ipyvolume Documentation

Release 0.6.0-dev.1

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May 24, 2019

Contents

IPyvolume is a Python library to visualize 3d volumes and glyphs (e.g. 3d scatter plots), in the Jupyter notebook, with minimal configuration and effort. It is currently pre-1.0, so use at own risk. IPyvolume's *volshow* is to 3d arrays what matplotlib's imshow is to 2d arrays.

Other (more mature but possibly more difficult to use) related packages are yt, VTK and/or Mayavi.

Feedback and contributions are welcome: Github, Email or Twitter.

CHAPTER 1

Quick intro

1.1 Volume

For quick resuls, use *ipyvolume.widgets.quickvolshow*. From a numpy array, we create two boxes, using slicing, and visualize it.

```
import numpy as np
import ipyvolume as ipv
V = np.zeros((128,128,128)) # our 3d array
# outer box
V[30:-30,30:-30,30:-30] = 0.75
V[35:-35,35:-35,35:-35] = 0.0
# inner box
V[50:-50,50:-50,50:-50] = 0.25
V[55:-55,55:-55,55:-55] = 0.0
ipv.quickvolshow(V, level=[0.25, 0.75], opacity=0.03, level_width=0.1, data_min=0,␣
↪data_max=1)
```

[widget]

1.2 Scatter plot

Simple scatter plots are also supported.

```
import ipyvolume as ipv
import numpy as np
x, y, z = np.random.random((3, 10000))
ipv.quickscatter(x, y, z, size=1, marker="sphere")
```

[widget]

1.3 Quiver plot

Quiver plots are also supported, showing a vector at each point.

```
import ipyvolume as ipv
import numpy as np
x, y, z, u, v, w = np.random.random((6, 1000))*2-1
quiver = ipv.quickquiver(x, y, z, u, v, w, size=5)
```

[widget]

1.4 Mesh plot

And surface/mesh plots, showing surfaces or wireframes.

```
import ipyvolume as ipv
x, y, z, u, v = ipv.examples.klein_bottle(draw=False)
ipv.figure()
m = ipv.plot_mesh(x, y, z, wireframe=False)
ipv.squarelim()
ipv.show()
```

[widget]

1.5 Built on Ipywidgets

For anything more sophisticed, use *ipyvolume.pylab*, ipyvolume's copy of matplotlib's 3d plotting (+ volume rendering).

Since ipyvolume is built on ipywidgets, we can link widget's properties.

```
import ipyvolume as ipv
import numpy as np
x, y, z, u, v, w = np.random.random((6, 1000))*2-1
selected = np.random.randint(0, 1000, 100)
ipv.figure()
quiver = ipv.quiver(x, y, z, u, v, w, size=5, size_selected=8, selected=selected)

from ipywidgets import FloatSlider, ColorPicker, VBox, jslink
size = FloatSlider(min=0, max=30, step=0.1)
size_selected = FloatSlider(min=0, max=30, step=0.1)
color = ColorPicker()
color_selected = ColorPicker()
jslink((quiver, 'size'), (size, 'value'))
jslink((quiver, 'size_selected'), (size_selected, 'value'))
jslink((quiver, 'color'), (color, 'value'))
jslink((quiver, 'color_selected'), (color_selected, 'value'))
VBox([ipv.gcc(), size, size_selected, color, color_selected])
```

[widget] Try changing the slider to the change the size of the vectors, or the colors.

CHAPTER 2

Quick installation

This will most likely work, otherwise read install

```
pip install ipyvolume
jupyter nbextension enable --py --sys-prefix ipyvolume
jupyter nbextension enable --py --sys-prefix widgetsnbextension
```

For conda/anaconda, use:

```
conda install -c conda-forge ipyvolume
```

CHAPTER 3

About

Ipyvolume is an offspring project from vaex. Ipyvolume makes use of threejs, an excellent Javascript library for OpenGL/WebGL rendering.

CHAPTER 4

Contents

4.1 Installation

4.1.1 Using pip

Advice: Make sure you use conda or virtualenv. If you are not a root user and want to use the `--user` argument for pip, you expose the installation to all python environments, which is a bad practice, make sure you know what you are doing.

```
$ pip install ipyvolume
```

4.1.2 Conda/Anaconda

```
$ conda install -c conda-forge ipyvolume
```

4.1.3 For Jupyter lab users

The Jupyter lab extension is not enabled by default (yet).

```
$ conda install -c conda-forge nodejs  # or some other way to have a recent node
$ jupyter labextension install @jupyter-widgets/jupyterlab-manager
$ jupyter labextension install ipyvolume
$ jupyter labextension install jupyter-threejs
```

4.1.4 Pre-notebook 5.3

If you are still using an old notebook version, ipyvolume and its dependend extension (widgetsnbextension) need to be enabled manually. If unsure, check which extensions are enabled:

```
$ jupyter nbextention list
```

If not enabled, enable them:

```
$ jupyter nbextension enable --py --sys-prefix ipyvolume
$ jupyter nbextension enable --py --sys-prefix widgetsnbextension
```

4.1.5 Pip as user: (but really, do not do this)

You have been warned, do this only if you know what you are doing, this might hunt you in the future, and now is a good time to consider learning virtualenv or conda.

```
$ pip install ipyvolume --user
$ jupyter nbextension enable --py --user ipyvolume
$ jupyter nbextension enable --py --user widgetsnbextension
```

4.1.6 Developer installation

```
$ git clone https://github.com/maartenbreddels/ipyvolume.git
$ cd ipyvolume
$ pip install -e .
$ jupyter nbextension install --py --symlink --sys-prefix ipyvolume
$ jupyter nbextension enable --py --sys-prefix ipyvolume
```

For all cases make sure ipywidgets is enabled if you use Jupyter notebook version < 5.3 (using `--user` instead of `--sys-prefix` if doing a local install):

```
$ jupyter nbextension enable --py --sys-prefix widgetsnbextension
$ jupyter nbextension enable --py --sys-prefix pythreejs
$ jupyter nbextension enable --py --sys-prefix ipywebrtc
$ jupyter nbextension enable --py --sys-prefix ipyvolume
```

4.1.7 Developer workflow

Jupyter notebook (classical)

Note: There is never a need to restart the notebook server, nbextensions are picked up after a page reload.

Start this command:

```
$ (cd js; npm run watch)
```

It will

- Watch for changes in the sourcecode and run the typescript compiler for transpilation of the `src` dir to the `lib` dir.
- Watch the lib dir, and webpack will build (among other things), `ROOT/ipyvolume/static/index.js`.

Refresh the page.

4.2 Examples

4.2.1 Mixing ipyvolume with Bokeh

This example shows how the selection from a ipyvolume quiver plot can be controlled with a bokeh scatter plot and it's selection tools.

Ipyvolume quiver plot

The 3d quiver plot is done using ipyvolume

[1]:
```
import ipyvolume
import ipyvolume as ipv
import vaex
```

We load some data from vaex, but only use the first 10 000 samples for performance reasons of Bokeh.

[2]:
```
ds = vaex.example()
N = 10000
```

We make a quiver plot using ipyvolume's matplotlib's style api.

[3]:
```
ipv.figure()
quiver = ipv.quiver(ds.data.x[:N],  ds.data.y[:N],  ds.data.z[:N],
                    ds.data.vx[:N], ds.data.vy[:N], ds.data.vz[:N],
                    size=1, size_selected=5, color_selected="grey")
ipv.xyzlim(-30, 30)
ipv.show()
```

```
A Jupyter Widget
```

Bokeh scatter part

The 2d scatter plot is done using Bokeh.

