Midterm

Coding in R Language

Vian Tran

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**Data Analysis Report**

The data science team wants to create a predicative model that will predict the number of bikes leaving each station and the number of bikes being returned to each station in the next three days. The following report will provide insight that will help the maintenance teams plan their bike maintenance operations.

**Summary of Data**

The report consists of three datasets containing data that represents stations where users can pick up or return bikes (station), individual bike trips (trip) and data about the weather on a specific day for certain cities (weather). There are 70 unique bike stations spanning across Mountain View, Palo Alto, Redwood City, San Francisco and San Jose, with majority of the stations residing in San Francisco and San Jose, as shown in Figure 1a. The dock count for each station ranged from 11 to 27 with most stations having around 15 bike docks, as shown in Figure 1b.

If we look at the distribution of the users’ start and end stations, the preference of stations remain relatively the same for starting and ending stations. For example, the station at San Francisco Caltrain (Townsend at 4th) remains the top starting and ending station. The start and end stations are ordered in alphabetical order, there are 4 checkpoints that lines up the data including 2nd at Folsom, Franklin at Maple, Ryland Park and Speak at Folsom as shown in Figure 2ab. Furthermore, majority of the users of Bay Area Bike Rental are subscribers indicating they use the services often. The bike rides for each customer ranged from 60 seconds (1 minute) to 17270400 seconds (200 days), with a median of 511 seconds (8.5 minutes). If we loge the duration and display it in a graph as shown in Figure 2d, the graph ranges from loge(duration) of 4 to 16 with much of the bike ride around 6. Most bike rides last for a few minutes but there are outliers that can last for days. This is an area we need to explore when preparing the data for analysis.

Throughout the year of 2014, the mean temperature ranged from 44˚F to 84˚F. The range of fluctuation between the minimum and maximum temperature per city and ultimately the making of the mean temperature can be seen in Figure 3, 4, 5, 6, and 7 a-c for San Francisco, Redwood City, Mountain View, Palo Alto and San Jose, respectively. We see the general trend that fall and winter months, there is a drop in temperature and in the spring and summer months, there is an increase in temperature. The mean visibility ranged from 4 to 20 miles. The range of fluctuation between the minimum and maximum visibility per city can be seen in Figure 3, 4, 5, 6, and 7 d-f. There are a few NAs in max, mean and min visibility variable that should be noted. For the most part, it was relatively visible throughout the year as shown in the mean visibility graph. The mean wind speed ranged from 0 to 19 mph. The range of fluctuation between maximum wind speed per city can be seen in Figure 3, 4, 5, 6, and 7 g-h. There is more fluctuation in the maximum wind speed, but the mean wind speed remained relative stable throughout the year. The max wind speed variable contains wind speed above 50 mph which indicates a strong gale to hurricane force level (over 75 mph) winds. During this time there were no reports of high dangerous winds in those cities in 2014. Therefore, for future analysis, max wind speed above 50 mph were set as NA. The max gust speed also is displayed in Figure 3, 4, 5, 6, and 7 i with a range between 6 and 114 mph. There is quite a bit of NAs in max gust speed, up to 450s NAs and should be noted. The max gust speed changed a lot between cities, some cities it was more stable, while other cities had a lot of fluctuation in the gust speed. The precipitation mostly remained around 0 inches throughout 2014 showcasing it did not rain often in 2014, the max it got was above 3 inches in precipitation in San Francisco, Mountain View and San Jose as shown in Figure 3, 4, 5, 6, and 7 j. There were a few NAs in precipitation variable. Furthermore, the cloud cover ranged between 0 to 8, with 0 being no cloud cover to 8 being high cloud cover as shown in Figure 3, 4, 5, 6 and 7 k. The cloud cover for each city does not seem to have any trend or relationship throughout 2014, it cloud cover was scattered.

