Traffic Flow Dynamics and Simulation

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Problem 2.1: Use cases of floating-car data

(a) Assume that some vehicles with GPS systems (accurate to approximately 10 m) send their (anonymized) locations to a traffic control center in fixed time intervals of 30 s. Can this data be used to reconstruct

(1) trajectories of single vehicles,

(2) location and time of lane changes,

(3) traffic density (vehicles per kilometer),

(4) traffic flow (vehicles per hour),

(5) vehicle speed,

(6) length and position of traffic jams,

(7) travel time

Justify your answers. Also assess, in which cases it would be problematic to use a non-representative vehicle population such as trucks from logistics companies.

Problem 2.2: Data aggregation at a cross-section

Consider the following 30 s excerpt from single-vehicle data of a cross-sectional detector:

Time [s]	Speed [m/s]	Lane (1=right, 2=left)	Vehicle length [m]
2	26	1	5
7	24	1	12
7	32	2	4
10	32	2	5
12	29	1	4
18	28	1	4
20	34	2	5
21	22	1	15
25	26	1	3
29	38	2	5

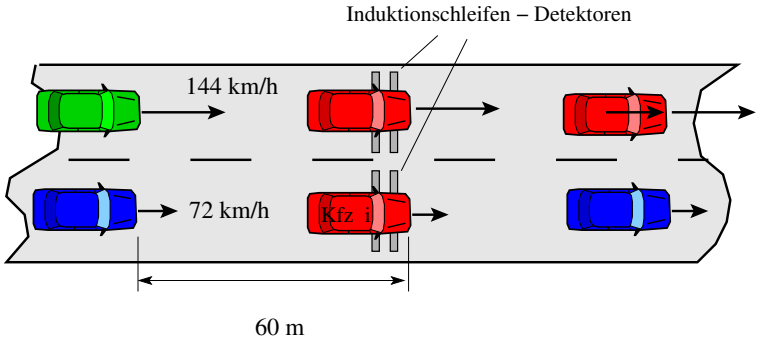
(a) Aggregate the data and calculate the macroscopic traffic flow and speed (arithmetic mean), separately for both lanes.

(b) Calculate the traffic density in each lane assuming that speed and time headway of two succeeding vehicles are uncorrelated (which is realistic for free traffic).

(c) Determine the flow, speed, and density of both lanes combined.

(d) What percentage of the vehicles on the right lane (and in total) are trucks? Is it possible to use the relative truck counting to assess the truck partial *density* or partial *flow*?

Problem 2.3: Determining macroscopic quantities from single-vehicle data



On a two-lane highway all vehicles drive with distance headway 60 m. The vehicles on the left lane all drive at speed 144 km/h, on the right lane at 72 km/h. A stationary detector captures single-vehicle data (cf. the figure) and aggregates them using $\Delta t = 60\,\mathrm{s}$

(a) What are the time headways Δt_i on both lanes? What are the time gaps, assuming all vehicles are 5 m long?

(b) Find the traffic flow, occupancy, and average speed (both arithmetic and harmonic time mean) separately for both lanes (i.e., each lane is captured by its own detector) and also for both lanes combined (i.e., one detector captures vehicles on both lanes).

(c) Besides two mathematical methods of averaging (arithmetic and harmonic), there are also two physical ways: temporal and spatial. For which type of physical averaging does, in the concrete situation, the following statement hold: The arithmetic mean speed on the road is equal to the *simple* arithmetic mean speed of the two lanes?

(d) Calculate the speed variance on the road and within the lanes