Integrating Smart Cars in a Smart World: A Particle Swarm Problem

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**Highlights**

**Objective:** Explore rules for controlling lateral and longitudinal movement of families of Autonomous Vehicles and generalize the functionality of autonomous cruise control to include multiple masters

- **Leverage an analogy with the physical behavior of flocks and schools**
- **Adapt the physical rules of particle swarms to families of AVs.**
- **Monitor safety threshold to ensure separation using hazard indices.**
- **Employs information from hazard indices as safety trigger to execute changes in steering and throttle/braking inputs.**

**Particle Swarm Optimization**

A meta-heuristic method based on an analogy with swarm movement. Generates particles to sample a non-linear function and find location of the minimum.

- **Rule #1:** Collision Avoidance
  - Need to ensure separation and that if a vehicle starts an emergency braking it won’t collide with who is in the front (rear-end remains the most common type of accidents among AVs)

- **Rule #2:** Weighted Heading Selection
  - The heading of the controlled vehicle is computed using a weighted average of the surrounding vehicles, using inverse distance weights (heading of vehicles that are closer are weighed more than those far away)

- **Rule #3:** Velocity Matching
  - The problem is adjusting the speed at which the swarm is traveling to accommodate the new vehicle and selecting the best distance between the vehicles

**Adaptation to Families of AVs**

1. Collision avoidance – Maintaining separation to avoid collision with the nearby vehicles
2. Heading selection – Maintaining the weighted average heading to neighboring vehicles
3. Velocity matching – Match the average velocity of the neighboring vehicles

**Implementation Chart**

Implementation considers breakdown into two phases of creation of the swarm: an initialization/transition stage and a steady constant state with fixed number of vehicles

**Summary of Contribution**

Creation of all-hor rules for lateral and longitudinal control of families of AVs and devices of four hazard indices for monitoring safety thresholds related to separation and collision avoidance, heading selection, and velocity matching.

**Function**

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<thead>
<tr>
<th>Function</th>
<th>Notes</th>
<th>Used</th>
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<tbody>
<tr>
<td>$R_1$: longitudinal distance</td>
<td>1D (moving distance) longitudinal distance to ensure sufficient separation</td>
<td>Reset of swarm target velocity (node/vehicle) and relative distance 3D steady condition</td>
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<tr>
<td>$R_2$: collision avoidance through spheres of influence to ensure separation and cohesion</td>
<td>Reset of swarm target velocity and relative distance 3D steady condition</td>
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<td>$R_3$: collision avoidance through relative distance</td>
<td>Computation of maximum time of refresh in comparison of steering and acceleration/braking inputs</td>
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<td>$R_4$: external forces</td>
<td>Computation of time for incoming vehicle to reach velocity of the swarm while resolving collision with safety margin</td>
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**Info and PI Contact**

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