



# Autopilot For an Ultra-light Flying Wing

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## Abstract

The purpose of this project is to develop an auto-pilot for a small, light fixed-wing aircraft named the Zagi. The first step is to develop optimal local trajectories given three waypoints and nominal speed. The second step is to integrate these local trajectories with the Zagi software to enable it to follow an incrementally-specified global trajectory.

## Motivation

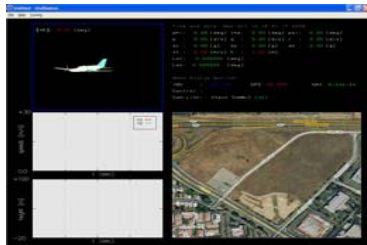
- The Zagi aircraft is inexpensive, simple and fast to deploy, and is virtually indestructible since it is made of expanded polypropylene (EPP) foam.
- Autonomous Zagis would be useful in formation flight, automated air-traffic control, and satellite constellations.

## Methods

- Implement local optimization in MATLAB
- Convert to C-language
- Integrate with existing autopilot
- Test on CRRCSim (Zagi simulator)
- Test flight at RFS, (Richmond Field Station)



Autopilot on the aircraft



Ground Test Station

## Optimality Criterion

$$\min_p \sum_{t=0}^{t_{\max}-1} \{ \min [ \text{dist}(p(t), l_{12}(t)), \text{dist}(p(t), l_{23}(t)) ] + \gamma \cdot \text{dist}(p(t), p_3) \},$$

where  $p(t)$  and  $l(t)$  represent the point and line at time  $t$ , respectively;  $l_{12}(t)$  and  $l_{23}(t)$  represent the lines between points  $p_1, p_2$  and points  $p_2, p_3$ , respectively; and  $\gamma$  is a constant.

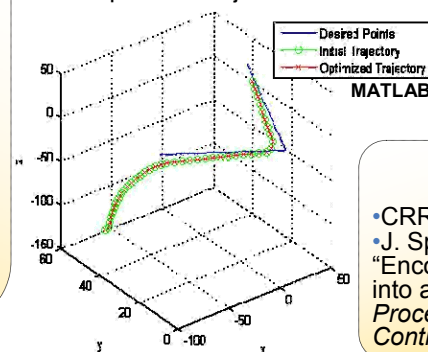


CRRCSim

## Results

- The initial and local optimal trajectories are nearly identical, so the greedy algorithm for creating the initial trajectory is sufficient.
- The system allows three points to be specified simultaneously, which allows planning to create a better trajectory than a system that only considers one point at a time.
- If needed, the three points can be changed at any time:  $x_2$  becomes the new  $x_0$ ,  $x_3$  becomes the new  $x_1$ , etc.
- Maximum values of velocity, acceleration, and orientation are enforced for more realistic planning.

Initial and Optimal Local Trajectories with Given Points



## Future Work

- Further test the simulator
- Further test the real Zagi
- Wind compensation

## References

- CRRCSim Flight Simulator <http://crrcsim.sourceforge.net/>
- J. Sprinkle, J. M. Eklund, H. J. Kim, and S. S. Sastry, "Encoding aerial pursuit/evasion games with fixed wing aircraft into a nonlinear model predictive tracking controller," in *Proceedings of the 43rd IEEE Conference on Decision and Control*, vol. 3, Dec. 2004, pp. 2609–2614.

