Linear Algebra Final Report

Skyler and Amber

2023-12-11

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.4
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.4.4     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.0
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter()  masks stats::filter()
## x purrr::flatten() masks jsonlite::flatten()
## x dplyr::lag()     masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```


Abstract

In densely populated urban areas like New York State, traffic congestion is a significant challenge, leading to substantial economic and time losses. The project we choose to focus on looked at the 2019 traffic volume report from New York State Department of Transportation (NYSDOT). Using data reports published by the NYSDOT, we manually inputed the data into R-Studio, creating the "onondaga_data" Data set. Organizing the data allowed us to use formulas predicting future traffic patterns. In reviewing the data it is important to note that it is limited to evaluating patterns from 2000 to 2019, excluding the impact of Covid-19 on present and future traffic patterns. It is important to note that population fluctuation can also effect traffic congestion in both positive or negative ways.

Introduction

New York State, characterized by its dense urban population and bustling streets, faces a perennial challenge of traffic congestion. This issue transcends mere inconvenience, impacting the economy, environment, and quality of life. Traffic jams lead to prolonged travel times, increased fuel consumption, heightened pollution, and contribute to stress and frustration among commuters. Studying traffic patterns show how changes in traffic can cause issues including increasede delays, accidents, and congestion on side roads that were not designed to accomodate extra traffic. Analyzing their congestion allows for these issues to be solved, meaning improved schedules, decreased accidents, and improved traffic flow. This project utilizes linear algebra to the model and analyze the traffic flow in New York State, aiming to understand and predict congested traffic patterns. Evaluating traffic volume and road capacity, allows for optimization, route planning and reduces delays, decreasing the impact on daily schedules ad overall urban mobility.

Model

The core of the project is a linear programming model, chosen for its efficacy in solving optimization problems under specific constraints. This approach is particularly suitable for traffic analysis, where multiple variables, such as road capacity and traffic volume, interact within defined limits. The model aims to predict Annual

