

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (1) (5)

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UTILIZATION OF VIDEO NAVIGATION FOR ATTITUDE DETERMINATION OF SOYUZ ROCKET
UPPER STAGE AFTER PAYLOAD SEPARATION

Abstract

The utilization of Soyuz rocket upper stages for carrying out of short-term experiments and nanosatellites piggy back orbiting is impossible without clear understanding of their attitude motion after separation of main payload. Video images are nice measurement source for attitude determination. An algorithm for the orientation and position determination of orbital stage by analyzing of video images of the separation process is requested for discussion. This navigation algorithm allows to determine orientation and position of the known geometry space object from the known orientation platform. The main source of measurement is the reference points coordinates of the space object projected on the photosensitive matrix measurement platform. As measurement platform could be used nanosatellite. The navigating algorithm consists of the following steps:

- Image analysis and reference points pattern recognition on it with the involvement of a object's 3D model;
- Evaluation of the current upper stage position and orientation relatively to the measuring platform;
- Aggregation video measurements with measurements of the platform and recalculation of motion parameters from body coordinate system to the orbital coordinate system;
- Analysis of subsequent images and obtaining the sampling object coordinates and orientations at different points in time;
- Evaluation of angular and linear velocities through the appropriate models.

Navigation algorithm has tested on outdoor video separation process from the Antares space rocket on April 21, 2013 and September 18, 2013 from Internet. Testing was carried out with the algorithm a number of assumptions due to lack of full Antares motion data. For algorithm flight verification with respect to "Soyuz" upper stage is required the video cameras installation on the platform, with equipped the navigation system and separated from the "Soyuz" upper stage. For these purposes SSAU designed CubeSat with two cameras mounted on the front face and captured the nanosatellite separation process from transfer compartment and its removal from the "Soyuz" upper stage. In addition to the motion parameters determination of the upper stage described algorithm allows to determine the launch adapter characteristics like separation velocity. This algorithm can be used for attitude determination of space debris for their removing from orbit.