Using Plotly Library for Interactive Data Visualization in Python

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By Usman Malik • December 27, 2018 •

In my previous article, I explained how the Pandas library can be used for plotting basic and time series plots. While Pandas, Matplotlib, and Seaborn libraries are excellent data plotting libraries, they can only plot static graphs. Static plots are like simple non-interactive images. In most of the cases, static plots are enough to convey the information. However, in some cases you may like to add user interactivity to your plots.

In this article, we will see how the Python's Plotly library can be used to plot interactive plots. We will plot geographical data using plotly and will explain how user can interact with such plots.

Installing Required Libraries

To install the Plotly library using the "pip" utility, you need to execute the following command:

```
$ pip install plotly
```

In addition to Plotly, we will also use Cufflinks, which works as a connector between the Pandas library and Plotly, and helps us plot interactive graphs directly using a Pandas dataframe.

To install Cufflinks using pip, execute the following script:

```
$ pip install cufflinks
```

Importing Required Libraries

Plotly is basically an online library that hosts your data visualizations, however, it also provides an offline data package that can be used to draw interactive plots offline.

Before we can run Plotly in Jupyter notebook, which I am using to run my scripts, I need to import both the Plotly and Cufflinks libraries along with Numpy and Pandas as usual.

The following script imports the Numpy and Pandas libraries:

```
import pandas as pd
import numpy as np
%matplotlib inline
```

Next, we need to import the offline versions of the Plotly modules that we will be using in this article. The following script does that:

```
from plotly.offline import download_plotlyjs, init_notebook_mode, plot, iplot
```

Before we can execute our scripts, we need to connect the JavaScript to our notebook. Since Plotly plots are interactive, they make use of JavaScript behind the scenes. The scripts that we are going to run will be executed in the Jupyter notebook. To connect Jupyter notebook with JavaScript, we need to execute the following script:

```
init_notebook_mode(connected=True)
```

Finally, we need to import the Cufflink library and make sure that we will be using it offline. To do so, run the following script:

```
cf.go_offline()
```

Now we have everything that we need to draw interactive Plotly graphs inside our Jupyter notebooks.

Loading…

Plotly for Basic Plots

In this section, we will be using the Plotly library to draw basic interactive plots. In the next section, we will see how Plotly can be used to plot geographical data.

The Dataset

The dataset that we are going to use for this section is the "Tips" dataset that is downloaded by default with the Seaborn library. The dataset contains information about the amount spent by a group of people at lunch and dinner. The dataset contains gender, price, tips, age, size, day, time and whether the people who had lunch or dinner were smokers or not.

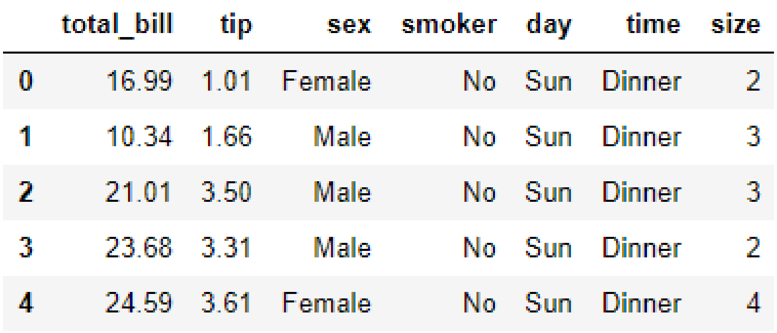
The following script imports the dataset and displays the first five rows of the dataset:

```
import seaborn as sns

dataset = sns.load_dataset('tips')

dataset.head()
```

The output of the script looks like this:



	total_bill	tip	sex	smoker	day	time	size
0	16.99	1.01	Female	No	Sun	Dinner	2
1	10.34	1.66	Male	No	Sun	Dinner	3
2	21.01	3.50	Male	No	Sun	Dinner	3
3	23.68	3.31	Male	No	Sun	Dinner	2
4	24.59	3.61	Female	No	Sun	Dinner	4

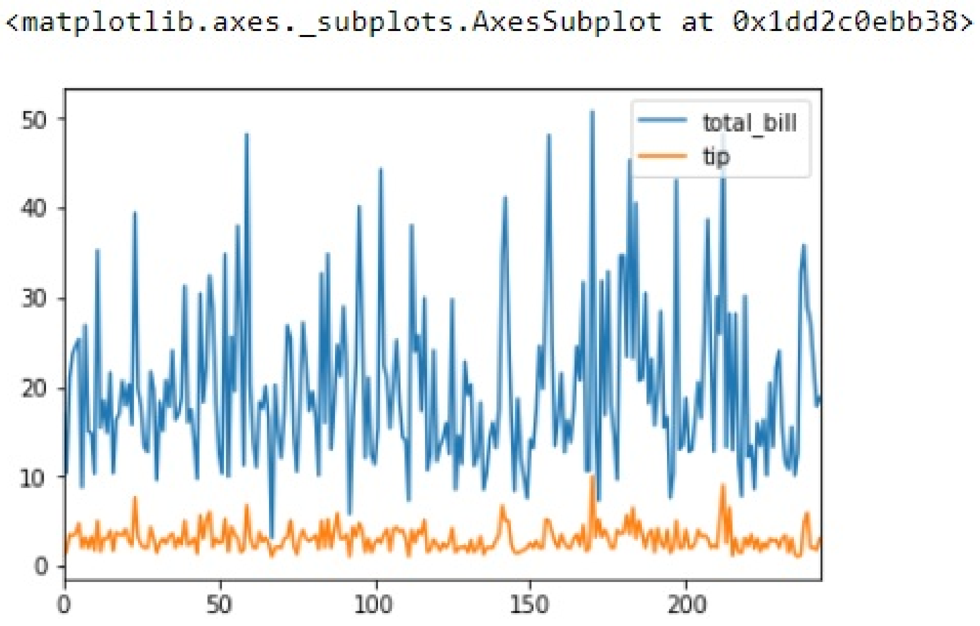
From the output, you can see that our dataset contains three numerical columns: `total_bill` , `tip` , and `size` and four categorical columns: `sex` , `smoker` , `day` , and `time` .

Before using Plotly to draw interactive plots, let's remind ourselves how we used Pandas for plotting static graphs. Let's call the `plot()` method on our dataframe to see how Pandas plot static plots. We will plot the values for the 'total_bill', 'tip', and 'sex' columns. Look at the following script:

```
dataset2 = dataset[["total_bill", "tip", "size"]]
dataset2.plot()
```

You can see that to plot a graph, we simply called the `plot` method on our dataframe.

Output:



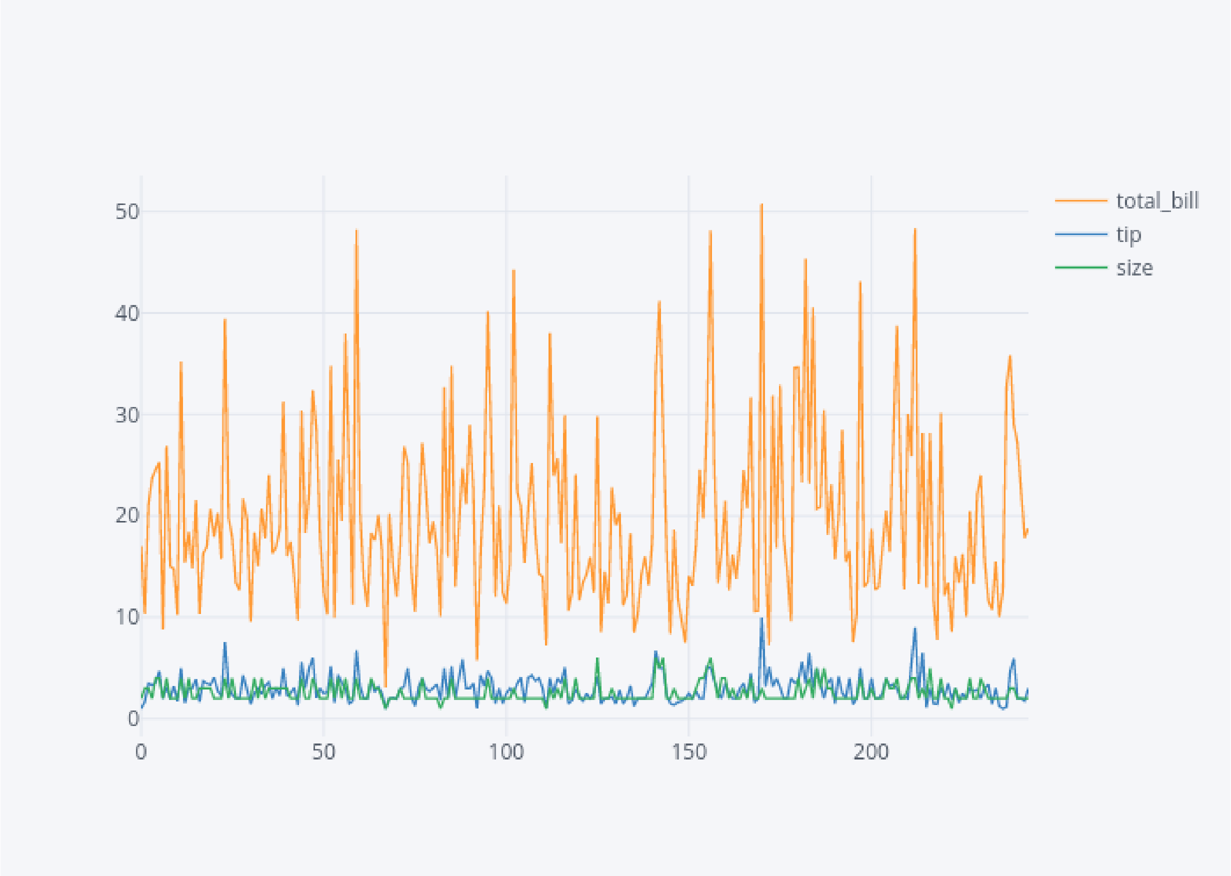
```
<matplotlib.axes._subplots.AxesSubplot at 0x1dd2c0ebb38>
```