Average Daily Traffic (AADT) by incorporating various factors, including road segment data, vehicle mix, and historical traffic patterns. By analyzing these elements, the model seeks to understand how different factors contribute to congestion and identify potential bottlenecks. This predictive capability is crucial for planning and implementing traffic management strategies. ## Onondaga Data

```
##     Station FC County_Order End_Mile_Point Section_Length       Road_Name
## 1  33_0044  4           08           0042           0042              NA
## 2  33_0026  4           08           0248           0206              NA
## 3  33_0136  4           08           0275           0027       E Main St
## 4  33_0137  4           08           0463           0188              NA
## 5  33_0024  4           08           0677           0214              NA
## 6  33_0151 14           08           0892           0215              NA
## 7  33_0082 12           08           1059           0167            NY 5
## 8  33_0196 12           08           1199           0140            NY 5
## 9  33_0197 12           08           1262           0063            NY 5
## 10 33_0198 12           08           1379           0117              NA
## 11 33_0120 12           08           1395           0016              NA
## 12 33_0083 12           08           1514           0119            NY 5
## 13 33_0155 14           08           1674           0160 W Genesee St NY
## 14 33_0941 14           08           1748           0074 W Genesee St NY
## 15 33_0926 14           08           1808           0060 W Genesee St NY
## 16 33_0385 14           08           1868           0060 W Genesee St NY
## 17 33_0927 14           08           1889           0021 W Genesee St NY
## 18 33_0389 14           08           1904           0015 W Genesee St NY
## 19 33_0390 14           08           1915           0011        James St
## 20 33_0946 14           08           1931           0016      Erie Blvd E
## 21 33_0948 14           08           2064           0133      Erie Blvd E
## 22 33_0386 14           08           2265           0201              NA
## 23 33_0139 14           08           2342           0077      Erie Blvd E
## 24 33_0152 14           08           2451           0109              NA
## 25 33_0174 14           08           2484           0033    E Genesee St
## 26 33_0175 14           08           2565           0081    E Genesee St
## 27 33_0106 14           08           2708           0143              NA
## 28 33_0109 14           08           2719           0011              NA
## 29 33_0096 14           08           2763           0044              NA
## 30 33_0177 14           08           2771           0008              NA
## 31 33_0178 14           08           2901           0139              NA
## 32 33_0187 14           08           3178           0268    E Genesee St
## 33 33_0045  4           08           3262           0084 Genesee TPKE NY
##         Beginning_Desccription               End_Description
## 1          Cayuga/Onon Co Line                E Brutus St Rd
## 2               E Brutus St Rd               RT 317 Elbridge
## 3              RT 317 Elbridge                    Crosset Rd
## 4                   Crosset Rd                    Halfway Rd
## 5                   Halfway Rd       RT 321 Jct Bennets Cor
## 6        RT 321 JCT Bennets Cor                       RT 174
## 7                       RT 174             Newport Rd Under
## 8             Newport Rd Under                    Bennett Rd
## 9                   Bennett Rd            Hinsdale Rd Under
## 10           Hinsdale Rd Under                        RT 173
## 11                      RT 173                    ACC RT 695
## 12                  ACC RT 695          RT 930W W Genesee St
## 13        RT 930W W Genesee St        Solvay Vl/Syracuse CL
## 14       Solvay VL/Syracuse CL                  Erie Blvd W
```

```
## 15                  Erie Blvd W                  N Geddes St
## 16                  N Geddes St                 N West St Sb
## 17                 N West St Sb                N Franklin St
## 18                N Franklin St                  N Salina St
## 19                  N Salina St         James St/Oswego Blvd
## 20         James St/Oswego Blvd               US 11 State St
## 21               US 11 State St                    Teall Ave
## 22                    Teall Ave                       NY 635
## 23                       NY 635            RT 930P Bridge St
## 24            RT 930P Bridge St     Start NY 5/NY 92 Overlap
## 25     Start NY 5/NY 92 Overlap                 RT I481 Over
## 26                 RT I481 Over                End 5/92 OLAP
## 27                End 5/92 Olap Town of Manlius Village of F
## 28 Town of Manlius Village of F                Highbridge Rd
## 29                Highbridge Rd              Salt Springs Rd
## 30              Salt Springs Rd                       RT 257
## 31                       RT 257                    Duguid Rd
## 32                    Duguid Rd               RT 290 Mycenae
## 33               RT 290 Mycenae             Onon/Mad Co Line
##    Percent_Trucks_2019_Estimate AADT_2019_Estimate AADT_2019 AADT_2018
## 1                           6.1              10254     10254        NA
## 2                           6.7              11830        NA        NA
## 3                           4.9              13347     13347        NA
## 4                           5.1              12552        NA        NA
## 5                           6.4              10604     10604        NA
## 6                          10.1              17172     17172     17503
## 7                           6.1              15997     15997        NA
## 8                          10.9              35388        NA        NA
## 9                           7.5              30782        NA        NA
## 10                          5.5              49723        NA        NA
## 11                          6.1              39615        NA        NA
## 12                          4.4              19016        NA        NA
## 13                          1.7              15422        NA     15427
## 14                          1.2              15786     15445        NA
## 15                            2              15445     15445        NA
## 16                          2.5              11128        NA        NA
## 17                          4.7              11502        NA        NA
## 18                          1.7              13001     13001        NA
## 19                          2.1              14759        NA     14761
## 20                          2.1               6239        NA      6240
## 21                          1.9              11605        NA     11607
## 22                          1.9              17201        NA        NA
## 23                          4.7              20915     20915        NA
## 24                          2.6              17672        NA        NA
## 25                          2.9              44808        NA        NA
## 26                          4.7              49907        NA        NA
## 27                            4              23166        NA        NA
## 28                          4.7              22698        NA        NA
## 29                          5.6              21309        NA        NA
## 30                          2.7              15499        NA        NA
## 31                          2.8               8751        NA      8752
## 32                          4.2               6656        NA      6657
## 33                          4.7              12763        NA     12749
##    AADT_2017 AADT_2016 AADT_2015 AADT_2014 AADT_2013 AADT_2012 AADT_2011
```

```
## 1         NA     10857        NA        NA      9615        NA        NA
## 2      11805        NA        NA        NA        NA        NA     12698
## 3         NA     13748        NA        NA     13475        NA        NA
## 4      12512     12512        NA        NA     11275        NA        NA
## 5         NA     11392        NA        NA     10502        NA        NA
## 6         NA     17172     16717     15101        NA        NA        NA
## 7         NA     15997        NA        NA        NA        NA        NA
## 8         NA        NA        NA        NA        NA        NA        NA
## 9         NA        NA        NA        NA        NA        NA     27711
## 10        NA        NA        NA        NA     44762        NA        NA
## 11        NA     37145        NA        NA     37145        NA        NA
## 12     18018        NA        NA     18018        NA        NA     17623
## 13     15427        NA        NA        NA        NA        NA        NA
## 14     15791        NA        NA        NA        NA        NA        NA
## 15        NA        NA        NA        NA        NA        NA        NA
## 16     11131        NA        NA        NA        NA        NA        NA
## 17     11506        NA        NA        NA        NA        NA        NA
## 18        NA     10483        NA        NA        NA        NA        NA
## 19        NA        NA        NA        NA        NA        NA     13452
## 20        NA        NA        NA        NA        NA        NA        NA
## 21        NA        NA        NA        NA        NA        NA        NA
## 22        NA     17209        NA        NA        NA        NA        NA
## 23        NA        NA     21427     21355     21452        NA        NA
## 24        NA     17680        NA        NA     19101        NA        NA
## 25        NA        NA        NA        NA        NA        NA        NA
## 26        NA     49931        NA        NA        NA        NA        NA
## 27        NA        NA        NA        NA        NA        NA        NA
## 28        NA        NA     22712        NA        NA        NA        NA
## 29        NA     21319        NA        NA        NA        NA        NA
## 30     15504        NA        NA        NA        NA        NA     15890
## 31        NA        NA        NA      8875        NA        NA      9018
## 32        NA        NA      7011        NA        NA        NA        NA
## 33        NA        NA     11771        NA        NA        NA        NA
##    AADT_2010 AADT_2009 AADT_2008 AADT_2007 AADT_2006 AADT_2005 AADT_2004
## 1      10495        NA        NA        NA        NA        NA        NA
## 2      14713        NA        NA        NA     12677        NA        NA
## 3      13475        NA        NA        NA        NA        NA        NA
## 4      12083        NA        NA        NA     11925        NA        NA
## 5      12748        NA        NA        NA        NA        NA        NA
## 6         NA        NA        NA        NA        NA        NA        NA
## 7      16480        NA     13432        NA        NA        NA     16480
## 8      24076        NA        NA     31234     22534        NA        NA
## 9         NA     27711        NA        NA        NA        NA     22524
## 10     28708     44762        NA        NA        NA        NA        NA
## 11     31033        NA        NA        NA        NA        NA     39602
## 12     14778        NA     14778        NA        NA     17226        NA
## 13        NA        NA        NA        NA     21800     19759        NA
## 14        NA        NA        NA        NA        NA        NA        NA
## 15        NA        NA        NA        NA        NA        NA        NA
## 16      9978        NA        NA      9158        NA        NA        NA
## 17        NA        NA        NA        NA        NA        NA        NA
## 18        NA        NA        NA      3181        NA        NA        NA
## 19        NA        NA        NA     13067        NA        NA        NA
## 20        NA        NA        NA        NA        NA        NA        NA
```

```
## 21        NA        NA        NA        NA        NA        NA        NA
## 22        NA        NA        NA        NA     19457        NA        NA
## 23        NA        NA        NA        NA        NA        NA        NA
## 24        NA        NA        NA        NA     26579     21557        NA
## 25        NA     44879        NA        NA        NA     34491        NA
## 26        NA        NA        NA        NA        NA        NA        NA
## 27        NA        NA     23206        NA        NA     34186        NA
## 28        NA        NA        NA        NA        NA        NA     28818
## 29     21238        NA        NA     28783        NA        NA     22133
## 30        NA        NA        NA     15615        NA        NA     16419
## 31        NA        NA     10935        NA        NA        NA        NA
## 32        NA      5973        NA        NA      6208        NA        NA
## 33        NA     10116        NA        NA        NA        NA        NA
##    AADT_2003 AADT_2002 AADT_2001 AADT_2000
## 1         NA        NA        NA     10495
## 2         NA        NA        NA        NA
## 3         NA        NA        NA     14713
## 4         NA        NA        NA        NA
## 5         NA        NA        NA        NA
## 6         NA        NA        NA        NA
## 7         NA        NA     14566        NA
## 8      24076        NA        NA     19691
## 9         NA        NA     19004        NA
## 10     35885        NA        NA     28708
## 11        NA        NA        NA     31033
## 12        NA        NA        NA        NA
## 13        NA     14623        NA        NA
## 14        NA        NA        NA        NA
## 15        NA        NA        NA        NA
## 16        NA        NA        NA        NA
## 17        NA        NA        NA        NA
## 18        NA        NA        NA        NA
## 19        NA        NA        NA        NA
## 20        NA        NA        NA        NA
## 21        NA        NA        NA        NA
## 22     21214        NA        NA     20520
## 23        NA        NA        NA        NA
## 24        NA        NA        NA        NA
## 25        NA     34491        NA        NA
## 26     53587        NA        NA        NA
## 27        NA        NA        NA     19691
## 28        NA        NA     27056        NA
## 29        NA        NA        NA        NA
## 30        NA        NA        NA        NA
## 31        NA        NA        NA        NA
## 32        NA        NA        NA        NA
## 33     11483        NA        NA        NA
```

The code above creates the data set regarding the data from the NYSDOT. Note that there are a lot of NA values for AADT. The NAs mean specifc years and roads were initally excludedfrom the dataset.