**Pre-Processing**

Preparing the datasets for future analysis requires the removal of any duplicate entries in each dataset. For comparability, any date column was change to POSIX using the “lubridate” package. Furthermore, the ZIP codes in the trip dataset were changed to only include USA ZIP codes. This includes codes that start with 0-9 digits and is exactly 5 digits longs, otherwise it was set to NA. Additionally, the T’s entries in the precipitate (inches) variables should be changed to NA as the purpose of the T’s were not explained.

It is necessary to remove any cancelled trips from the dataset before analyzing it as it could skew the results. A trip less than 3 minutes long (180 seconds) was considered cancelled. We can also ensure the trip did not leave the station if the starting and ending station IDs are the same. There was a total of 1082 cancelled trip and the trip IDs can be summarized in the trip\_cancelled CSV file. The cancelled trips were removed from the dataset. Additionally, outliers that are skewing the data should be removed. We are interested in seeing the return of bikes to each station within the next 3 days. Therefore, outliers should be considered as those above 3 days long and should be removed from the dataset. Considering the median duration is around 8.5 minutes, most bike users do not use the bikes for a long time. Therefore, setting the outliers as above 3 days is reasonable and generous. There were 27 outliers that can be summarized in the trip\_outlier CSV file. The outliers were removed from the dataset and the loge(duration) frequencies plot can be seen in Figure 2e.

**Findings**

To create a strong predictive model to predict the number of bikes leaving each station and the number of bikes being returned we need to gather some information from the dataset such as rush hours times, frequently used starting and ending stations during rush hours and weekends, average utilization of bikes for each month and the impact of weather conditions on bike rental patterns that can influence the predictive model.

*Rush Hour and Frequencies*

Isolating for the weekdays and extracting the hours of each day, we can see the frequencies of the highest volume hours also known as weekday rush hours for bike rental. The rush hour during the week is from 7 to 9 am and 4 to 6 pm (16 to 18 hours) as shown in Figure 8. Furthermore, we can determine the top 10 most frequently used start and end stations during the rush hours. The top 10 most frequently used start and end station can be summarized in Table 1 and 2. The start and the end stations remained relatively the same but in different order of top frequencies. The only different station in the start and end is 2nd at South Park and Market at 10th. We can see this general trend in Figure 2 a-b as the popular stations remain relatively the same for the start and end stations. The following can provide helpful insight that can help the maintenance team plan their bike maintenance during times of high customer volume.

*Weekend Frequencies*

We can apply the same concept as above to find the top 10 most frequently used start and end stations during the weekend. The top 10 most frequently used start and end station can be summarized in Table 3 and 4. The start and the end stations remained relatively the same but in different order of top frequencies. The only different station in the start and end is Steuart at Market and Powell at Post (Union Square). We can see this general trend in Figure 2 a-b as the stations remain relatively the same for the start and end stations. The frequently used start and end stations on the weekend do vary from the frequently used stations during rush hour on the weekdays. This can be useful as rush hour bike rent tend to relate to locations near user’s offices, while weekend bike trends tend to relate to recreation bike rental and activities.

*Average Use per Month*

Finding the monthly use of the bikes can provide helpful insight to update the predictive model on the popular and active months. We can find the average utilization per month by dividing total time used by total time available. We can find the total time used for each month by adding up all the bike ride durations for each month. The total time available is the total time in each month, and ensuring the total time available is in the same units as total time used. For example, there are 744 hours in October. The average use per month can be summarized in Table 5. It is common for people to have a higher interest in bike rides in the summer, fall and spring months. There is lower use in bikes in the winter months where it is colder and may be snowing. The visibility also decreases during the cold winter months.

