

# Data Visualization Techniques Demo

This notebook demonstrates a range of data visualization techniques using Matplotlib, Seaborn, and Plotly. Datasets used: `iris`, `tips`, and `flights` from seaborn.

## Setup: installs and imports

Run the next cell to import libraries. If Plotly is not installed, the cell will install it programmatically.

```
In [1]: # Core imports and plotting defaults
import sys
import subprocess
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Set styles
%matplotlib inline
sns.set_theme(style="darkgrid", context="notebook")
plt.rcParams['figure.figsize'] = (10, 5)
plt.rcParams['font.size'] = 12

# Ensure plotly is available
try:
    import plotly.express as px
except Exception:
    subprocess.check_call([sys.executable, '-m', 'pip', 'install', 'plotly'])
    import plotly.express as px

print('libraries loaded')
```

libraries loaded

## Load example datasets

We'll load `iris`, `tips`, and `flights` from seaborn and inspect them briefly.

```
In [2]: import seaborn as sns
iris = sns.load_dataset('iris')
tips = sns.load_dataset('tips')
flights = sns.load_dataset('flights')

print('iris:', iris.shape)
display(iris.head())
print('tips:', tips.shape)
```

```
display(tips.head())
print('flights:', flights.shape)
display(flights.head())
```

iris: (150, 5)

	sepal_length	sepal_width	petal_length	petal_width	species
0	5.1	3.5	1.4	0.2	setosa
1	4.9	3.0	1.4	0.2	setosa
2	4.7	3.2	1.3	0.2	setosa
3	4.6	3.1	1.5	0.2	setosa
4	5.0	3.6	1.4	0.2	setosa

tips: (244, 7)

	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

flights: (144, 3)

	year	month	passengers
0	1949	Jan	112
1	1949	Feb	118
2	1949	Mar	132
3	1949	Apr	129
4	1949	May	121

## Line plots & time series (Matplotlib / pandas)

Aggregate the `flights` dataset into a time series and demonstrate line plotting with rolling mean and shaded confidence band.

```
In [3]: # prepare a datetime index from flights dataset
fl = flights.copy()
fl['month_num'] = pd.to_datetime(fl['month'], format='%b').dt.month
fl['date'] = pd.to_datetime(fl['year'].astype(str) + '-' + fl['month_num'].astype(str))
ts = fl.set_index('date')['passengers'].sort_index()
ts = ts.asfreq('MS')

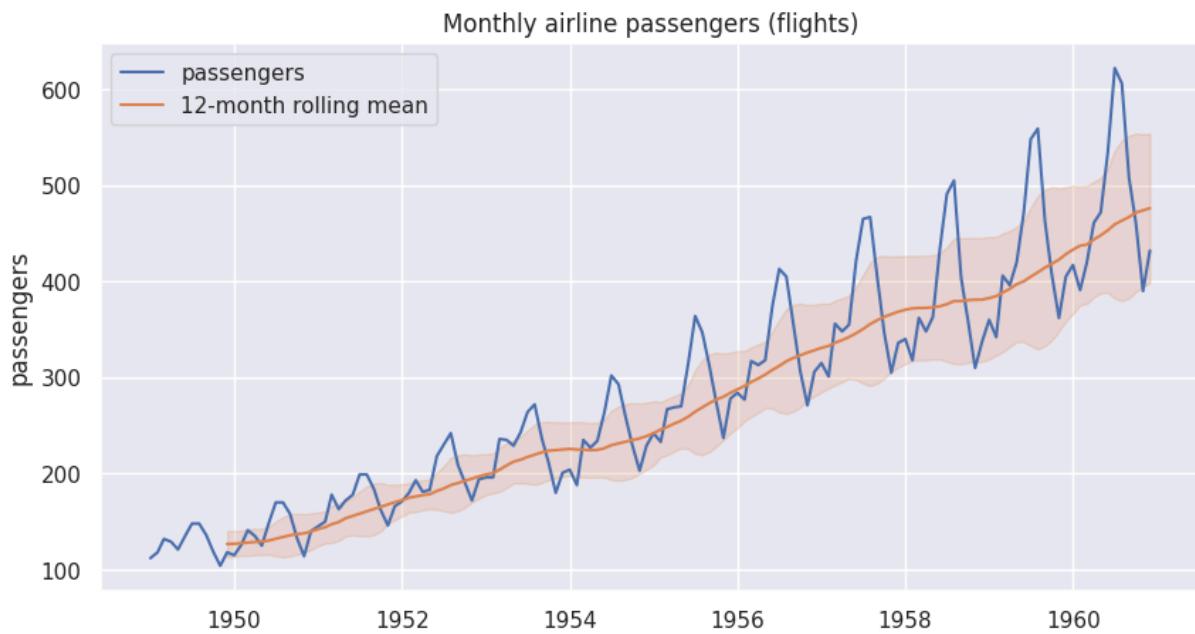
# plot with rolling mean and confidence band
fig, ax = plt.subplots()
```

```

ax.plot(ts.index, ts.values, label='passengers', color='C0') # type: ignore
rolling = ts.rolling(window=12).mean()
ax.plot(rolling.index, rolling.values, label='12-month rolling mean', color='C1')
# simple band: rolling +/- std
rolling_std = ts.rolling(window=12).std()
ax.fill_between(ts.index, (rolling - rolling_std).values, (rolling + rolling_std).values, color='C2', alpha=0.2)
ax.set_title('Monthly airline passengers (flights)')
ax.set_ylabel('passengers')
ax.legend()

