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Histograms with Plotly Express: Complete Guide

One dataset, over 60 charts, and all the parameters explained

Most of the graphics are created with canva

A histogram is a special kind of bar chart showing the distribution of a variable(s).

Plotly.Express is the higher-level API of the python Plotly library specially designed to work with the data frames. It creates interactive charts which you can zoom in and out, switch on and off parts of the graph and a tooltip with information appears when you hover over any element on the plot.

All the charts can be created using **this notebook on the GitHub**. Feel free to download, play, and update it.

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Installation

Plotly.Express was introduced in the version 4.0.0 of the plotly library and you can easily install it using:

```
# pip
pip install plotly

# anaconda
conda install -c anaconda plotly
```

Plotly Express also requires pandas to be installed, otherwise, you will get this error when you try to import it.


There are additional requirements if you want to use the plotly in Jupyter notebooks. For Jupyter Lab you need `jupyterlab-plotly`. In a regular notebook, I had to install `nbformat` (`conda install -c anaconda nbformat`)

The Dataset

Histogram is used anytime you want to overview a distribution:

- occurrences of error over time
- finished products for each shift
- statistical distribution — height, weight, age, prices, salaries, speed, time, temperature, cycle, delta ranges

Plotly's histogram is easy to use not only for regular histograms but it's easy to use it for the creation of some types of bar charts. You can recognize the histogram from the bar chart through the gaps — the histogram doesn't have gaps between the bars.

I'll use my favorite dataset about tourist arrivals to the countries worldwide and how much they spend on their vacation. The data were preprocessed into a long-form — each category `Country Name`, `Region`, `Year` is a column and each combination of these categories occupy a row showing two data-values `number of visotors` and `receipts` locals got from these tourists in USD. Data about tourists go from 1995–2018.


	Country Name	Country Code	Region	years	visitors	receipts
58	Spain	ESP	Europe & Central Asia	1995	32971000.0	2.736900e+10
63	France	FRA	Europe & Central Asia	1995	60033000.0	3.129500e+10
94	Italy	ITA	Europe & Central Asia	1995	31052000.0	3.041100e+10
5003	Spain	ESP	Europe & Central Asia	2018	82773000.0	8.125000e+10
5008	France	FRA	Europe & Central Asia	2018	89322000.0	7.312500e+10
5039	Italy	ITA	Europe & Central Asia	2018	61567200.0	5.160200e+10
4730	Aruba	ABW	Latin America & Caribbean	2017	1070500.0	1.857000e+09
620	Tajikistan	TJK	Europe & Central Asia	1997	2100.0	0.000000e+00
4003	Mozambique	MOZ	Sub-Saharan Africa	2013	1886000.0	2.280000e+08

Sample of the preprocessed dataset — data about 2015 countries for 1995–2018

Plotly.Express can do miracles in case each category and each value is a column of the dataset. In the example I'll use:

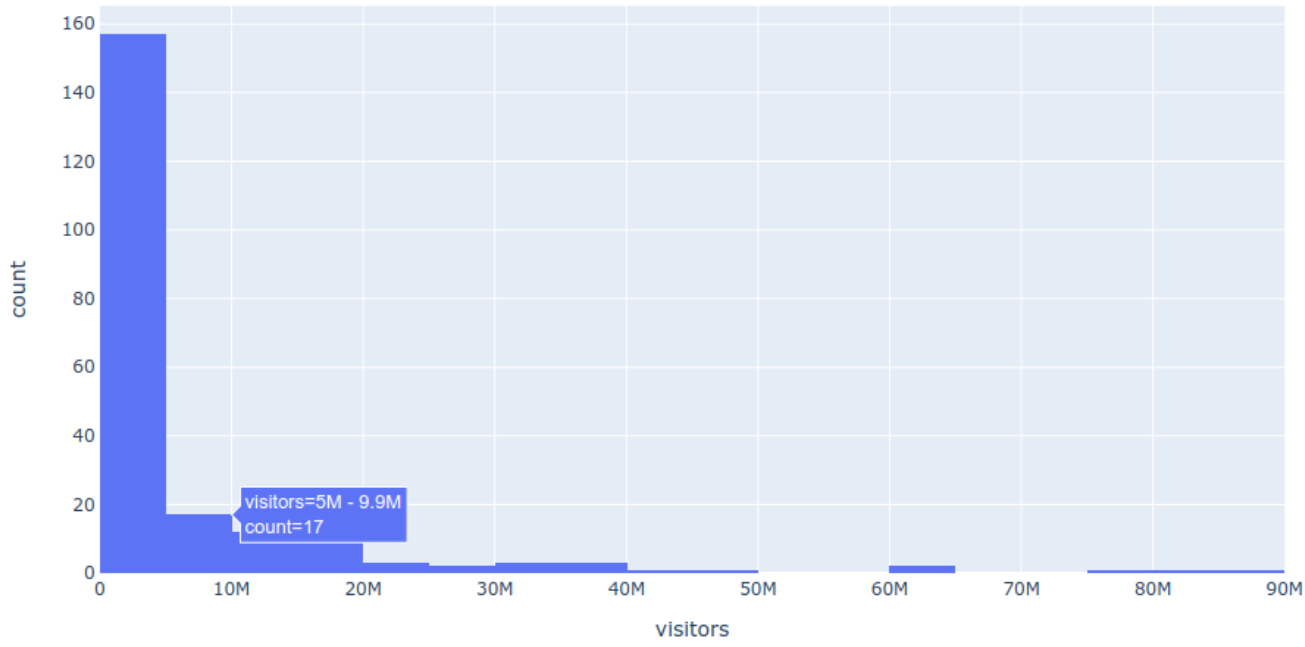
- `long_df` — full dataset for 215 countries and years 95–2018
- `yr2018` — data for the year 2018
- `spfrit` — data about Spain, France, and Italy

Types of histogram

The most usual histogram displays a distribution of a numeric variable split into bins. In our case, the number of visitors in 2018 is spread between 0 and 89 322 000.

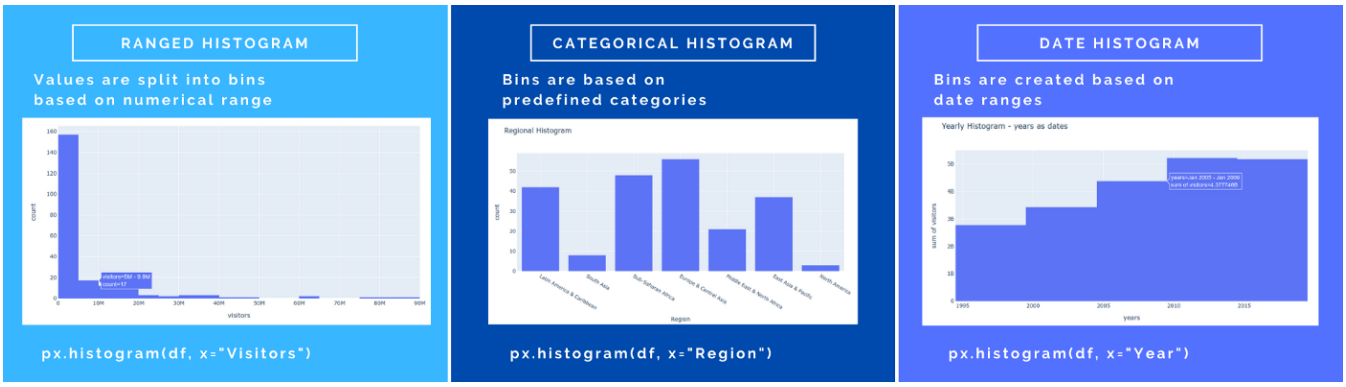
```
# import the libraries
import plotly.express as px
import pandas as pd

# create the simples histogram
px.histogram(yr2018, x="visitors")
```

The simples histogram split 215 countries into 18 bins each covering 5 million visitors range. The first bin includes 157 countries which were visited by 0–4.9M tourists, seconds 17 countries which attracted 5–9.9M visitors and so on.

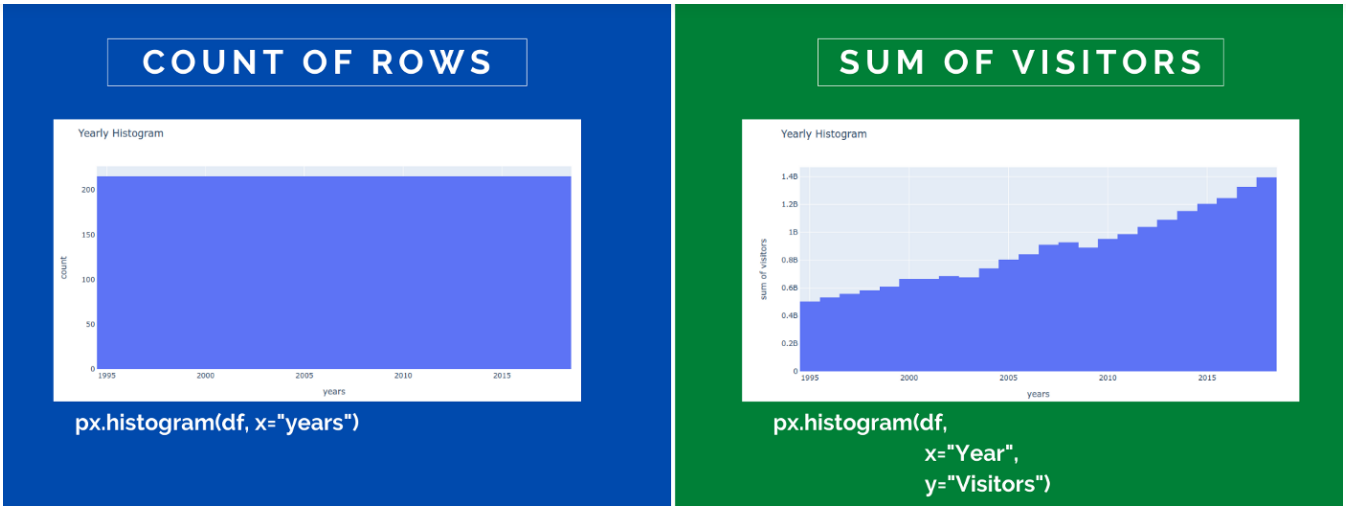
Simples histogram split the countries into bins

You have more options about how to create the bins, they can be based on a category (e.g. `Region` in our dataframe) or a date value which plotly split into bins containing several days, months or years.



