Decentralized Control of Autonomous Vehicles

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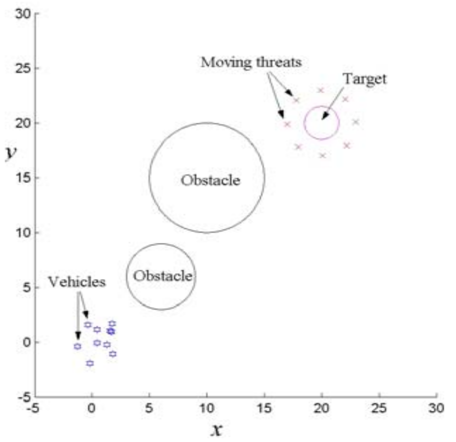
Motivation

- ❑ Explore a decentralized approach to autonomous multi-vehicle control
- ❑ Study the collective behavior arising from local interactions
- ❑ Accommodate competing objectives in a complex environment

Scenario



- ❑ **Mission**
  - Autonomous, distributed maneuvering of vehicles to reach and cover a target area
- ❑ **Constraints**
  - Desired inter-vehicle distance
  - Obstacles avoidance
  - Threats (stationary or moving) avoidance
- ❑ **Requirement**
  - Using only local or static information

Path Generation based on Potential Functions

The velocity of the *i*-th vehicle, $\dot{q}_i$, is determined by the gradient flow of its potential function:

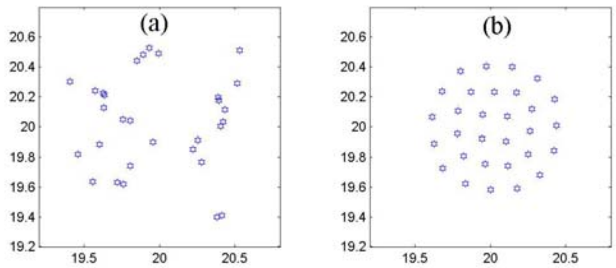
$$J_{i,t}(q_i) = \lambda_g J^g(q_i) + \lambda_n J_{i,t}^n(q_i) + \lambda_o J^o(q_i) + \lambda_s J^s(q_i) + \lambda_m J_t^m(q_i)$$

Gradient flow: $$\dot{q}_i(t) = -\frac{\partial J_{i,t}(q_i)}{\partial q_i}$$

- ▪Target (attraction) potential J^g
- ▪Neighbor (avoidance) potential J^n
- ▪Obstacle potential J^o
- ▪Potential J^s due to stationary threats
- ▪Potential J^m due to moving threats

Vehicle Behavior Analysis

- ❑ **Formations** under inter-vehicle interactions
  - For two or three vehicles, optimal inter-vehicle distances are achieved;
  - For more than three vehicles, multiple locally stable formation exist.

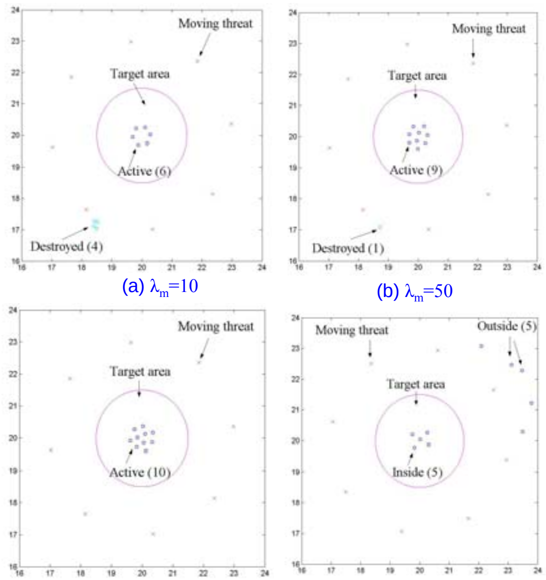


Formation of 30 vehicles from a random initialization.

- ❑ **Effects of weighting constant** λ when

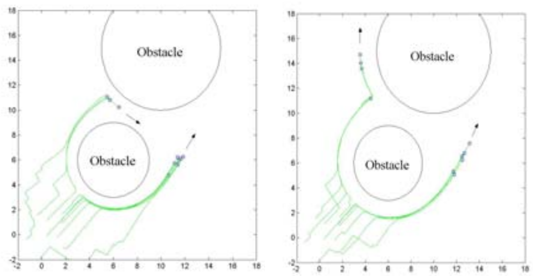
$$J = \lambda J^g + J^o.$$

Simulation Results



(a) λ_m=10 (b) λ_m=50 (c) λ_m=200 (d) λ_m=2000

Effect of the weighting constant λ_m for the moving threat potential. Too small: vehicles get destroyed; too big: vehicles cannot enter the target.



(a) λ_o=1000 (b) λ_o=5000

Effect of the weighting constant λ_o for the moving potential. Small: some vehicles take short-cut; big: vehicles take detour.