

## ON A PROBLEM OF DYNAMIC DISTURBANCE RECONSTRUCTION IN A NONLINEAR SYSTEM OF DIFFERENTIAL EQUATIONS

V. L. Rozenberg

The problem of reconstructing an unknown disturbance in a system of ordinary differential equations of a special kind is investigated on the basis of the approach of the theory of dynamic inversion. A statement is considered in which the disturbance is reconstructed synchronously with the process from incomplete discrete information on a part of coordinates of the phase trajectory. A finite-step software-oriented solution algorithm based on the method of auxiliary closed-loop models is proposed, and its error is estimated. The novelty of the paper is that we consider the inverse problem for a partially observed system with a nonlinear with respect to disturbance equation describing the dynamics of the unmeasured coordinate.

Keywords: system of ordinary differential equations, nonlinearity with respect to disturbance, lack of information, dynamic reconstruction, controlled model.

MSC: 9K15, 93C41

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### REFERENCES

1. Brockett R.W., Mesarovich M.P. The reproducibility of multivariable control systems. *J. Math. Anal. Appl.*, 1965, vol. 11, no. 1–3, pp. 548–563.
2. Sain M.K., Massey J.L. Invertibility of linear time-invariant dynamical systems. *IEEE Trans. Automat. Contr.*, 1969, vol. AC-14, pp. 141–149. doi: 10.1109/TAC.1969.1099133.
3. Norton J.P. *An introduction to identification*. London: Acad. Press, 1986, 310 p.
4. Ljung L., Söderström T. *Theory and practice of recursive identification*. Cambridge: M.I.T. Press, 1983, 528 p.
5. Bar-Shalom Y., Li X.R. *Estimation and tracking: principles, techniques, and software*. Boston: Artech House, 1993, 511 p.
6. Tikhonov A.N., Arsenin V.Ya. *Methods for Solutions of Ill-Posed Problems*. N Y: Wiley, 1977, 258 p. ISBN: 0470991240. Original Russian text published in Tikhonov A.N., Arsenin V.Ya. *Metody resheniya nekorrektnykh zadach*. Moscow: Nauka Publ., 1979, 285 p.
7. Kabanikhin S.I. *Inverse and ill-posed problems*. Berlin: De Gruyter, 2011, 459 p.
8. Papadimitriou T., Diamantaras K.I., Strintzis M.G., and Roumeliotis M. Robust estimation of rigid-body 3-D motion parameters based on point correspondences. *IEEE Trans. Circuits Syst. Video Techn.*, 2000, vol. 106, no. 4, pp. 541–549. doi: 10.1109/76.844999.
9. Keller J.Y., Sauter D. Kalman filter for discrete-time stochastic linear systems subject to intermittent unknown inputs. *IEEE Trans. Autom. Contr.*, 2013, vol. 104, no. 7, pp. 1882–1887. doi: 10.1109/TAC.2013.2264739.
10. Kryazhimskii A.V., Osipov Yu.S. Modelling of a control in a dynamic system. *Engrg. Cybernetics*, 1983, vol. 21, no. 2, pp. 38–47.
11. Osipov Yu.S., Kryazhimskii A.V. *Inverse problems for ordinary differential equations: dynamical solutions*. Basel: Gordon and Breach, 1995, 625 p. ISBN: 9782881249440.
12. Osipov Yu.S., Kryazhimskii A.V., Maksimov V.I. *Metody dinamicheskogo vosstanovleniya vkhodov upravlyaemykh sistem* [Methods of dynamic reconstruction of inputs of controlled systems]. Ekaterinburg: Izd-vo UrO RAN, 2011, 292 p.
13. Krasovskii N.N., Subbotin A.I. *Game-theoretical control problems*. N Y: Springer, 1988, 517 p. ISBN: 978-1-4612-8318-8. Original Russian text published in Krasovskii N.N., Subbotin A.I. *Pozitsionnye differentsial'nye igry*. Moscow: Nauka Publ., 1984, 456 p.

14. Kryazhimskii A.V., Osipov Yu.S. Stable positional reconstruction of a control from measurements of some of the coordinates. In: A.V. Kim and V.I. Maksimov (eds.) *Some control and stability problems*. Sverdlovsk: Akad. Nauk SSSR Ural. Otdel., 1989. pp. 33–47 (in Russian).
15. Maksimov V.I. *Zadachi dinamicheskogo vosstanovleniya vkhodov beskonechnomernykh sistem* [Problems of dynamic reconstruction of the inputs of infinite-dimensional systems]. Ekaterinburg: Ross. Akad. Nauk Publ., 2000, 305 p. ISBN: 5-7691-1082-1.
16. Rozenberg V.L. On a problem of dynamical input reconstruction for a system of special type under conditions of uncertainty. *AIMS Mathematics*, 2020, vol. 5, no. 5, pp. 4108–4120. doi: 10.3934/math.2020263.
17. Kryazhimskii A.V., Osipov Yu.S. Best approximation of the differentiation operator in the class of nonanticipatory operators. *Math. Notes*, 1985, vol. 37, no. 2, pp. 109–114. doi: 10.1007/BF01156754.
18. Vdovin A.Yu. *K zadache vosstanovleniya vozmushcheniya v dinamicheskoi sisteme* [On the problem of reconstruction of perturbation in a dynamical system]. Candidate Sci. (Phys.–Math.) Dissertation. Sverdlovsk: UrO AN SSSR, 1989, 117 p.

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*Valeriy Lvovich Rozenberg*, Cand. Sci. (Phys.-Math.), Krasovskii Institute of Mathematics and Mechanics of the Ural Branch of the Russian Academy of Sciences, Yekaterinburg, 620108 Russia; Ural State University of Railway Transport, Yekaterinburg, 620034 Russia,  
e-mail: rozen@imm.uran.ru.

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