GEOMONITORING OF TECHNOGENIC OBJECTS USING ROBOTECHNICS ON THE BASIS OF MULTIAGENT SYSTEM THEORY

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Currently, robotics and the theory of multi-agent systems are used in the Ministry of Emergencies, transport, and trade, however, the theory of multi-agent systems is not currently used in geodesy. The article describes the geomonitoring technique of technogenic objects using robotics based on the theory of multi-agent systems, and presents the results of the experiment. To compare the developed technique with traditional geodetic methods, the article presents the results of geomonitoring of the laboratory building of the SSUGT obtained by a geo-robot and geometric leveling with short beams (the comparison is implemented in two parameters - accuracy and time). It is concluded that the measurements obtained using robotic devices have less accuracy compared to the method of geometric leveling with short rays, but if necessary, operational monitoring of technogenic objects in the process of emergency response is possible. The methodology for the geomonitoring of technogenic objects using robotics based on the theory of multi-agent systems described in the article is recommended to be considered as the primary control used in difficult shooting conditions, followed by the application of traditional methods that give high measurement accuracy.

Key words: theory of multi-agent systems, geomonitoring, robotic device, technogenic object, spatio-temporal state, geoinformation resources, web application.

REFERENCES

1. Kapralov, E. G., Koshkarev, A. V., & Tikunov, V. S. (2005). *Geoinformatika: [Geoinformatics]*. Tikunov, V. S. (Ed.). Moscow: "Akademiya" Publ. [in Russian]

2. Pinde, Fu, Jiulin, Sun. (2011). *Web GIS: principles and applications* (1st ed.). Esri Press, 380 New York Street, Redlands, California, P. 16.

3. Karpik, A. P. (2004). *Metodologicheskie i tekhnologicheskie osnovy geoinformatsionnogo obespecheniya territoriy [Methodological and technological bases of geoinformation support areas]*. Novosibirsk: SSGA Publ., 259 p. [in Russian]

4. Ustavich, G. A., Poshivaylo, Ya. G., Dubrovsky, A. V., Akhmetov, B. Zh., & Poshivaylo, A. O. (2016). Zoning and delimitation lands, adjacent to nuclear test sites, for purposes of commercial using (for example Semipalatinsk test site territory). *Vestnik SGUGiT [Vestnik SSUGT]*, 4(36), 145–160 [in Russian].

5. Lisitsky, D. V., & Chernov, A. V. (2018). Theoretical basis of three-dimensional cadaster of real estate objects. *Vestnik SGUGiT [Vestnik SSUGT]*, *23*(2), 153–170 [in Russian].

6. Karpik, A. P., & et al. (2014). Methodological principles of precise satellite navigation system of mobile objects with the use of GLONASS. *Izvestiya vuzov. Geodeziya i aerofotos"emka. [Izvestiya Vuzov. Geodesy and Aerophotography]*, 5, 69–74 [in Russian]

7. Goryainov, I. V. (2018). Pilot studies of linear – angular resection application for point stability estimation in horizontal deformation geodetic network. *Vestnik SGUGiT [Vestnik SSUGT]*, *23*(1), 28–39 [in Russian].

8. Mogilny, S. G., Sholomitsky, A. A., Ivanov, A. V., Seredovich, A. V., Lagutina, E. K., & Martynov, A. V. (2018). Research of rotating agrigates geometrical parameters determination methods on the basis of laser scanning. *Vestnik SGUGiT [Vestnik SSUGT]*, *23*(3), 89–107 [in Russian].

9. Kraev, A. N., & Novikov, Y. A. (2019). Geodetic overseeing by building settlings within carrying out geotechnical monitoring. *Vestnik SGUGiT [Vestnik SSUGT]*, *24*(1), 28–41 [in Russian].

10. Timofeev, V. Yu., Semibalamut, V. M., Ardyukov, D. G., Timofeev, A. V., Fomin, Yu. N., Gribanova, E. I., Boyko, E. V., Panov, S. V., & Parushkin, M. D. (2019). Laser extensometer and time variation of tidal deformation. *Vestnik SGUGiT [Vestnik SSUGT]*, *24*(1), 42–58 [in Russian].

11. Thanh Son Tran, & Kuzin, A. A. (2019). Algorithm of transforming coordinates from a geocentric system to a topocentric system and its application in construction in Vietnam. *Vestnik SGUGiT [Vestnik SSUGT]*, *24*(1), 59–71 [in Russian].

12. Wojnarowski, A. E., & Tikhonov, S. G. (2019). Laser scanner calibration using scans of test polygon. Vestnik SGUGiT [Vestnik SSUGT], *24*(2), 5–18 [in Russian].

13. Gordeev, V. F., Malyshkov, S. Yu., & Polivach, V. I. (2019). Geophysical monitoring of technogenic hazards on anthropogenic soils. *Vestnik SGUGiT [Vestnik SSUGT]*, *24*(2), 35–44 [in Russian].

14. Kalenizkiy, A. I., & Solowitskiy, A. N. (2019). The development of multilevel structured on the geodynamic polygon in exploitation of subsurface resources in Kuzbass. *Vestnik SGUGiT [Vestnik SSUGT]*, *24*(2), 45–55 [in Russian].

