Plotly and the Plotly Figure

INTRODUCTION TO DATA VISUALIZATION WITH PLOTLY IN PYTHON

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What is Plotly?

- A JavaScript graphing library
  - Don't worry - no need to know JavaScript!
- Plotly has a Python wrapper

Why Plotly?

Plotly has a number of unique advantages:

- Fast and easy to implement simple plots
- Low code/low effort options using `plotly.express`
- (If desired) Extremely customizable
- Interactive plots by default

Creating Plotly Figures

Plotly graphs can be created:

1. With `plotly.express` for simple, quick plots (`px`)
2. With `plotly.graph_objects` (`go`) for more customization
3. With `plotly.figure_factory` for specific, advanced figures

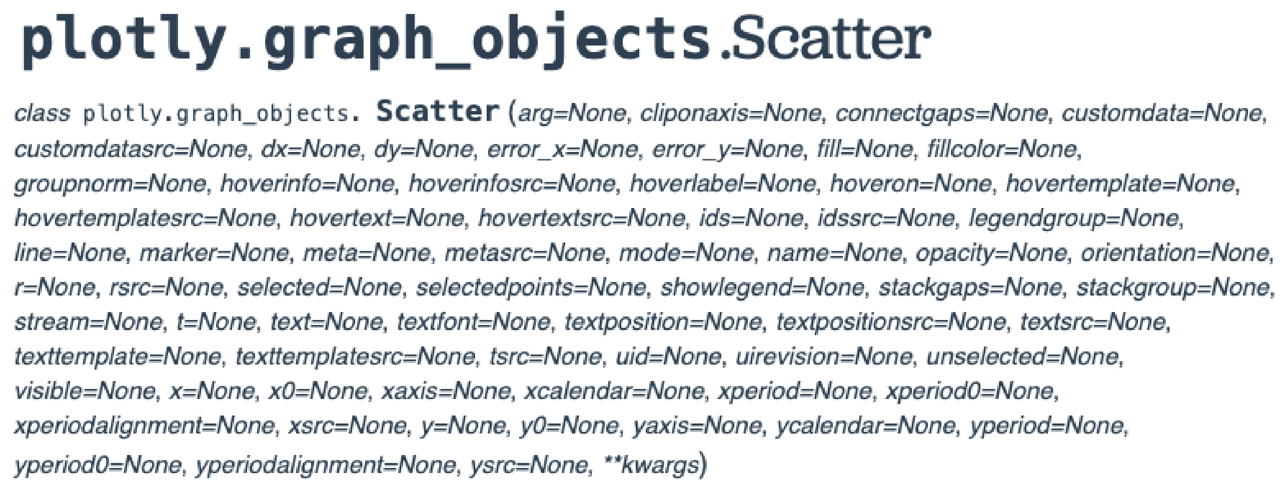
We will spend most of our time on **1** and **2**!

The importance of documentation

Save the links to key documentation!

1. Interactive, introductory docs (with many examples!)
   - **https://plotly.com/python**
2. Graph_objects pages for specific plots
   - Index **here**
   - For example, `go.scatter` **here**
3. The base `go.Figure` documentation linked **here**
   - Important when we cover `update_layout()` later!

The `go.scatter` documentation page:



plotly.graph_objects.Scatter

class `plotly.graph_objects.` **`Scatter`** *(arg=None, cliponaxis=None, connectgaps=None, customdata=None, customdatasrc=None, dx=None, dy=None, error_x=None, error_y=None, fill=None, fillcolor=None, groupnorm=None, hoverinfo=None, hoverinfosrc=None, hoverlabel=None, hoveron=None, hovertemplate=None, hovertemplatesrc=None, hovertext=None, hovertextsrc=None, ids=None, idssrc=None, legendgroup=None, line=None, marker=None, meta=None, metasrc=None, mode=None, name=None, opacity=None, orientation=None, r=None, rsrc=None, selected=None, selectedpoints=None, showlegend=None, stackgaps=None, stackgroup=None, stream=None, t=None, text=None, textfont=None, textposition=None, textpositionsrc=None, textsrc=None, texttemplate=None, texttemplatesrc=None, tsrc=None, uid=None, uirevision=None, unselected=None, visible=None, x=None, x0=None, xaxis=None, xcalendar=None, xperiod=None, xperiod0=None, xperiodalignment=None, xsrc=None, y=None, y0=None, yaxis=None, ycalendar=None, yperiod=None, yperiod0=None, yperiodalignment=None, ysrc=None, **kwargs)*

The Plotly Figure

A Plotly Figure has 3 main components:

- `layout` : Dictionary controlling style of the figure
  - One `layout` per figure
- `data` : List of dictionaries setting graph type and data itself
  - Data + type = a `trace` . There are over 40 types!
  - Can have multiple traces per graph
- `frames` : For animated plots (beyond this course)

Inside a Plotly Figure

Let's see inside an example Plotly `figure` object:

```
print(fig)
```

```
Figure({'data': [{'type': 'bar',
         'x': [Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday],
          'y': [28, 27, 25, 31, 32, 35, 36]}],
     'layout': {'template': '...',
                'title': {'font': {'color': 'red', 'size': 15},
                 'text': 'Temperatures of the week', 'x': 0.5}}})
```

- What do you think this graph will look like?

Inside our Figure

```
Figure({ 'data': [{'type': 'bar',
      'x': [Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday],
      'y': [28, 27, 25, 31, 32, 35, 36]}],
      'layout': {'template': '...','title': {'font': {'color': 'red', 'size': 15},
      'text': 'Temperatures of the week', 'x': 0.5}}})
```

- Type 'bar'
- An X and Y axis with data noted
- A title with some text around temperatures of the week

