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論 文 要 旨

THESIS SUMMARY

専攻： Department of	機械宇宙システム　　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（　工学　）
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Title: **A Study on Control Methods of Rapid Attitude Maneuver using Control Moment Gyros for Microsatellites**

Chapter 1 Introduction presents and evaluates about trend of the development of microsatellites. Together with the expansion of microsatellite application, those missions become more complex, their attitude Control (AC) requirements also become more difficult to achieve. The paper focuses on control moment gyro (CMG), and attitude control algorithms and single gimbal CMG singular mechanism are summarized. According to different process methods near singular surface, existing steering laws are broadly divided into singularity avoidance steering law, singularity passing through steering law and hybrid steering law. Combined with these steering laws and control algorithms, research purpose of this thesis on rapid attitude maneuver is described.

Chapter 2 Mathematical Models introduces the satellite attitude kinematics and dynamics equations which are suitable for large-angle maneuver. The equations of motion for the control moment gyros are derived in detail as a kinetic model for micro satellites. Two classical control methods for AC problem and G-SR steering logic are introduced here. Three simulation cases are listed to illustrate the feasibility and efficiency of proposed control system. It is also the basic knowledge for the following chapters.

Chapter 3 Sliding Mode Control describes two conventional sliding mode controllers (classical sliding mode controller and higher order sliding mode controller) and proposes a Modified Rodrigues Parameter (MRP)-based feedback sliding mode control with a saturation compensation method for robust satellite attitude control in the presence of environmental disturbance. The sliding mode control method is regarded as the main approach for processing non-parametric uncertainties and un-modelled dynamics. The higher order sliding mode control is proved to maintain all the characteristics while to decrease the chattering effect. The new controller is based on a MRP sliding mode control law for a pyramid-type configuration using four CMGs. The three sliding mode controllers are compared through numerical simulations. A Monte Carlo satellite simulation is conducted to demonstrate that the proposed control method successfully tracks the rest-to-rest maneuvering process for a range of system uncertainties and un-modeled dynamics. The numerical simulation results show that the proposed control method works better on convergence speed and pointing accuracy.

Chapter 4 Steering Logic of Control Moment Gyros explains the reason for existence of singularity, presents conventional singularity direction avoidance based on singular value decomposition logic, and illustrates that this method is not suitable for our attitude control system using a typical simulation case. Then a new modified steering logic called W-SR based on G-SR is proposed A new selection criteria of the two key parameters in G-SR is proposed in order to avoid singularity and realize accurate torque at the same time. Two simulation cases compared with G-SR are considered, and simulation results show that the proposed steering logic W-SR works well in large angle slew maneuver and is suitable for on-board computers in real microsatellites. At last, a failure tolerant control simulation is conducted with the modified sliding mode control and the W-SR steering logic to show its feasibility.

Chapter 5 Extended Applications of Proposed Control Methods includes two contents: adaptability to angular velocity error and capability to structural vibration damping. First, an adaptive sliding mode control is proposed by adding an adaptive compensation part to the classical sliding mode control method. Simulation results show that this method has some advanced aspects but still needs to be improved in the future work. Second, the proposed attitude control system is applied for a satellite with flexible structure. Numerical simulations show some range of flexibility factors for damping the structural vibration.

Chapter 6 Evaluation of Attitude Determination and Control System for Micro Satellite TSUBAME evaluates control performances of the proposed attitude control methods through a real 50kg microsatellite TSUBAME developed in Matunaga Laboratory. Specially, on-ground experimental results of GRB mission case are given using both a software in the loop simulation (SiLS) and a hardware in the loop simulation (HiLS), and the feasibility and efficiency of the proposed methods are confirmed. In addition, a further evaluation plans for the attitude control system are addressed using TSUBAME on orbit.

Chapter 7 Conclusions and Future Works make the concluding remarks with a list of the principal results. Future comments are also given.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).