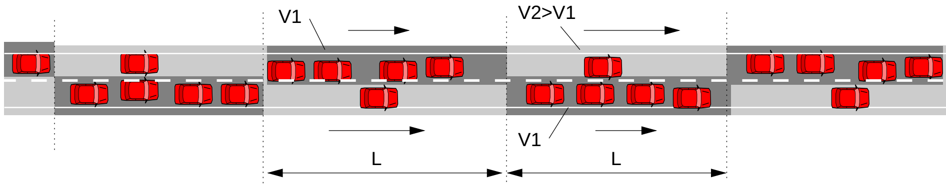
TECHNISCHE UNIVERSITÄT DRESDEN

Traffic Flow Dynamics and Simulation

SS 2024, Tutorial 10, page 1

Problem 10.1: Why the grass is always greener on the other side

Give the reason why, when driving in congested conditions, one generally spends more time in the slower lanes and that a lane change does not help. Consider following situation:



The figure shows two-lane traffic with staggered traffic waves of length L containing jammed traffic creeping at average speed V_1, and the regions in between (of length L as well) where traffic flows more quickly ($V_2 > V_1$) but yet not freely (the congested branch of the fundamental diagram remains relevant). Assume a triangular fundamental diagram and negligible speed adaptation times (which is a good approximation for the OVM or Newell's model). Calculate the fraction p_{slow} of the time one drives inside a wave, i.e., the other lane is faster, as a function of V_1, V_2, and the model parameters$T$ and l_{eff}. Be astounded by the result!

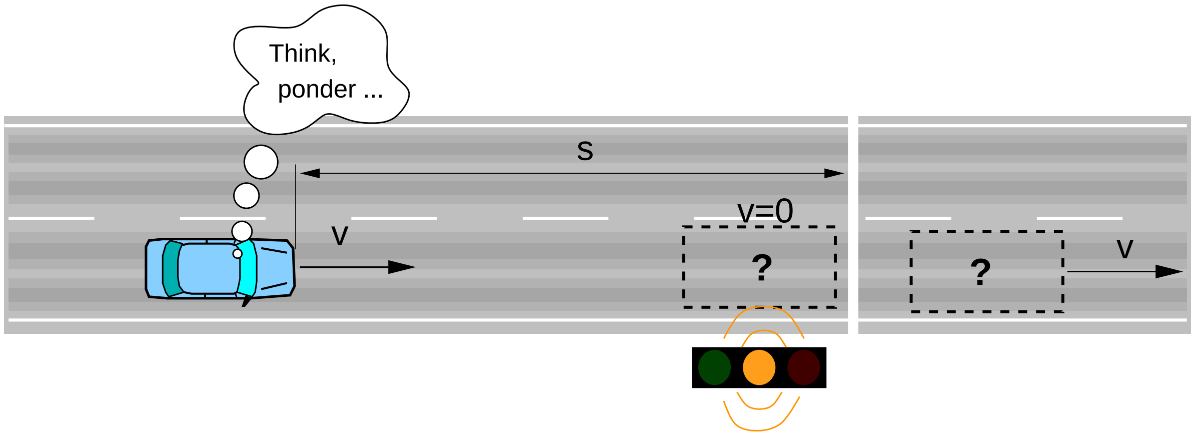
Hint: You can solve this problem by calculating the relative velocity between the driven speed and the wave velocity. Or simply count the vehicles.

Problem 10.2: Stop or cruise? 1. Yellow (amber) time intervals

A decision strategy abiding traffic regulation and restricting braking decelerations to minimal values while taking into account reaction times is the following (cf. the IDM condition (**??**)): Anticipate if you can pass the traffic light at unchanged speed before it turns red. If so, cruise. Otherwise, brake smoothly with constant deceleration so as to stop just before the stopping line. When the speed limit is 50 km/h (70 km/h), the minimum duration of the yellow phase prescribed by law is $\tau_y = 3\,\text{s}$ (4 s). What is the maximum deceleration the legislative authority expects you to use, assuming a complex reaction time of 1 s?

Problem 10.3: Stop or cruise? 2. decisions implied by car-following models

The lane-changing model MOBIL presented in the lecture can easily be adapted to other discrete-choice situations such as the *stop or cruise?* decision when a traffic light turns yellow (amber) when approaching:



The MOBIL safety criterion now serves as the decision criterion:

$$\text{stop?} \quad \begin{cases} \text{yes} & \text{if } \ \dot{v}(s, v, \Delta v = v) \geq -b_{\text{safe}} \\ \text{no} & \text{otherwise.} \end{cases}$$

(a) Discuss & motivate this formula

(b) Give the critical gap for the IDM as a function of its parameters assuming that one approaches at the desired speed

(c) Specialize the resulting condition to the special case $a = b = b_{\text{safe}}$ and calculate the critical gap *and* the critical time gap for the parameters $a = b = b_{\text{safe}} = 2\,\text{m/s}^2$, $s_0 = 0$, $T = 1\,\text{s}$ and (i) $v = v_0 = 50\,\text{km/h}$, (ii) $v = v_0 = 70\,\text{km/h}$.

(d) Discuss why the above assumption $a = b = b_{\text{safe}} = 2\,\text{m/s}^2$ leads to situations where one crosses a red traffic light by referring to the result of the problem *Stop or cruise 1*. Assume now $a = b$ but $b_{\text{safe}} > b$ and compare the result with the stopping distance (=reaction distance plus braking distance).

(e) Determine the critical gap using the OVM for $\tau = T/2$, the triangular fundamental diagram $v(s) = \min(s/T, v_0)$ as a function of T und $v_0 = v$. Compare the critical gaps with that obtained for the IDM and discuss the result for $v = v_0 = 72\,\text{km/h}$ und $b_{\text{safe}} = 4\,\text{m/s}^2$.

Problem 10.4: Reconstruction of the traffic situation around an accident

Different data sources provide information about a road segment of length 10 km ($0 \leq x \leq$ 10 km) indicating a road block caused by an accident: (i) At 4.00 pm, a floating car enters the area and crosses it at 120 km/h. (ii) At 4.19 pm, another floating car, driving at the same speed, has to stop at the end of a traffic jam at $x = 5$ km. (iii) Two stationary detectors at $x = 4$ km and 8 km measure the traffic flow (but not the speed). The detector at $x = 4$ km reports a flow of zero between 4.25 pm and 4.58 pm. The detector at $x = 8$ km reports zero flow between 4.14 pm and 4.51 pm. (iv) At 4.40 pm, a driver reports (via cell phone) that he has been stuck in a traffic jam at $x = 5$ km for a few minutes already. (v) At 4.30 pm, another caller, driving on the opposite lane, reports an empty road at $x = 7$ km.

(a) Visualize the available information in a space-time diagram. Mark all information as one of (i) „free traffic“, (ii) „traffic jam“, (iii) „empty road“, (iv) „do not know; either empty road or stopped traffic“.

(b) Determine the location and time of the accident, assuming an immediate and total road block causing a traffic jam that propagates upstream with constant velocity. Also, determine the propagation velocity.

(c) Determine the time at which the road block clears. (Keep in mind that downstream jam fronts move with a universal propagation velocity of -15 km/h.)