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# DEVELOPMENT OF SLIDING MODE CONTROLLER FOR SMALL SATELLITE IN PLANETARY ORBITAL ENVIRONMENT FORMATION FLYING MISSIONS

**Abstract**

In the recent years the concept of Coulomb Spacecraft Formation (CSF) in Geostationary Orbits (GEO) and other high Earth orbits has gained a lot of attention in the space community. The advances in the field of Coulomb Spacecraft Formations prove that the electrostatic forces of the order of 10-1000 $\mu$N generated on the surface of the satellites due to ambient plasma and the photoelectric effect can be effectively utilized to propel satellites flying the close formations. There is an increasing interest to prove the feasibility of this new hybrid propulsion technology through harvesting the naturally available electrostatic forces to propel the satellites in a formation. Advances in propulsion technology will dramatically reduce the mission cost in addition to prolonging the mission lifetime.

Success of a formation flying missions depends not only on the efficiency of the propulsion system but also on the onboard Guidance, Navigation and Control strategies. The authors have done extensive research to develop novel Sliding Mode Controllers (SMC) for implementing Coulomb Spacecraft formations. The inherent robustness of the controller guarantees that the spacecraft is insensitive to a class of bounded disturbances due to solar radiation drag and other perturbation in high altitudes. The previous research utilized a generic, non-linear inertial model to describe the satellite dynamics.

This paper describes further progress in modeling and control of CSF for circular orbits around the Earth. The dynamics of the satellites are governed by the Hill-Clohessy-Wiltshire (HCW) equations and a nonlinear, robust controller based on Sliding Mode Control is implemented for demonstrating how a group of satellites can aggregate from their initial positions to form a desired formation. The dynamics of the satellites in the formation is non-linear because it is a combination of the linear HCW equations and the non-linear Columbic forces. Since linearization is not recommended, this non-linearity increases the complexity in designing the sliding mode controller. Collision free navigation is achieved using the Artificial Potential Filed (APF) method - a popular path planning technique used in terrestrial robotics. The drift of the formation centre of mass can be prevented by integrating APF with SMC and by eliminating the reaching phase of the controller. The efficacy of the proposed algorithms for CSF will be presented through illustrating a few formation reconfiguration scenarios.