From the output, you can see the static line plot for the 'total_bill' and 'tips' column.

Now let's see how we can draw interactive plots using Plotly. In the section where we imported the libraries, we import the `plot()` function from the `plotly.offline` module. To plot interactive plots using Pandas dataframe, we simply need to call the `iplot()` method instead of the `plot` method. Take a look at the following example:

```
dataset2.iplot()
```

Once you execute the above script, you should see an interactive line plot for the `total_bill`, `tip` and `sex` columns as shown below:



If you hover over the plot you should see values changing. You can zoom in and zoom out of the plot using the options available at the top right corner of the plot. You can also add and remove columns from the plot. Finally, you can also save the graph as a static image.

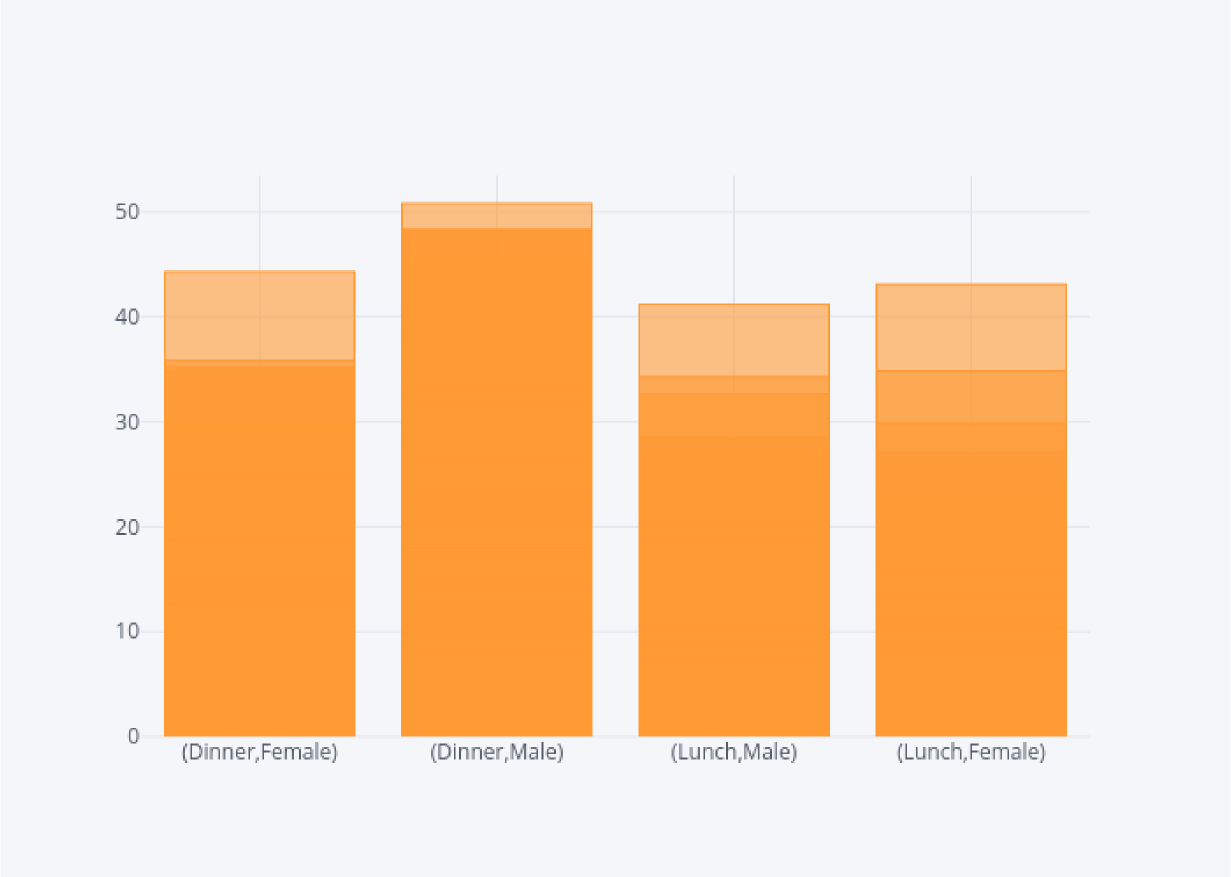
In the rest of the section, we will plot some of the most commonly used interactive plots using Plotly.

The Bar Plot

To plot the interactive bar plot using Plotly, you can use the `iplot()` function. You need to pass "bar" as the value for the `kind` parameter of the `iplot()` function. Furthermore, you need to pass the list of the categorical columns for which you want to plot your graphs to the `x` attribute. Finally, the numerical column is passed as a value to the `y` attribute. The following script plots a bar plot for the `time` and `sex` columns on the x-axis and `total_bill` on the y-axis.

```
dataset.iplot(kind='bar', x=['time', 'sex'],y='total_bill')
```

Output:

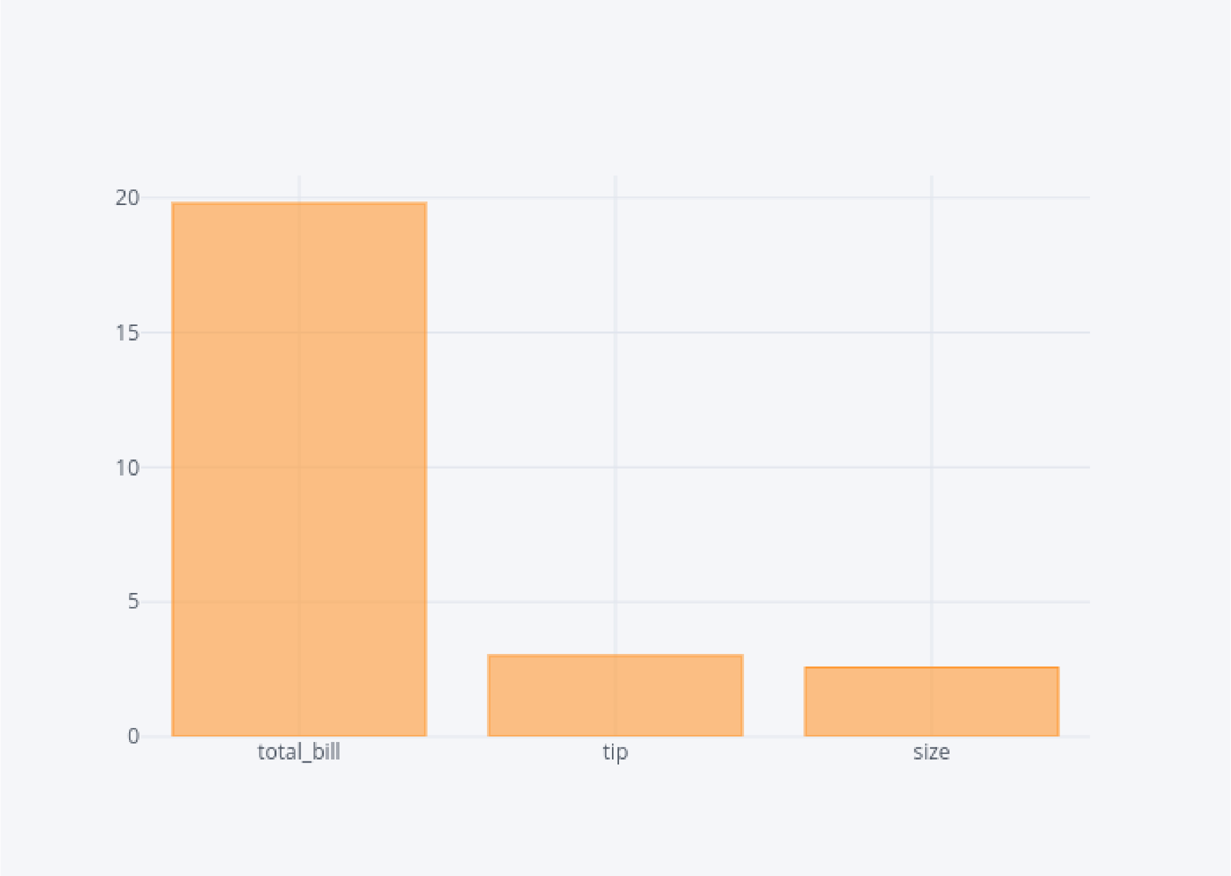


You can see from the output that four bars have been plotted for the total bill. The bars show all possible combinations of values in the `sex` and `time` columns.

In addition to specifying columns for the bar plots, you can simply call an aggregate function on the Pandas dataframe and then call the `iplot()` function and pass "bar" as the value for `kind` attribute. This will plot the bar for every numerical column according to the aggregate function. For instance, if you want to plot the bar plot containing the average values for `total_bill`, `tip` and `size` column, you can use the following script:

```
dataset.mean().iplot(kind='bar')
```

Output:

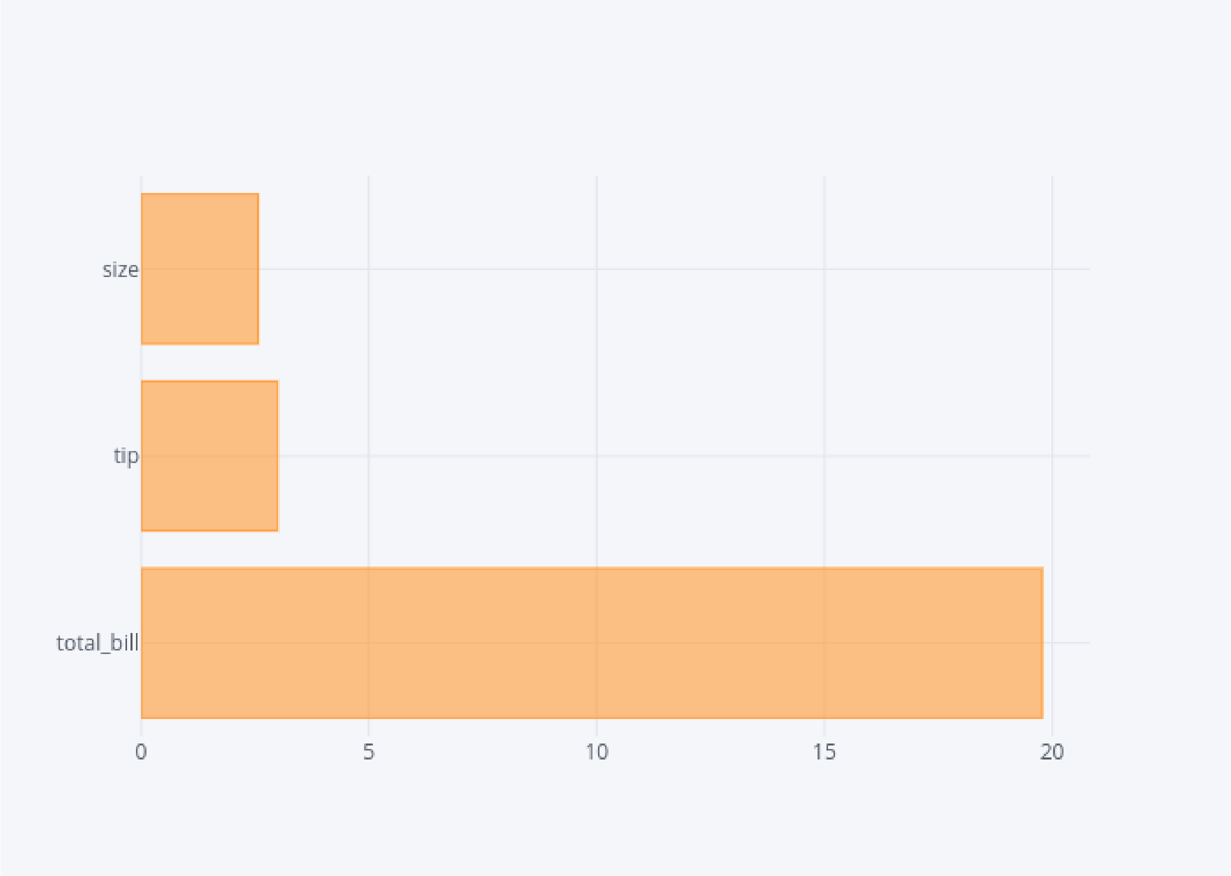


In the output, you can see the bar plots with mean values for `total_bill`, `tip` and `size` column.

In addition to vertical bar plots, you can also plot horizontal bar plots. All you have to do is to pass "barh" as an attribute to the `kind` parameter, as shown in the following script:

```
dataset.mean().iplot(kind='barh')
```

Output:



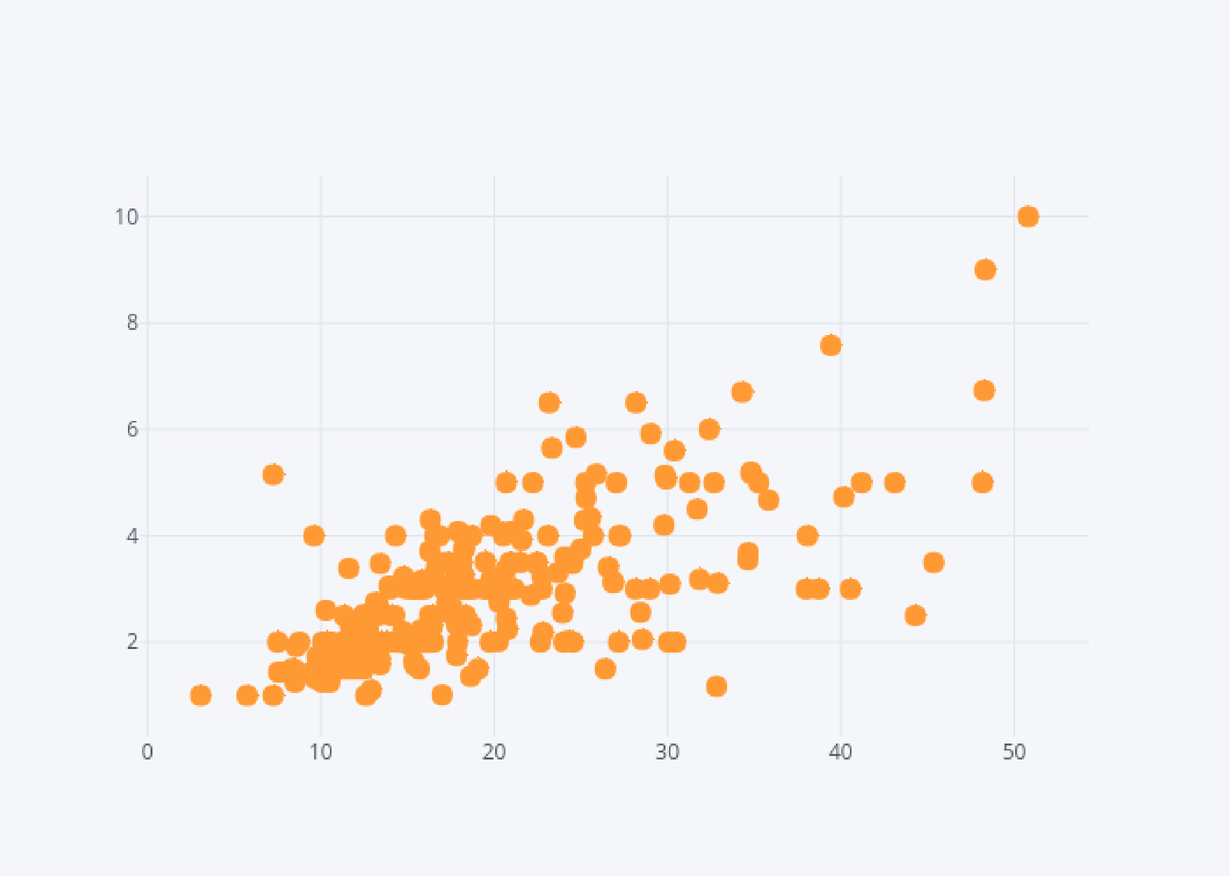
In the output, you can see the horizontal bar plots for the mean values of `total_bill`, `tip` and `size` columns.