```

Out[3]: <matplotlib.legend.Legend at 0x7f802ce38fb0>



## Scatter plots and regression overlays

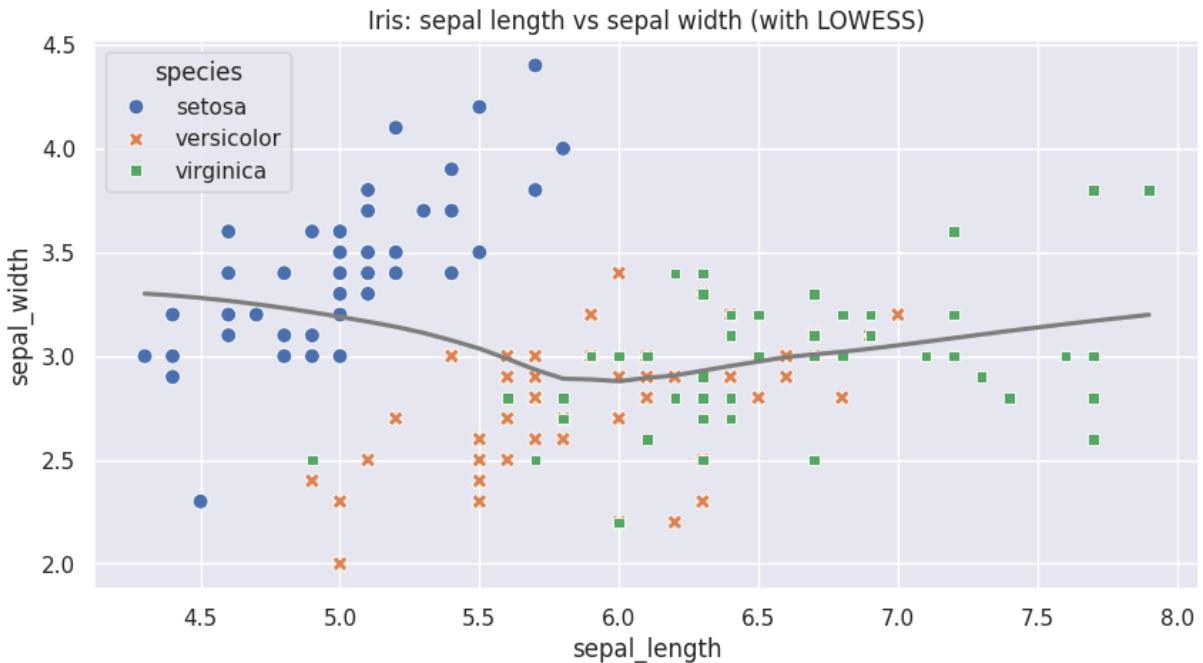
Scatter plot for `iris` (sepal length vs sepal width) with Seaborn regression overlay.

```

In [4]: # scatter with seaborn and regression line
fig, ax = plt.subplots()
sns.scatterplot(data=iris, x='sepal_length', y='sepal_width', hue='species',
sns.regplot(data=iris, x='sepal_length', y='sepal_width', scatter=False, ax=ax)
ax.set_title('Iris: sepal length vs sepal width (with LOWESS)')
ax.legend(title='species')

```

Out[4]: <matplotlib.legend.Legend at 0x7f802cd09df0>

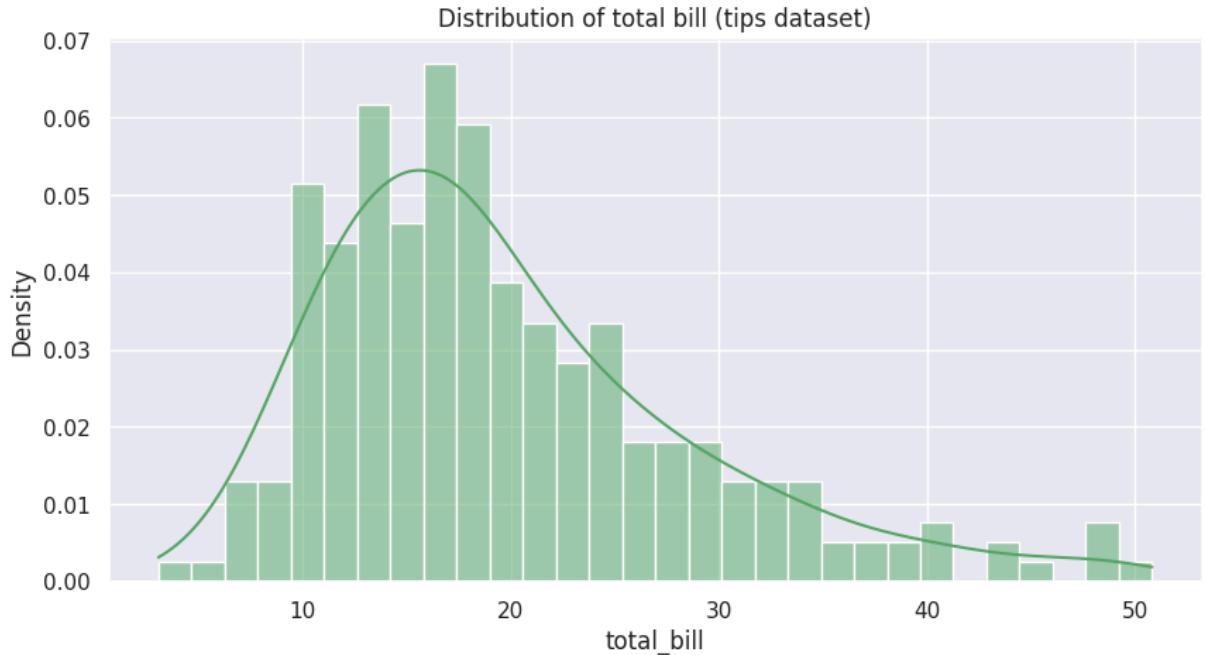


## Histograms and KDE

Histogram and KDE of `tips.total_bill` comparing density and bins.

```
In [5]: fig, ax = plt.subplots()
sns.histplot(tips['total_bill'], bins=30, kde=True, stat='density', ax=ax, color='green')
ax.set_title('Distribution of total bill (tips dataset)')
```

```
Out[5]: Text(0.5, 1.0, 'Distribution of total bill (tips dataset)')
```

