Data-Driven Mobility Simulation and Modeling
(CUSP-GX9007)
HW #3
Due 03/30/2018

HW #3 has a total value of 200 points.

- Problems are worth 100 points.
- Computational questions are also worth 100 points

Problems – 100 PTS

Problem 1 (25 PTS):
From a photograph one observes that on a level section of highway 10% of the vehicles are trucks, 90% are cars, and that there are 50 vehicles per mile of highway. The trucks travel at 40 mi/hr, and the cars at 50 mi/hr. This highway also has a section with a steep grade on which the speed of the trucks drops to 20 mi/hr, and the speed of the cars to 40 mi/hr. No vehicles enter the observed sections of highways (except at the ends), and the flows are (nearly) stationary.
Determine:
(a) The flow of vehicles on the level section.
(b) The density of vehicles on the grade.
(c) The percent of trucks on the grade as seen on a photograph.
(d) The percent of trucks as seen by a stationary observer on the grade.

Answer：
(a)
The flow of vehicles on the level section

$$q = No.of\ cars\ per\ mile\ \times Speed\ of\ cars + No.of\ trucks\ per\ mile\ \times Speed\ of\ trucks$$

$$\begin{aligned} q &= k(car) \times v(car) + k(truck) \times v(truck) \\ &= 50 \times 90\% + 50 \times 10\% \times 40 \\ &= 2450 \text{ vehicles/hr} \end{aligned}$$

(b)The density of vehicles on the grade
∵ flow of vehicles on the level section = flow of vehicles on the grade section
$\therefore k_{total}^{grade} = k_{truck}^{grade} + k_{car}^{grade}$

$$\begin{aligned} k(average\ grade) &= k(car\ grade) + k(truck\ grade) \\ &= q(car)/v(car\ g) + \ q(truck)/v(truck\ g) \\ &= \frac{2250}{40} + \frac{200}{20} \\ &= 66.25 \text{ vehicles/mi} \end{aligned}$$

(c)The percent of trucks on the grade as seen on a photograph should be:

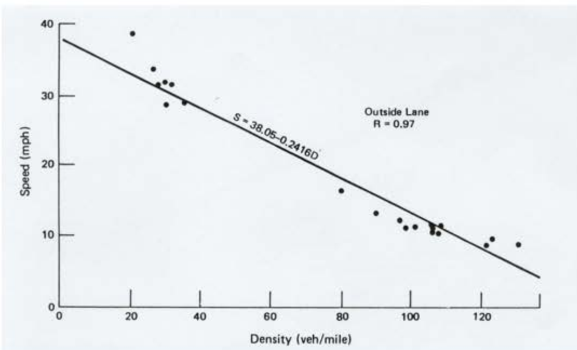
$$\begin{aligned} percent &= \ k\ (truck\ grade)/(k(car\ grade)\ \ + k(truck\ grade)) \\ &= 10/66.25 \\ &= 15.1\% \end{aligned}$$

(d)the percent of trucks as seen by a stationary observer on the grade is $\frac{q_{truck}}{q_{total}} = \frac{200}{2450} = 8.2\%$

Problem 2 (15 PTS):
If the speed limit on a highway network is changed so that the average speed drops from v to v' (100km/hr to 80 km/hr, for example), what happens to q and k if people continue to make the same trips every day?

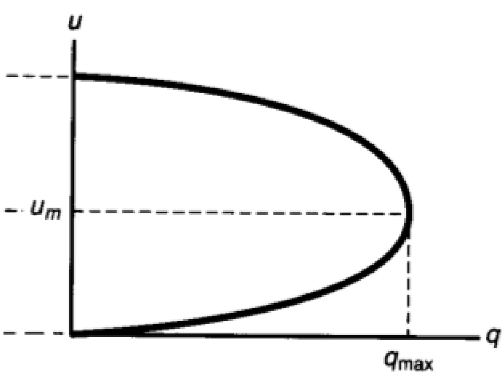
Answer:
I chose Greenshield's Linear Model for this problem.

Greenshields model



$$\bar{u}_s = u_f - \frac{u_f}{k_j} k$$

$$q = \bar{u}_s k = u_f k - \frac{u_f}{k_j} k^2$$



There is a linear negative correlation between v and k. So when v decreases, k goes up;
And there are 3 conditions for q (if v decrease from v_1 to v_2):
(1). If U_m>(v_1+ v_2)/2, q increases.
(2). If U_m=(v_1+ v_2)/2, q keeps the same.
(3). If U_m<(v_1+ v_2)/2, q decreases.

