Culver Road and East Main Street Intersection

Traffic Analysis Report

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Introduction

There has been intense study in the area of traffic management

Data Analysis

To assess the traffic conditions at the Culver Road and East Main Street intersection, we determined the current state of the intersection in terms of federal DOT guidelines for this class of intersection, as well as analyses to examine trends and patterns in the traffic recorded and to predict occurances of traffic congestion based on time of day, day of the week, and the weather conditions present.

Traffic Analysis

There are a few common characteristics to examine when determining the traffic flow for a particular intersection. Namely, it is important to determine the amount of delay experience by drivers as they enter the intersection, the density of the vehicles as they pass through the intersection, and the velocity at which traffic flows through the intersection. With these three variables, it is possible to determine the effects of traffic congestions on the flow of traffic through the intersection.

The amount of time that vehicles wait at an intersection is refered to as the Level of Service (LOS). Ranked in letter grades from A to F, the LOS is an identifier for the overal health of the intersection. Ideally, an intersecton should be classified as being either A, B, or C, denoting free flow, reasonably free flow, and stable flow, respectively. The 2010 Highway Capacity Manual classifications for LOS can be seen in Table **??**, in which grade A intersections have less then 10 seconds of vehicle control delay, whereas grade F intersections have more than 80 of vehicle control delay.

Table 1: Level of Service classifications published in the 2010 Highway Capacity Manual.

LOS	**Vehicle Control Delay (Sec.)**
A	≤ 10
B	$10 - 20$
C	$20 - 35$
D	$35 - 55$
E	$55 - 80$
F	≥ 80

Using these classifications, we examined the average vehicle control delay for each five minute observation period. As shown in Figure **??**, the majority of observations have a Grade F Level of Service (58.38%). Each of the other levels of service occured in between 7.45% and 8.63% of observations. This suggests that the Culver Road and East Main Street intersections is experienceing traffic congestion, in which each vehicle move in lock step with the vehicle in front of it [**?**].

We also examined the relationship between the traffic density and traffic volume, also known as flux. Whe plotted, the relationship between the traffic density and the traffic volume creates the fundamental diagram of traffic flow [**?**], as shown in Figure **??**. Using linear regression techniques, we were able to estimate the free flow velocity to be 19.5 miles per hour and the traffic wave velocity to be 2.43 miles per hour against the direction of traffic. We also determiend thecritical traffic density to be 42.8 vehicles per mile. As the vehicle denisty passes the critical density, the traffic flow becomes more unstable leading to traffic waves and congestion. To maximize the traffic flow, the vehicle density must remain below the critical density.

Trend and Pattern Analysis

To examine the general trend in the metrics we were provided, we performed linear and multivariate regression. These techniques allows us to approximate the traffic volume and delay. Figure **??** shows the median delay for each week and the median traffic volume for each week with the linear regression for each data set. Our data suggest that the median amount of time that vehicles wait at the intersection

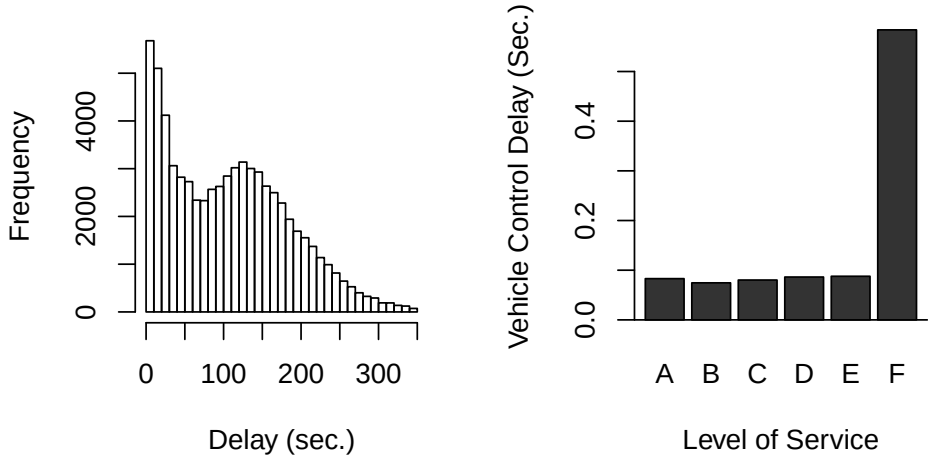

Figure 1: The Culver Road/East Main Street intersection has a poor Level of Service. The histogram on the left shows the distribution of the average vehicle control delay for each observation. The distribution is bimodal with peaks at zero seconds and 140 seconds. The median delay was 103 seconds with a IQR of 123 seconds. The bar plot on the right shows the distribution of each LOS grade for each observation in our data set. Observations were given a letter grade based on the average vehicle control delay for each 5 minute interval. The majority of all observations had a delay of greater than 80 seconds, suggesting that the intersection is predominantly grade F.

