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DECENTRALIZED CONTROL OF SWARM OF NANOSATELLITES WITH COMMUNICATION RESTRICTIONS USING AERODYNAMIC FORCES

Abstract

Multisatellite space systems promise a breakthrough in space exploration and scientific experiments. A group of satellites flying in short relative distances could solve ambitious tasks such as on-orbit station assembly, exploration of the asteroid belt and construction of distributed remote sensing system. Group of satellites can form a specific configuration, e.g. a "flower" formation or tetrahedral one. On the other hand, satellites can fly along random relative trajectories like a swarm. Swarm-type flight requires only bounded relative motion with no other restrictions in contrary with formation type. However, satellites in swarm has restrictions in number of communication links between neighbors like in natural swarms. Using on-board motion determination system each satellite can estimate relative motion of other satellites of the swarm. However, because of sensor limitations it can estimate relative motion of satellites that are located only in its certain vicinity. Decentralized control could be applied to the swarm with such a communication limitations.

The paper considers a problem of 3U CubeSats swarm construction right after their separation from the bus launcher. During the separation of the satellites, some difference in the ejection velocity is inevitable. It results in a slightly different orbital period of the satellites, so they will gradually fly apart along the orbit and the relative trajectories will be unbounded. Aerodynamic force acting on the satellite depends on its attitude. Therefore, it is possible to control relative motion without spending any propellant. Each satellite has information about relative motion of satellites inside communication area. Purpose of the control is to eliminate the relative drift between neighbor satellites. The paper develops such decentralized control algorithm. Effect of clustering – when the swarm is divided into several groups – is studied. This effect depends on size of the communication area, initial conditions and control parameters. Boundary values of these parameters in case of ten 3U CubeSats are investigated. The numerical study of the developed algorithm includes detailed model of upper atmosphere and non-central gravitational field. Influence of control errors due to inaccurate knowledge of atmosphere density and attitude errors is estimated.