# Visual Modeling System for Optimization-Based, Real-Time Trajectory Planning for Autonomous Aerial Drones

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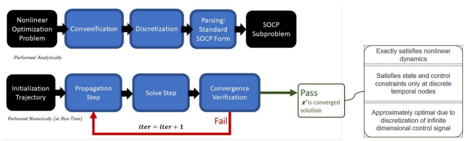
## Motivation

- Physics-based problem formulations posed as optimal control problems ensure dynamically-feasible trajectory solutions
- Convex optimization-based algorithms allow motion planning solutions to be achieved in real-time
- Formulating and solving analytical problems can take subject-matter experts hours to days
- Our Visual Modeling System will allow non-expert users to formulate problems intuitively in a matter of seconds via a graphical user interface
- Motion planning for aerial drones can now be performed for vehicles flying in dynamic environments where evolving constraints and objectives are considered
- These trajectories can be transmitted to the aerial drones on-the-fly

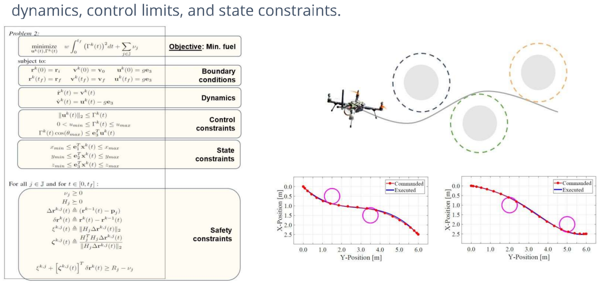
## Background: SCP Algorithm

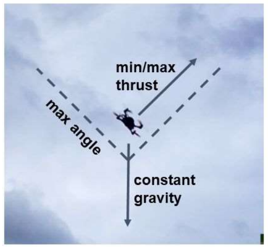
- A sequential convex programming framework has been developed by the ACL to algorithmically solve nonconvex optimal control problems via convex optimization to a locally optimal solution of the original problem

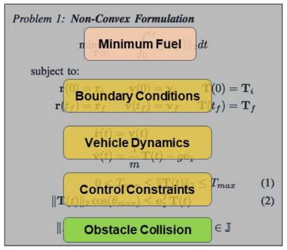



## Analytical Problem Formulation

- Obstacle avoidance optimal control problems produce minimum-fuel trajectories that avoid designated keep-out zones while adhering to vehicle dynamics, control limits, and state constraints.

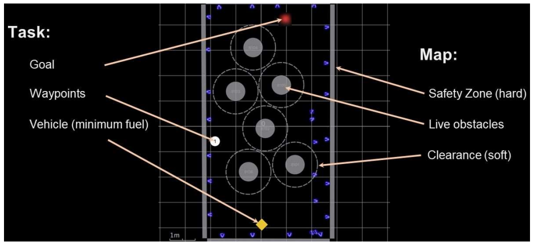


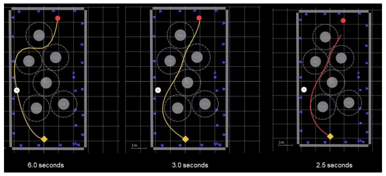




## Graphical Problem Formulation

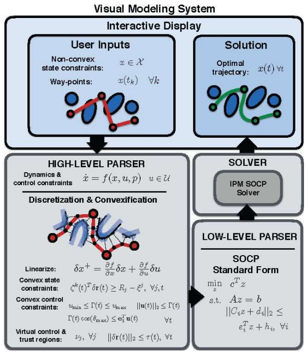
- These problems can instead be formulated graphically via the Visual Modeling System:

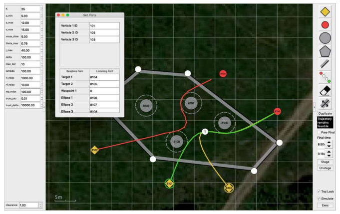



## Visual Modeling System: User Interface

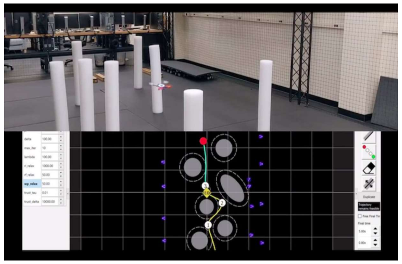
- The Visual Modeling System forms the highest layer of parsing in the stack
- Constraints and goals are inputs to the algorithm
- Solution outputs are displayed before transmission to aerial drones for flight



## Flight Experiments

- Flight experiments can be viewed at the following link: https://depts.washington.edu/uwacl/media/visual-modeling-system-demo/



## Future Work, References, and Acknowledgments

- Integration of the novel first-order solver PIPG into the tablet interface
- Integration of state-triggered constraints into the tablet interface
- Displaying sensitivity to constraints via dual variables of optimization problem

**Szmuk, Pascucci, Acikmese, B. (2018).** Real-Time Quad-Rotor Path Planning for Mobile Obstacle Avoidance Using Convex Optimization. IROS 2018

**Szmuk, Pascucci, Dueri, Acikmese (2017).** Convexification and Real-Time On-Board Optimization for Agile Quad-Rotor Maneuvering and Obstacle Avoidance. IEEE IROS 2017.

**Dueri, Mao, Mian, Ding, Acikmese (2017).** Trajectory Optimization with Inter-sample Obstacle Avoidance via Successive Convexification. IEEE CDC 2017.

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