may be increasing by 0.24 seconds per week. Our data also suggest that the median number of vehicles utilizing the intersection may be increasing by approximately 11 vehicles per week. Although the correlation coefficients are rather low, we are confident that the traffic congestions will worsen as more vehicles utilize the intersection.

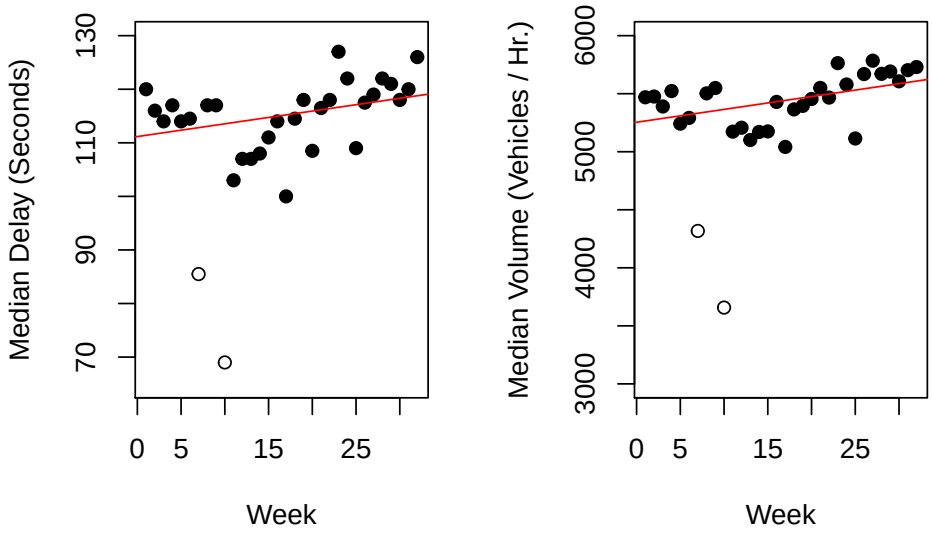

Figure 3: The median traffic delay and median weekly traffic volume are increasing over time. A linear regression of the median traffic delay for each week suggests that the traffic delay may be increasing 0.24 seconds per week ($R^2 = 0.13$). Similarly, a linear regression of the median number of vehicles to pass through the intersection per week suggests that the number of vehicles utilizing the intersection may be increasing at a rate of 11.08 vehicles per week ($R^2 = 0.24$).

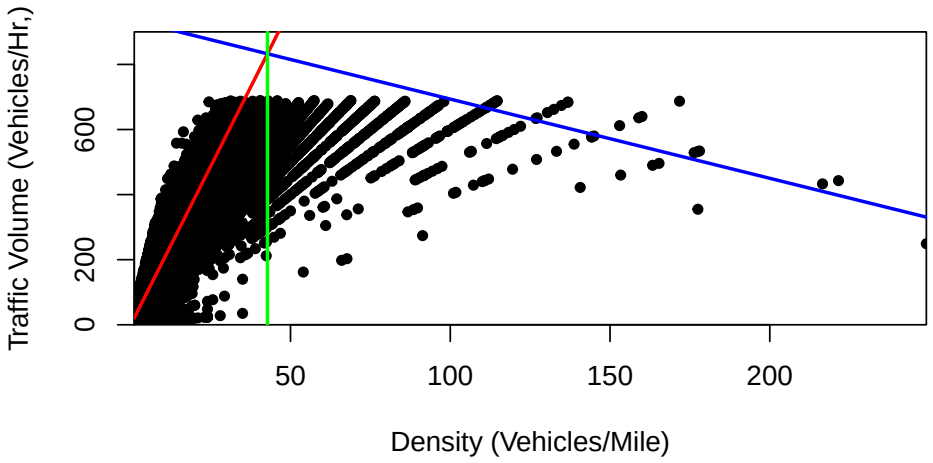

Figure 2: Fundamental diagram of traffic flow provides free flow and traffic wave velocities. Traffic density was calculated by dividing the traffic volume by the traffic speed. Using linear regression, we found the free flow velocity (19.5 mph) as depicted in red, the traffic wave velocity (2.43 mph) as depicted in blue, and the critical density (42.8 vehicles per mile) as depicted in green.