Specifying the x variable to be a numerical, categorical or date column leads to different bins. In this case, the years can be numerical values and the resulting bins would be int(1995) till int(1999) or dates Jan-1995 till Jan-1999.

You might have noticed that ranged and categorical histograms show **count of countries** which fall into the bin, but date histogram shows **the number of visitors**. You can specify what column is aggregated into the histogram using `y` — parameter. Because our dataset contains 215 countries each year, counting the rows would result in a flat histogram



Specifying Y in Plotly Express histogram change the aggregation

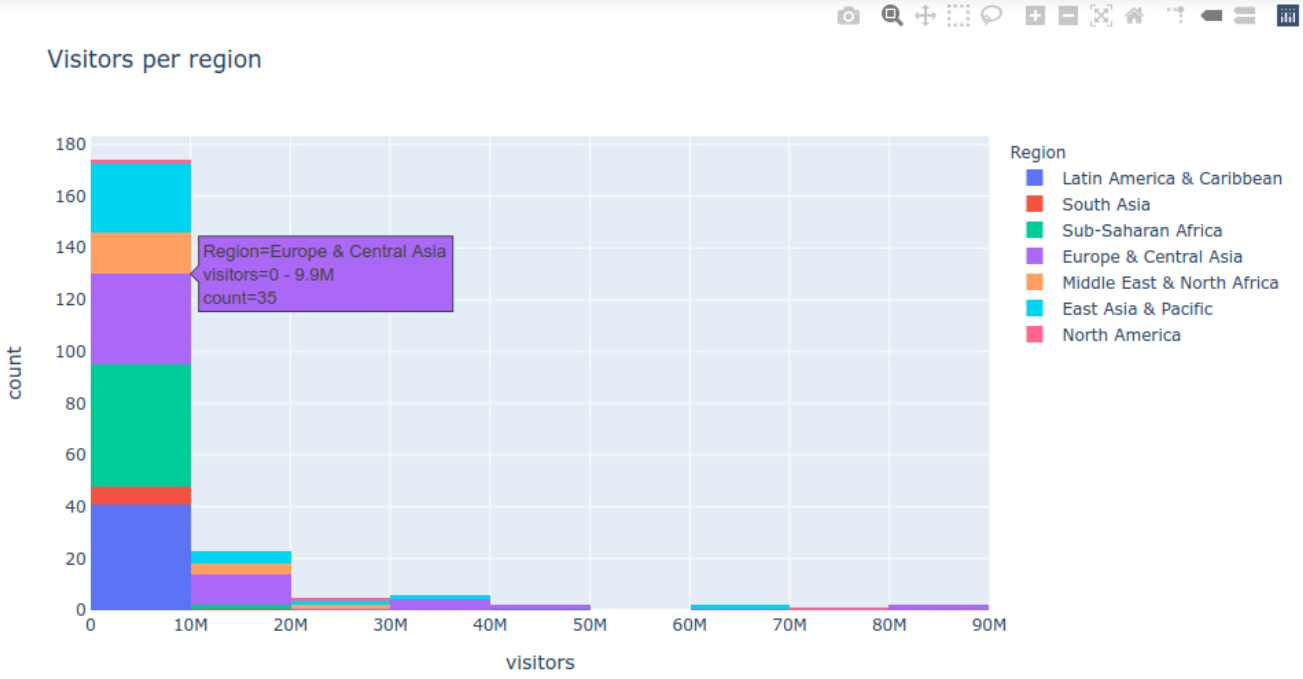
Parameters

Beside `x` and `y` plotly's histograms have many other parameters which are described in the documentation — histogram. Let's review them one by one, so that you get some idea how to include histogram into your next visualization.

Parameter: Color

Like all the other Plotly.Express chart, `color` parameter expects a column which contains some category and it will color values belonging to this category by a separate color.

```
fig = px.histogram(yr2018, x="visitors", nbins=10, color="Region",
title="Visitors per region")
fig.show()
```

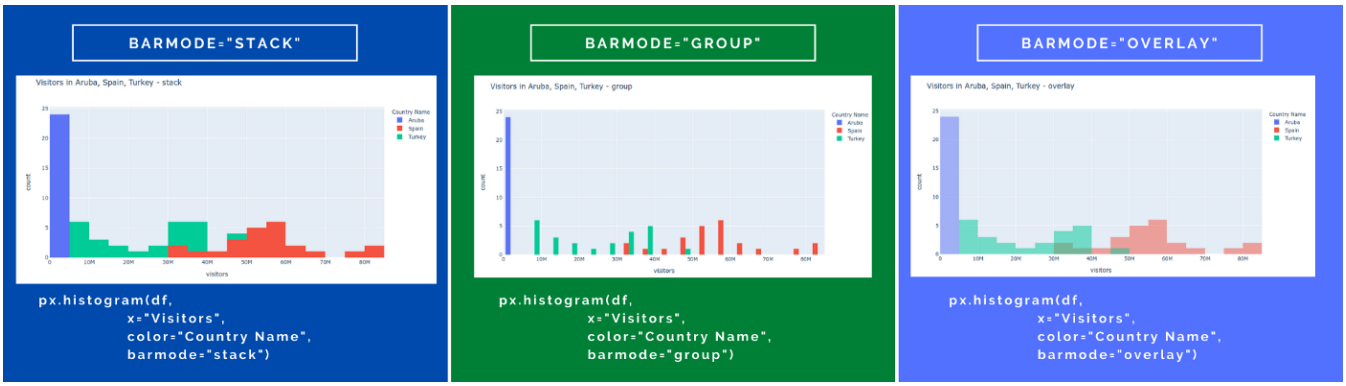


Define the color to specify the split of histograms by color.

Parameter: Barmode

Because the histogram is actually a bar chart, you can set three types of bars:

- `stacked` — values are stacked on top of one another
- `grouped` — shows histogram as a grouped bar chart
- `overlayed` — displays the semi-transparent bars on the top of each other

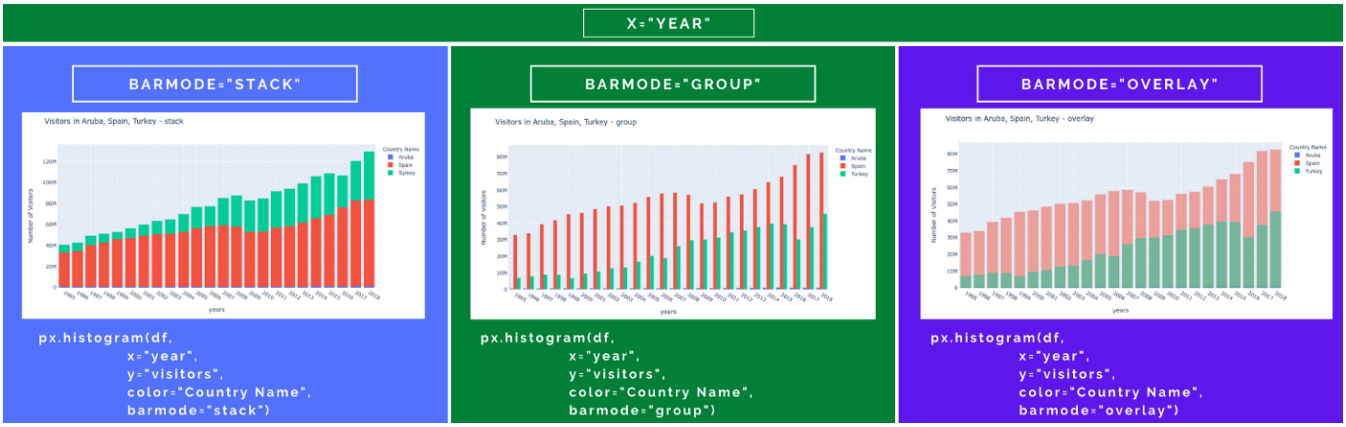


Combining color and the bar mode leads to different chart types. Barmode without splitting the groups by colors result always in the same chart.

The bars must be split by color so that `barmode` has any effect. In the example above we

If you're interested in how tourism evolved in these countries over the years, you can quickly achieve it by changing `x` and `y` parameters.

```
fig = px.histogram(sptuar,
             x="years",
             y="visitors",
             color="Country Name",
             barmode="group",
             title=f"Visitors in Aruba, Spain, Turkey - {barmode}")
fig.update_layout(yaxis_title="Number of Visitors")
fig.update_xaxes(type='category')
fig.show()
```



Plotly.Express is very versatile and by changing the x and y parameters you get a different plot.

Besides changing `x` and `y` I have also assigned the chart into a variable `fig` which allowed us to update the `yaxis` using `fig.update_layout(yaxis_title="title axis")` and more importantly, modify the year color not to be considered neither as `int` nor as `date`, but as a category which means every year has a separate bar `fig.update_xaxes(type="category")`.

