Bokeh is better than ever!

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EuroPython 2016, Bilbao

Hi!

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SUMMARY

- Introductions
- Gimme good stuff :)
    - Bokeh Server
    - Bokeh Command
    - Client Side Callbacks
    - New Layout
    - Custom Extensions
    - Annotations
    - Geo Support
    - JS/Typescript API
    - JS Transforms
    - [More] WebGL support
- Extras
- What’s next?

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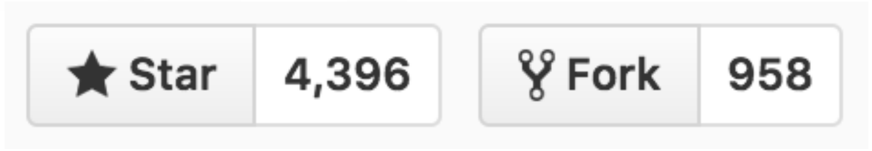
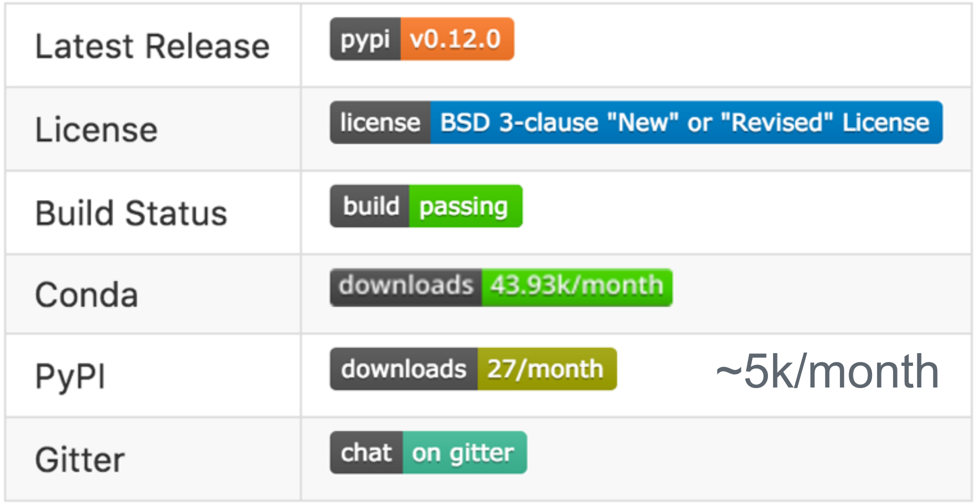
Introduction

Show some hands

Introduction



★ Star 4,396 | Fork 958



Latest Release	pypi v0.12.0
License	license BSD 3-clause "New" or "Revised" License
Build Status	build passing
Conda	downloads 43.93k/month
PyPI	downloads 27/month
Gitter	chat on gitter

~5k/month

Introduction

CONTINUUM ANALYTICS

What is Bokeh?

http://bokeh.pydata.org/

https://bokeh.github.io/blog/2016/6/28/release-0-12/

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CONTINUUM ANALYTICS

Bokeh Server (a.k.a. Bokeh Apps)

- Completely rewritten since 0.11
- Powerful and performant
- Based on tornado and web sockets
- Integrated with *bokeh* command (*bokeh serve*)
- keep the "model objects" in python and in the browser in sync
    - respond to UI and tool events generated in a browser with computations or queries using python
    - automatically push updates the UI (i.e. widgets or plots), in a browser
    - use periodic, timeout, and asynchronous callbacks to drive streaming updates

See the new User's Guide for much more info:

http://bokeh.pydata.org/en/latest/docs/user_guide/server.html#userguide-server-applications

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Bokeh Server (a.k.a. Bokeh Apps)

https://demo.bokehplots.com/

Bokeh Server (a.k.a. Bokeh Apps)

- Running bokeh server:
  - to serve bokeh applications:
    - *bokeh serve* app_dir|app_script.py [options]
  - for output_server or bokeh.client connections:
    - *bokeh serve*

See the new User's Guide for much more info:

http://bokeh.pydata.org/en/latest/docs/user_guide/cli.html#module-bokeh.command.subcommands.serve

http://bokeh.pydata.org/en/latest/docs/user_guide/server.html#running-a-bokeh-server

Bokeh Server (Bokeh App - Single Module Format)

```
[imports…]
from bokeh.plotting import figure, curdoc

# create a plot and style its properties
p = figure(x_range=(0, 100),
          y_range=(0, 100),
toolbar_location=None)
p.border_fill_color = 'black'
p.background_fill_color = 'black'
p.outline_line_color = None
p.grid.grid_line_color = None

# add a text renderer to out plot (no data yet)
r = p.text(x=[], y=[], text=[], text_color=[],
          text_font_size="20pt",
           text_baseline="middle",
     text_align="center")
```

```
i = 0
rnd = np.random.random
ds = r.data_source
def callback():
    global i
    ds.data['x'].append(rnd()*70 + 15)
    ds.data['y'].append(rnd()*70 + 15)
    ds.data['text_color'].append(RdYlBu3[i%3])
    ds.data['text'].append(str(i))
    ds.trigger('data', ds.data, ds.data)
    i = i + 1

# add a button widget and configure with the
# call back
button = Button(label="Press Me")
button.on_click(callback)

# put everything a layout & to the document
curdoc().add_root(column(button, p))
```

Bokeh Server (Bokeh App - Directory Format)

- A directory with at least a **main.py** *file can be used.*
- Similar to a single module format but functionality extended to:
    - A ***server_lifecycle.py*** file that allows optional callbacks to be triggered at different stages of application creation, as described in Lifecycle Hooks.
    - A ***static*** subdirectory that can be used to serve static resources associated with this application.
    - A ***theme.yaml*** file that declaratively defines default attributes to be applied to Bokeh model types.
    - A templates subdirectory with ***index.html*** Jinja template file. The directory may contain additional Jinja templates for index.html to refer to. The template should have the same parameters as the FILE template.

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Bokeh Command

The bokeh html command can create standalone HTML documents from any kind of Bokeh application source: e.g., python scripts, app directories, JSON files, jupyter notebooks and others. For example:

bokeh **html** myapp.py

The bokeh json command will generate a serialized JSON representation of a Bokeh document from any kind of Bokeh application source. For example:

bokeh **json** myapp.py

The bokeh serve command let's you instantly turn Bokeh documents into interactive web applications. For example:

bokeh **serve** myapp.py

See the new User's Guide for much more info:

http://bokeh.pydata.org/en/latest/docs/user_guide/cli.html

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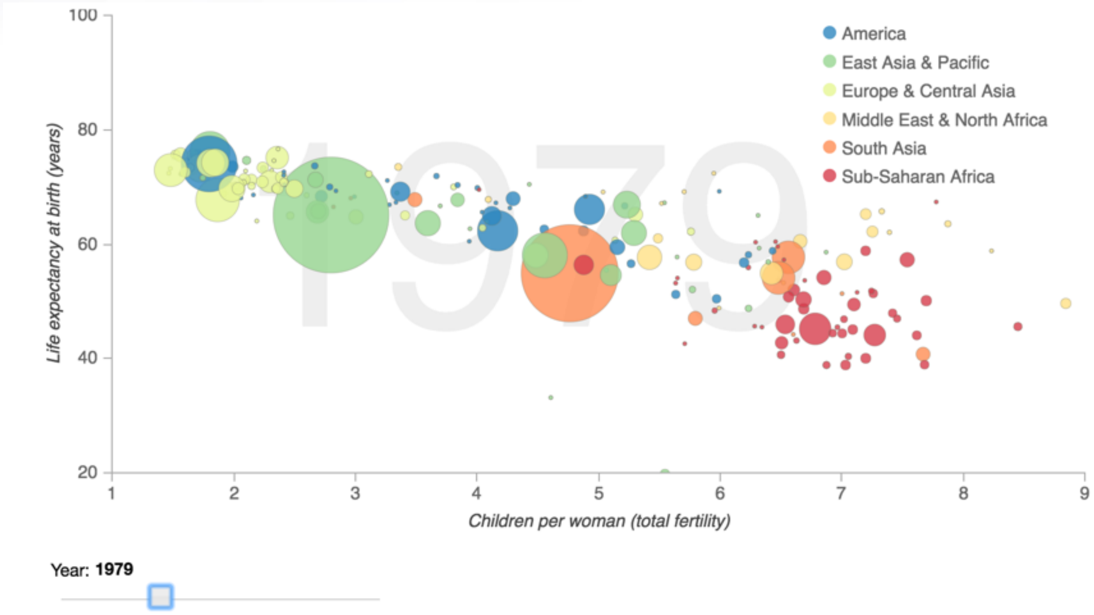
Static Documents, Dynamic Interaction