We can also use the recorded vehicle volumes for each day to detect traffic abnormailties as a means of locating interesting traffic patterns. To perform this analysis we constructed template days of the week, seven traffic time series that are the median traffic volume for every 5 minute interval. We then calculated the correlation between the weekday template and the day of interest for each day in our data set. A plot of each day's correlation, as shown in Figure **??**, outlines the variablity in each day's traffic patterns. An apt example of abnormal driving is the seventh Thursday of the data set, which corresponds to Thanksgiving. The 2013 Thanksgiving traffic was abnormally low for a Thursday. Similarly, the 10th and 20th Wednesdays of the data set exhibit similar patterns of minimal traffic..

We can directly compare the low traffic seen on the 10th Wednesday (December 18, 2013), a typical Wednesday like October 16, 2013 and Thanksgiving. As seen in Figure , the traffic pattern exhibited by December 18, 2013 is very similar to that of Thanksgiving and not similar to a typical Wednesday.

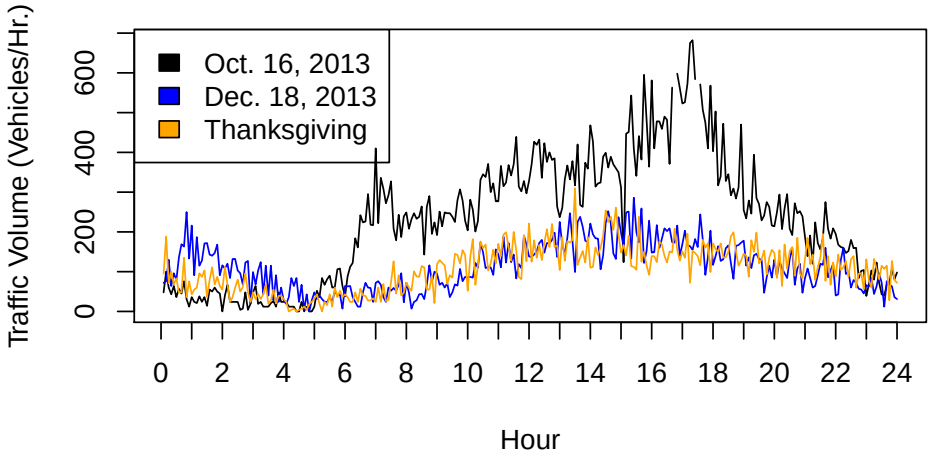

Figure 5: The traffic from December 18, 2013 is similar to Thanksgiving holiday traffic.

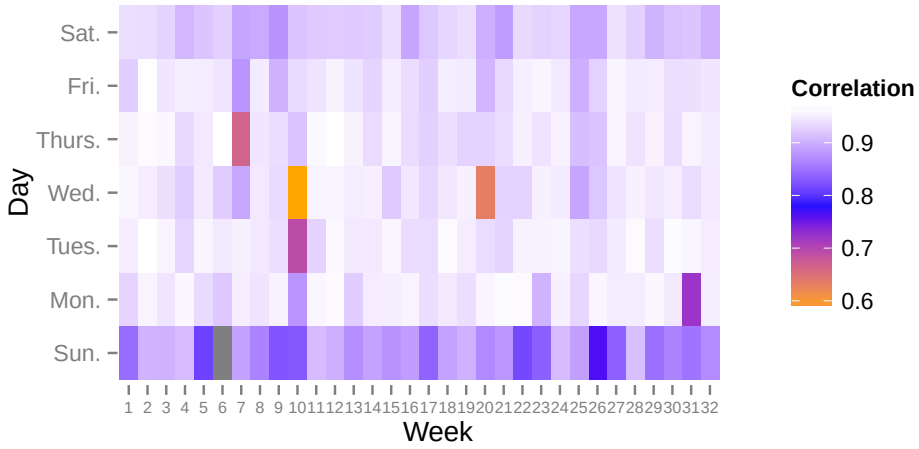

Figure 4: Correlation analysis shows holidays, data collection errors, and small-scale traffic patterns. In this color scale, white indicates high correlation, purple indicates moderate correlation, and orange indicates low correlation. Some days of interest include the seventh Thursday, which corresponds with Thanksgiving, the 10th Tuesday and Wednesday, and the 20th Wednesday.