Problem 3 (20 PTS):
Suppose that the q(t, x) and k(t, x) on a one-directional road are given by the following (in an unspecified system of units):
a) $q(t,x) = q_0 e^{(t/t_0 - x/x_0)}$ and $k(t,x) = k_0 e^{(t/t_0 - x/x_0)}$
b) $q(t,x) = f(x/t)/t$ and $k(t,x) = f(x/t)/x$

c) $q(t,x) = f(x/t)x$ and $k(t,x) = f(x/t)t$
for $(t,x) \approx (t_0,x_0) > (0,0)$

Identify which of these formulas is physically possible, without traffic generation in the vicinity of $(t_0,x_0)$and which is not (if any) and explain why.

a) and b) is feasible, but c) is not.

Because I think when the traffic flow gets higher upstream, the traffic would be accumulated, in function c) it would be $q(t_1,x_1) = f(x_1/t_1)x_1 = f(\frac{(x_0+a)}{(t_0+a)}) \times (x_0 + a)$, when a gets larger, it would be more inaccuracy.

Problem 4 (35 PTS):

A vehicle (A) traveling on a freeway joins a 1/2-mile queue that contains 100 vehicles at a time t = 0 min. Vehicles in this queue pass through the bottleneck at a rate of 50 veh/min. When there is no queue, vehicles travel (in free flow) at a rate of 1 mile/min, provided that the flow satisfies: q < qmax = 100 veh/min. Do the following:

(a) Determine the delay and the time in queue for our hypothetical vehicle.

(b) Determine the (average) density of vehicles in the queue.

(c) Plot a triangular flow-density relation for our freeway that will be consistent with the given data.

(d) If the (free) flow upstream of the bottleneck is 80 veh/min, determine the location of the end of the queue (in miles upstream of the bottleneck) 1 minute after the arrival of vehicle A. Solve this with the help of a picture, drawn to scale, as follows:

(1) Construct the virtual arrival curve, the bottleneck departure curve and the back-of-queue curve, starting with vehicle A.

(2) Identify on the picture the vehicle (B) that joins the queue at t = 1 min.

(3) Determine the distance in queue for such vehicle.

Answer:

(a) T(queue) = vehicle number in queue / q(bottleneck)
= 100/50
= 2 mins

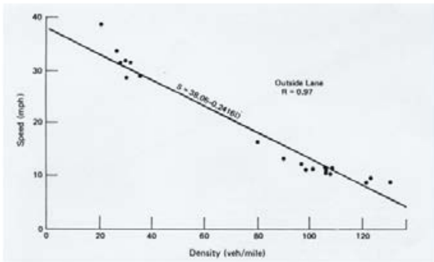
t(free flow) = length of queue / v(free flow)
= 0.5/1
= 0.5mins

t(delay) = t(queue) – t (free flow)
=1.5 mins

(b) k(density) = vehicles number of queue / queue length
= 100 / 0.5
= 200 veh/mile

(c) I chose Greenshield’s Linear Model for this problem.

