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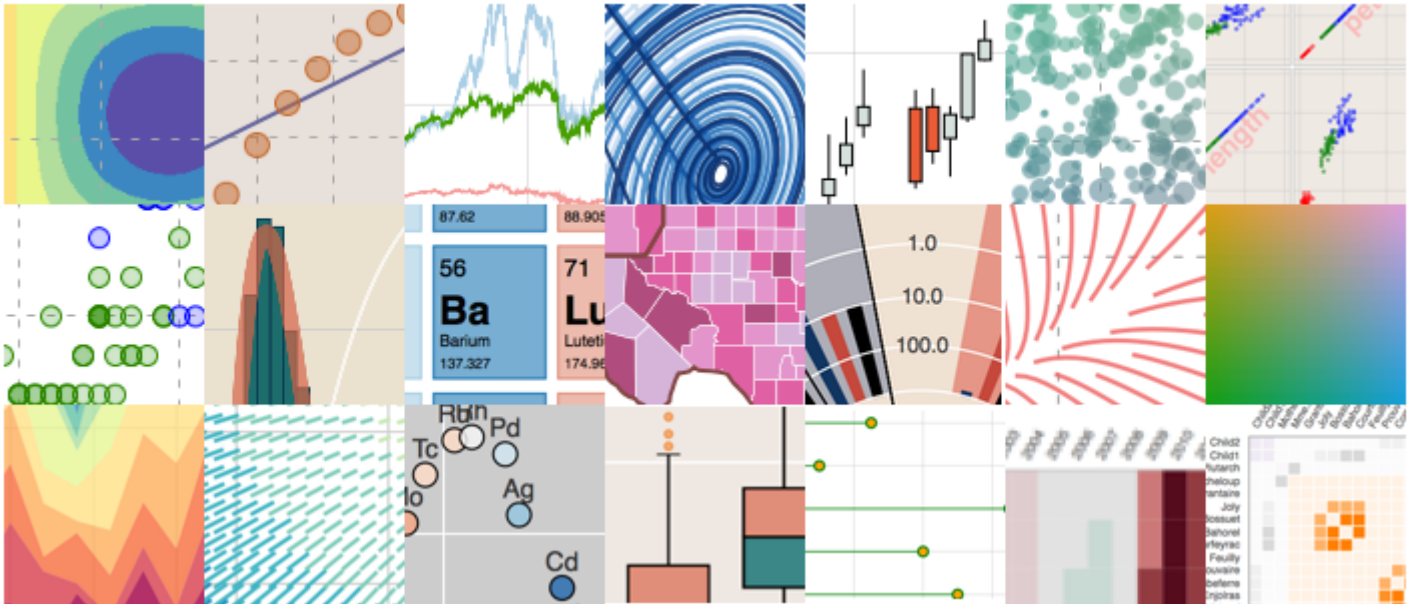
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## Interactive Data Visualization using Bokeh (in Python)

**[SUNIL RAY \(HTTPS://WWW.ANALYTICSVIDHYA.COM/BLOG/AUTHOR/SUNIL-RAY/\)](https://www.analyticsvidhya.com/blog/author/sunil-ray/), AUGUST 28, 2015**

### Introduction

Recently, I was going through a [video from SciPy 2015 \(https://www.analyticsvidhya.com/blog/2015/07/data-science-videos-scipy-2015/\)](https://www.analyticsvidhya.com/blog/2015/07/data-science-videos-scipy-2015/) conference, “[Building Python Data Apps with Blaze and Bokeh \(https://www.youtube.com/watch?v=1gD9LMqREd&list=PLYx7XA2nY5Gcpabmu61kKcToLz0FapmHu&index=31\)](https://www.youtube.com/watch?v=1gD9LMqREd&list=PLYx7XA2nY5Gcpabmu61kKcToLz0FapmHu&index=31)”, recently held at Austin, Texas, USA. I couldn't stop thinking about the power these two libraries provide to data scientists using Python across the globe. In this article, I will introduce you to the world of possibilities in data visualization using Bokeh and why I think this is a must learn / use library for every data scientist out there.