http://nbviewer.jupyter.org/github/bokeh/bokeh-notebooks/blob/master/tutorial/00%20-%20intro.ipynb#Interaction

Client Side (Javascript) Callbacks

- JS Callbacks extend capability now, for a marginal cost (a few lines of JS)
- [Will] encapsulate common patterns as they are discovered (no more JS!)
- ~~A dream~~: write callbacks in Python, translate automatically !!!
- **no python code is ever executed when a CustomJS callback is used**
- A CustomJS callback is only executed inside a browser JavaScript interpreter, and can only directly interact JavaScript data and functions (e.g., BokehJS Backbone models).

See the new User's Guide for much more info:

http://bokeh.pydata.org/en/latest/docs/user_guide/interaction.html

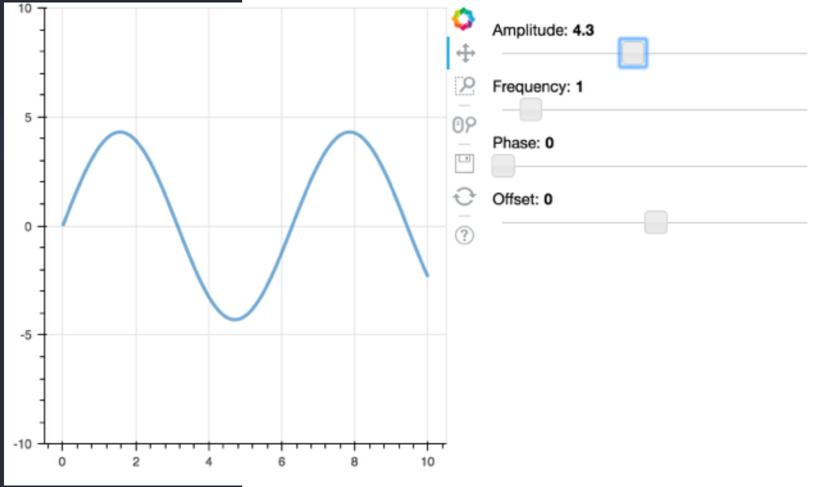
Client Side "Python" Callbacks

```python
plot.line('x', 'y', source=source, line_width=3, line_alpha=0.6)

def callback(source=source, window=None):
    data = source.get('data')
    A, B = amp.get('value'), offset.get('value')
    k, phi = freq.get('value'), phase.get('value')
    x, y = data['x'], data['y']
    for i in range(len(x)):
        y[i] = B + A * window.Math.sin(k * x[i] + phi)
    source.trigger('change')

# turn our function into a CustomJS object.
# print(callback.code) to see the generated JavaScript
callback = CustomJS.from_py_func(callback)

amp_slider = Slider(start=0.1, end=10, value=1, step=.1,
                    title="Amplitude", callback=callback)
callback.args["amp"] = amp_slider
```



Amplitude: 4.3

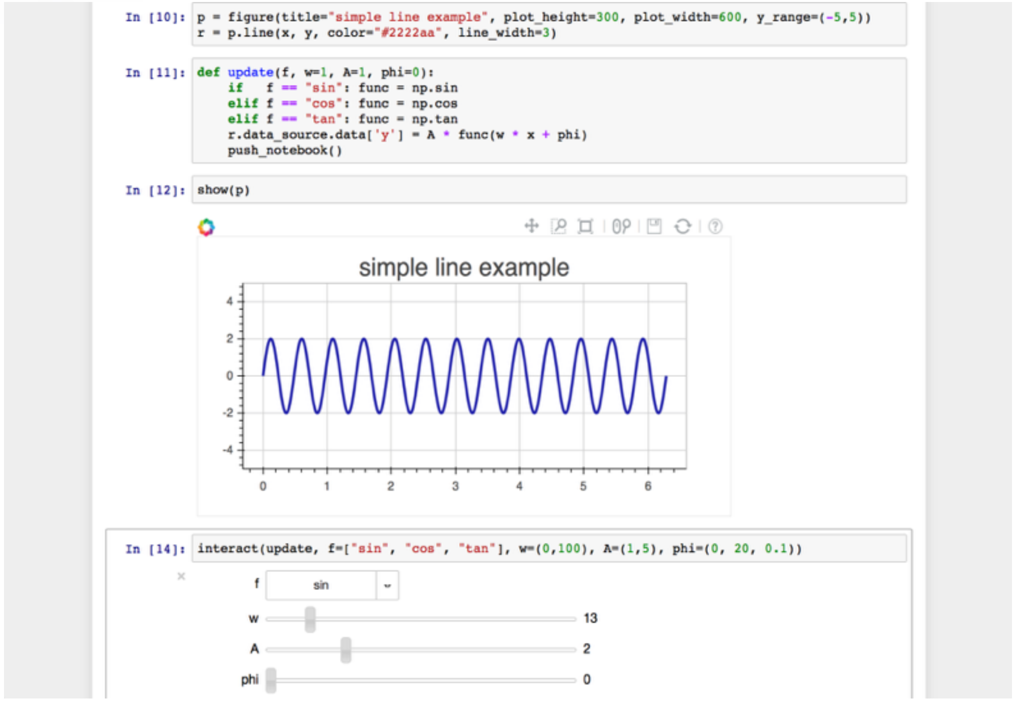
Frequency: 1

Phase: 0

Offset: 0

[Python] Jupyter Interactors Callbacks

- widgets in the GUI can trigger python callback functions that execute in the Jupyter Python kernel
- these callbacks call **push_notebook**() to push updates
- It is currently possible to push udpdates from python, to BokehJS (i.e., to update plots, etc.) using push_notebook() but not the opposite



```
In [10]: p = figure(title="simple line example", plot_height=300, plot_width=600, y_range=(-5,5))
         r = p.line(x, y, color="#2222aa", line_width=3)

In [11]: def update(f, w=1, A=1, phi=0):
             if   f == "sin": func = np.sin
             elif f == "cos": func = np.cos
             elif f == "tan": func = np.tan
             r.data_source.data['y'] = A * func(w * x + phi)
             push_notebook()

In [12]: show(p)
```

```
In [14]: interact(update, f=["sin", "cos", "tan"], w=(0,100), A=(1,5), phi=(0, 20, 0.1))
```

