Check Your Gap or Get Scrapped

An Investigation of a Car Following Model

Kaeshav Danesh & Kevin Phan

April 22, 2022

Table of Contents

Table of Contents

Introduction

- Traffic flow theory deals with modeling vehicular flow.
- Focus on microscopic model which model cars as a single unit.
- Examine scenarios of homogeneous traffic, obstacles, and multi-lane bottleneck.

Table of Contents

Introducing variables

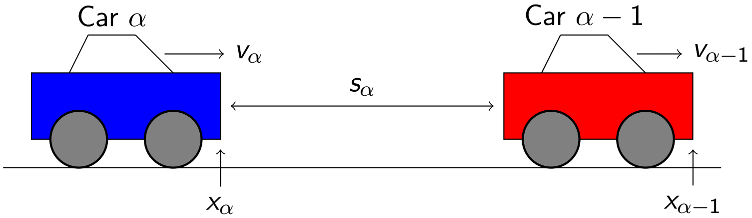

Figure 1: Defining index, position, velocity, and gap of a car.

- x_α, position of αth car.
- v_α, velocity of αth car.
- a_α, acceleration of αth car.
- s_α, gap of αth car.
- Will denote the car $\alpha - 1$ by car l.

Coupled Differential Equations

$$\frac{\mathrm{d}x_\alpha(t)}{\mathrm{d}t} = v_\alpha(t),$$
$$\frac{\mathrm{d}v_\alpha(t)}{\mathrm{d}t} = a_{\mathrm{mic}}(s_\alpha, v_\alpha, v_l).$$

Each car following model has a specific acceleration function: $a_{\mathrm{mic}}(s_\alpha, v_\alpha, v_l)$.

Full Velocity Difference Model

$$a_{\mathrm{mic}}(s_\alpha, v_\alpha, v_l) = \frac{v_{\mathrm{opt}}(s) - v_\alpha}{\tau} - \gamma \Delta v,$$

$$v_{\mathrm{opt}}(s) = \max\left(0, \min\left(v_0, \frac{s - s_0}{T}\right)\right).$$

---

v_0	desired speed
s_0	minimum distance gap
T	time gap
τ	speed adaptation time
γ	speed difference sensitivity

Graph of Optimal Velocity Function

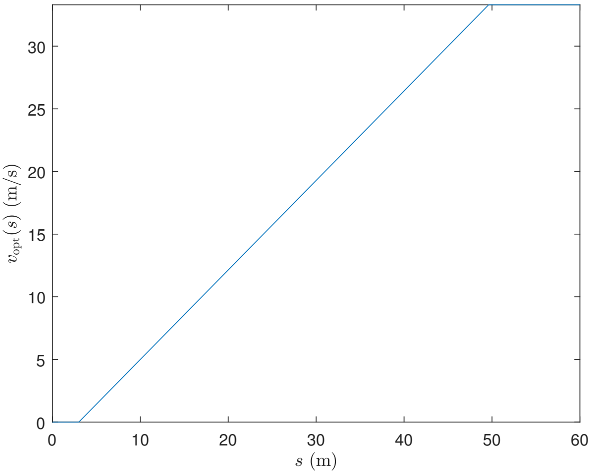

Figure 2: Graph of the optimal velocity function over a range of gaps.

Table of Contents

Forward Euler Method Scheme

$$v_\alpha(t + \Delta t) = v_\alpha(t) + a_{\mathrm{mic}}(s_\alpha(t), v_\alpha(t), v_l(t))\Delta t,$$
$$x_\alpha(t + \Delta t) = x_\alpha(t) + \frac{v_\alpha(t) + v_\alpha(t + \Delta t)}{2}\Delta t.$$

Pseudocode for FVDM

Algorithm 1 Simplified algorithm for FDVM

Require: Initial state variables for each car at $t = 0$.
Require: carArr, an array of cars.
  for $i = 1$:numsteps **do**
    for $j =$ length(carArr):-1:1 **do**
      State variables of jth car $\leftarrow$ Update jth car by a timestep.
    end for
  end for

Table of Contents

Homogeneous Traffic

Obstacle

Multi-lane Bottleneck