Guess: A bar chart of temperatures of the days of the week

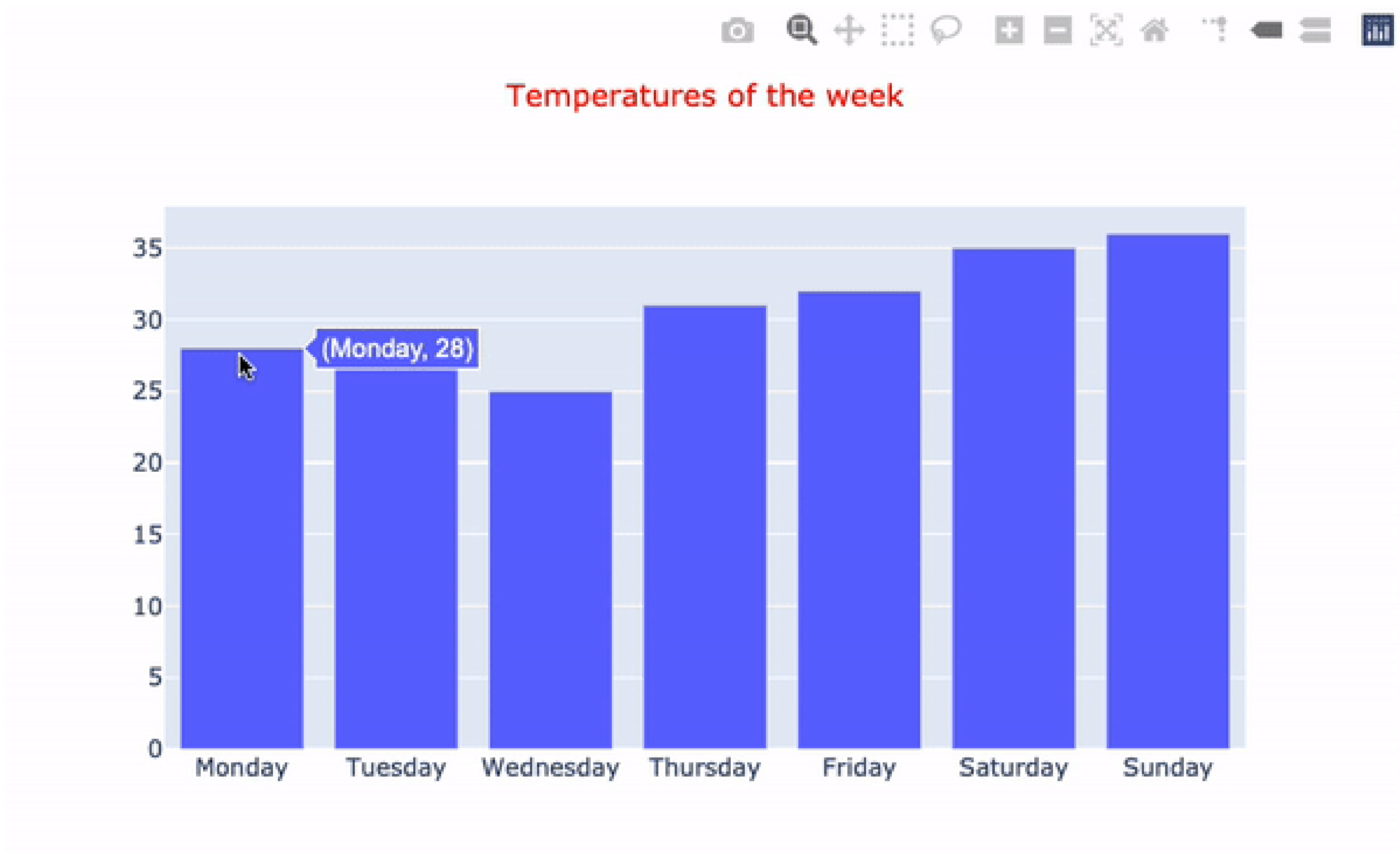
Creating our Figure

Constructing this figure from scratch (just this once!):

```
import plotly.graph_objects as go
figure_config = dict({ "data": [{"type": "bar",
              "x": ["Monday", "Tuesday", "Wednesday",
              "Thursday", "Friday", "Saturday", "Sunday"],
              "y": [28, 27, 25, 31, 32, 35, 36]}],
            "layout": {"title": {"text": "Temperatures of the week",
            "x": 0.5, "font": {'color': 'red', 'size': 15}}}})
fig = go.Figure(figure_config)
fig.show()
```

Our Figure revealed

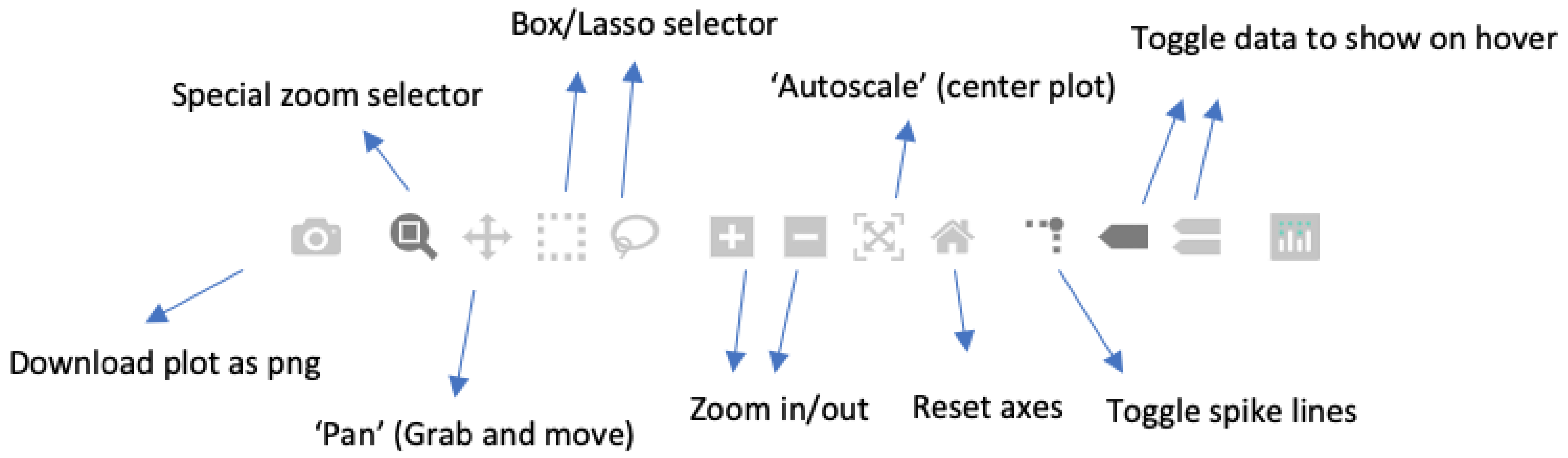
Let's see what is produced!



Plotly's instant interactivity

Plotly provides instant interactivity:

- Hover over data points
- Extra interactive buttons



Let's practice!

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Univariate visualizations

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Our approach

Plotly shortcut methods:

1. `plotly.express`
   - Specify a DataFrame and its columns as arguments
   - Quick, nice but less customization
2. `graph_objects` `go.X` methods (`go.Bar()` , `Go.Scatter()`) etc.
   - Many more customization options, but more code needed

What are univariate plots?

Univariate plots display only one variable

For analyzing the *distribution* of that variable

Common univariate plots:

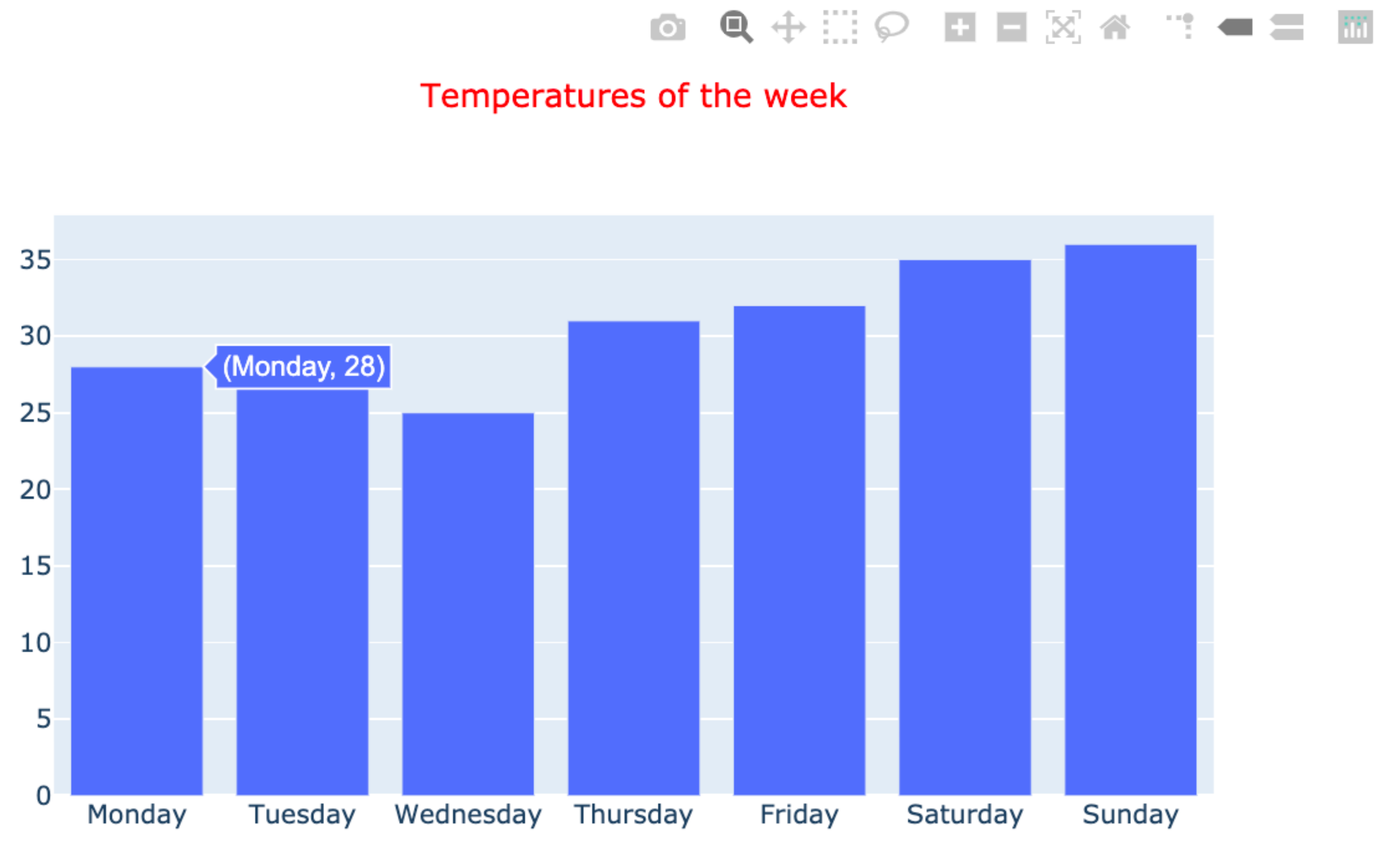
- Bar chart
- Histogram
- Box plot
- Density plots