Population Data

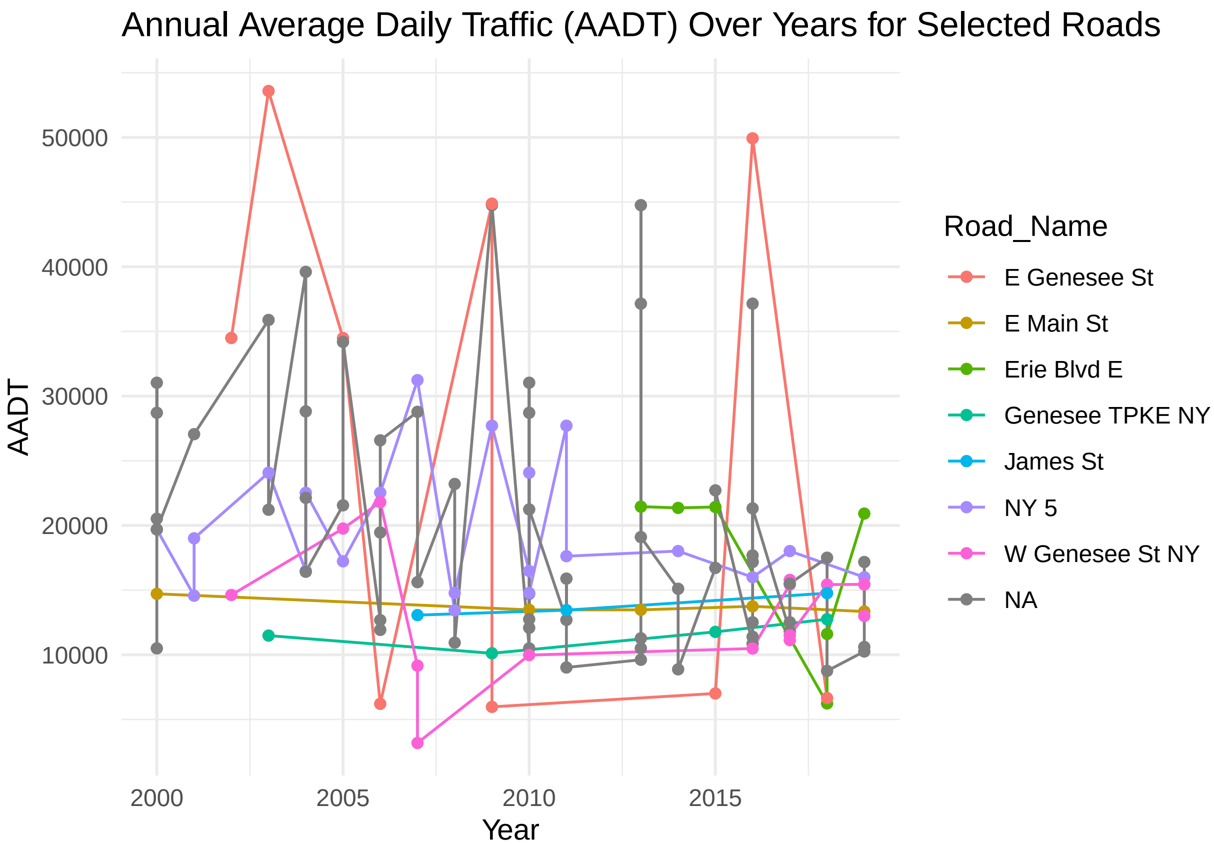
```
##    Year Population
## 1  2000     458336
```

```
## 2  2001      458576
## 3  2002      459484
## 4  2003      460961
## 5  2004      461412
## 6  2005      460910
## 7  2006      460925
## 8  2007      461287
## 9  2008      463427
## 10 2009      465633
## 11 2010      467549
## 12 2011      467679
## 13 2012      467138
## 14 2013      468302
## 15 2014      467472
## 16 2015      466320
## 17 2016      464139
## 18 2017      461843
## 19 2018      461890
## 20 2019      460870
## 21 2020      459214
```

This data set represents minor population data for us to add to our analysis. This population data set allows us to see if the traffic going down is due to popualtion decline or another outside factor besides traffic and population.

Line Graph of Annual Average Daily Traffic (AADT) Over Years for Selected Roads

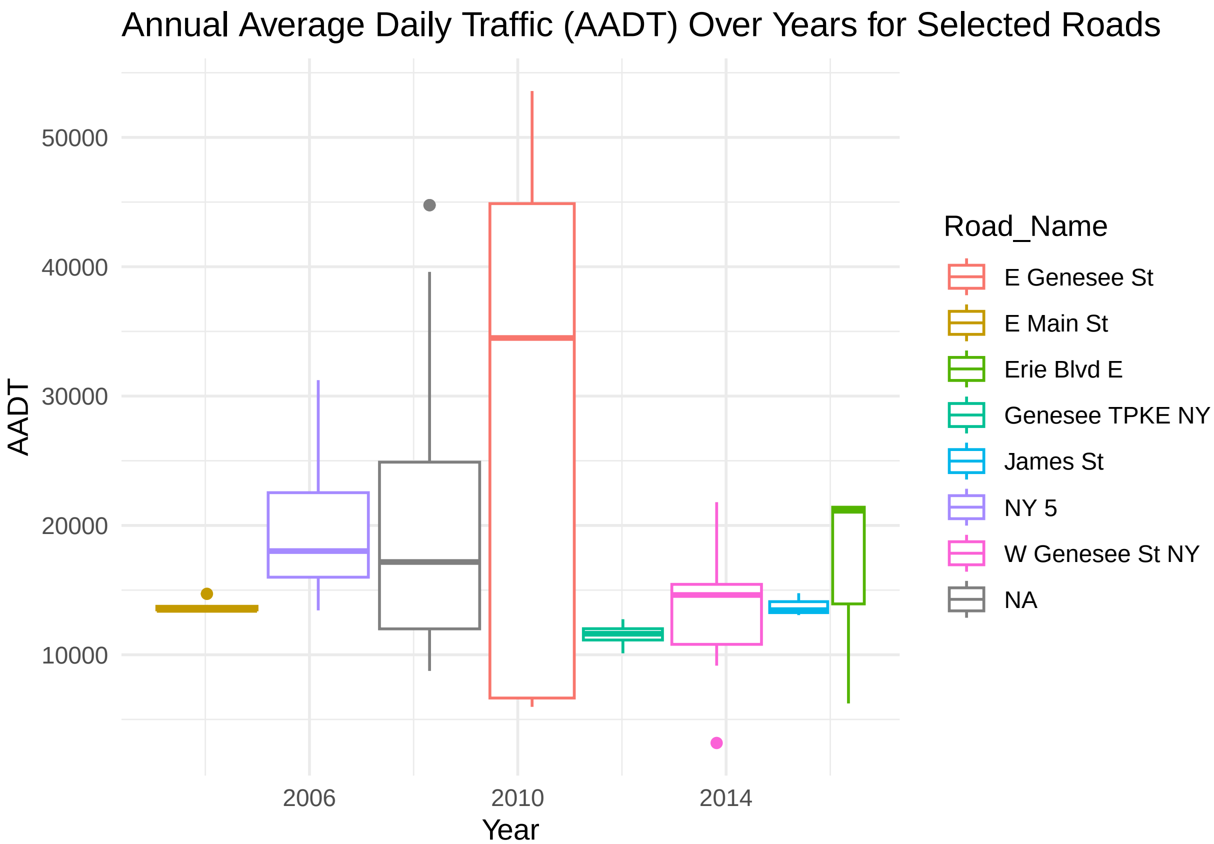
```
## Warning: There was 1 warning in `mutate()`.
## i In argument: `Year = as.numeric(gsub("AADT_", "", Year))`.
## Caused by warning:
## ! NAs introduced by coercion

## Warning: Removed 33 rows containing missing values (`geom_line()`).

## Warning: Removed 33 rows containing missing values (`geom_point()`).
```



