plotly

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Dash Python > **Part 2. Basic Callbacks**

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Basic Dash Callbacks

This is the 2nd chapter of the **Dash Fundamentals**. The **previous chapter** covered the Dash app `layout` and the **next chapter** covers interactive graphing. Just getting started? Make sure to **install the necessary dependencies**.

In the **previous chapter** we learned that `app.layout` describes what the app looks like and is a hierarchical tree of components. The Dash HTML Components (`dash.html`) module provides classes for all of the HTML tags, and the keyword arguments describe the HTML attributes like `style`, `className`, and `id`. The Dash Core Components (`dash.dcc`) module generates higher-level components like controls and graphs.

This chapter describes how to make your Dash apps using *callback functions*: functions that are automatically called by Dash whenever an input component's property changes, in order to update some property in another component (the output).

For optimum user-interaction and chart loading performance, production Dash apps should consider the **Job Queue**, **HPC**, **Datashader**, and horizontal scaling capabilities of Dash Enterprise.

Let's get started with a simple example of an interactive Dash app.

Simple Interactive Dash App

If you're using Dash Enterprise's **Data Science Workspaces**, copy & paste the below code into your Workspace (**see video**).

Find out if your company is using Dash Enterprise

```
from dash import Dash, dcc, html, Input, Output, callback

app = Dash()

app.layout = html.Div([
    html.H6("Change the value in the text box to see callbacks in action!"),
    html.Div([
        "Input: ",
        dcc.Input(id='my-input', value='initial value', type='text')
    ]),
    html.Br(),
    html.Div(id='my-output'),

])


@callback(
    Output(component_id='my-output', component_property='children'),
    Input(component_id='my-input', component_property='value')
)
def update_output_div(input_value):
    return f'Output: {input_value}'


if __name__ == '__main__':
    app.run(debug=True)
```

Change the value in the text box to see callbacks in action!

Input:

initial value

Output: initial value

Let's break down this example:

1. The "inputs" and "outputs" of our application are described as the arguments of the `@callback` decorator.

▶ Learn more about using the `@callback` decorator.

2. In Dash, the inputs and outputs of our application are simply the properties of a particular component. In this example, our input is the "`value`" property of the component that has the ID "`my-input`". Our output is the "`children`" property of the component with the ID "`my-output`".
3. Whenever an input property changes, the function that the callback decorator wraps will get called automatically. Dash provides this callback function with the new value of the input property as its argument, and Dash updates the property of the output component with whatever was returned by the function.
4. The `component_id` and `component_property` keywords are optional (there are only two arguments for each of those objects). They are included in this example for clarity but will be omitted in the rest of the documentation for the sake of brevity and readability.
5. Don't confuse the `dash.dependencies.Input` object and the `dcc.Input` object. The former is just used in these callback definitions and the latter is an actual component.
6. Notice how we don't set a value for the `children` property of the `my-output` component in the `layout`. When the Dash app starts, it automatically calls all of the callbacks with the initial values of the input components in order to populate the initial state of the output components. In this example, if you specified the div component as `html.Div(id='my-output', children='Hello world')`, it would get overwritten when the app starts.

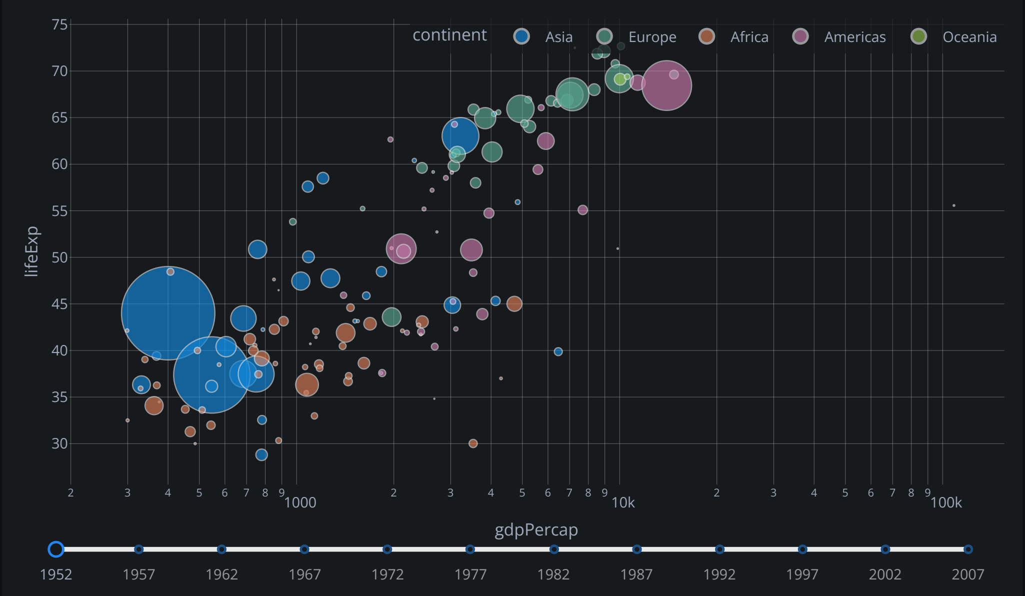
It's sort of like programming with Microsoft Excel: whenever a cell changes (the input), all the cells that depend on that cell (the outputs) will get updated automatically. This is called "Reactive Programming" because the outputs *react* to changes in the inputs automatically.