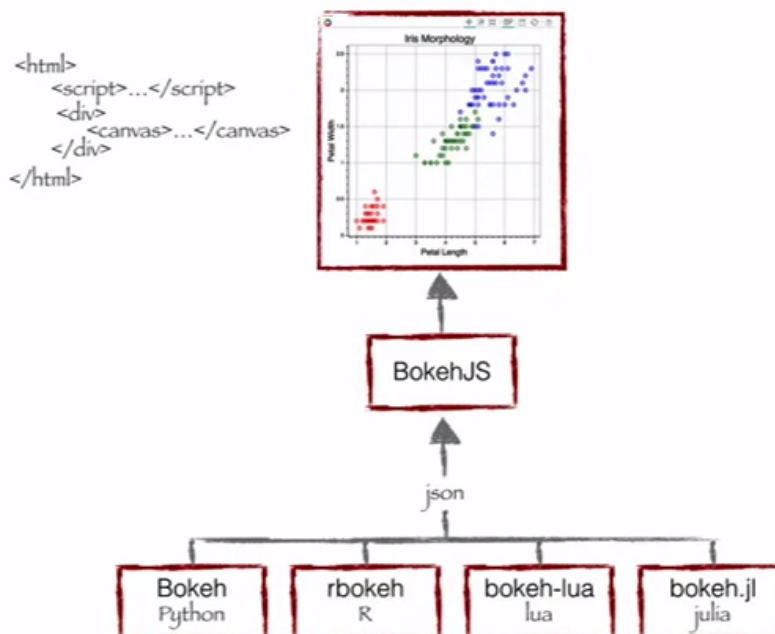


([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Introduction.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Introduction.png))

Source: bokeh.pydata.org

## What is Bokeh?

Bokeh is a Python library for interactive visualization that targets web browsers for representation. This is the core difference between Bokeh and other visualization libraries. Look at the snapshot below, which explains the process flow of how Bokeh helps to present data to a web browser.



([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Intro.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Intro.png)) Source: Continuum Analytics

As you can see, Bokeh has multiple language bindings (Python, R, lua and Julia). These bindings produce a JSON file, which works as an input for BokehJS ([http://bokeh.pydata.org/en/latest/docs/dev\\_guide/bokehjs.html](http://bokeh.pydata.org/en/latest/docs/dev_guide/bokehjs.html)) (a Javascript library), which in turn presents data to the modern web browsers.

Bokeh can produce elegant and interactive visualization like D3.js with high-performance interactivity over very large or streaming datasets. Bokeh can help anyone who would like to quickly and easily create interactive plots, dashboards, and data applications.

## What does Bokeh offer to a data scientist like me?

I started my data science journey as a BI professional and then worked my way through predictive modeling, data science and machine learning. I have primarily relied on tools like QlikView & Tableau for data visualization and SAS & Python for predictive analytics & data science. I had near zero experience of using JavaScript.

So, for all my data products or ideas, I had to either outsource the work or had to pitch my ideas through wireframes, both of which are not ideal for building quick prototypes. Now, with Bokeh, I can continue to work in Python ecosystem, but still create these prototypes quickly.

## Benefits of Bokeh:

- Bokeh allows you to build complex statistical plots quickly and through simple commands
- Bokeh provides you output in various medium like html, notebook and server
- We can also embed Bokeh visualization to flask and django app
- Bokeh can transform visualization written in other libraries like matplotlib, seaborn, ggplot
- Bokeh has flexibility for applying interaction, layouts and different styling option to visualization