[4]:
```
from bokeh.io import output_notebook, show
from bokeh.plotting import figure
import ipyvolume.bokeh
output_notebook()
```

[5]:
```
tools = "wheel_zoom,box_zoom,box_select,lasso_select,help,reset,"
p = figure(title="E Lz space", tools=tools, webgl=True, width=500, height=500)
r = p.circle(ds.data.Lz[:N], ds.data.E[:N],color="navy", alpha=0.2)
# A 'trick' from ipyvolume to link the selection (one way traffic atm)
ipyvolume.bokeh.link_data_source_selection_to_widget(r.data_source, quiver, 'selected
↪')
show(p)
```

Now try doing a selection and see how the above 3d quiver plot reflects this selection.

[ ]:
```
# this code is currently broken
# import ipywidgets
#out = ipywidgets.Output()
#with out:
#    show(p)
#ipywidgets.HBox([out, ipv.gcc()])
```

Embedding in html

A bit of a hack, but it is possible to embed the widget and the bokeh part into a single html file (use at own risk).

[8]:
```
from bokeh.resources import CDN
from bokeh.embed import components

script, div = components((p))
template_options = dict(extra_script_head=script + CDN.render_js() + CDN.render_css(),
                        body_pre="<h2>Do selections in 2d (bokeh)<h2>" + div + "<h2>
↪And see the selection in ipyvolume<h2>")
ipyvolume.embed.embed_html("tmp/bokeh.html",
                           [ipv.gcc(), ipyvolume.bokeh.wmh], all_states=True,
                           template_options=template_options)
```

[7]:
```
!open tmp/bokeh.html
```

[ ]:
```

```

4.2.2 Mixing ipyvolume with bqplot

This example shows how the selection from a ipyvolume quiver plot can be controlled with a bqplot scatter plot and it's selection tools. We first get a small dataset from vaex

[1]:
```
import numpy as np
import vaex
```

[2]:
```
ds = vaex.example()
N = 2000 # for performance reasons we only do a subset
x, y, z, vx, vy, vz, Lz, E = [ds.columns[k][:N] for k in "x y z vx vy vz Lz E".
↪split()]
```

bqplot scatter plot

And create a scatter plot with bqplot

[3]:
```
import bqplot.pyplot as plt
```

[4]:
```
plt.figure(1, title="E Lz space")
scatter = plt.scatter(Lz, E,
                      selected_style={'opacity': 0.2, 'size':1, 'stroke': 'red'},
                      unselected_style={'opacity': 0.2, 'size':1, 'stroke': 'blue'},
                      default_size=1,
                     )
```

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```
plt.brush_selector()
plt.show()
```

```
A Jupyter Widget
```

Ipyvolume quiver plot

And use ipyvolume to create a quiver plot

[5]:
```
import ipyvolume.pylab as p3
```

[6]:
```
p3.clear()
quiver = p3.quiver(x, y, z, vx, vy, vz, size=2, size_selected=5, color_selected="blue
↪")
p3.show()
```

```
A Jupyter Widget
```

Linking ipyvolume and bqplot

Using jslink, we link the `selected` properties of both widgets, and we display them next to eachother using a VBox.

[7]:
```
from ipywidgets import jslink, VBox
```

[8]:
```
jslink((scatter, 'selected'), (quiver, 'selected'))
```

[9]:
```
hbox = VBox([p3.current.container, plt.figure(1)])
hbox
```

```
A Jupyter Widget
```

Embedding

We embed the two widgets in an html file, creating a standlone plot.

[10]:
```
import ipyvolume.embed
# if we don't do this, the bqplot will be really tiny in the standalone html
bqplot_layout = hbox.children[1].layout
bqplot_layout.min_width = "400px"
```

[14]:
```
ipyvolume.embed.embed_html("bqplot.html", hbox, offline=True, devmode=True)
```

[ ]:
```
!open bqplot.html
```

[ ]:
```

```

4.2.3 MCMC & why 3d matters

This example (although quite artificial) shows that viewing a posterior (ok, I have flat priors) in 3d can be quite useful. While the 2d projection may look quite 'bad', the 3d volume rendering shows that much of the volume is empty, and the posterior is much better defined than it seems in 2d.

[3]:
```
import pylab
import scipy.optimize as op
import emcee
import numpy as np
%matplotlib inline
```

[4]:
```
# our 'blackbox' 3 parameter model which is highly degenerate
def f_model(x, a, b, c):
    return x * np.sqrt(a**2 +b**2 + c**2) + a*x**2 + b*x**3
```

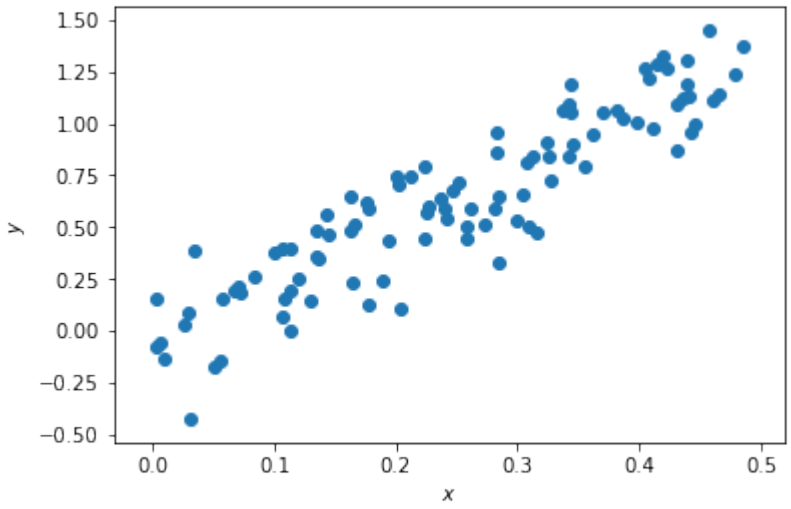
[5]:
```
N = 100
a_true, b_true, c_true = -1., 2., 1.5

# our input and output
x = np.random.rand(N)*0.5#+0.5
y = f_model(x, a_true, b_true, c_true)

# + some (known) gaussian noise
error = 0.2
y += np.random.normal(0, error, N)

# and plot our data
pylab.scatter(x, y);
pylab.xlabel("$x$")
pylab.ylabel("$y$")
```

[5]:
```
<matplotlib.text.Text at 0x10d7b35c0>
```



[6]:
```
# our likelihood
def lnlike(theta, x, y, error):
    a, b, c = theta
    model =  f_model(x, a, b, c)
    chisq = 0.5*(np.sum((y-model)**2/error**2))
    return -chisq
result = op.minimize(lambda *args: -lnlike(*args), [a_true, b_true, c_true], args=(x,␣
↪y, error))
# find the max likelihood
a_ml, b_ml, c_ml = result["x"]
```

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```
print("estimates", a_ml, b_ml, c_ml)
print("true values", a_true, b_true, c_true)
result["message"]
```