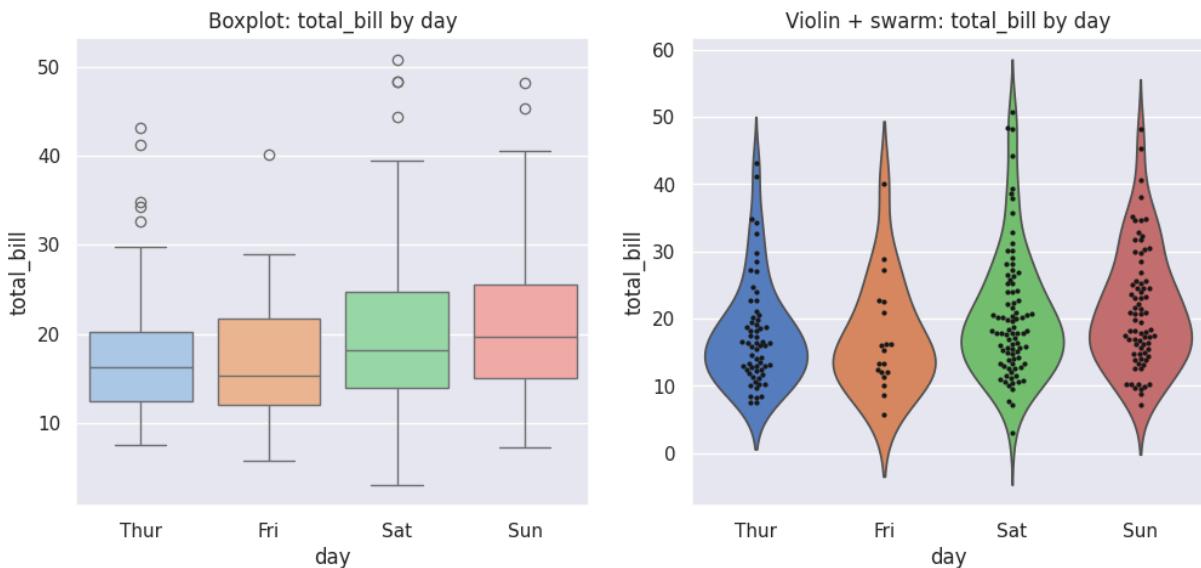


## Boxplots and violin plots

Boxplot of total bill by day and violinplot with swarm overlay.

```
In [6]: fig, axes = plt.subplots(ncols=2, figsize=(12,5))
# Use `hue`=x and remove the legend to avoid the palette-without-hue deprecation warning
sns.boxplot(data=tips, x='day', y='total_bill', hue='day', dodge=False, ax=axes[0])
if axes[0].get_legend() is not None:
    axes[0].get_legend().remove()
axes[0].set_title('Boxplot: total_bill by day')
# For violinplot we also pass hue and then remove the generated legend
sns.violinplot(data=tips, x='day', y='total_bill', hue='day', split=False, inner='quartile', ax=axes[1])
if axes[1].get_legend() is not None:
    axes[1].get_legend().remove()
# overlay the raw points (swarm) as before
sns.swarmplot(data=tips, x='day', y='total_bill', color='k', size=3, ax=axes[1])
axes[1].set_title('Violin + swarm: total_bill by day')
```

Out[6]: Text(0.5, 1.0, 'Violin + swarm: total\_bill by day')