Remember how every component is described entirely through its set of keyword arguments? Those arguments that we set in Python become *properties* of the component, and these properties are important now. With Dash's interactivity, we can dynamically update any of those properties using callbacks. Often we'll update the `children` property of HTML components to display new text (remember that `children` is responsible for the contents of a component) or the `figure` property of a `dcc.Graph` component to display new data. We could also update the `style` of a component or even the available `options` of a `dcc.Dropdown` component!

Let's take a look at another example where a `dcc.Slider` updates a `dcc.Graph`.

Dash App Layout With Figure and Slider

```
from dash import Dash, dcc, html, Input, Output, callback
import plotly.express as px

import pandas as pd

df = pd.read_csv('https://raw.githubusercontent.com/plotly/datasets/master/gapminderDataFiveYea

app = Dash()

app.layout = html.Div([
    dcc.Graph(id='graph-with-slider'),
    dcc.Slider(
        df['year'].min(),
        df['year'].max(),
        step=None,
        value=df['year'].min(),
        marks={str(year): str(year) for year in df['year'].unique()},
        id='year-slider'
    )
])


@callback(
    Output('graph-with-slider', 'figure'),
    Input('year-slider', 'value'))
def update_figure(selected_year):
    filtered_df = df[df.year == selected_year]

    fig = px.scatter(filtered_df, x="gdpPercap", y="lifeExp",
                     size="pop", color="continent", hover_name="country",
                     log_x=True, size_max=55)

    fig.update_layout(transition_duration=500)

    return fig


if __name__ == '__main__':
    app.run(debug=True)
```



▶ Theming with **Dash Enterprise Design Kit**

In this example, the `"value"` property of the `dcc.Slider` is the input of the app, and the output of the app is the `"figure"` property of the `dcc.Graph`. Whenever the `value` of the `dcc.Slider` changes, Dash calls the callback function `update_figure` with the new value. The function filters the dataframe with this new value, constructs a `figure` object, and returns it to the Dash application.

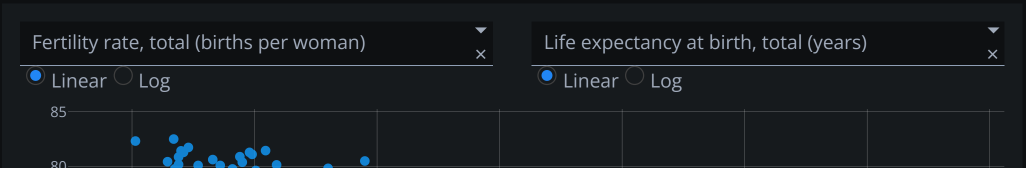
There are a few nice patterns in this example:

1. We use the **Pandas** library to load our dataframe at the start of the app: `df = pd.read_csv('...')`. This dataframe `df` is in the global state of the app and can be read inside the callback functions.
2. Loading data into memory can be expensive. By loading querying data at the start of the app instead of inside the callback functions, we ensure that this operation is only done once -- when the app server starts. When a user visits the app or interacts with the app, that data (`df`) is already in memory. If possible, expensive initialization (like downloading or querying data) should be done in the global scope of the app instead of within the callback functions.
3. The callback does not modify the original data, it only creates copies of the dataframe by filtering using pandas. **This is important:** *your callbacks should never modify variables outside of their scope*. If your callbacks modify global state, then one user's session might affect the next user's session and when the app is deployed on multiple processes or threads, those modifications will not be shared across sessions.
4. We are turning on transitions with `layout.transition` to give an idea of how the dataset evolves with time: transitions allow the chart to update from one state to the next smoothly, as if it were animated.