f: sin
w: 13
A: 2
phi: 0

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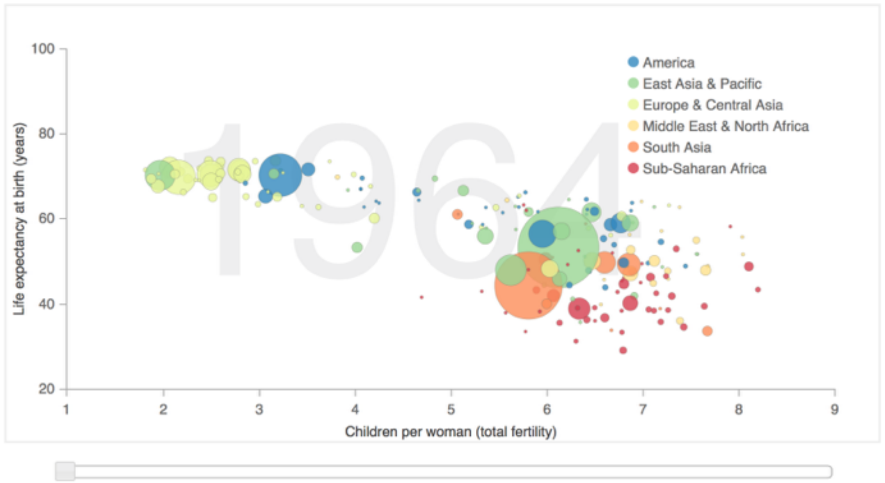
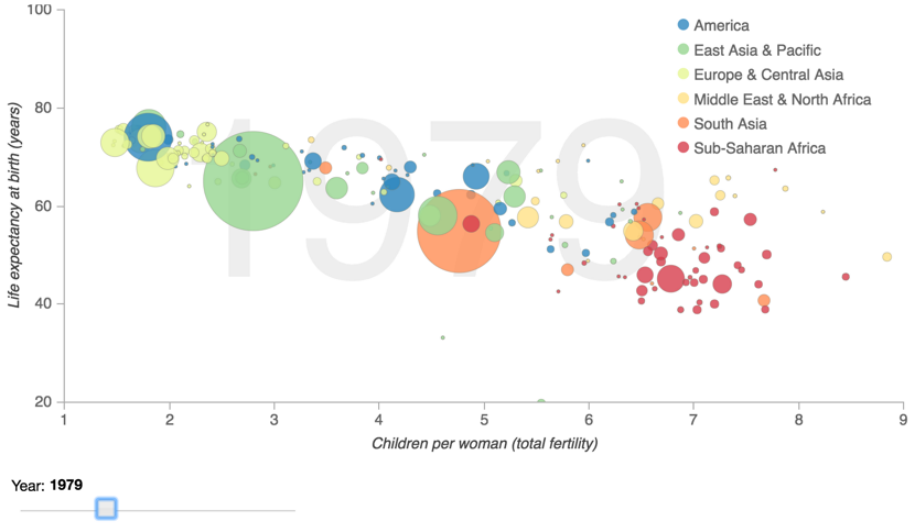
New Layout



1964
100
80
60
40
20
Life expectancy at birth (years)
1
2
3
4
5
6
7
8
9
Children per woman (total fertility)
America
East Asia & Pacific
Europe & Central Asia
Middle East & North Africa
South Asia
Sub-Saharan Africa



1979
100
80
60
40
20
Life expectancy at birth (years)
1
2
3
4
5
6
7
8
9
Children per woman (total fertility)
America
East Asia & Pacific
Europe & Central Asia
Middle East & North Africa
South Asia
Sub-Saharan Africa
Year: 1979

Layouts

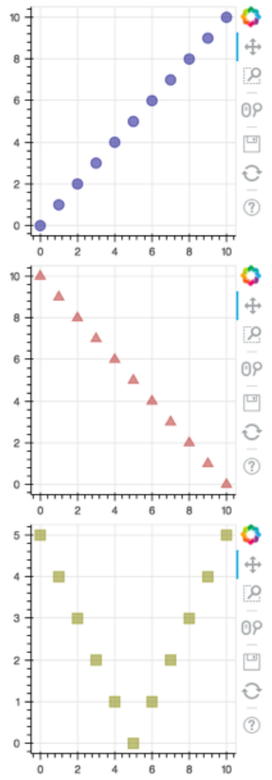
- Bye bye VBox and HBox
- Welcome **Row, Column, and WidgetBox \o/**
  - row(), column(), and widgetbox()
  - let you build a grid of plots and widgets (rows, columns, and plots)
  - support a number of “sizing modes”. These sizing modes allow plots and widgets to resize based on the browser window (all items must have the same sizing mode & Widgets should be inside a widget box)

See the new User’s Guide for much more info:

http://bokeh.pydata.org/en/latest/docs/user_guide/layout.html

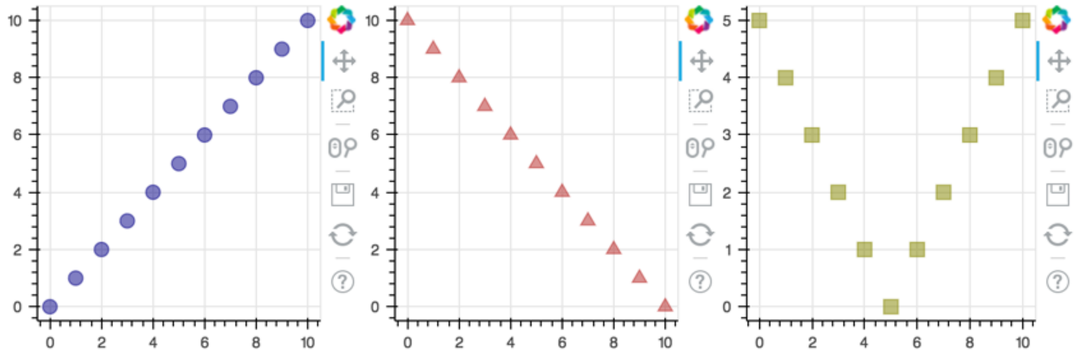
Layouts (column)

```
output_file("layout.html")

x = list(range(11))
y0 = x
y1 = [10 - i for i in x]
y2 = [abs(i - 5) for i in x]

# create a new plot
s1 = figure(width=250, plot_height=250, title=None)
s1.circle(x, y0, size=10, color="navy", alpha=0.5)

# create another one
s2 = figure(width=250, height=250, title=None)
s2.triangle(x, y1, size=10, color="firebrick", alpha=0.5)

# create and another
s3 = figure(width=250, height=250, title=None)
s3.square(x, y2, size=10, color="olive", alpha=0.5)

# put the results in a column and show
show(column(s1, s2, s3))
```



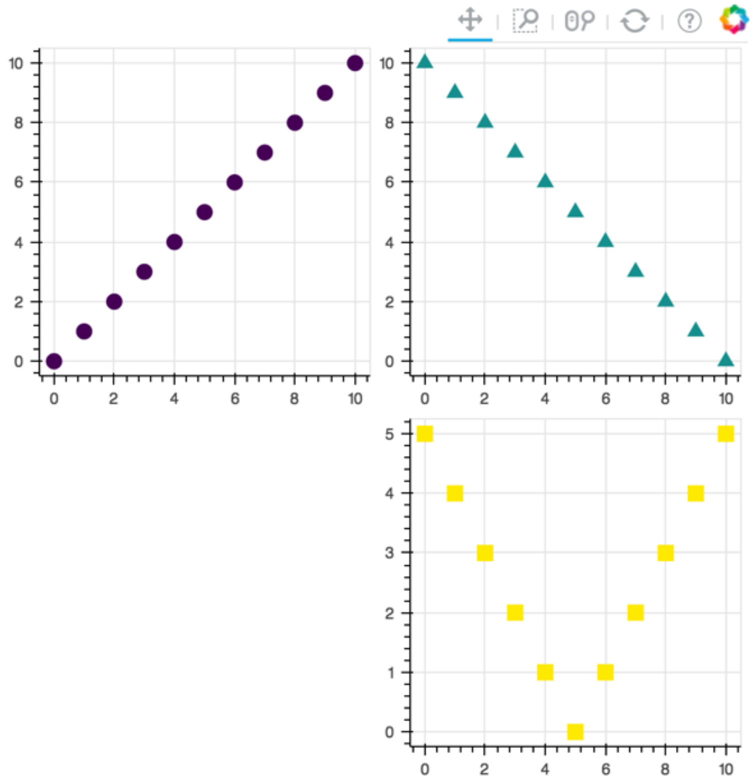
Layouts (row)

```
output_file("layout.html")

x = list(range(11))
y0 = x
y1 = [10 - i for i in x]
y2 = [abs(i - 5) for i in x]

# create a new plot
s1 = figure(width=250, plot_height=250, title=None)
s1.circle(x, y0, size=10, color="navy", alpha=0.5)

# create another one
s2 = figure(width=250, height=250, title=None)
s2.triangle(x, y1, size=10, color="firebrick", alpha=0.5)

# create and another
s3 = figure(width=250, height=250, title=None)
s3.square(x, y2, size=10, color="olive", alpha=0.5)

# put the results in a column and show
show(row(s1, s2, s3))
```