Greenshields model



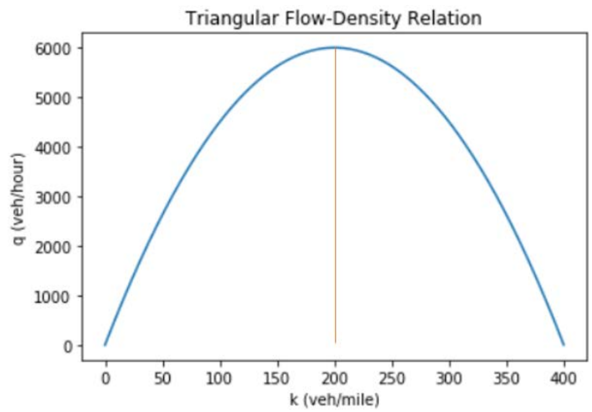
$$\bar{u}_s = u_f - \frac{u_f}{k_j} k$$

$$q = \bar{u}_s k = u_f k - \frac{u_f}{k_j} k^2$$

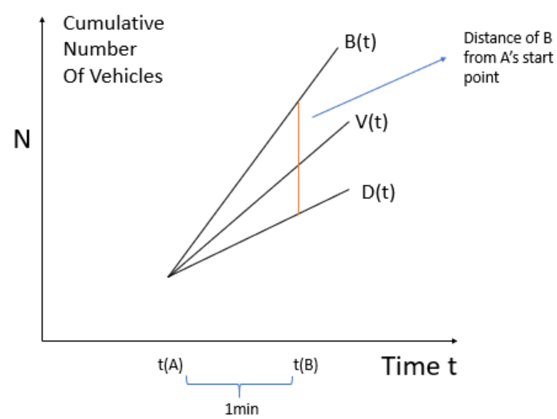
Where $U_f = v(free\ flow) = 1 mile/\min = 60\ mile/hr$

$$Q_{max} = k_j \times \frac{U_f}{4} = 100$$

After calculation: $q = -0.15k^2 + 60k$



(d).



The Virtual arrival(), bottleneck departure() and the back-of-queue() curve are showed like above.

Computational Questions -100 PTS

1. Please pick a district and download Station 5-Minute PEMS dataset used in class. The downloaded data must be different than the class example (The district may be the same if you select a different day). Use the downloaded dataset to draw the temporal distribution of flow, average speed, and average occupancy for each of the two consecutive sensor stations and comment on the results. Please generate plots for only temporal distributions not the flow-speed-density relationship plots. (**25PTS**)

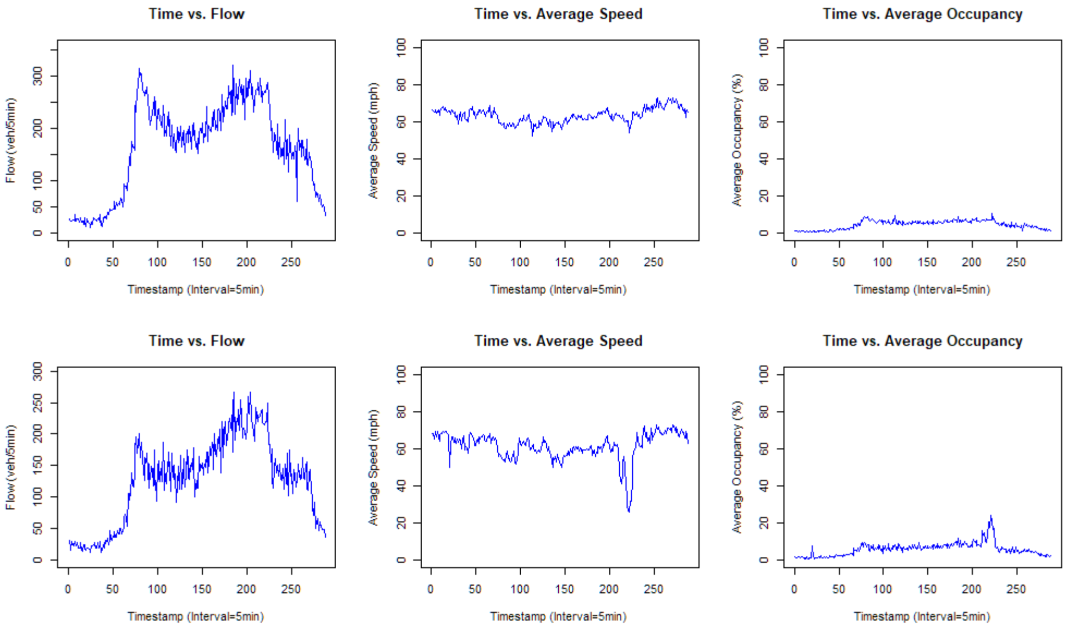
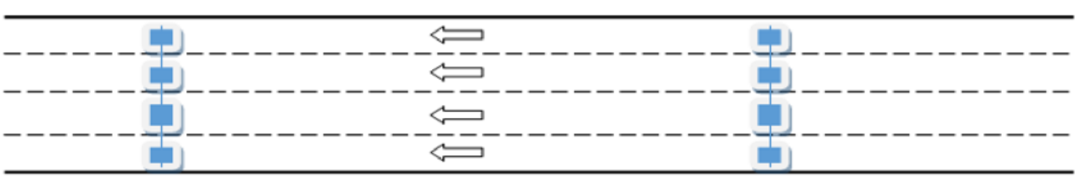


Figure 1Temporal distribution of flow, average speed, and average occupancy(row 1: Station 312133, row 2: Station 312134)

Comment: Comment: As the figure shows, the traffic flow and the average occupancy between two consecutive sensor station during the record time follow a similar distribution. The average speed shows a more significant fluctuation in the first sensor station, especially in the noon and around evening.