*Weather Conditions*

The data science team assumes that the weather conditions have an impact on the bike rental patterns. Currently, they are unsure whether they should use temperature, weather events, visibility or other weather measurements metrics available. Therefore, a correlation matrix between the trip and weather dataset was created to test the relationship between the number of trips each day and the different weather metric. It was broken down into each city. The different weather metric tested were max/mean/min temperature, max/mean/min visibility, max/mean wind speed, max wind speed and precipitation. Summarized in Table 6, we can see the highest correlation tended to correspond with temperature (weather it was max, mean or min temperature) and visibility (weather it was max, mean or min visibility). Nice weather and user’s ability to see play the biggest role in influencing their decisions to go on bike rides. The visibility and weather can also play a role in the average use per month we see above. However, a metric like precipitation, because it mostly did not rain in 2014, it resulted in 0 inches for most of the data points in the precipitation variable. The correlation matrix would not show a relationship between the two because the y variable (precipitation in inches) was mostly 0s. Realistically, weather it rains or not would influence a user’s decision to go on a bike ride. Therefore, the correlation matrix should be used as a starting point, but you also need to add logic and research into what weather metrics could influence user’s decision to rent a bike. Weather metrics that had a lot of fluctuations and unclear relationships or metrics that were relatively stable throughout the year such as max wind speed and mean wind speed, respectively, it was difficult to establish a strong correlation with those metrics.

**Conclusions**

Our goal is to predict the number of bikes leaving each station and the number of bikes being returned. Ultimately, the model will provide insight that will help the maintenance teams plan their bike maintenance operations. Based on the data gathered and its analysis, important factors and information that need to be considered to create a strong predictive model are the rush hour times and frequently used start and end stations during rush hour times during the weekdays and the weekend. Furthermore, they need to consider the average utilization of bikes for each month and be aware of popular and high-volume months where there is an interest in bike rental. Based on the correlation matrix, weather conditions such as temperature and visibility have an impact on bike rental patterns. A suggestion is to also obtain questionnaire and feedback from customers and their opinions of these matter. For example, would they go biking in the rain or would they prefer if the bikes available at popular stations during the rush hour times to be refilled faster, etc. User input can help create and pinpoint necessary factors to consider when creating a thorough predictive model.

**Appendix**

a.

b.

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**Figure 1: Categorical variable summary of the station dataset including the frequencies of dock counts and cities.**

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**Figure 2: Categorical and numerical summary of the trip dataset including start stations, end stations, subscription type, and loge(duration).** The start and end stations are ordered in alphabetical order, there are 4 checkpoints that lines up the data including 2nd at Folsom, Franklin at Maple, Ryland Park and Speak at Folsom.

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**Figure 3: Weather metrics of San Francisco including temperature, visibility wind speed, gust speed, precipitation and cloud cover.**

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Description automatically generated A graph of precipitation and date

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**Figure 4: Weather metrics of Redwood City including temperature, visibility wind speed, gust speed, precipitation and cloud cover.**

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**Figure 5: Weather metrics of Mountain View including temperature, visibility wind speed, gust speed, precipitation and cloud cover.**

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**Figure 6: Weather metrics of Palo Alto including temperature, visibility wind speed, gust speed, precipitation and cloud cover.**

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**Figure 7: Weather metrics of San Jose including temperature, visibility wind speed, gust speed, precipitation and cloud cover.**

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**Figure 8: Rush hours during the weekday.**

**Table 1: Rush Hour Top 10 Frequently Used Start Stations**

|  |  |  |
| --- | --- | --- |
| Start Station ID | Name | Trip Count |
| 70 | San Francisco Caltrain (Townsend at 4th) | 17908 |
| 69 | San Francisco Caltrain 2 (330 Townsend) | 10198 |
| 55 | Temporary Transbay Terminal (Howard at Beale) | 9519 |
| 50 | Harry Bridges Plaza (Ferry Building) | 7887 |
| 61 | 2nd at Townsend | 7288 |
| 74 | Steuart at Market | 7280 |
| 77 | Market at Sansome | 6527 |
| 65 | Townsend at 7th | 6398 |
| 67 | Market at 10th | 5519 |
| 60 | Embarcadero at Sansome | 5265 |

