

SYNTHESIS METHOD OF SYSTEMS FOR HIGH-PRECISION MOVEMENTS CONTROL OF UNDERWATER MANIPULATORS

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The paper presents a synthesis method of combined systems providing high-precision movements control of multilink manipulator arm tool mounted on underwater vehicles. The proposed method allows precise identification of negative torques on the output shaft of the manipulator electric drives that emerged during its motion in a viscous medium and moments of coulomb and viscous friction in these drives. This method begins with a preliminary analytical calculation of external moments appearing in underwater manipulator axes of motion by the recurrent algorithm of solving the inverse dynamic problem. This calculation is highly coarse due to the complexity of determining parameters of the real interaction between all links of the manipulator, engaged load, and seawater medium. Additional diagnostic observers are then synthesized using dynamic models of electric drives of every axis of freedom, including analytically determined external moments. These observers can more precisely determine the values of unpredicted changes of the viscous and coulomb friction moments in drives itself using formed discrepancy signals. Then identified torques on the electric drives of all manipulator axes are compensated using self-regulated correcting devices capable of stabilizing these drives' dynamic properties on the nominal level. The paper contains numerical modeling of the system synthesized by a developed method for a multilink manipulator with a PUMA kinematic scheme, an arm tool of which was moved alongside a complex three-dimensional trajectory. The numerical modeling results showed a significant increase in the accuracy of different technological operations performed by underwater manipulators using a synthesized system.

Key words: underwater multilink manipulator, underwater vehicle, identification, high precision, observer.

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REFERENCES

1. Filaretov V.F., Konoplin A.Yu., Konoplin N.Yu. *Sistema dlya avtomaticheskogo vypolneniya manipulyatsionnykh operatsiy s pomoshch'yu podvodnogo robota. Mekhatronika, avtomatizatsiya, upravlenie*. 2017. Vol. 18, No. 8. P. 543–549.
2. Konoplin A.Yu., Konoplin N.Yu., Shuvalov B.V. Approach for performing of technological manipulation operations with various underwater objects by AUV. *Underwater Investigations and Robotics*. 2019. No. 1 (27). P. 31–37.
3. Filaretov V.F., Konoplin A.Yu. *Sistema avtomaticheskoy stabilizatsii podvodnogo apparata v rezhime zavisaniya pri rabotayushchem mnogozvennom manipulyatore*. Ch. 1. *Mekhatronika, avtomatizatsiya, upravlenie*. 2014. No. 6. P. 53–56.
4. Kuafe F. *Vzaimodeystvie robota s vneshney sredoy*. M.: Mir, 1985. 285 p.
5. Zhang Q. Adaptive Kalman filter for actuator fault diagnosis. *Automatica*. 2018. Vol. 93. P. 333–342.
6. He J., Zhang C. Fault reconstruction based on sliding mode observer for nonlinear systems. *Mathematical Problems in Engineering*. 2012. Vol. 2012. ID 451843. P. 1–22.
7. Zhirabok A., Zuev A., Shumsky A. Sliding Mode Observers Based Fault Identification in Mechatronic Systems. *Proceeding of the IEEE Industrial Electronics Conference*. Zaragoza, Spain, 2019. P. 161–166.
8. Zhirabok A.N., Usol'tsev S.A. *Lineynye metody pri diagnostirovanii nelineynykh system. Avtomatika i telemekhanika*. 2000. No. 7. P. 149–159.
9. Filaretov V.F. *Samonastrayayushchiesya sistemy upravleniya privodami manipulyatorov*. Vladivostok: Izd-vo DVGUTU, 2000. 304 p.
10. Utkin V.I. *Skol'zyashchie rezhimy i ikh primeneniye v sistemakh s peremennoy strukturoy*. M.: Nauka, 1974.

11. Filaretov V.F., Zhirabok A.N., Zuev A., Protchenko A. The development of the faults accommodation system for actuators of multilink manipulators. Proceedings of the 23rd DAAAM Int. Symp. on Intelligent Manufacturing and Automation 2012. Zadar, Croatia, 2012. Vol. 23, No. 1. P. 575–578.

12. Filaretov V.F., Konoplin A.Yu. *Sistema avtomaticheskoy korrektsii programmnoy traektorii dvizheniya mnogozvennogo manipulyatora, ustanovlennogo na podvodnom apparate. Mekhatronika, avtomatizatsiya, upravlenie.* 2013. No. 1. P. 40–45.

13. Filaretov V.F., Konoplin A.Yu. *Sistema avtomaticheskoy stabilizatsii podvodnogo apparata v rezhime zavisaniya pri rabotayushchem mnogozvennom manipulyatore. Ch. 2. Mekhatronika, avtomatizatsiya, upravlenie.* 2014. No. 7. P. 29–34.

14. Filaretov V.F., Zuev A.V., Gubankov A.S. *Upravlenie manipulyatorami pri vypolnenii razlichnykh tekhnologicheskikh operatsiy.* M.: Nauka, 2018. 232 p.

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