## Challenges with Bokeh:

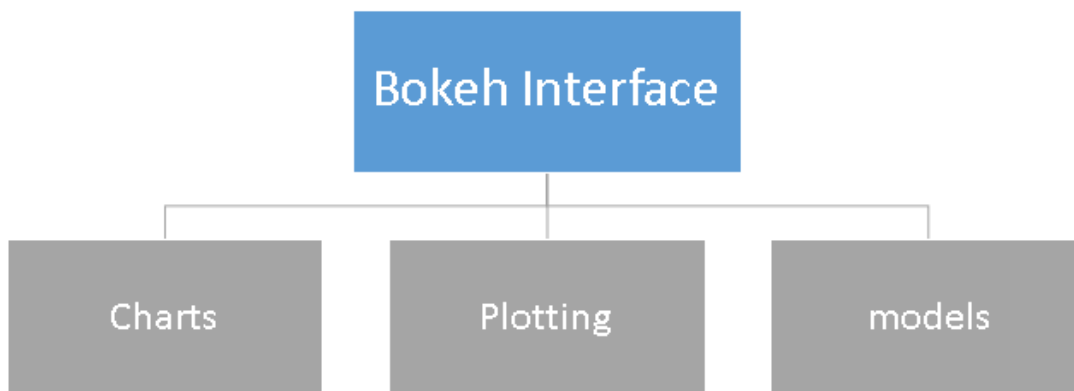
- Like with any upcoming open source library, Bokeh is undergoing a lot of development. So, the code you write today may not be entirely reusable in future.
- It has relatively less visualization options, when compared to D3.js. Hence, it is unlikely in near future that it will challenge D3.js for its crown.

Given the benefits and the challenges, it is currently ideal to rapidly develop prototypes. However, if you want to create something for production environment, D3.js might still be your best bet.

To install Bokeh, please follow the instruction given [here](http://bokeh.pydata.org/en/latest/docs/quickstart.html#quick-installation) (<http://bokeh.pydata.org/en/latest/docs/quickstart.html#quick-installation>).

## Visualization with Bokeh

Bokeh offers both powerful and flexible features which imparts simplicity and highly advanced customization. It provides multiple visualization interfaces to the user as shown below:



([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Interface.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Interface.png))

- **Charts** (<http://bokeh.pydata.org/en/latest/docs/reference/charts.html#bokeh-charts>): a *high-level* interface that is used to build complex statistical plots as quickly and in a simplistic manner.
- **Plotting** (<http://bokeh.pydata.org/en/latest/docs/reference/plotting.html#bokeh-plotting>): an *intermediate-level* interface that is centered around composing visual glyphs.
- **Models** (<http://bokeh.pydata.org/en/latest/docs/reference/models.html#bokeh-models>): a *low-level* interface that provides the maximum flexibility to application developers.

In this article, we will look at first two interfaces charts & plotting only. We will discuss models and other advance feature of this library in next post.

## Charts

As mentioned above, it is a high level interface used to present information in standard visualization form. These forms include box plot, bar chart, area plot, heat map, donut chart and many others. You can generate these plots just by passing data frames, numpy arrays and dictionaries.

Let's look at the common methodology to create a chart:

1. Import the library and functions/ methods
2. Prepare the data
3. Set the output mode (Notebook, Web Browser or Server)
4. Create chart with styling option (if required)
5. Visualize the chart

To understand these steps better, let me demonstrate these steps using example below:

### **Charts Example-1: Create a bar chart and visualize it on web browser using Bokeh**

We will follow above listed steps to create a chart:

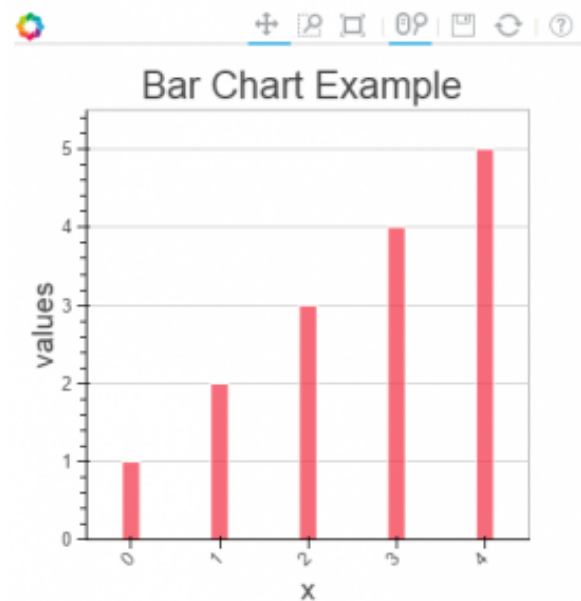
```
#Import library  
from bokeh.charts import Bar, output_file, show #use output_notebook to visualize it in notebook
```

```
# prepare data (dummy data)  
data = {"y": [1, 2, 3, 4, 5]}
```

```
# Output to Line.HTML  
output_file("lines.html", title="line plot example") #put output_notebook() for notebook
```

```
# create a new line chat with a title and axis labels  
p = Bar(data, title="Line Chart Example", xlabel='x', ylabel='values', width=400, height=400)
```

```
# show the results  
show(p)
```