The Scatter Plot

To plot an interactive scatter plot, you need to pass "scatter" as the value for the `kind` parameter of the `iplot()` function. Furthermore, you need to pass column names for the x and y-axis. The following script plots a scatter plot for the `total_bill` column on the x-axis and `tip` column in the y-axis.

```
dataset.iplot(kind='scatter', x='total_bill', y='tip', mode='markers')
```

Output:



Hover your mouse over the interactive plot to see the changing values for `total_bill` and `tip` columns.

The Box Plot

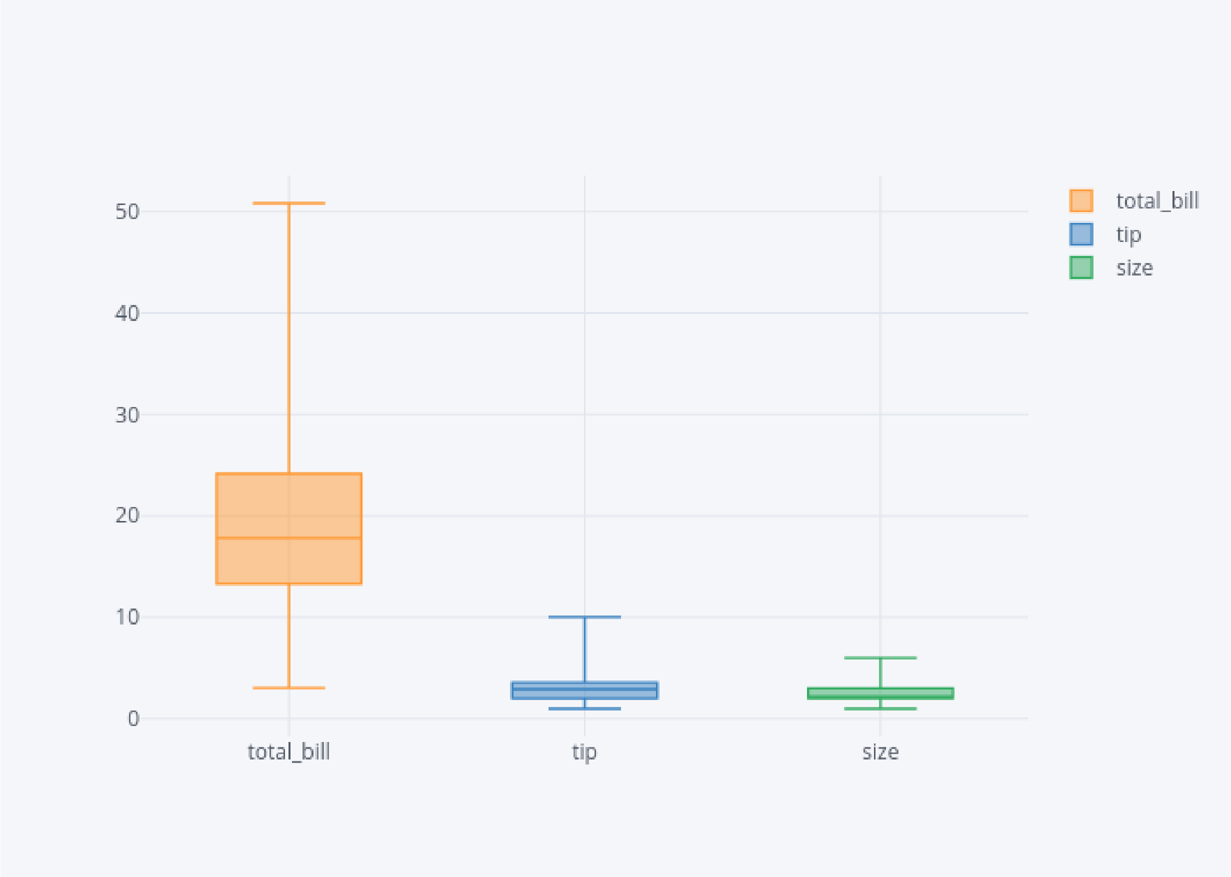
In one of my earlier articles I explained what is a box plot and how we can draw it using the Seaborn library. The box plot plots the quartile information for the numerical columns. The distance between the bottom whisker and the bottom of the box displays the first quartile. The distance between the bottom of the box to the middle of the box displays the second quartile. Similarly, the distance from the middle of the box to the upper end of the box quantifies the third quartile while the distance from the top of the box to the top whisker displays the last quartile.

Using Plotly, you can draw interactive box plots. All you have to do is pass the `box` as value to the `kind` parameter of the `iplot()` function as shown below:

```
dataset2.iplot(kind='box')
```

In the output, you will see box plots for all the numerical columns in the data i.e. `total_bill`, `tip` and `size`.

Output:

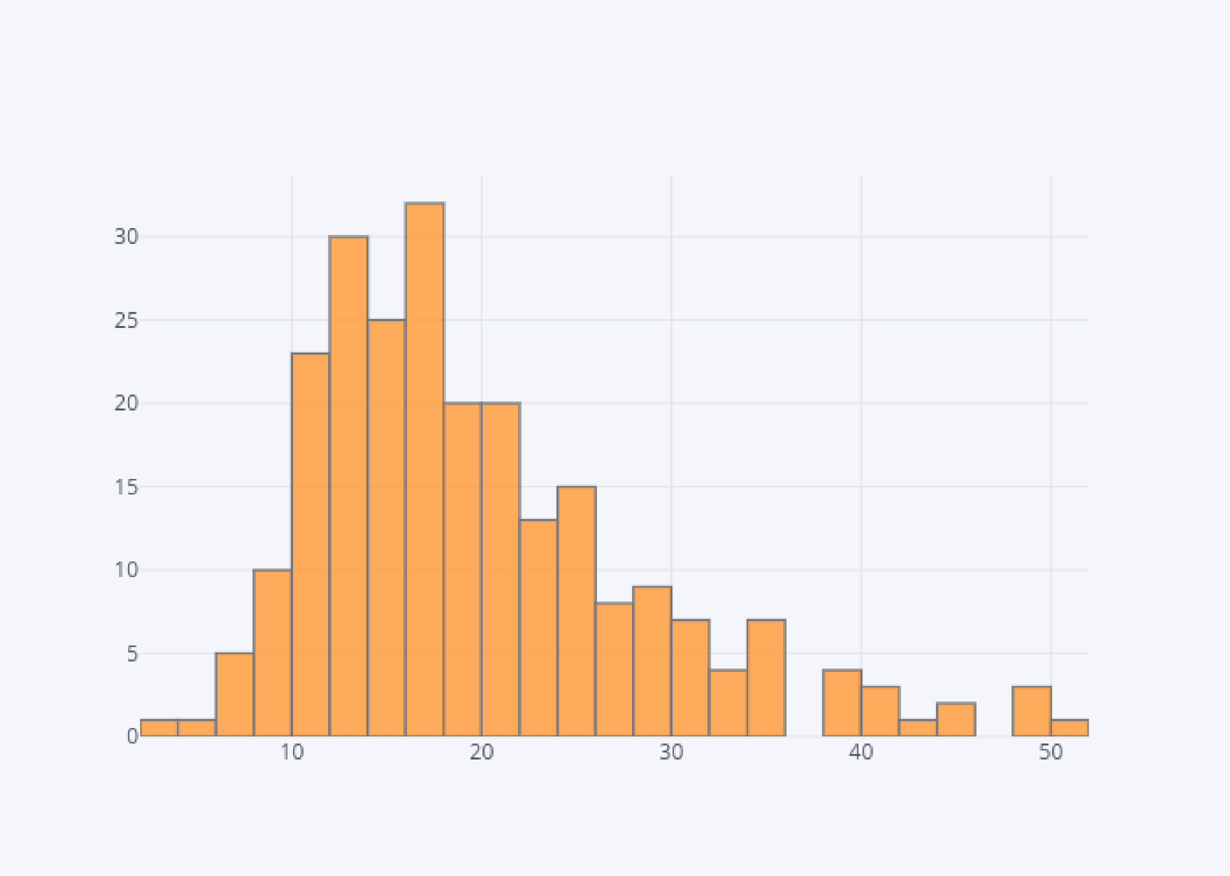


The Hist Plot

The Plotly library can also be used to plot interactive histogram plots for any column in the dataset. To do so, you have to pass "hist" as value to the `kind` parameter of the `iplot()` function. You can also specify the number of bins using the `bins` attribute. The following script plots histogram for the `total_bill` column:

```
dataset['total_bill'].iplot(kind='hist',bins=25)
```