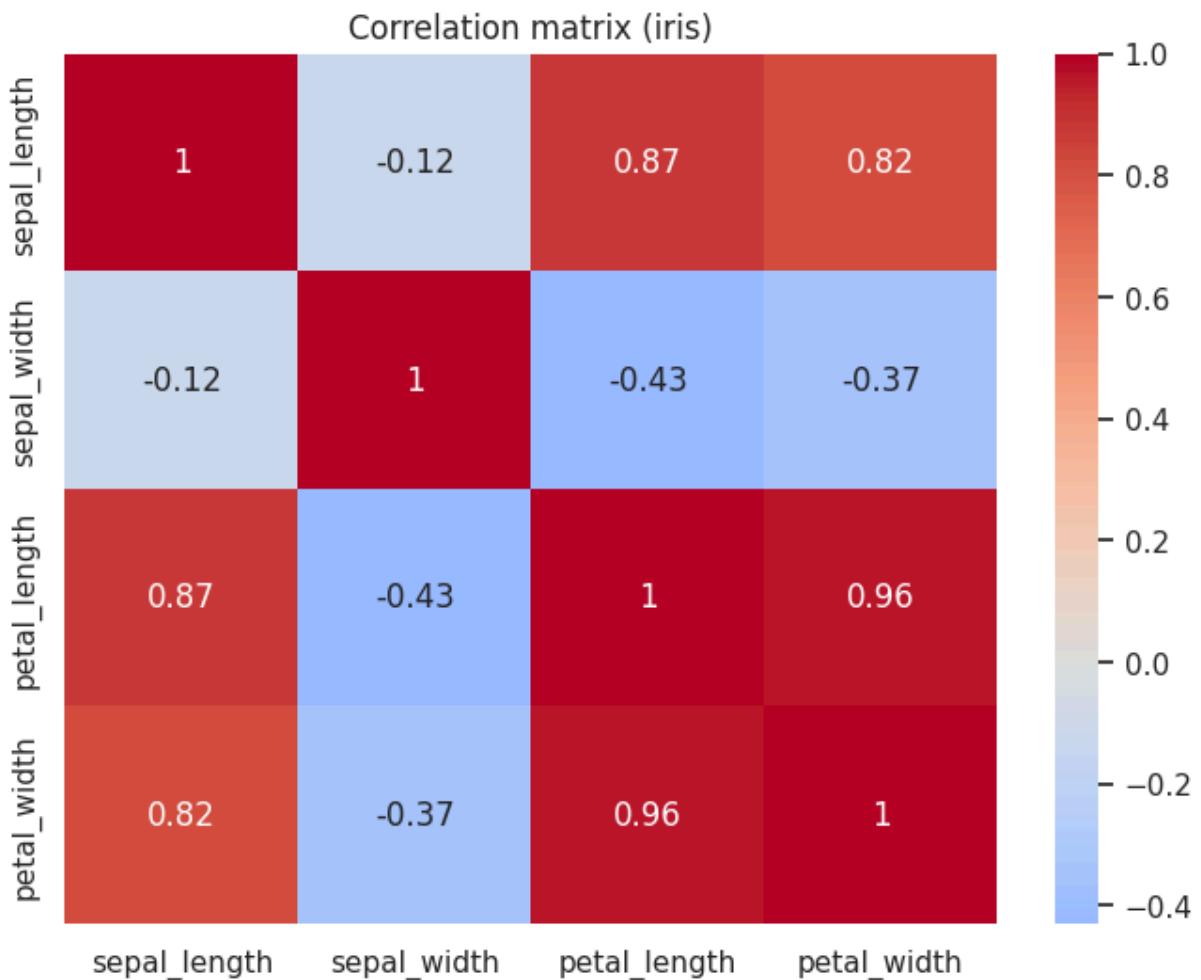


## Heatmap and correlation matrix

Show correlations for the `iris` dataset.

```
In [7]: corr = iris.select_dtypes(include=np.number).corr()
fig, ax = plt.subplots(figsize=(8,6))
sns.heatmap(corr, annot=True, cmap='coolwarm', center=0, ax=ax)
ax.set_title('Correlation matrix (iris)')
```

Out[7]: Text(0.5, 1.0, 'Correlation matrix (iris)')

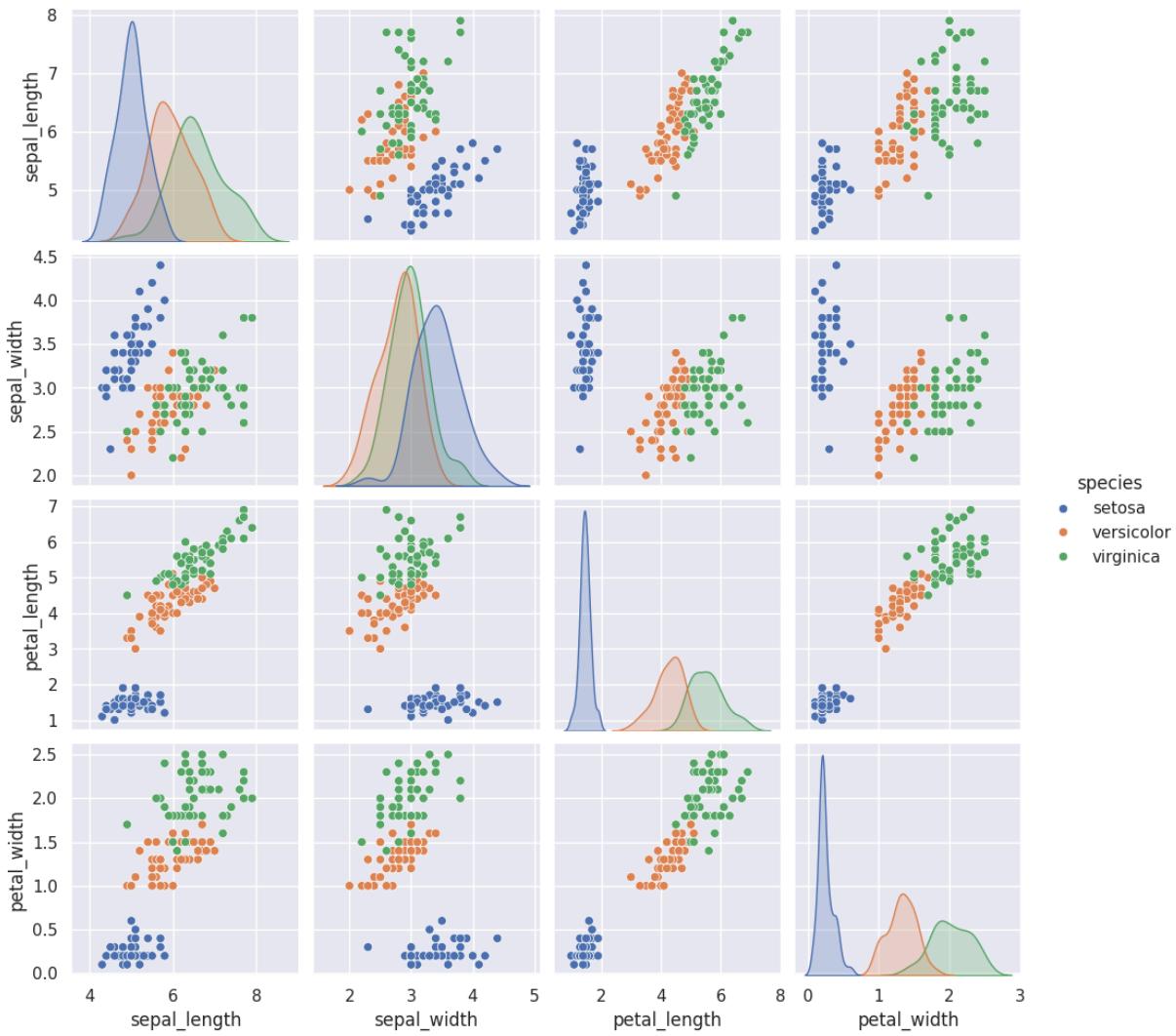


## Pairplot for multivariate exploration

Pairwise relationships with hue by species. This can be slow on large datasets.

```
In [8]: # Pairplot (can take a moment)
sns.pairplot(iris, hue='species', diag_kind='kde', corner=False)
```

```
Out[8]: <seaborn.axisgrid.PairGrid at 0x7f80291d0260>
```