[https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bar\\_Chart.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bar_Chart.png)

In the chart above, you can see the tools at the top (zoom, resize, reset, wheel zoom) and these tools allow you to interact with the chart. You can also look at the multiple chart options (legend, xlabel, ylabel, xgrid, width, height and many other) and various examples of charts [here](http://bokeh.pydata.org/en/latest/docs/user_guide/charts.html) ([http://bokeh.pydata.org/en/latest/docs/user\\_guide/charts.html](http://bokeh.pydata.org/en/latest/docs/user_guide/charts.html)).

## Chart Example-2: Compare the distribution of sepal length and petal length of IRIS data set using Box plot on notebook

To create this visualization, firstly, I'll import the iris data set using sklearn library. Then, follow the steps as discussed above to visualize the chart in ipython notebook.

```
#IRIS Data Set  
from sklearn.datasets import load_iris  
import pandas as pd  
iris = load_iris()  
df=pd.DataFrame(iris.data)  
df.columns=['petal_width','petal_length','sepal_width','sepal_length']
```

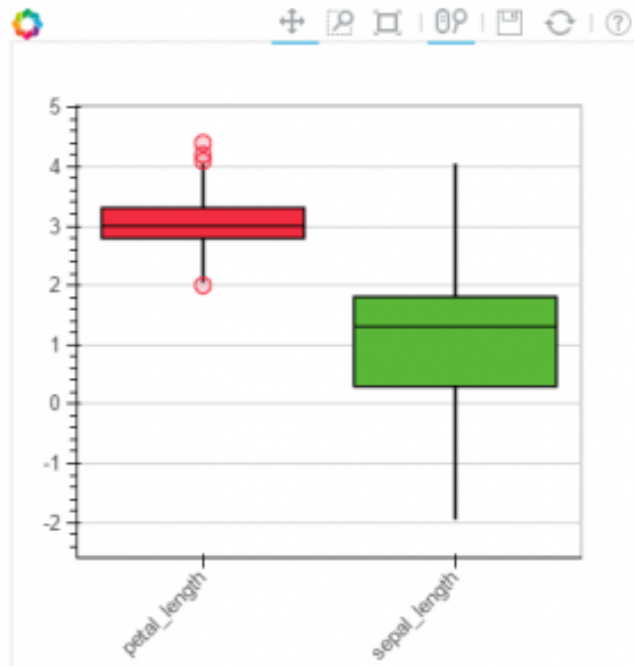
```
#Import library  
from bokeh.charts import BoxPlot, output_notebook, show
```

```
data=df[['petal_length','sepal_length']]
```

```
# Output to Notebook  
output_notebook()
```

```
# create a new line chat with a title and axis labels  
p = BoxPlot(data, width=400, height=400)
```

```
# show the results  
show(p)
```



([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Box\\_Plot.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Box_Plot.png))

### Chart Example-3: Create a line plot to bokeh server

Prior to plotting visualization to Bokeh server, you need to run it.

If you are using a conda package, you can use run command **bokeh-server** from any directory using command. Else, **python ./bokeh-server** command should work in general. For more detail on this please refer this link "[Deploying Bokeh Server \(http://bokeh.pydata.org/en/latest/docs/user\\_guide/server.html\)](http://bokeh.pydata.org/en/latest/docs/user_guide/server.html)".