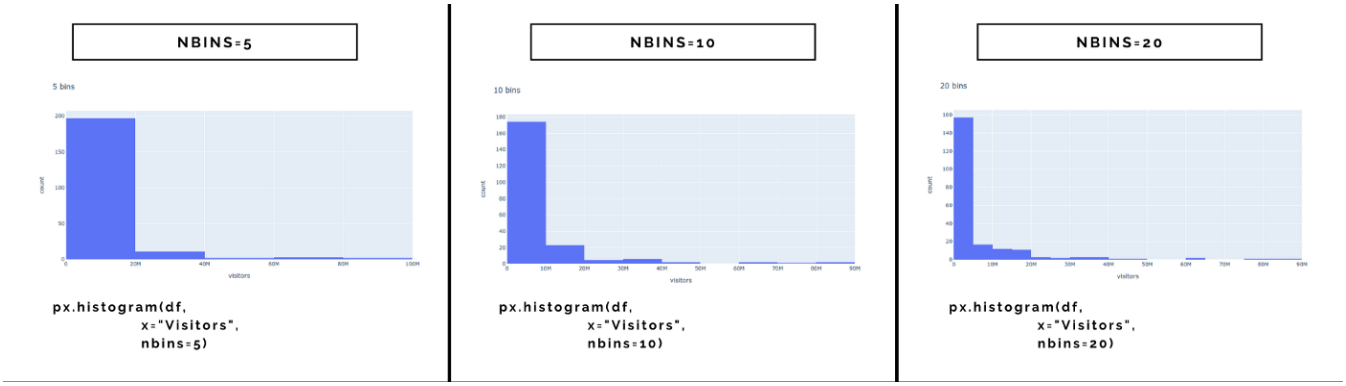
> *Plotly chart is stored as a dictionary in the background, which you can review by printing* `fig.to_dict()`

Parameter: nbins

If you use the categories, nbins parameter is ignored and plotly draws a bar for each category. But if your `x` is numerical or date type, plotly split your data into `n` number

But in reality, the number of bins usually differs. I have tried to run my chart with different `nbins` with these results:

- nbins = 3–2 bins
- nbins = 5–5 bins
- nbins = 10–9 bins
- nbins = 20–18 bins



Increasing the nbins parameter leads to higher number of bins

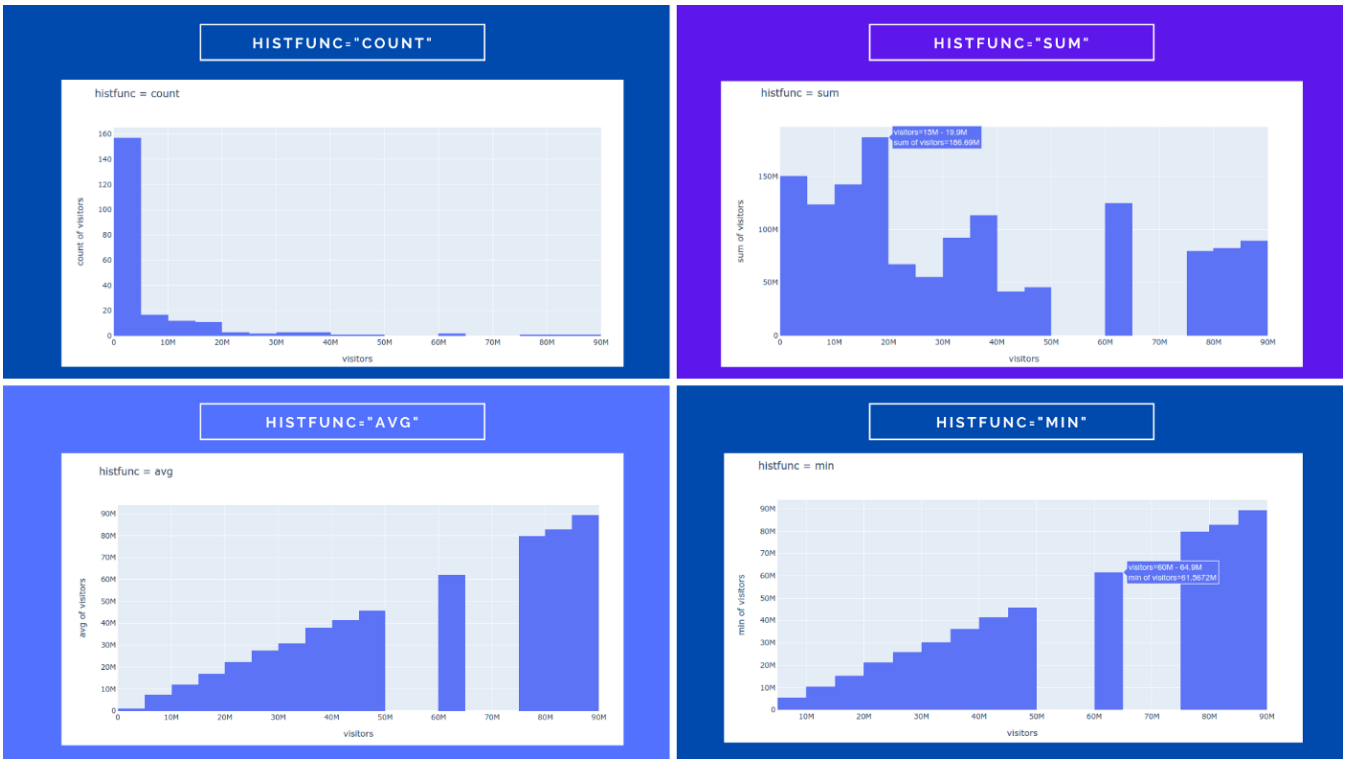
Even the example page about plotly histograms has nbins=20 resulting in 11 bins only. Though increasing the number usually leads to an increased number of bins. Plotly also determines where the bins start and end. For example, using years for binning can start the range in either 1990, 1994 or 1995.

- nbins = 3–3 bins (1990–1999, 2000–2009, 2010–2019)
- nbins = 5–5 bins (95–99, 00–04, 05–09, 10–14, 15–19)
- nbins = 10–5 bins (95–99, 00–04, 05–09, 10–14, 15–19)
- nbins = 20–13 bins (94–95, 96–97, 98–99, 00–01 …)

> *You have limited ability to influence the number and the ranges of the bins, but Plotly quickly evolves so this will most probably improve in the future versions.*

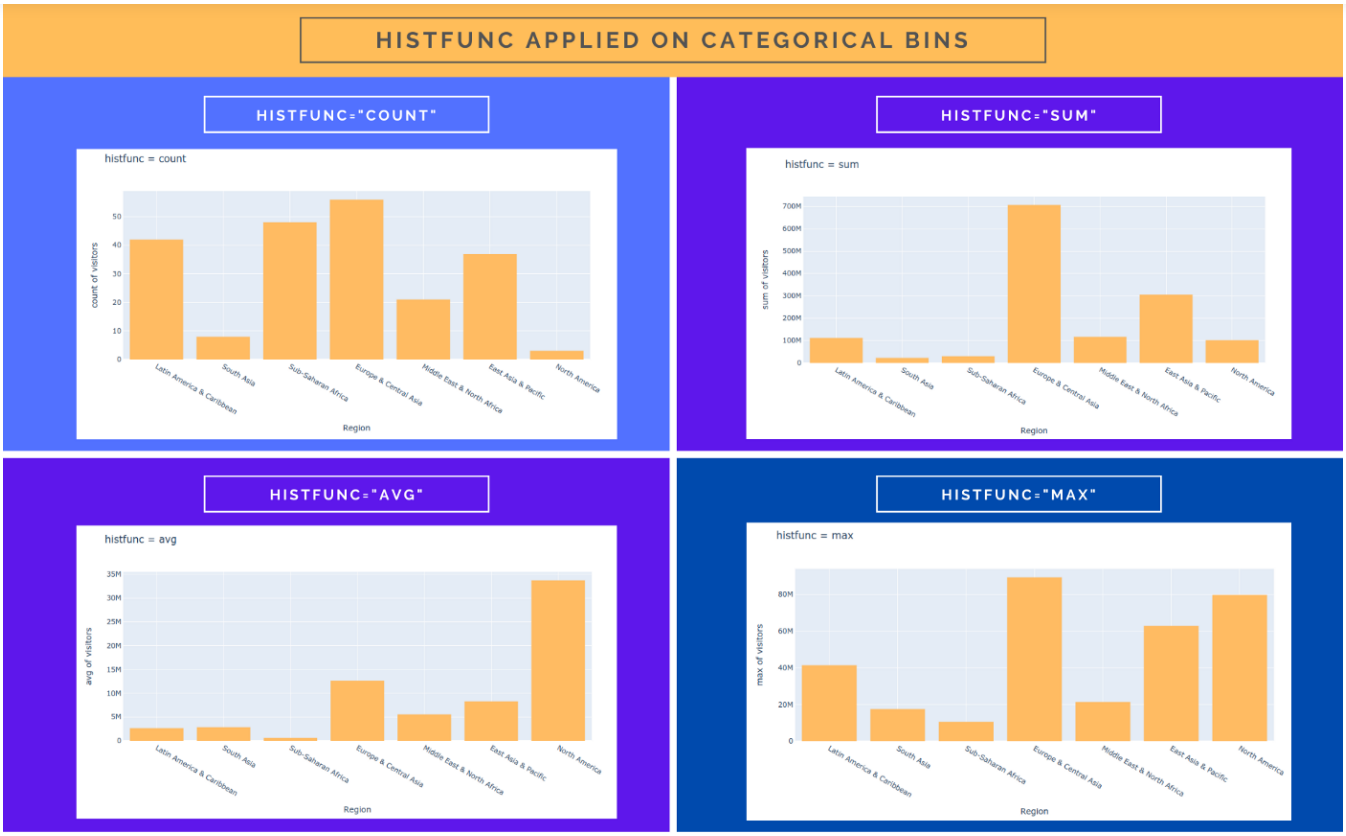
To get the complete power over the bins, calculate them yourself and plot using plotly

So far we have seen histogram counting and summing the values. Plotly's histogram allows to aggregate values using 5 functions — `count`, `sum`, `avg`, `min`, `max`.



Various parameter of Plotly's histfunc.

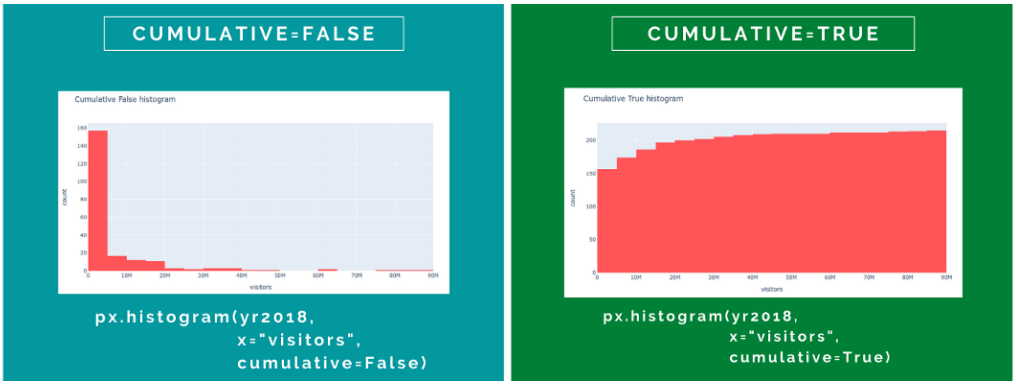
Of course, when we use ranged bins, then the avg yields the average of the bin, min its minimum and max the maximum, so the `avg`, `min` and `max` always form kind of raising stairs. In this case, it's more interesting to apply a histogram to the categorical values, which technically creates a bar chart.