## Interactive plots with Plotly Express

Interactive scatter (tips) and an interactive time series (flights).

```
In [9]: import plotly.express as px
from IPython.display import HTML, display
# Create interactive scatter and attempt to show inline; fall back to HTML if not supported
fig = px.scatter(tips, x='total_bill', y='tip', color='day', hover_data=['size'])
try:
    fig.show()
except ValueError as _err:
    fname = 'interactive_tips.html'
    fig.write_html(fname, include_plotlyjs='cdn')
    display(HTML(f'<a href="{fname}" target="_blank">Open interactive_tips.html</a>'))

# interactive time series
ts_df = ts.reset_index().rename(columns={'index': 'date', 'passenger': 'passengers'})
fig2 = px.line(ts_df, x='date', y='passengers', title='Monthly passengers (interactively)')
try:
    fig2.show()
except ValueError:
    fname2 = 'interactive_flights.html'
```

```
fig2.write_html(fname2, include_plotlyjs='cdn')
display(HTML(f'<a href="{fname2}" target="_blank">Open interactive flight
```

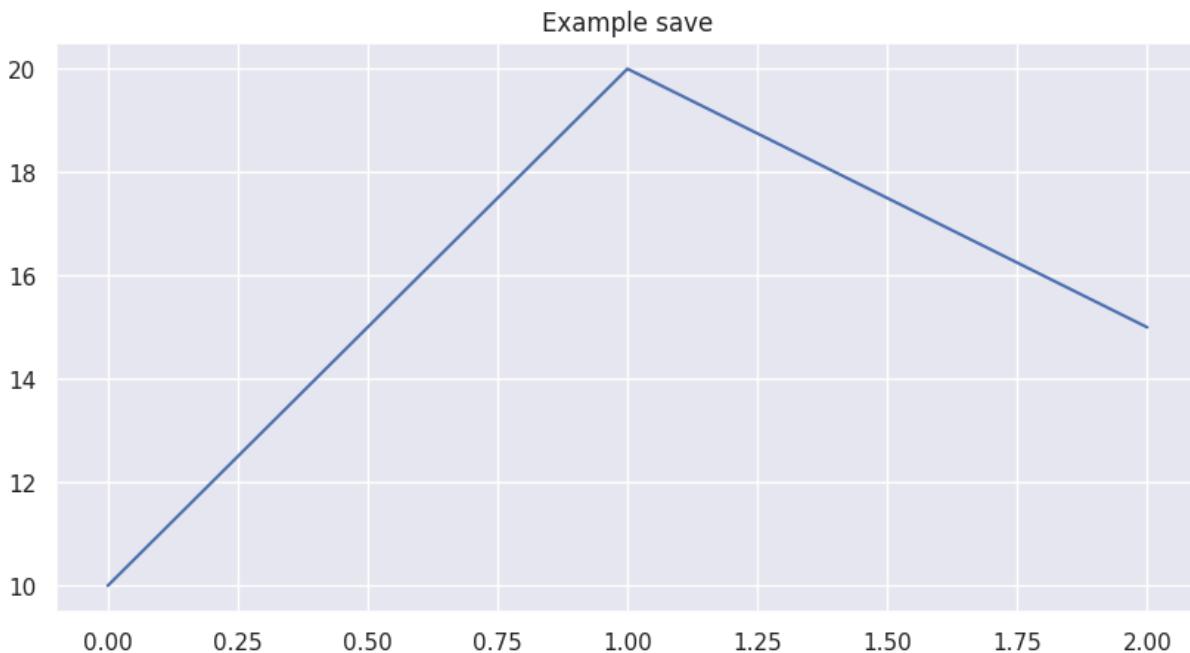
## Saving figures and exporting

Examples of saving static Matplotlib figures and exporting Plotly to HTML.

```
In [10]: # save last matplotlib figure (if any)
fig_static, ax = plt.subplots()
ax.plot([0,1,2], [10,20,15])
ax.set_title('Example save')
fig_static.savefig('example_plot.png', dpi=150, bbox_inches='tight')
print('saved example_plot.png')

# save plotly to HTML
fig.write_html('interactive_tips.html')
print('saved interactive_tips.html')
```

saved example\_plot.png  
saved interactive\_tips.html



## Notes on performance and large datasets

For very large point clouds consider hexbin, datashader, or downsampling.  
`plt.hexbin` and `sns.kde` are useful for dense plots.

## Datashader example (for very large datasets)

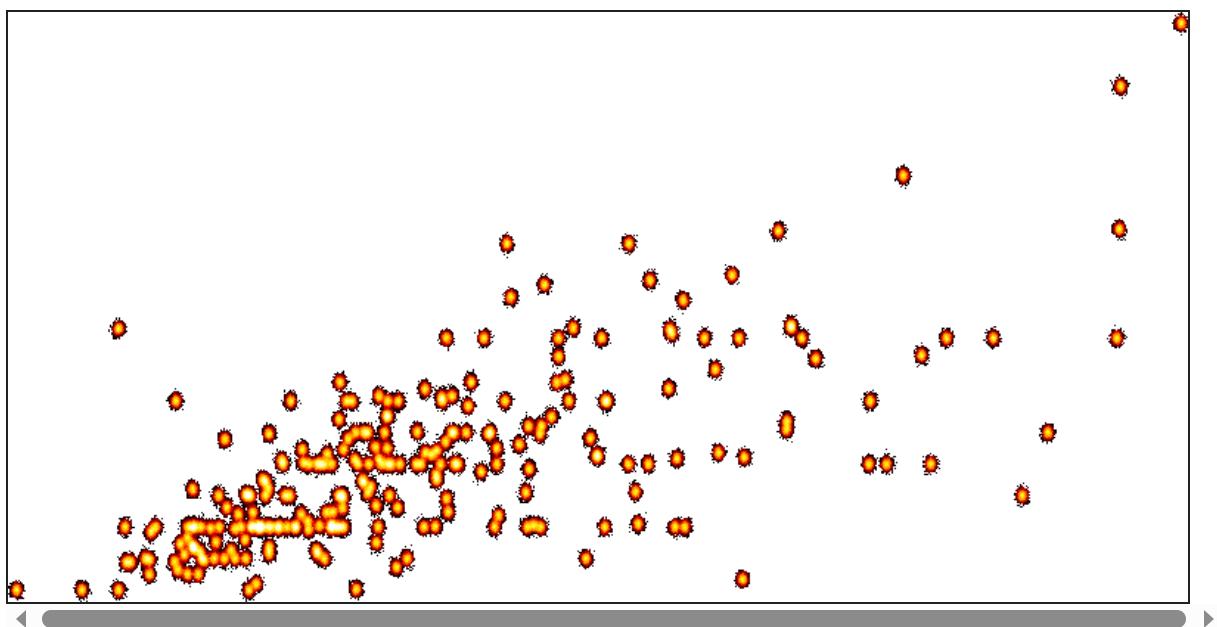
This cell demonstrates how to use `datashader` to render large scatter clouds efficiently. If `datashader` is not installed in your environment the cell will fall