There are multiple benefits of Plotting visualization on Bokeh server:

- Plots can be published to larger audience
- Visualize large data set interactively
- Streaming data to automatically updating plots
- Building dashboards and apps

To start plotting on Bokeh server, I have executed the command **bokeh-server** to initialize it followed by the commands used for visualization.



```
Command Prompt - bokeh-server

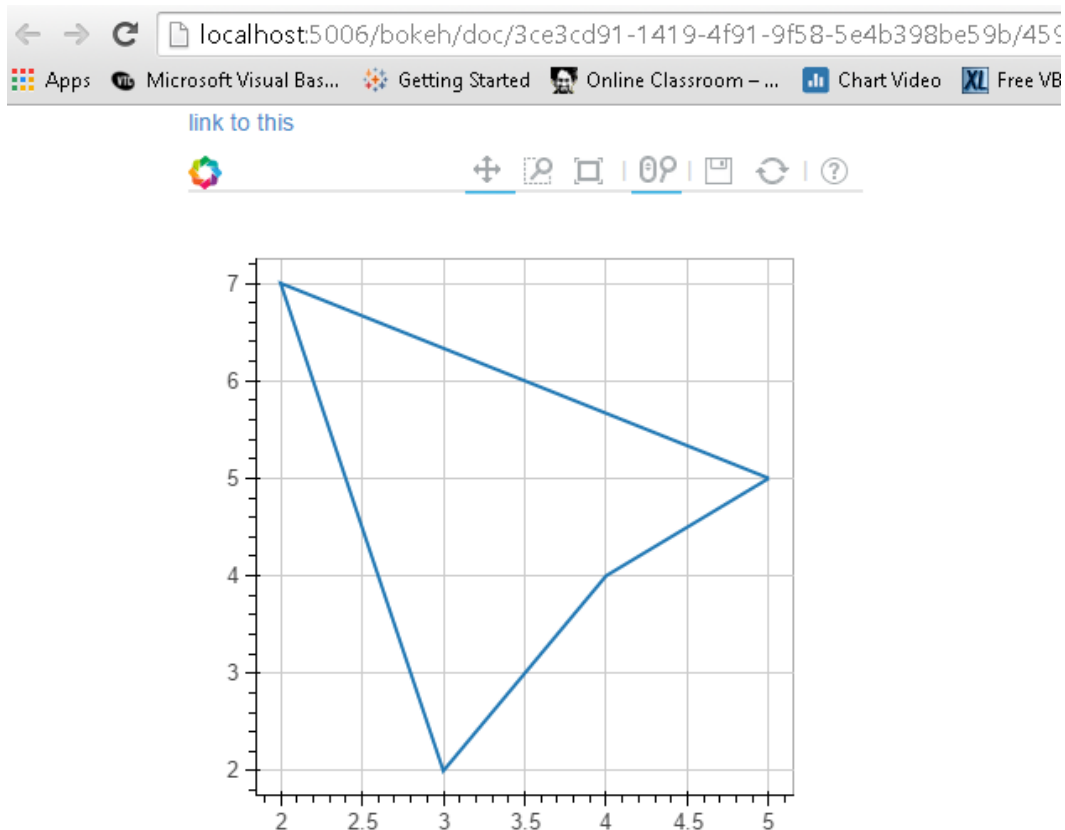
Microsoft Windows [Version 6.3.9600]
(c) 2013 Microsoft Corporation. All rights reserved.

C:\Users\Analytics Vidhya>e:
E:\>bokeh-server

Bokeh Server Configuration
=====
python version : 2.7.8
bokeh version  : 0.9.0
listening      : 127.0.0.1:5006
backend        : memory
python options : debug:OFF, verbose:OFF, filter-logs:OFF, multi-user:OFF
js options     : splitjs:OFF, debugjs:OFF
```

([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Server.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Server.png))

```
from bokeh.plotting import figure, output_server, show
output_server("line")
p = figure(plot_width=400, plot_height=400)
# add a line renderer
p.line([5, 2, 3, 4, 5], [5, 7, 2, 4, 5], line_width=2)
show(p)
```



([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Server\\_Visualization.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Server_Visualization.png))

## **Plotting**

Plotting is an *intermediate-level* interface that is centered around composing visual glyphs. Here, you create a visualization by combining various visual elements ([http://bokeh.pydata.org/en/latest/docs/user\\_guide/styling.html#userguide-styling](http://bokeh.pydata.org/en/latest/docs/user_guide/styling.html#userguide-styling)) (dot, circles, line, patch & many others) and tools ([http://bokeh.pydata.org/en/latest/docs/user\\_guide/tools.html#userguide-tools](http://bokeh.pydata.org/en/latest/docs/user_guide/tools.html#userguide-tools)) (hover tool, zoom, Save, reset and others).

