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THE STRUCTURE OF THE SOFTWARE CONTROL PACKAGE FOR AUTONOMOUS UNDERWATER VEHICLE

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The work is devoted to the control system of heavy-class AUV, which differ from AUV of other classes in a wider range of tasks, including sailling at great depths and at a large distance from their base, which required equipping them with a large range of special equipment and high power capacity. These differences impose higher requirements on the heavy-class AUV control system. The AUV control system is based on a multi-agent principle, which makes it possible to reduce its complexity by transferring some of its functions to AUV systems, or rather their control systems. The core of the AUV multi-agent control system is the software control package (SCP), which is responsible for coordinating the functioning of all AUV systems in order to perform a mission assignment as accurately as possible by issuing commands to AUV systems and verifying their implementation, if necessary, adjusting the mission assignment, monitoring the current state of the AUV in terms of safety navigation, the accuracy of monitoring its location, the serviceability of equipment and the remaining supply of electricity, taking appropriate measures in case of a critical situation, radio and sonar communications with the command post and interoperable facilities. The purpose of the work is to describe the structure of the SCP, developed by the authors and characterized by simplicity, ensuring reliable operation of SCP, and versatility, allowing the use of the developed SCP in AUV for various purposes. The developed structure is based on the multi-agent principle of SCP, which consists in the provision of a set of independent agent programs, each of which controls AUV when solving a specific task, and a coordinator program that transfers control to the appropriate program when appropriate conditions arise. This approach makes it possible to simplify the SCP and thereby increase its reliability.

Keywords: AUV control system, software control package, control algorithms.

References

1. Podvodnie robototehnicheskie komplekci: sistemi, tehnologii, primenenie (Underwater robotic complexes: systems, technologies, applications) / A.V. Inzartsev, L.V. Kiselev, V.V. Kostenko, Yu.V. Matvienko, A.M. Pavin, A.F. Shcherbatyuk. [ed. by L.V. Kiselyov]; FSBI Institute of Problems of Marine Technologies, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, 2018. 368 p.

2. Jane's unmanned maritime vehicle. 2022-2023. Ed. Kelvin Wong. IHS Markit. Coulsdon, Surrey, UK. 2023.

3. Yang R., Liu Y., Utne I. B., Paltrinieri N. Dynamic Risk Analysis of Operation of the Autonomous Underwater Vehicle. The 30th European Safety and Reliability Conference and the 15th Probabilistic Safety Assessment and Management. Italy. June 2020. DOI:10.3850/978-981-14-8593-0_4118-cd.

4. Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress. 2020. https://sgp.fas.org/crs/weapons/R45757.pdf. (Date of access: 24.05.2025).

5. Avtonomnyye neobitayemyye podvodnyye apparaty bolshogo i sverkhbolshogo vodoizmeshcheniya v inostrannykh voyenno-morskikh flotakh. (Autonomous underwater vehicles of large and extra-large displacement in foreign navies) / A.A. Boreyko, G.Yu. Illarionov, A.Yu. Konoplin, K.Z. Laptev K.Z., IMTP FEB RAS, Vladivostok, 2025. 53 p.

6. Rzhevsky G.A., Skobelev P.O. Kak upravlyat slozhnimi sistemami? Multiagentnie tehnologii dlya sozdaniya intellektualnih sistem upravleniya predpriyatiyami (How to manage complex systems? Multi-agent technologies for creating intelligent enterprise management systems). Samara: Etching, 2015, 290 p.

7. Pshikhopov V., Medvedev M., Kostjukov V., Houssein F., Kadhim A.T. Trajectory Planning Algorithms in Two-Dimensional Environment with Obstacles. Informatics and Automation. 2022. Vol.21, No. 3. P. 459-492.

8. Innocenti, B., A multi-agent architecture with distributed coordination for an autonomous robot. Ph.D. dissertation, Universitat de Girona, 2009.

9. Kim, T.W., Yuh, J., Development of a real-time control architecture for a semi-autonomous underwater vehicle for intervention missions, Autonomous Systems Laboratory, Department of Mechanical Engineering, University of Hawaii, 2003, pp. 1521-1530.

10. Sutarto H., Budiyono A. Development of linear parameter varying control system for autonomous underwater vehicle, Indian J. Geo-Marine Sci., 2011, vol. 40, pp. 275-286.