Applying histfunc on the categorical bins shows that even though we have similar number of countries in Latin America, Africa, Europe and East Asia, that European countries are the most visited in total, while North American countries in average. The African country with the highest number of visitors doesn't exceed 12M.

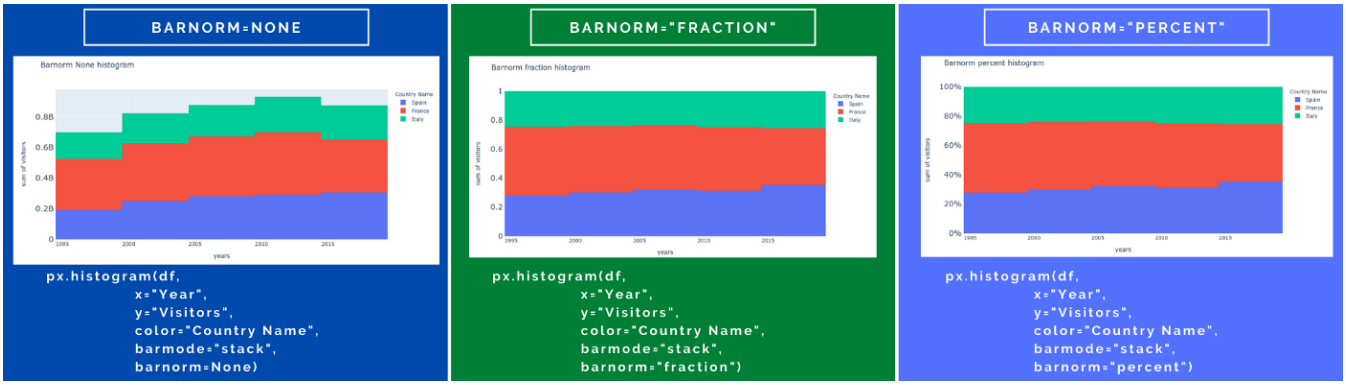
Parameter: Cumulative

If the cumulative parameter is set to `False`, the histogram displays the frequency (sum, avg …) as it is, though if it's `True` then each follow-up bar cumulates the values of all the preceding bars.



Cumulative histogram cummulates the values of all previous bars.

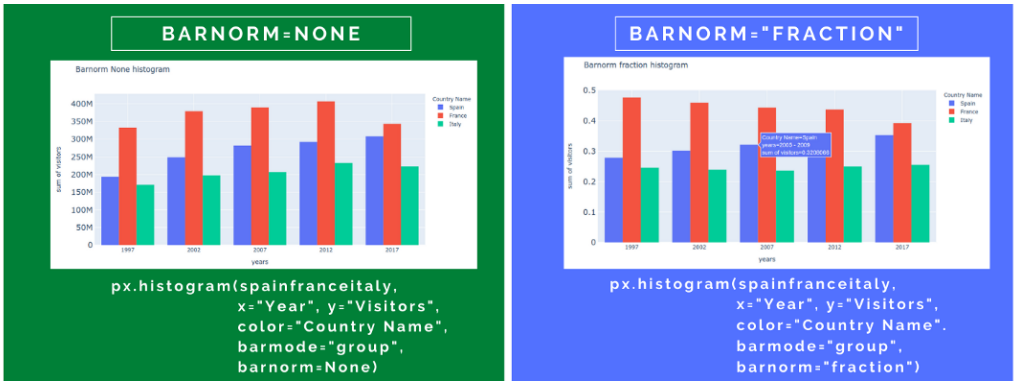
`fraction` or `percent`.



Barnorm being None, fraction or percent on the stacked histogram.

The last image on the right was modified adding a percent sign by `fig.update_layout(yaxis={"ticksuffix":"%"})`.

In case you apply barnorm on the grouped chart, the proportions remain the same, but the absolute values change to fractions or percentages:



Grouped histogram retain the proportions of the bars, but the axis labels change.

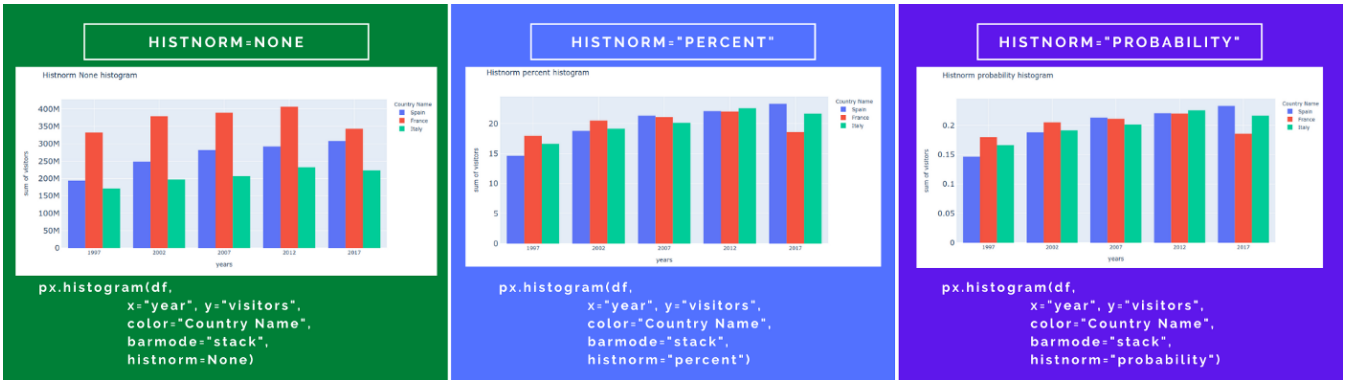
The `xaxis` was formatted so that the labels are bigger using `fig.update_layout(yaxis={"tickfont":{"size":18}})`.

Parameter histnorm

Sum of `barnorm` percentages for one bin equals to 100% while `histnorm` reaches 100% once all the bars with the same color are summed up. It offer 5 options:

- `None` — absolute value of the aggregate is displayed

- `density` — aggregate divided by total (the sum of all bar areas equals the total number of sample points)
- `probability density` — the output of `histfunc` for a given bin is normalized such that it corresponds to the probability that a random event whose distribution is described by the output of `histfunc` will fall into that bin (the sum of all bar areas equals 1)



First three parameters of the histnorm.

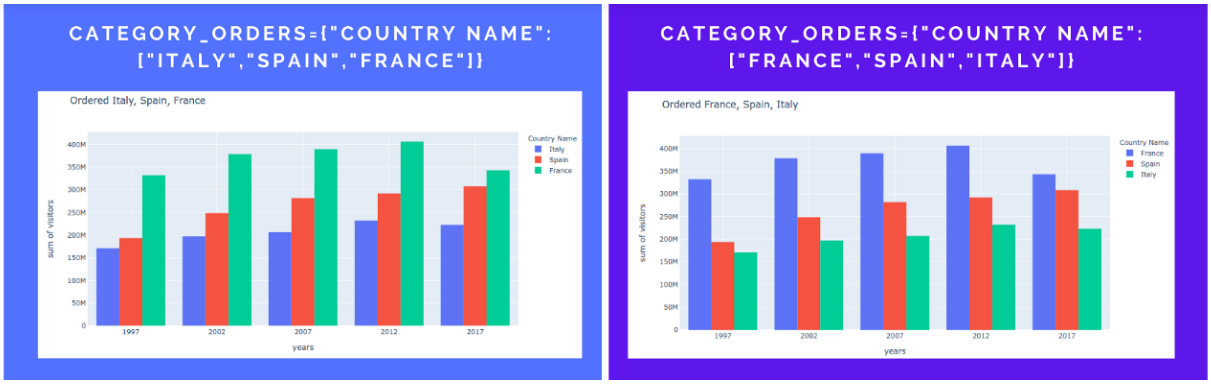
I have explored the `density` and `probability density` from several perspectives, but there might be a bug because the values for cumulative and ordinary chart per bin differs.

Parameter category_orders

When you divide the chart by `color` you might be interested in defining the order of these colored categories. By default, the order is based on the appearance in the input dataframe which can be hard to control. Using `category_order` let you order the categories on the plot.

You must specify for which column you define the order (as a dictionary). It's the column you used in the `color` parameter.

```
fig = px.histogram(spfrit,
      x="years",
      y="visitors",
      color="Country Name",
```

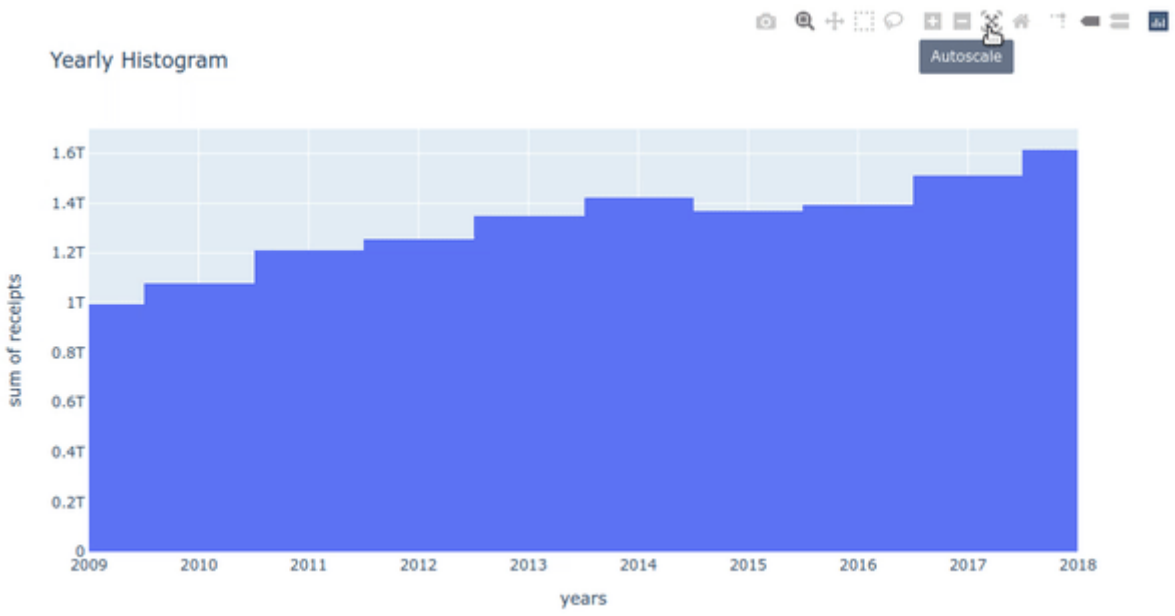


Plotly Express histogram parameters allowing to change the order of the categories