Bar charts

Bar charts have:

- X-axis with a bar per group
  - One group = one bar! (Hence UNI-variate)
- The y-axis height represents the value of some variable

We built one in the last lesson!



Bar charts with plotly.express

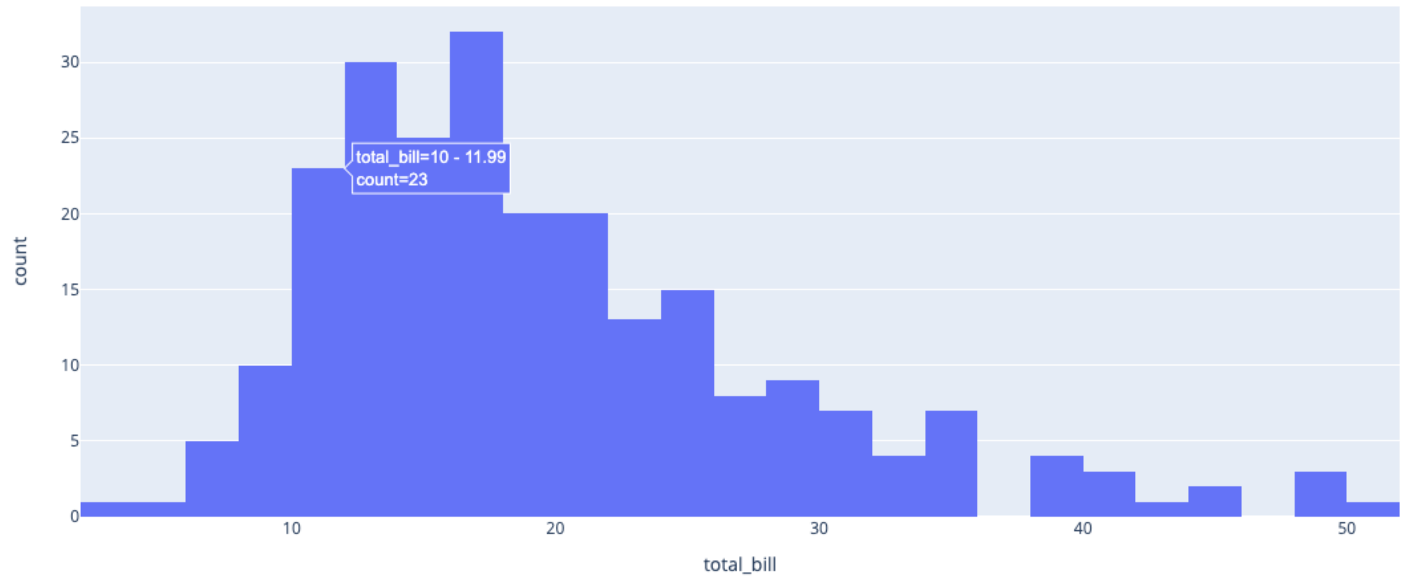
Let's rebuild with `plotly.express`

```python
import plotly.express as px
weekly_temps = pd.DataFrame({
    'day': ['Monday', 'Tuesday',
            'Wednesday', 'Thursday', 'Friday',
            'Saturday', 'Sunday'],
    'temp': [28, 27, 25, 31, 32, 35, 36]})
fig = px.bar(data_frame=weekly_temps, x='day', y='temp')
fig.show()
```

Histograms

Histograms have:

- Multiple columns (called 'bins') representing a range of values
  - The height of each bar = count of samples within that bin range
- The number of bins can be manual or automatic



Our dataset

Dataset collected by scientific researchers on Penguins!

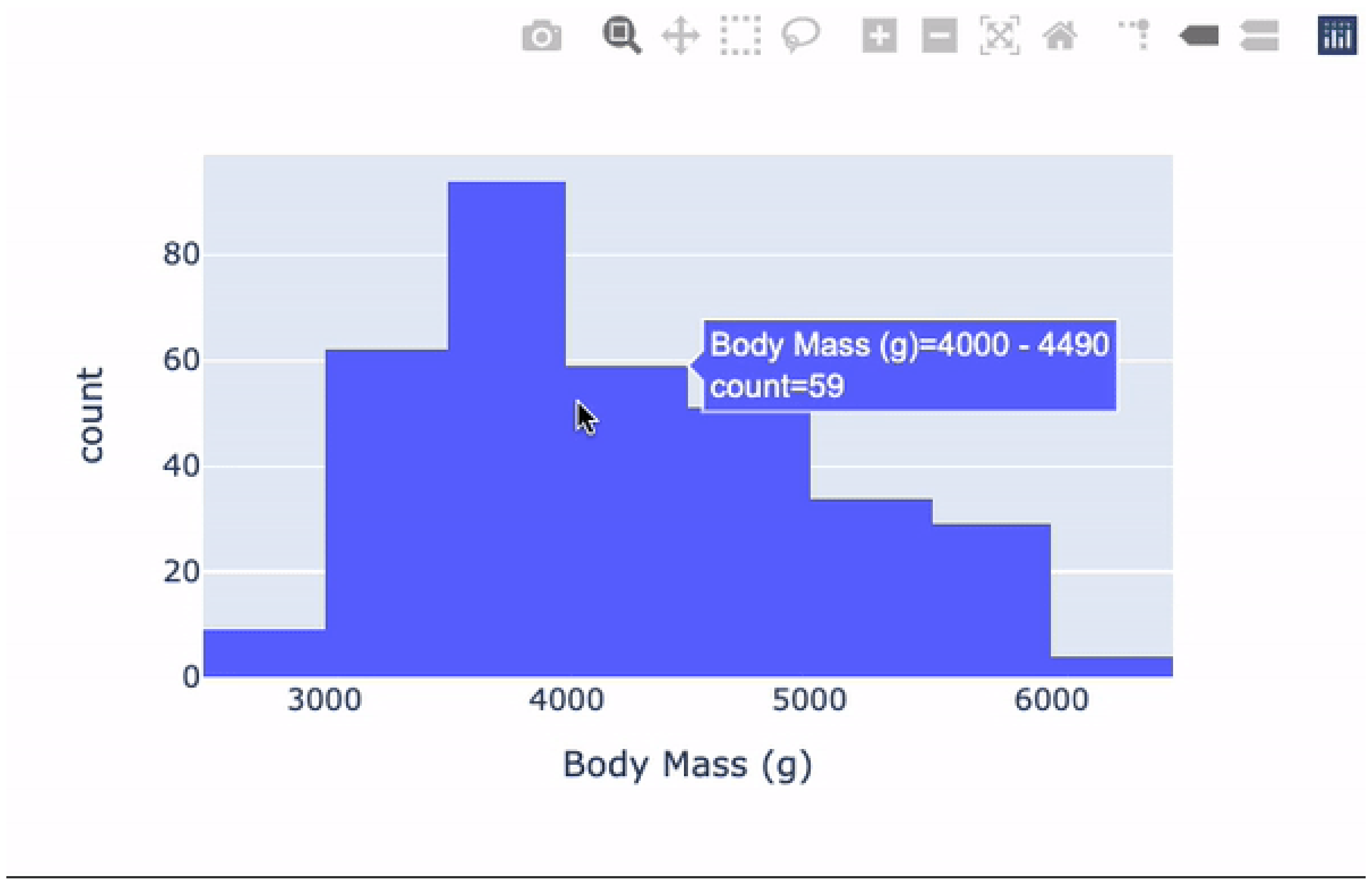
- Contains various body measurements like, beak size, weight, etc.
- Contains different species, genders, and ages of penguins