11. Kurochkin S.Yu., Tachkov A.A. Metody upravlenia gruppovim dvizeniem mobilnih robotov (obzor). Mehatronika, avtomatizatsia, upravlenie. 2021. Vol. 22, No. 6. P. 304-312.

12. Bykova V.S., Martynova L.A., Mashoshin A.I., Pashkevich I.V. A Dispatcher for a Multi-Agent Control System of an Autonomous Underwater Vehicle: Structure, Algorithms, and Simulation Results. Gyroscopy and Navigation. 2020. Vol. 10, No. 4. P. 341-349. DOI: 10.1134/S2075108720040033.

13. Goldberg D. Huxley: A Flexible Robot Control Architecture for Autonomous Underwater Vehicles. OCEANS 2011 IEEE - Spain. 2011.

14. Bykova V.S., Mashoshin A.I., Pashkevich I.V. Safe Navigation Algorithm for Autonomous Underwater Vehicles. Gyroscopy and Navigation. 2021. Vol. 12, No. 1. P. 86-95 (DOI: 10.1134/S2075108721010028).

15. Martynova L.A. Multiagentnyye tekhnologii v morskoy robototekhnike (Multi-agent technologies in marine robotics). International Conference on Marine Robotics in Ocean Exploration, MarineRobotics, 2019, September 17-19, Saint-Petersburg, Russia. 2019. P. 278-291.

16. Martynova L.A. Metod razresheniya konflikta v multiagentnoy sisteme upravleniya avtonomnogo neobitayemogo podvodnogo apparata s ispolzovaniyem raspredelennykh vychisleniy (The method of resolution of the conflict in the multiagent control system of the autonomous underwater vehicle with the use of distributed calculations). Izvestiya SFEDU. Engineering sciences. 2018. No. 8(202). P. 69-83.

17. Martynova L.A.,Kiselev N.K.,Myslivyi A.A. Metod vybora arkhitektury multiagentnoy sistemy upravleniya avtonomnogo neobitayemogo podvodnogo apparata (Choice of architecture for a multi-agent control system of an autonomous underwater vehicle). Information and control systems. 2020. No.4, P.31-41. (DOI: 10.31799/1684-8853-2020-4-31-41)

18. Martynova L.A Vybor multiagentnoy arkhitektury pri razrabotke sistemy upravleniya avtonomnogo neobitayemogo podvodnogo apparata (Selection of multi-agent architecture when developing a control system for an autonomous underwater vehicle). Izvestiya SFEDU. Engineering sciences. 2019. No. 7(209). P. 18-35.

19. Zhang L, Jiang D, Zhao J and Ma S An AUV for Ocean Exploring and its Motion Control System Architecture. The Open Mechanical Engineering Journal, 2013, 7, 40-47.

20. Novikov D.A. (Ed.). Theory of Control (Additional Chapters). Moscow: LENAND. 2019, P. 552.

21. Gurenko B.V. Razrabotka sistemy upravleniya i navigatsii avtonomnogo neobitayemogo podvodnogo apparata (Development of a control and navigation system for an autonomous uninhabited underwater vehicle) // http://rirpc.ru/razrabotka-sistem-upravleniya-i-navigacii-avtonomnymi-neobitaemymi-podvodnymi-apparatami/.

22. Sprague Ch.I., Özkahraman Ö, Munafo A., Marlow R., Phillips A., Ögren P. Improving the Modularity of AUV Control Systems using Behaviour Trees. Submitted to 2018 IEEE OES Autonomous Underwater Vehicle Symposium, DOI: https://doi.org/10.48550/arXiv.1811.00426

23. Bykova V.S., Mashoshin A.I. Tsifrovoi polygon dlya otrabotki sistemi upravleniya avtonomnogo neobitaemogo podvodnogo apparata (Digital test site for testing the control system of an autonomous uninhabited underwater vehicle). Marine radioelectronics. 2023, No. 2 (84). Pp. 32-26.

24. Mashoshin A.I. Predlozheniya po sovershenstvovaniyu organizatsii razrabotki I ispitanii avtonomnih neobitaemih podvodnih apparatov tyazhelogo klassa (Proposals for improving the organization of development and testing of autonomous uninhabited heavy-class underwater vehicles). Marine equipment and Technologies. 2024. No. 2 (39). Pp.49-55.

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