Parameters range_x and range_y

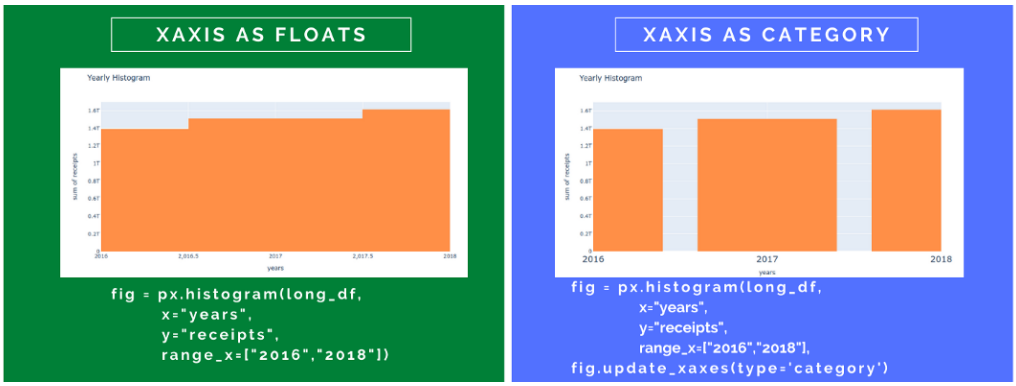
These two parameters don't change the chart's ranges, but they zoom in the data based on the boundaries set. You can always unzoom using Plotly's interactive menu.

```
fig = px.histogram(long_df,
                   x="years",
                   y="receipts",
                   range_x=["2009","2018"],
                   title="Yearly Histogram",
                  )
fig.show()
```



When you zoom in a lot, you can see that plotly thinks that the years are `floats`.

`fig.update_xaxes(type='category')` . That will hoverer change the histogram to a bar chart and gaps between the bins will appear.



Bins as numbers can get unexpected grid lines with decimals while categorical histogram turns into bar chart with gaps.

Parameter color_discrete_sequence

The color_discrete_sequence parameter lets you influence the color of the bars. The simples histogram has all the bars having the same color, which you can change using:

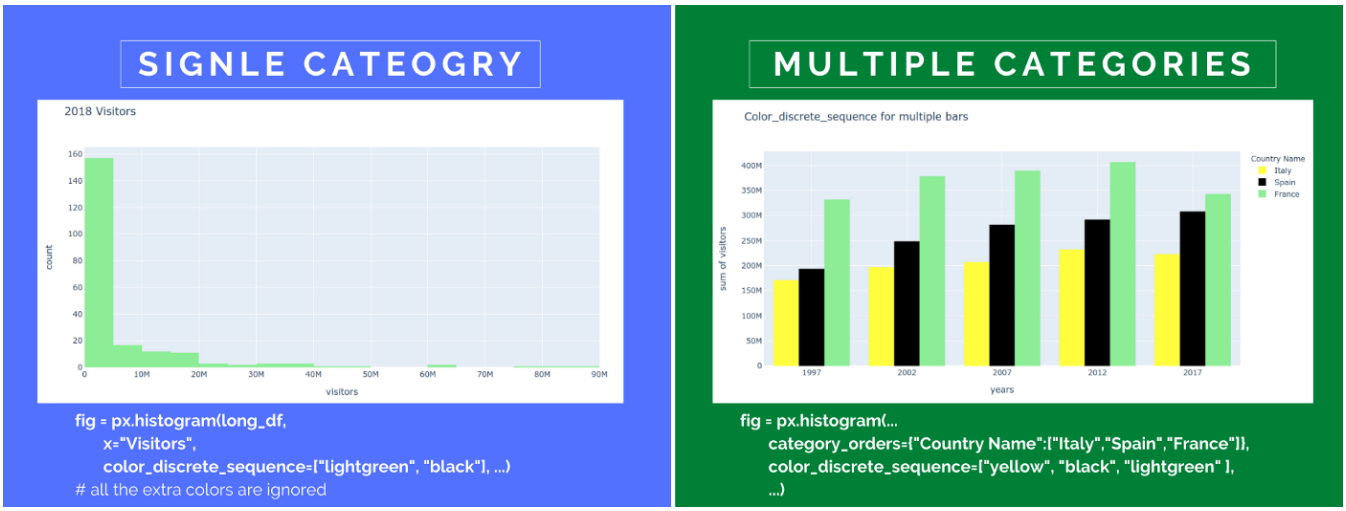
```
px.histogram(df, x="column",
    color_discrete_sequence=["blue"])
```

Plotly expects a list as input, so you have to wrap your color into a list `["#00ff00"]` . You can use either color name — blue, red, lightgrey and if you don't guess the correct name, plotly's error will provide the full list of colors accessible by name:

```
ValueError:
    Invalid value of type 'builtins.str' received for the 'color'
property of histogram.marker
        Received value: 'lightgreene'

    The 'color' property is a color and may be specified as:
      - A hex string (e.g. '#ff0000')
      - An rgb/rgba string (e.g. 'rgb(255,0,0)')
      - An hsl/hsla string (e.g. 'hsl(0,100%,50%)')
      - An hsv/hsva string (e.g. 'hsv(0,100%,100%)')
      - A named CSS color:
            aliceblue, antiquewhite, aqua, aquamarine, azure
```

You can also use hash string or rgb/rgba, hsl/hsla and hsv/hsva (google this term if they don't right the bell). The last `a` stands for `alpha` which controls the opacity of the bar.

If you list more than one color for an un-split histogram where you don't use the `color` parameter, only the first color in the list is applied. When you split the bars using `color` the tints you provide in the `color_discrete_sequence` will paint bars in each category. You can change the order or categories using the previous param — category_orders.



If you can only one category, the first color in the list is used for all bars. Having multiple categories, you can specify more colors. If you don't set as many colors as you have categories, the first one is used for those unspecified.

If you are not certain which colors to pick, but you want to have the colors which fit together, try some prebuild color sets which are part of plotly.

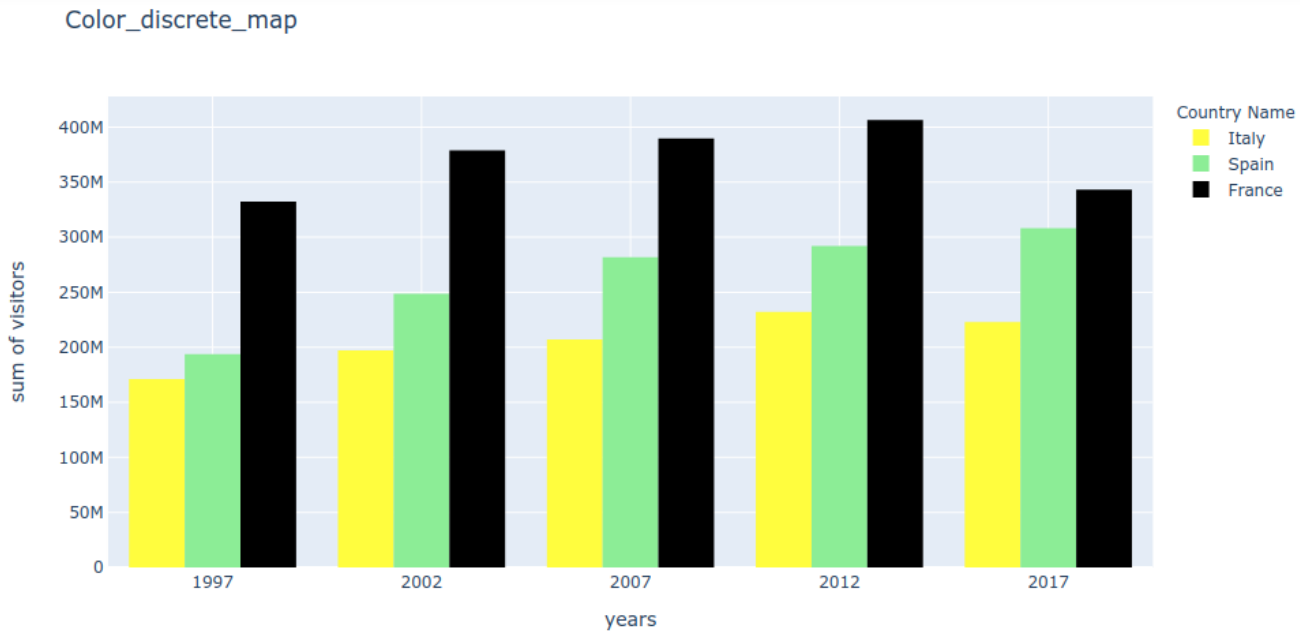
```
fig = px.histogram(...
color_discrete_sequence=px.colors.qualitative.Pastel2,
...)
```

Using qualitative.Pastel2 build in color sequence.