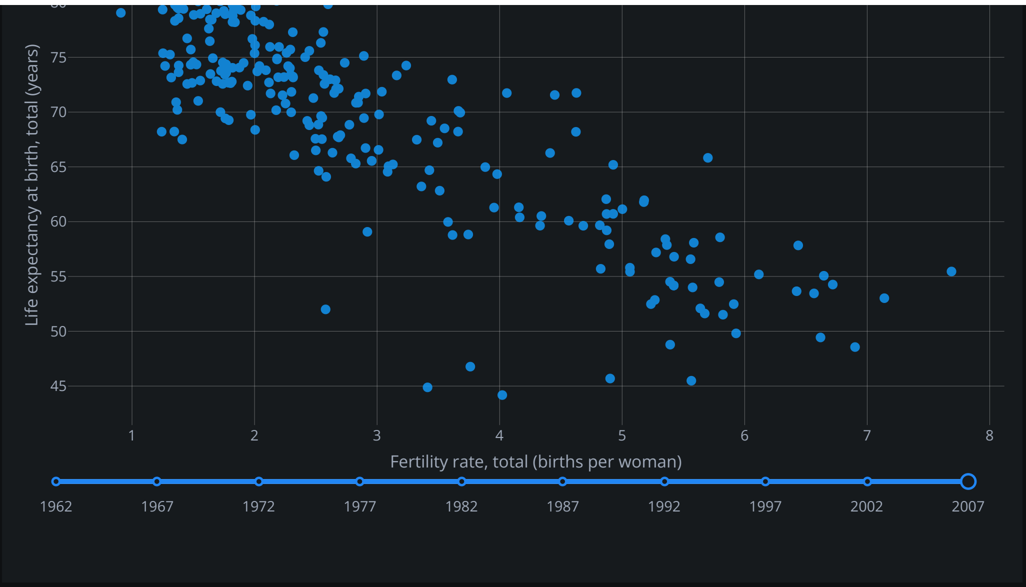
Dash App With Multiple Inputs

In Dash, any "output" can have multiple "input" components. Here's a simple example that binds five inputs (the `value` property of two `dcc.Dropdown` components, two `dcc.RadioItems` components, and one `dcc.Slider` component) to one output component (the `figure` property of the `dcc.Graph` component). Notice how `app.callback` lists all five `Input` items after the `Output`.

```python
from dash import Dash, dcc, html, Input, Output, callback
import plotly.express as px

import pandas as pd

app = Dash()

df = pd.read_csv('https://plotly.github.io/datasets/country_indicators.csv')

app.layout = html.Div([
    html.Div([

        html.Div([
            dcc.Dropdown(
                df['Indicator Name'].unique(),
                'Fertility rate, total (births per woman)',
                id='xaxis-column'
            ),
            dcc.RadioItems(
                ['Linear', 'Log'],
                'Linear',
                id='xaxis-type',
                inline=True
            )
        ], style={'width': '48%', 'display': 'inline-block'}),

        html.Div([
            dcc.Dropdown(
                df['Indicator Name'].unique(),
                'Life expectancy at birth, total (years)',
                id='yaxis-column'
            ),
            dcc.RadioItems(
                ['Linear', 'Log'],
                'Linear',
                id='yaxis-type',
                inline=True
            )
        ], style={'width': '48%', 'float': 'right', 'display': 'inline-block'})
    ]),

    dcc.Graph(id='indicator-graphic'),

    dcc.Slider(
        df['Year'].min(),
        df['Year'].max(),
        step=None,
        id='year--slider',
        value=df['Year'].max(),
        marks={str(year): str(year) for year in df['Year'].unique()},

    )
```


Fertility rate, total (births per woman)
[✓ Linear] Log

Life expectancy at birth, total (years)
[✓ Linear] Log



▸ Theming with **Dash Enterprise Design Kit**

In this example, the callback executes whenever the `value` property of any of the `dcc.Dropdown`, `dcc.Slider`, or `dcc.RadioItems` components change.

The input arguments of the callback are the current value of each of the "input" properties, in the order that they were specified.

Even though only a single `Input` changes at a time (i.e. a user can only change the value of a single Dropdown in a given moment), Dash collects the current state of all the specified `Input` properties and passes them into the callback function. These callback functions are always guaranteed to receive the updated state of the app.

Let's extend our example to include multiple outputs.