This graph presents the Annual Average Daily Traffic (AADT) over several years for selected roads. Each colored line represents a different road, with fluctuations indicating the traffic volume changes over time. Notable observations include the significant variability in AADT across different roads; some show spikes in traffic at certain times, possibly due to construction, rerouting, or economic factors affecting traffic patterns. For instance, E Genesee St and E Main St show particularly high peaks, suggesting episodes of high traffic volume. Erie Blvd E, Genesee TPKE NY, James St, and NY 5 demonstrate more moderate fluctuations. W Genesee St NY shows a general increase in AADT over the years. The "NA" category may indicate missing data or unclassified road segments. Overall, the graph underscores the dynamic nature of road usage and the need to understand factors influencing traffic changes over time.

Box Plot Annual Average Daily Traffic (AADT) Over Years for Selected Roads

```
## Warning: Removed 33 rows containing missing values (`stat_boxplot()`).
```



This box-plot graph illustrates the spread and central trends of Annual Average Daily Traffic (AADT) for selected roads over a span of years. Each box denotes the middle 50% of data for that road, with the median marked by the horizontal line. Extended lines or "whiskers" show the typical range, while dots indicate outlier years with unusually high or low traffic volumes. Variations among the roads are evident, with some roads showing a wide range of AADT and others more consistent traffic flow.

Predictions

```
## Warning: There was 1 warning in `mutate()`.
## i In argument: `Year = as.numeric(str_replace(Year, "AADT_", ""))`.
## Caused by warning:
## ! NAs introduced by coercion

## Warning in predict.lm(model, newdata = future_data): prediction from
## rank-deficient fit; attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(model, newdata = future_data): prediction from
## rank-deficient fit; attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(model, newdata = future_data): prediction from
## rank-deficient fit; attr(*, "non-estim") has doubtful cases

## Warning in predict.lm(model, newdata = future_data): prediction from
## rank-deficient fit; attr(*, "non-estim") has doubtful cases

## $`33_0024`
##   Year AADT_Prediction
## 1 2020       10295.467
## 2 2021       10110.733
```

```
## 3 2022        9926.000
## 4 2023        9741.267
## 5 2024        9556.533
##
## $`33_0026`
##   Year AADT_Prediction
## 1 2018        12152.67
## 2 2019        12035.44
## 3 2020        11918.22
## 4 2021        11800.99
## 5 2022        11683.77
##
## $`33_0044`
##   Year AADT_Prediction
## 1 2020        10287.15
## 2 2021        10280.48
## 3 2022        10273.80
## 4 2023        10267.13
## 5 2024        10260.46
##
## $`33_0045`
##   Year AADT_Prediction
## 1 2019        12271.25
## 2 2020        12366.93
## 3 2021        12462.61
## 4 2022        12558.29
## 5 2023        12653.97
##
## $`33_0082`
##   Year AADT_Prediction
## 1 2020        16105.95
## 2 2021        16165.36
## 3 2022        16224.78
## 4 2023        16284.19
## 5 2024        16343.61
##
## $`33_0083`
##   Year AADT_Prediction
## 1 2018        18036.81
## 2 2019        18217.73
## 3 2020        18398.66
## 4 2021        18579.59
## 5 2022        18760.51
##
## $`33_0096`
##   Year AADT_Prediction
## 1 2017        21288.96
## 2 2018        21020.67
## 3 2019        20752.37
## 4 2020        20484.08
## 5 2021        20215.78
##
## $`33_0106`
##   Year AADT_Prediction
```

```
## 1 2009        28916.00
## 2 2010        29606.36
## 3 2011        30296.71
## 4 2012        30987.07
## 5 2013        31677.43
##
## $`33_0109`
##   Year AADT_Prediction
## 1 2016        22682.56
## 2 2017        22306.20
## 3 2018        21929.83
## 4 2019        21553.46
## 5 2020        21177.09
##
## $`33_0120`
##   Year AADT_Prediction
## 1 2017        36796.25
## 2 2018        36987.27
## 3 2019        37178.30
## 4 2020        37369.33
## 5 2021        37560.36
##
## $`33_0136`
##   Year AADT_Prediction
## 1 2020        13195.80
## 2 2021        13129.63
## 3 2022        13063.46
## 4 2023        12997.30
## 5 2024        12931.13
##
## $`33_0137`
##   Year AADT_Prediction
## 1 2018        12340.31
## 2 2019        12390.12
## 3 2020        12439.92
## 4 2021        12489.73
## 5 2022        12539.53
##
## $`33_0139`
##   Year AADT_Prediction
## 1 2020        20855.46
## 2 2021        20764.55
## 3 2022        20673.65
## 4 2023        20582.75
## 5 2024        20491.84
##
## $`33_0151`
##   Year AADT_Prediction
## 1 2020        18017.49
## 2 2021        18374.29
## 3 2022        18731.09
## 4 2023        19087.90
## 5 2024        19444.70
##
```