Bokeh plots created using the `bokeh.plotting` (<http://bokeh.pydata.org/en/latest/docs/reference/plotting.html#bokeh-plotting>) interface comes with a default set of tools and visual styles. For plotting, follow the below steps:

1. Import library, methods or functions
2. Select the output mode (notebook, web browser, server)
3. Activate a figure (similar like matplotlib)
4. Perform subsequent plotting operations, it will affect the generated figure.
5. Visualize it

To understand these steps better, let me demonstrate these steps using examples below:

### **Plot Example-1: Create a scatter square mark on XY frame of notebook**

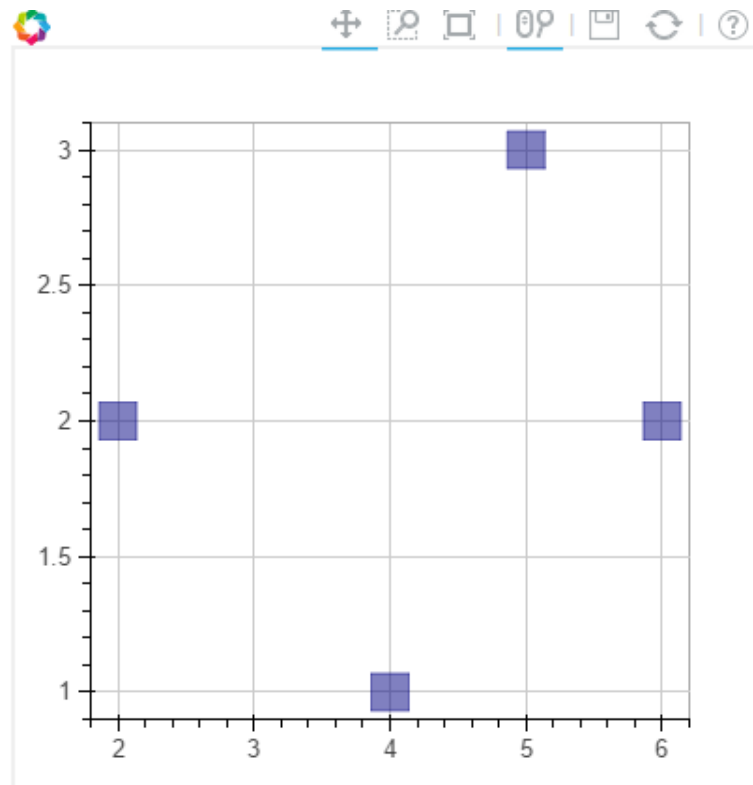
```
from bokeh.plotting import figure, output_notebook, show

# output to notebook
output_notebook()

p = figure(plot_width=400, plot_height=400)

# add square with a size, color, and alpha
p.square([2, 5, 6, 4], [2, 3, 2, 1, 2], size=20, color="navy")

# show the results
show(p)
```



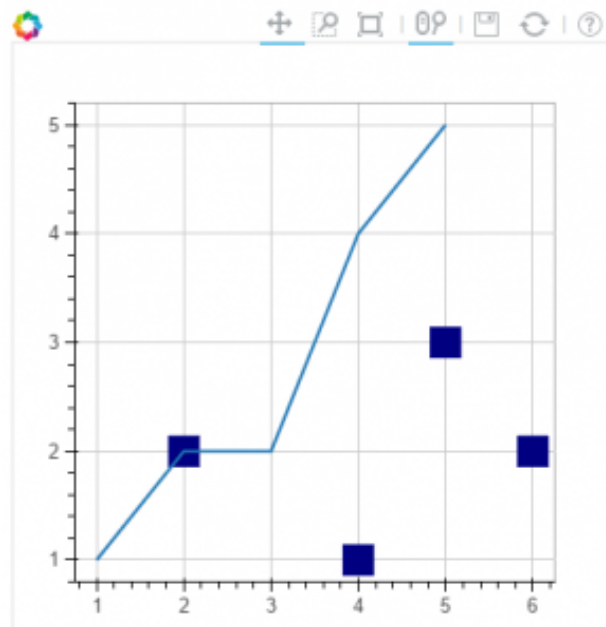
[\\_\(https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Scatter.png\)](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Scatter.png).