back to a Matplotlib `hexbin` plot and print installation instructions.

```
In [11]: # Datashader example: create a large synthetic point cloud by repeating `tips` dataset
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

# build a larger dataset by repeating tips several times (adjust multiplier)
mult = 2000 # result ~244 * 2000 ~ 488k rows; reduce if memory is constrained
try:
    big = pd.concat([tips]*mult, ignore_index=True)
except Exception:
    big = tips.sample(frac=1, replace=True).reset_index(drop=True)
# add small jitter so points are not identical
np.random.seed(1)
big['x'] = big['total_bill'] + np.random.normal(0, 0.1, size=len(big))
big['y'] = big['tip'] + np.random.normal(0, 0.05, size=len(big))

# Try to use datashader, otherwise fallback to hexbin
try:
    import datashader as ds
    import datashader.transfer_functions as tf
    import colorcet
    from IPython.display import HTML, display
    # create canvas and aggregate
    cvs = ds.Canvas(plot_width=800, plot_height=400)
    agg = cvs.points(big, 'x', 'y', ds.count())
    img = tf.shade(agg, cmap=colorcet.m_fire, how='eq_hist')
    display(img)
except Exception as e:
    print('datashader not available or failed to render (' , e , ') . Falling back to hexbin')
    fig, ax = plt.subplots(figsize=(10,4))
    hb = ax.hexbin(big['x'], big['y'], gridsize=80, cmap='viridis')
    fig.colorbar(hb, ax=ax, label='counts')
    ax.set_xlabel('total_bill (jittered)')
    ax.set_ylabel('tip (jittered)')
    ax.set_title('Hexbin fallback (datashader not installed)')
    plt.show()
print('To enable datashader: pip install datashader colorcet')
```



## Animated plots (Matplotlib FuncAnimation)

This example creates a simple animated sine wave using Matplotlib's FuncAnimation and displays it inline using HTML/JS. If your environment does not support JS rendering, you can save the animation to MP4/GIF (may require ffmpeg).

```
In [12]: import numpy as np
import matplotlib.pyplot as plt
from matplotlib import animation
from IPython.display import HTML

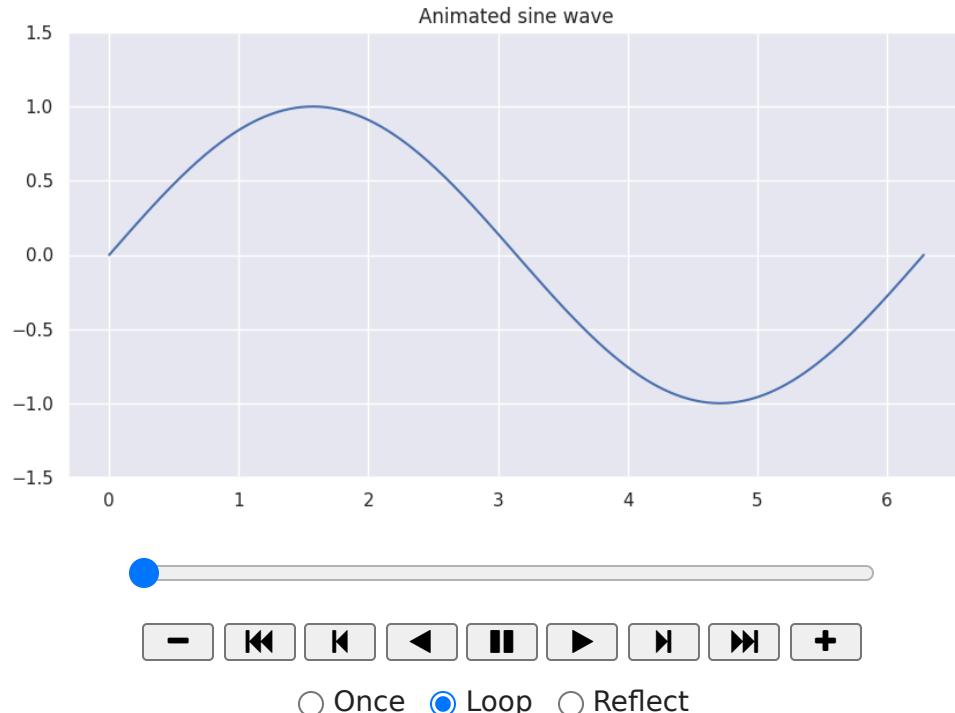
fig, ax = plt.subplots()
x = np.linspace(0, 2*np.pi, 400)
line, = ax.plot(x, np.sin(x))
ax.set_xlim(-1.5, 1.5)
ax.set_title('Animated sine wave')

def init():
    line.set_ydata(np.sin(x))
    return (line,)

def animate(i):
    line.set_ydata(np.sin(x + i/10.0))
    return (line,)

anim = animation.FuncAnimation(fig, animate, init_func=init, frames=200, interval=20)
plt.close(fig)
# Display as JS animation in the notebook (will embed JS/CSS)
HTML(anim.to_jshtml())
```

Out[12]:



In [13]:

```
# Export the previously-created `anim` to MP4 or GIF.
# This tries MP4 using ffmpeg first, then falls back to GIF via pillow.
from matplotlib import animation as anim_module
out_mp4 = 'sine_animation.mp4'
out_gif = 'sine_animation.gif'
saved = False
# Try MP4 (requires ffmpeg available on PATH)
try:
    Writer = anim_module.writers['ffmpeg']
    writer = Writer(fps=30, metadata=dict(artist='auto'), bitrate=1800)
    anim.save(out_mp4, writer)
    print(f'Saved animation as MP4: {out_mp4}')
    saved = True
except Exception as e:
    print('MP4 export failed or ffmpeg not available:', e)
# Fallback to GIF using pillow writer
if not saved:
    try:
        anim.save(out_gif, writer='pillow', fps=30)
        print(f'Saved animation as GIF: {out_gif}')
        saved = True
    except Exception as e:
        print('GIF export failed:', e)
# Final message with install hints if nothing worked
if not saved:
    print('Unable to save animation. To enable MP4 export install ffmpeg on')
    print('For GIF export ensure pillow is installed: pip install pillow')
```

Saved animation as MP4: sine\_animation.mp4

## Requirements and how to run

Required Python packages: numpy, pandas, matplotlib, seaborn, plotly, statsmodels. Install with: `pip install numpy pandas matplotlib seaborn plotly statsmodels`

Recommended quick steps to run locally:

1. Create and activate a virtual environment (recommended): `python -m venv .venv` On Linux/macOS: `source .venv/bin/activate` On Windows (PowerShell): `./.venv/Scripts/Activate.ps1`
2. Install dependencies: `pip install -r requirements.txt` or the pip line above.
3. Start Jupyter: `jupyter lab` or `jupyter notebook` and open this file: `/home/sysadmin/Notebooks/data-visualization-demo.ipynb`.

Notes:

- Plotly inline rendering may raise an error if `nbformat` or notebook MIME renderers are missing; the notebook already falls back to writing interactive HTML files and showing links.
- To export animations to MP4/GIF you may need `ffmpeg` installed on your system.
- For very large datasets consider using datashader (optional) or downsampling before plotting.

## Conclusion and next steps

This notebook provided quick examples across Matplotlib, Seaborn, and Plotly. Next steps: experiment with custom palettes, GridSpec layouts, animations, or datashader for very large datasets.

To run locally: in a terminal run `jupyter lab` or `jupyter notebook` and open this file: `/home/sysadmin/Notebooks/data-visualization-demo.ipynb`.

# Exporting this notebook to PDF

This section demonstrates how to produce a PDF copy of this notebook programmatically using `nbconvert`. The cell below first attempts a direct PDF export (which commonly requires a LaTeX installation such as TeX Live). If that fails it falls back to exporting an HTML file which you can open in a browser and print/save as PDF.

Note: the code assumes this notebook file is named `data-visualization-demo.ipynb` and is in the current working directory. If your notebook has a different name or path, update the `nb` variable in the code cell.

```
In [14]: # Programmatic notebook -> PDF example with fallback to HTML
from pathlib import Path
import subprocess
import sys
import shutil

# Assumption: notebook file is in the current working directory with this name
nb = Path('data-visualization-demo.ipynb')
if not nb.exists():
    print(f'Notebook file not found at {nb.resolve()}. Update the `nb` variable')
else:
    out_pdf = nb.with_suffix('.pdf')

    def run_cmd(cmd):
        print('Running:', ' '.join(cmd))
        res = subprocess.run(cmd, stdout=subprocess.PIPE, stderr=subprocess.PIPE)
        print(res.stdout)
        return res.returncode == 0

    success = False
    # Try jupyter nbconvert (preferred). Note: PDF conversion usually requires LaTeX
    jupyter = shutil.which('jupyter')
    if jupyter:
        success = run_cmd([jupyter, 'nbconvert', '--to', 'pdf', str(nb)])

    # If direct PDF failed, export to HTML and instruct the user to print to PDF
    if not success:
        print('Direct PDF export failed or is not available. Falling back to HTML')
        html_file = nb.with_suffix('.html')
        # Try nbconvert to HTML (more widely supported)
        if jupyter:
            ok = run_cmd([jupyter, 'nbconvert', '--to', 'html', str(nb)])
        else:
            ok = run_cmd([sys.executable, '-m', 'nbconvert', '--to', 'html', str(nb)])
        if ok:
            print(f'HTML exported to {html_file}. You can open it in a browser and print it')
        else:
            print('HTML export also failed. You may need to install jupyter/nbconvert')
```

```
else:  
    print(f'PDF exported to: {out_pdf.resolve()}'")
```

```
Running: /home/sysadmin/Projects/data-visualization-demo/.venv/bin/jupyter nbconvert --to pdf data-visualization-demo.ipynb
[NbConvertApp] Converting notebook data-visualization-demo.ipynb to pdf
[NbConvertApp] ERROR | Error while converting 'data-visualization-demo.ipynb'
Traceback (most recent call last):
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/nbconvertapp.py", line 487, in export_single_notebook
    output, resources = self.exporter.from_filename(
                           ^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/exporters/templateexporter.py", line 390, in from_filename
    return super().from_filename(filename, resources, **kw) # type:ignore[return-value]
                           ^^^^^^^^^^^^^^^^^^^^^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/exporters/exporter.py", line 201, in from_filename
    return self.from_file(f, resources=resources, **kw)
                           ^^^^^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/exporters/templateexporter.py", line 396, in from_file
    return super().from_file(file_stream, resources, **kw) # type:ignore[return-value]
                           ^^^^^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/exporters/exporter.py", line 220, in from_file
    return self.from_notebook_node()
                           ^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/exporters/pdf.py", line 184, in from_notebook_node
    latex, resources = super().from_notebook_node(nb, resources=resources, **kw)
                           ^^^^^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/exporters/latex.py", line 92, in from_notebook_node
    return super().from_notebook_node(nb, resources, **kw)
                           ^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/exporters/templateexporter.py", line 429, in from_notebook_node
    output = self.template.render(nb=nb_copy, resources=resources)
                           ^^^^^^
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/jinja2/environment.py", line 1295, in render
    self.environment.handle_exception()
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/jinja2/environment.py", line 942, in handle_exception
    raise rewrite_traceback_stack(source=source)
  File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/index.tex.j2", line 8, in top-level template code
    ((* extends cell_style *))
```

```
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/style_jupyter.tex.j2", line 176, in top-level template code  
    \prompt{{{{(prompt)}}}}{{{{(prompt_color)}}}}{{{{(execution_count)}}}}{{{{(extra_space)}}}}  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/base.tex.j2", line 7, in top-level template code  
    ((*- extends 'document_contents.tex.j2' -*))  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/document_contents.tex.j2", line 51, in top-level template code  
    ((*- block figure scoped -*))  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/display_priority.j2", line 5, in top-level template code  
    ((*- extends 'null.j2' -*))  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/null.j2", line 30, in top-level template code  
    ((*- block body -*))  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/base.tex.j2", line 241, in block 'body'  
    ((( super() )))  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/null.j2", line 32, in block 'body'  
    ((*- block any_cell scoped -*))  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/null.j2", line 85, in block 'any_cell'  
    ((*- block markdowncell scoped-*)) ((*- endblock markdowncell -*))  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/latex/document_contents.tex.j2", line 68, in block 'markdowncell'  
    ((( cell.source | citation2latex | strip_files_prefix | convert_pandoc('markdown+tex_math_double_backslash', 'json', extra_args=[]) | resolve_references | convert_explicitly_relative_paths | convert_pandoc('json', 'latex'))))  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/filters/pandoc.py", line 36, in convert_pandoc  
    return pandoc(source, from_format, to_format, extra_args=extra_args)  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/utils/pandoc.py", line 50, in pandoc  
    check_pandoc_version()  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/utils/pandoc.py", line 98, in check_pandoc_version  
    v = get_pandoc_version()  
~~~~~  
File "/home/sysadmin/Projects/data-visualization-demo/.venv/lib/python3.12/site-packages/nbconvert/utils/pandoc.py", line 75, in get_pandoc_version
```