Bayesian Analysis

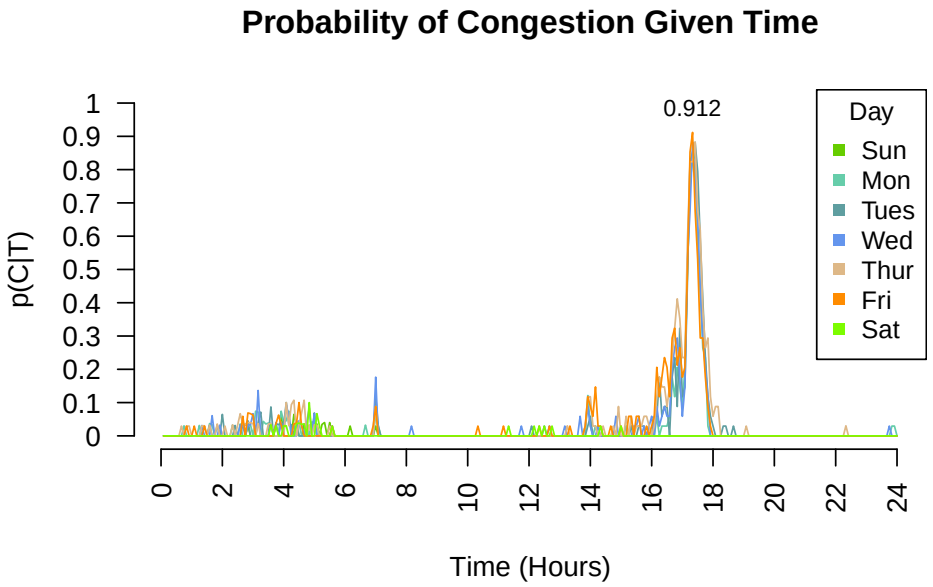

Figure 6: Probability of observing congestion based on specific times throughout the day (represented as p(C|T)). All days are represented as separate lines. A maximum probability of 91.2% is shown on the graph and occurs at 5:15pm on Friday. Most weekdays have the highest probability of congestion between 5:00pm and 5:25pm, or during evening rush hour.

In order to determine how the probability of congestion relates to the time of day we adapted Bayes' Theorum for use with the data provided. Because the traffic on the weekend is not as intense as the traffic during the weekdays, the decision was made to evaluate each day independently of one another so as not to

induce any sort of bias into the results. Congestion was determined simply by using the critical density of the intersection, identified as 42.8 Vehicles per Mile. Any situation where the density is equal to or greater than this measure is determined to be 'congested.' Any situation below this measure is simply 'not congested.'

This is then sorted for each time step, and a proportion is generated about how many times (on a specific day of the week) that particular time is considered congested. For example, this means that if 2 out of the 10 observations at 2:10am on Wednesdays is considered to be congested, equal or exceeding the critical density, the proportion is calculated to be 0.2. This is then multiplied by the probability of congestion at any time amongst all the observations, and is then divided by the probability of randomly selecting that time from the dataset. The results for each day are shown in **??**.

Table 2: Selected results from Bayesian analysis of traffic data. These times represent the highest probability of observing traffic congestion. Saturday and Sunday were omitted from the table due to the fact that their relative probabilities were approximately zero.

Time	**Mon**	**Tues**	**Wed**	**Thur**	**Fri**
17:05	0.500	0.471	0.529	0.588	0.500
17:10	0.765	0.824	0.677	0.824	0.853
17:15	0.824	0.853	0.882	0.824	0.912
17:20	0.853	0.882	0.765	0.882	0.677
17:25	0.588	0.794	0.647	0.677	0.529

Furthermore, each weekday has a particularly high probability of congestion between 5:00pm in the afternoon and 5:30pm. The results of the Bayesian analysis are shown in **??** for increased clarity. Interestingly enough, this is also when the road typically has the highest vehicular flow or volume. Because the area directly north of the intersection is mainly residential, it is hard to understand what is causing all of the volume and congestion.

We could speculate that it is being used to circumvent other possibly congested roadways, however we lack the ability to determine that because we do not have the data.

Weather Analysis

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Recommendations

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Cited Literature

Bibliography

[1] Transportation Research Board of the National Academies, *Highway Capacity Manual 2010*. 5th edition, 2010.