EGR111
Traffic Project

Introduction

When designing road systems, engineers often use a measure of traffic flow variability called **Peak Hour Factor (PHF)**. In this project, we are going to observe the traffic flow on Willamette Boulevard and use MATLAB to compute the PHF.

Background

When designing roads, a key consideration is the **peak hourly flow**, which is the maximum number of vehicles that pass a point on the road in a given direction in any one hour interval. The units of hourly flow are **vehicles per hour (VPH)**. If the road is adequate for the peak hourly flow, it should be adequate for the rest of the day as well, so the PHF is computed only for the hour that has the maximum flow.

In order to compute the PHF, we will count the number of vehicles that pass a point in the road for each 15 minute interval in a day. Then the PHF is defined as follows:

$$PHF = \frac{V_{max}}{4V_{15}}$$

where V_{max} is the maximum hourly flow (in VPH) for the day, and V_{15} is the maximum 15 minute flow for any of the four 15-minute intervals during the hour of maximum flow.

So in order to compute PHF, we start with each 15 minute interval and add the values from four consecutive 15-minute intervals to compute the hourly flow (in VPH). Then V_{max} is the maximum of these hourly flow values, and the four 15 minute intervals that combine to form the maximum is the **peak hour**. Note that the peak hour can start at any of the 15 minute intervals, such as 4:15 PM.

Next, for the hour that has the maximum flow, we find the maximum of the four 15-minute intervals, which we call V_{15}. And finally, we compute the PHF using the equation above.

Example

Let's look at an example. Suppose that we measure the 15 minute flow values shown in Table 1 below.

Table 1. Example Data of Traffic Flow

Time	15 Minute Flow (Number of Vehicles in 15 Minutes)
4:00 – 4:15 PM	10
4:15 – 4:30 PM	-1
4:30 – 4:45 PM	50
4:45 – 5:00 PM	50
5:00 – 5:15 PM	60
5:15 – 5:30 PM	50
5:30 – 5:45 PM	40
5:45 – 6:00 PM	10

We compute the PHF as follows:

1. Missing values will be marked in our data file with -1. Replace any missing values with the previous value. If the first value is missing, replace it with 0. So the value of -1 would be replaced with the previous value which is 10.

2. Starting with each 15 minute interval, we compute the hourly flow as shown in Table 2.

Table 2. Example Calculation of Hourly Flow

Time	Hourly Flow (VPH)
4:00 – 5:00 PM	10 + 10 + 50 + 50 = 120
4:15 – 5:15 PM	10 + 50 + 50 + 60 = 170
4:30 – 5:30 PM	50 + 50 + 60 + 50 = 210
4:45 – 5:45 PM	50 + 60 + 50 + 40 = 200
5:00 – 6:00 PM	60 + 50 + 40 + 10 = 160

3. Find the maximum hourly flow. In this example, the maximum occurs from 4:30 – 5:30 PM and is given by the following value.

$$V_{max} = max\{120,170,210,200,160\} = 210$$

4. For the hour with the maximum flow (4:30 – 5:30 PM), find the maximum 15 minute flow, which is given by the following value.

$$V_{15} = max\{50,50,60,50\} = 60$$

5. Finally, compute PHF:

$$PHF = \frac{V_{max}}{4V_{15}} = \frac{210}{4 \cdot 60} = 0.875$$

The PHF helps engineers determine if the traffic flow on a road is constant or variable, which is taken into consideration when designing roads. In order to get some intuition of what the values of PHF mean, let's look at the extreme cases.

Extreme Cases

First let's look at the extreme case where all of the traffic for the entire day occurs in a single 15 minute interval as shown in Table 3 below.

