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RELATIVE ORBIT ATTITUDE COUPLED PICO SATELLITES FORMATION CONFIGURATION FOR DISTRIBUTED MIMO

Abstract

Space Information Networks (SINs) enables any IoT device to connect to the Internet even if it is located in a severe environment. Depending on the amount of IoT devices, throughput must be increasing. One solution to this problem is the MIMO, which requires many cooperative antennas. This research utilizes pico-satellites formation flying as distributed cooperative antennas. pico-satellites can cheaply mass produce and it improves the feasibility of the proposed distributed MIMO system. Formation configuration has a significant role to establish a pico-satellites swarm system. Conventional studies considered the configuration under orbit disturbances. However, as satellites become small, the magnetic effect due to the scale effect becomes stronger, and the relative orbit and attitude of pico-satellites with magnetic torque are coupled via magnetic force and torque, and plasma drag. This research considers the formation configuration coupled with relative orbit and attitude and periodic stability analysis is conducted. Formation configuration coupled with relative orbit and attitude has 12N DOF and it is difficult to use parameter studies such as grid search or Poincare map. To find the configuration effectively, floquet theory and shooting-method are adapted. This approach is consisting of two steps, periodic configuration findings and stability analysis. the first step is solved as a two-point boundary value problem (TPBVP). To express the relative orbit and attitude dynamics, the CW equation, attitude dynamics, and kinematics by quaternion are used. the time integral of Jacobian becomes State Transition Matrix (STM). STM can show characteristics of stability. Furthermore, the correction amount for the shooting method can calculate by the STM. A matching between initial state variables and final variables becomes the boundary to establish periodic configuration. With these dynamics, STM, and boundary, TPBVP is solved. The second step is stability analysis using floquet theory. after periodic configuration is found out, the stability of this system recognizes from the eigenvalue of STM. At this moment, a formation configuration of two pico-satellites is investigated. the result shows the periodic configuration that the formation size is about several meters and they rotate by several times of mean orbit angular velocity. satellites' angular velocity strongly changes due to magnetic torque at the nearest distance. the result of stability analysis shows that this system has both stable and unstable modes, strongly coupled with relative orbit and attitude. As a future task, stable formation configuration will be investigated.