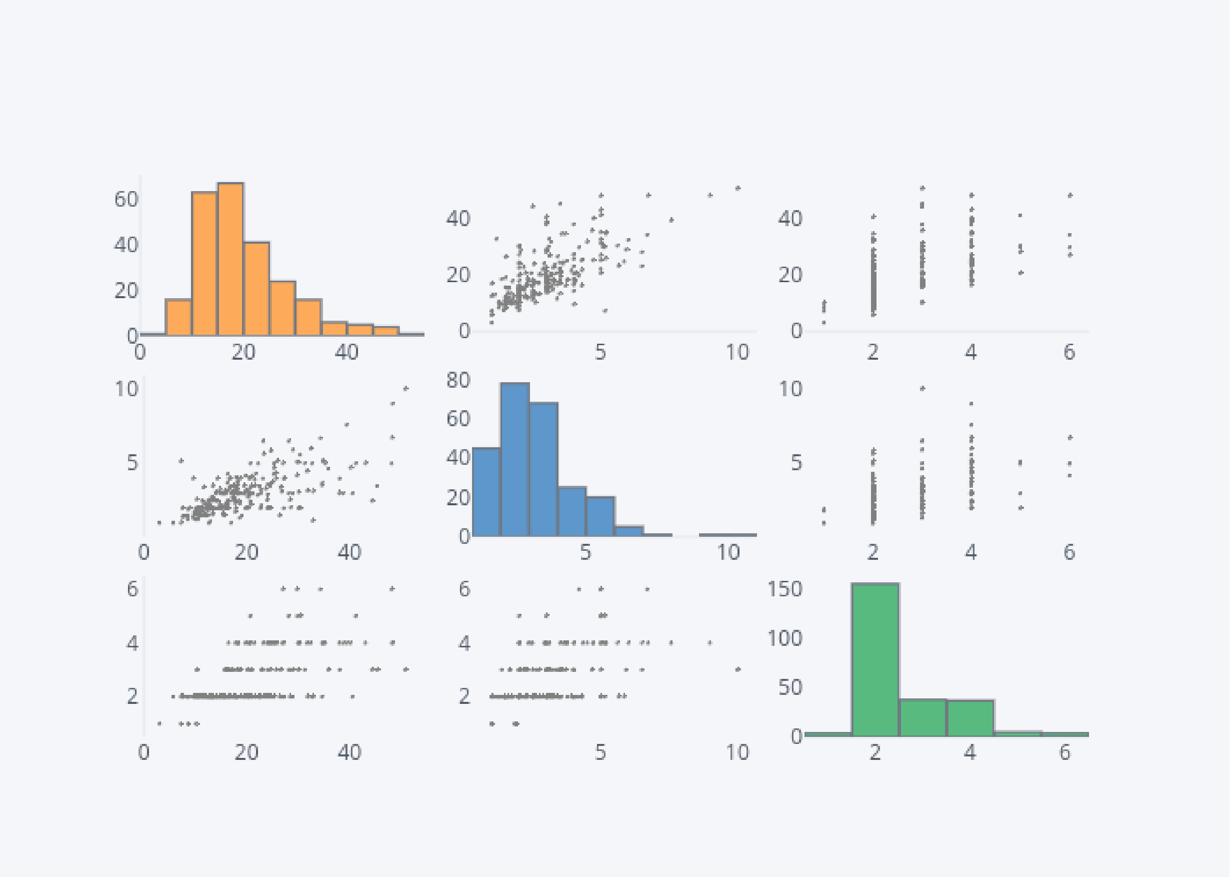
Output:



The Scatter Matrix Plot

The scatter matrix plot is basically a set of all the scatter plots for numeric columns in your dataset.

```
dataset2.scatter_matrix()
```

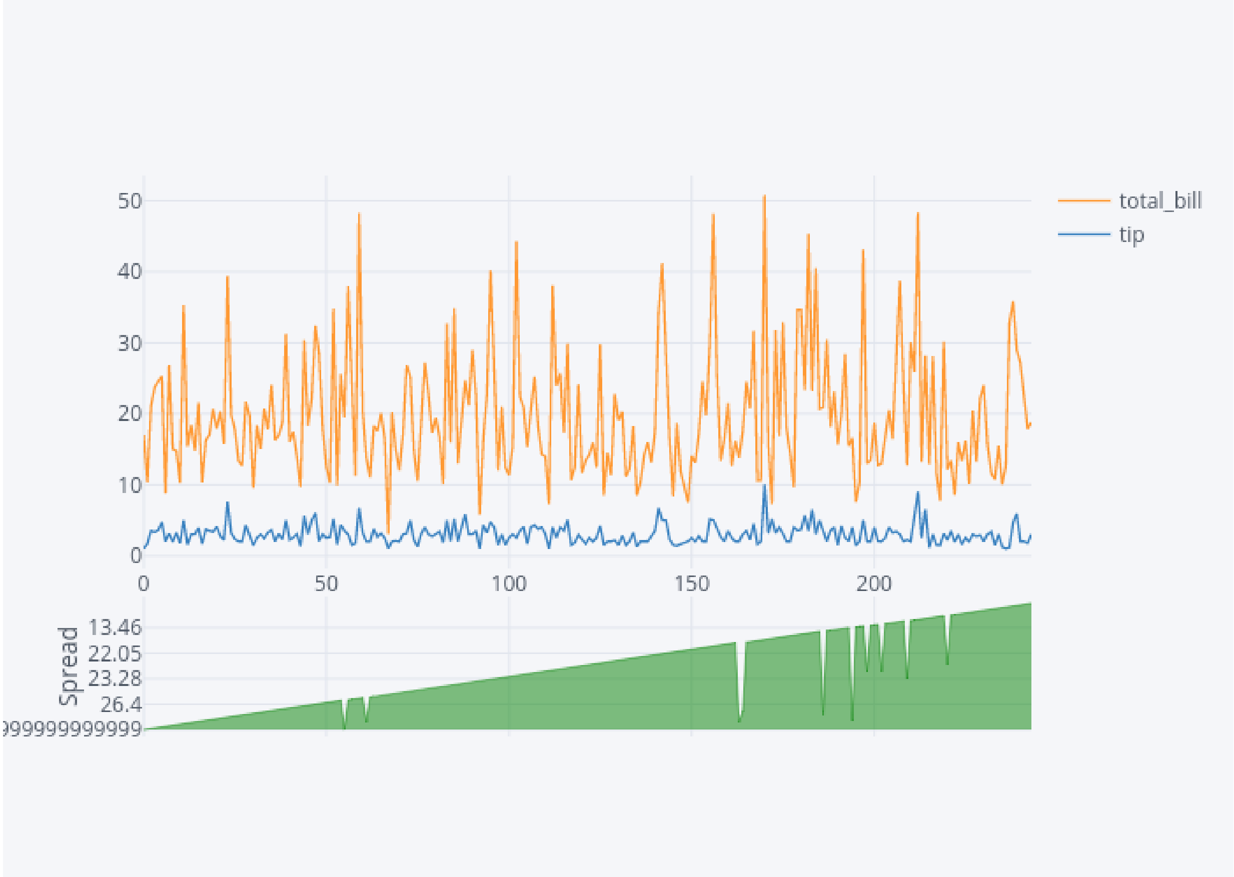


The Spread Plot

The spread plot shows the spread between two or more than numerical columns at any particular point. For instance, to see the spread between `total_bil` and `tip`, you can use the spread function as follows:

```
dataset[['total_bill','tip']].iplot(kind='spread')
```

Output:



From the output, you can see that as the `total_bill` increases, the spread between the `total_bill` and `tip` also increases.

