Obstacle-Aware Waypoint Tracking for UAVs

Using SCS Switching and L1 Nonlinear Guidance

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Version: 1.1
Last Updated: July 3, 2025
GitHub: `https://github.com/Heavenly-cyber/Obstacle_avoidance_waypoints`

July 3, 2025

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1 Introduction

In UAV trajectory tracking, obstacles like restricted zones can appear between waypoints. The goal is to smoothly guide the UAV around these zones without violating safety buffers or sacrificing tracking accuracy.

2 Proposed Guidance Method

We adopt a three-phase Straight-Circle-Straight (SCS) strategy integrated with L1 guidance. The UAV dynamically computes entry and exit points for the obstacle-avoidance maneuver using tangents to the obstacle's circular danger zone. These transitions are smoothened with blending and enforced with distance and direction locks.

2.1 Straight-Line Convergence

We use vector projection to compute the reference point on the line segment and generate lateral acceleration using L1 logic:

- Project UAV's position onto line.
- Compute L1 vector from UAV to reference point.
- Generate lateral acceleration based on angular deviation η.

2.2 Circular Convergence

For avoiding circular obstacles, L1 guidance tracks a circular arc:

- Compute angle from UAV to circle center.
- Compute entry/exit using tangent points.
- Track arc with adjusted heading until exit point.

2.3 Mode Switching

We use a 3-mode SCS system:

- Mode 1: Straight Line to Entry Point
- Mode 2: Arc Tracking from Entry to Exit
- Mode 3: Straight Line to Next Waypoint

Each mode transition is triggered by reaching its respective target within a threshold.

3 Implementation Details

- Language: MATLAB
- Simulation: Discrete 2D simulator
- L1 Distance: Tuned per mode and test
- Smoothing: Blending functions over 5–10 seconds
- Transition Detection: Euclidean distance to reference points
- Plots: Curvature, mode switch timeline, lateral acceleration

4 Results

- Path tracking was successful across 10 waypoints.
- The UAV strictly avoided the obstacle buffer.
- Curvature and lateral acceleration stayed within safe bounds.