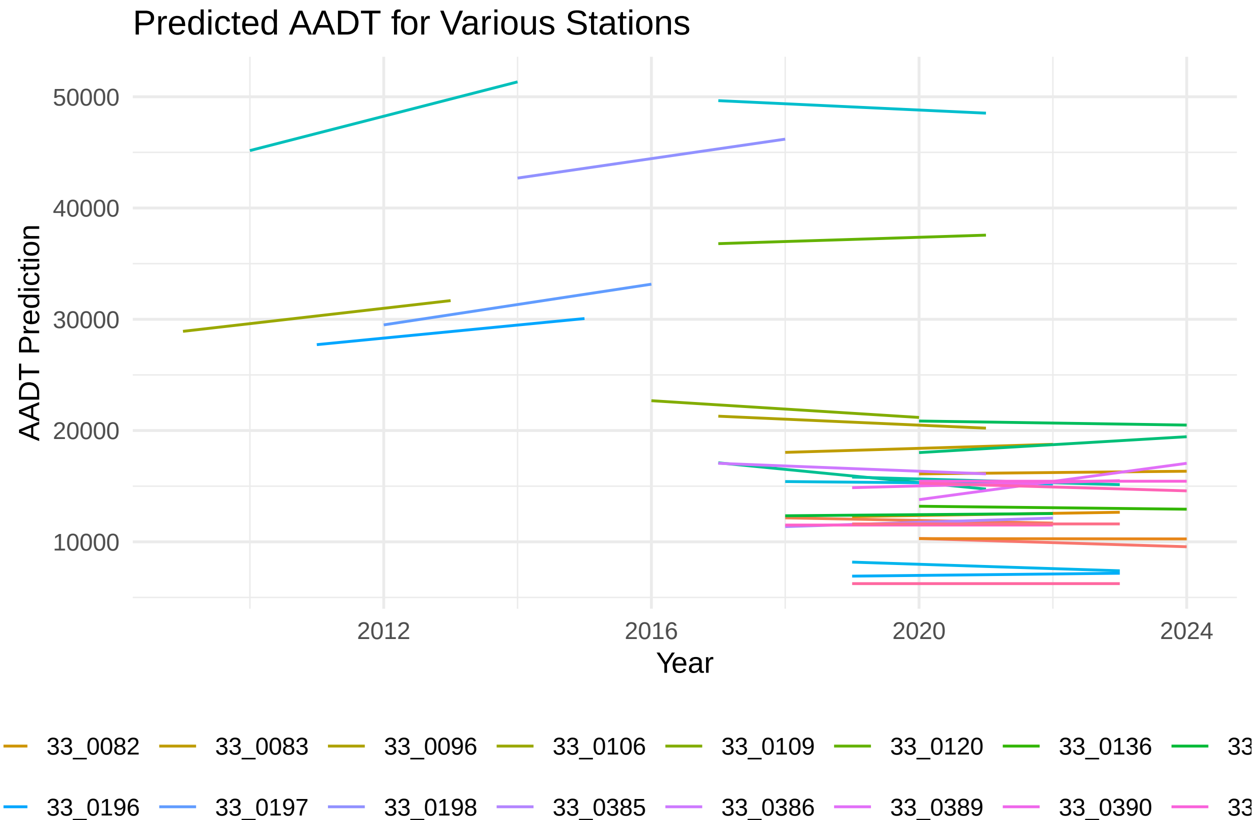
```
## $`33_0152`
##   Year AADT_Prediction
## 1 2017        17101.04
## 2 2018        16511.30
## 3 2019        15921.55
## 4 2020        15331.81
## 5 2021        14742.06
##
## $`33_0155`
##   Year AADT_Prediction
## 1 2019        15816.31
## 2 2020        15647.07
## 3 2021        15477.83
## 4 2022        15308.59
## 5 2023        15139.34
##
## $`33_0174`
##   Year AADT_Prediction
## 1 2010        45159.76
## 2 2011        46703.92
## 3 2012        48248.08
## 4 2013        49792.24
## 5 2014        51336.41
##
## $`33_0175`
##   Year AADT_Prediction
## 1 2017        49649.77
## 2 2018        49368.54
## 3 2019        49087.31
## 4 2020        48806.08
## 5 2021        48524.85
##
## $`33_0177`
##   Year AADT_Prediction
## 1 2018        15414.33
## 2 2019        15360.67
## 3 2020        15307.02
## 4 2021        15253.36
## 5 2022        15199.70
##
## $`33_0178`
##   Year AADT_Prediction
## 1 2019        8175.708
## 2 2020        7980.621
## 3 2021        7785.534
## 4 2022        7590.447
## 5 2023        7395.361
##
## $`33_0187`
##   Year AADT_Prediction
## 1 2019        6913.983
## 2 2020        6978.517
## 3 2021        7043.050
## 4 2022        7107.583
```

```
## 5 2023        7172.117
##
## $`33_0196`
##   Year AADT_Prediction
## 1 2011        27720.61
## 2 2012        28306.54
## 3 2013        28892.47
## 4 2014        29478.40
## 5 2015        30064.33
##
## $`33_0197`
##   Year AADT_Prediction
## 1 2012        29495.66
## 2 2013        30410.12
## 3 2014        31324.58
## 4 2015        32239.04
## 5 2016        33153.51
##
## $`33_0198`
##   Year AADT_Prediction
## 1 2014        42688.40
## 2 2015        43563.18
## 3 2016        44437.95
## 4 2017        45312.72
## 5 2018        46187.49
##
## $`33_0385`
##   Year AADT_Prediction
## 1 2018        11365.84
## 2 2019        11557.36
## 3 2020        11748.89
## 4 2021        11940.41
## 5 2022        12131.94
##
## $`33_0386`
##   Year AADT_Prediction
## 1 2017        17054.76
## 2 2018        16817.99
## 3 2019        16581.22
## 4 2020        16344.46
## 5 2021        16107.69
##
## $`33_0389`
##   Year AADT_Prediction
## 1 2020        13788.64
## 2 2021        14605.36
## 3 2022        15422.08
## 4 2023        16238.79
## 5 2024        17055.51
##
## $`33_0390`
##   Year AADT_Prediction
## 1 2019        14864.08
## 2 2020        15021.81
```

```
## 3 2021        15179.53
## 4 2022        15337.26
## 5 2023        15494.98
##
## $`33_0926`
##   Year AADT_Prediction
## 1 2020           15445
## 2 2021           15445
## 3 2022           15445
## 4 2023           15445
## 5 2024           15445
##
## $`33_0927`
##   Year AADT_Prediction
## 1 2018           11506
## 2 2019           11506
## 3 2020           11506
## 4 2021           11506
## 5 2022           11506
##
## $`33_0941`
##   Year AADT_Prediction
## 1 2020           15272
## 2 2021           15099
## 3 2022           14926
## 4 2023           14753
## 5 2024           14580
##
## $`33_0946`
##   Year AADT_Prediction
## 1 2019            6240
## 2 2020            6240
## 3 2021            6240
## 4 2022            6240
## 5 2023            6240
##
## $`33_0948`
##   Year AADT_Prediction
## 1 2019           11607
## 2 2020           11607
## 3 2021           11607
## 4 2022           11607
## 5 2023           11607
```

