Unmanned aerial vehicle flight control

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Being among the simplest unmanned aerial vehicles, quadcopters have gained widespread use nowadays. In order to control the quadcopter's flight precisely, it is necessary not only to understand the process of its movement but also know the dynamics of its construction. Most commonly, the closedness of the vehicle guidance system results in low efficiency by the ratio between the tasks performed and the expenditures for maintenance, reconfiguration and operation. For this reason the work justifies the possibility of constructing an open source system, considers the functioning of the primary flight modes and investigates some causes for the emergence of self-oscillations and diverging oscillations of the vehicle position hold system. The developed mathematical model of the aircraft power plant allows analyzing and forecasting the specific features of the vehicle guidance system when setting it up for a particular task.

Keywords: *quadcopter, automatic control system, flight controller, flight modes, PID control, motor*

REFERENCES

[1] Gen K., Chulin N.A. *Vestnik MGTU im. N.E. Baumana. Ser. Priborostroenie — Herald of the Bauman Moscow State Technical University. Series Instrument Engineering*, 2017, no. 3, pp. 76–94. DOI: 10.18698/0236-3933-2017-3-76-94

[2] Gen K., Chulin N.A. *Nauka i obrazovanie — Science and Education*, 2015, no. 5. DOI: 10.7463/0515.0771076

[3] Gen K., Chulin N.A. *Izvestiya Tulskogo gosudarstvennogo universiteta. Tekhnicheskie nauki — Proceedings of the TSU*, 2016, no. 6, pp. 80–88. Available at: https://elibrary.ru/item.asp?id=26281163 (accessed November 21, 2017).

[4] Kozlovskiy V.B., Parshentsev S.A., Efimov V.V. *Vertolet s gruzom na vneshney podveske* [Helicopter with suspended load]. Moscow, Mashinostroenie Publ., 2008, 304 p.

[5] *Voliro*. Available at: https://www.voliro.ethz.ch/ (accessed May 7, 2018).

[6] Schollig A., Augugliaro F., Lupashin S., D'Andrea R. Synchronizing the Motion of a Quadrocopter to Music. *2010 IEEE International Conference on Robotics and Automation*, 2010, pp. 3355–3360. Available at: https://www.ethz.ch/content/dam/ethz/special-interest/mavt/dynamic-systems-n-control/idsc-dam/Research_DAndrea/FMA/Schoellig_ICRA2010.pdf (accessed September 7, 2017).

[7] Mironova I.V. Sistema upravleniya kvadrokopterom [Quadcopter control system]. *Nauchno-tekhnicheskiy seminar molodykh spetsialistov, uchenykh i studentov, posvyashchennyy pamyati Glavnogo konstruktora, akademika AN SSSR V.I. Kuznetsova, 26 aprelya 2017 goda. Sb. nauch. statey* [Scientific and technical colloquium of young professionals, scientists and students dedicated to the memory of the Chief Designer, academician of the Academy of Sciences of the Union of Soviet Socialist Republics V.I. Kuznetsov, April 26, 2017. Collection of scientific articles], 2017, pp. 75–82.

[8] Zhiltsov A.I., Zhukov K.S., Ryleev D.A., Chernichkin A.A., Chulin N.A., Yudin A.E. *Inzhenernyy zhurnal: nauka i innovatsii — Engineering Journal: Science and Innovation*, 2013, iss. 2 (14). DOI: 10.18698/2308-6033-2013-2-522

[9] Beard R.W. *Quadrotor Dynamics and Control*. Brigham Young University, 2008, 47 p. Available at: http://rwbclasses.groups.et.byu.net/lib/exe/fetch.php?media=quadrotor:beardsquadrotornotes.pdf (accessed October 25, 2017).

[10] Kanatnikov A.N., Krishchenko A.P., Tkachev S.B. *Nauka i obrazovanie — Science and Education*, 2012, no. 3. DOI: 10.18698/1812-3368-2016-3-70-81

[11] *Copter Home*. Available at: http://ardupilot.org/copter/index.html (accessed November 20, 2017).

[12] Guryanov A.E. *Inzhenernyy vestnik — Engineering Bulletin,* 2014, no. 8. Available at: http://engbul.bmstu.ru/doc/723331.html (accessed October 1, 2017).

[13] Shlyaykher M. *Tekhnika avtomaticheskogo regulirovaniya dlya praktikov* [Automatic control engineering for practitioners]. Moscow, JUMO GmbH Publ., 2006, 124 p.

[14] Luukkonen T. Modelling and Control of Quadcopter. *School of Science, Espoo*, 2011, 26 p. Available at: http://sal.aalto.fi/publications/pdf-files/eluu11_public.pdf (accessed November 16, 2017).

[15] *Develop BLDC motor control algorithms using simulation*. Available at: https://www.mathworks.com/discovery/bldc-motor-control.html (accessed October 15, 2017).

[16] *APM 2.6*. Available at: http://ardupilot.org/copter/docs/common-apm25-and-26-overview.html (accessed November 18, 2017).

[17] Santos O., Romero H., Salazar S, Lozano R. Real-time Stabilization of a Quadrotor UAV: Nonlinear Optimal and Suboptimal Control. *Journal of Intelligent & Robotic Systems*, 2013, vol. 70, no. 1-4, pp. 79–91. DOI: 10.1007/s10846-012-9711-8

[18] Belinskaya Yu.S. *Molodezhnyy nauchno-tekhnicheskiy vestnik — Youth Scientific and Technical Bulletin of BMSTU,* 2013, no. 4. Available at: http://ainsnt.ru/doc/551872.html (accessed October 11, 2017).

[19] Belinskaya Yu.S., Chetverikov V.N. *Nauka i obrazovanie — Science and Education,* 2012, no. 5. DOI: 10.7463/0512.0397373

[20] *T-Motor MN3110 780KV*. Available at: http://store-en.tmotor.com/goods.php?id=336 (accessed November 20, 2017).

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