ROCKET-SPACE DEVICE ENGINEERING AND INFORMATION SYSTEMS
2025, Vol. 12, Iss. 2, pp. 63–71

УДК 629.78 EDN NCTMAZ

Orientation of a Dynamic Object with Resolution of Integer Ambiguities of the Second Differences of Pseudoranges by the Carrier Phase

V.V. Betanov, *Dr. Sci. (Engineering)*, *Prof.*, contact@spacecorp.ru
Joint Stock Company "Russian Space Systems", Moscow, Russian Federation
V.E. Vovasov, *Cand. Sci. (Engineering)*, *Associate Prof.*, contact@spacecorp.ru
Joint Stock Company "Russian Space Systems", Moscow, Russian Federation
A.V. Voropaeva, contact@spacecorp.ru,
Joint Stock Company "Russian Space Systems", Moscow, Russian Federation

Abstract. Orientation of a dynamic object with resolution of integer ambiguities of the second differences of pseudoranges by the carrier phase is a rather complex task, requiring a significant initialization time for a given high confidence probability of ambiguity resolution. Involvement of rough measurements of inclinometers and the heading meter as a priori data makes it possible to significantly reduce the initialization time. To obtain highly accurate estimates, a Kalman-type filter is formed, the measurements of which are the Euler angles obtained from the former, using a priori data on the roll, pitch and heading from the specified sensors, and its algorithm is presented.
The modeling carried out by the authors showed the high efficiency of the proposed method for resolving phase ambiguities. The initialization time of the orientation system is practically zero at a confidence probability of 0.997. The standard deviation of the Euler angle estimate by the former with eight observed satellites is 0.003 radians. The Kalman-type filter proposed by the authors enables smoothing out of anomalous measurements and brings the orientation accuracy to 0.001 radians. The article's contents will be useful to specialists in the field of satellite navigation, geodesy and related disciplines.
Keywords: Euler angles, carrier phase pseudoranges, second differences of pseudoranges, resolution of phase ambiguities
For citation: Betanov V.V., Vovasov V.E., Voropaeva A.V. Orientation of a Dynamic Object with Resolution of Integer Ambiguities of the Second Differences of Pseudoranges by the Carrier. *Rocket-Space Device Engineering and Information Systems.* 2024. Vol. 12. No. 2. pp. 63–71. (in Russian)

References

1. GLONASS. Printsipy postroeniya i funktsionirovaniya [GLONASS. Principles of Design and Operation]. R.V. Bakit'ko et al.; ed. by A.I. Perov, V.N. Kharisov. 4th ed. Moscow, Radiotekhnika, 2010. (in Russian)

2. Povalyaev A.A. Sputnikovye radionavigatsionnye sistemy: vremya, pokazaniya chasov, formirovanie izmereniy i opredelenie otnositel'nykh koordinat [Satellite Radio Navigation Systems: Time, Clock Readings, Formation of Measurements and Determination of Relative Coordinates]. Moscow, Radiotekhnika, 2008. (in Russian)

3. Povalyaev A.A. Veytsel' V.A., Mazepa R.B. Global'nye sputnikovye sistemy sinkhronizatsii i upravleniya v okolozemnom prostranstve [Global Satellite Systems for Synchronization and Control in Near-Earth Space]. Textbook. Ed. by A.A. Povalyaev. Moscow, Vuzovskaya kniga, 2012. (in Russian)

4. Antonovich, K.M. Ispol'zovanie sputnikovykh radionavigatsionnykh sistem v geodezii [Use of satellite radio navigation systems in geodesy]. Moscow, FSUE Kartgeotsentr, 2005. ISBN 5-86066-072-3. (in Russian)

5. Vovasov V.E., Mazepa R.B., Sukharev D.A., Voropaeva A.V. Metod raskrytiya fazovykh neodnoznachnostey, ispol'zuyushchiy obrabotku psevdodal'nostey po kodu i faze nesushchey v fil'tre kalmanovskogo tipa [A method for disclosing phase ambiguities using pseudorange processing by code and carrier phase in a Kalman filter]. Raketno-kosmicheskoe priborostroenie i informatsionnye sistemy [Rocket-Space Device Engineering and Information Systems]. 2021, No. 3, Vol. 8, pp. 1-10. (in Russian)

© V.V. Betanov, V.E. Vovasov, A.V. Voropaeva, 2025

6. Vovasov V.E., Betanov V.V., Voropaeva A.V. Metod vysokotochnogo pozitsionirovaniya potrebiteley informatsii sputnikovykh system [Method of high-precision positioning of consumers of satellite systems information]. Pravovaya informatika [Legal informatics]. 2020, No. 3, pp. 53 – 64. DOI: 10.21681/1994-1404-2020-3-53-64 (in Russian)

7. Betanov V.V., Fedotov S.A., Vovasov V.E. Metod raskrytiya fazovykh neodnoznachnostey s zadannoy doveritel'noy veroyatnost'yu [Method of disclosing phase ambiguities with a given confidence probability]. Trudy Voenno-kosmicheskoy akademii imeni A.F. Mozhayskogo [Proceedings of the A. F. Mozhaisky Military Space Academy]. 2024, No. 693, pp. 14 – 21. (in Russian)

8. Povalyaev E.A. Sistema opredeleniya orientatsii po odnomomentnym izmereniyam v CPHC GPS/GLONASS [Orientation determination system based on instantaneous measurements in CPHC GPS/GLONASS]. Cand. Sci. (Engineering) thesis. Moscow, MAI, 2002. (in Russian)

9. Glukhov P.B. Opredelenie orientatsii ob"ekta po odnomomentnym izmereniyam v SRNS [Determination of object orientation based on instantaneous measurements in SRNS]. Cand. Sci. (Engineering) thesis. Moscow, MAI, 2008. (in Russian)

10. Kasulin E.A. Razrabotka submetrovykh po tochnosti algoritmov otnositel'noy navigatsii podvizhnykh ob"ektov po fazovym izmereniyam signalov global'nykh navigatsionnykh sistem [Development of submeter-accuracy algorithms for relative navigation of moving objects using phase measurements of global navigation system signals]. *66th All-Russian Scientific Conference of MIPT*. 02.04.2024, RKK Energiya, Moskva 2024. (in Russian)

11. Guter R.S., Reznikovskiy P.T. Programmirovanie i vychislitel'naya matematika, vyp.2. Vychislitel'naya matematika. Programmnaya realizatsiya vychislitel'nykh metodov [Programming and computational mathematics, issue 2. Computational mathematics. Software implementation of computational methods]. Moscow, Nauka, 1971. (in Russian)

12. Gantmakher F.R. Teoriya matrits [Matrix theory]. Moscow, Nauka, 1978. (in Russian)

Received ***14.04.2025***
Accepted ***29.05.2025***