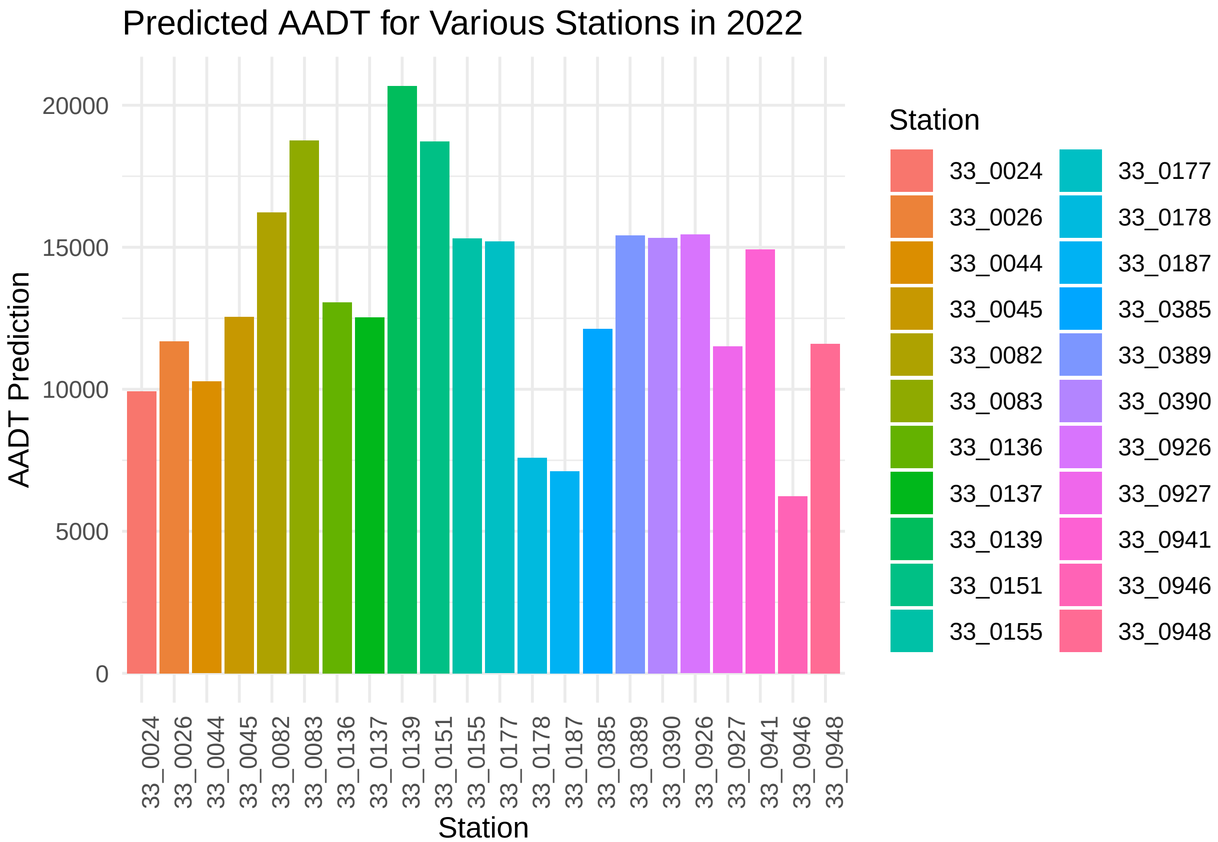
The predictions list above is created by defining a function that constructs a linear model to relate traffic volume (AADT) to the year. Using this model, the function predicts AADT for the next five years. The script applies this prediction function to data from each traffic station and compiles the results into a list. Finally, it prints out these predictions, providing a year-by-year forecast of traffic volumes for each station.

Predicted AADT for Various Station



This line graph depicts the predicted Annual Average Daily Traffic (AADT) for various traffic monitoring stations over time. Each line represents a different station, with the AADT values on the vertical axis and time on the horizontal axis. The graph shows that some stations are expected to experience an increase in AADT, while others remain relatively stable or show minimal change. The predictions extend from historical data out to the year 2024, allowing for traffic trend analysis and planning for future infrastructure needs.

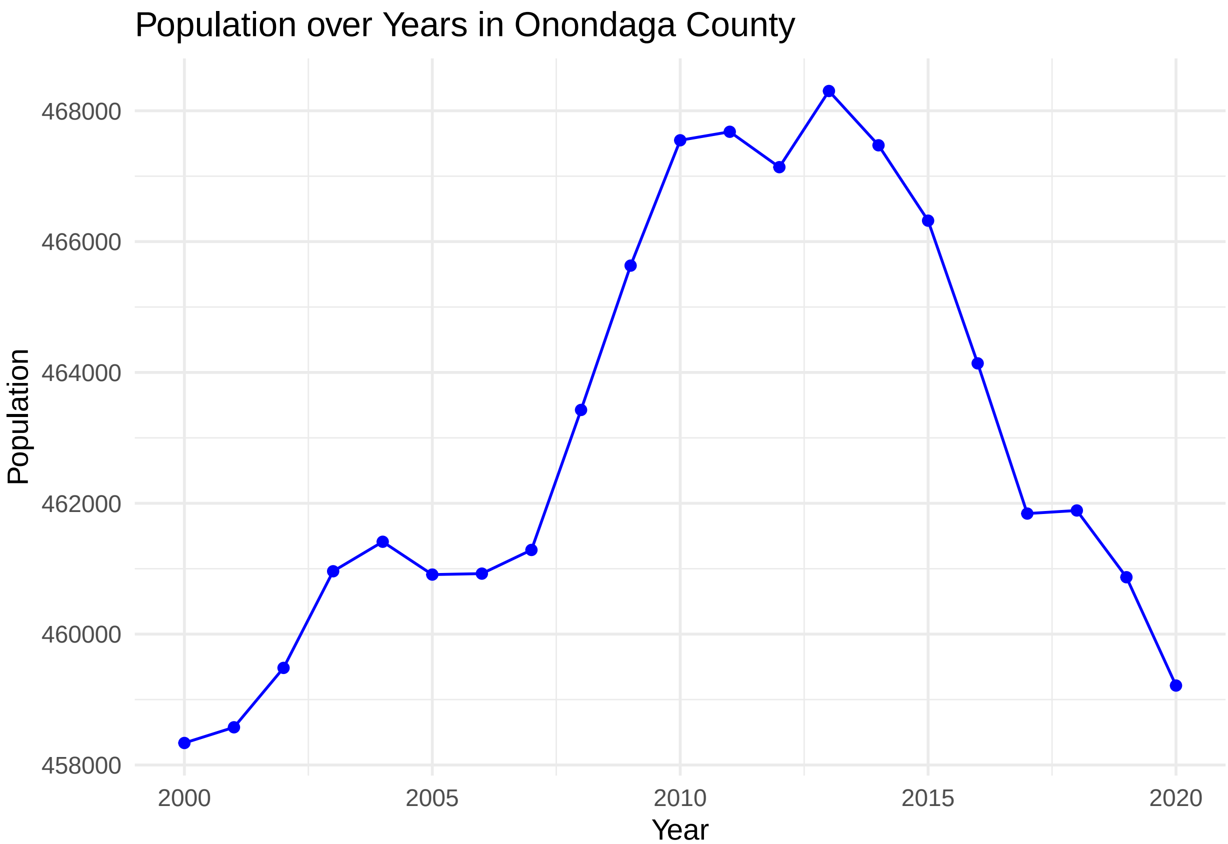
Predicted AADT for Various Stations in 2022



This bar chart displays the predicted Annual Average Daily Traffic (AADT) for various traffic monitoring stations in the year 2022. Each bar represents a different station, color-coded for identification, with the height of the bar indicating the predicted traffic volume. The chart clearly shows the variation in predicted AADT across the stations, with some stations anticipating significantly higher traffic volumes than others. This visualization aids in comparing the expected congestion levels across different locations within a given year, providing a snapshot of traffic distribution for planning and management purposes.

