LINEAR-QUADRATIC CONTROL OF AIRCRAFT GROUP

D.L. VINOKURSKY[1], N.V. KONONOVA[1], L.A. LYUTIKOVA[2], S.A. MAKHOSHEVA[3], M.M. KANDROKOVA[3]

[1]North-Caucasian Federal University, Stavropol
355000, Stavropol region, Stavropol, Kulakov str, 2
[2]Institute of Applied Mathematics and Automation –
branch of the FSBSE «Federal Scientific Center
«Kabardin-Balkar Scientific Center of the Russian Academy of
Sciences»
360000, KBR, Nalchik, Shortanov street, 89-a E-
mail: ipma@niipma.ru
[3]Institute of Computer Science and Problems of Regional Management –
branch of Federal public budgetary scientific establishment "Federal scientific
center "Kabardin-Balkar Scientific Center of the Russian Academy of
Sciences" 360000, KBR, Nalchik, 37-a, I. Armand St. E-mail:
iipru@rambler.ru

Today, there are a large number of tasks that can not be performed by a single unmanned aerial vehicle. In this case, the use of a group of unmanned aerial vehicles is a good solution. These tasks include the task of mapping the area, work in the field of technogenous (human-caused) or natural disasters, monitoring and processing of agricultural land, the study in real time remote areas. In terms of a megapolis a group of aircraft can be used to create panoramic views, and tracking the dynamics of traffic jams. A group of unmanned aerial vehicles can be used for express cargo transportation, a group of unmanned aerial vehicles can be used in mineral exploration tasks.

In this paper we consider the problem of joint movement of several unmanned aerial vehicles based on rigid links. The method of linear-quadratic regulation is applied. The movement of a group of drones is modeled by the method of leader-follower and the method of RD control with linear – quadratic regulation is applied. An algorithm for constructing an optimal control system for a tightly coupled group of quadcopters is developed. To solve the problem it is proposed to use the method of linear-quadratic regulation.

The mathematical model of the system of quadcopters with rigid connection is constructed. The graphs show the results of modeling the system of rigid-coupled quadcopters.

Keywords: unmanned aerial vehicle, linear-quadratic regulation, quadcopter (quadrotor), Euler angles, moving coordinate system, moment of inertia.

REFERENCES

1. *Roldao V., Cunha R., Cabecinhas D., Oliveira P. and Silvestre C.* A novel leader-following strategy applied to formations of quadrotors. In European Control Conference (ECC), 2013.

2. *Hiroaki Yamaguchi.* A distributed motion coordination strategy for multiple nonholonomic mobile robots in cooperative hunting operations. Robotics and Autonomous Systems, 43(4):257 – 282, 2003.

3. *James G. Bellingham and Kanna Rajan.* Robotics in remote and hostile environments. Science, 318(5853):1098–1102, 2007.

4. *Jonathan Fink, Nathan Michael, Soonkyum Kim and Vijay Kumar.* Planning and control for cooperative manipulation and transportation with aerial robots. The International Journal of Robotics Research, 30(3), March 2011.

5. *Summers T.H., Changbin Yu and Brian D.O. Anderson.* Robustness to agent loss in vehicle formations and sensor networks. In Decision and Control, 2008. CDC 2008, pages 1193–1199, 2008.

6. *Silvia Mastellone, Dusan M. Stipanovic, Christopher R. Graunke, Koji A. Intlekoferand Mark W. Spong.* Formation control and collision avoidance for multi-agent nonholonomic systems: Theory and experiments. I. J. Robotic Res., 27(1):107–126, 2008.

7. *Rongxin Cui, Shuzhi Sam Ge, Bernard VoonEe How, and Yoo Sang Choo.* Leader-follower formation control of underactuated autonomous underwater vehicles. Ocean Engineering, 37(17–18):1491 – 1502, 2010.

8. *Zhaoxia Peng, Guoguang Wen, Ahmed Rahmani, and Yongguang Yu.* Leader-follower formation control of nonholonomic mobile robots based on a bioinspired neurodynamic based approach. Robotics and Autonomous Systems, June, 2013.

9. *Mariottini G.L., Morbidi F., Prattichizzo D., Pappas G.J. and Daniilidis K.* Leaderfollower formations: Uncalibrated vision-based localization and control. In Robotics and Automation, 2007 IEEE International Conference on, pages 2403–2408, 2007.

10. *Andrew J. Hanson and Hui Ma.* Parallel transport approach to curve framing.Technical report, 1995.

11. L. Consolini, F. Morbidi, D. Prattichizzo, and M. Tosques. On a class of hierarchical formations of unicycles and their internal dynamics. Automatic Control, IEEE, Transactions on, 57(4):845–859, 2012.

12. *Consolini L., Morbidi F., Prattichizzo D. and M. Tosques.* Stabilization of a hierarchical formation of unicycle robots with velocity and curvature constraints. Robotics, IEEE Transactions on, 25(5):1176–1184, 2009.

13. *Eric W Justh and PS Krishnaprasad.* Equilibria and steering laws for planar formations. Systems & Control Letters, 52(1):25–38, 2004.

14. *Mellinger D., Shomin M., Michael N. and V. Kumar.* Cooperative grasping and transport using multiple quadrotors. Springer Distributed autonomous robotic systems, Berlin, Heidelberg, 2013.

Vinokursky Dmitry Leonidovich, Candidate of physical-mathematical sciences, Associate professor of Information systems and technology Chair, North-Caucasian Federal University.
355000, Stavropol region, Stavropol, Kulakov street, 2.
Ph. 8-918-877-39-23.
E-mail: dlvinokursky@gmail.com

Kononova Natalia Vladimirovna, Candidate of physical-mathematical sciences, , Associate professor of Information systems and technology Chair, North-Caucasian Federal University, Stavropol.
355000, Stavropol region, Stavropol, Kulakov street, 2.
Ph. 8-962-445-56-84.
E-mail: knv_fm@mail.ru

Lyutikova Larisa Adolfovna, Candidate of physical-mathematical sciences, Institute of Applied Mathematics and Automation, KBSC RAS.
360000, KBR, Nalchik, Shortanov street, 89.
Ph. 8-963-166-40-14.
E-mail: lylarisa@yandex.ru

Makhocheva Salima Aleksandrovna, Doctor of Sciences in economics, Professor, head of the Department "Knowledge economy and advanced regional development", Institute of Computer Science and Problems of Regional Management of KBSC of the Russian Academy of Sciences.
360000, KBR, Nalchik, I. Armand street, 37-a.
Ph. (8662) 42-65-62.

E-mail: salima@list.ru

Kandrokova Marina Mukharbievna, Candidate of sciences in economics, senior staff scientist of the Department "Knowledge economy and advanced regional development", Institute of Computer Science and Problems of Regional Management of KBSC of the Russian Academy of Sciences.

360000, KBR, Nalchik, I. Armand street, 37-a.

Ph. (8662) 42-65-62.

E-mail: kandrokova-marina@mail.ru