Histograms with plotly.express

We can create a simple histogram:

```
fig = px.histogram(
            data_frame=penguins,
            x='Body Mass (g)',
            nbins=10)
fig.show()
```

This is what is produced:



Useful histogram arguments

Other `px.histogram` arguments :

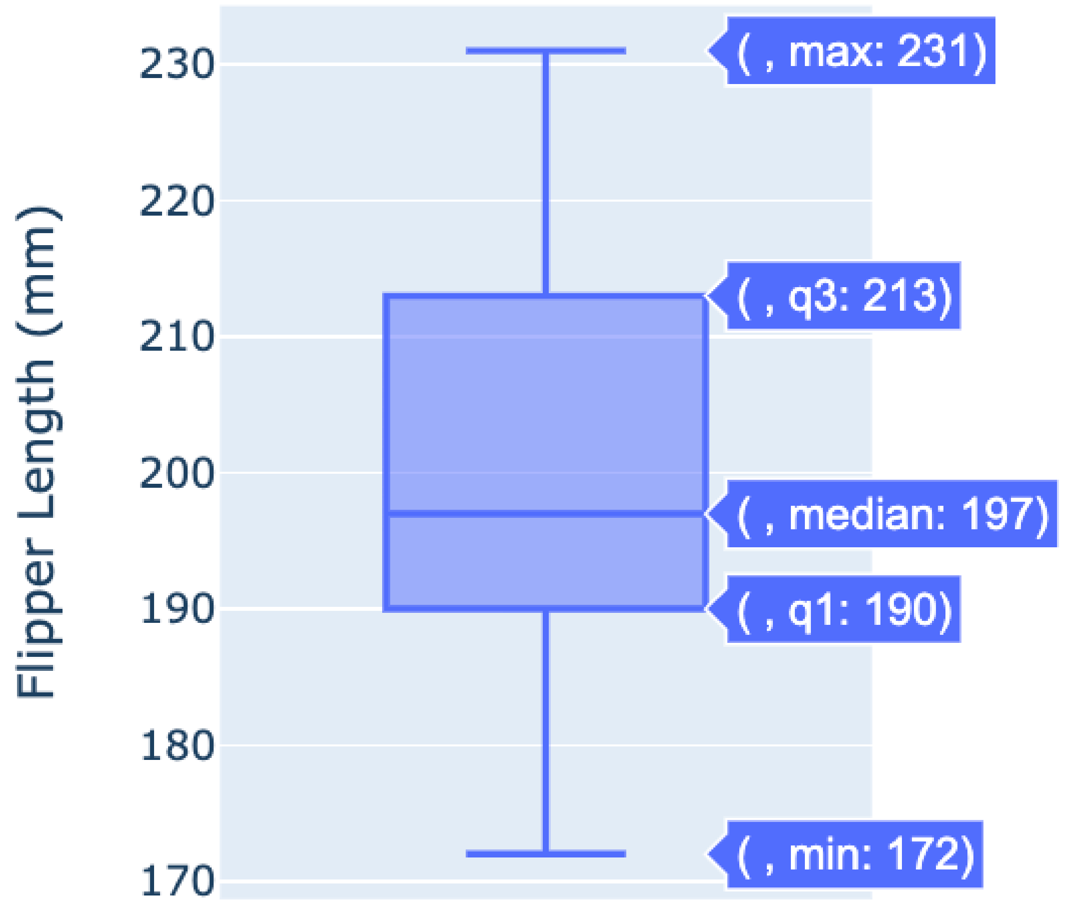
- `orientation` : To orient the plot vertically (`v`) or horizontally (`h`)
- `histfunc` : Set the bin aggregation (eg: average, min, max).

Check the **docs** for more!

Box (and whisker) plots

Summarizes a variable visually using quartile calculations;

- Middle area represents *interquartile range*
  - Top line = 3rd quartile (75th percentile)
  - Middle line = median (50th percentile)
  - Bottom line = first quartile (25th percentile)
- Top/bottom bars = min/max, excluding outliers
- Outlying dots are outliers

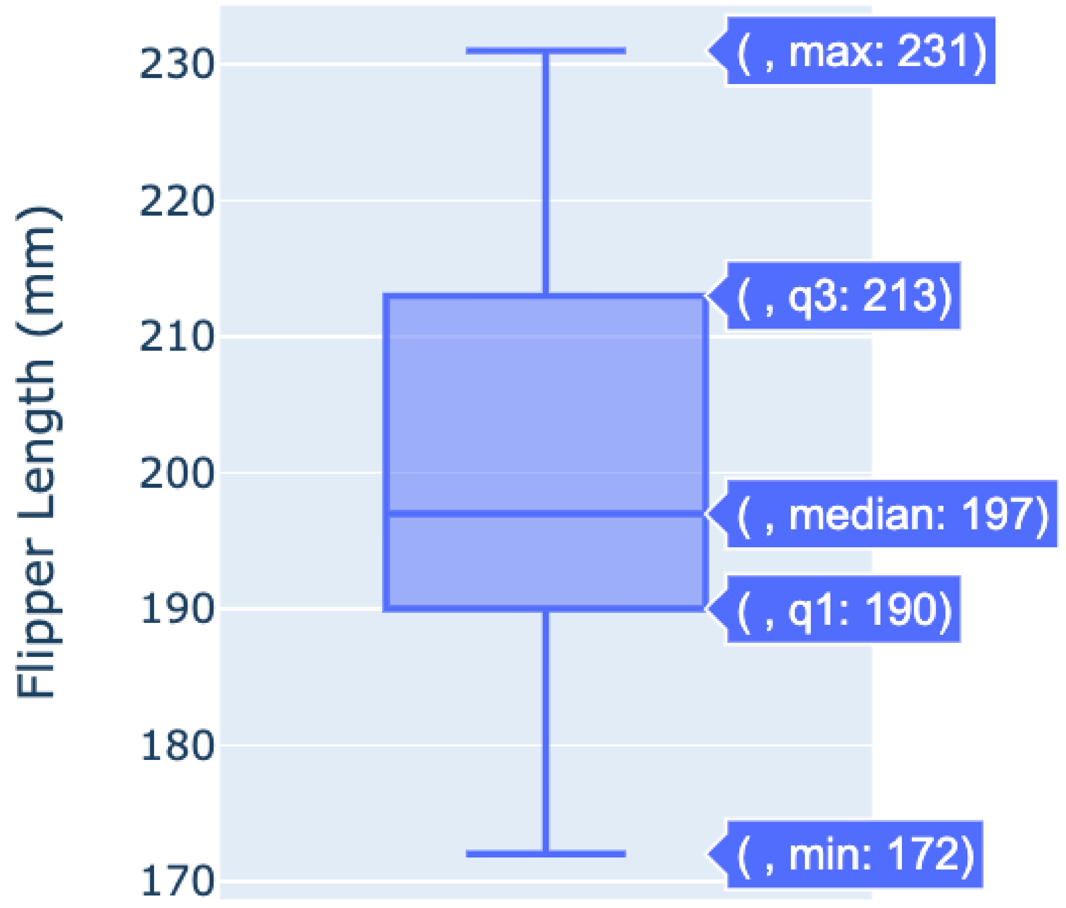


Box plots with plotly.express

Let's create a simple box plot:

```
fig = px.box(data_frame=penguins,
             y="Flipper Length (mm)")
fig.show()
```

This is what is produced:



Useful box plot arguments

Useful box plot arguments:

- `hover_data` : A list of column name(s) to display on hover
  - Useful to understand outliers
- `points` : Further specify how to show outliers

Check the **docs** for more!

