Robust model predictive approach for flocking of a team of quadrotor in cluttered environments

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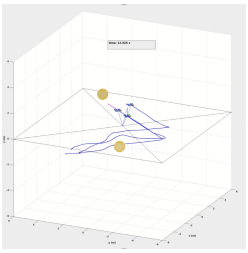
The semester project DISAL-SP158 proposed an algorithm capable of endowing swarming agents to flock with decentralized prediction-based control. Promising results were found in simulation and the ultimate aim of this internship was to transfer it on hardware. However, it is known that due to unmodelled dynamics and perturbations, reduced performance and loss of feasibility are witnessed when using nominal MPC formulations. Hence, in order to mitigate the impact of such inaccuracies, the proposed solution had to be extended with a Robust MPC scheme called Tube-MPC. In this method, a robust controller is designed offline and keeps the system in an invariant tube around a desired nominal trajectory generated online.

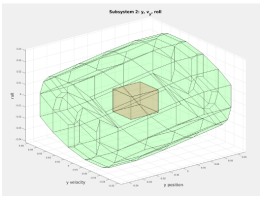
As the initial constraint in the Tube-MPC formulation could not be formulated with the former solver (ACADO), the flocking algorithm has been changed to interface another solver (Acados). A screenshot of the resulting simulation can be seen below.



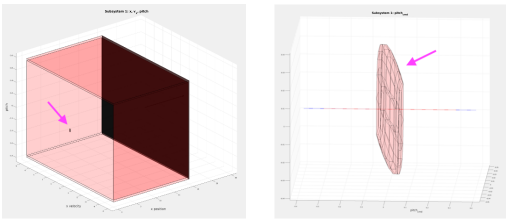
Flocking algorithm tested in a MATLAB simulator with the new solver Acados

The Tube-MPC scheme requires to compute a minimum robust invariant set, as well as tightened state and input sets. These tasks involve computing Minkowski sums and Pontryagin differences of sets. Several toolboxes handling these types of set operations in polyhedral and ellipsoidal form have been tested. However, none of them provided satisfactory results for the leader and follower systems due to their high dimensionalities. To tackle this issue, the systems have been decomposed in 3 independant subsystems: the pitch, roll and yaw subsystems.

The minimum robust invariant set and the robust state and input sets have been computed for each subsystem, and the results can be seen for the leader pitch subsystem below.



(a)Disturbance set in orange and minimum robust invariant set in green



(b) Robust state space on the left and robust input space on the right in red. The minimum robust invariant set is pointed with a pink arrow.

After concatenating the results of each subsystem, the flocking algorithm extended with Tube-MPC was ready to be tested. However, due to an undocumented technical issue related with Acados, it could not happen.

However, regarding future work, we believe that the Tube-MPC implementation of this flocking algorithm could work by changing the solver and CVXGEN and GRAMPC seem to be promising solvers towards this aim.