
Formation motion planning for indoor applications using B-splines parametrization and evolutionary computation

Vincent Marguet^{*1}, Cong Khanh Dinh¹, Ionela Prodan¹, and Florin Stoican²

¹Laboratoire de Conception et d'Intégration des Systèmes – Université Grenoble Alpes, Institut polytechnique de Grenoble - Grenoble Institute of Technology, Institut Polytechnique de Grenoble - Grenoble Institute of Technology – France

²Universitatea Politehnica din Bucuresti [Bucarest, Roumanie] – Roumanie

Résumé

This work aims to generate off-line feasible trajectories for multiple indoor nanodrones : the input effort of the drones is minimized while satisfying various constraints on position, angle, velocity, angular velocity, thrust, waypoint passing (1), obstacle avoidance, connectivity maintenance and formation switching. All the constraints are expressed in function of the control points defining the B-spline trajectory planned for each agent (2). We formulate sufficient conditions to guarantee the constraint satisfaction considering various properties of B-splines (3) :

i) the convexity property implies that the trajectory lies inside the union of convex hulls obtained with $p + 1$ consecutive control points (p is the degree of the basis functions), hence collision avoidance is reduced to constraints on the control points ;

ii) to tighten the approximation, knot refinement is used, allowing to express a B-spline trajectory in terms of a linear combination of control points without increasing the complexity of the problem (4, Corollary 1). Furthermore, it also provides more flexibility in working with the decision variables to obtain a relative displacement between the nanodrones, when the

formation needs to change while maintaining the connectivity.

The motion planning optimisation problem is solved using a differential evolution algorithm. We first design the trajectory of the leader that needs to pass in the neighborhood of some a priori given waypoints, while respecting the physical constraints. Knot refinement is employed in the design of the followers trajectories where we take into account the relative position of

the control points defining the followers trajectories.

The proposed approach is validated in practice on specific indoor scenarios related to the formation motion planning of 4 nanodrones which need to ensure connectivity and obstacle avoidance.

Mots-clés : Trajectories generation, Formation planning, B-spline curves, Knot refinement, DE (Differential Evolution), Multicopters

Références:

(1) Victor Freire and Xiangru Xu. Flatness-based quadcopter trajectory planning and tracking

*Intervenant

with continuous-time safety guarantees. *IEEE Transactions on Control Systems Technology*, 31(6) :2319–2334, 2023.

(2) Vincent Marguet, Cong Khanh Dinh, Florin Stoican, and Ionela Prodan. Constrained pso-splines trajectory generation for an indoor nanodrone. In Submitted to the 12th International Conference on Unmanned Aircraft Systems (ICUAS). 2024.

(3) Vincent Marguet, Florin Stoican, and Ionela Prodan. On the application of the schoenberg quasi-interpolant for complexity reduction in trajectory generation. In 2023 European Control Conference (ECC), pages 1–6, 2023.

(4) Florin Stoican, Alexandru Postolache, and Ionela Prodan. Nurbs-based trajectory design for motion planning in a multi-obstacle environment. In 2021 European Control Conference (ECC), pages 2014–2019, 2021.