Table 3. Example Data of Traffic Flow with Maximum Variability

Time	15 Minute Flow (Number of Vehicles in 15 Minutes)
4:00 – 4:15 PM	0
4:15 – 4:30 PM	0
4:30 – 4:45 PM	-1
4:45 – 5:00 PM	0
5:00 – 5:15 PM	0
5:15 – 5:30 PM	200
5:30 – 5:45 PM	0
5:45 – 6:00 PM	0

We compute the PHF as follows:

1. Replace the missing value marked by -1 with the previous value which is 0.

2. Compute the hourly flow as shown in Table 4.

Table 4. Example Calculation of Hourly Flow

Time	Hourly Flow (VPH)
4:00 – 5:00 PM	0 + 0 + 0 + 0 = 0
4:15 – 5:15 PM	0 + 0 + 0 + 0 = 0
4:30 – 5:30 PM	0 + 0 + 0 + 200 = 200
4:45 – 5:45 PM	0 + 0 + 200 + 0 = 200
5:00 – 6:00 PM	0 + 200 + 0 + 0 = 200

3. Find the maximum hourly flow. In this example, the maximum is V_{max} = 200 VPH and occurs in the interval 4:30 – 5:30 PM (or equivalently 4:45 – 5:45 PM or 5:00 – 6:00 PM).

4. For the hour with the maximum flow, find the maximum 15 minute flow. If we use the 4:30 – 5:30 PM hour, we get the following (we would get the same result if we use either of the other maximum hours):

$$V_{15} = max\{0, 0, 0, 200\} = 200$$

5. Compute PHF:

$$PHF = \frac{V_{max}}{4V_{15}} = \frac{200}{4 \cdot 200} = \frac{1}{4} = 0.25$$

The value of 0.25 is the minimum possible value for PHF, and it indicates the maximum possible amount of variability in flow rates. The PHF of real roads are not expected to be this low. If a road had a PHF of 0.25, it could only carry about 25% as much total traffic as a road with a PHF of 1.0.

Now let's look at the other extreme case where the flow is perfectly constant throughout the day as shown in Table 5.

Table 5. Example Data of Traffic Flow with Perfectly Constant Flow

Time	Flow (Number of Vehicles in 15 Minutes)
4:00 – 4:15 PM	50
4:15 – 4:30 PM	50
4:30 – 4:45 PM	50
4:45 – 5:00 PM	50
5:00 – 5:15 PM	50
5:15 – 5:30 PM	50
5:30 – 5:45 PM	-1
5:45 – 6:00 PM	50

Exercise 1: Compute the PHF for the case of perfectly constant flow as shown in Table 5.

Checkpoint 1: Show your instructor your result from Exercise 1.

The value of 1.0 is the maximum possible value for PHF, and it indicates that the flow was perfectly constant during the hour of maximum flow. Very high values of PHF (say above 0.95) may occur for very high volumes of traffic and when the flow is constrained.

Typically the PHF for urban areas ranges between 0.80 and 0.98, and rural areas and smaller streets typically have lower values than urban areas.

Collecting the Data

For this project, we will work together with the students from the other sections of EGR111 to observe the traffic on Willamette Boulevard on Friday, March 21, 2014. Working in teams (about) three students, please go to http://when2meet.com/?1612976-sOvB9 and log in (using one of your teammate's name), and sign up for a time slot by clicking on one of the 15 minute time slots that haven't yet been taken. Then, a few minutes before the 15 minute time slot that your team signed up for, go out to the bus stop near the main entrance to the UP campus (see Figure 1 below). One student should count the number of vehicles that pass in the South-East direction in the 15 minute interval, and another student should count the number of vehicles that pass in the North-West direction (see Figure 1 below). The third student should help record the results. Only count motorized vehicles (not bicycles).

Then write an email to Dr. Hoffbeck (hoffbeck@up.edu) with the subject line "EGR111 Traffic Data" and put the following information in the email:

1. Names of all group members
2. Your section of EGR111 (Section A, B, C, D, or E)
3. Time slot (for example 9:15 – 9:30 AM)
4. Number of Vehicles that passed in the South-East direction
5. Number of Vehicles that passed in the North-West direction

The email is due by 9PM on Friday, March 21, 2014 so that the data from all students can be collected and made available on the course website.

