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

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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*

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