Let's practice!

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Customizing color

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Customization in general

How to customize plots:

1. At figure creation if an argument exists (like `color` !)
2. Using an **important** function `update_layout()`
   - Takes a dictionary argument
   - E.g.: `fig.update_layout({'title':{text:'A New Title'}})`

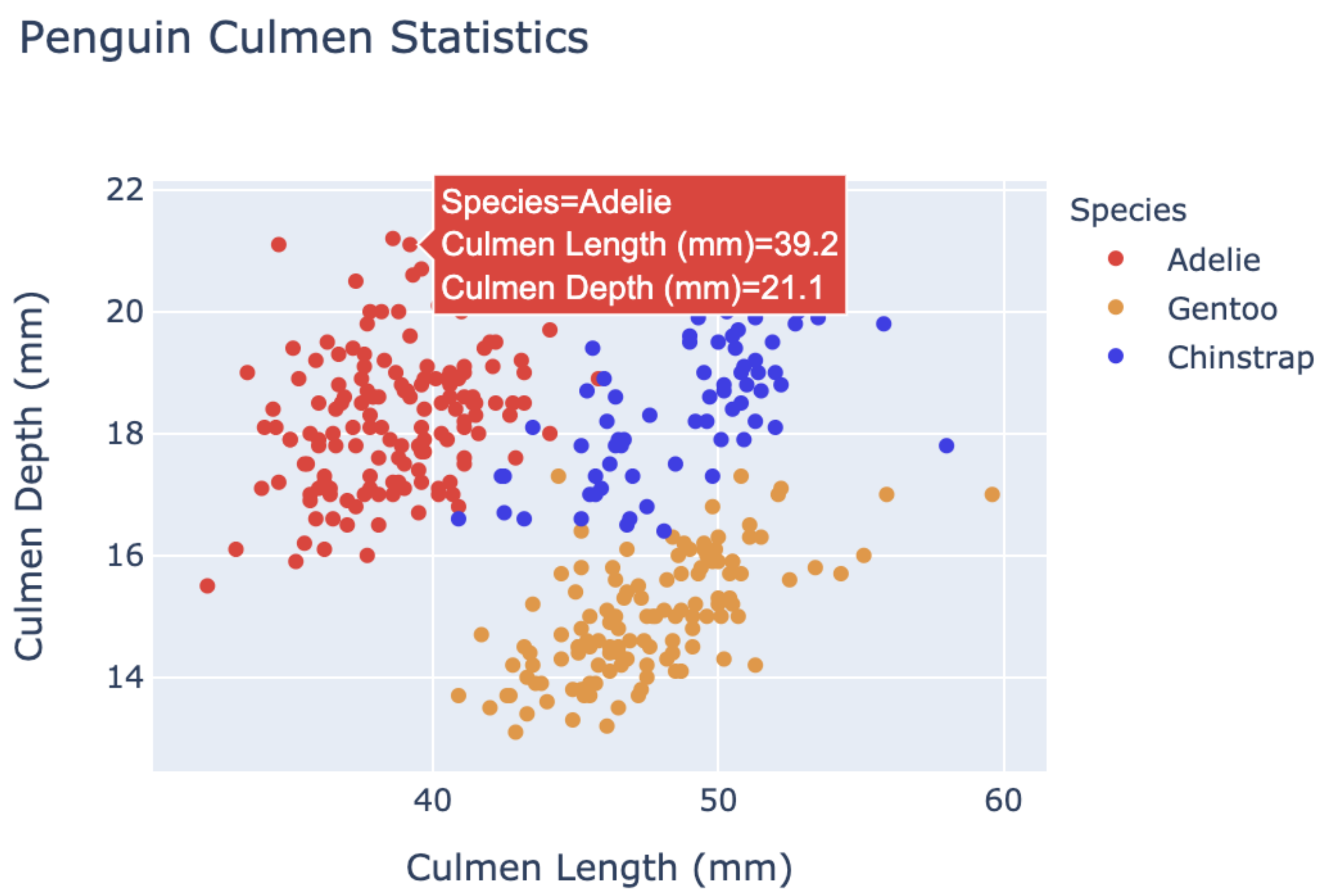
The method chosen depends on plot type how it was created.

MANY properties possible — See the **documentation**

Why customize color?

Customizing color can help you

1. Make plots look awesome!
2. Convey analytical insights
   - Color in this scatterplot adds a 3rd dimension.



Some color theory

Computers use RGB encoding to specify colors:

- RGB = A 3-digit code (each 0-255) mixing **R**ed, **G**reen, **B**lue together to make colors.
  - Imagine mixing Red, Green and Blue paint together!
  - (0,0,255) is totally blue and (255,255,0) is yellow

See more in **this article**

Some other examples of RGB colors:

Color	RGB Code
🟪	(245, 66, 230)
🟩	(105, 245, 66)
🟥	(245, 66, 87)
🟦	(50, 47, 247)

Specifying colors in plotly.express

In `plotly.express`:

- Often a `color` argument (DataFrame column)
  - A different (*automatic*) color given to each category in this column
  - A color scale/range is used if numerical column specified

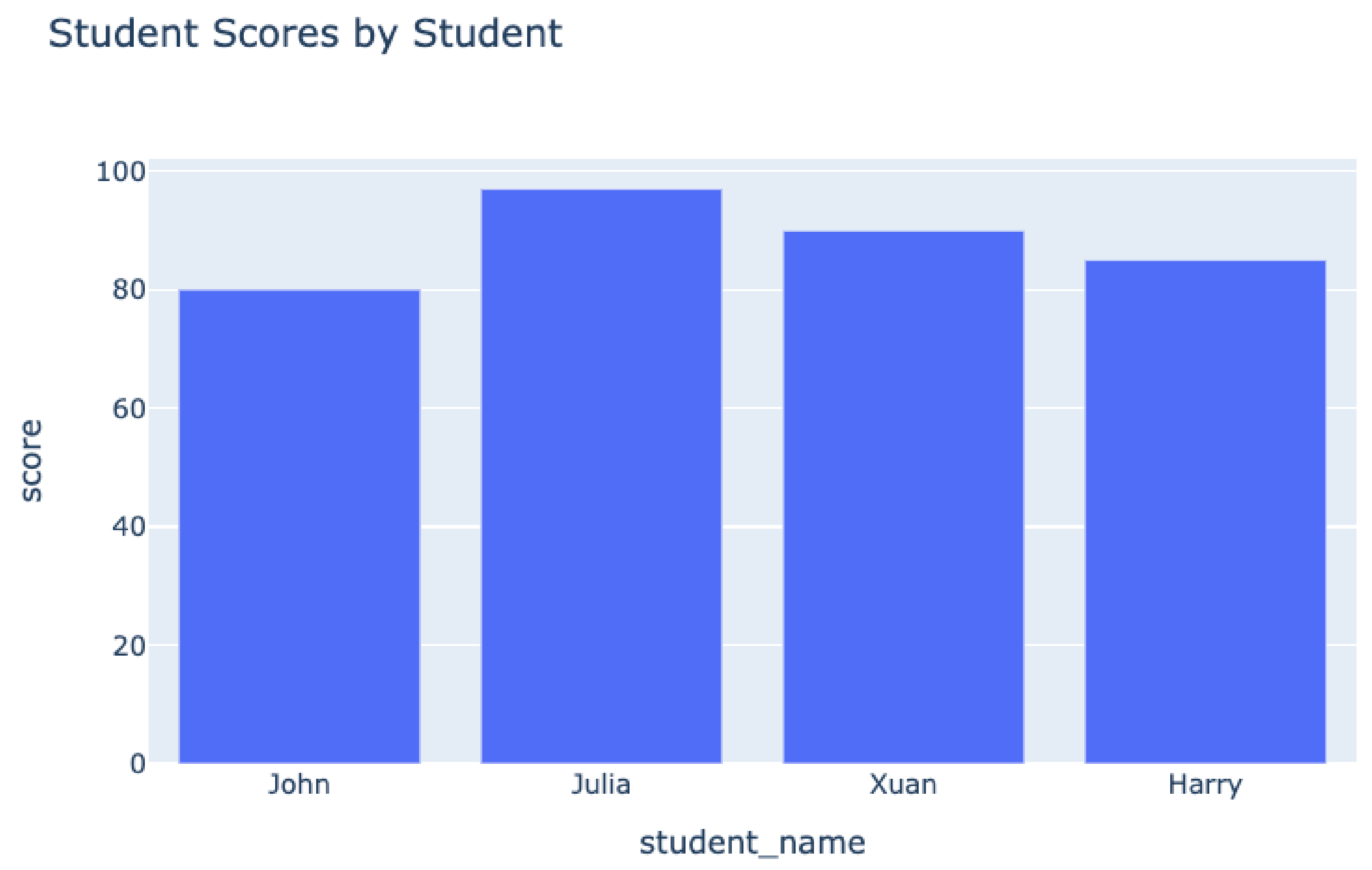
Our simple bar chart from a previous lesson (adding a `City` column)

```
fig = px.bar(data_frame=student_scores,
       x='student_name',
       y='score',
       title='Student Scores by Student'
       color='city')
fig.show()
```