```
raise PandocMissing()
nbconvert.utils.pandoc.PandocMissing: Pandoc wasn't found.
Please check that pandoc is installed:
https://pandoc.org/installing.html

Direct PDF export failed or is not available. Falling back to HTML export.
Running: /home/sysadmin/Projects/data-visualization-demo/.venv/bin/jupyter nbconvert --to html data-visualization-demo.ipynb
[NbConvertApp] Converting notebook data-visualization-demo.ipynb to html
/home/sysadmin/Projects/data-visualization-demo/.venv/share/jupyter/nbconvert/templates/base/display_priority.j2:32: UserWarning: Your element with mime type(s) dict_keys(['application/vnd.plotly.v1+json']) is not able to be represented.
{%- elif type == 'text/vnd.mermaid' -%}
[NbConvertApp] WARNING | Alternative text is missing on 9 image(s).
[NbConvertApp] Writing 8807583 bytes to data-visualization-demo.html
```

HTML exported to `data-visualization-demo.html`. You can open it in a browser and use Print -> Save as PDF (or a headless browser) to create a PDF.

## Notes and alternatives

- Direct PDF export via `nbconvert --to pdf` typically uses a LaTeX intermediate; installing a TeX distribution (TeX Live on Linux) is often required: e.g., `sudo apt install texlive-xetex texlive-fonts-recommended texlive-latex-recommended`.
- If you prefer not to install LaTeX, export to HTML (`nbconvert --to html`) and then: open in a browser and Print -> Save as PDF, or use a headless browser (Chromium/Chrome) to print-to-pdf programmatically (e.g., Puppeteer/Playwright).
- Example command-line alternative (if you have chromium): `chromium --headless --disable-gpu --print-to-pdf=output.pdf data-visualization-demo.html`
- If you want, I can also add an automated Chromium-based HTML->PDF step (requires installing Chromium) or a Playwright/Puppeteer example—tell me which fallback you'd prefer.

## Automated Chromium HTML -> PDF (optional)

The cell below will look for a Chromium/Chrome binary on your PATH and, if found, will run it in headless mode to convert the previously-exported HTML (`data-visualization-demo.html`) to a PDF. This is useful when LaTeX is not installed and you want a fully automated HTML->PDF step.

If you don't have Chromium/Chrome installed, the cell will print install suggestions for common Linux distributions.

```
In [15]: # Automated Chromium/Chrome HTML -> PDF converter
from pathlib import Path
import shutil
import subprocess
import sys

nb = Path('data-visualization-demo.ipynb')
html = nb.with_suffix('.html')
out_pdf = nb.with_suffix('.chromium.pdf')

if not html.exists():
    print(f'HTML file not found at {html.resolve()}. Run the HTML export step')
else:
    # Common executable names for chromium/google-chrome
    candidates = ['chromium', 'chromium-browser', 'chromium-stable', 'google-chrome']
    exe = None
    for c in candidates:
        path = shutil.which(c)
        if path:
            exe = path
            break

    if not exe:
        print('No Chromium/Chrome executable found on PATH.')
        print('Install suggestions (Debian/Ubuntu): sudo apt install chromium')
        print('Or on Debian/Ubuntu to get a recent Chrome: install google-chrome')
    else:
        # Use an absolute path to the HTML file
        html_path = str(html.resolve())
        pdf_path = str(out_pdf.resolve())
        cmd = [exe, '--headless', '--no-sandbox', '--disable-gpu', f"--print-to-pdf={pdf_path}"]
        print('Running:', ' '.join(cmd))
        res = subprocess.run(cmd, stdout=subprocess.PIPE, stderr=subprocess.PIPE)
        print(res.stdout)
        if res.returncode == 0 and Path(pdf_path).exists():
            print(f'Chromium produced PDF: {pdf_path}')
        else:
            print('Chromium print-to-pdf failed. Review the output above. As')


```

No Chromium/Chrome executable found on PATH.  
Install suggestions (Debian/Ubuntu): sudo apt install chromium-browser  
Or on Debian/Ubuntu to get a recent Chrome: install google-chrome-stable from Google repository.