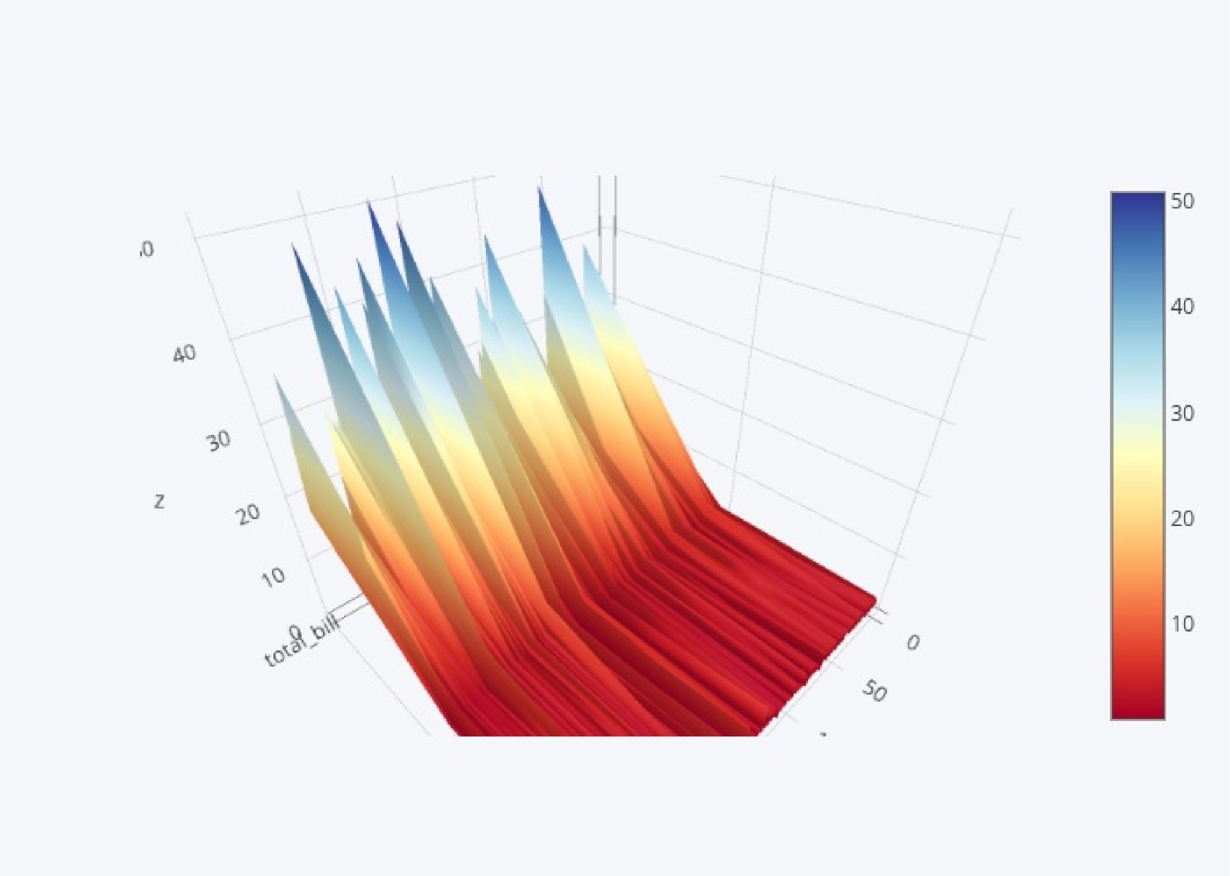
3D Plots

Finally, in addition to 2D plots, you can also create 3-D interactive plots using Plotly library. For instance to see 3D plot for `total_bill`, `tip` and `size` columns, execute the following script.

```
dataset2 = dataset[["total_bill", "tip", "size"]]
data = dataset2.iplot(kind='surface', colorscale='rdylbu')
```

In the output you can see 3D plot, you can move, turn it around, and zoom in and zoom out of the plot.

Output:



In this section, we saw some of the most commonly used interactive plots offered Plotly. In the next section, we will see how Plotly library can be used to plot geographical data.

Plotly for Geographical Plots

To draw geographical plots with Plotly, we will use Choropleth Maps. Choropleth Maps are special types of Plotly plots that are used to plot geographical data. The detailed documentation regarding how to use the choropleth maps is available here.

In this section we will see, with the help of examples, how to draw geographical maps for United States as well as for the whole world. But before we actually write the code to plot the geographical plots, let's first import the desired libraries.

```
import plotly.plotly as py
import plotly.graph_objs as go
from plotly.offline import download_plotlyjs, init_notebook_mode, plot, iplot

init_notebook_mode(connected=True)
import pandas as pd
```

Geographical Maps for the United States

There are four steps to drawing geographical maps using the Plotly.

Step 1: Create a Data Dictionary

The first step is to create a data dictionary that actually contains the data that you want to display on the map. To do this, execute the following script, which I will explain line by line after that.

```
map_data = dict(type='choropleth',
            locations=['MI', 'CO', 'FL', 'IN'],
            locationmode='USA-states',
            colorscale='Portland',
            text=['Michigan', 'Colorado', 'Florida', 'Indiana'],
            z=[1.0,2.0,3.0,4.0],
            colorbar=dict(title="USA States")
           )
```

You need to specify values for several keys in the data dictionary. They are as follows:

1. `type` : Since we are using choropleth maps, the type will always be `choropleth` .
2. `locations` : Here we need to pass the abbreviations for the states that we want to display on our map. Four states will be displayed on our map: 'Michigan (MI)', 'Colorado (CO)', 'Florida (FL), 'Indiana (IN)'
3. `locationmode` will be `USA-state` since we are only displaying the map for the United States.
4. `colorscale` : This key is used to specify the color of the plot. Check the documentation for more color options.
5. `text` : Contains a list of strings that will be displayed when the mouse hovers over the state location.
6. The `z` key contains a list of numerical values that will be displayed when the mouse hovers over the state location.
7. `colorbar` is a dictionary. For the `title` key, you can specify the text that will be displayed on the color bar.

Step 2: Create a Layout

Once, you have created a data dictionary, the next step is to create the layout dictionary. The layout dictionary for USA is simple as shown in the following script.

```
map_layout = dict(geo = {'scope':'usa'})
```

The dictionary takes another dictionary named `geo` . We passed the value "usa" for the `scope` key since our map is only limited to USA.

Step 3: Create Graph Object

If you look at the section where we imported the libraries, we imported the `plotly.graph_objs` class. The third step is to create an object of this graph. To do so we need to call the `Figure` function from the object. The object takes two parameters: `data` and `layout` . We will pass our data dictionary to the first parameter and the layout dictionary to the second parameter, as shown below:

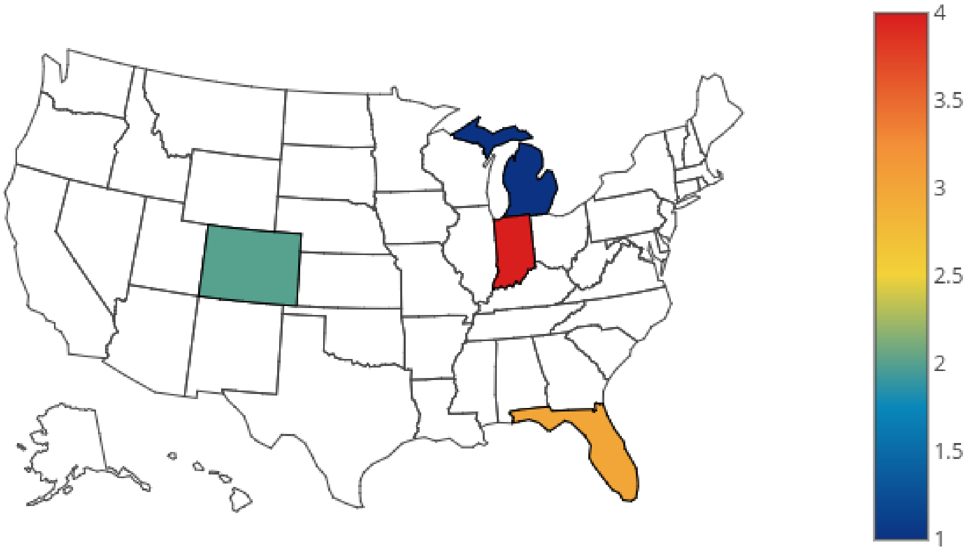
```
map_actual = go.Figure(data=[map_data], layout=map_layout)
```

Step 4: Call iplot() Method

The final step is to call the `iplot()` function and pass it the graph object that we created in the third step as shown below:

```
iplot(map_actual)
```

In the output, you will see the geographical plot for four US states. You can see that the rest of the state have not been colored since we did not specify any information regarding those states. If you hover the mouse over the colored states, you will see the corresponding values of the `text` and `z` keys that we specified when we created our data dictionary.