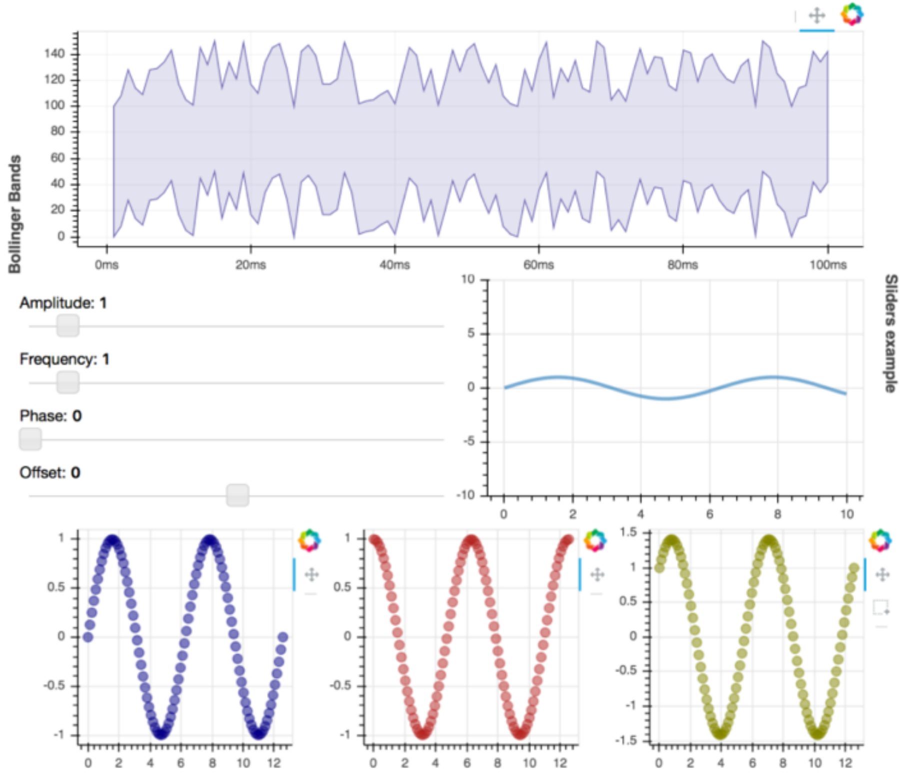
Layout (gridplot)

```
...
from bokeh.layouts import grid plot

output_file("layout_grid.html")

x = list(range(11))
y0 = x
y1 = [10 - i for i in x]
y2 = [abs(i - 5) for i in x]

# create three plots
p1 = figure(width=250, plot_height=250, title=None)
p1.circle(x, y0, size=10, color=Viridis3[0])
p2 = figure(width=250, height=250, title=None)
p2.triangle(x, y1, size=10, color=Viridis3[1])
p3 = figure(width=250, height=250, title=None)
p3.square(x, y2, size=10, color=Viridis3[2])

# make a grid
grid = gridplot([[p1, p2], [None, p3]])

# show the results
show(grid)
```



Layout (layout)

```
l = layout([
  [bollinger],
  [sliders, plot],
  [p1, p2, p3],
],
sizing_mode=‘stretch_both')
```



The full code for this plot is available at examples/howto/layouts/dashboard.py in the project GitHub repository.

Layout (examples)

https://bokeh.github.io/blog/2016/6/28/release-0-12/

https://demo.bokehplots.com/apps/movies

https://demo.bokehplots.com/apps/stocks

https://demo.bokehplots.com/apps/selection_histogram

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Custom Extensions

- It is possible to extend Bokeh by creating custom user extensions to:
  - Modify the behaviour of existing Bokeh models
  - Add new models to connect third-party JavaScript libraries to Python
  - Create highly specialized models for domain specific use-cases
- do not require setting up a development environment or building anything from source

See the new User's Guide for much more info:

http://bokeh.pydata.org/en/latest/docs/user_guide/extensions.html

Custom Extensions (Python Models)

- Python Models
    - For the most part, completely declarative classes
    - Custom extensions are created by making a subclass Model and including special class attributes to declare the properties that are mirrored on the JavaScript side

```
from bokeh.core.properties import String, Instance
from bokeh.models import LayoutDOM, Slider

class Custom(LayoutDOM):
    text = String(default="Custom text")
    range = Instance(Slider)
```

Custom Extensions (JavaScript Models and Views)

- JavaScript side requires code to implement the model
- When appropriate, code for a corresponding view must also be provided.
- Currently BokehJS models and views are subclasses of Models and View from the Backbone JavaScript library.

```
from bokeh.core.properties import String, Instance
from bokeh.models import LayoutDOM, Slider

class Custom(LayoutDOM):
    __implementation__ = open("custom.coffee").read()
    text = String(default="Custom text")
    slider = Instance(Slider)
```

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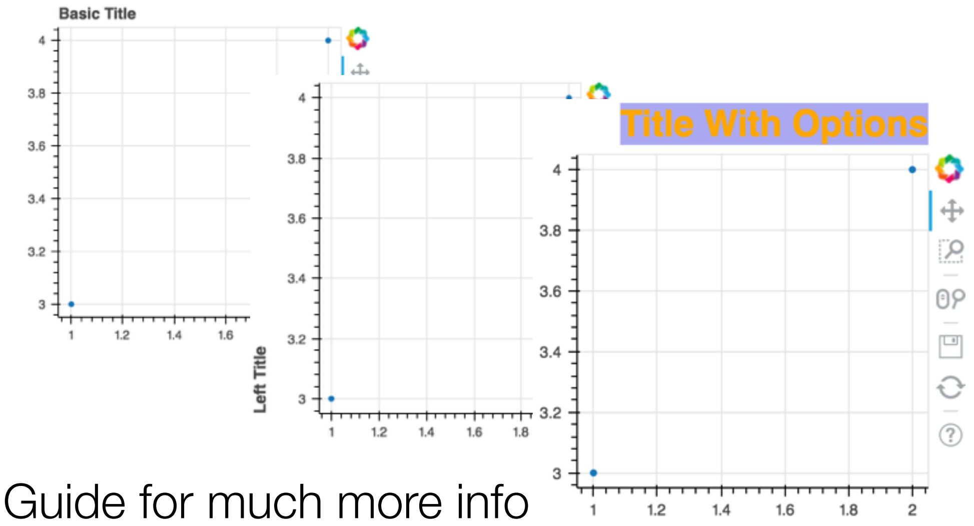
Annotations

allow users to add supplemental information to their visualizations

Title and Legends are annotations now!