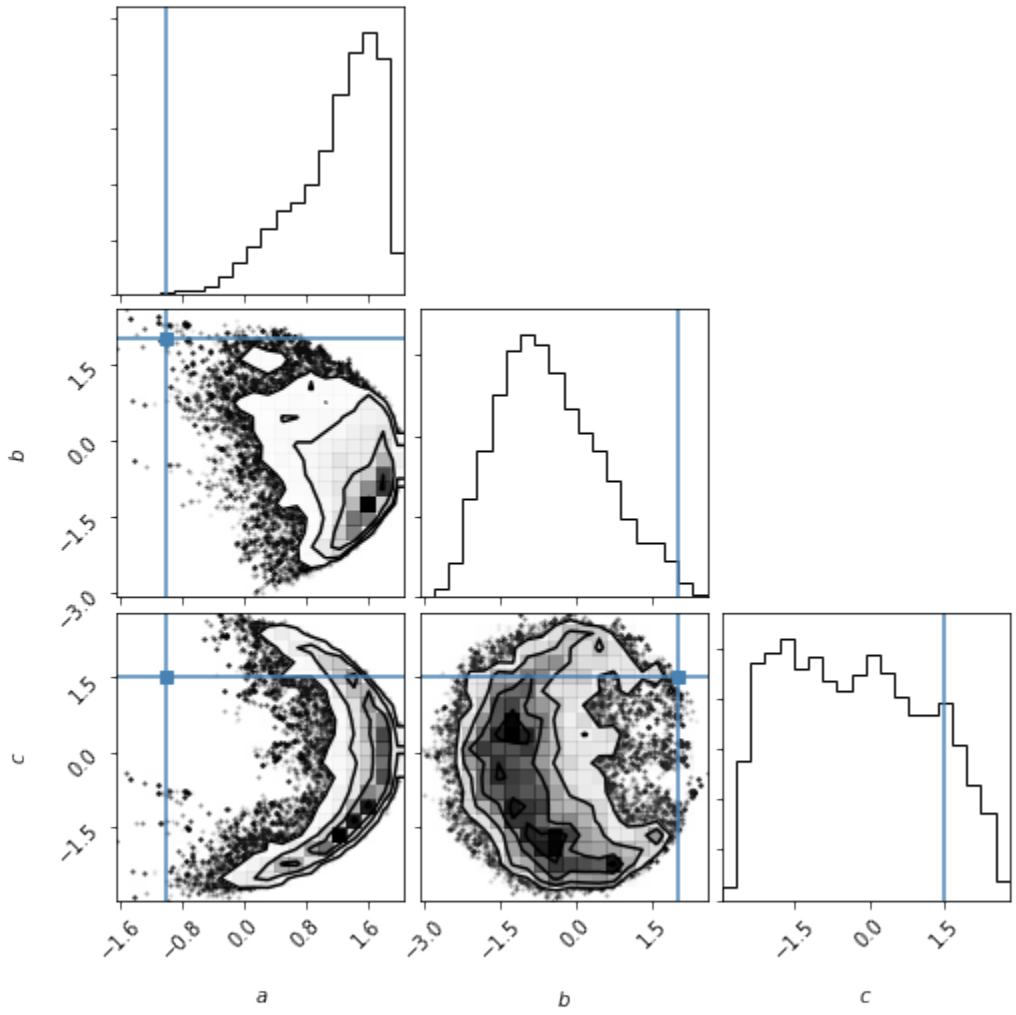
```
estimates 1.74022905195 -1.23351935318 -1.68793098984e-05
true values -1.0 2.0 1.5
```

[6]:
```
'Optimization terminated successfully.'
```

[7]:
```
# do the mcmc walk
ndim, nwalkers = 3, 100
pos = [result["x"] + np.random.randn(ndim)*0.1 for i in range(nwalkers)]
sampler = emcee.EnsembleSampler(nwalkers, ndim, lnlike, args=(x, y, error))
sampler.run_mcmc(pos, 1500);
samples = sampler.chain[:, 50:, :].reshape((-1, ndim))
```

Posterior in 2d

[8]:
```
# plot the 2d pdfs
import corner
fig = corner.corner(samples, labels=["$a$", "$b$", "$c$"],
                    truths=[a_true, b_true, c_true])
```



Posterior in 3d

[9]:
```
import vaex
import scipy.ndimage
import ipyvolume
```

[10]:
```
ds = vaex.from_arrays(a=samples[...,0].copy(), b=samples[...,1].copy(), c=samples[...,
↪2].copy())
# get 2d histogram
v = ds.count(binby=["a", "b", "c"], shape=64)
# smooth it for visual pleasure
v = scipy.ndimage.gaussian_filter(v, 2)
```

[11]:
```
ipyvolume.quickvolshow(v, lighting=True)
```

```
A Jupyter Widget
```

Note that actually a large part of the volume is empty.

[ ]:

4.3 Meshes / Surfaces

Meshes (or surfaces) in ipyvolume consist of triangles, and are defined by their coordinate (vertices) and faces/triangles, which refer to three vertices.

[1]:
```
import ipyvolume as ipv
import numpy as np
```

4.3.1 Triangle meshes

Lets first construct a 'solid', a tetrahedron, consisting out of 4 vertices, and 4 faces (triangles) using plot_trisurf

[2]:
```
s = 1/2**0.5
# 4 vertices for the tetrahedron
x = np.array([1.,  -1, 0,  0])
y = np.array([0,   0, 1., -1])
z = np.array([-s, -s, s,  s])
# and 4 surfaces (triangles), where the number refer to the vertex index
triangles = [(0, 1, 2), (0, 1, 3), (0, 2, 3), (1,3,2)]
```

[3]:
```
ipv.figure()
# we draw the tetrahedron
mesh = ipv.plot_trisurf(x, y, z, triangles=triangles, color='orange')
# and also mark the vertices
ipv.scatter(x, y, z, marker='sphere', color='blue')
ipv.xyzlim(-2, 2)
ipv.show()
```

```
VBox(children=(Figure(camera=PerspectiveCamera(fov=46.0, position=(0.0, 0.0, 2.0),␣
↪quaternion=(0.0, 0.0, 0.0, ...
```

4.3.2 Surfaces

To draw parametric surfaces, which go from $\mathbb{R}^2 \to \mathbb{R}^3$, it's convenient to use plot_surface, which takes 2d numpy arrays as arguments, assuming they form a regular grid (meaning you do not need to provide the triangles, since they can be inferred from the shape of the arrays). Note that plot_wireframe has a similar api, as does plot_mesh which can do both the surface and wireframe at the same time.

[4]:
```
# f(u, v) -> (u, v, u*v**2)
a = np.arange(-5, 5)
U, V = np.meshgrid(a, a)
X = U
Y = V
Z = X*Y**2

ipv.figure()
ipv.plot_surface(X, Z, Y, color="orange")
ipv.plot_wireframe(X, Z, Y, color="red")
ipv.show()
```

```
VBox(children=(Figure(camera=PerspectiveCamera(fov=46.0, position=(0.0, 0.0, 2.0),␣
↪quaternion=(0.0, 0.0, 0.0, ...
```

4.3.3 Colors

Vertices can take colors as well, as the example below (adapted from matplotlib) shows.

[5]:
```
X = np.arange(-5, 5, 0.25*1)
Y = np.arange(-5, 5, 0.25*1)
X, Y = np.meshgrid(X, Y)
R = np.sqrt(X**2 + Y**2)
Z = np.sin(R)
```

[6]:
```
from matplotlib import cm
colormap = cm.coolwarm
znorm = Z - Z.min()
znorm /= znorm.ptp()
znorm.min(), znorm.max()
color = colormap(znorm)
```

[7]:
```
ipv.figure()
mesh = ipv.plot_surface(X, Z, Y, color=color[...,:3])
ipv.show()
```

```
VBox(children=(Figure(camera=PerspectiveCamera(fov=46.0, position=(0.0, 0.0, 2.0),␣
↪quaternion=(0.0, 0.0, 0.0, ...
```

4.3.4 Texture mapping

Texture mapping can be done by providing a PIL image, and UV coordiante (texture coordinates, between 0 and 1). Note that like almost anything in ipyvolume, these u & v coordinates can be animated, as well as the textures.

[8]:
```
# import PIL.Image
# image = PIL.Image.open('data/jupyter.png')
```

[9]:
```
# fig = p3.figure()
# p3.style.use('dark')
# # we create a sequence of 8 u v coordinates so that the texture moves across the␣
↪surface.
# u = np.array([X/5 +np.sin(k/8*np.pi)*4. for k in range(8)])
# v = np.array([-Y/5*(1-k/7.) + Z*(k/7.) for k in range(8)])
# mesh = p3.plot_mesh(X, Z, Y, u=u, v=v, texture=image, wireframe=False)
# p3.animation_control(mesh, interval=800, sequence_length=8)
# p3.show()
```

We now make a small movie / animated gif of 30 frames.