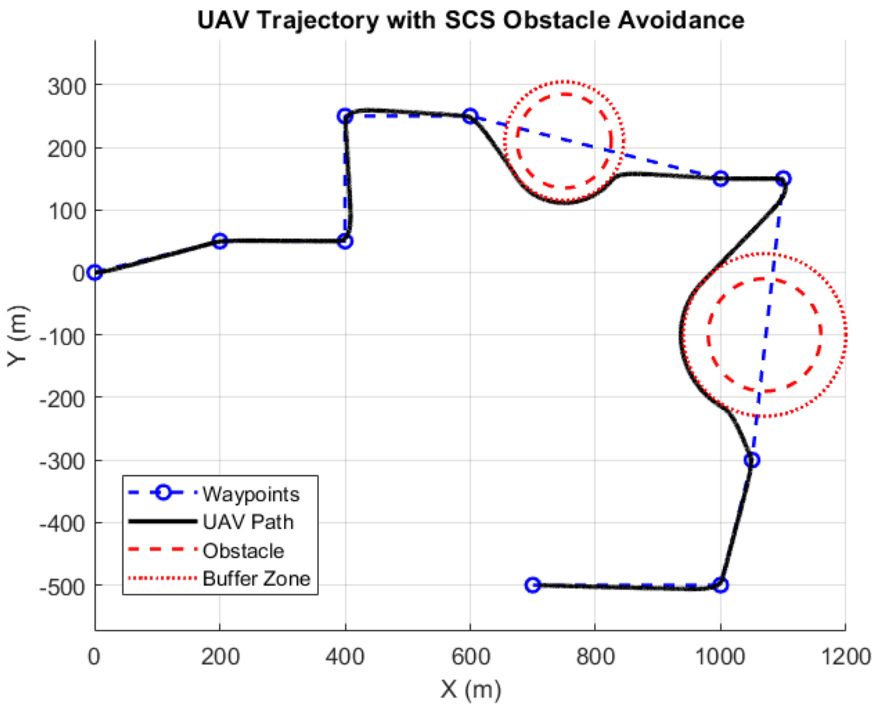

Figure 1: Final UAV Trajectory with Obstacle Avoidance

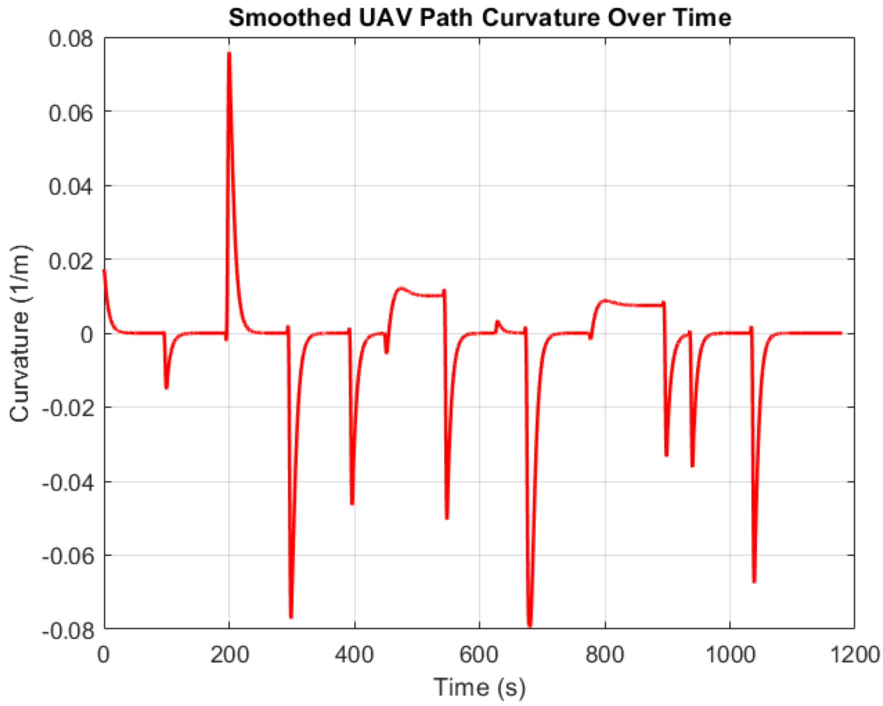

Figure 2: Path Curvature After Smoothing

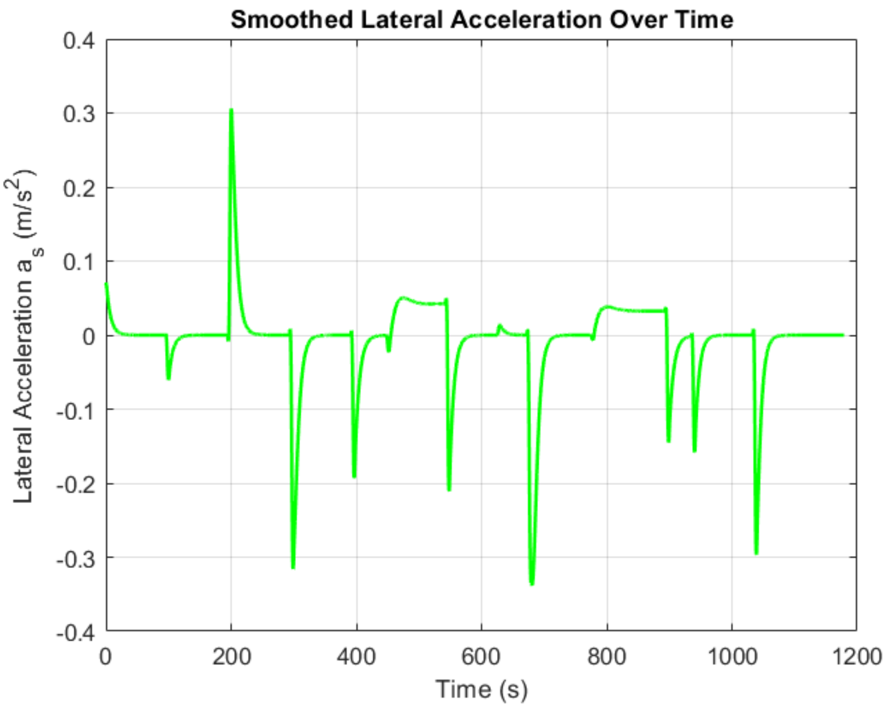

Figure 3: Lateral Acceleration Over Time

5 Conclusion

The proposed L1-based SCS strategy with tangent-based transitions and smoothing effectively solves the problem of obstacle-aware waypoint tracking. The system maintains safety, robustness, and trajectory fidelity. This foundation can be extended to dynamic and 3D path planning.

References

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