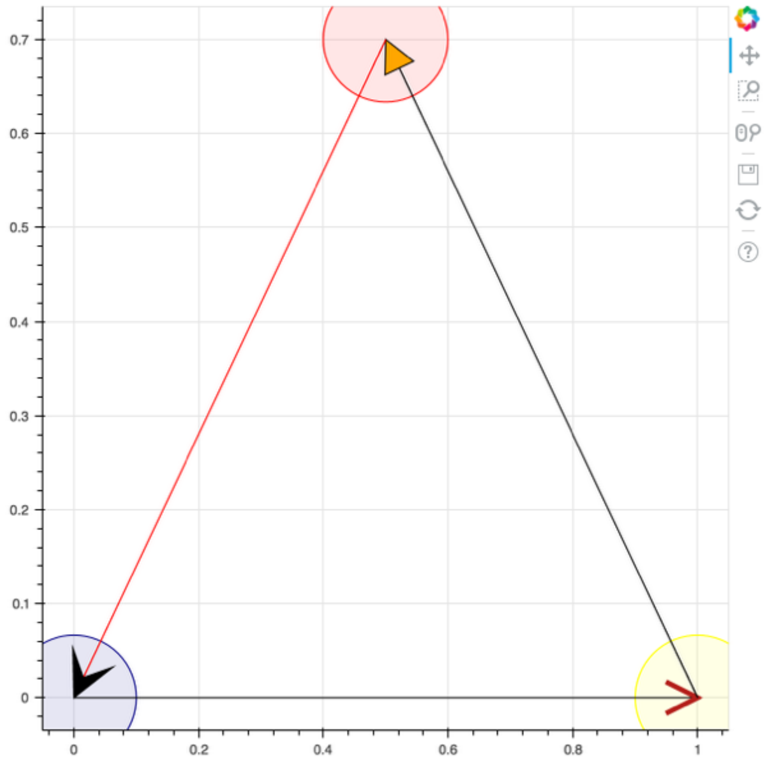


See the new User's Guide for much more info

http://bokeh.pydata.org/en/latest/docs/user_guide/plotting.html#adding-annotations

[New] Annotations (Arrows)

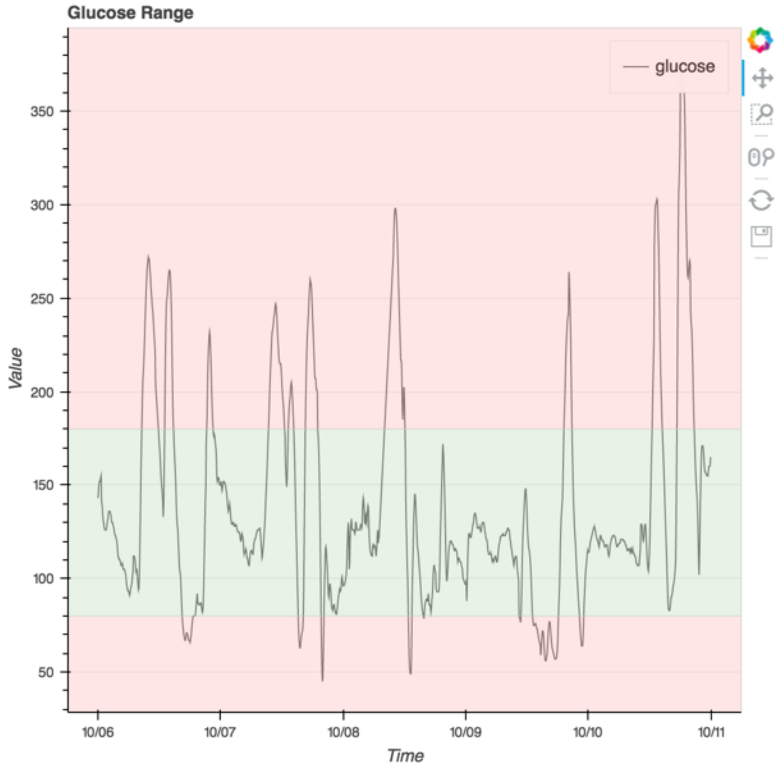
```
from bokeh.models import Arrow, OpenHead, NormalHead,
VeeHead

p = figure(plot_width=600, plot_height=600)

p.circle(x=[0, 1, 0.5], y=[0, 0, 0.7], radius=0.1,
         color=["navy", "yellow", "red"],
fill_alpha=0.1)
p.add_layout(Arrow(end=OpenHead(line_color="firebrick",
line_width=4),
                   x_start=0, y_start=0, x_end=1,
y_end=0))
p.add_layout(Arrow(end=NormalHead(fill_color="orange"),
                   x_start=1, y_start=0, x_end=0.5,
y_end=0.7))
p.add_layout(Arrow(end=VeeHead(size=35),
line_color="red",
                   x_start=0.5, y_start=0.7, x_end=0,
y_end=0))
show(p)
```



[New] Annotations (BoxAnnotation)

CONTINUUM ANALYTICS

```
from bokeh.models import BoxAnnotation
…

data = data.ix['2010-10-06':'2010-10-13']

p = figure(x_axis_type="datetime", tools=TOOLS)
p.line(data.index.to_series(), data['glucose'],
line_color="gray", line_width=1, legend="glucose")

low_box = BoxAnnotation(top=80, fill_alpha=0.1,
fill_color='red')
mid_box = BoxAnnotation(bottom=80, top=180,
fill_alpha=0.1, fill_color='green')
high_box = BoxAnnotation(bottom=180, fill_alpha=0.1,
fill_color=‘red')

p.add_layout(low_box)
p.add_layout(mid_box)
p.add_layout(high_box)

show(p)
```



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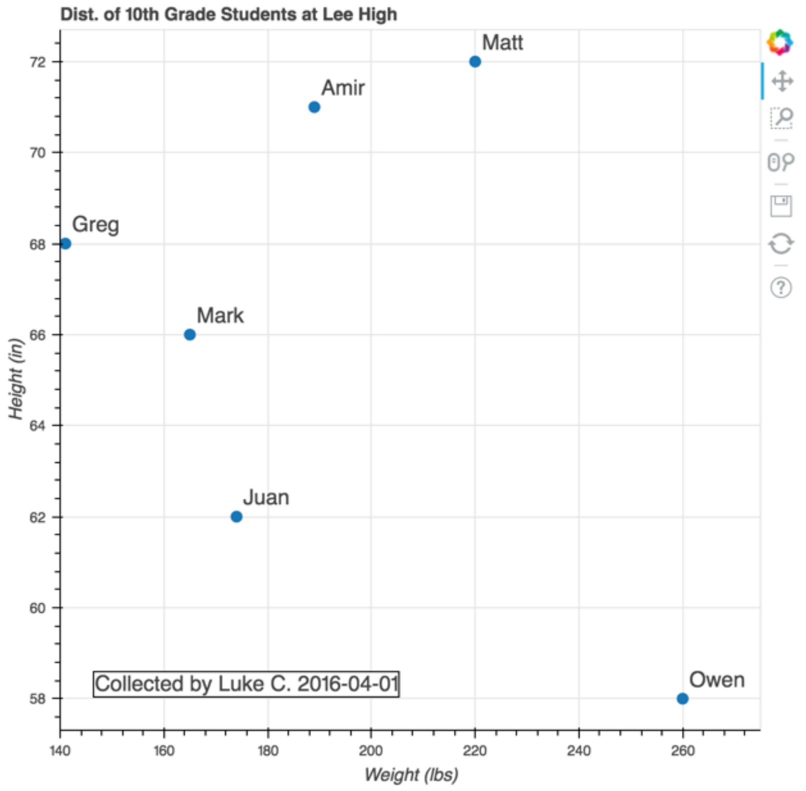
[New] Annotations (Label)