**Table 2: Rush Hour Top 10 Frequently Used End Stations**

|  |  |  |
| --- | --- | --- |
| End Station ID | Name | Trip Count |
| 70 | San Francisco Caltrain (Townsend at 4th) | 23611 |
| 69 | San Francisco Caltrain 2 (330 Townsend) | 10483 |
| 77 | Market at Sansome | 8376 |
| 61 | 2nd at Townsend | 8195 |
| 55 | Temporary Transbay Terminal (Howard at Beale) | 7753 |
| 50 | Harry Bridges Plaza (Ferry Building) | 7668 |
| 65 | Townsend at 7th | 7270 |
| 74 | Steuart at Market | 7142 |
| 60 | Embarcadero at Sansome | 5223 |
| 64 | 2nd at South Park | 4775 |

**Table 3: Weekend Top 10 Frequently Used Start Stations**

|  |  |  |
| --- | --- | --- |
| Start Station ID | Name | Trip Count |
| 50 | Harry Bridges Plaza (Ferry Building) | 3164 |
| 60 | Embarcadero at Sansome | 3116 |
| 76 | Market at 4th | 1661 |
| 54 | Embarcadero at Bryant | 1603 |
| 61 | 2nd at Townsend | 1546 |
| 39 | Powell Street BART | 1486 |
| 70 | San Francisco Caltrain (Townsend at 4th) | 1361 |
| 73 | Grant Avenue at Columbus Avenue | 1298 |
| 77 | Market at Sansome | 1095 |
| 71 | Powell at Post (Union Square) | 1090 |

**Table 4: Weekend Top 10 Frequently Used End Stations**

|  |  |  |
| --- | --- | --- |
| End Station ID | Name | Trip Count |
| 60 | Embarcadero at Sansome | 3368 |
| 50 | Harry Bridges Plaza (Ferry Building) | 3174 |
| 76 | Market at 4th | 1877 |
| 39 | Powell Street BART | 1676 |
| 70 | San Francisco Caltrain (Townsend at 4th) | 1660 |
| 61 | 2nd at Townsend | 1591 |
| 54 | Embarcadero at Bryant | 1384 |
| 74 | Steuart at Market | 1223 |
| 77 | Market at Sansome | 1110 |
| 73 | Grant Avenue at Columbus Avenue | 1097 |

**Table 5: Average Use per Month**

|  |  |  |  |
| --- | --- | --- | --- |
| Month | Total Time Used (hours) | Total Time Available (hours) | Average Utilization |
| August | 9676.478 | 744 | 13.006019 |
| June | 9180.204 | 720 | 12.750283 |
| July | 9362.854 | 744 | 12.584481 |
| September | 8901.983 | 720 | 12.363865 |
| October | 8850.099 | 744 | 11.895295 |
| May | 8839.435 | 744 | 11.880961 |
| April | 7695.530 | 720 | 10.688236 |
| March | 7796.084 | 744 | 10.478608 |
| January | 6553.868 | 744 | 8.808962 |
| November | 6150.414 | 720 | 8.542241 |
| February | 5536.062 | 672 | 8.238187 |
| December | 6100.219 | 744 | 8.199219 |

**Table 6: Correlation between the Number of Trips each Day to the Weather Metric**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Mountain View | Palo Alto | Redwood City | San Francisco | San Jose |
| Max Temperature | 0.353 | **0.393** | 0.138 | 0.338 | **0.429** |
| Mean Temperature | **0.389** | 0.370 | **0.145** | **0.349** | 0.400 |
| Min Temperature | 0.352 | 0.256 | 0.121 | 0.259 | 0.280 |
| Max Visibility | NA | 0.211 | 0.0143 | 0.0998 | NA |
| Mean Visibility | 0.183 | **0.257** | **0.161** | **0.174** | **0.232** |
| Min Visibility | **0.222** | 0.241 | 0.0860 | 0.162 | 0.251 |
| Max Wind Speed | 0.120 | 0.0885 | -0.0310 | -0.0633 | 0.00633 |
| Mean Wind Speed | 0.156 | 0.106 | 0.0238 | -0.0414 | -0.000420 |
| Max Gust Speed | -0.0340 | -0.0343 | 0.0189 | -0.0148 | -0.0429 |
| Precipitation | -0.141 | -0.0804 | -0.104 | -0.230 | -0.253 |