РАКЕТНО-КОСМИЧЕСКОЕ ПРИБОРОСТРОЕНИЕ И ИНФОРМАЦИОННЫЕ СИСТЕМЫ
2021, том 8, выпуск 2, с. 51–61

КОСМИЧЕСКИЕ НАВИГАЦИОННЫЕ СИСТЕМЫ И ПРИБОРЫ. РАДИОЛОКАЦИЯ И РАДИОНАВИГАЦИЯ

The Use of the Lattice Packing Theory for Precise Point Positioning with Ionosphere-Free Measurements in CDMA GNSS

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Abstract. The paper considers the use of the lattice packing theory for Integer Precise Point Positioning (Integer PPP) with the errors usually not exceeding 1–3 cm based on GNSS signals with code division multiple access (CDMA). Positioning is carried out by processing ionosphere-free linear combinations of code and phase measurements with ambiguity resolution employing satellite corrections.

The main issue of PPP algorithms is overcoming the rank deficiency problem of the linear equation system obtained by linearization of nonlinear mathematical models of measurements. Nowadays Float PPP is quite well developed, where rank deficiency is tackled by combining systematic biases in measurement models with integer carrier phase ambiguities. As a result, the number of unknowns is reduced to the rank of design matrix, which allows unambiguous estimation of precise user coordinates and values of new variables generated by the performed combinations. However, under such conditions the information about integer nature of carrier phase ambiguities is lost, and this leads to a significant increase in convergence time to obtain user coordinates estimates with the errors of 1–3 cm. It is possible to involve the information on the integer nature of phase ambiguities into processing by applying ambiguity resolution algorithms. Though, as a result of the conducted combinations, the integer nature is destroyed, which makes it impossible to apply these algorithms.

In Integer PPP rank deficiency is overcome by projecting the state space of the initial linear equation system onto a so-called S-space, whose dimension is equal to the rank of this system. The orientation of the S-space and the direction of projecting are chosen so that the variables of the initial system corresponding to user coordinates are not changed during the projecting and the projections of integer variables remain integer. This makes it possible to estimate precise user coordinates involving information on the integer nature of phase ambiguities.

In the literature on Integer PPP based on CDMA GNSS signals processing the description of the S-space orientation with the desired properties is given, but there is no description of the method to determine this orientation. This paper based on the notions of the lattice packing theory considers an algorithm for determining the S-space with the desired properties. It is shown that there exists an infinite set of such S-spaces connected by unimodular transformations, and a technique is proposed to enable selection from this set the S-space, which requires minimal computational cost.

The use of the lattice packing theory to the Integer PPP network solution with CDMA GNSS signals will be considered in the following publication of the authors.

Keywords: satellite navigation, space vehicle (SV), ionosphere-free linear combination of code and carrier phase measurements based on CDMA SV signals, Integer Precise Point Positioning (Integer PPP), ambiguity resolution of phase measurements, integer lattice reference, unimodular transformation matrix