Mobility model with flocking for a swarm of UAVs: Application to the coverage problem with connectivity constraints

Martin Rosalie[1], Grégoire Danoy[2], Matthias R. Brust[1], Serge Chaumette[3], Pascal Bouvry[2]
[1] SnT Interdisciplinary Centre, University of Luxembourg
[2] FSTC-CSC, University of Luxembourg
[3] Univ. Bordeaux, LaBRI, UMR5800, Talence, France

ABSTRACT

Recent advances in technologies for UAVs allow the development of new applications for both the civilian and military domains. Indeed, with an increased flight autonomy, computing power and ad hoc communication capabilities, UAVs are nowadays capable of tackling a wider range of missions.

A particularly active research topic focuses on the cooperative usage of multiple autonomous UAVs that evolve as a fleet. This UAV application setting does not only permit larger scale missions but also brings resilience to the system, for instance in case of hardware failure or harsh weather conditions. The vast majority of these works have relied on simulations, but few of them have actually considered real-world test-beds [1], [2]. A preliminary step in the development of such demonstrators is to conceive UAV mobility models with sufficient guarantees in terms of connectivity maintenance and mission achievement including sense-and-avoid procedures. Such features are mandatory to ensure that the developed mobility models can have sufficient performance while subject to a changing environment.

In this paper we address two antagonist objectives for swarms of UAVs: maximizing the surveillance, i.e. coverage, of an area while maximizing the network connectivity. The latter objective is imposed by the necessity to efficiently propagate locally acquired and/or computed information to other swarm members to ensure a more efficient global behavior of the system.

To this aim, we here propose to extend one of our previous mobility models, Chaotic Ant Colony Optimization for Coverage (CACOC) [3], that focused on coverage maximization alone, with a flocking behavior to maintain more stable groups of UAVs. Its performance is compared using simulation to another connectivity preserving mobility model [4] using several coverage and connectivity metrics (e.g., fairness of the coverage, number of connected components, network stability coefficient, etc.). Experimental results are analyzed, highlighting the assets of each model. Our future work will focus on deploying these mobility models on a set of real UAVs, i.e. quadcopters.

Keywords: UAVs, swarming, flocking, connectivity, coverage

REFERENCES

[1] S. Chaumette, R. Laplace, C. Mazel, R. Mirault, A. Dunand, Y. Lecoutre, and J.-N. Perbet, "Carus, an operational retasking application for a swarm of autonomous uavs: First return on experience," in *Military Communications Conference, MILCOM 2011*. IEEE, 2011, pp. 2003–2010.

[2] D. Mellinger, M. Shomin, N. Michael, and V. Kumar, "Cooperative grasping and transport using multiple quadrotors," in *Distributed autonomous robotic systems*. Springer, 2013, pp. 545–558.

[3] M. Rosalie, G. Danoy, S. Chaumette, and P. Bouvry, "From random process to chaotic behavior in swarms of UAVs," in *Proceedings of the 6th ACM Symposium on Development and Analysis of Intelligent Vehicular Networks and Applications - DIVANet'16*. Association for Computing Machinery (ACM), 2016. [Online]. Available: http://dx.doi.org/10.1145/2989275.2989281

[4] G. Danoy, M. R. Brust, and P. Bouvry, "Connectivity stability in autonomous multi-level UAV swarms for wide area monitoring," in *Proceedings of the 5th ACM Symposium on Development and Analysis of Intelligent Vehicular Networks and Applications - DIVANet'15*. Association for Computing Machinery (ACM), 2015. [Online]. Available: http://dx.doi.org/10.1145/2815347.2815351