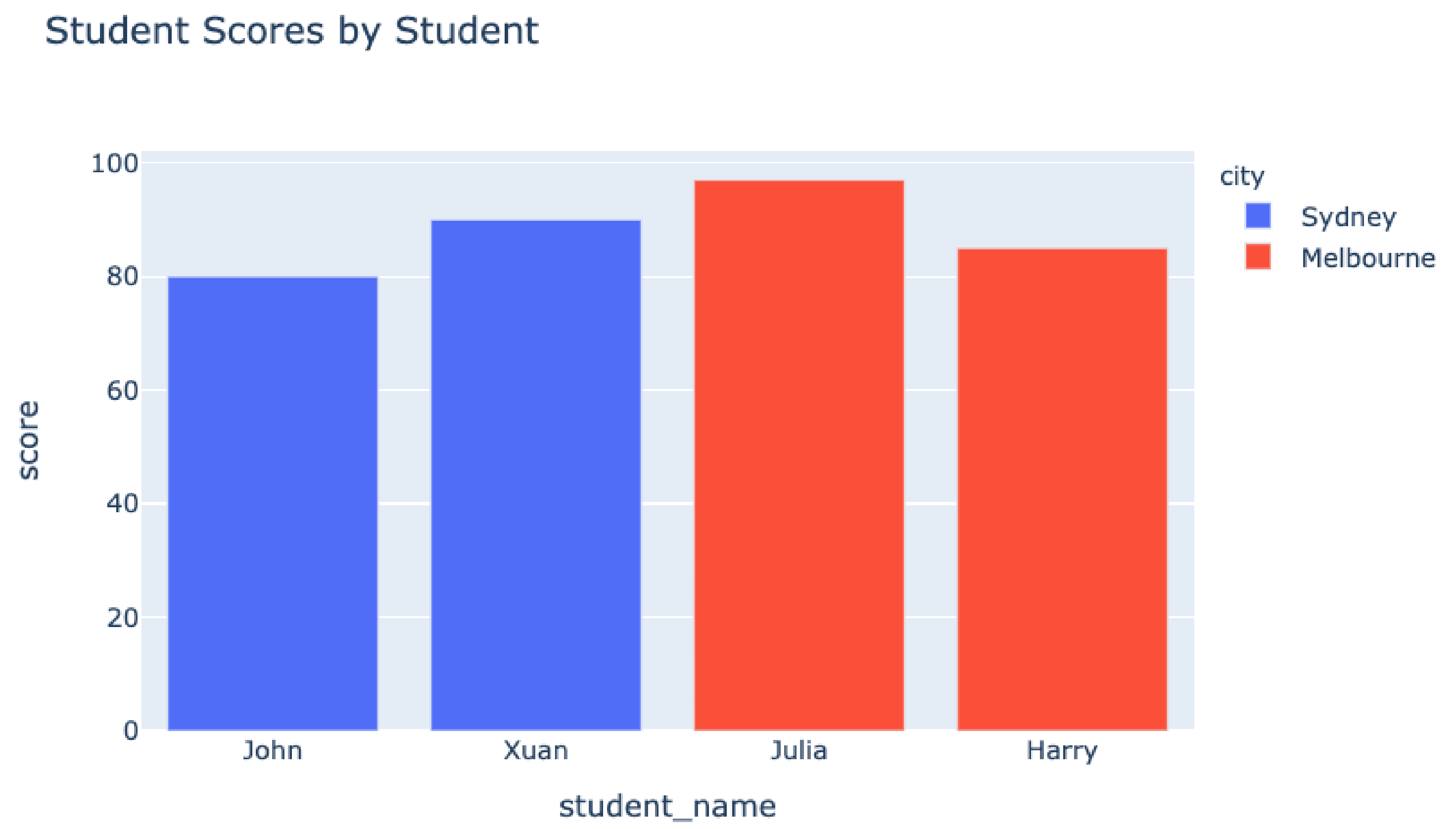
[1] Make sure to check the documentation for each figure.

Our colors revealed

The plot before:



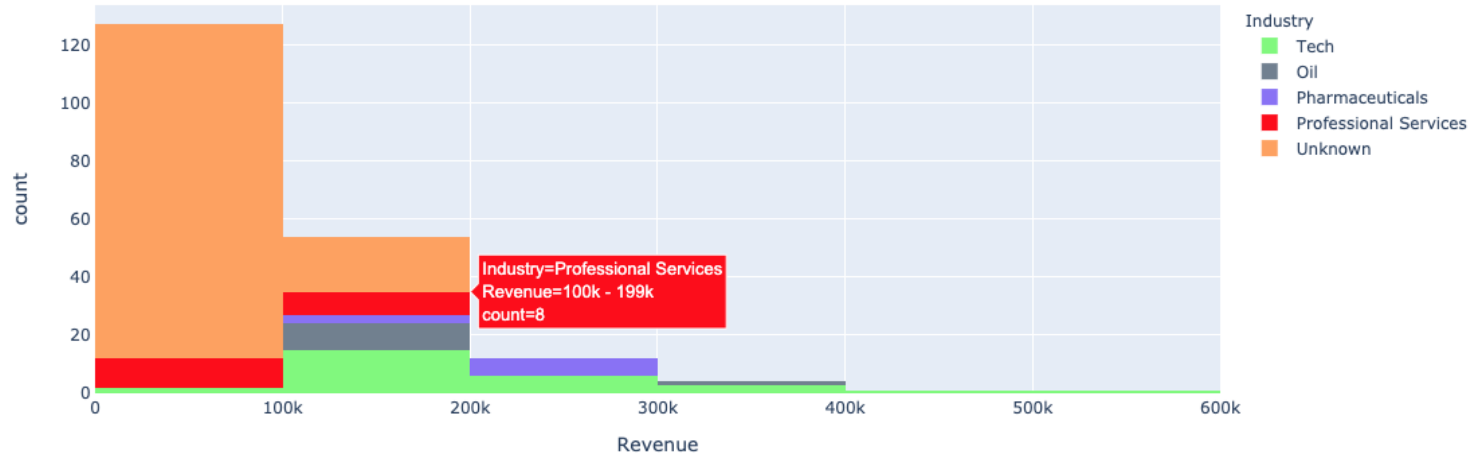
Our plot after:

