Paper ID: 18143
student

ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (1)

Author: Ms. Yan Wei
Beihang University, China, wytt0324@163.com

Dr. Ming Xu
Beihang University, China, xuming@buaa.edu.cn
Dr. Shengli Liu
DFH Satellite Co. Ltd., China, zhangyanhit@126.com
Prof. Xu Shijie
Beijing University of Aeronautics and Astronautics (BUAA), China, starshijiexu@gmail.com

DRAG-FREE AND ATTITUDE CONTROL FOR CHINESE PLANNING ASTROD-I MISSION

Abstract

The drag-free spacecraft, which has potential applications in exploring gravitational waves, and drawing the Earth's gravitational field, applies successive voluntarily control to thrusters so as to counteract the drag of the atmosphere, solar radiation and other perturbations, thus obtaining an utterly free falling motion. Up to now, several drag-free spacecrafts have been launched: TRIAD, NOVA and Gravity Probe-B by NASA, and GRACE and GOCE by ESA. A new mission named as ASTROD-I, has been proposed by Purple Mountain Observatory in China to investigate the Earth's gravity field.

For these new types of spacecrafts, how to compensate the perturbations as efficiently as possible and how to maintain the orbital and attitude as accurate as possible, are extraordinarily required to design some suitable controller to adjust the thrusters. This paper mainly focuses on the orbital and attitude controller design for Chinese planning ASTROD-I mission.

Several requirements are demanded on the controller, such as: **i**) an efficient controller is expected to guarantee target requirements on the power spectral density (abbr. PSD) of the orbit and attitude components under uncertainties in the aspects of spacecraft and its environment; **ii**) an attitude estimator is expected to exploit the best combination of gradiometer angular accelerations and star tracker units measurements to recover target attitude accuracy in the measurement bandwidth. **iii**) a minimized energy consumption is needed to be designed. Hence, one contribution of this paper is proposing a controller to obtain a relative free falling for an accurate gravity mapping, considering the basic perturbing forces atmosphere drag and torque, gravity gradient torque and Earth magnetic torque, through 2 ion thrusters and 8 micro-thrusters owing to data of gravity gradiometer, GPS receivers and star tracker units.

Previous researches on the control subsystem of drag-free spacecraft included H2 optimistic theory and the embedded model control theory; however the definitions of the gain matrix in these researches are not clear. Another contribution in this paper is to demonstrate the way of acquiring these values, i.e. designing an optimistic controller and defining the average matrix $\mathbf{Q}$ and $\mathbf{R}$ of the optimistic function for the optimistic theory of second order respecting the requirements mentioned above. Specifically, since an efficient optimistic controller depends on an efficient state-predictor with the modified state being one input of the control loop and the state error being the controller's switch, this paper also presents an optimistic state-predictor for the spacecraft.