2. Use the dataset (**d04_text_station_5min_2018_02_07.txt.gz**) given in class to draw the cumulative curves and oblique curves for both stations shown in Figure 1. Assume that capacity is 600 vehicles for each lane, the number of lanes 4, and the normal occupancy is 5%.



I80

Station:403430 Station: 401513

Figure 1. Sensor stations on a given highway section

Please describe the traffic conditions based on the figure you show. Can you tell any information about the prevailing traffic status? (**25 PTS**)

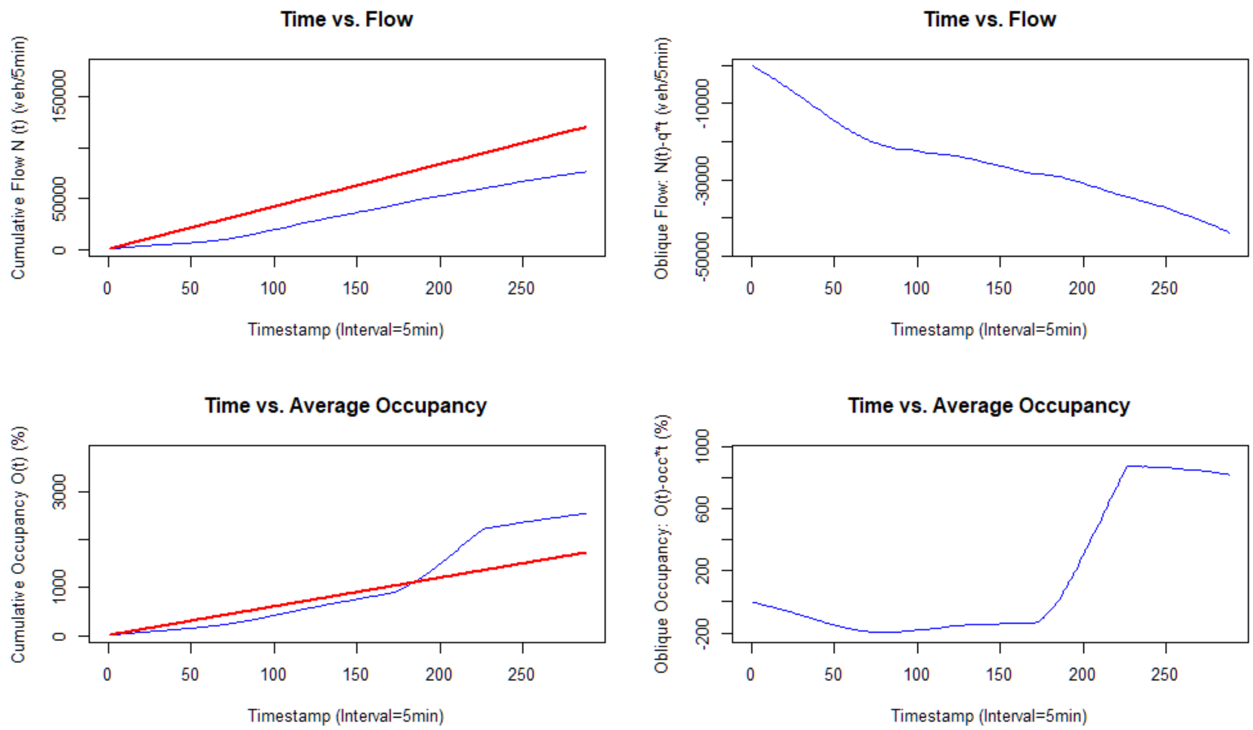


Figure 2 Station 403430

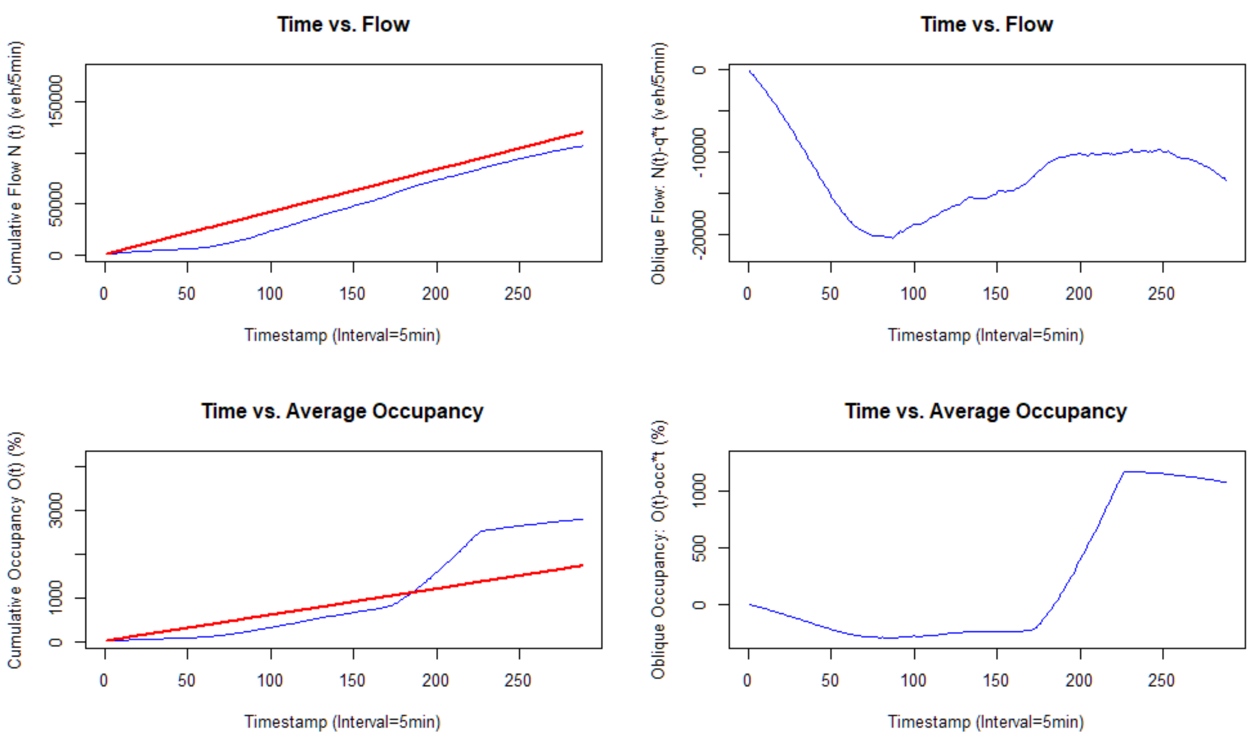


Figure 3 Station 401513

Traffic conditions:

Based on the plots above, the observed cumulative occupancy curve and cumulative flow curve exceed the red reference line around timestamp 180, indicates there is significant speed declination occurred between the two sensor stations.

Thus, in general, there is a queuing happens between noon to around 20:00, which means that the average traffic speed keeps low during afternoon.

3. Download SUMO to your machine and try to run the same scenario (Example Network) that we did in the class. Scenario files are located under (“YourSumoDirectory/Sumo/doc/tutorial/quickstart”)
    a) Change vehicle IDs in vType as follows. CarA -> YournameA (e.g. AbdullahA). Update sigma values using the equation: sigma = maxspeed/100 (**10 PTS**)
    b) Add 25 vehicles to quickstart.rou.xml with <u>different colors and departure times</u>. (**10 PTS**)
    c) Add a new link type with properties:(priority = “1” numlanes = “2” speed = “15”) (**5 PTS**)
    d) Change the link type of edges that have ids L1, L10, L15 and L18 to the new link type that you created. (**5 PTS**)
    e) Add a connection from the edge L9 to the edge L11 from the lane 2 to the lane 2 and re-generate your network file using NETCONVERT. (**20 PTS**)

please find the .xml files in the data folder.

```
C:\Users\xihao\Documents\学习\4. Data-driven Mobility Model\HW3\data>netconvert --node-files=quickstart.nod.xml --edge-files=quickstart.edg.xml --connection-files=quickstart.con.xml --type-files=quickstart.typ.xml --output-file=quickstart.net.xml
Warning: Target lane 'L11_2' is already connected from 'L9'.
Success.
```

Here is the NETCONVERT screenshot which is generated after being edited.