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Formation Flying Design Applied for an Aurora Borealis Monitoring Mission

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Abstract : Aurora Borealis is an optical phenomenon composed of luminous events observed in the night skies in the polar regions resulting from disturbances in the magnetosphere due to the impact of solar wind particles with the Earth's upper atmosphere, channeled by the Earth's magnetic field, which causes atmospheric molecules to become excited and emit electromagnetic spectrum, leading to the display of lights in the sky. However, there are still different implications of this phenomenon under study: high intensity auroras are often accompanied by geomagnetic storms that cause blackouts on Earth and impair the transmission of signals from the Global Navigation Satellite Systems (GNSS). Auroras are also known to occur on other planets and exoplanets, so the activity is an indication of active space weather conditions that can aid in learning about the planetary environment. In order to improve understanding of the phenomenon, this research aims to design a satellite formation flying solution for collecting and transmitting data for monitoring aurora borealis in northern hemisphere, an approach that allows studying the event with multipoint data collection in a reduced time interval, in order to allow analysis from the beginning of the phenomenon until its decline. To this end, the ideal number of satellites, the spacing between them, as well as the ideal topology to be used will be analyzed. From an orbital study, approaches from different altitudes, eccentricities and inclinations will also be considered. Given that at large relative distances between satellites in formation, controllers tend to fail, a study on the efficiency of nonlinear adaptive control methods from the point of view of position maintenance and propellant consumption will be carried out. The main orbital perturbations considered in the simulation: non-homogeneity terrestrial, atmospheric drag, gravitational action of the Sun and the Moon, accelerations due to solar radiation pressure and relativistic effects.

Keywords : formation flying, nonlinear adaptive control method, aurora borealis, adaptive SDRE method
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