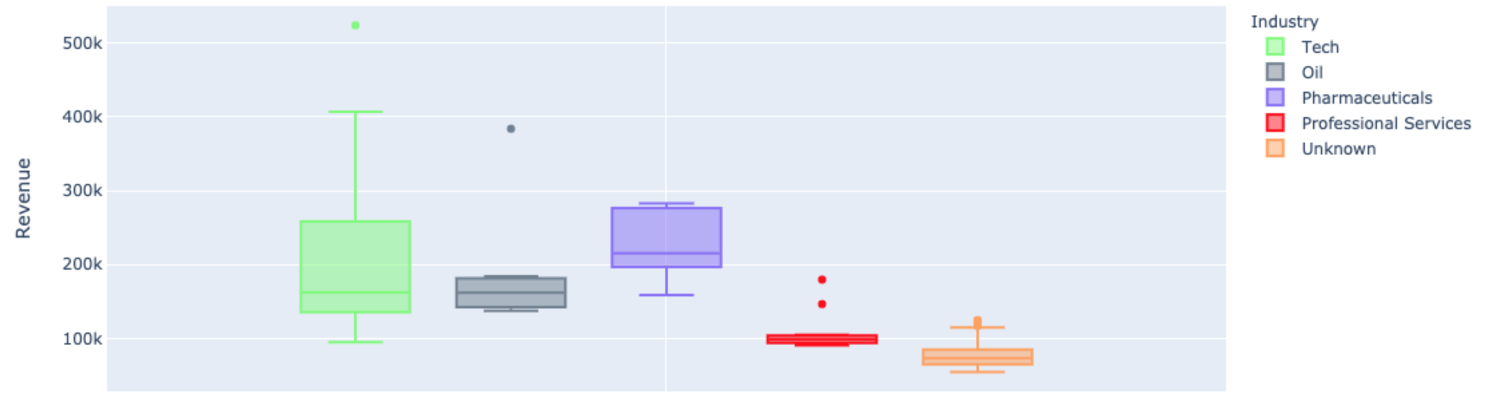


Color with univariate plots

Using `plotly.express` `color` argument with univariate (bar, histogram) plots:

- Histograms - stacked bars
- Box plots - produces multiple (one per category)





Specific colors in plotly.express

What if we don't like the automatic colors?

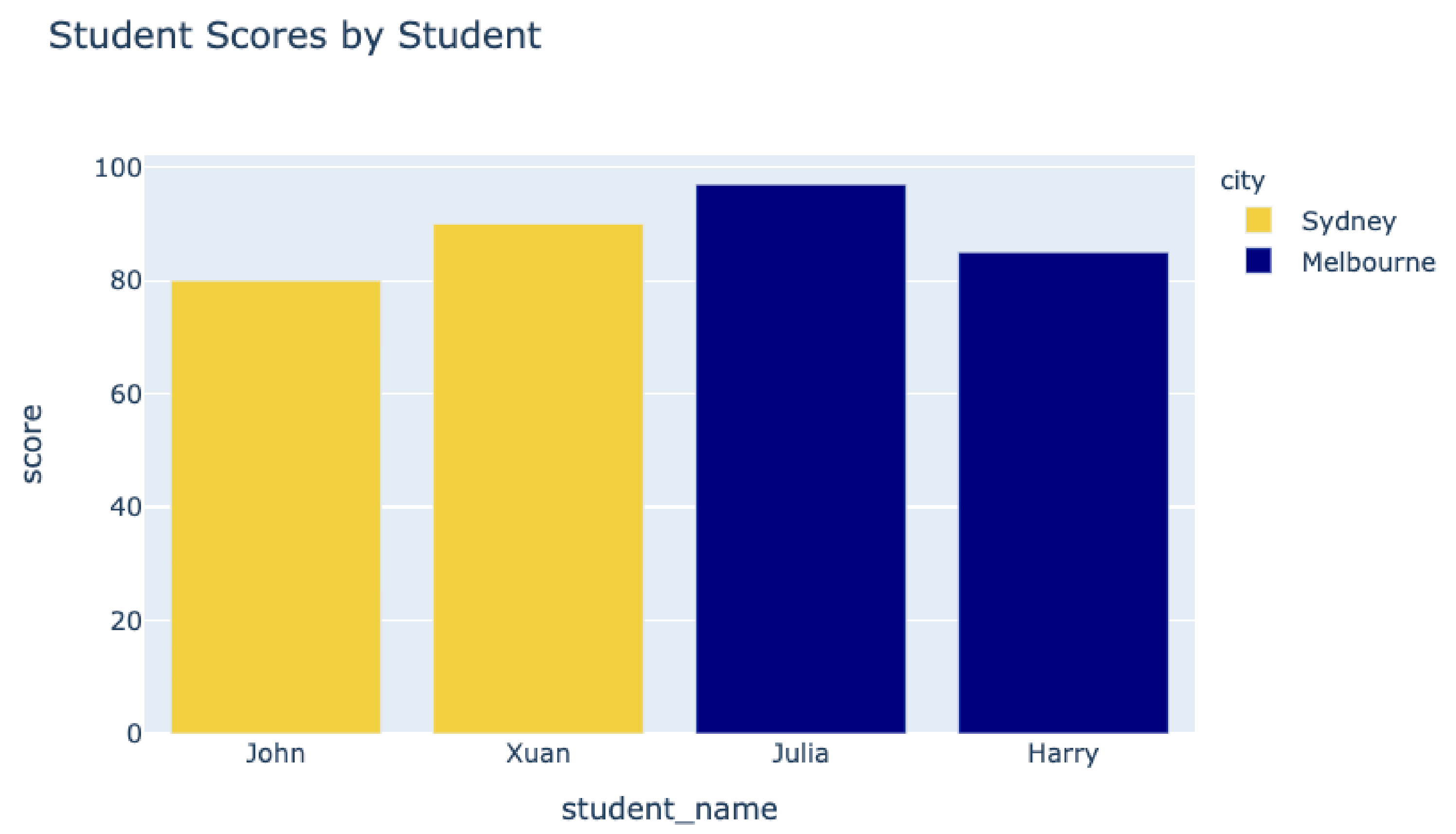
- `color_discrete_map` : A dictionary mapping specific categorical values to colors using a string RGB code specification — `'rgb(X,X,X)'`
- Can also express (basic) colors as strings such as `'red'` , `'green'` etc.

Our specific colors

Let's update our colors. Sandy yellow for 'Sydney' and navy blue for 'Melbourne'

```
fig = px.bar(
    data_frame=student_scores,
    x='student_name', y='score',
    title="Student Scores by Student",
    color_discrete_map={
    'Melbourne': 'rgb(0,0,128)',
    'Sydney': 'rgb(235, 207, 52)'},
    color='city')
```

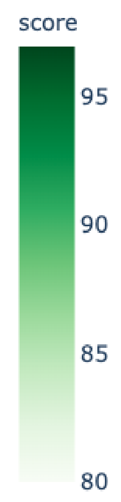
Produces:



Color scales in plotly.express

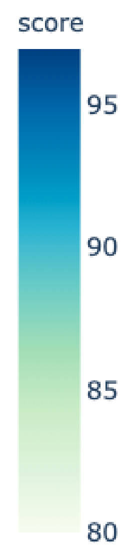
You can create color scales too.

- Single color scales. For example, light to dark green.



- Multiple colors to merge into each other. For example, green into blue.

`color_continuous_scale` allows us to do this with built-in or constructed color scales.



