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STABILIZATION OF SPACE-ADVERTISEMENT SATELLITE FORMATION

Abstract

This paper deals with ideally positioning and stabilization of multi-satellite formation projected to an observer on the ground.

Space-advertisement is to exhibit an artificial pixel image in the night sky using satellite formation with sunlight reflectors or other light sources in the low earth orbit. This topic is recently remarked as research and business, so there are few previous studies. The shape observed from the ground is different from one in the relative orbit and is deformed during the visible time. Concerning these two problems, this paper derives equations relating orbital elements to the exhibiting shape in the topocentric equatorial coordinate system and finds one of stable orbits without control to enhance mission quality.

New differential orbital elements and derivation via direction cosine enable smooth approximation and ideal formation positioning by linear solutions. Differential topocentric right ascension and declination are functions of a linear combination of the four differential orbital elements. Their coefficients depend on the conditions of a chief and an observer. The solutions express paths traced by moving deputies centering a chief. Validation shows that errors between the approximate solutions and true values are up to 1 arcmin of human eye resolution. That means the derived equations portrait almost the same visible situations as the reality.

The definition of stability is to keep the observed formation shape during the visible time. The same shape is equivalent to the situation that amounts of relative angular extension and rotation change in chief-centering coordinate are equal for all deputies. Relative angular velocity isn't adequate, because the sharp change of velocity direction and incomplete point-symmetry of paths affects the uniformity of trajectories even if velocities of all deputies are the same. Analysis reveals that two of the five parameters almost don't affect extension and rotation. Also, under the two are zero, another parameter has optimum range near zero that all positioning locations in pixel image are stable, which means amounts of extension and rotation almost but incompletely accord within. Making three parameters zero allows time-varying parameters constant temporally. These results indicate a simple stable solution that has applications under any conditions of chief and observer. An example of illumination designed using that solution and its stability is presented. This solution guarantees stable shape for two minutes, but it is sufficiently stable within about seven minutes visible span.