A11 for Autonomous Vehicles — Conflict Resolution Model

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Annotation

This document presents a conflict-resolution model for autonomous vehicles based on structured decision-making principles derived from Algorithm 11 (A11).

The model provides a predictable, interpretable, and safety-oriented method for resolving situations where two or more autonomous vehicles must negotiate priority, avoid deadlock, or coordinate movement in constrained environments.

The approach is domain-agnostic and can be integrated into existing autonomous driving stacks as a decision-layer module.

Contents

1. Introduction

Autonomous vehicles frequently encounter conflict situations:

- narrow passages
- intersections without clear priority
- merging lanes
- occluded environments
- multi-vehicle negotiation scenarios

Traditional rule-based or ML-based systems often fail to provide:

- predictable behavior
- mutual understanding between agents
- deadlock-free negotiation
- interpretable decision flow

This document introduces a structured conflict-resolution model designed to address these challenges.

2. Problem Definition

A conflict situation occurs when:

- two or more autonomous vehicles
- cannot proceed simultaneously
- must negotiate priority
- under uncertainty or incomplete information

The model must ensure:

- safety
- predictability
- fairness
- deadlock avoidance
- minimal communication requirements

- compatibility with heterogeneous agents

3. Limitations of Existing Approaches

3.1 Rule-Based Systems

- brittle
- hard to scale
- fail in edge cases

3.2 Machine Learning Approaches

- opaque
- unpredictable
- difficult to certify

3.3 V2V Communication-Dependent Models

- require infrastructure
- fail with partial adoption
- vulnerable to communication loss

A robust solution must work **without** assuming shared communication channels or identical decision policies.

4. A11-Based Conflict Resolution Model

The proposed model uses a structured decision-making loop with:

- explicit goals
- contextual interpretation
- controlled expansion of options
- constraint-based stabilization
- final selection based on safety and convergence

This ensures:

- deterministic behavior

- interpretable decisions
- reproducibility
- compatibility with heterogeneous agents

5. Architecture Overview

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┌─────────────────────────────────────────────┐
│     Perception & Environment Model     │
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            ▼
┌─────────────────────────────────────────────┐
│    Conflict Situation Detection       │
└─────────────────────────────────────────────┘
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┌─────────────────────────────────────────────┐
│    A11 Conflict Resolution Module      │
│  • Context Interpretation          │
│  • Option Generation              │
│  • Constraint Filtering            │
│  • Priority Assignment             │
│  • Action Selection               │
└─────────────────────────────────────────────┘
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        ▼
┌──────────────────────────────┐
│     Motion Planning     │
└──────────────────────────────┘
        │
        ▼
┌──────────────────────────────┐
│       Control       │
└──────────────────────────────┘
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6. Decision Algorithm

Step 1 — Context Interpretation

Extract:

- relative positions
- velocities
- available space
- risk zones
- environmental constraints

Step 2 — Option Generation

Each vehicle generates a small set of feasible actions:

- proceed
- yield
- slow down
- stop
- lateral adjustment

Step 3 — Constraint Filtering

Remove unsafe or non-viable options based on:

- collision risk
- braking distance
- visibility
- road geometry

Step 4 — Priority Assignment

Priority is assigned using:

- minimal-risk principle
- minimal-change principle
- fairness principle
- deadlock-avoidance rule

Step 5 — Action Selection

Each vehicle selects the action with:

- highest safety score
- highest convergence probability
- lowest deviation from intended path

7. Example Scenarios

Scenario A — Narrow Passage

Two vehicles approach a one-car-wide corridor.

Outcome:

- vehicle with lower escape cost yields
- vehicle with higher escape cost proceeds
- no communication required

Scenario B — Merge Conflict

Two vehicles attempt to merge into a single lane.

Outcome:

- priority assigned based on relative position and risk
- yielding vehicle adjusts speed
- merging vehicle proceeds smoothly

Scenario C — Occluded Intersection

Vehicles cannot see each other fully.

Outcome:

- conservative priority assignment
- minimal-risk action selection
- deadlock avoided through fallback rules

8. Integration into Autonomous Driving Systems

The model integrates as a **decision-layer module**:

- above motion planning
- below perception
- independent of control stack
- compatible with ROS2, Apollo, Autoware, and custom stacks

Inputs:

- environment model
- predicted trajectories
- vehicle state

Outputs:

- selected action
- priority decision
- safety justification

9. Safety Considerations

The model ensures:

- deterministic behavior
- bounded decision time
- monotonic risk reduction
- fallback to safe stop
- no reliance on communication

It is suitable for safety-critical certification.

10. Performance Notes

- low computational cost
- deterministic runtime
- scalable to multi-vehicle scenarios
- robust to perception noise
- compatible with heterogeneous agents

11. Extensions

Future extensions include:

- multi-agent negotiation
- swarm-level coordination
- integration with V2V when available
- off-Earth autonomous mobility

12. Conclusion

This document presents a structured conflict-resolution model for autonomous vehicles.

It provides predictable, interpretable, and safe decision-making in constrained environments without requiring communication between agents.

The model is based on principles derived from the A11 cognitive architecture.

13. References

1. A11 — Cognitive Architecture Specification https://doi.org/10.5281/zenodo.18536520
2. A11 — Language Specification https://doi.org/10.5281/zenodo.18540045
3. Autonomous Driving Safety Literature
4. Multi-Agent Decision-Making Research