Objective Functions for Autonomous Driving

Course 4, Module 1, Lesson 3

UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Learning Objectives

- List some useful objective functions for performing motion planning
- Understand the benefits and the behaviours that each objective function tries to encourage

Efficiency

- Path length:
  - Minimize the arc length of a path to generate the shortest path to the goal

$$s_f = \int_{x_i}^{x_f} \sqrt{1 + \left(\frac{dy}{dx}\right)^2}\, dx$$

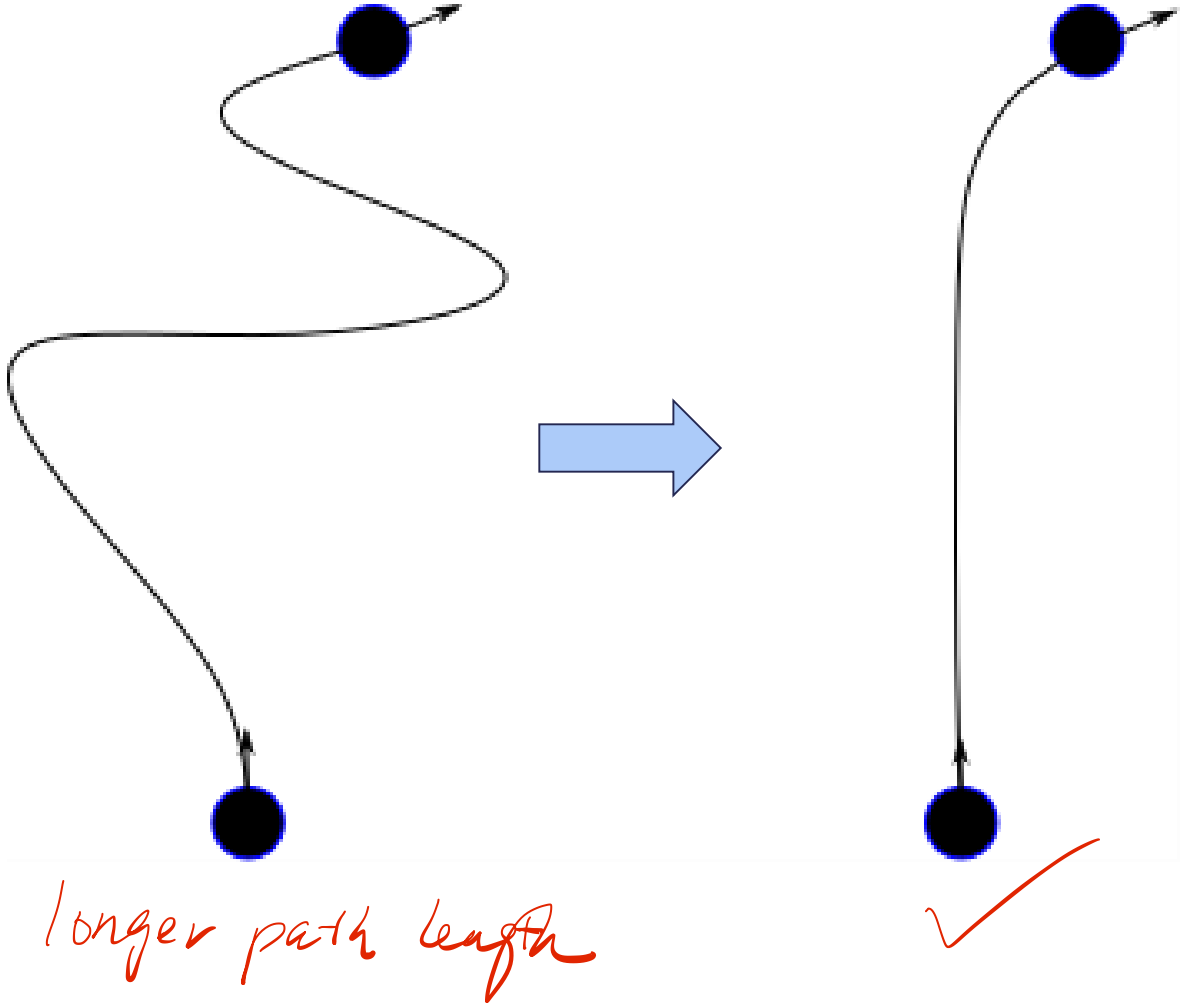
starting x coordinate

- Travel time:
  - Minimize time to destination while following the planned path

$$T_f = \int_0^{s_f} \frac{1}{v(s)}\, ds$$

Efficiency – Path Length Example

$$s_f = \int_{x_i}^{x_f} \sqrt{1 + \left(\frac{dy}{dx}\right)^2}\, dx$$



Reference Tracking

- Penalize deviation from the reference path or speed profile

$$\int_0^{s_f} \left\| x(s) - x_{ref}(s) \right\| ds$$

$$\int_0^{s_f} \left\| v(s) - v_{ref}(s) \right\| ds$$

- For velocity:
  - Hinge loss to penalize speed limit violations severely

$$\int_0^{s_f} \left(v(s) - v_{ref}(s) \right)_+ ds$$

positive

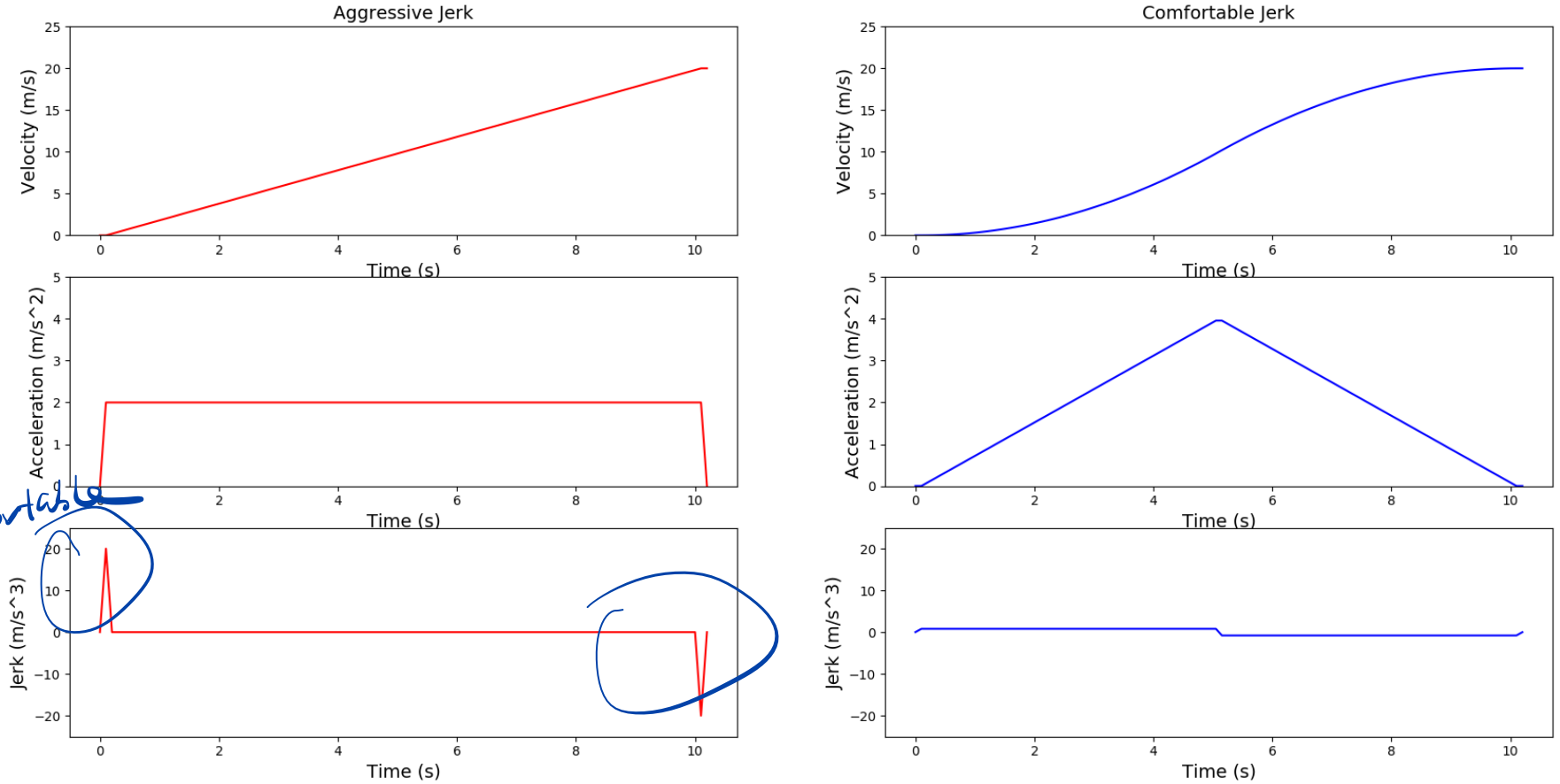
velocity exceeds speed limit