[10]:
```
# frames = 30
# p3.movie('movie.gif', frames=frames)
```

And play that movie on a square

[11]:
```
# p3.figure()
# x = np.array([-1.,  1,  1,  -1])
# y = np.array([-1,  -1, 1., 1])
# z = np.array([0., 0, 0., 0])
# u = x / 2 + 0.5
# v = y / 2 + 0.5
# # square
# triangles = [(0, 1, 2), (0, 2, 3)]
# m = p3.plot_trisurf(x, y, z, triangles=triangles, u=u, v=v, texture=PIL.Image.open(
↪'movie.gif'))
# p3.animation_control(m, sequence_length=frames)
# p3.show()
```

[ ]:
```
```

4.4 Animation

All (or most of) the changes in scatter and quiver plots are (linearly) interpolated. On top top that, scatter plots and quiver plots can take a sequence of arrays (the first dimension), where only one array is visualized. Together this can make smooth animations with coarse timesteps. Lets see an example.

[1]:
```
import ipyvolume as ipv
import numpy as np
```

4.4.1 Basic animation

[4]:
```
# only x is a sequence of arrays
x = np.array([[-1, -0.8], [1, -0.1], [0., 0.5]])
y = np.array([0.0, 0.0])
z = np.array([0.0, 0.0])
ipv.figure()
s = ipv.scatter(x, y, z, marker='sphere', size=10)
ipv.xyzlim(-1, 1)
ipv.animation_control(s) # shows controls for animation controls
ipv.show()
```

```
VBox(children=(Figure(animation=200.0, camera=PerspectiveCamera(fov=46.0, position=(0.
↪0, 0.0, 2.0), quaternion...
```

You can control which array to visualize, using the `scatter.sequence_index` property. Actually, the `pylab.animate_glyphs` is connecting the `Slider` and `Play` button to that property, but you can also set it from Python.

[5]:
```
s.sequence_index = 1
```

4.4.2 Animating color and size

We now demonstrate that you can also animate color and size

[6]:
```
# create 2d grids: x, y, and r
u = np.linspace(-10, 10, 25)
x, y = np.meshgrid(u, u)
```

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```
r = np.sqrt(x**2+y**2)
print("x,y and z are of shape", x.shape)
# and turn them into 1d
x = x.flatten()
y = y.flatten()
r = r.flatten()
print("and flattened of shape", x.shape)
```

```
x,y and z are of shape (25, 25)
and flattened of shape (625,)
```

Now we only animate the z component

[7]:
```
# create a sequence of 15 time elements
time = np.linspace(0, np.pi*2, 15)
z = np.array([(np.cos(r + t) * np.exp(-r/5)) for t in time])
print("z is of shape", z.shape)
```

```
z is of shape (15, 625)
```

[8]:
```
# draw the scatter plot, and add controls with animate_glyphs
ipv.figure()
s = ipv.scatter(x, z, y, marker="sphere")
ipv.animation_control(s, interval=200)
ipv.ylim(-3,3)
ipv.show()
```

```
VBox(children=(Figure(animation=200.0, camera=PerspectiveCamera(fov=46.0, position=(0.
↪0, 0.0, 2.0), quaternion...
```

[9]:
```
# Now also include, color, which containts rgb values
color = np.array([[np.cos(r + t), 1-np.abs(z[i]), 0.1+z[i]*0] for i, t in␣
↪enumerate(time)])
size = (z+1)
print("color is of shape", color.shape)
```

```
color is of shape (15, 3, 625)
```

color is of the wrong shape, the last dimension should contain the rgb value, i.e. the shape of should be (15, 2500, 3)

[10]:
```
color = np.transpose(color, (0, 2, 1)) # flip the last axes
```

[11]:
```
ipv.figure()
s = ipv.scatter(x, z, y, color=color, size=size, marker="sphere")
ipv.animation_control(s, interval=200)
ipv.ylim(-3,3)
ipv.show()
```

```
VBox(children=(Figure(animation=200.0, camera=PerspectiveCamera(fov=46.0, position=(0.
↪0, 0.0, 2.0), quaternion...
```

4.4.3 Creating movie files

We now make a movie, with a 2 second duration, where we rotate the camera, and change the size of the scatter points.

[14]:
```
def set_view(figure, framenr, fraction):
    ipv.view(fraction*360, (fraction - 0.5) * 180, distance=2 + fraction*2)
    s.size = size * (2+0.5*np.sin(fraction * 6 * np.pi))
ipv.movie('wave.gif', set_view, fps=20, frames=40)
```

```
Output()
```

[15]:
```
# include the gif with base64 encoding
import IPython.display
import base64
with open('wave.gif', 'rb') as gif:
    url = b"" +base64.b64encode(gif.read())
IPython.display.Image(url=url.decode('ascii'))
```

[15]:
```
<IPython.core.display.Image object>
```

4.4.4 Animated quiver

Not only scatter plots can be animated, quiver as well, so the direction vector (vx, vy, vz) can also be animated, as shown in the example below, which is a (subsample of) a simulation of a small galaxy orbiting a host galaxy (not visible).

[16]:
```
import ipyvolume.datasets
stream = ipyvolume.datasets.animated_stream.fetch()
print("shape of steam data", stream.data.shape) # first dimension contains x, y, z,␣
↪vx, vy, vz, then time, then particle
```

```
shape of steam data (6, 200, 1250)
```

[18]:
```
fig = ipv.figure()
# instead of doing x=stream.data[0], y=stream.data[1], ... vz=stream.data[5], use␣
↪*stream.data
# limit to 50 timesteps to avoid having a huge notebook
q = ipv.quiver(*stream.data[:,0:50,:200], color="red", size=7)
ipv.style.use("dark") # looks better
ipv.animation_control(q, interval=200)
ipv.show()
```