Parameter color_discrete_map

You can assign the colors using a dictionary as well. In that case you use the parameter `color_discrete_map`. The keys of this dict are the values in the column specified in `color`.

```
px.histogram(df, x="column",
color="Country Names",
color_discrete_map={
    "Spain":"lightgreen",
    "France":"rgba(0,0,0,100)",
    "Italy":"#FFFF00"}
)
```

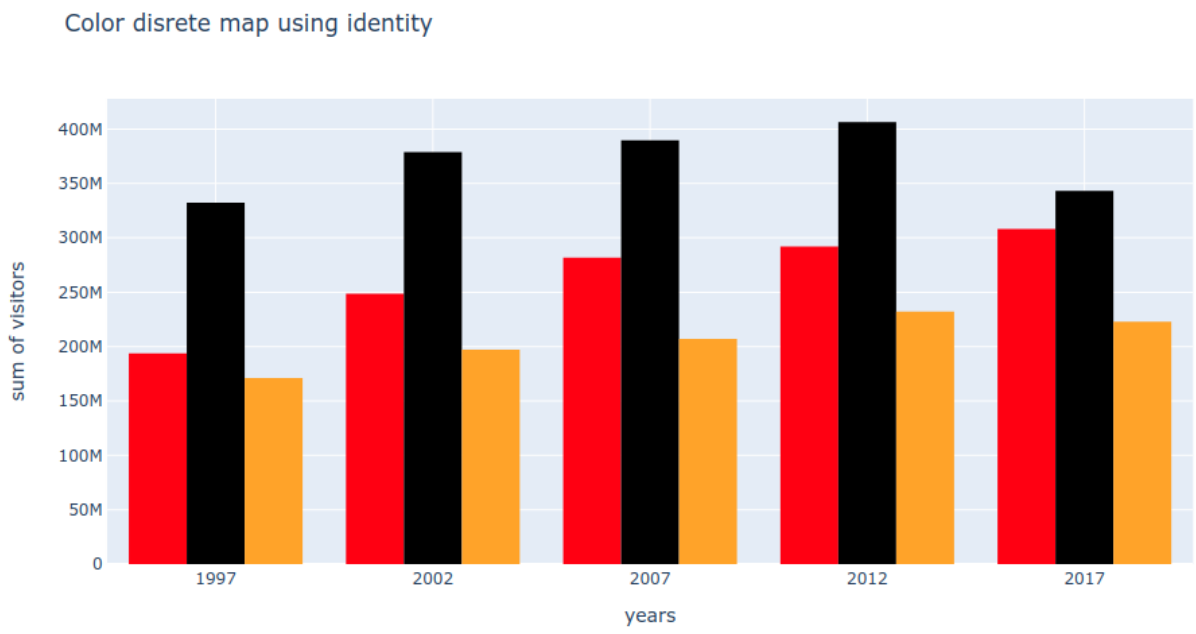


Colors set using color_discrete_map

There is also an option to use a column in the data frame which contains the names of the colors or their hash codes. In the case you use `color="column with colors name"` and `color_discrete_map="identity"` . The downside of this approach is that you lose the interactive legend, because it doesn't contain the names of the categories (e.g. Country Names) anymore, but the names of the colors.

```
# create a color column specifying color for each of the countries

spfrit["color"] = spfrit["Country Name"].map(
{"Spain":"red",
"France":"black",
"Italy":"orange"}
)

# spfrit now contains:
# country_name year visitors color
# Spain        1995 32971000 red
# France       1995 60033000 black
# ...

""" Parameter color_discrete_map using identity in case color
contains real color names/hex codes """

fig = px.histogram(spfrit,
```

```
 color_discrete_map="identity"
)
fig.show()
```



Legend is missing if you use color_discrete_map="identity", but you can use existing column with color names to specify the color of the bars

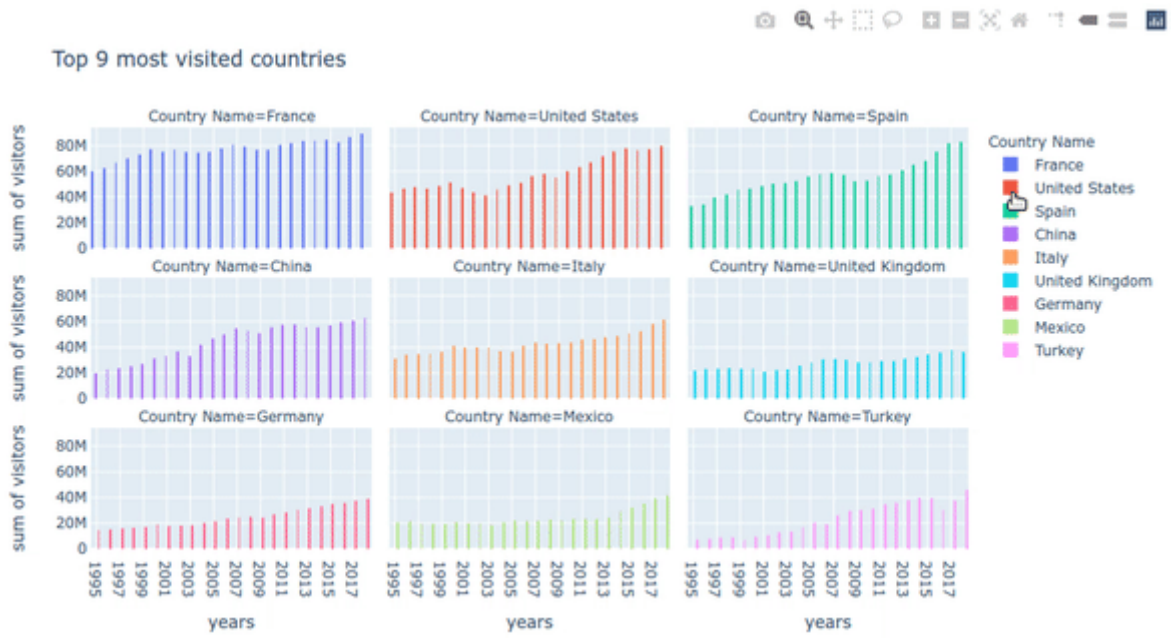
Parameters facet_col and facet_row

Sometimes you prefer to show the categories separately next to each other in the columns or on the top of each other in rows. `facet_col` and `facet_row` parameters are destined for this purpose.

```
px.histogram(df,
  x="value column",
  color="column",
  facet_col="column")
```

If you have too many columns you can split them after every x-th column by parameter `facet_col_wrap` . The following example shows 9 categories split after 3 columns by `facet_col_wrap=3`

```
px.histogram(df, x="value column",
  color="column",
  facet_col="column",
  facet_col_wrap=n)
```

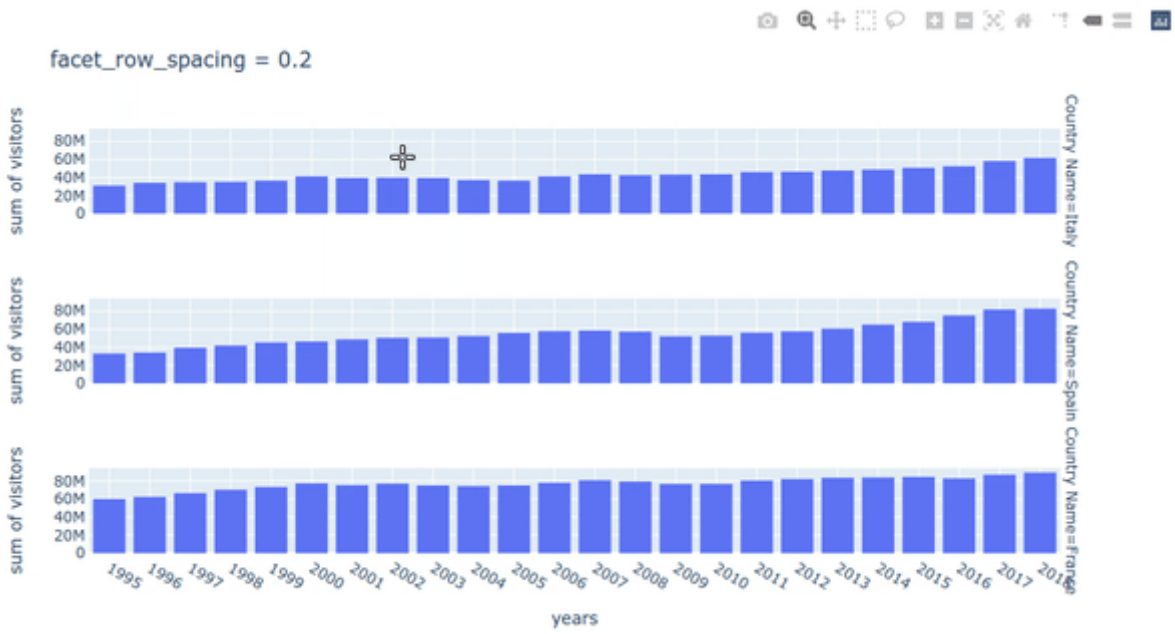


9 different categories split into 3 rows using `facet_col_wrap=3`

> *All the plots are connected so that when you zoom in or pan one of the graphs, all the others will change as well.*

Rows don't have facet_row_wrap argument, but you can adjust the spacing between the rows via `facet_row_spacing` .

```
    facet_row="column",
    facet_row_spacing=0.2)
```



Facet_row_spacing creates a gap between the rows. When you zoom in on one row, all the others zoom too.

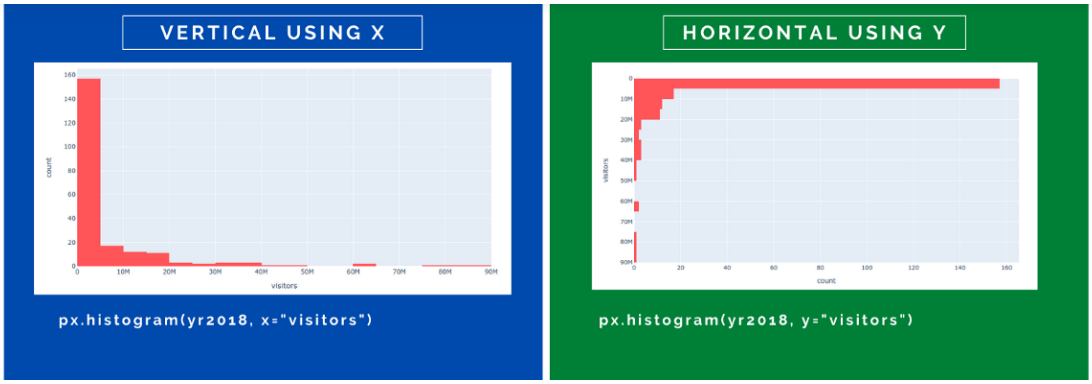
Parameters hover_name and hover_data

Hover_name and hover_data influence the look of the tooltip. `hover_name` highlights the column on the top of the tooltip and `hover_data` allow to remove or add a column to the tooltip using

```
hover_data={
# to remove
"Column Name 1":False,

# to add
"Column Name 2":True
}
```

These parameters always worked well in plotly, but in the case of histogram there's some bug and `hover_name` doesn't work at all while `hover_data` only works sometimes.