Dash App With Multiple Outputs

So far all the callbacks we've written only update a single `Output` property. We can also update several outputs at once: list all the properties you want to update in `app.callback`, and return that many items from the callback. This is particularly useful if two outputs depend on the same computationally intensive intermediate result, such as a slow database query.

```
from dash import Dash, dcc, html, Input, Output, callback

external_stylesheets = ['https://codepen.io/chriddyp/pen/bWLwgP.css']

app = Dash(__name__, external_stylesheets=external_stylesheets)

app.layout = html.Div([
    dcc.Input(
        id='num-multi',
        type='number',
        value=5
    ),
    html.Table([
        html.Tr([html.Td(['x', html.Sup(2)]), html.Td(id='square')]),
        html.Tr([html.Td(['x', html.Sup(3)]), html.Td(id='cube')]),
        html.Tr([html.Td([2, html.Sup('x')]), html.Td(id='twos')]),
        html.Tr([html.Td([3, html.Sup('x')]), html.Td(id='threes')]),
        html.Tr([html.Td(['x', html.Sup('x')]), html.Td(id='x^x')]),
    ]),
])


@callback(
    Output('square', 'children'),
    Output('cube', 'children'),
    Output('twos', 'children'),
    Output('threes', 'children'),
    Output('x^x', 'children'),
    Input('num-multi', 'value'))
def callback_a(x):
    return x**2, x**3, 2**x, 3**x, x**x


if __name__ == '__main__':
    app.run(debug=True)
```

5

x^2 25

x^3 125

2^x 32

3^x 243

x^x 3125

A word of caution: it's not always a good idea to combine outputs, even if you can:

- If the outputs depend on some, but not all, of the same inputs, then keeping them separate can avoid unnecessary updates.
- If the outputs have the same inputs but they perform very different computations with these inputs, keeping the callbacks separate can allow them to run in parallel.

Dash App With Chained Callbacks

You can also chain outputs and inputs together: the output of one callback function could be the input of another callback function.

This pattern can be used to create dynamic UIs where, for example, one input component updates the available options of another input component. Here's a simple example.

```
from dash import Dash, dcc, html, Input, Output, callback

external_stylesheets = ['https://codepen.io/chriddyp/pen/bWLwgP.css']

app = Dash(__name__, external_stylesheets=external_stylesheets)

all_options = {
    'America': ['New York City', 'San Francisco', 'Cincinnati'],
    'Canada': ['Montréal', 'Toronto', 'Ottawa']
}
app.layout = html.Div([
    dcc.RadioItems(
        list(all_options.keys()),
        'America',
        id='countries-radio',
    ),

    html.Hr(),

    dcc.RadioItems(id='cities-radio'),

    html.Hr(),

    html.Div(id='display-selected-values')
])


@callback(
    Output('cities-radio', 'options'),
    Input('countries-radio', 'value'))
def set_cities_options(selected_country):
    return [{'label': i, 'value': i} for i in all_options[selected_country]]


@callback(
    Output('cities-radio', 'value'),
    Input('cities-radio', 'options'))
def set_cities_value(available_options):
    return available_options[0]['value']


@callback(
    Output('display-selected-values', 'children'),
    Input('countries-radio', 'value'),
    Input('cities-radio', 'value'))
def set_display_children(selected_country, selected_city):
    return f'{selected_city} is a city in {selected_country}'


if __name__ == '__main__':
    app.run(debug=True)
```

[✓ America]
Canada

[✓ New York City]
San Francisco
Cincinnati

New York City is a city in America

The first callback updates the available options in the second `dcc.RadioItems` component based off of the selected value in the first `dcc.RadioItems` component.

The second callback sets an initial value when the `options` property changes: it sets it to the first value in that `options` array.

The final callback displays the selected `value` of each component. If you change the `value` of the countries `dcc.RadioItems` component, Dash will wait until the `value` of the cities component is updated before calling the final callback. This prevents your callbacks from being called with inconsistent state like with `"America"` and `"Montréal"`.

Dash App With State

In some cases, you might have a "form"-like pattern in your application. In such a situation, you may want to read the value of an input component, but only when the user is finished entering all of their information in the form rather than immediately after it changes.

Attaching a callback to the input values directly can look like this:

```
from dash import Dash, dcc, html, Input, Output, callback

external_stylesheets = ["https://codepen.io/chriddyp/pen/bWLwgP.css"]

app = Dash(__name__, external_stylesheets=external_stylesheets)

app.layout = html.Div([
    dcc.Input(id="input-1", type="text", value="Montréal"),
    dcc.Input(id="input-2", type="text", value="Canada"),
    html.Div(id="number-output"),
])


@callback(
    Output("number-output", "children"),
    Input("input-1", "value"),
    Input("input-2", "value"),
)
def update_output(input1, input2):
    return f'Input 1 is "{input1}" and Input 2 is "{input2}"'


if __name__ == "__main__":
    app.run(debug=True)
```

Montréal Canada

Input 1 is "Montréal" and Input 2 is "Canada"

In this example, the callback function is fired whenever any of the attributes described by the `Input` change. Try it for yourself by entering data in the inputs above.