```
VBox(children=(Figure(animation=200.0, camera=PerspectiveCamera(fov=46.0, position=(0.
↪0, 0.0, 2.0), quaternion...
```

[19]:
```
# fig.animation = 0 # set to 0 for no interpolation
```

[ ]:
```

```

4.5 API docs

Note that ipyvolume.pylab and ipyvolume.widgets are imported in the ipyvolume namespace, to you can access ipyvolume.scatter instead of ipyvolume.pylab.scatter.

4.5.1 Quick list for plotting.

ipyvolume.pylab.volshow(data[, lighting, ...])	Visualize a 3d array using volume rendering.
ipyvolume.pylab.scatter(x, y, z[, color, ...])	Plots many markers/symbols in 3d
ipyvolume.pylab.quiver(x, y, z, u, v, w[, ...])	Create a quiver plot, which is like a scatter plot but with arrows pointing in the direction given by u, v and w
ipyvolume.pylab.plot(x, y, z[, color])	Plot a line in 3d
ipyvolume.pylab.plot_surface(x, y, z[, ...])	Draws a 2d surface in 3d, defined by the 2d ordered arrays x,y,z
ipyvolume.pylab.plot_trisurf(x, y, z[, ...])	Draws a polygon/triangle mesh defined by a coordinate and triangle indices
ipyvolume.pylab.plot_wireframe(x, y, z[, ...])	Draws a 2d wireframe in 3d, defines by the 2d ordered arrays x,y,z
ipyvolume.pylab.plot_mesh(x, y, z[, color, ...])	Draws a 2d wireframe+surface in 3d: generalization of *plot_wireframe* and *plot_surface*
ipyvolume.pylab.plot_isosurface(data[, ...])	Plot a surface at constant value (like a 2d contour)

4.5.2 Quick list for controlling the figure.

ipyvolume.pylab.figure([key, width, height, ...])	Create a new figure (if no key is given) or return the figure associated with key
ipyvolume.pylab.gcf()	Get current figure, or create a new one
ipyvolume.pylab.gcc()	Return the current container, that is the widget holding the figure and all the control widgets, buttons etc.
ipyvolume.pylab.clear()	Remove current figure (and container)
ipyvolume.pylab.show([extra_widgets])	Display (like in IPython.display.dispay(...)) the current figure
ipyvolume.pylab.view([azimuth, elevation, ...])	Sets camera angles and distance and returns the current.
ipyvolume.pylab.xlim(xmin, xmax)	Set limits of x axis
ipyvolume.pylab.ylim(ymin, ymax)	Set limits of y axis
ipyvolume.pylab.zlim(zmin, zmax)	Set limits of zaxis
ipyvolume.pylab.xyzlim(vmin[, vmax])	Set limits or all axis the same, if vmax not given, use [-vmin, vmax]

4.5.3 Quick list for style and labels.

ipyvolume.pylab.xlabel(label)	Set the labels for the x-axis
ipyvolume.pylab.ylabel(label)	Set the labels for the y-axis
ipyvolume.pylab.zlabel(label)	Set the labels for the z-axis
ipyvolume.pylab.xyzlabel(labelx, labely, labelz)	Set all labels at once
ipyvolume.pylab.style.use(style)	Set the style of the current figure/visualization
ipyvolume.pylab.style.set_style_dark()	Short for style.use('dark')
ipyvolume.pylab.style.set_style_light()	Short for style.use('light')
ipyvolume.pylab.style.box_off()	Do not draw the box around the visible volume
ipyvolume.pylab.style.box_on()	Draw a box around the visible volume
ipyvolume.pylab.style.axes_off()	Do not draw the axes

Continued on next page

Table 3 – continued from previous page

ipyvolume.pylab.style.axes_on()	Draw the axes
ipyvolume.pylab.style.background_color(color)	Sets the background color

4.5.4 Quick list for saving figures.

ipyvolume.pylab.save(filepath[, makedirs, ...])	Save the current container to a HTML file
ipyvolume.pylab.savefig(filename[, width, ...])	Save the figure to an image file.
ipyvolume.pylab.screenshot([width, height, ...])	Save the figure to a PIL.Image object.

4.5.5 ipyvolume.pylab

ipyvolume.pylab.**scatter**(*x*, *y*, *z*, *color='red'*, *size=2*, *size_selected=2.6*, *color_selected='white'*, *marker='diamond'*, *selection=None*, *grow_limits=True*, ***kwargs*)

Plots many markers/symbols in 3d

Parameters

- **x** – numpy array of shape (N,) or (S, N) with x positions. If an (S, N) array, the first dimension will be used for frames in an animation.
- **y** – idem for y
- **z** – idem for z
- **color** – color for each point/vertex/symbol, can be string format, examples for red:'red', '#f00', '#ff0000' or 'rgb(1,0,0), or rgb array of shape (N, 3 or 4) or (S, N, 3 or 4)
- **size** – float representing the size of the glyph in percentage of the viewport, where 100 is the full size of the viewport
- **size_selected** – like size, but for selected glyphs
- **color_selected** – like color, but for selected glyphs
- **marker** – name of the marker, options are: 'arrow', 'box', 'diamond', 'sphere', 'point_2d', 'square_2d', 'triangle_2d', 'circle_2d'
- **selection** – numpy array of shape (N,) or (S, N) with indices of x,y,z arrays of the selected markers, which can have a different size and color
- **kwargs** –

Returns *Scatter*

ipyvolume.pylab.**quiver**(*x*, *y*, *z*, *u*, *v*, *w*, *size=20*, *size_selected=26.0*, *color='red'*, *color_selected='white'*, *marker='arrow'*, ***kwargs*)

Create a quiver plot, which is like a scatter plot but with arrows pointing in the direction given by u, v and w

Parameters

- **x** – numpy array of shape (N,) or (S, N) with x positions. If an (S, N) array, the first dimension will be used for frames in an animation.
- **y** – idem for y
- **z** – idem for z

- **u** – numpy array of shape (N,) or (S, N) indicating the x component of a vector. If an (S, N) array, the first dimension will be used for frames in an animation.
- **v** – idem for y
- **w** – idem for z
- **size** – float representing the size of the glyph in percentage of the viewport, where 100 is the full size of the viewport
- **size_selected** – like size, but for selected glyphs
- **color** – color for each point/vertex/symbol, can be string format, examples for red:'red', '#f00', '#ff0000' or 'rgb(1,0,0), or rgb array of shape (N, 3 or 4) or (S, N, 3 or 4)
- **color_selected** – like color, but for selected glyphs
- **marker** – (currently only 'arrow' would make sense)
- **kwargs** – extra arguments passed on to the Scatter constructor

Returns *Scatter*

ipyvolume.pylab.**plot**(*x*, *y*, *z*, *color='red'*, ***kwargs*)

Plot a line in 3d

Parameters

- **x** – numpy array of shape (N,) or (S, N) with x positions. If an (S, N) array, the first dimension will be used for frames in an animation.
- **y** – idem for y
- **z** – idem for z
- **color** – color for each point/vertex/symbol, can be string format, examples for red:'red', '#f00', '#ff0000' or 'rgb(1,0,0), or rgb array of shape (N, 3 or 4) or (S, N, 3 or 4)
- **kwargs** – extra arguments passed to the Scatter constructor

Returns *Scatter*

ipyvolume.pylab.**volshow**(*data, lighting=False, data_min=None, data_max=None, max_shape=256, tf=None, stereo=False, ambient_coefficient=0.5, diffuse_coefficient=0.8, specular_coefficient=0.5, specular_exponent=5, downscale=1, level=[0.1, 0.5, 0.9], opacity=[0.01, 0.05, 0.1], level_width=0.1, controls=True, max_opacity=0.2, memorder='C', extent=None*)

Visualize a 3d array using volume rendering.

Currently only 1 volume can be rendered.

Parameters

- **data** – 3d numpy array
- **origin** – origin of the volume data, this is to match meshes which have a different origin
- **domain_size** – domain size is the size of the volume
- **lighting** (*bool*) – use lighting or not, if set to false, lighting parameters will be overriden
- **data_min** (*float*) – minimum value to consider for data, if None, computed using np.nanmin
- **data_max** (*float*) – maximum value to consider for data, if None, computed using np.nanmax
- **tf** – transfer function (or a default one)

- **stereo** (*bool*) – stereo view for virtual reality (cardboard and similar VR head mount)
- **ambient_coefficient** – lighting parameter
- **diffuse_coefficient** – lighting parameter
- **specular_coefficient** – lighting parameter
- **specular_exponent** – lighting parameter
- **downscale** (*float*) – downscale the rendering for better performance, for instance when set to 2, a 512x512 canvas will show a 256x256 rendering upscaled, but it will render twice as fast.
- **level** – level(s) for the where the opacity in the volume peaks, maximum sequence of length 3
- **opacity** – opacity(ies) for each level, scalar or sequence of max length 3
- **level_width** – width of the (gaussian) bumps where the opacity peaks, scalar or sequence of max length 3
- **controls** (*bool*) – add controls for lighting and transfer function or not
- **max_opacity** (*float*) – maximum opacity for transfer function controls
- **extent** – list of [[xmin, xmax], [ymin, ymax], [zmin, zmax]] values that define the bounds of the volume, otherwise the viewport is used

Parap int max_shape maximum shape for the 3d cube, if larger, the data is reduced by skipping/slicing (data[::N]), set to None to disable.

Returns

ipyvolume.pylab.**plot_surface**(*x*, *y*, *z*, *color='red'*, *wrapx=False*, *wrapy=False*)

Draws a 2d surface in 3d, defined by the 2d ordered arrays x,y,z

Parameters

- **x** – numpy array of shape (N,M) or (S, N, M) with x positions. If an (S, N, M) array, the first dimension will be used for frames in an animation.
- **y** – idem for y
- **z** – idem for z
- **color** – color for each point/vertex string format, examples for red:'red', '#f00', '#ff0000' or 'rgb(1,0,0), or rgb array of shape (2, N, 3 or 4) or (S, 2, N, 3 or 4)
- **wrapx** (*bool*) – when True, the x direction is assumed to wrap, and polygons are drawn between the end end begin points
- **wrapy** (*bool*) – simular for the y coordinate

Returns *Mesh*

ipyvolume.pylab.**plot_trisurf**(*x*, *y*, *z*, *triangles=None*, *lines=None*, *color='red'*, *u=None*, *v=None*, *texture=None*)

Draws a polygon/triangle mesh defined by a coordinate and triangle indices

The following example plots a rectangle in the z==2 plane, consisting of 2 triangles:

```
>>> plot_trisurf([0, 0, 3., 3.], [0, 4., 0, 4.], 2,
       triangles=[[0, 2, 3], [0, 3, 1]])
```

Note that the z value is constant, and thus not a list/array. For guidance, the triangles refer to the vertices in this manner:

```
^ ydir
|
2 3
0 1  ---> x dir
```

Note that if you want per face/triangle colors, you need to duplicate each vertex.

Parameters

- **x** – numpy array of shape (N,) or (S, N) with x positions. If an (S, N) array, the first dimension will be used for frames in an animation.
- **y** – idem for y
- **z** – idem for z
- **triangles** – numpy array with indices referring to the vertices, defining the triangles, with shape (M, 3)
- **lines** – numpy array with indices referring to the vertices, defining the lines, with shape (K, 2)
- **color** – color for each point/vertex/symbol, can be string format, examples for red:'red', '#f00', '#ff0000' or 'rgb(1,0,0), or rgb array of shape (N, 3 or 4) or (S, N, 3 or 4)
- **u** – numpy array of shape (N,) or (S, N) indicating the u (x) coordinate for the texture. If an (S, N) array, the first dimension will be used for frames in an animation.
- **v** – numpy array of shape (N,) or (S, N) indicating the v (y) coordinate for the texture. If an (S, N) array, the first dimension will be used for frames in an animation.
- **texture** – PIL.Image object or ipywebrtc.MediaStream (can be a seqence)

Returns *Mesh*

ipyvolume.pylab.**plot_wireframe**(*x*, *y*, *z*, *color='red'*, *wrapx=False*, *wrapy=False*)

Draws a 2d wireframe in 3d, defines by the 2d ordered arrays x,y,z

See also *ipyvolume.pylab.plot_mesh*

Parameters

- **x** – numpy array of shape (N,M) or (S, N, M) with x positions. If an (S, N, M) array, the first dimension will be used for frames in an animation.
- **y** – idem for y
- **z** – idem for z
- **color** – color for each point/vertex string format, examples for red:'red', '#f00', '#ff0000' or 'rgb(1,0,0), or rgb array of shape (2, N, 3 or 4) or (S, 2, N, 3 or 4)
- **wrapx** (*bool*) – when True, the x direction is assumed to wrap, and polygons are drawn between the begin and end points
- **wrapy** (*bool*) – idem for y

Returns *Mesh*

ipyvolume.pylab.**plot_mesh**(*x*, *y*, *z*, *color='red'*, *wireframe=True*, *surface=True*, *wrapx=False*, *wrapy=False*, *u=None*, *v=None*, *texture=None*)

Draws a 2d wireframe+surface in 3d: generalization of *plot_wireframe* and *plot_surface*

Parameters

- **x** – {x2d}

- **y** – {y2d}
- **z** – {z2d}
- **color** – {color2d}
- **wireframe** (*bool*) – draw lines between the vertices
- **surface** (*bool*) – draw faces/triangles between the vertices
- **wrapx** (*bool*) – when True, the x direction is assumed to wrap, and polygons are drawn between the begin and end points
- **wrapy** (*boool*) – idem for y
- **u** – {u}
- **v** – {v}
- **texture** – {texture}

Returns *Mesh*

ipyvolume.pylab.**plot_isosurface**(*data*, *level=None*, *color='red'*, *wireframe=True*, *surface=True*, *controls=True*, *extent=None*)

Plot a surface at constant value (like a 2d contour)

Parameters

- **data** – 3d numpy array
- **level** (*float*) – value where the surface should lie
- **color** – color of the surface, although it can be an array, the length is difficult to predict beforehand, if per vertex color are needed, it is better to set them on the returned mesh afterwards.
- **wireframe** (*bool*) – draw lines between the vertices
- **surface** (*bool*) – draw faces/triangles between the vertices
- **controls** (*bool*) – add controls to change the isosurface
- **extent** – list of [[xmin, xmax], [ymin, ymax], [zmin, zmax]] values that define the bounding box of the mesh, otherwise the viewport is used

Returns *Mesh*

ipyvolume.pylab.**xlim**(*xmin*, *xmax*)

Set limits of x axis

ipyvolume.pylab.**ylim**(*ymin*, *ymax*)

Set limits of y axis

ipyvolume.pylab.**zlim**(*zmin*, *zmax*)

Set limits of zaxis

ipyvolume.pylab.**xyzlim**(*vmin*, *vmax=None*)

Set limits or all axis the same, if vmax not given, use [-vmin, vmax]

ipyvolume.pylab.**xlabel**(*label*)

Set the labels for the x-axis

ipyvolume.pylab.**ylabel**(*label*)

Set the labels for the y-axis

ipyvolume.pylab.**zlabel**(*label*)

Set the labels for the z-axis

ipyvolume.pylab.**xyzlabel**(*labelx*, *labely*, *labelz*)
Set all labels at once

ipyvolume.pylab.**view**(*azimuth=None*, *elevation=None*, *distance=None*)
Sets camera angles and distance and returns the current.

Parameters

- **azimuth** (*float*) – rotation around the axis pointing up in degrees
- **elevation** (*float*) – rotation where +90 means 'up', -90 means 'down', in degrees
- **distance** (*float*) – radial distance from the center to the camera.

ipyvolume.pylab.**figure**(*key=None*, *width=400*, *height=500*, *lighting=True*, *controls=True*, *controls_vr=False*, *controls_light=False*, *debug=False*, ***kwargs*)
Create a new figure (if no key is given) or return the figure associated with key

Parameters

- **key** – Python object that identifies this figure
- **width** (*int*) – pixel width of WebGL canvas
- **height** (*int*) –
- **lighting** (*bool*) – use lighting or not
- **controls** (*bool*) – show controls or not
- **controls_vr** (*bool*) – show controls for VR or not
- **debug** (*bool*) – show debug buttons or not

Returns *Figure*

ipyvolume.pylab.**gcf**()
Get current figure, or create a new one

Returns *Figure*

ipyvolume.pylab.**gcc**()
Return the current container, that is the widget holding the figure and all the control widgets, buttons etc.

ipyvolume.pylab.**clear**()
Remove current figure (and container)

ipyvolume.pylab.**show**(*extra_widgets=[]*)
Display (like in IPython.display.dispay(...)) the current figure

ipyvolume.pylab.**save**(*filepath*, *makedirs=True*, *title=u'IPyVolume Widget'*, *all_states=False*, *offline=False*, *scripts_path='js'*, *drop_defaults=False*, *template_options=(('extra_script_head', ''), ('body_pre', ''), ('body_post', ''))*, *devmode=False*, *offline_cors=False*)
Save the current container to a HTML file

By default the HTML file is not standalone and requires an internet connection to fetch a few javascript libraries. Use offline=True to download these and make the HTML file work without an internet connection.

Parameters

- **filepath** (*str*) – The file to write the HTML output to.
- **makedirs** (*bool*) – whether to make directories in the filename path, if they do not already exist
- **title** (*str*) – title for the html page

- **all_states** (*bool*) – if True, the state of all widgets know to the widget manager is included, else only those in widgets
- **offline** (*bool*) – if True, use local urls for required js/css packages and download all js/css required packages (if not already available), such that the html can be viewed with no internet connection
- **scripts_path** (*str*) – the folder to save required js/css packages to (relative to the filepath)
- **drop_defaults** (*bool*) – Whether to drop default values from the widget states
- **template_options** – list or dict of additional template options
- **devmode** (*bool*) – if True, attempt to get index.js from local js/dist folder
- **offline_cors** (*bool*) – if True, sets crossorigin attribute of script tags to anonymous

ipyvolume.pylab.**savefig**(*filename*, *width=None*, *height=None*, *fig=None*, *timeout_seconds=10*, *output_widget=None*, *headless=False*, *devmode=False*)

Save the figure to an image file.

Parameters

- **filename** (*str*) – must have extension .png, .jpeg or .svg
- **width** (*int*) – the width of the image in pixels
- **height** (*int*) – the height of the image in pixels
- **fig** (*ipyvolume.widgets.Figure or None*) – if None use the current figure
- **timeout_seconds** (*float*) – maximum time to wait for image data to return
- **output_widget** (*ipywidgets.Output*) – a widget to use as a context manager for capturing the data
- **headless** (*bool*) – if True, use headless chrome to save figure
- **devmode** (*bool*) – if True, attempt to get index.js from local js/dist folder

ipyvolume.pylab.**screenshot**(*width=None*, *height=None*, *format='png'*, *fig=None*, *timeout_seconds=10*, *output_widget=None*, *headless=False*, *devmode=False*)

Save the figure to a PIL.Image object.

Parameters

- **width** (*int*) – the width of the image in pixels
- **height** (*int*) – the height of the image in pixels
- **format** – format of output data (png, jpeg or svg)
- **fig** (*ipyvolume.widgets.Figure or None*) – if None use the current figure
- **timeout_seconds** (*int*) – maximum time to wait for image data to return
- **output_widget** (*ipywidgets.Output*) – a widget to use as a context manager for capturing the data
- **headless** (*bool*) – if True, use headless chrome to take screenshot
- **devmode** (*bool*) – if True, attempt to get index.js from local js/dist folder

Returns PIL.Image

ipyvolume.pylab.**selector_default**(*output_widget=None*)

Capture selection events from the current figure, and apply the selections to Scatter objects

Example:

