**Near Accident Avoidance System**

*Hierarchical RL for Autonomous Intersection Navigation*

**Objective**

Develop an AI system that safely navigates autonomous vehicles through intersections while avoiding collisions, achieving human-level performance in near-accident scenarios.

**Technical Approach**

**Hierarchical Architecture**

PPO Agent (High-Level)

↓ Selects Mode

CoIL Network (Low-Level)

↓ Controls Throttle

CARLO Environment

**Key Components**

* **Expert Policy**: TTC-based decision making (3 modes: timid/normal/aggressive)
* **CoIL Training**: Behavior cloning from expert demonstrations
* **PPO Optimization**: Reinforcement learning with GAE and entropy regularization
* **Multi-Modal Control**: Conditioned on driving style and scenario risk

**Performance Results**

**Final Evaluation (100 episodes)**

|  |  |
| --- | --- |
| **Metric** | **Result** |
| Success Rate | 94% |
| Collision Rate | 0% |
| Timeout Rate | 6% |
| Avg Completion Time | 6.42s |

**Training Performance**

* Expert Success Rate: 94%
* CoIL Validation Loss: 0.006253
* PPO Convergence: ~50 episodes
* Training Stability: Excellent

**Key Achievements**

**Technical Innovations**

1. 94% success rate with zero collisions
2. Hierarchical RL combining imitation and reinforcement learning
3. Multi-modal behavior selection (87.9% timid, 7.1% normal, 5.0% aggressive)
4. Stable training with proper regularization and advantage normalization

**System Features**

* Safety-first approach with conservative mode preference
* Real-time decision making based on TTC calculations
* Smooth control transitions between driving modes
* Robust performance across varied scenarios

**Implementation Details**

**Environment Setup**

# CARLO Simulator Parameters

ego\_start\_vel = 10.0

ado\_pos\_range = (60.0, 100.0)

success\_threshold = 60.0

max\_steps = 200

**Training Pipeline**

1. Expert Data Generation (600 episodes)
2. CoIL Behavior Cloning (15 epochs)
3. PPO Policy Optimization (500 episodes)

**Impact & Applications**

**Immediate Applications**

* Autonomous intersection navigation
* Collision avoidance systems
* Driver assistance technology
* Simulation testing frameworks

**Future Extensions**

* Multi-agent scenarios
* Real-world deployment
* Adverse weather conditions
* Pedestrian interaction

**Technical Specifications**

|  |  |  |
| --- | --- | --- |
| **Component** | **Technology** | **Performance** |
| High-Level Policy | PPO (Actor-Critic) | 94% success |
| Low-Level Policy | CoIL Network | 0.006 loss |
| Training Framework | PyTorch | 15 min total |
| Action Space | Continuous throttle | -1 to +1 |