 3 October 2016

Please cite this article in press as: L. Cao et al., A practical parameter determination strategy based on improved hybrid PSO algorithm for higher-order sliding mode control of air-breathing hypersonic vehicles, *Aerosp. Sci. Technol.* (2016), http://dx.doi.org/10.1016/j.ast.2016.10.001

A Practical Parameter Determination Strategy Based on Improved Hybrid PSO Algorithm for Higher-order Sliding Mode Control of Air-breathing Hypersonic Vehicles

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Abstract: A hybrid particle swarm optimization (PSO) algorithm for longitudinal dynamic models of air-breathing hypersonic flight vehicles (HFV) is proposed and applied to determine design parameters for a higher-order sliding model controller (HOSMC) while considering the effects of parameter uncertainty on trajectory tracking control. The input and output linearization of air-breathing HFV longitudinal dynamic models were achieved using the feedback linearization approach. Also, an HOSMC was designed for air-breathing HFV trajectory tracking control, and the design parameters were determined based on stochastic robustness analysis and hybrid PSO algorithm. Simulations revealed that the HOSMC design parameters can be optimized effectively and easily using the parameter determination strategy based on an improved hybrid PSO algorithm. The proposed HOSMC was used to stabilized the trajectory tracking of air-breathing HFV and the controller proposed exhibited great robustness.

Keywords: **Higher-order sliding mode control; Hypersonic flight vehicle; Parameter determination strategy; Improved particle swarm optimization algorithm**

1. Introduction

Compared with conventional flight vehicles, HFVs are characterized by complicated flight environments, large flight envelope spans, and high sensitivity to flight condition variations. Owing the airframe-propulsion integration configurations, slender bodies, and light structures, HFVs exhibit significant couplings of aerodynamic, propulsions, and structural dynamic factors; The propulsions are highly sensitive to angle of attack variations, resulting in significant nonlinear couplings of engine working conditions and flight conditions. Additionally, measurements of air characteristics and estimations of aerodynamic properties are extremely challenging, and HFV motions tend to be highly