Geographical Maps for the United States Using CSV

Now we have a basic idea of how we can create geographical plots using Plotly and choropleth maps. Let us now create a more complex map. We will see how we can use data from a CSV file to create a geographical plot. We will create a geographical map that will display the Per Capita GDP for all the states in the United States.

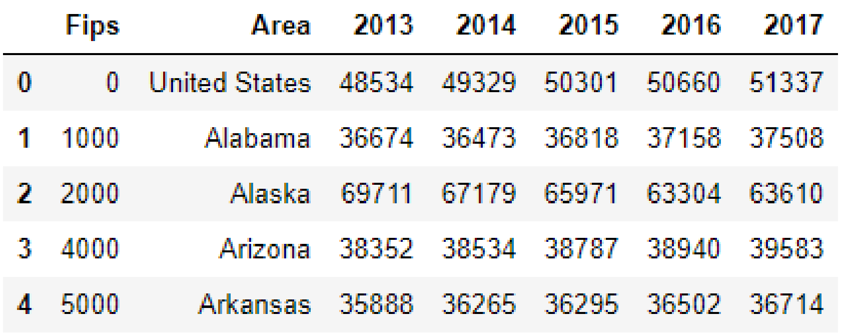
The Dataset

The dataset for this section can be downloaded from this Kaggle Link, which comes in a CSV format. I have changed the name of the file for readability purposes.

The following script imports the dataset and prints its first five rows to the console.

```
df = pd.read_csv(r'E:/state_gdp.csv')
df.head()
```

The output looks like this:



	Fips	Area	2013	2014	2015	2016	2017
0	0	United States	48534	49329	50301	50660	51337
1	1000	Alabama	36674	36473	36818	37158	37508
2	2000	Alaska	69711	67179	65971	63304	63610
3	4000	Arizona	38352	38534	38787	38940	39583
4	5000	Arkansas	35888	36265	36295	36502	36714

The dataset contains the names of the states in USA in the `Area` column. The dataset also contains the Per Capita GDP for the five years from 2013 to 2017. We will plot the data for the year 2017.

One problem with the dataset is that it contains full names of the states, while the choropleth maps accept the abbreviation for the state names. The first thing that we need to do is to add a column to our dataset that contains the abbreviations for the state names.

One way to do this is to create a dictionary for the state names and their abbreviations and then later create a column that contains abbreviated values from that dictionary. The following script creates a dictionary where the keys are the full state names and the values are the corresponding state abbreviations:

```
us_state_abbrev = {
    'Alabama': 'AL',
    'Alaska': 'AK',
    'Arizona': 'AZ',
    'Arkansas': 'AR',
    'California': 'CA',
    'Colorado': 'CO',
    'Connecticut': 'CT',
    'Delaware': 'DE',
    'Florida': 'FL',
    'Georgia': 'GA',
    'Hawaii': 'HI',
    'Idaho': 'ID',
    'Illinois': 'IL',
    'Indiana': 'IN',
    'Iowa': 'IA',
    'Kansas': 'KS',
    'Kentucky': 'KY',
    'Louisiana': 'LA',
    'Maine': 'ME',
    'Maryland': 'MD',
    'Massachusetts': 'MA',
    'Michigan': 'MI',
    'Minnesota': 'MN',
    'Mississippi': 'MS',
    'Missouri': 'MO',
    'Montana': 'MT',
    'Nebraska': 'NE',
    'Nevada': 'NV',
    'New Hampshire': 'NH',
    'New Jersey': 'NJ',
    'New Mexico': 'NM',
    'New York': 'NY',
    'North Carolina': 'NC',
    'North Dakota': 'ND',
    'Ohio': 'OH',
    'Oklahoma': 'OK',
    'Oregon': 'OR',
    'Pennsylvania': 'PA',
    'Rhode Island': 'RI',
    'South Carolina': 'SC',
    'South Dakota': 'SD',
    'Tennessee': 'TN',
    'Texas': 'TX',
    'Utah': 'UT',
    'Vermont': 'VT',
    'Virginia': 'VA',
    'Washington': 'WA',
    'West Virginia': 'WV',
    'Wisconsin': 'WI',
    'Wyoming': 'WY',
}
```

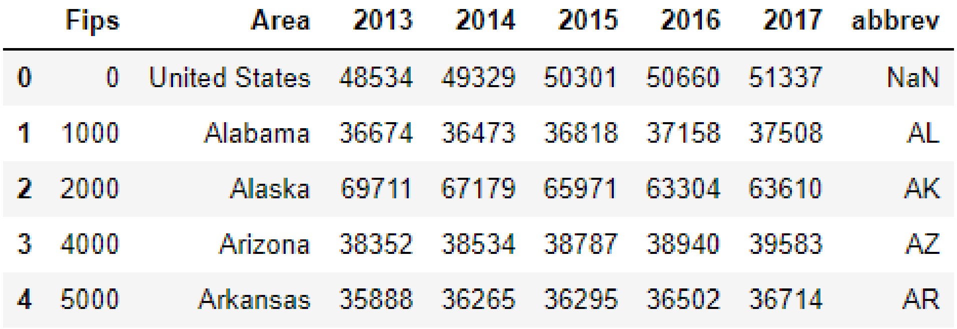
The next step is to add a column in the dataset that contains abbreviations. We can do so by mapping the values in the `Area` column to the keys in the `us_state_abbrev` dictionary. The corresponding values can then be added to the newly created abbreviation column as shown below:

```
df['abbrev'] = df['Area'].map(us_state_abbrev)
```

Now if you again print the top of the dataframe using the `head()` function, you will see the newly created `abbrev` column, as shown below:

```
df.head()
```

The output looks like this:



	Fips	Area	2013	2014	2015	2016	2017	abbrev
0	0	United States	48534	49329	50301	50660	51337	NaN
1	1000	Alabama	36674	36473	36818	37158	37508	AL
2	2000	Alaska	69711	67179	65971	63304	63610	AK
3	4000	Arizona	38352	38534	38787	38940	39583	AZ
4	5000	Arkansas	35888	36265	36295	36502	36714	AR

You can see the state abbreviations in the `abbrev` column. It is important to mention that the `Area` column has values for the whole country as well. However, the country will have a corresponding abbreviation of NaN in the `abbrev` column, and therefore will be ignored when you plot the graph.

Now that we have preprocessed our data, the next steps are straight forward. First, we will create a data dictionary containing values from our dataset, as shown below:

```
map_data = dict(type='choropleth',
            locations=df['abbrev'],
            locationmode='USA-states',
            colorscale='Reds',
            text=df['Area'],
            marker=dict(line=dict(color='rgb(255,0,0)', width=2)),
            z=df['2017'],
            colorbar=dict(title="GDP Per Capita - 2017")
           )
```

You can see that in the above script, for the `locations` key we are passing the `abbrev` column of our dataset. This means that the geographical plot for all the states in the United States will be printed on the screen.

Similarly, for the `text` key we are passing the "Area" column that contains the full name of the state. Finally, for the `z` key, we pass the Per capita GDP for the year 2017.

It is also important to mention that we have a new key here i.e. `marker`. This is used to create a border between different states. An RGB value of `255,0,0` means that the border will be red. A width of 2 specifies the width of the border is 2 pixels.

The next step is to create the layout for our map. The following script does that:

```
map_layout = dict(title='USA States GDP Per Capita - 2017',
               geo=dict(scope='usa',
                           showlakes=True,
                           lakecolor='rgb(85,173,240)')
              )
```

Notice that in the script above we pass `True` for the `showlakes` key, which means that the lakes will be displayed on the map and their color will be light blue as specified by the RGB value of `rgb(85,173,240)`.

