Robustly-Safe Automated Driving (ROAD) Systems

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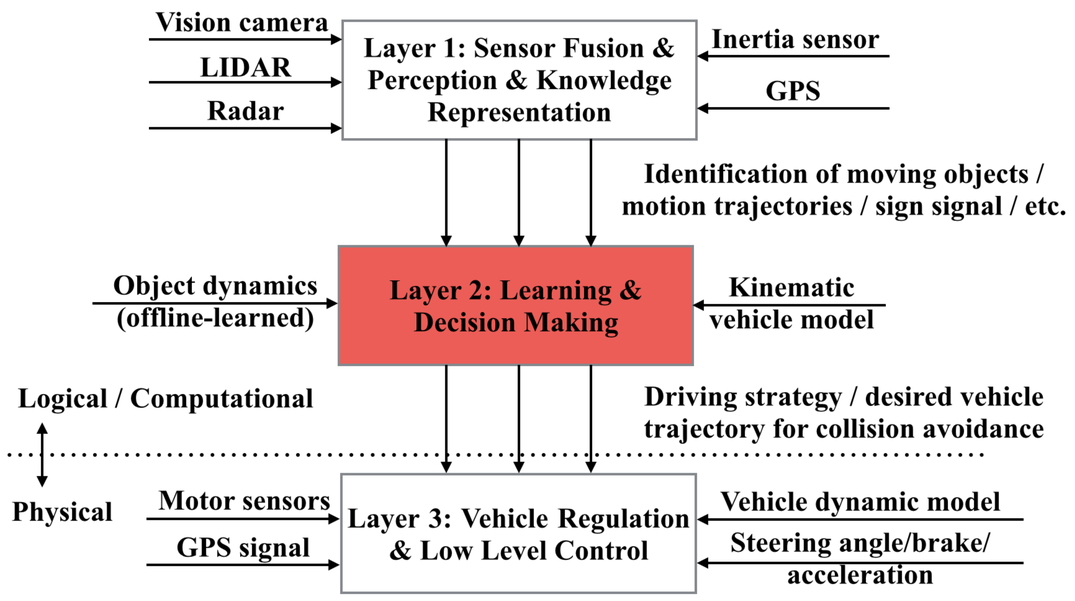
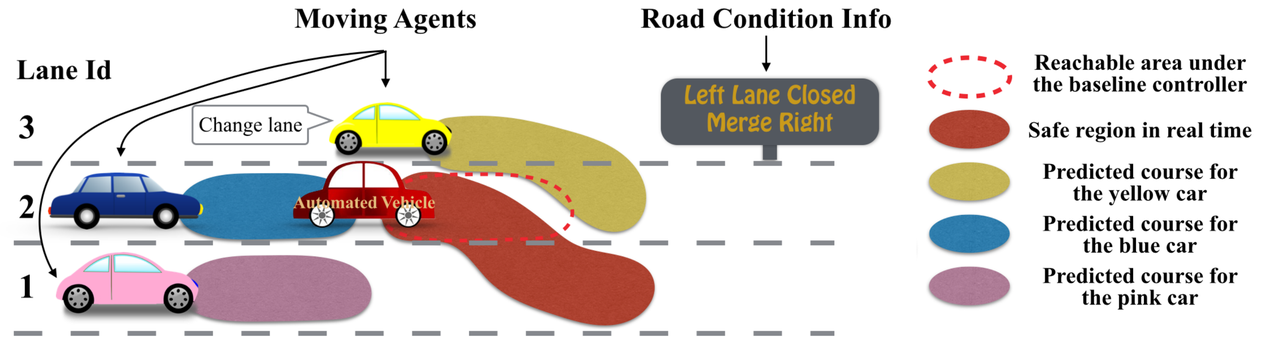
Autonomous Driving and the ROAD System

The ROAD System



Efficiency: Navigate to the destination in minimum time

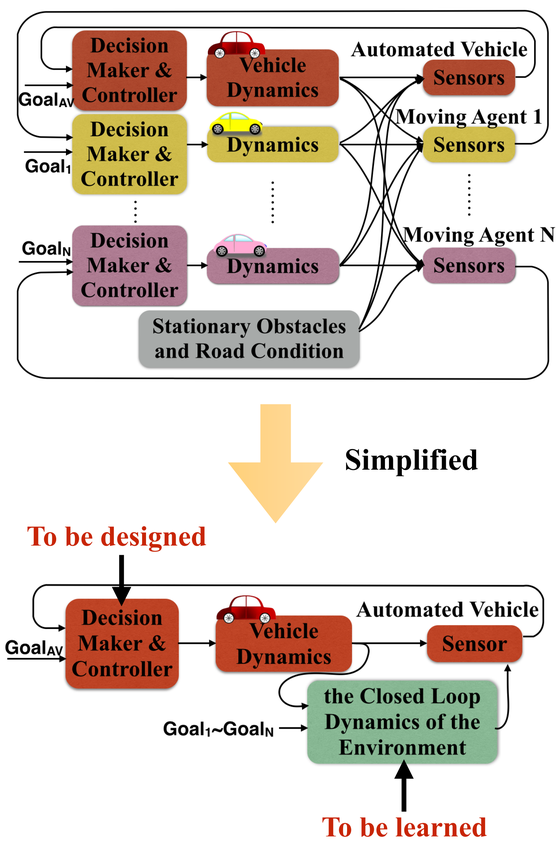
Safety: Interact with surrounding vehicles properly