Parameter orientation

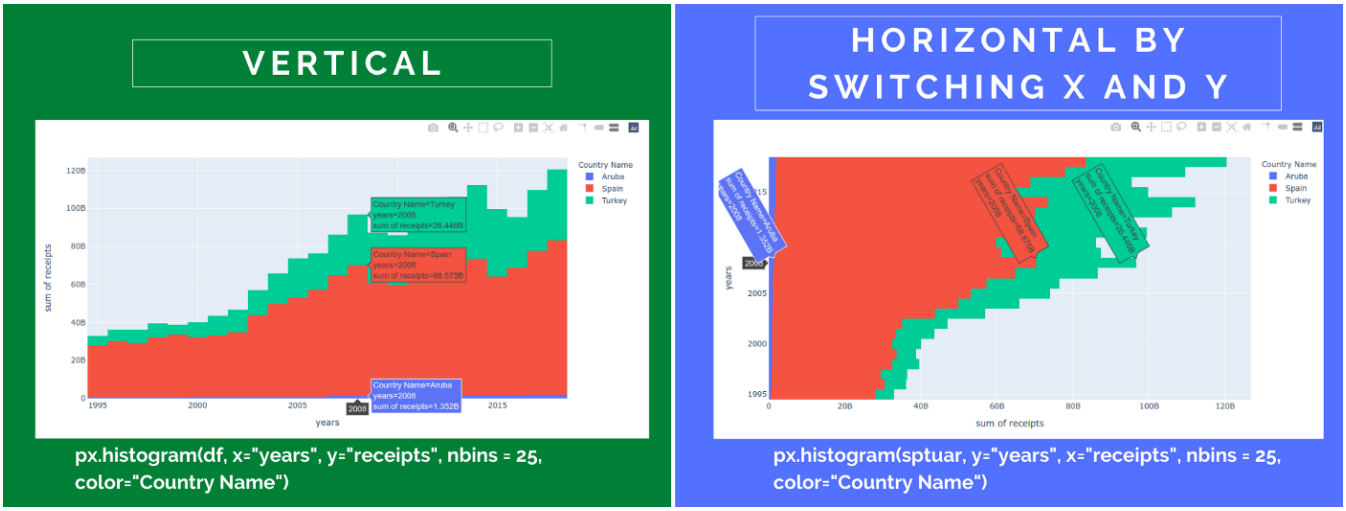


Rather than the orientation parameter, the vertical or horizontal bars are influenced by the x and y parameter.

If you need to reverse the order of the axes, so that the lowest numerical bin is on the top rather than the bottom, use:

```
fig.update_yaxes(autorange="reversed")
```

The same applies in case you specify both `x` and `y`. By switching them you turn the horizontal plot into a vertical one and v.v.

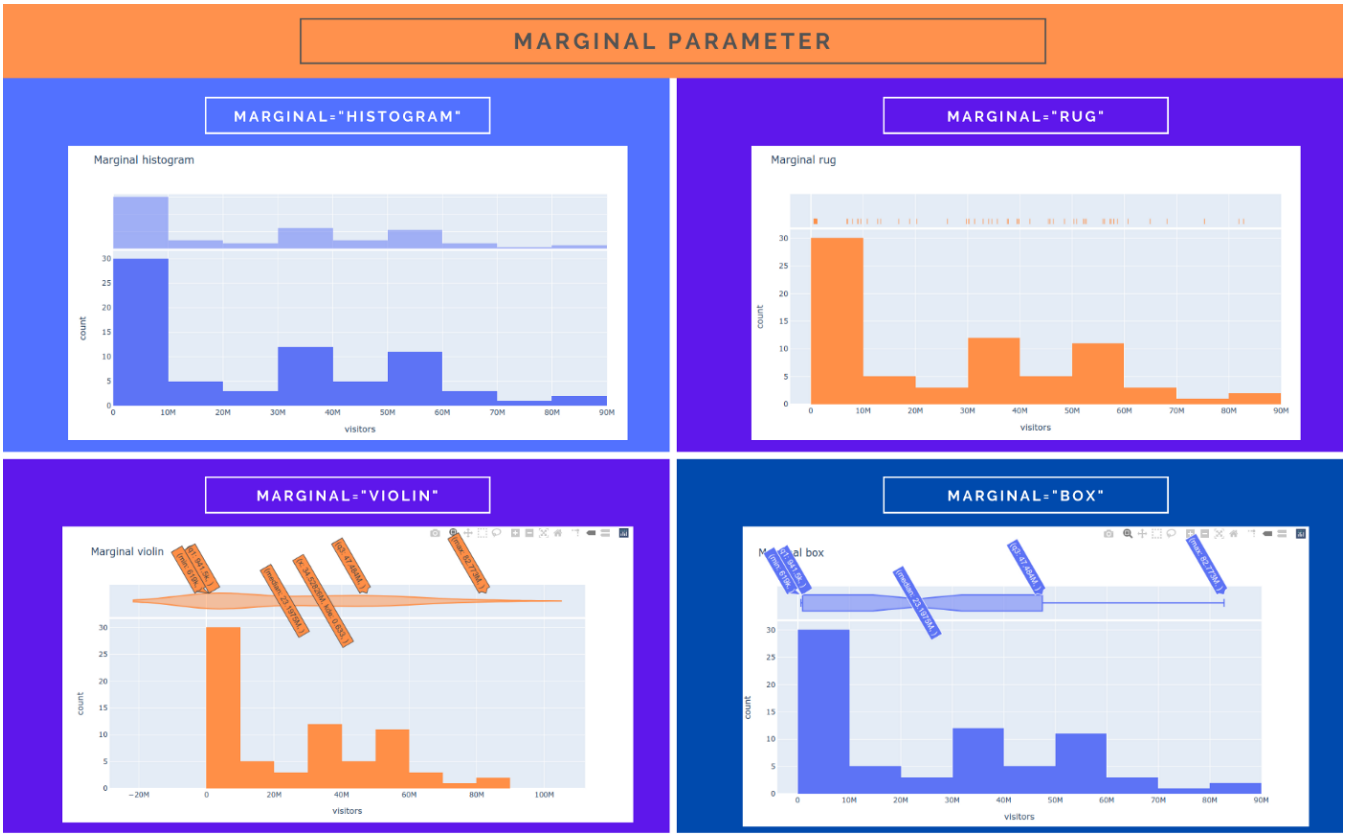


Changing x=”years” to y=”years” you change the orientation.

On the picture above you can see that hover shows tooltips for all the categories. It’s because I’ve clicked on the `Compare data on hover` icon (second from the right) in the Plotly menu.

marginal plot:

- `histogram` — which is basically the same as the histogram below it
- `rug` — which shows exact spots of each data value within the
- `violin` — doing the violin plot, estimating the probability density of the variable
- `box` — box plot highlighting the median, first and third quartile



4 types of marginal parameter — histogram, rug, violin and box. The plots appear above the vertical histogram and are also interactive.

Marginal plots can be drawn even for more than one category. In such a case a separate marginal chart will be calculated. Note that in this case, you cannot use `barmode="group"`.

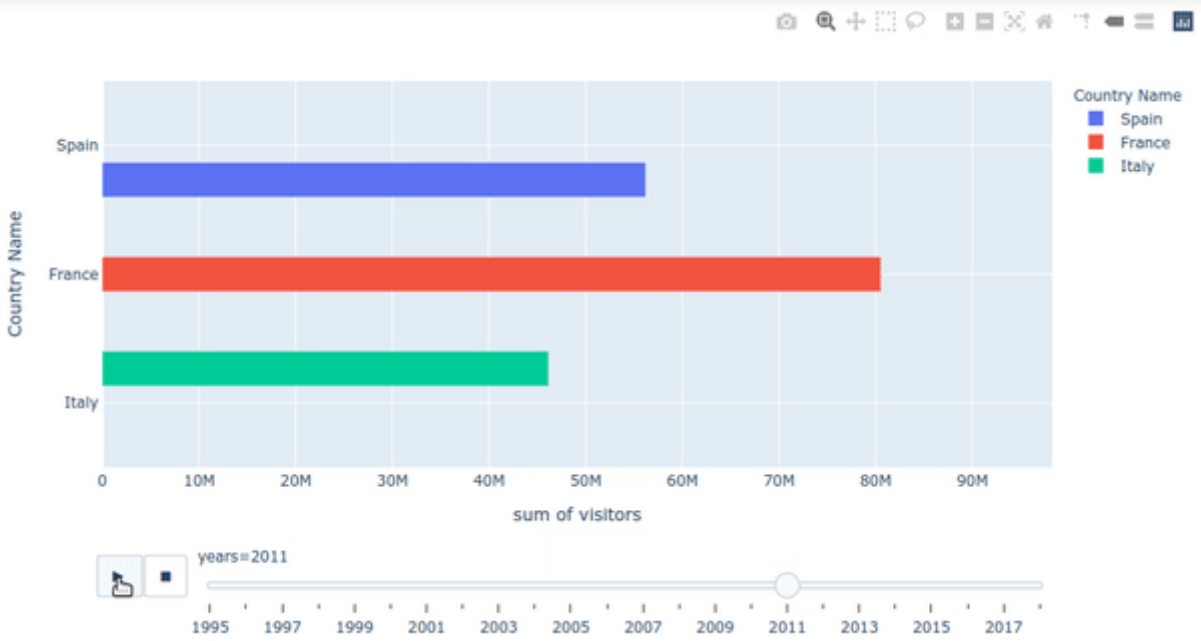
Vertical and horizontal martial charts of four types in case of multiple categories

Parameter Animation_Frame

The last parameter we will discuss today is another interactive feature of Plotly which let you animate the chart. Adding a single parameter `animation_frame="years"` turns the plot into an animation which can be started by the `play` and `stop` buttons or you can navigate to separate slides by clicking to the menu.