Smoothness

$$\int_0^{s_f} \|\dddot{x}(s)\|^2 ds$$

Jerk

minizing jerk:
rate of change of acceleration over time



uncomfortable

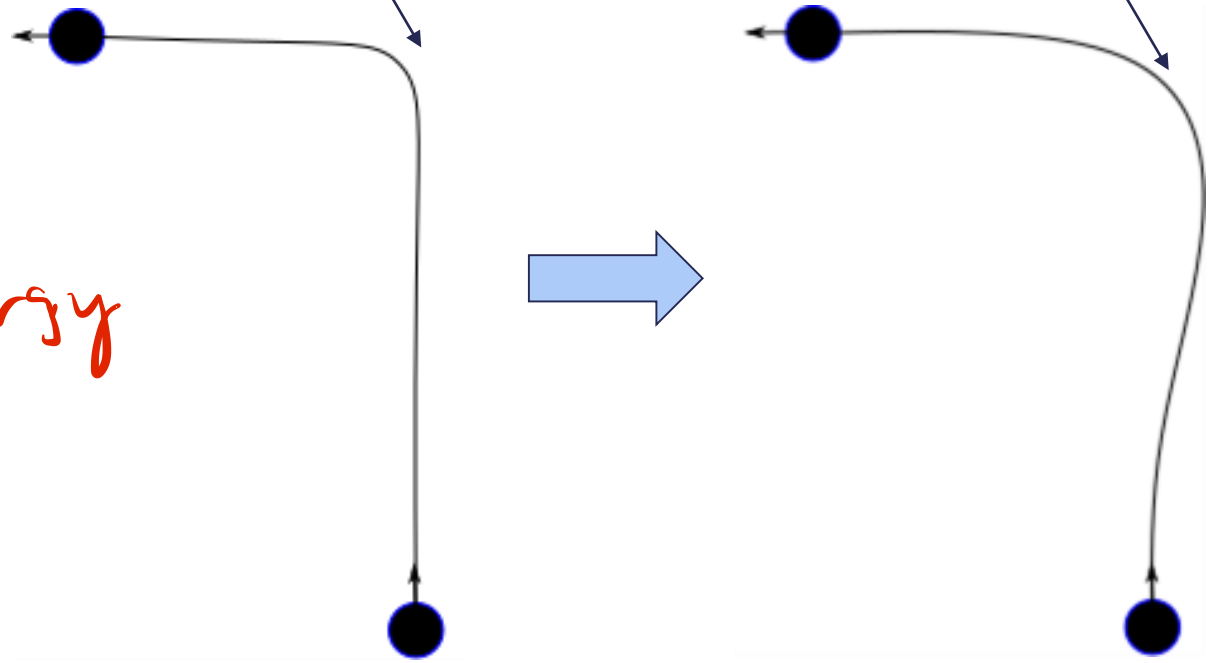
Curvature

lower v → needs deceleration

from $v^2 \leq \frac{a_{lat\,max}}{\kappa}$

$$\int_0^{s_f} \|\kappa(s)\|^2 ds$$

bending energy



Summary

- Explored objective functions related to efficiency, comfort, and reference tracking
- Discussed how each of these objectives changes the optimal path
- Described the benefits the objectives impart to the planned path

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