Population over Years in Onondaga County

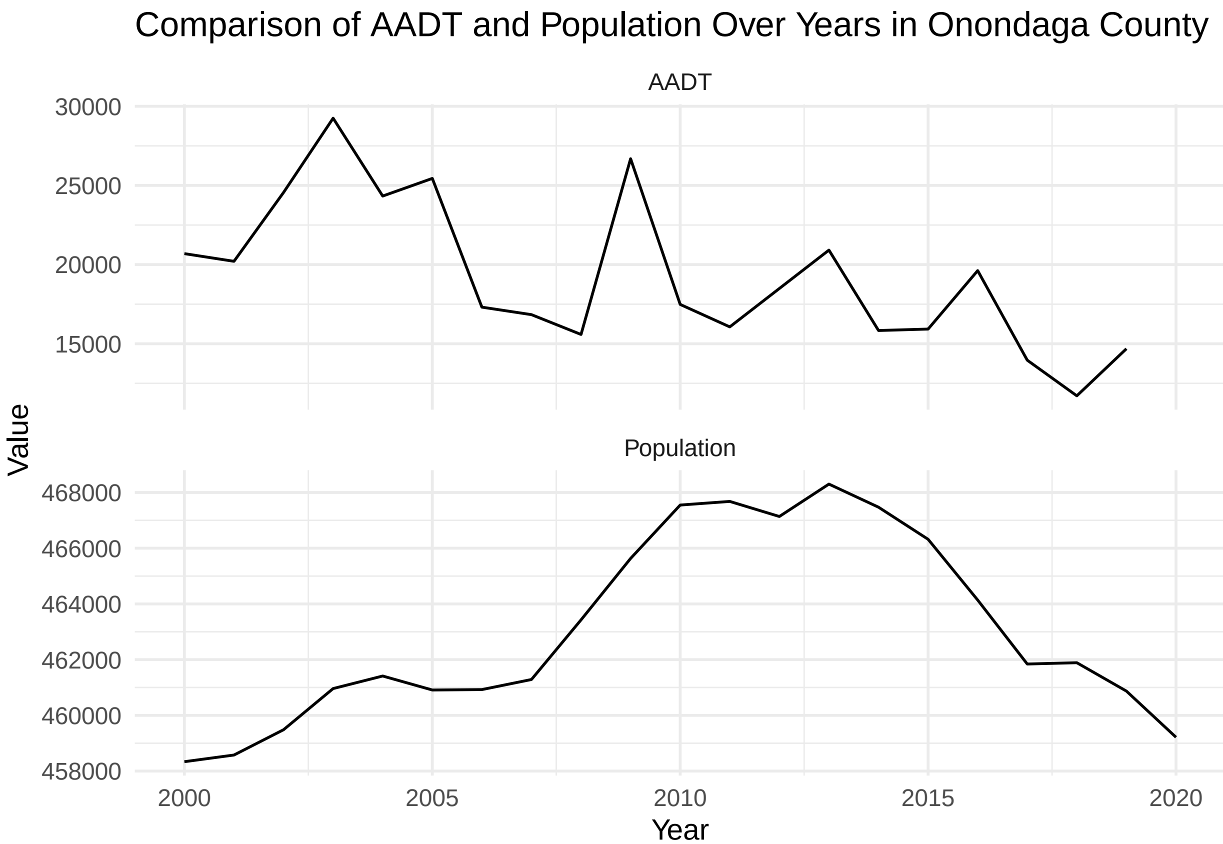
```
## Warning: There was 1 warning in `mutate()`.
## i In argument: `Year = as.numeric(sub("AADT_", "", Year))`.
## Caused by warning:
## ! NAs introduced by coercion
```



This line graph tracks the population size in Onondaga County over several years. The population grew steadily until reaching a peak, after which it shows a sharp decline. The data points are connected by a line, emphasizing the trend over time. The specific years of population change are not labeled, but the trend is clear from the plotted line. The reasons behind the growth and subsequent decline are not provided by the graph and would require further context to fully understand.

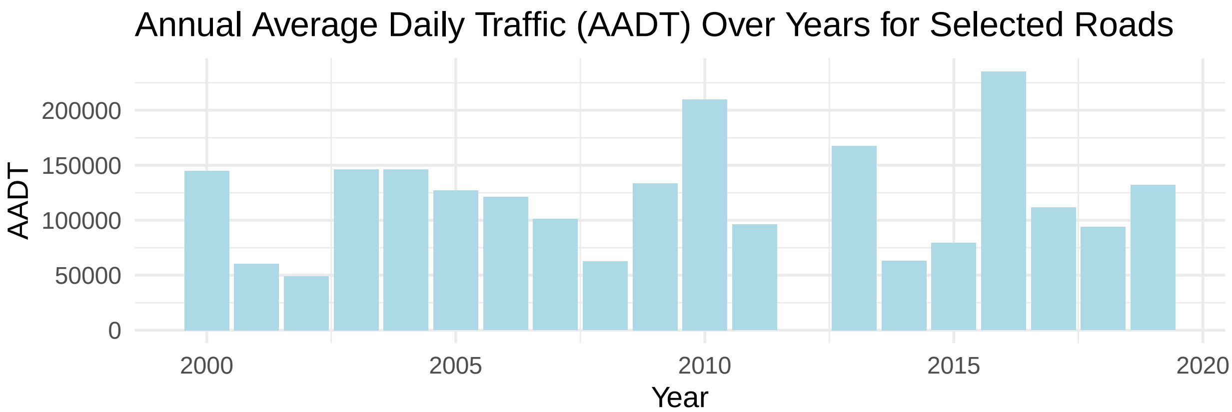
Comparison of AADT and Population Over Years in Onondaga County

