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NEW METHOD FOR INTERPLANETARY SPACECRAFT PASSIVE NAVIGATION

Abstract

The number of missions to various bodies of the solar system is growing. For high-quality scientific problems solution, it is necessary to quickly determine the spacecraft position along its orbit. The optimal solution to this problem is to use data from onboard optical measuring devices, in particular star sensors. These devices give out measurement results in form of sets of reference objects (including the Sun, planets or other Solar system bodies) angular coordinates in devices coordinate systems.

Thus, we face with the problem of spacecraft state vector at the required time determination as a solution to the problem of minimizing the quadratic functional that determines the difference between the "simulated" measurements (i.e., those that would have been made on the "simulated" trajectory generated by current state vector approximation) from the real ones (i.e., those that were obtained from on-board sensors):

$$J := \sum_{i=1}^{N} ||\vec{\mu}_i(t_i) - \vec{\mu}_i^m(t_i; (\vec{r}_m, \vec{v}_m))||^2 \to \min_{(\vec{r}_m, \vec{v}_m)},$$

where t_i – moments of measurement, $\vec{\mu}_i$ – measurements made by on-board sensors at these times (on the real trajectory) and $\vec{\mu}_i^m$ – "simulated" measurements made by the same sensors and at the same times, but on the trajectory generated by the current approximation $(\vec{r}_m, \vec{v}_m)$ of real initial condition of spacecraft movement dynamical system.

Currently, we consider the spacecraft center of mass dynamics and model attitude motion "kinematically" by targeting certain devices' optical axes at reference objects.

To find a solution, we use a software implementation of the Levenberg-Marquardt method and a prototype of a software package that allows one to configure spacecraft sensors set (the result is certain form of $\vec{\mu}_i$ vectors) and the measurements series parameters (the result is current times t_i distribution).

We present the results of the suggested method work for model space missions with on-board sensors of editable error parameters.