Similarly, you can create various other plots like line, wedges & arc, ovals, images, patches and many others, refer this [link \(http://bokeh.pydata.org/en/latest/docs/user\\_guide/plotting.html#userguide-plotting\)](http://bokeh.pydata.org/en/latest/docs/user_guide/plotting.html#userguide-plotting) to see various example.

## Plot Example-2: Combine two visual elements in a plot

```
from bokeh.plotting import figure, output_notebook, show
```

```
# output to notebook
output_notebook()
p = figure(plot_width=400, plot_height=400)
# add square with a size, color, and alpha
p.square([2, 5, 6, 4], [2, 3, 2, 1, 2], size=20, color="navy")
p.line([1, 2, 3, 4, 5], [1, 2, 2, 4, 5], line_width=2) #added a line plot to existing figure
# show the results
show(p)
```



([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Multiple\\_Plots.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Multiple_Plots.png))

### Plot Example-3: Add a hover tool and axis labels to above plot

```
from bokeh.plotting import figure, output_notebook, show
from bokeh.models import HoverTool, BoxSelectTool #For enabling tools
```

```
# output to notebook  
output_notebook()
```

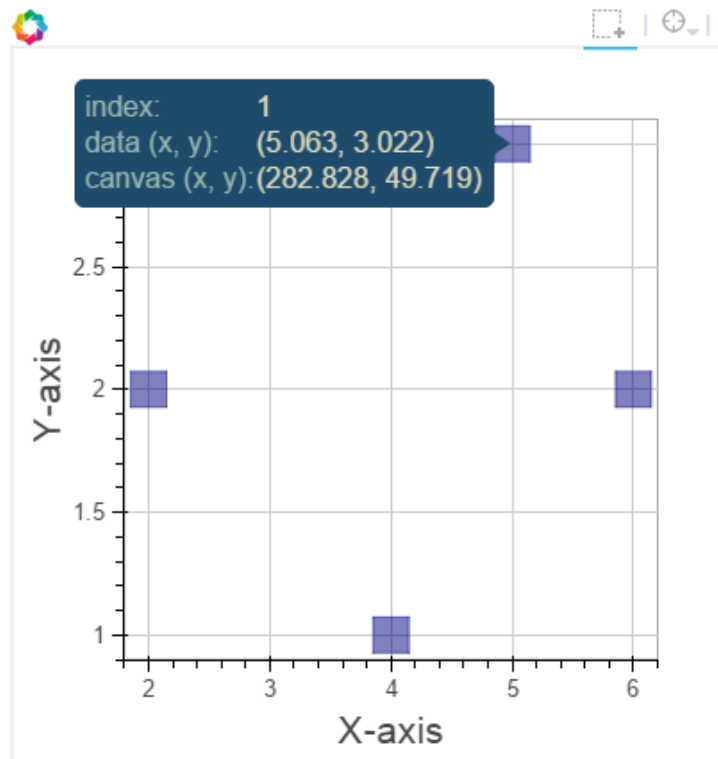
```
#Add tools  
TOOLS = [BoxSelectTool(), HoverTool()]
```

```
p = figure(plot_width=400, plot_height=400, tools=TOOLS)
```

```
# add a square with a size, color, and alpha  
p.square([2, 5, 6, 4], [2, 3, 2, 1, 2], size=20, color="navy", alpha=0.5)
```

```
#Visual Elements  
p.xaxis.axis_label = "X-axis"  
p.yaxis.axis_label = "Y-axis"
```

```
# show the results  
show(p)
```



([https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh\\_Tools\\_Visualize.png](https://www.analyticsvidhya.com/wp-content/uploads/2015/08/Bokeh_Tools_Visualize.png))

For more details on visual attributes and tools refer these links:

- [Styling visual attributes](http://bokeh.pydata.org/en/latest/docs/user_guide/styling.html#userguide-styling) ([http://bokeh.pydata.org/en/latest/docs/user\\_guide/styling.html#userguide-styling](http://bokeh.pydata.org/en/latest/docs/user_guide/styling.html#userguide-styling))
- [Configuring plot tools](http://bokeh.pydata.org/en/latest/docs/user_guide/tools.html#userguide-tools) ([http://bokeh.pydata.org/en/latest/docs/user\\_guide/tools.html#userguide-tools](http://bokeh.pydata.org/en/latest/docs/user_guide/tools.html#userguide-tools))

#### Plot Example-4: Plot map of India using latitude and longitude data for boundaries

Note: I have data for polygon of latitude and longitude for boundaries of India in a csv format. I will use that for plotting.

Here, we will go with patch plotting, let's look at the commands below:

```
#Import libraries
```

```
import pandas as pd
from bokeh.plotting import figure, show, output_notebook
```

```
#Import Latitude and lanogitude co-ordinates
India=pd.read_csv('E:/India.csv')
del India['ID']
India.index=['IN0','IN1','IN2','IN3','IN4','IN5']
```

```
#Convert string values to float as co-ordinates in dataframe are string
for j in range(0,len(India)):
    a = India['lats'][j]
    India['lats'][j] = [float(i) for i in a[1:len(a)-1].split(",")]
```

```
for j in range(0,len(India)):
    a = India['lons'][j]
    India['lons'][j] = [float(i) for i in a[1:len(a)-1].split(",")]
```

```
# Output option
output_notebook()
```

```
# Create your plot
p = figure(plot_height=400, plot_width=400, toolbar_location="right",x_axis_type=None, y_axis_type=None)
p.patches(xs=India['lons'], ys=India['lats'], fill_color="white",line_color="black", line_width=0.5)
```

```
#Visualize your chart
show(p)
```



(<https://www.analyticsvidhya.com/wp-content/uploads/2015/08/INDIA.png>)

## End Notes

In this article, we looked at creating visualizations using Bokeh and methods to present them on notebooks, html and bokeh-server. We also looked at the methods to create customized visualization using plotting, here you can combine multiple visual elements to represent information.

In my next post on Bokeh, I will discuss about models and more interactive features of visualization. For example, I have co-ordinates boundaries for each country across the world. Now, I want to create a visualization to represent each country map in a cycle (loop). It starts plotting with a country map and wait for a 3 sec and iterates for all countries. Sounds interesting! Isn't it?

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I am a Business Analytics and Intelligence professional with deep experience in the Indian Insurance industry. I have worked for various multi-national Insurance companies in last 7 years.

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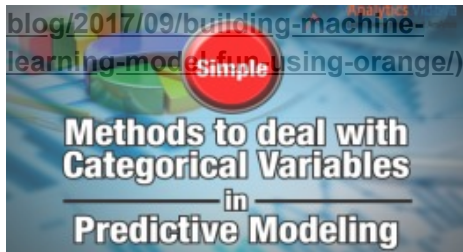
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## 2 COMMENTS



**ARVIND**

[Reply](#)

August 28, 2015 at 4:00 pm (<https://www.analyticsvidhya.com/blog/2015/08/interactive-data-visualization-library-python-bokeh/#comment-93682>)

Very useful info and example.

Sunil,

Could you please provide some example on R as well? Is installation of Bokeh server mandatory for R. I tried to run some samples in R studio and display this in R studio viewer, but got into error. Not had enough time to explore more to resolve issues. Some examples in R will definitely of great help.



**GARY BAGGETT**

[Reply](#)

August 31, 2015 at 1:46 pm (<https://www.analyticsvidhya.com/blog/2015/08/interactive-data-visualization-library-python-bokeh/#comment-93877>)

This appears to be a good overview article. I did not know that this product existed.

How does Bokeh compare with the R-version called "Shiny"? Also, like Arvind above, I would like to see an R example also using ggplot2 .

Thanks,



(<https://www.analyticsvidhya.com/datahack-summit-2018/?>

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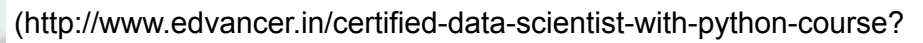
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