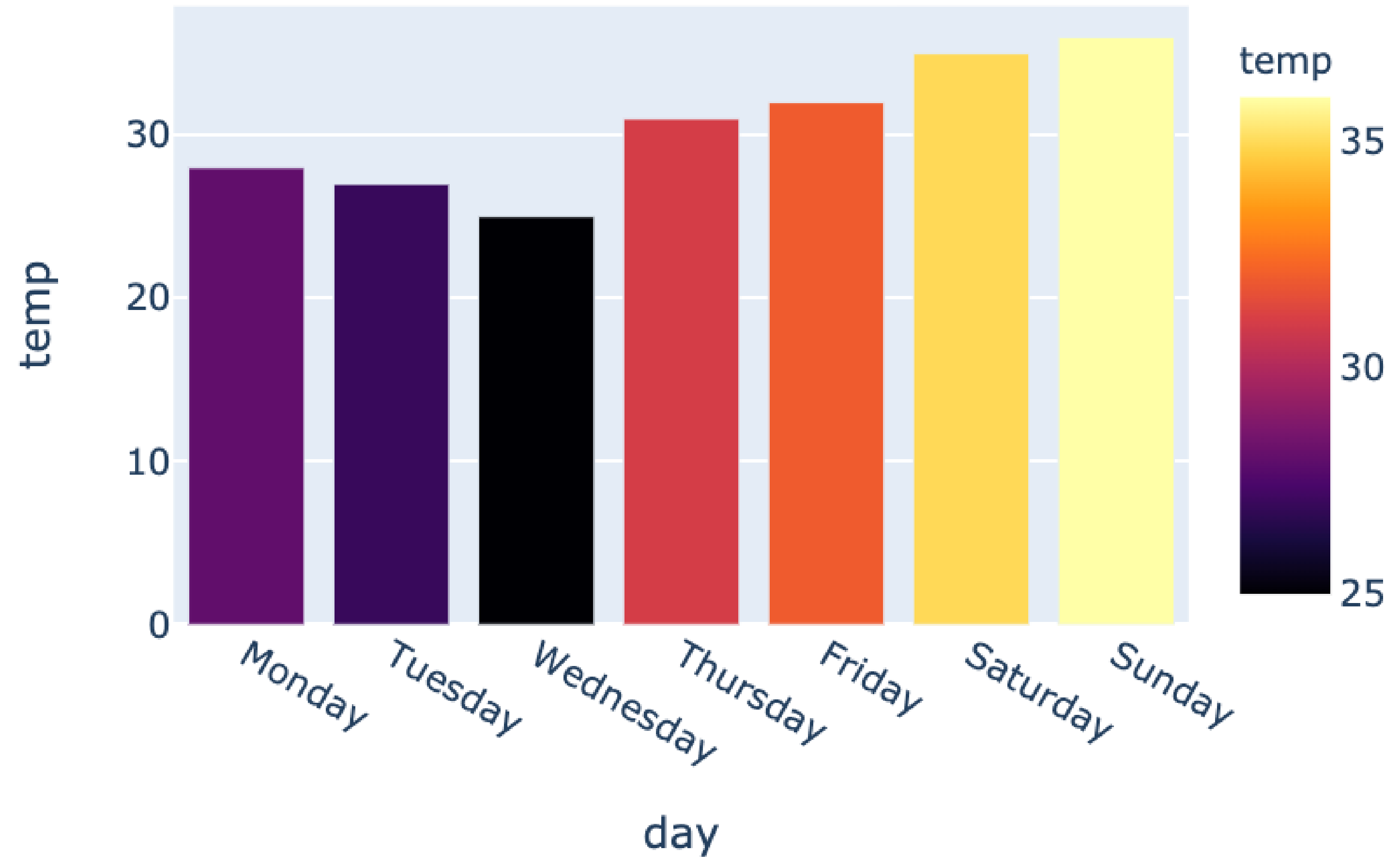
Using built-in color scales

Let's use a built-in color scale:

```
fig = px.bar(data_frame=weekly_temps,
    x='day', y='temp',
    color='temp',
    color_continuous_scale='inferno')
fig.show()
```

- Many **built-in scales** available

Our plot:

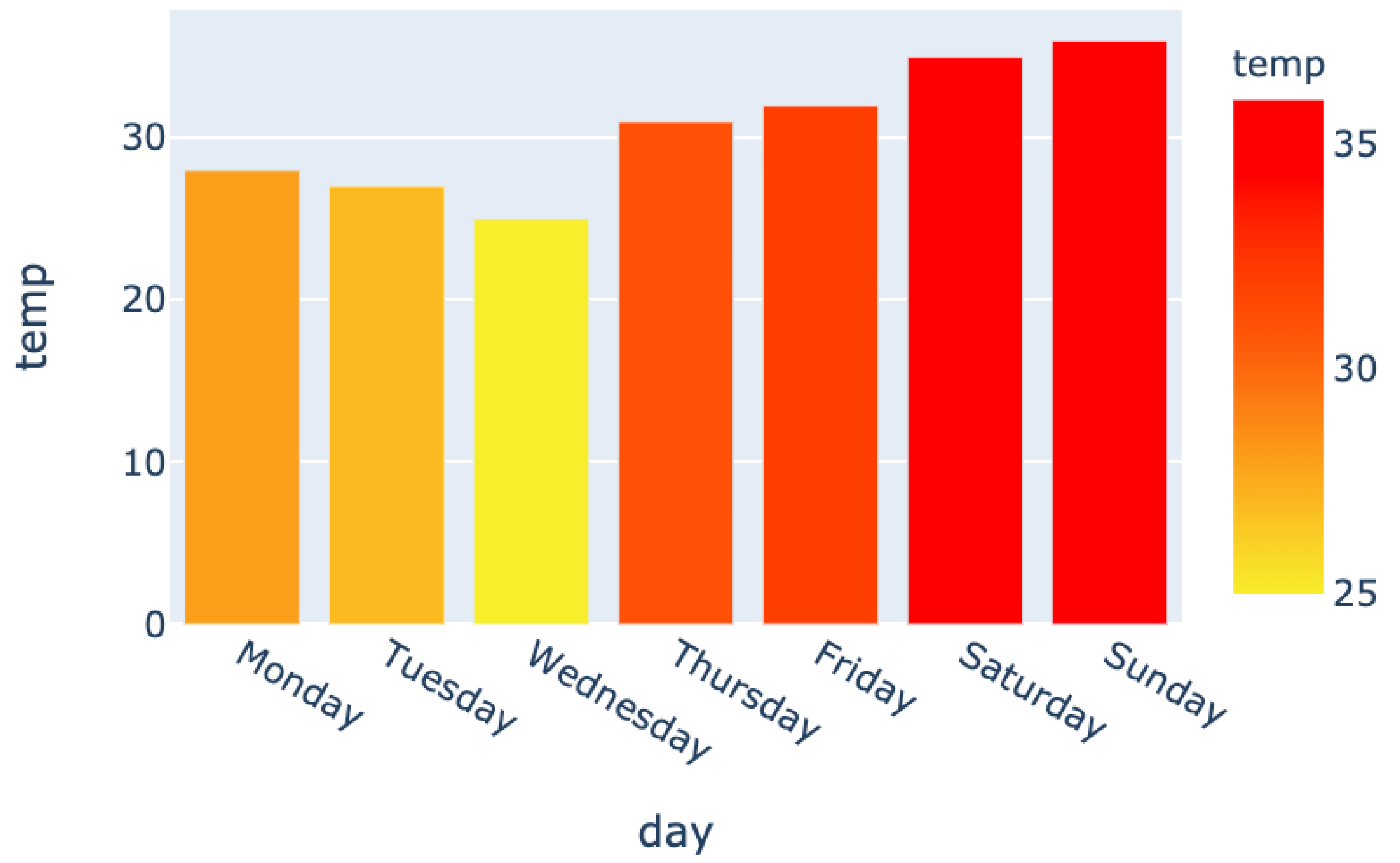


Constructing our own color range

Let's construct our own color scale - yellow through orange to red

```
my_scale=[('rgb(242, 238, 10)'),
          ('rgb(242, 95, 10)'),
          ('rgb(255,0,0)')]
fig = px.bar(data_frame=weekly_temps,
    x='day', y='temp',
    color_continuous_scale=my_scale,
    color='temp')
```

Our plot:



Let's practice!

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