It's often necessary to specify the range of the animated chart to avoid changes in the dimensions of the grid.

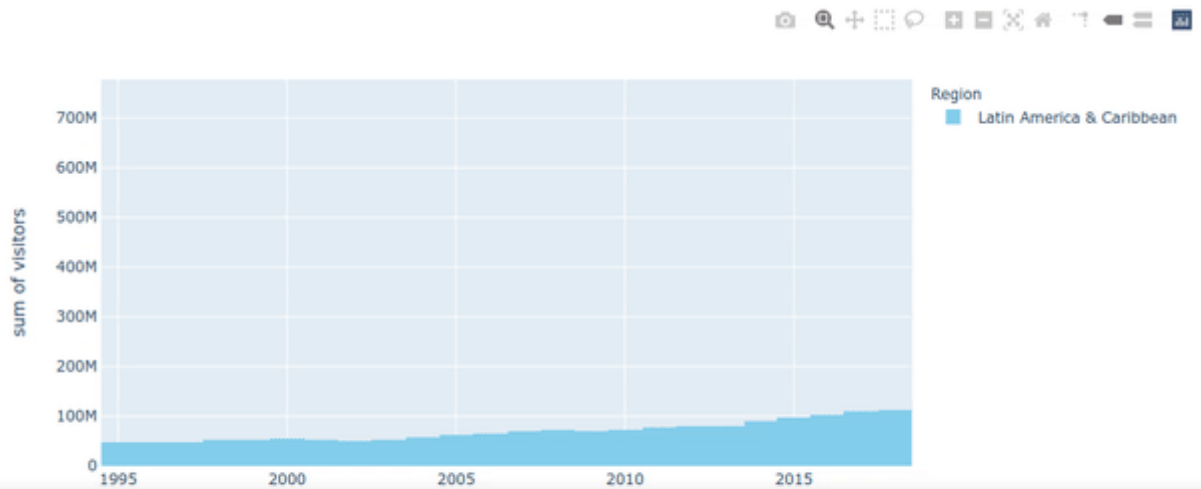
```
px.histogram(spfrit,
    y="Country Name",
    x="visitors",
    color="Country Name",
    barmode="group",
    # add the animation
    animation_frame="years",
    # anchor the ranges so that the chart doesn't change frame to
frame

    range_x=[0,spfrit["visitors"].max()*1.1]
)
```



Animation frame let you animate the progress of the values

It can be used on the categorical column too.

```
px.histogram(long_df,
    x="years",
    y="visitors",
    color="Region",
    animation_frame="Region",
    color_discrete_sequence=px.colors.qualitative.Safe,
    range_y=[0,long_df.groupby(["Region","years"])
["visitors"].sum().max()*1.1]
           )
```

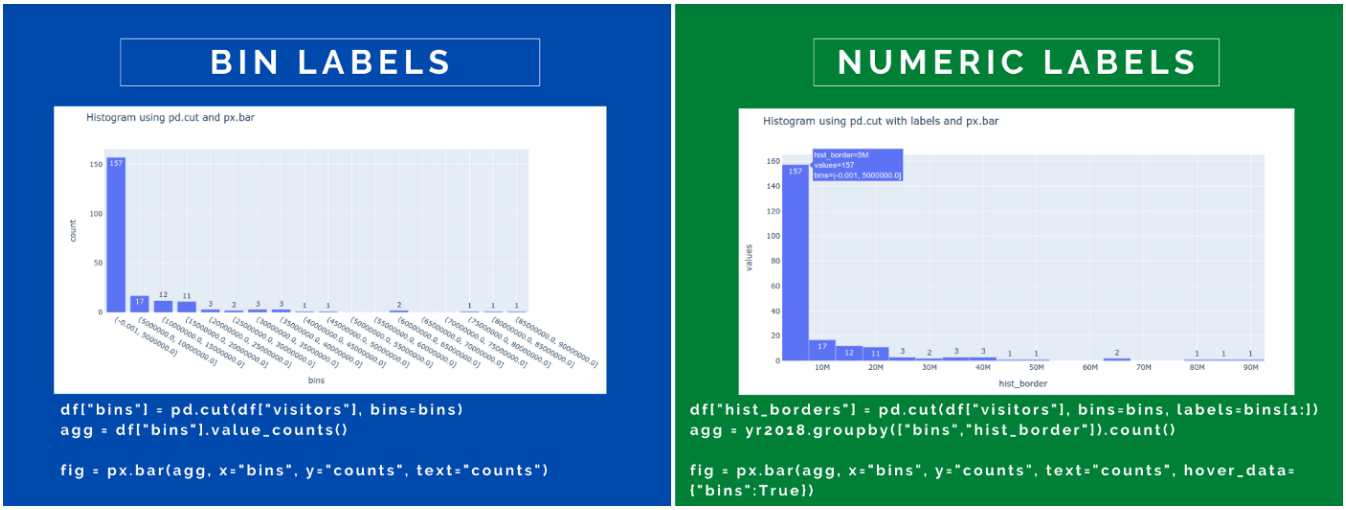


Animation using a categorical column is maybe not useful as animation, but the slider can help users review various options.

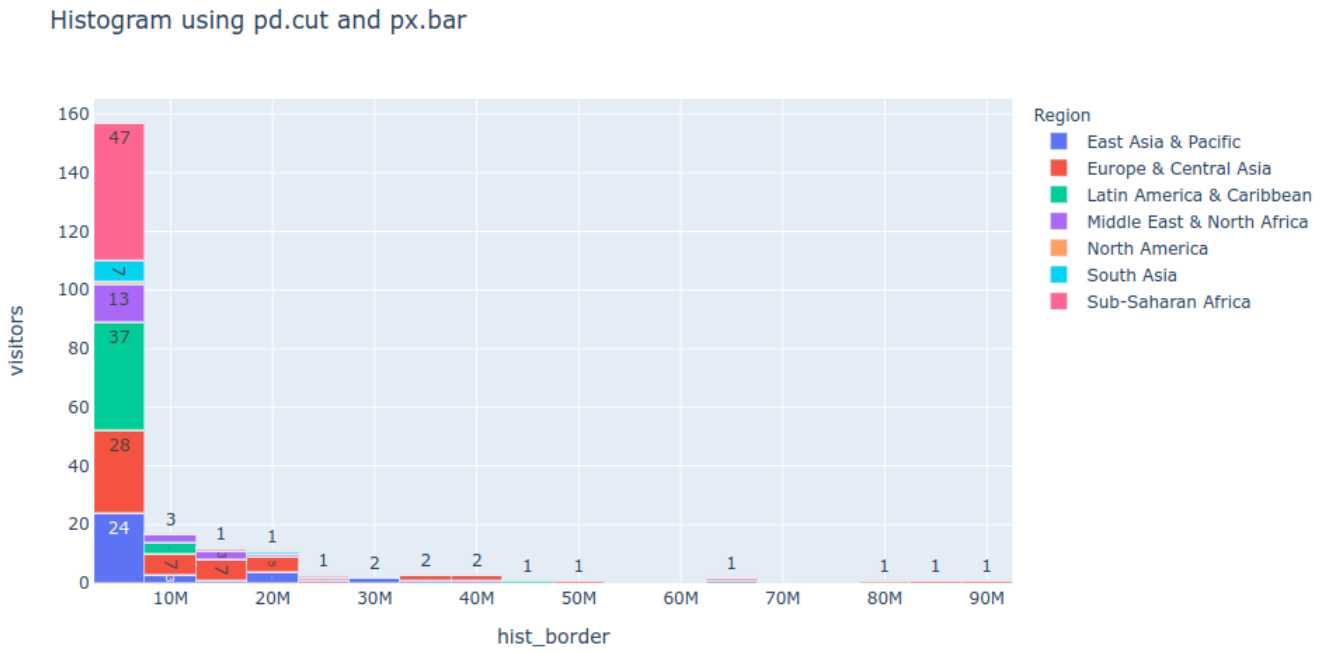
Histogram using plotly Bar chart

As you have seen when we have discussed the `nbins` parameter Plotly is stubborn about binning the data. If you want to keep your freedom you can always bin the data yourself and plot a regular bar chart. Using `pd.cut` to bin the data, `groupby` to aggregate the values in the bin and passing the results to the `px.bar(df, parameter)` allow you to get the histogram of your own.

This way you have many more options. You can display the bins on the x-axis `(5, 10]` or you can display just the bordering number `10M, 20M etc.` when you bin using `pd.cut(df, bins=bins, labels=bins[1:])` . You can add labels into or above the bars showing how many occurrences contain each bar. Using `fig.update_layout(bargap=0)`

Histogram calculated using pd.cut and drawn via px.bar



Multiple categories, when grouped by bins and the category

Alternatively, you can bin the data by numpy's `np.histogram`.

```
# bin with np.histogram
counts, bins = np.histogram(yr2018["visitors"], bins=bins)

# turn into data frame
df = pd.DataFrame({"bins":bins[1:], "counts":counts})

# chart using Plotly.Express
```

Plotly's histograms are a quick way to picture a distribution of the data variable. Plotly Express histograms are also useful to draw many kinds of bar charts, aggregating data into categories or over time.

So far Plotly histograms however lack some features (which are available for other plotly charts), especially the option to add labels. The bins are not easy to modify and `nbins` parameter doesn't always deliver the expected results. You can always do the calculations yourself and draw the results using `px.bar()`.

Plotly is being regularly improved, so maybe these things will be updated soon and we might have an option to add an estimated distribution curve overlay too.

Now it's your turn to explore the histograms. Download a dataset, for example, historical temperatures in cities around the world and study the distribution of temperatures in various regions.


```
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link, when you click on it and purchase a product, you won't pay
more, but I can receive a small reward; you can always write
canva.com to your browser to avoid this). Canva offer some free
```

All the charts can be run through the python script in this notebook — Histograms with Plotly on Github.