TRUDY INSTITUTA MATEMATIKI I MEKHANIKI UrO RAN

Vol. 26 No. 4 **2020**

APPROXIMATION OF A GUARANTEED ESTIMATION PROBLEM WITH MIXED CONSTRAINTS

B. I. Anan'ev, P. A. Yurovskikh

Questions of finite-dimensional approximation for a guaranteed estimation problem are considered for linear nonstationary systems with disturbances subject to mixed integral and geometric constraints, where the geometric constraints are not assumed to be compact. The parameters of the system and the measurement equation are formed in such a way that the state vector of the system is not subject to geometric constraints. Under these assumptions, one can reduce the estimation problem to an optimal control problem without state constraints and use Pontryagin's maximum principle. A discrete multistep system is proposed for which the information set converges in the Hausdorff metric to the corresponding information set of a continuous system as the partition step of the observation interval vanishes. Estimates characterizing the convergence rate are derived and an example is given.

Keywords: guaranteed estimation, filtering, variational inequalities, normal cone, maximum principle, information set.

MSC: 93E10, 62L12, 34G25

DOI: 10.21538/0134-4889-2020-26-4-48-63

REFERENCES

1. Kurzhanskii A.B. *Upravlenie i nablyudenie v usloviyakh neopredelennosti* [Control and Observation Under the Conditions of Uncertainty]. Moscow: Nauka Publ., 1977, 306 p.
2. Bertsecas D.P., Rhodes I.B. Recursive state estimation for a set-membership description of uncertainty. *IEEE Trans. on Auto. Control*, 1971, vol. 16, no. 2, pp. 117–128. doi: 10.1109/TAC.1971.1099674 .
3. Schweppe F.C. *Uncertain dynamic systems*. N Y: Prentice Hall, 1973, 563 p. ISBN: 0139355936 .
4. Schmitendorf W.E. Minimax Control of Systems with Uncertainty in the Initial State and in the State Equations. *IEEE Trans. on Auto. Control*, 1971, vol. 22, no. 3, pp. 439–443. doi: 10.1109/TAC.1977.1101506 .
5. Chernous'ko F.L. *Otsenivanie fazovogo sostoyaniya dinamicheskikh sistem. Metod ellipsoidov.* (Phase state estimation for dynamical systems. The method of ellipsoids.) Moscow: Nauka Publ., 1988, 319 p. ISBN: 5-02-013899-1 .
6. Kurzhanski A.B., Valyi I. *Ellipsoidal Calculus for Estimation and Control*. Basel: Birkhäuser, 1997, 321 p. ISBN: 978-0-8176-3699-9 .
7. Kurzhanski A.B., Varaiya P. *Dynamics and Control of Trajectory Tubes: Theory and Computation.* SCFA, vol. 85. Basel: Birkhäuser, 2014, 445 p. doi: 10.1007/978-3-319-10277-1 .
8. Ananyev B.I., Yurovskih P.A. On the Approximation of Estimation Problems for Controlled Systems. *AIP Conference Proceedings*, 2019, vol. 2164, iss. 1, art.-no. 110001, 9 p. doi: 10.1063/1.5130846 .
9. Anan'ev B.I. Minimax quadratic problem of motion correction. *J. Appl. Math. Mech.*, 1977, vol. 41, no. 3, pp. 434–445. doi: 10.1016/0021-8928(77)90035-1 .
10. Anan'ev B.I. The problem of motion correction with Gaussian communications channel. *Autom. Remote Control*, 2011, vol. 72, no. 2, pp. 240–254. doi: 10.1134/S0005117911020044 .
11. Vasilyev F.P. *Chislennye metody resheniya ekstremal'nykh zadach* [Numerical methods for solving extremal problems]. Moscow: Nauka Publ., 1988, 552 p. ISBN: 5-02-013796-0 .
12. Clarke H. *Optimization and nonsmooth analysis*. Canadian Mathematical Society Series in Mathematics, N Y et al., John Wiley & Sons, 1983, 308 p.
13. Dontchev A., Rockafellar T. *Implicit functions and solution mappings. A view from variational analysis*, N Y: Springer, 2014, 466 p.

14. Propoy A.I. *Elementy teorii optimal'nykh diskretnykh protsessov* (Elements of the theory of optimal discrete processes). Moscow: Nauka Publ., 1973, 256 p.

Received August 30, 2020
Revised October 19, 2020
Accepted October 26, 2020

Funding Agency: This study was supported by the Scientific Educational Center of the IMM UB RAS working under the Ural Mathematical Center.

Boris Ivanovich Ananyev, Dr. Phys.-Math. Sci., Leader Sci. Collaborator, Krasovskii Institute of Mathematics and Mechanics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, 620108 Russia, e-mail: abi@imm.uran.ru .

Polina Aleksandrovna Yurovskih, doctoral student, Krasovskii Institute of Mathematics and Mechanics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, 620108 Russia, e-mail: polina2104@list.ru .

Cite this article as: B. I. Anan'ev, P. A. Yurovskikh. Approximation of a guaranteed estimation problem with mixed constraints, *Trudy Instituta Matematiki i Mekhaniki UrO RAN*, 2020, vol. 26, no. 4, pp. 48–63 .