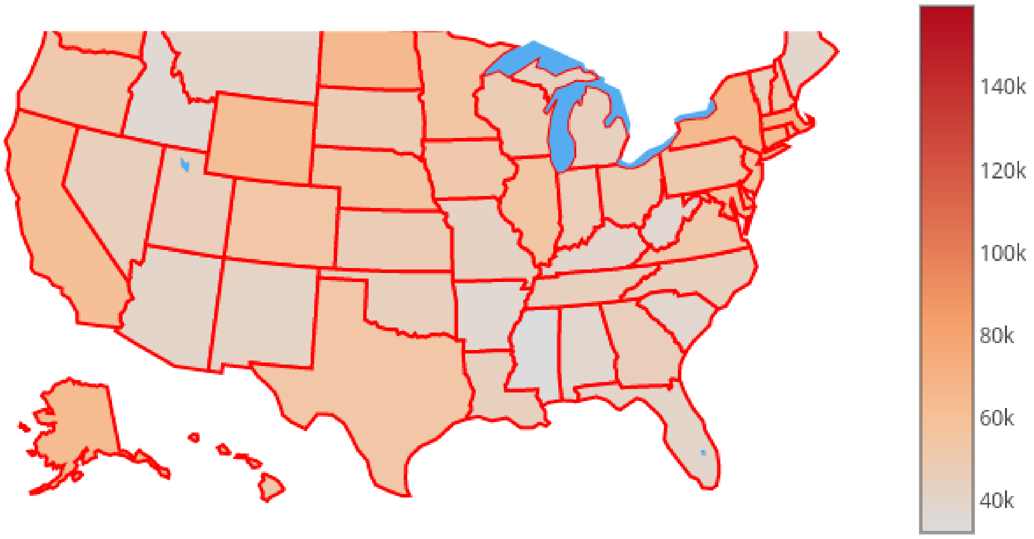
Finally, you need to create the graph object and pass it the data and layout dictionaries, as we did in the last section. Look at the following script:

```
map_actual = go.Figure(data=[map_data], layout=map_layout)
```

As the last step, we need to call the `iplot()` method and pass it our newly created graph object:

```
iplot(map_actual)
```

Once you execute the above script, you will see a map of United States with per capita GDP. The states lighter in color have lesser GDP than the ones darker in color.



Geographical Maps for the World

In the previous sections, we saw graphical maps for the United States. In this section, we will see how to plot geographical maps for the world. The process remains more or less similar. As a first step, we will create a data dictionary, followed by the layout dictionary and the graph object. Finally, we will use the `iplot()` function to plot the graph.

The Dataset

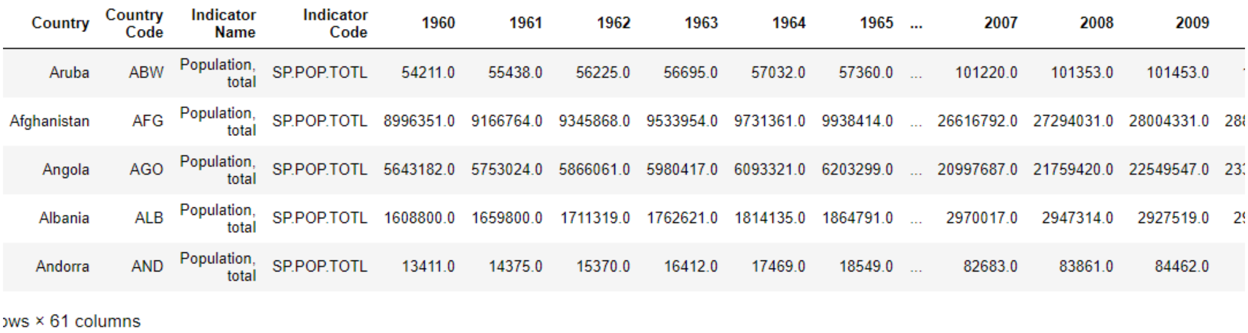
The dataset that we are going to use contains a country-wise population of the world for the years 1960-2016. We will be plotting a geographical map of the world displaying the population for each country for the year 2016.

The dataset can be downloaded from this Kaggle link. The dataset will be downloaded in the CSV format.

The following script imports the dataset and displays its first five rows using the `head()` method.

```
df = pd.read_csv(r'E:/world_pop.csv')
df.head()
```

The following image contains screenshot of the output:



Country	Country Code	Indicator Name	Indicator Code	1960	1961	1962	1963	1964	1965	...	2007	2008	2009	
Aruba	ABW	Population, total	SP.POP.TOTL	54211.0	55438.0	56225.0	56695.0	57032.0	57360.0	...	101220.0	101353.0	101453.0	1
Afghanistan	AFG	Population, total	SP.POP.TOTL	8996351.0	9166764.0	9345868.0	9533954.0	9731361.0	9938414.0	...	26616792.0	27294031.0	28004331.0	28
Angola	AGO	Population, total	SP.POP.TOTL	5643182.0	5753024.0	5866061.0	5980417.0	6093321.0	6203299.0	...	20997687.0	21759420.0	22549547.0	23
Albania	ALB	Population, total	SP.POP.TOTL	1608800.0	1659800.0	1711319.0	1762621.0	1814135.0	1864791.0	...	2970017.0	2947314.0	2927519.0	2
Andorra	AND	Population, total	SP.POP.TOTL	13411.0	14375.0	15370.0	16412.0	17469.0	18549.0	...	82683.0	83861.0	84462.0	

ows × 61 columns

Let's create a data dictionary that will store the information about the data that we want to plot from the population dataset that we just loaded.

```
map_data = dict(
        type='choropleth',
        locations=df['Country Code'],
        z=df['2016'],
        text=df['Country'],
        colorbar={'title': 'World Population 2016'},
      )
```

From the script above, you can see that the only change that we made is in the `locations` key; now we are passing the "Country Code" instead of the abbreviations for the state. This is a mandatory requirement for plotting the geographical plot of the world. For the `text` key, we pass the values from the "Country" column that contains the full name of the country. Similarly, for the `z` key, we pass the values from column "2016" because this is the column that contains the population values for the year 2016.

The next step is to create a layout dictionary. Look at the following script:

```
map_layout = dict(
    title='World Population 2016',
    geo=dict(showframe=False)
)
```

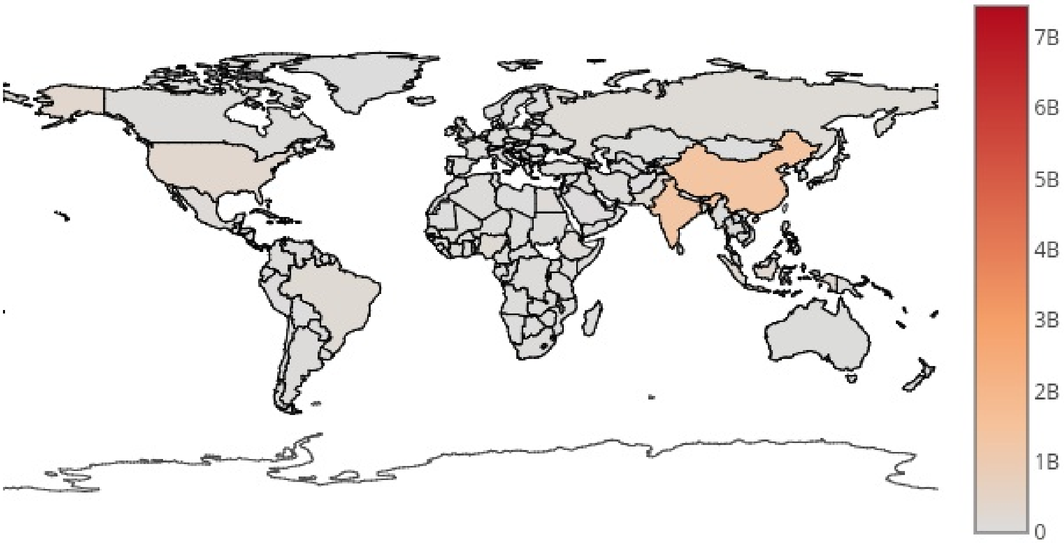
In the layout, the only parameter that we change is the `showFrame` key for the `geo` dictionary. If this key is set to `False`, the resultant plot does not contain a boundary.

Next, we need to create a Plotly graph object and pass it both the data and the layout dictionaries that we created, as shown below:

```
map_actual = go.Figure(data=[map_data], layout=map_layout)
```

As the last step, we need to call the `iplot()` function and pass it the graph object that we just created.

The output should look like this:



In the output, you can see the map of the whole world along with the population densities. You can see that the map for India and China is darker compared to the other countries since they are much more populated compared to European countries that are less populated. If you hover the mouse over any country, you should see the name of the country along with the total population.

Conclusion

Plotly is an extremely useful Python library for interactive data visualization. In this article, we saw how we can use Plotly to plot basic graphs such as scatter plots, line plots, histograms, and basic 3-D plots. We also saw how Plotly can be used to plot geographical plots using the choropleth map. As an example, we plot geographical plots for the United State as well as for the whole world.