`State` allows you to pass along extra values without firing the callbacks. Here's the same example as above but with the two `dcc.Input` components as `State` and a new button component as an `Input`.

```python
from dash import Dash, dcc, html, Input, Output, State, callback

external_stylesheets = ['https://codepen.io/chriddyp/pen/bWLwgP.css']

app = Dash(__name__, external_stylesheets=external_stylesheets)

app.layout = html.Div([
    dcc.Input(id='input-1-state', type='text', value='Montréal'),
    dcc.Input(id='input-2-state', type='text', value='Canada'),
    html.Button(id='submit-button-state', n_clicks=0, children='Submit'),
    html.Div(id='output-state')
])


@callback(Output('output-state', 'children'),
              Input('submit-button-state', 'n_clicks'),
              State('input-1-state', 'value'),
              State('input-2-state', 'value'))
def update_output(n_clicks, input1, input2):
    return f'''
        The Button has been pressed {n_clicks} times,
        Input 1 is "{input1}",
        and Input 2 is "{input2}"
    '''


if __name__ == '__main__':
    app.run(debug=True)
```

Montréal Canada SUBMIT

The Button has been pressed 0 times, Input 1 is "Montréal", and Input 2 is "Canada"

In this example, changing text in the `dcc.Input` boxes won't fire the callback, but clicking on the button will. The current values of the `dcc.Input` values are still passed into the callback even though they don't trigger the callback function itself.

Note that we're triggering the callback by listening to the `n_clicks` property of the `html.Button` component. `n_clicks` is a property that gets incremented every time the component has been clicked on. It's available in every component in Dash HTML Components (`dash.html`), but most useful with buttons.

Passing Components Into Callbacks Instead of IDs

When creating app layouts in earlier examples, we assigned IDs to components within the layout and later referenced these in callback inputs and outputs.

In the first example, there is a `dcc.Input` component with the `id` 'my-input' and a `html.Div` with the `id` 'my-output':

```python
app.layout = html.Div([
    html.H6("Change the value in the text box to see callbacks in action!"),
    html.Div([
        "Input: ",
        dcc.Input(id='my-input', value='initial value', type='text')
    ]),
    html.Br(),
    html.Div(id='my-output'),
@callback(
    Output('my-output', 'children'),
    Input('my-input', 'value')
)
def update_output_div(input_value):
    return f'Output: {input_value}'
```

You can also provide components directly as inputs and outputs without adding or referencing an `id`. Dash autogenerates IDs for these components.

Here is the first example again. Prior to declaring the app layout, we create two components, assigning each one to a variable. We then reference these variables in the layout and pass them directly as inputs and outputs to the callback.

```
from dash import Dash, dcc, html, Input, Output, callback

app = Dash()

my_input = dcc.Input(value='initial value', type='text')
my_output = html.Div()

app.layout = html.Div([
    html.H6("Change the value in the text box to see callbacks in action!"),
    html.Div([
        "Input: ",
        my_input
    ]),
    html.Br(),
    my_output
])


@callback(
    Output(my_output, 'children'),
    Input(my_input, 'value')
)
def update_output_div(input_value):
    return f'Output: {input_value}'


if __name__ == '__main__':
    app.run(debug=True)
```

In Python 3.8 and higher, you can use the walrus operator to declare the component variables within the app layout:

```
app.layout = html.Div([
    html.H6("Change the value in the text box to see callbacks in action!"),
    html.Div([
        "Input: ",
        my_input := dcc.Input(value='initial value', type='text')
    ]),
    html.Br(),
    my_output := html.Div(),
])

@callback(
    Output(my_output, 'children'),
    Input(my_input, 'value')
)
def update_output_div(input_value):
    return f'Output: {input_value}'
```

Note: Auto component IDs won't work with dynamic callback content unless the component variables are defined out of the callback scope. Additionally, they are not compatible with **Pattern-Matching Callbacks**.

Summary

We've covered the fundamentals of callbacks in Dash. Dash apps are built off of a set of simple but powerful principles: UIs that are customizable through reactive callbacks. Every attribute/property of a component can be modified as the output of a callback, while a subset of the attributes (such as the `value` property of `dcc.Dropdown` component) are editable by the user through interacting with the page.

The next part of the Dash Fundamentals covers interactive graphing. **Dash Fundamentals Part 3: Interactive Graphing**

Dash Python ***> Part 2. Basic Callbacks***