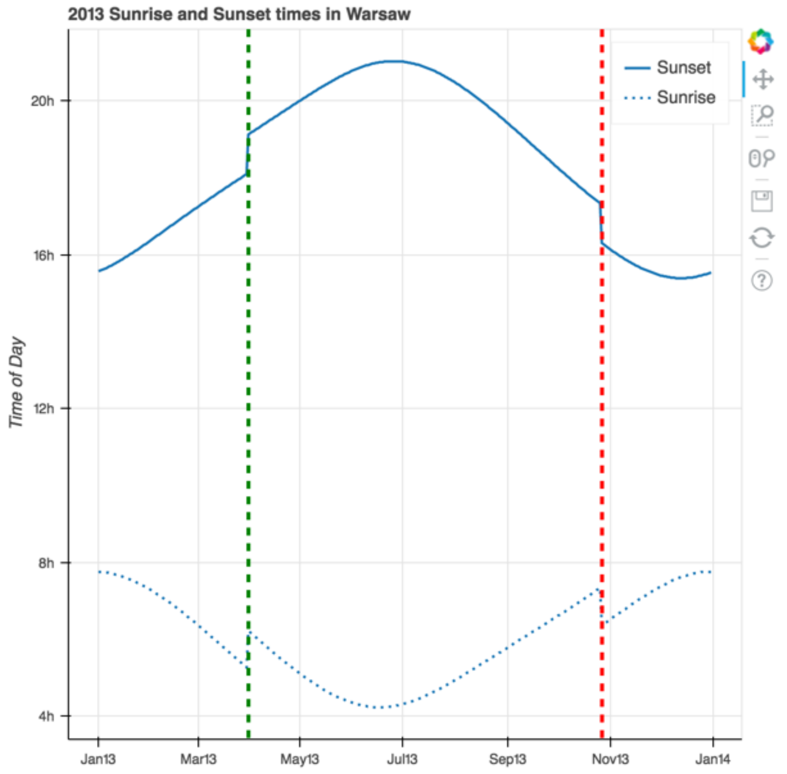
```
from bokeh.models import ColumnDataSource, Range1d, LabelSet,
Label
…
p = figure(title='Dist. of 10th Grade Students at Lee High',
           x_range=Range1d(140, 275))
p.scatter(x='weight', y='height', size=8, source=source)
p.xaxis[0].axis_label = 'Weight (lbs)'
p.yaxis[0].axis_label = 'Height (in)'

labels = LabelSet(x='weight', y='height', text='names',
level='glyph',x_offset=5, y_offset=5, source=source,
render_mode='canvas')

citation = Label(x=70, y=70, x_units='screen', y_units='screen',
text='Collected by Luke C. 2016-04-01', render_mode=‘css',
border_line_color='black', border_line_alpha=1.0,
background_fill_color='white', background_fill_alpha=1.0)

p.add_layout(labels)
p.add_layout(citation)

show(p)
```



CONTINUUM ANALYTICS

[New] Annotations (Span)

```
from bokeh.models import Span

p = figure(x_axis_type="datetime", y_axis_type="datetime")

p.line(daylight_warsaw_2013.Date, daylight_warsaw_2013.Sunset,
       line_dash='solid', line_width=2, legend="Sunset")
p.line(daylight_warsaw_2013.Date, daylight_warsaw_2013.Sunrise,
       line_dash='dotted', line_width=2, legend="Sunrise")


…
daylight_savings_start = Span(location=start_date,
dimension='height', line_color='green',
line_dash='dashed', line_width=3)
p.add_layout(daylight_savings_start)

daylight_savings_end = Span(
   location=end_date, dimension='height',
   line_color='red',line_dash='dashed', line_width=3)
p.add_layout(daylight_savings_end)

show(p)
```



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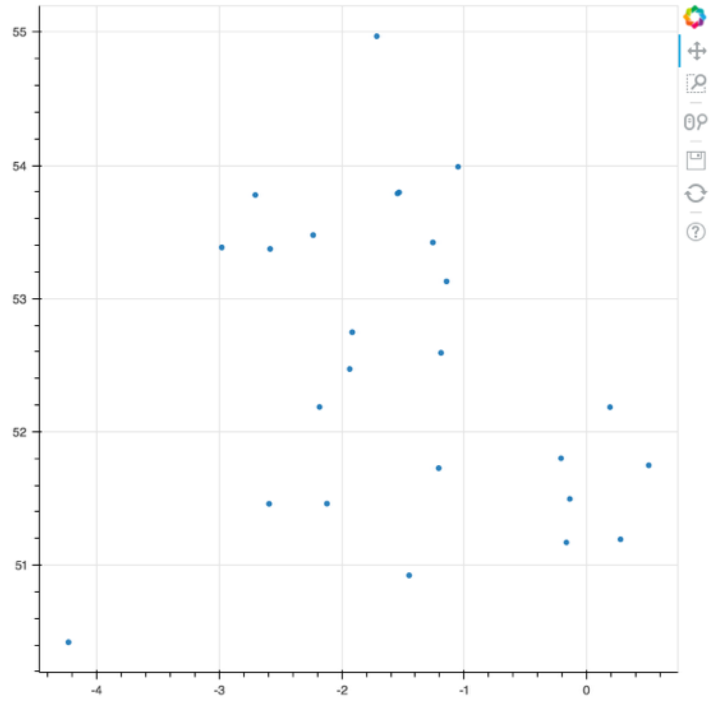
Geo Support (GeoJSON Datasource)

```
from bokeh.models import GeoJSONDataSource
from bokeh.plotting import figure
from bokeh.sampledata.sample_geojson import geojson

geo_source = GeoJSONDataSource(geojson=geojson)

p = figure()
p.circle(x='x', y='y', alpha=0.9, source=geo_source)
output_file("geojson.html")
show(p)
```

```
{
  "type": "Feature",
  "geometry": {
    "type": "Point",
    "coordinates": [125.6, 10.1]
  },
  "properties": {
    "name": "Dinagat Islands"
  }
```



Geo Support (~~Google Maps~~)

Warning :(

There is an open issue documenting points appearing to be ~10px off from their intended location.

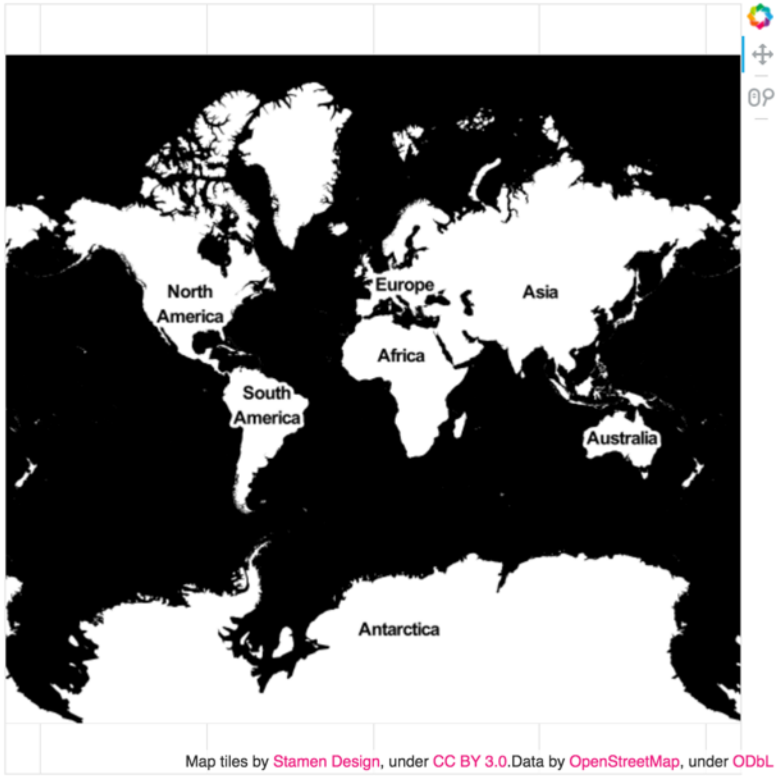
Google has its own terms of service for using Google Maps API and any use of Bokeh with Google Maps must be within Google’s Terms of Service

