SS 2020-2021, SMT-ROB, DISAL-SP151 Project Summary

Distributed Model Predictive Control Architectures for Multi-rotor Micro Aerial Vehicles (MAV's)

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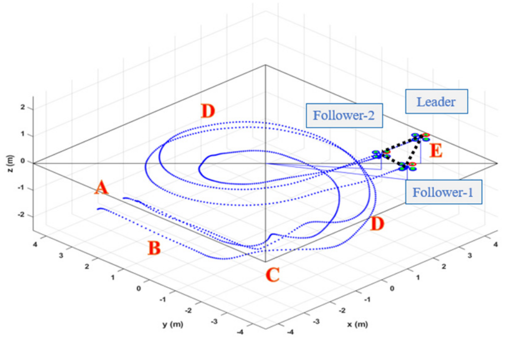
One efficient method to carry out formation control of multiple Multi-rotor Micro Aerial Vehicles (MAV's) is to adopt a Model Predictive Control (MPC) paradigm. The main goal of this project is to compare the effectiveness of different Distributed MPC architectures. In this project, three types of Distributed MPC architectures are theoretically formulated for the leader-follower formation control problem and implemented in MATLAB:

1) Velocity sharing based:
   Distribute the overall formation control into several sub-MPC problem and each agent obtain the coupled information, i.e. velocity, of its neighbors from communication.

2) ADMM-based:
   Rewrite the centralized problem and distribute it by Alternating Direction Method of Multipliers (ADMM).

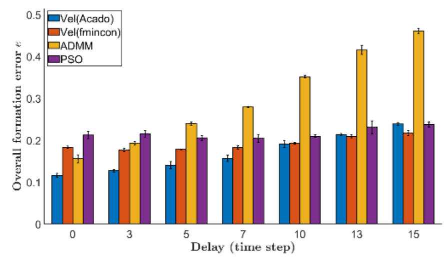
3) PSO-based:
   Separate the overall control problem into several sub-task, each agent solve its sub-task by Particle Swarm Optimization (PSO).

The simulation experiments on the three types of Distributed MPC have been carried out in MATLAB 2020b with an Intel i7-8550U processor.



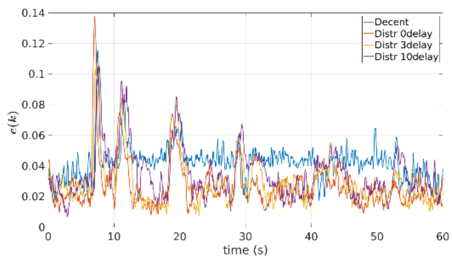
Reference trajectory in MATLAB. A: Starting point, B: Linear motion (2 m/s), C: Agile movement with a sudden turning and increase of height, D: Spiral motion (1.88 m/s), E: Destination

According the simulation result in MATLAB, the PSO-based MPC has the worst performance on formation maintenance. The ADMM-based MPC has better performance on formation control than the velocity sharing based type if using same solver. However, it is very sensitive to the communication quality and requires more computational time. Moreover, the velocity sharing type using ACADO code generate has far better performance than the ADMM-based type even with perfect communication and is more robust to the communication delay.



Overall average relative formation error with different communication delay (constant)

Finally, the velocity sharing based Distributed MPC with ACADO is selected to compare with a Decentralized MPC in a high-fidelity framework consisting of the Webots simulator and ROS. The results show that the Distributed MPC controller has less formation error than the Decentralized MPC controller most of time despite some special moments.



Average relative formation error in Webots-ROS