TECHNISCHE UNIVERSITÄT DRESDEN

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Traffic Flow Dynamics and Simulation
SS 2024, Tutorial 4, page 1

Problem 4.1: A simple fundamental diagram (Greenshields, 1935)

Given is following speed-density relation

$$V(\rho) = V_0 \left(1 - \frac{\rho}{\rho_{\max}}\right)$$

with desired speed V_0 and maximum density $\rho_{\max}$.

(a) Give the equation for the fundamental diagram

(b) Calculate the density at which the maximum flow is reached and the maximum flow (capacity) itself. Provide expressions as a function of V_0 and $\rho_{\max}$.

(c) Draw the fundamental diagram for $V_0 = 100\,\text{km/h}$ and $\rho_{\max} = 100\,\text{veh/km}$.

(d) Calculate the speed-flow diagram and draw it with the speed on the vertical axis.

Problem 4.2: Fundamental diagram estimated from stationary detector data

Given are speed-density and flow-density scatter plots obtained from stationary detector data aggregated as arithmetic averages over one minute of the German freeway A8-East (near Munich) and the Dutch A9 (near Amsterdam):
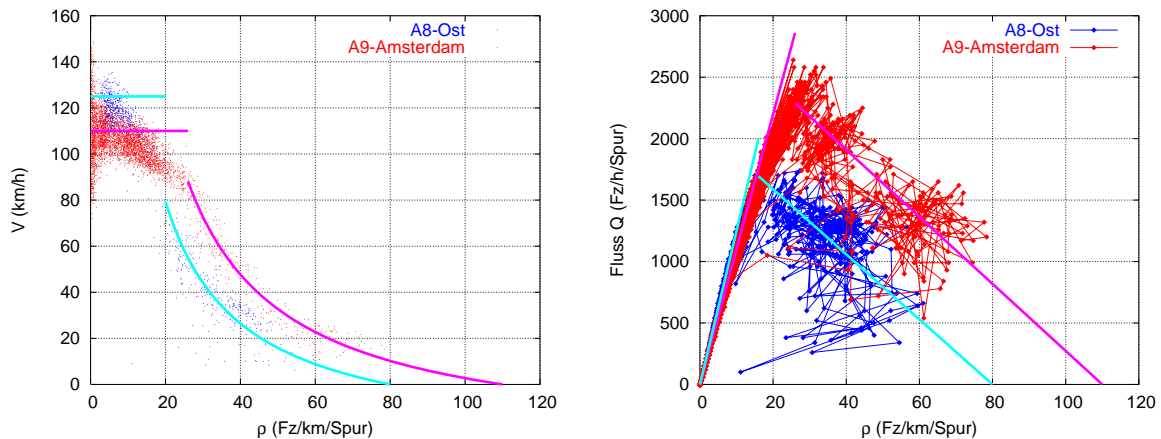
These data should be approximated by triangular fundamental diagrams of the general form

$$Q_e(\rho) = \begin{cases} V_0 \rho & \rho \leq \rho_c \\ \frac{1}{T}\left[1 - \frac{\rho}{\rho_{\max}}\right] & \rho > \rho_c \end{cases} .$$

(a) Determine for both freeways the parameters V_0, T und $\rho_{\max} = 1/(s_0 + l)$ as obtained from the drawn fit curves. Also estimate the *capacity drop* as the flow difference between the intersection of the free and congested traffic fit lines, and the end of the free branch (not considering the few outliers). Is it possible to imply from these data some general statements about the collective behaviour of the drivers on these freeways?

(b) Do you expect biases in the estimation of T, $\rho_{\max}$, and the capacity drop as obtained from the fit lines? If so, in which direction?

(c) Is there a way to improve the estimate by using several detector sites (all of them only provide arithmetic time means)?

(d) Give a substantiated statement whether it is possible to detect a complete standstill ($\rho = \rho_{\max}$) using stationary detectors, only