Geo Support (Tile Providers)

Bokeh plots can also consume XYZ tile services which use the Web Mercator projection. The module bokeh.tile_providers contains several pre-configured tile sources with appropriate attribution which can be added to a plot using the .add_tile() method.

```
from bokeh.io import output_file, show
from bokeh.plotting import figure
from bokeh.tile_providers import STAMEN_TONER

bound = 20000000 # meters
fig = figure(tools='pan, wheel_zoom', x_range=(-bound, bound),
y_range=(-bound, bound))
fig.axis.visible = False
fig.add_tile(STAMEN_TONER)
output_file("stamen_toner_plot.html")
show(fig)
```



Map tiles by Stamen Design, under CC BY 3.0.Data by OpenStreetMap, under ODbL

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Bokeh JS

- BokehJS now has its own [real] API
- The BokehJS APIs are new as of version 0.12 and may undergo some changes before a 1.0 release.
- available via CDN and npm
- Low Level Models
- Plotting interface
- Charts interface**
    - bar
    - pie

See the new User’s Guide for much more info:

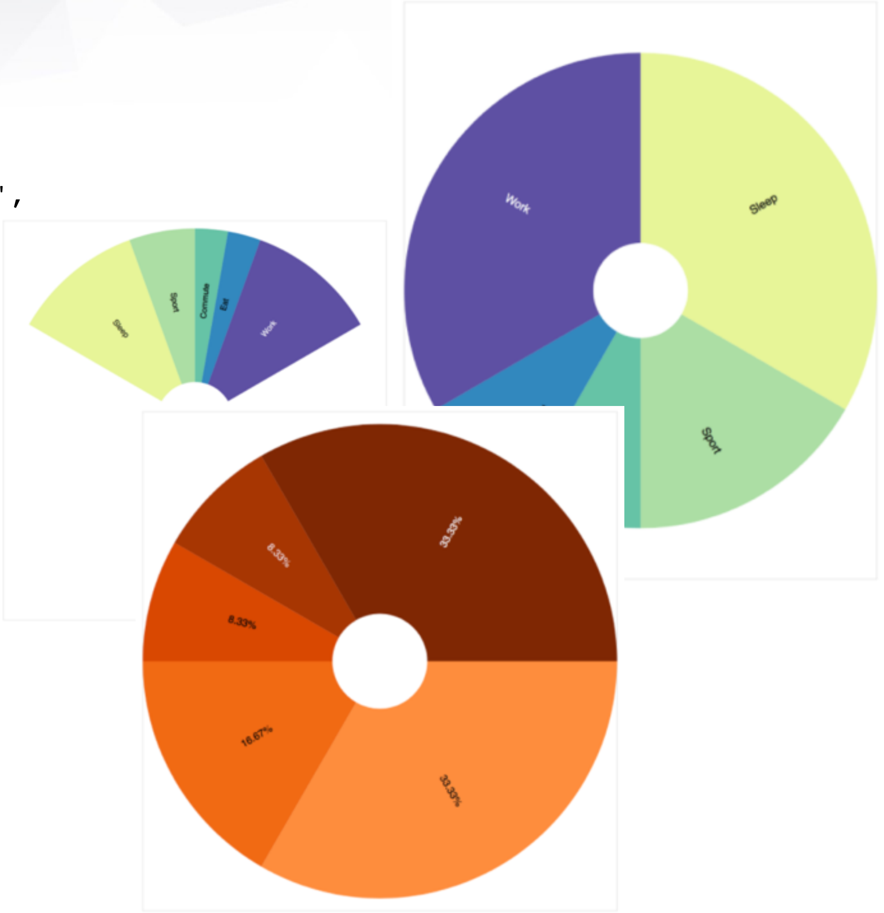
http://bokeh.pydata.org/en/latest/docs/user_guide/bokehjs.html

Bokeh JS

```
var plt = Bokeh.Plotting;

var pie_data = {
    labels: ['Work', 'Eat', 'Commute', 'Sport', 'Watch TV',
'Sleep'],
    values: [8, 2, 2, 4, 0, 8],
};
var p2 = Bokeh.Charts.pie(pie_data, {
    inner_radius: 0.2,
    start_angle: Math.PI / 2
});
var p3 = Bokeh.Charts.pie(pie_data, {
    inner_radius: 0.2,
    start_angle: Math.PI / 6,
    end_angle: 5 * Math.PI / 6
});
var p4 = Bokeh.Charts.pie(pie_data, {
    inner_radius: 0.2,
    palette: "Oranges9",
    slice_labels: "percentages"
});

plt.show(plt.gridplot([p2, p3, p4]));
```



Bokeh JS

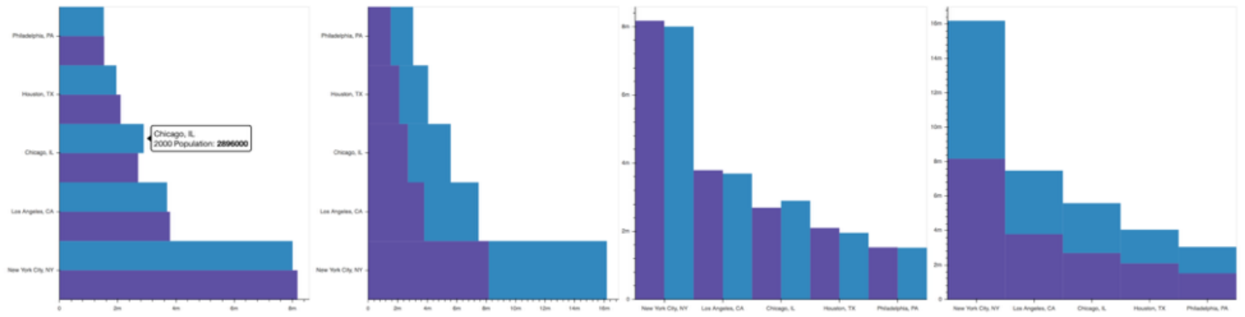
```
var plt = Bokeh.Plotting;

var bar_data = [
    ['City', '2010 Population', '2000
Population'],
    ['New York City, NY', 8175000, 8008000],
    ['Los Angeles, CA', 3792000, 3694000],
    ['Chicago, IL', 2695000, 2896000],
    ['Houston, TX', 2099000, 1953000],
    ['Philadelphia, PA', 1526000, 1517000],
];

var p1 = Bokeh.Charts.bar(bar_data, {
    axis_number_format: "0.[00]a"
});
```

```
var p2 = Bokeh.Charts.bar(bar_data, {
    axis_number_format: "0.[00]a",
    stacked: true
});
var p3 = Bokeh.Charts.bar(bar_data, {
    axis_number_format: "0.[00]a",
    orientation: "vertical"
});
var p4 = Bokeh.Charts.bar(bar_data, {
    axis_number_format: "0.[00]a",
    orientation: "vertical",
    stacked: true
});

plt.show(plt.gridplot([p1, p2, p3, p4]));
```



