Autonomous Visual Line-of-sight Inspections for Micro Aerial Vehicles

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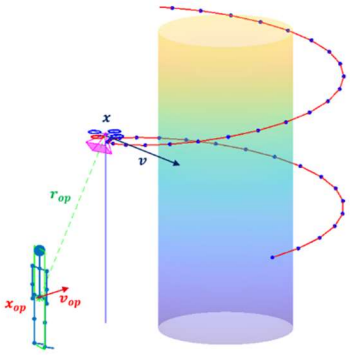
This project investigates the use of Model Predictive Control (MPC) to enable autonomous **Visual Line-of-Sight (VLOS)** inspections for Micro Aerial Vehicles (MAVs). Swiss regulations mandate VLOS for MAVs in the "Open" category, requiring the operator to maintain uninterrupted visual contact with the drone. The goal is to develop a framework ensuring VLOS compliance during inspection tasks, integrating operator tracking, obstacle avoidance, and path adjustment.

Problem Definition

An MPC formulation containing constraints such as operator visibility, maximum allowable distance, and obstacle occlusions is defined. The project was tested in MATLAB using simplified dynamics, with future implementations planned in the *Webots* simulator for more realistic environments.



Simple MATLAB simulation environment

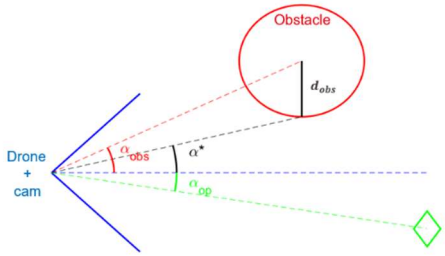
MPC formulation

Path following: introducing s_k to model path progression with the following constraint:

$$s_{k-1} + \xi_k < s_k$$

This ensures progression at each time step while allowing stopping or backtracking at a higher cost.

Dual perception objective:



Operator and obstacle model used in MPC

Where α_{op} *and* α^* are weighted accordingly to provide occlusion free tracking of operator.

Results

Scenario 1: Basic path-following with an operator moving in a circular trajectory. Results showed smooth path progression but solver instabilities (high KKT values) due to the nonlinear formulation.

Scenario 2: Introduced operator motion variations (pausing and reversing). The MAV successfully abandoned the inspection path when VLOS was at risk, highlighting the dynamic path activation mechanism.

Scenario 3: The MAV maintained operator visibility despite it moving towards an obstructed zone (obstacle). Could be improved by allowing height changes to easily overcome obstacle.

Conclusions

The proposed MPC framework effectively ensures VLOS compliance during inspections but is computationally demanding due to its nonlinearity. High solver KKT values indicate the need for further optimization and convexification. Future work includes extending the framework to more realistic conditions in *Webots*, integrating sensor noise, and enhancing solver performance.

Available simulation results at:
https://www.youtube.com/playlist?list=PL8cx2cevn_sbN0pgqydm0C-0Qm3tfScyd