

Stochastic Estimation of Dynamically Changing Object Orientation Parameters Using Satellite Measurements

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Abstract—It is solved a problem of a posteriori estimation of dynamically modified parameters of angular movement of the object by satellite measurements. There are shown advantages of application of the methods of stochastic non-linear dynamic filtration before single-stage measurements. It is represented an example, showing efficiency of proposed approach.

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INTRODUCTION

Complete solution of navigation problem for movable object supposes definition of parameters of both linear and angular movement. In this connection object positioning precision achieve due to application of satellite navigation systems (SNS) up to sub-centimeter wavelength range [1–3] requires solution of the next stage problems of increase of accuracy of satellite definition of angular movement parameters up to values, specific for current-technology angular-measuring systems of geodesic class [3–11].

Now all methods for orientation definition by means of SNS are possible to be divided in two classes: definition of orientation by previously obtained basis vectors [9–16] and direct calculation of orientation angles [11, 12, 17]. For all these methods it is typical to use single-stage measurements by basic vectors with their further processing with traditional algorithms. It does not allow to take into account specificities of dynamics of rotation of specific objects, and also to provide required estimation accuracy for medium- and high-dynamic rotating objects, and also to use completely the methods of current theory of stochastic filtration, providing possibility of optimal estimation of angular parameters with arbitrary dynamics of their modification.

In [18] it is tried to apply the methods of stochastic optimal filtration for estimation of the parameters of object space orientation on a basis of processing of the measurements of pseudo-distances and pseudo-phases, but in case of SNS interconnecting with inertial system. Time filtration in this case is used for achieve of small probability of incorrect resolution.

In this connection it is of interest to develop the approach, allowing using just satellite measurements to obtain required accuracy for estimation of parameters of object space orientation. In this case for estimation of object angular position it is possible to use the methods of dynamic non-linear filtration, providing required estimation accuracy for object space orientation parameters due to taking into account specific object rotation dynamics.

We consider phase and Doppler measurements of SNS as the measurements used for algorithms development, realizing this approach. At that, the solution of stated problems is considered for SNS of high frequency of navigation messages, allowing to take into account the character of satellite measurements with regard to object navigation parameters dynamics to continuous ones. Now the frequency of satellite messages in navigation receivers Topcon (Javad before), Trimble is 100 Hz with further trend to its increase [3].

PROBLEM STATEMENT

For application of the methods of the theory of non-linear stochastic filtration in case of estimation of object orientation parameters it is necessary to obtain the equation of dynamic of modification of the lasts,