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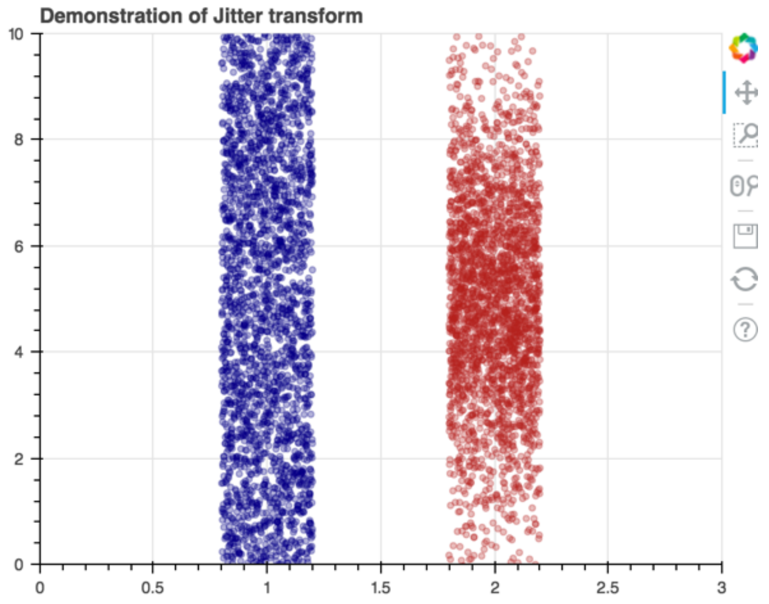
Bokeh JS

```
import numpy as np
from bokeh.models import Jitter
from bokeh.plotting import figure, show, output_file

p = figure(plot_width=500, plot_height=400,
x_range=(0,3), y_range=(0,10),
           title="Demonstration of Jitter transform")

y1 = np.random.random(2500) * 10
y2 = np.random.normal(size=2500)*2 + 5

p.circle(x={'value': 1, 'transform':
Jitter(width=0.4)}, y=y1, color="navy", alpha=0.3)

p.circle(x={'value': 2, 'transform':
Jitter(width=0.4)}, y=y2, color="firebrick", alpha=0.3)

output_file("jitter.html")
show(p)
```



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CONTINUUM ANALYTICS

WebGL [Better] Support

- support to all markers
- fixed WebGL bugs
- fast!

See the new User's Guide for much more info:

http://bokeh.pydata.org/en/latest/docs/user_guide/webgl.html

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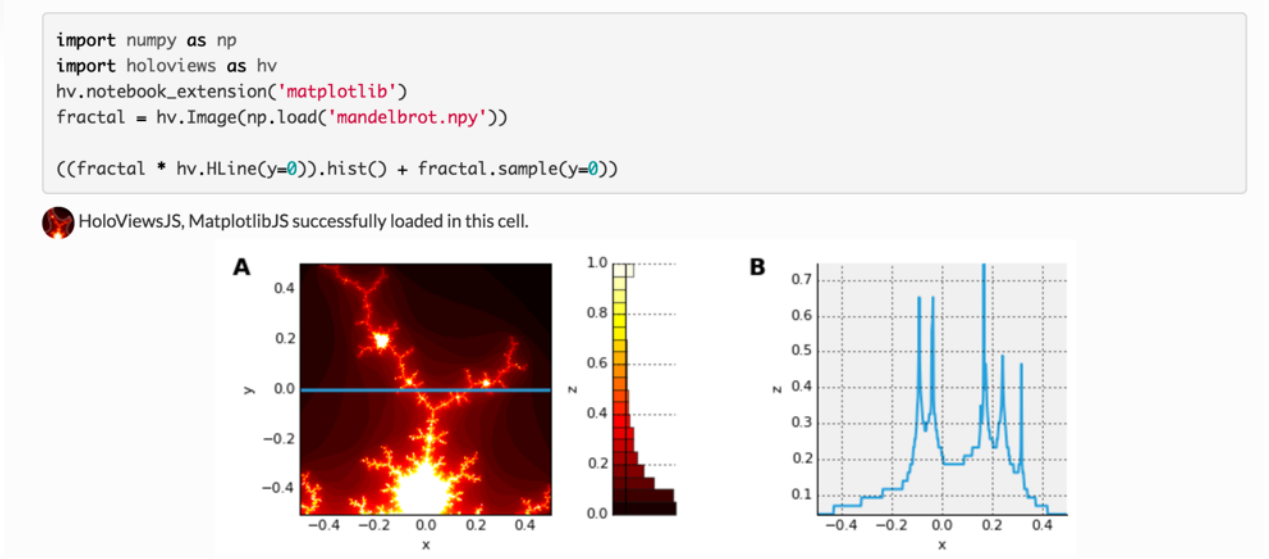
HoloViews



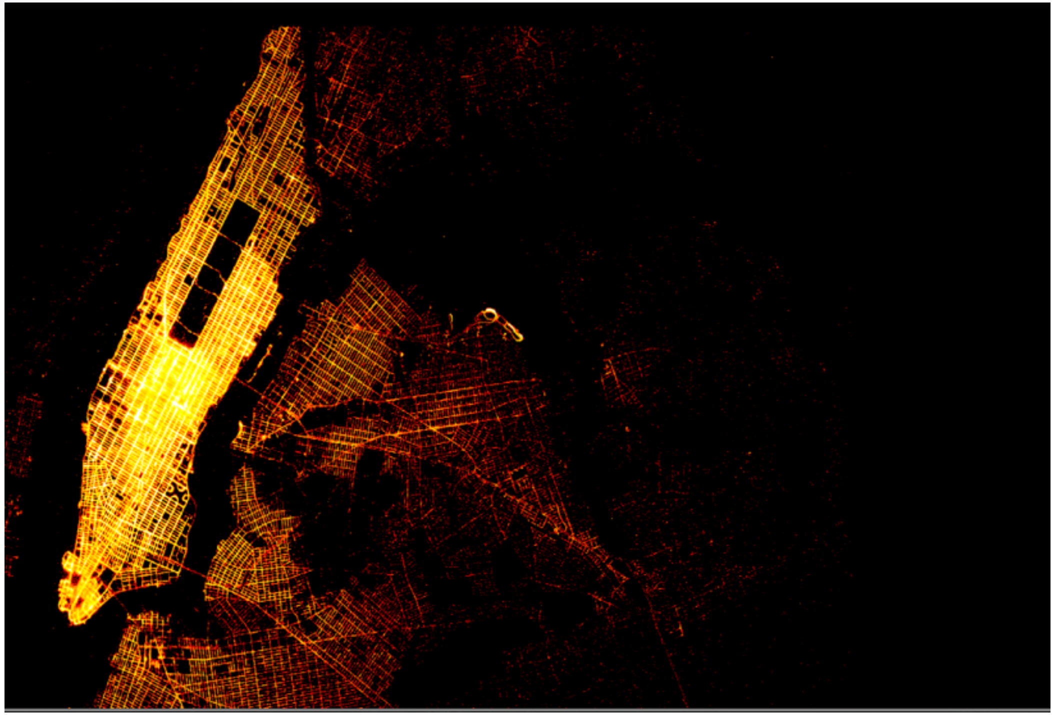
```
import numpy as np
import holoviews as hv
hv.notebook_extension('matplotlib')
fractal = hv.Image(np.load('mandelbrot.npy'))

((fractal * hv.HLine(y=0)).hist() + fractal.sample(y=0))
```

HoloViewsJS, MatplotlibJS successfully loaded in this cell.

more info at http://holoviews.org/

DataShader



http://datashader.readthedocs.io/

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1.0!

THANK YOU!

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