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Coordinated standoff tracking of moving targets using differential geometry

Key words: Unmanned aircraft, Standoff tracking, Differential geometry, Coordinated control

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Motivation

- **Disadvantages of existing methods:** Most methods analyze the stability of standoff tracking for a stationary target.

- **Advantages of our method: 1.** It can analyze the stability of standoff tracking for a moving target. **2.** It is superior to Oh *et al*.'s algorithm with a smaller residual error. **3.** It requires little communication and is very simple to implement.

Framework of our method (I)

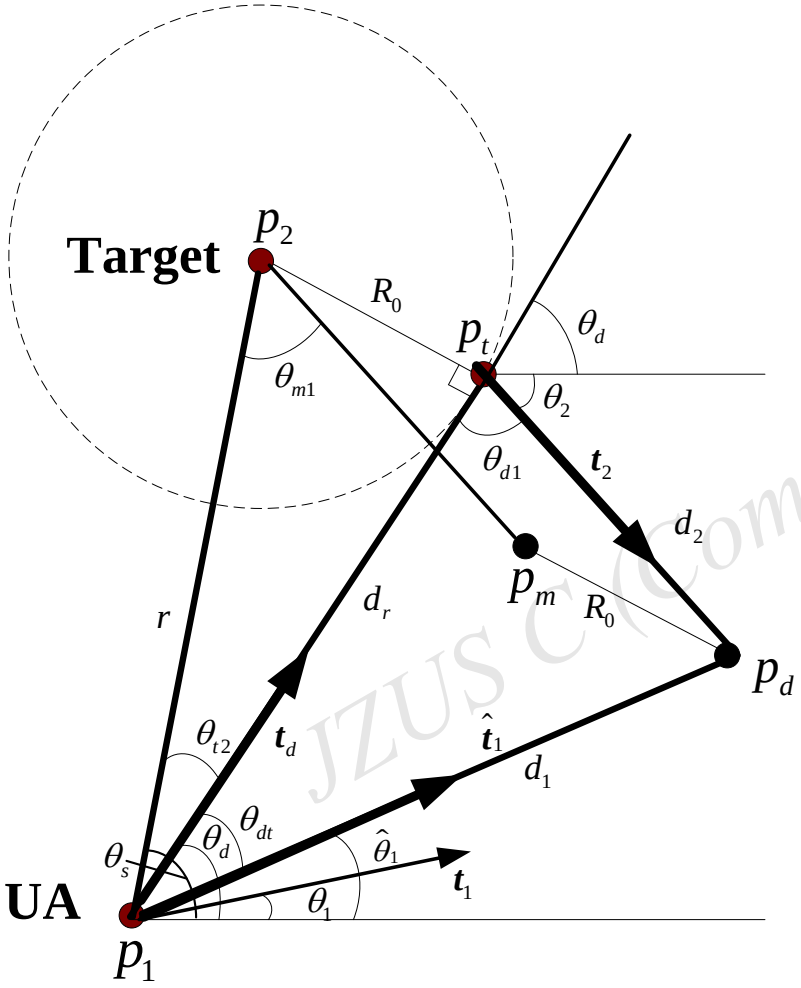

Fig. 1 Geometry for standoff tracking

The research presented here restricts the analysis to the tracking of a constant velocity target in two dimensions. Standoff tracking consists of following and orbiting around a stationary or moving target with a specified standoff distance from the target. The geometry for standoff tracking is as shown in Fig. 1.

The turning rate $\dot{\theta}_1$ is set as

$$\dot{\theta}_1 = -\left(1+\frac{1}{\alpha}\right)|\dot{\theta}_{\mathrm{d}}|\,\mathrm{sign}(e) - k_{\mathrm{p}}e - k_{\mathrm{d}}\dot{e}$$

Framework of our method (II)

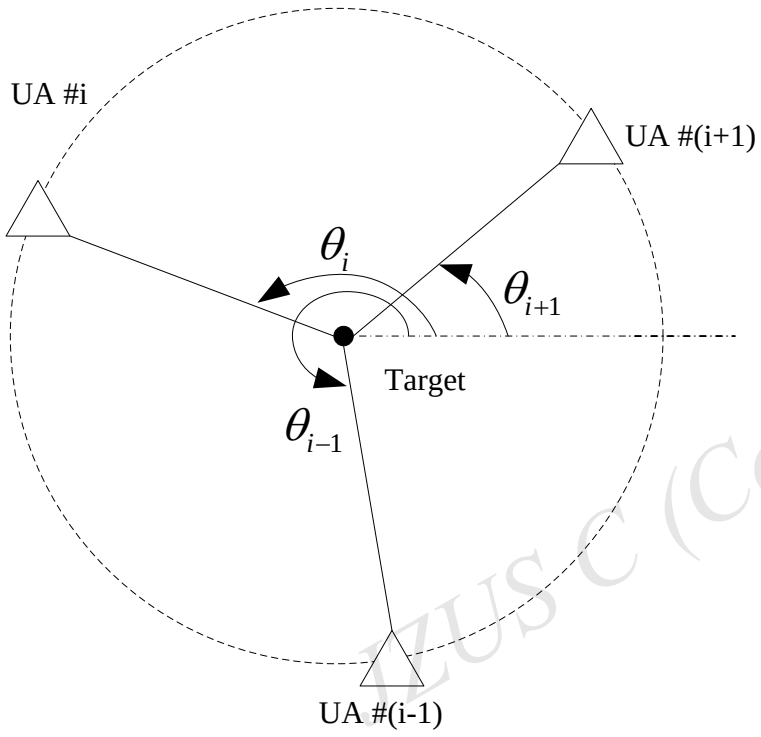

Fig. 2 Phase angle coordination between UAs

Define ϕ_d as the desired phase angle offset.

For coordination of three UAs, the corresponding speed commands are

$$\begin{cases} u_{v_1} = -K_{\mathrm{p}} R_0 (\theta_1 - \theta_2 - \phi_{\mathrm{d}}) - K_{\mathrm{d}} R_0 \Delta\dot{\theta} + v_1, \\ u_{v_2} = v_2, \\ u_{v_3} = K_{\mathrm{p}} R_0 (\theta_2 - \theta_3 - \phi_{\mathrm{d}}) + K_{\mathrm{d}} R_0 \Delta\dot{\theta} + v_3. \end{cases}$$

Summary

- **Motivation:** Design the guidance law for tracking a moving target in a coordinated way.
- **Methodology:** We propose a guidance law against a moving target using differential geometry. To keep the phase angle difference of multiple UAs, a derivative term is added to the relevant control law.
- **Performance:** Simulations showed that the proposed algorithm has a good tracking performance in terms of the standoff distance error and phase angle offset error.