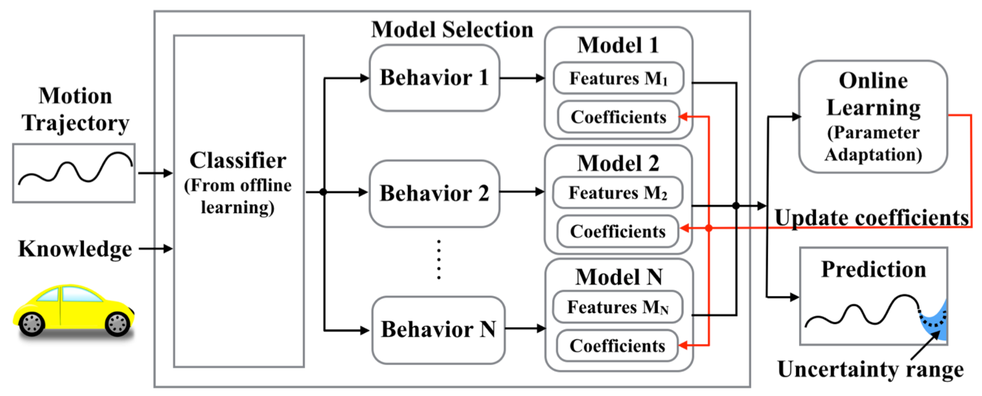
- **Predict the future course for each surrounding vehicle (learning and prediction);**
- **Find a trajectory in the safe region (decision making).**

Layer 2: Learning and Decision Making

The Multi-Agent System



Learning and Prediction

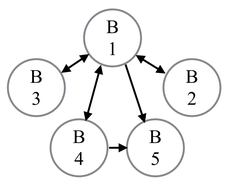


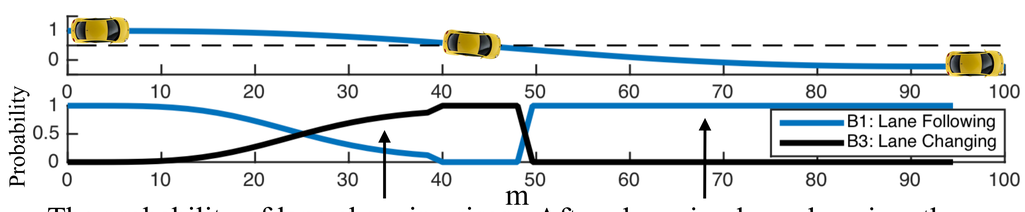
Steady State Behavior: Behavior 1 (B1) : Lane Following

Maneuvers: Behavior 2 (B2) : Lane Changing to the Left; Behavior 3 (B3) : Lane Changing to the Right; Behavior 4 (B4) : Lane Merging

Exiting Behavior: Behavior 5 (B5) : Lane Exiting

The transition model





The probability of lane changing rises since the lateral speed is nonzero.

After observing lane changing, the probability of lane following rises.

The Optimization Problem in Decision Making

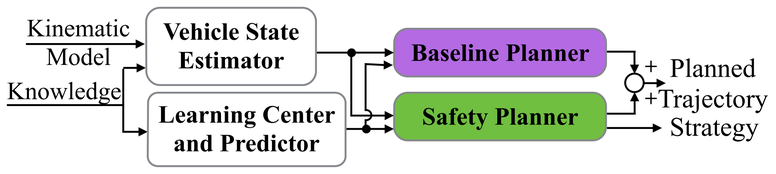
minimize a cost function for the automated vehicle

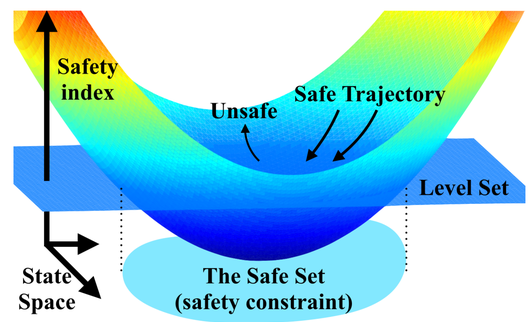
subject to constraint on control, vehicle dynamics

safety constraint regarding surrounding vehicles

Procedures in solving the optimization problem:

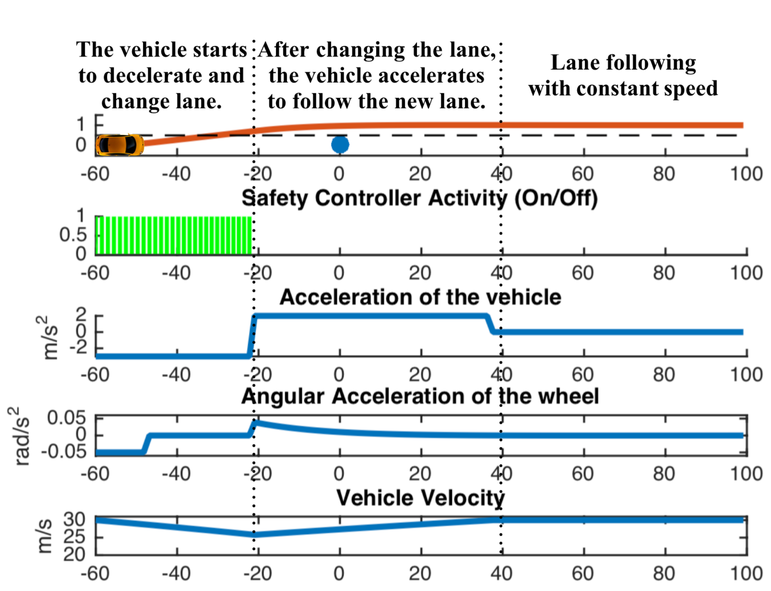
1. Solve the optimal control problem without the safety constraint
2. Check if the resulting trajectory violates the safety constraint
3. If no, execute the resulting trajectory
4. If yes, modify the trajectory to make it safe



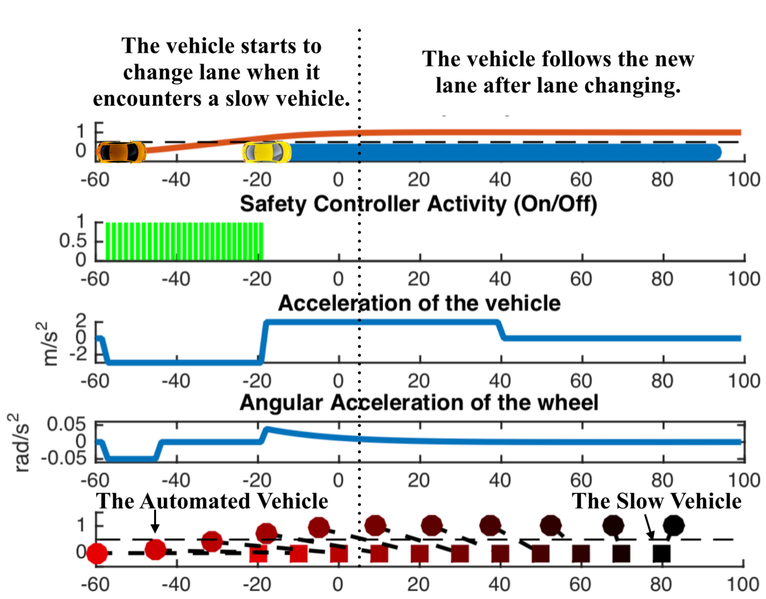


Case Study

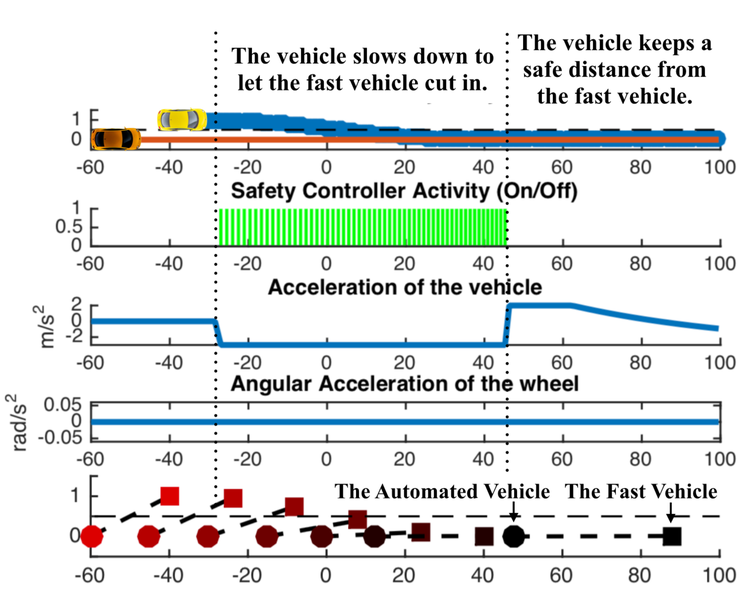
Case 1: A stationary obstacle



Case 2: A slow front vehicle



Case 3: Overtaken by a fast vehicle



Objective: speed tracking and lane following, e.g. the cost function penalizes 1) the deviation from the desired speed and 2) the deviation from the lane center (the target lane center is subject to change according to different strategies)

Safety constraint: the distance d between the automated vehicle and the front and rear vehicles on the same lane should be greater than $d_{min}=40m$. The safety index $\phi = d_{min}^2 - d^2 - \dot{d}$.