Common methodology for joint application of operator-driven and automated lunar rover motion guidance in night-side craters on lunar poles

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The study considers issues of guiding lunar rover motion under insufficient illumination conditions of the north and south lunar pole regions. We present options for operator-driven and automated motion guidance. Operator-driven guidance means that a human being (an operator) located at a remote control centre on the Earth or the Moon generates motion commands. The commands are transmitted to the rover by radio links. In the case of automated guidance, motion commands are generated independently on board the rover. We consider the case of automated motion guidance using on-board stereo television cameras, when the rover employs their data and on-board software to construct a three-dimensional grid of the terrain surface and automatically chart its path on it. We compare advantages and disadvantages of operator-driven and automated lunar rover motion guidance methods and work out the recommendations dealing with the logic of their joint application in night-side lunar craters.

Keywords*: lunar rover motion guidance, shadow in craters, machine vision system, path-finding*

REFERENCES

[1] Pugacheva S.G., Feoktistova E.A. *Innovatsii i investitsii — Innovations and Investments*, 2015, no. 11, pp. 227–232.

[2] Researchers Estimate Ice Content of Crater at Moon's South Pole. *NASA.* 20.06.2012.
Available at: https://www.nasa.gov/mission_pages/LRO/news/crater-ice.html (accessed February 8, 2017).

[3] Tonkiy led v kratere vechnoy tmy. *ASTROnovosti.* 25.06.2012 [AstroNews. Thin ice in a crater of eternal darkness].
Available at: http://astronovosti.ru/tonkij-led-v-kratere-vechnoj-tmy/ (accessed February 8, 2017).

[4] Robson D. No ice rinks on the Moon after all, 23.10.2008. *New Scientist.* Available at: https://www.newscientist.com/article/dn15024-no-ice-rinks-on-the-moon-after-all/ (accessed February 8, 2017).

[5] The Clementine Mission. *Lunar and Planetary Institute.* Available at: http://www.lpi.usra.edu/lunar/missions/clementine/data/ (accessed February 8, 2017).

[6] "Tovarishchi, vam doverili bestsennyy kosmicheskiy apparat…" [Comrades, you have been trusted with priceless spacecraft]. *Rossiyskie kosmicheskie sistemy* [Russian space systems].
Available at: http://russianspacesystems.ru/2017/01/10/lunokhod-2/ (accessed February 6, 2017).

[7] Polishchuk G.M., Pichkhadze K.M., Rogovskiy G.N., Buslaev S.P. Razrabotka v NPO im. S.A. Lavochkina tekhnicheskogo stereozreniya dlya avtonomnogo upravleniya dvizheniem planetokhoda [Lavochkin Science and Production Association developing stereoscopic machine vision for autonomous planetary

rover motion guidance]. *Tezisy dokladov mezhdunarodnoy nauchno-prakticheskoy konferentsii 2–3 oktyabrya 2007 g. Osobennosti razvitiya kosmicheskoy otrasli Rossii i perspektivy ee dalneyshey integratsii v sistemu mezhdunarodnykh ekonomicheskikh svyazey* [Proc. of the International Scientific and Applied Conference, October 2–3, 2007. Specifics of the development of the Russian space industry and the prospects of its further integration into the international economic relation system]. Saint Petersburg, Ustinov Baltic State Technical University VOENMEH Publ., 2007, pp. 120–122.

[8] Buslaev S.P. *Vestnik FGUP NPO S.A. Lavochkina — Vestnik NPO im. S.A. Lavochkina (Herald of the Lavochkin Science and Production Association)*, 2013, no. 1, pp. 24–28.

[9] Lamboley M., Proy C., Rastel L., Zashchirinski A. and Buslaev S. *Autonomous Robots*, 1995, no. 2, pp. 345–351.

[10] Eyes and Other Senses. *NASA. Mars Science Laboratory*. Available at: http://mars.nasa.gov/msl/mission/rover/eyesandother/ (accessed February 08, 2017).

[11] Tekhnika. Marsokhod. Curiosity [Technology. Mars rover. Curiosity]. *Ecoruspace.Me.* Available at: http://ecoruspace.me/Марсоход.+Curiosity.html (accessed March 10, 2017).

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