1 Lecture 1b: Quick Introduction to New Libraries

Data Visualization · 1-DAV-105

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- We will now briefly discuss several libraries which will be used in the next tutorial.
- We will cover details of these libraries in the coming weeks, this is just a glipse of things to come.

[2]:

```
# importing libraries
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
```

1.1 Libraries NumPy and Pandas

- Pandas is a Python library for working with tabular data.
- NumPy is a library of efficient multi-dimensional arrays used for numerical computations.

1.1.1 NumPy array and arithmetical operations with arrays

- Function `np.arange` below creates a list of numbers in interval $[1,3)$ with step 0.5 (generalization of Python `range`).
- It is stored as an object of array class from the Numpy library.

[3]:

```
x = np.arange(1, 3, 0.5)
print('x:', x)
```

```
x: [1.  1.5 2.  2.5]
```

- We can do various arithmetic operations on whole NumPy arrays or apply predefined functions such as `np.exp`.
- Such operations are typically done element-by-element.

[4]:

```
print('x:', x)
print('x+1:', x+1)
print('x*x:', x*x)
print('np.exp(x):', np.exp(x))
```

```
x: [1.  1.5 2.  2.5]
x+1: [2.  2.5 3.  3.5]
x*x: [1.   2.25 4.   6.25]
np.exp(x): [ 2.71828183  4.48168907  7.3890561  12.18249396]
```

1.1.2 Creating Pandas DataFrame

- Below we create an object of Pandas DataFrame class.

- We will cover most Pandas functions used below next week, for now the details are not important.

[5]:
```
def convert_table(x, function_dict):
    # convert dictionary to dataframe with a column for each function
    functions_wide = pd.DataFrame(function_dict, index=x)
    # reformat to long format where each row is a tripple x, function name,␣
  ↪function value
    functions = (functions_wide.reset_index()
                 .melt(id_vars='index')
                 .rename(columns={'variable':'function', 'index':'x'}))
    # mask values <= 0 as missing values
    val = functions['value']
    functions['value'] = val.mask(val <= 0, np.nan)
    return functions

functions = convert_table(x, {'quadratic': x * x,'cubic': x * x * x})
```

Let us look at the resulting table `functions`:

- It has three columns named `'x'`, `'function'` and `'value'`.
- Each row is a triple, containing a function name and the values of x and $f(x)$.
- E.g. one of the rows for the cubic function has $x = 2$ and $f(x) = 2^3 = 8$.

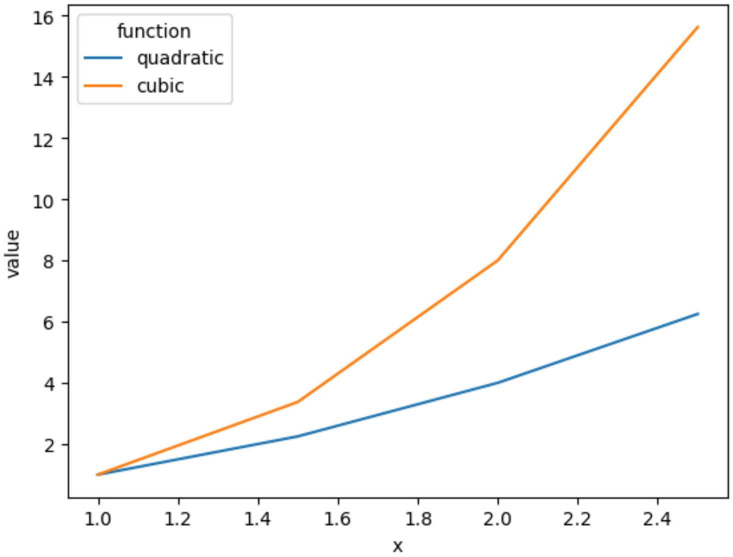
[6]:
```
display(functions)
```

```
     x   function   value
0  1.0  quadratic   1.000
1  1.5  quadratic   2.250
2  2.0  quadratic   4.000
3  2.5  quadratic   6.250
4  1.0      cubic   1.000
5  1.5      cubic   3.375
6  2.0      cubic   8.000
7  2.5      cubic  15.625
```

1.2 Displaying Pandas DataFrame using Seaborn and Plotly libraries

- Seaborn library is an extension of Matplotlib.
- It is very convenient for displaying tables.
- In the `sns.lineplot` we first give the table and then specify, which columns should be used as x coordinate, y coordinate and color (`hue`).
- One line will be automaticlaly drawn for each distinct value in the `hue` column and a legend will be added.

[7]:
```
figure, axes = plt.subplots()
sns.lineplot(functions, x='x', y='value', hue='function', ax=axes)
pass
```



- Another popular library is Plotly.
- It provides some additional plot types and all plots are interactive.
- For example, we can also zoom into parts of the plot by selecting a rectangle.
- A menu with additional options appears in the top right corner of the plot.
- A line plot is created similarly as in Seaborn (option `color` is used instead of `hue`).

[8]:
```
figure = px.line(functions, x="x", y="value", color='function')
figure.show()
```

1.3 Interactive plots in Plotly Dash

- Dash library by Plotly allows adding control elements (selectors, sliders, buttons, …).
- It is not preinstalled in Colab, so the next line will install it.

[ ]:
```
! pip install dash
```

- The code below creates an interactive plot in which the user can choose which functions from the list to display.
- The code has many comments so read through it carefully.

[16]:
```
from dash import Dash, dcc, html, Input, Output

# create a list of all functions
all_functions = list(functions['function'].unique())

# create a new dash application app
app = Dash(__name__)

# Create layout of items in application
#   one html <div> item containing text as small headwers (H4),
#   items for individual inputs and a graph at the bottom
# Currently we have two inputs:
#   an input field for entering title text
#   checkboxes for selecting functions
# These elements have identifiers which will be used later in the code
app.layout = html.Div([
    html.H4("Plot title: "),
    # input field for entering title text:
    dcc.Input(
        id='graph-title',
        type='text',
        value='My plot'
    ),
    html.H4("Select functions: "),
    # checkboxes for selecting functions:
    dcc.Checklist(
        id='selected-functions',
        options=all_functions,
        value=['quadratic'],
        inline=True   # place checkboxes horizontally
    ),
    # graph itself
    dcc.Graph(id='graph-content')
])

# @app.callback is a function decorator applied to function update_figure below.
# It defines that this function will be called to update the graph when the user makes a change.
#    Input will be the value entered to the input field with id graph-title and
#      the list of functions selected in dcc.Checklist object with id 'selected-functions'.
#    Output will be the graph created by the function update_figure below, which will be used
#      to update dcc.Graph object with id 'graph-content'
@app.callback(
    Output('graph-content', 'figure'),
    [Input('graph-title', 'value'),
     Input('selected-functions', 'value')
    ]
)
def update_figure(title, selected_functions):
    """ Function for ploting functions listed in list selected_functions
    with plot title given in title"""

    # select a subset of functions table with just those functions in input list
    functions_subset = functions.query('function in @selected_functions')
```

```python
    # create a plotly line plot using the smaller table in functions_subset
    fig = px.line(
        functions_subset, x="x", y="value",
        color="function",
        title="Selected functions", width=800, height=500
    )

    # add title to the plot
    fig.update_layout(title_text=title)

    return fig

# run the whole application
app.run_server(mode='inline')
```

```
<IPython.lib.display.IFrame at 0x7fac16dc9970>
```