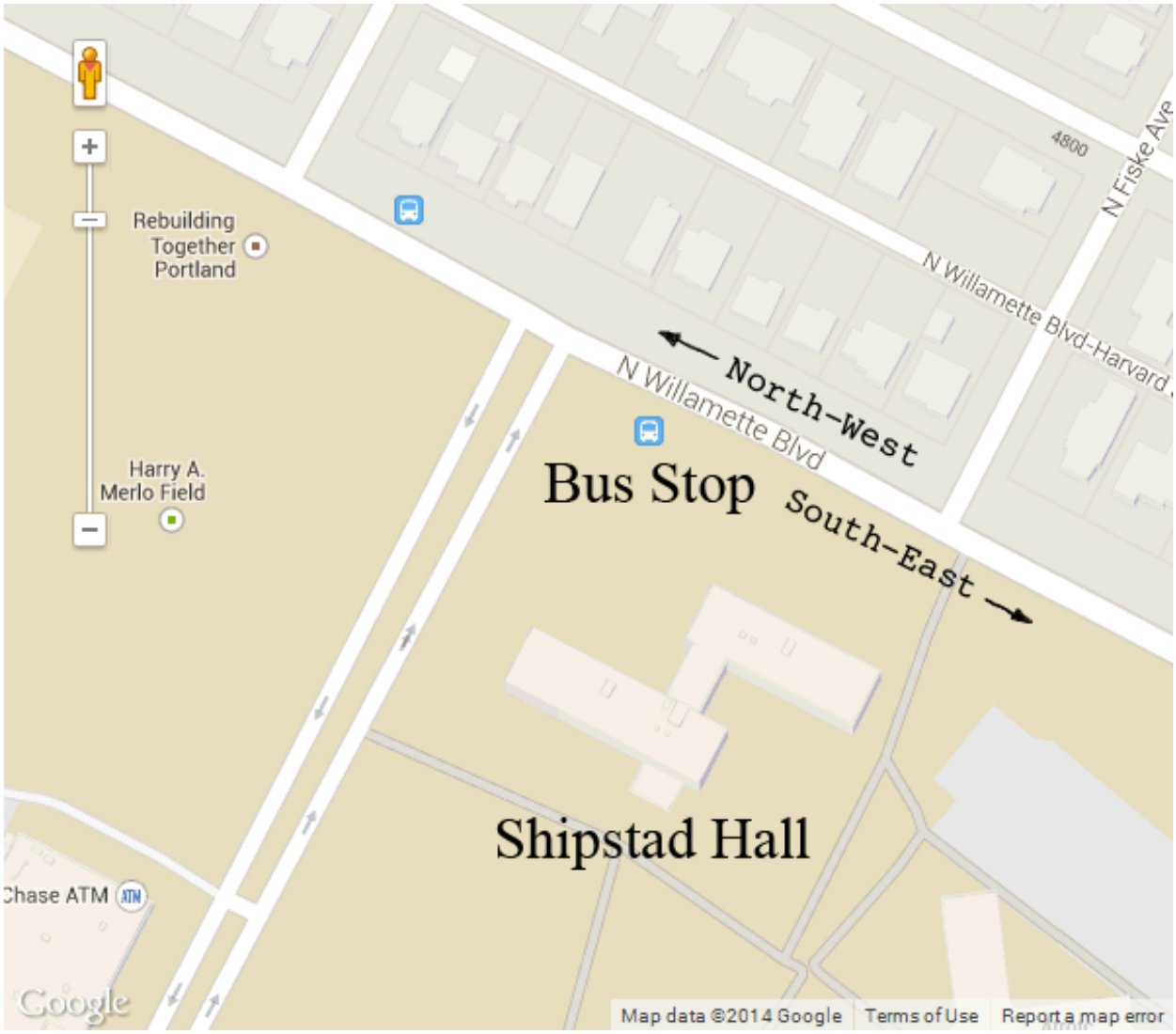

Figure 1: Location of the Bus Stop at UP's Main Entrance

Analyzing the Data

Exercise 2: Write a MATLAB program to compute the PHF and test it with the sample data from Tables 1, 3, and 5 above. The file "Traffic Project Example Data.xlsx" on the course website has the example data from Tables 1, 3, and 5 above. Download this file and write a MATLAB program to load the Excel file into MATLAB and compute the PHF as follows:

a. If there are any missing values (marked by -1), replace the missing values with the previous value. If the first value is missing, change it to zero.
b. Plot the number of vehicles for each 15 minute interval.
c. Compute the PHF (and check your answers)

Exercise 3: Download the file "Traffic Project.xlsx" from the course website. This file has the data observed by the EGR111 students on Willamette Blvd. Modify your program to load this file and compute the PHF for the South-East direction and the North-West direction.

Checkpoint 2: Show your instructor your group's script file, plots, and values of PHF for Willamette Blvd. from Exercise 3.