15. Kamnev, I. S. (2017). Research of laser scanning technology at engineering geodesic surveys for repairing motorway. *Vestnik SGUGiT [Vestnik SSUGT]*, *22*(2), 67–77 [in Russian].

16. Standarts Russian Federation. (2005). GOST R 22.1.12-2005. Structured system for monitoring and control of engineering systems of buildings and structures. General requirements. Moscow : IPK, Standards Publ.

17. Bugakova, T. Yu. (2011). On the question of risk assessment of geotechnical systems for geodetic data. In *Sbornik materialov GEO-Sibir'-2011: T. 1, ch. 1 [Proceedings of GEO-Siberia-2011. Vol. 1, Part 1]* (pp. 151–157). Novosibirsk: SSGA Publ. [in Russian].

18. Tarasov, V. B. (2002). *Ot mnogoagentnykh sistem k intellektual'nym organizatsiyam. Filosofiya, psikhologiya, informatika [From multi-agent systems to intelligent organizations. Philosophy, psychology, computer science]*. Moscow: Editorial Publ., p. 8 [in Russian].

19. Evgeny, G. B. (2000). Multi-agent systems computer engineering. *Informatsionnye tekhnologii [Information Technology]*, 4, 2–7 [in Russian].

20. Rygalov, A. Y., & Kubarkov, J. P. (2012). Application of multi-agent systems in the power industry. In *Sbornik trudov Kol'skogo nauchnogo tsentra RAN [Proceedings of the Kola Science Center RAS]* (pp. 102–105) [in Russian].

21. Russell, S., & Norvig, P. (2007) *Iskusstvennyy intellekt. Sovremennyy podkhod [Artificial Intelligence. Modern approach]* (2d ed). Moscow: Vil'yams Publ., 1410 p. [in Russian]

22. Chekina, S. G. (2001). Intelligent software actuators (agents) in communication systems. *Informatsionnye tekhnologii [Information Technology]*, 4, 6–11 [in Russian].

23. Bugakova, T. Yu., Shlyakhova, M. M., & Knol' I. A. (2016). Structural decomposition methods of mathematical modeling of the object, followed by visualization based on WebGL. In *Sbornik materialov Interekspo GEO-Sibir'-2016: Mezhdunarodnoy nauchnoy konferentsii: T. 4 Geodeziya, geoinformatika, kartografiya, marksheyderiya [Proceedings of Interexpo GEO-Siberia-2016: International Scientific Conference: Vol. 1. Geodesy, Geoinformatics, Cartography, Mine Surveying]* (pp. 142–147). Novosibirsk: SSUGT Publ. [in Russian].

24. Matsuda, K., & Li, R. (2015). *WebGL: programmirovanie trekhmernoy grafiki [WebGL: three-dimensional graphics programming]*. A. N. Kiselev (Trans.). Moscow: DMK Press Publ., 494 p. [in Russian].

25. Eremenko, O. S., Cherdyntsev, E. S. Comparison of three-dimensional Internet technologies. In *Elektronnyy sbornik statey XI mezhdunarodnoy studencheskoy nauchno-prakticheskoy konferentsii: No. 4(11). Molodezhnyy nauchnyy forum: Tekhnicheskie i matematicheskie nauki [Elektronic Proceedings of XI International Students Scientific and Practical Conference: No. 4 (11).*

Youth Scientific Forum: Technical and Mathematical Sciences]. Retrieved from at http://nauchforum.ru/node/3187 [in Russian].

26. Bugakova T. Y. (2015). Modeling spatio-temporal changes in the state of engineering structures and natural sites on geodetic data. *Vestnik SGUGiT [Vestnik SSUGT]*, 1(29), 34–42 [in Russian].

27. Leibo, J. Z., Zambaldi, V., Lanctot, M., Marecki, J., & Graepel, T. (2017). Multi-agent reinforcement learning in sequential social dilemmas. In *Proceedings of the 16th International Conference on Autonomous Agents and Multi-Agent Systems* (pp. 464–473).

28. Shoham, Y., Powers, R., & Grenager, T. (2007). If multi-agent learning is the answer, what is the question? *Artificial Intelligence*, *171*(7), 365–377, 2007.

29. He, H., Boyd-Graber, J., Kwok, K., & Daumé III, H. (2016). Opponent modeling in deep reinforcement learning. In *Proceedings of the 33rd International Conference on Machine Learning* (pp. 1804–1813).

30. Stone, P., Kaminka, G., Kraus, S., & Rosenschein, J. (2010). Ad hoc autonomous agent teams: collaboration without pre-coordination. In *Proceedings of the 24th AAAI Conference on Artificial Intelligence* (pp. 1504–1509).

31. Genter, K., Laue, T., & Stone, P. (2017). Three years of the RoboCup standard platform league drop-in player competition: Creating and maintaining a large scale ad hoc teamwork robotics competition. *Autonomous Agents and Multi-Agent Systems*, *31*(4), 790–820.

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