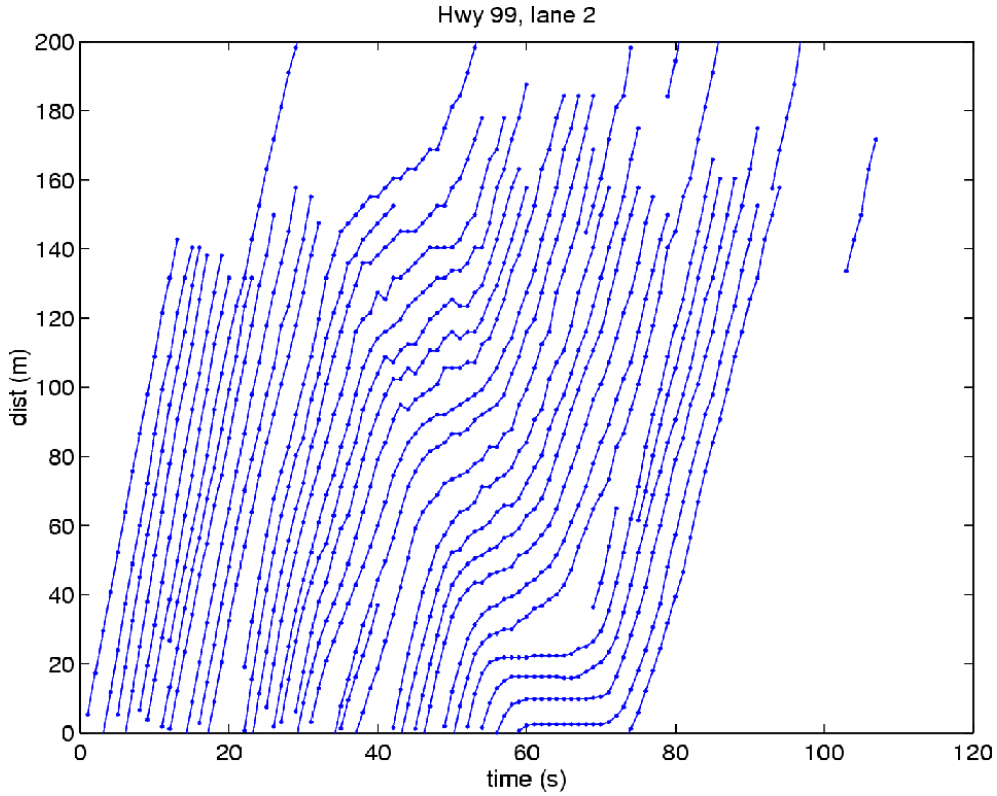
Traffic Flow Dynamics and Simulation

Summer semester, Tutorial 1, page 1

Problem 1.1: Trajectory data



(a) Give criteria for the dimensions of spatiotemporal regionms for determining local macroscopic variables out of trajectory diagrams

(b) Determine from the trajectory diagram the local traffic density ρ and flow Q in selected regions with free and congested traffic, e.g., $[10\,\mathrm{s}, 30\,\mathrm{s}] \times [20\,\mathrm{m}, 80\,\mathrm{m}]$ (free) and $[50\,\mathrm{s}, 60\,\mathrm{s}] \times [40\,\mathrm{m}, 100\,\mathrm{m}]$ (congested)

(c) Determine, for the same regions, the local speed (i) by the gradient of representative trajectories, (ii) by the hydrodynamic relation $V = Q/\rho$. Compare the outcome of both procedures and discuss possible differences

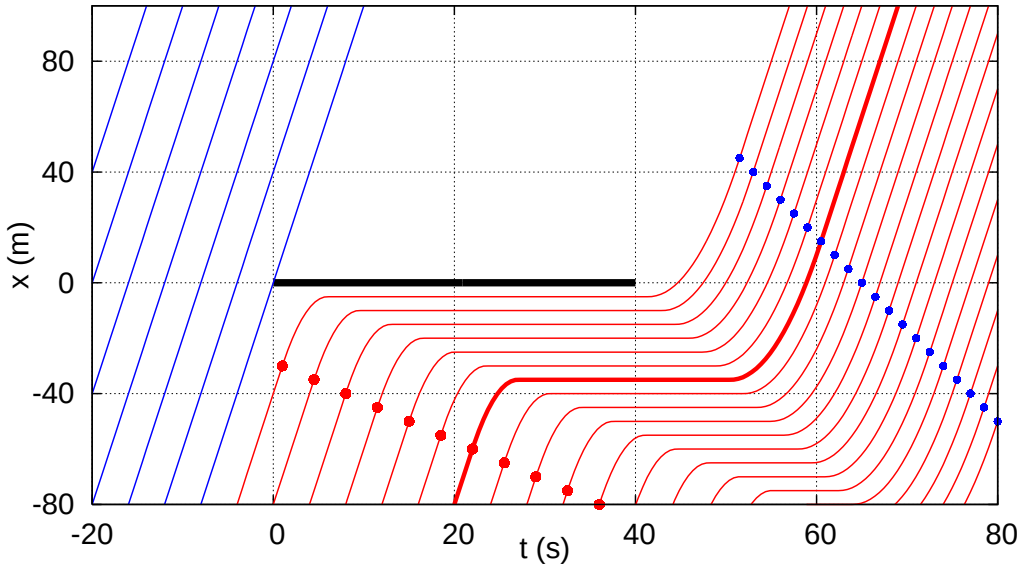
(d) Determine the propagation velocity and direction of the traffic wave observed in the data

(e) Estimate the delay caused by the congestions for a driver crossing $x = 0$ at the time $t \approx 50\,\mathrm{s}$. Is this the time given in jam warnings of navigation systems / radio broadcasts?

(f) Estimate the lane-changing intensity (lane changes per km and hour) for the spatiotemporal region $[0\,\mathrm{s},\ 80\,\mathrm{s}] \times [20\,\mathrm{m},\ 120\,\mathrm{m}]$

Problem 1.2: Trajectories of traffic flow with a disturbance

Given are trajectories with a temporary road block (black line):



(a) Give a plausible situation represented by these data

(b) Estimate the traffic demand (potential inflow) inferred from this diagram

(c) Estimate speed and traffic density in the "demand region" upstream of the bottleneck

(d) What does the "traffic jam" represent in this context? Give its density

(e) Estimate the steady-state outflow from the congested region once the bottleneck is "lifted". Also calculate speed and density in this region. Notice that the steady state is separated from the dynamic outflow region by the blue symbols.

(f) Estimate the propagation velocities of the upstream and downstream jam fronts free → congested and congested → outflow, respectively. Also compare the obtained velocities with that calculated by the formulas (we will derive them later)

$$c_{12} = \frac{Q_1 - Q_2}{\rho_1 - \rho_2}$$

where 1 and 2 stands for the upstream and downstream steady-state regions.

(g) Give the delay experienced by the driver of the fat red trajectory

(h) Calculate the decelerations and accelerations when approaching/leaving the congestion (red and blue symbols) assuming a constant acceleration. Calculate them in two ways: (i) $\frac{\mathrm{d}v}{\mathrm{d}t} = \Delta v / \Delta t$, (ii) $\frac{\mathrm{d}v}{\mathrm{d}t} = \pm v_0^2/(2\Delta x)$