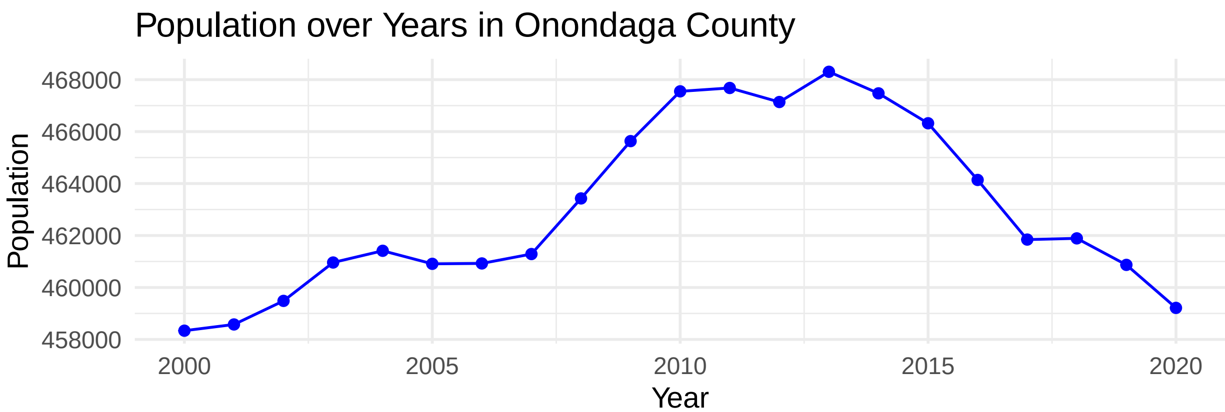
```
## Warning: There was 1 warning in `mutate()`.
## i In argument: `Year = as.numeric(sub("AADT_", "", Year))`.
## Caused by warning:
## ! NAs introduced by coercion
```



This graph provides a side-by-side comparison of the Annual Average Daily Traffic (AADT) and population trends over several years in Onondaga County. The top panel shows fluctuations in AADT, with no clear long-term trend, while the bottom panel shows the population trend, which increases until about 2010 and then declines sharply. This visual comparison might be used to analyze the relationship between population dynamics and traffic volume within the county.

```
##
## Attaching package: 'cowplot'

## The following object is masked from 'package:lubridate':
##
##     stamp
```





The relationship between the two graphs above appears to be an initial correlation where both the population of Onondaga County and the Annual Average Daily Traffic (AADT) increase until around 2010. After this point, the population begins to decline sharply, while the AADT shows some volatility but not as pronounced a decrease. This could imply that while the population might influence traffic volumes, other factors are also at play in determining AADT. For instance, even as the population decreases, the AADT does not follow the same steep downward trend, suggesting that the remaining population might still be contributing to relatively high traffic volumes, or that there could be an increase in through traffic from non-residents.

Solutions to the Model

The solution to our linear model is realized through the application of predictive analytics, specifically through the development of a linear regression analysis in R Studio. This model harnesses historical AADT data to extrapolate future traffic volumes, applying numerical methods to estimate the parameters of the regression equation. The preliminary solutions suggested a declining trend in traffic volumes. However, as the model was iteratively refined to assimilate more complex relationships and additional predictors—such as demographic variables—the emergent patterns became multifaceted. These enhancements to the model unveiled a richer tapestry of traffic flow dynamics, contrasting the initial simplistic downward trend with a set of predictions that capture the intricacies of traffic behavior. The analytical prowess of our model lies in its adaptability, allowing it to incorporate evolving data sets and offer a robust set of predictions that inform on potential future traffic scenarios. This adaptability is crucial, as it empowers the model to serve as a dynamic tool for urban planners and policymakers to anticipate and strategically manage traffic congestion.

Predictions and variable Analysis

The solutions derived from the linear regression model provide a predictive look at traffic patterns, with a particular emphasis on Annual Average Daily Traffic (AADT) as the outcome of interest. The model's predictions, based on historical traffic data, offer insights into future traffic volumes. These forecasts are generated through the model's ability to identify and quantify relationships between the year and traffic counts, while considering the impact of additional variables.

The variable analysis component of the model is critical, as it examines the influence of each predictor on AADT. This analysis showed that not only time (years) but also demographic variables, such as population changes, significantly affect traffic trends. For instance, an increase in population in Onondaga County was mirrored by a rise in AADT, suggesting a direct correlation between the two.

The model's predictions initially indicated a downward trend in AADT, reflecting perhaps a historical moment or an initial incomplete picture of the influencing factors. However, after refining the model to include demographic shifts, the predictions adjusted, revealing a more complex and realistic projection of future AADT. These refined predictions provide a crucial foundation for strategic planning in traffic management and infrastructure development, allowing for a proactive rather than reactive approach.

Overall, the predictive solutions from the linear model demonstrate the importance of continuous variable analysis and model updating. As new data becomes available, the model can be recalibrated to ensure that the predictions remain accurate and relevant, thereby serving as a valuable tool for decision-makers in addressing traffic congestion challenges.

Conclusions and Discussions

The conclusion drawn from our linear regression analysis on traffic data for New York State, specifically focusing on Onondaga County, reveals insightful trends and correlations. The model's initial predictions of a general decrease in Annual Average Daily Traffic (AADT) were nuanced by subsequent refinements that included demographic variables. The enhanced model, reflecting a more complex interplay of factors, suggests that traffic patterns are not merely a function of time but are also significantly influenced by demographic changes.

The inclusion of population data allowed for a richer understanding of the underlying causes of traffic fluctuations. Notably, the model identified a correlation between population growth and increases in AADT, providing empirical evidence to support the intuitive link between urban development and traffic volume. Furthermore, the model highlighted the importance of continuous data analysis, as changing population trends directly impact traffic projections.

The data analysis underscores the necessity for adaptive traffic management strategies that can accommodate dynamic changes within the county. As the model incorporated more variables and refined its predictions, it became evident that a static approach to traffic management is insufficient. Instead, a dynamic, data-driven approach is required to effectively manage and plan for the county's future transportation needs.

In conclusion, the study demonstrates that linear regression models are valuable tools in traffic analysis and urban planning. They provide a means to forecast traffic trends and to adapt to evolving urban landscapes. Our findings advocate for the integration of diverse data sets, including demographic information, to predict traffic volumes accurately. These conclusions are essential for developing informed strategies to alleviate traffic congestion and enhance the efficiency of transportation networks.

References

https://www.dot.ny.gov/divisions/engineering/technical-services/hds-respository/NYSDOT_2019Traffic VolumeReport-Routes.pdf

https://www.mapon.com/us-en/blog/2014/10/20-amazing-facts-about-traffic-and-traffic-jams #:~:text=Traffic%20jams%20result%20in%205.7,American%20homes%20for%20a%20year.

Source Code

The detailed R script, encompassing data preparation, model development, and analysis, will be provided. This script serves not only as a record of the methodology used in this study but also as a resource for further research and application in the field of traffic management and urban planning.