```
>>> import ipyvolume as ipv
>>> ipv.figure()
>>> ipv.examples.gaussian()
>>> ipv.selector_default()
>>> ipv.show()
```

Now hold the control key to do selections, type

- 'C' for circle
- 'R' for rectangle
- 'L' for lasso
- '=' for replace mode
- '&' for logically and mode
- 'l' for logically or mode
- '-' for subtract mode

ipyvolume.pylab.**movie**(*f='movie.mp4', function=<function _change_azimuth_angle>, fps=30, frames=30, endpoint=False, cmd_template_ffmpeg='ffmpeg -y -r {fps} -i {tempdir}/frame-%5d.png -vcodec h264 -pix_fmt yuv420p {filename}', cmd_template_gif='convert -delay {delay} {loop} {tempdir}/frame-*.png {filename}', gif_loop=0*)

Create a movie (mp4/gif) out of many frames

If the filename ends in *.gif*, *convert* is used to convert all frames to an animated gif using the *cmd_template_gif* template. Otherwise *ffmpeg is assumed to know the file format*.

Example:

```
>>> def set_angles(fig, i, fraction):
>>>     fig.angley = fraction*np.pi*2
>>> # 4 second movie, that rotates around the y axis
>>> p3.movie('test2.gif', set_angles, fps=20, frames=20*4,
        endpoint=False)
```

Note that in the example above we use *endpoint=False* to avoid to first and last frame to be the same

Parameters

- **f** (*str*) – filename out output movie (e.g. 'movie.mp4' or 'movie.gif')
- **function** – function called before each frame with arguments (figure, framenr, fraction)
- **fps** – frames per seconds
- **frames** (*int*) – total number of frames
- **endpoint** (*bool*) – if fraction goes from [0, 1] (inclusive) or [0, 1) (endpoint=False is useful for loops/rotatations)
- **cmd_template_ffmpeg** (*str*) – template command when running ffmpeg (non-gif ending filenames)
- **cmd_template_gif** (*str*) – template command when running imagemagick's convert (if filename ends in .gif)

- **gif_loop** – None for no loop, otherwise the framenumber to go to after the last frame

Returns the temp dir where the frames are stored

ipyvolume.pylab.**animation_control**(*object*, *sequence_length=None*, *add=True*, *interval=200*)
Animate scatter, quiver or mesh by adding a slider and play button.

Parameters

- **object** – *Scatter* or *Mesh* object (having an sequence_index property), or a list of these to control multiple.
- **sequence_length** – If sequence_length is None we try try our best to figure out, in case we do it badly, you can tell us what it should be. Should be equal to the S in the shape of the numpy arrays as for instance documented in *scatter* or *plot_mesh*.
- **add** – if True, add the widgets to the container, else return a HBox with the slider and play button. Useful when you want to customise the layout of the widgets yourself.
- **interval** – interval in msec between each frame

Returns If add is False, if returns the ipywidgets.HBox object containing the controls

ipyvolume.pylab.**transfer_function**(*level=[0.1, 0.5, 0.9], opacity=[0.01, 0.05, 0.1], level_width=0.1, controls=True, max_opacity=0.2*)
Create a transfer function, see volshow

class ipyvolume.pylab.**style**
'Static class that mimics a matplotlib module.

Example:

```
>>> import ipyvolume as ipv
>>> ipv.style.use('light'])
>>> ipv.style.use('seaborn-darkgrid'])
>>> ipv.style.use(['seaborn-darkgrid', {'axes.x.color':'orange'}])
```

Possible style values:

- figure.facecolor: background color
- axes.color: color of the box around the volume/viewport
- xaxis.color: color of xaxis
- yaxis.color: color of xaxis
- zaxis.color: color of xaxis

static axes_off()
Do not draw the axes

static axes_on()
Draw the axes

static background_color(*color*)
Sets the background color

static box_off()
Do not draw the box around the visible volume

static box_on()
Draw a box around the visible volume

static set_style_dark()
Short for style.use('dark')

static set_style_demo()
Short for style.use('demo')

static set_style_light()
Short for style.use('light')

static set_style_nobox()
Short for style.use('nobox')

static use(*style*)
Set the style of the current figure/visualization

Parameters **style** – matplotlib style name, or dict with values, or a sequence of these, where the last value overrides previous

Returns

4.5.6 ipyvolume.widgets

Test pythreejs.Camera

ipyvolume.widgets.**quickvolshow**(*data, lighting=False, data_min=None, data_max=None, max_shape=256, level=[0.1, 0.5, 0.9], opacity=[0.01, 0.05, 0.1], level_width=0.1, extent=None, memorder='C', **kwargs*)
Visualize a 3d array using volume rendering

Parameters

- **data** – 3d numpy array
- **lighting** – boolean, to use lighting or not, if set to false, lighting parameters will be overriden
- **data_min** – minimum value to consider for data, if None, computed using np.nanmin
- **data_max** – maximum value to consider for data, if None, computed using np.nanmax
- **extent** – list of [[xmin, xmax], [ymin, ymax], [zmin, zmax]] values that define the bounds of the volume, otherwise the viewport is used
- **level** – level(s) for the where the opacity in the volume peaks, maximum sequence of length 3
- **opacity** – opacity(ies) for each level, scalar or sequence of max length 3
- **level_width** – width of the (gaussian) bumps where the opacity peaks, scalar or sequence of max length 3
- **kwargs** – extra argument passed to Volume and default transfer function

Parap int max_shape maximum shape for the 3d cube, if larger, the data is reduced by skipping/slicing (data[::N]), set to None to disable.

Returns

ipyvolume.widgets.**quickscatter**(*x*, *y*, *z*, ***kwargs*)

ipyvolume.widgets.**quickquiver**(*x*, *y*, *z*, *u*, *v*, *w*, ***kwargs*)

ipyvolume.widgets.**volshow**(**args*, ***kwargs*)
Deprecated: please use ipyvolume.quickvolshow or use the ipyvolume.pylab interface

class ipyvolume.widgets.**Figure**(***kwargs*)
Bases: ipywebrtc.webrtc.MediaStream

Widget class representing a volume (rendering) using three.js

ambient_coefficient
A float trait.

animation
A float trait.

animation_exponent
A float trait.

camera
A pythreejs.Camera instance to control the camera

camera_center
An instance of a Python list.

camera_control
A trait for unicode strings.

camera_fov
A casting version of the float trait.

capture_fps
A casting version of the float trait.

cube_resolution
A casting version of the int trait.

diffuse_coefficient
A float trait.

displayscale
A casting version of the float trait.

downscale
A casting version of the int trait.

eye_separation
A casting version of the float trait.

height
A casting version of the int trait.

matrix_projection
An instance of a Python list.

matrix_world
An instance of a Python list.

meshes
An instance of a Python list.

mouse_mode
A trait for unicode strings.

on_screenshot(*callback*, *remove=False*)

on_selection(*callback*, *remove=False*)

panorama_mode
An enum whose value must be in a given sequence.

project(*x*, *y*, *z*)

render_continuous
A boolean (True, False) trait.

scatters
An instance of a Python list.

scene
A trait whose value must be an instance of a specified class.

The value can also be an instance of a subclass of the specified class.

Subclasses can declare default classes by overriding the klass attribute

screenshot(*width=None*, *height=None*, *mime_type='image/png'*)

selection_mode
A trait for unicode strings.

selector
A trait for unicode strings.

show
A trait for unicode strings.

specular_coefficient
A float trait.

specular_exponent
A float trait.

stereo
A boolean (True, False) trait.

style
An instance of a Python dict.

volumes
An instance of a Python list.

width
A casting version of the int trait.

xlabel
A trait for unicode strings.

xlim
An instance of a Python list.

ylabel
A trait for unicode strings.

ylim
An instance of a Python list.

zlabel
A trait for unicode strings.

zlim
An instance of a Python list.

class ipyvolume.widgets.**Volume**(***kwargs*)
Bases: ipywidgets.widgets.widget.Widget

Widget class representing a volume (rendering) using three.js

brightness
A casting version of the float trait.

clamp_max
A casting version of the boolean trait.

clamp_min
A casting version of the boolean trait.

data
A numpy array trait type.

data_max
A casting version of the float trait.

data_max_shape
A casting version of the int trait.

data_min
A casting version of the float trait.

data_original
A numpy array trait type.

extent
A trait which allows any value.

extent_original
A trait which allows any value.

lighting
A boolean (True, False) trait.

opacity_scale
A casting version of the float trait.

ray_steps
defines the length of the ray (1/ray_steps) for each step, in normalized coordintes.

rendering_method
An enum whose value must be in a given sequence.

show_max
A casting version of the float trait.

show_min
A casting version of the float trait.

tf
A trait whose value must be an instance of a specified class.

The value can also be an instance of a subclass of the specified class.

Subclasses can declare default classes by overriding the klass attribute

update_data(***kwargs*)

class ipyvolume.widgets.**Scatter**(***kwargs*)
Bases: ipywidgets.widgets.widget.Widget

color
A numpy array trait type.

color_selected
A trait type representing a Union type.

connected
A casting version of the boolean trait.

geo
A trait for unicode strings.

line_material
A pythreejs.ShaderMaterial that is used for the lines/wireframe

material
A pythreejs.ShaderMaterial that is used for the mesh

selected
A numpy array trait type.

sequence_index
An integer trait.

Longs that are unnecessary (<= sys.maxint) are cast to ints.

size
A trait type representing a Union type.

size_selected
A trait type representing a Union type.

texture
A trait type representing a Union type.

visible
A casting version of the boolean trait.

vx
A numpy array trait type.

vy
A numpy array trait type.

vz
A numpy array trait type.

x
A numpy array trait type.

y
A numpy array trait type.

z
A numpy array trait type.

class ipyvolume.widgets.**Mesh**(***kwargs*)
Bases: ipywidgets.widgets.widget.Widget

color
A numpy array trait type.

line_material
A pythreejs.ShaderMaterial that is used for the lines/wireframe

lines
A numpy array trait type.

material
A pythreejs.ShaderMaterial that is used for the mesh

sequence_index
An integer trait.

Longs that are unnecessary (<= sys.maxint) are cast to ints.

texture
A trait type representing a Union type.

triangles
A numpy array trait type.

u
A numpy array trait type.

v
A numpy array trait type.

visible
A casting version of the boolean trait.

x
A numpy array trait type.

y
A numpy array trait type.

z
A numpy array trait type.

4.5.7 ipyvolume.examples

Some examples for quick testing/demonstrations

All function accept *show* and *draw* arguments

- If *draw* is *True* it will return the widgets (Scatter, Volume, Mesh)
- If *draw* is *False*, it will return the data
- if *show* is *False*, *ipv.show()* will not be called.

ipyvolume.examples.**ball**(*rmax=3, rmin=0, shape=128, limits=[-4, 4], draw=True, show=True, **kwargs*)
Show a ball

ipyvolume.examples.**brain**(*draw=True, show=True, fiducial=True, flat=True, inflated=True, subject='S1', interval=1000, uv=True, color=None*)
Show a human brain model

Requirement:

$ pip install https://github.com/gallantlab/pycortex

ipyvolume.examples.**example_ylm**(*m=0, n=2, shape=128, limits=[-4, 4], draw=True, show=True, **kwargs*)
Show a spherical harmonic

ipyvolume.examples.**gaussian**(*N=1000, draw=True, show=True, seed=42, color=None, marker='sphere'*)
Show N random gaussian distributed points using a scatter plot

ipyvolume.examples.**head**(*draw=True*, *show=True*, *max_shape=256*)
Show a volumetric rendering of a human male head

ipyvolume.examples.**klein_bottle**(*draw=True*, *show=True*, *figure8=False*, *endpoint=True*, *uv=True*, *wireframe=False*, *texture=None*, *both=False*, *interval=1000*)
Show one or two Klein bottles

ipyvolume.examples.**xyz**(*shape=128, limits=[-3, 3], spherical=False, sparse=True, centers=False*)

4.5.8 ipyvolume.headless

4.6 Virtual reality

Ipyvolume can render in stereo, and go fullscreen (not supported for iOS). Together with Google Cardboard or other VR glasses (I am using VR Box 2) this enables virtual reality visualisation. Since mobile devices are usually less powerful, the example below is rendered at low resolution to enable a reasonable framerate on all devices.

Open this page on your mobile device, enter fullscreen mode and put on your glasses, looking around will rotate the object to improve depth perception.

```
import ipyvolume as ipv
aqa2 = ipv.datasets.aquariusA2.fetch()
ipv.quickvolshow(aqa2.data.T, lighting=True, level=[0.16, 0.25, 0.46], width=256,␣
↪height=256, stereo=True, opacity=0.06)
```

[widget]

CHAPTER 5

Changelog

- 0.5
  - New
    - Volume is now its own widget, allowing multivolume rendering
    - Depth aware zooming (Hold Alt key, or toggle in menu) and zoom into any object or volume rendering
    - double click centers that point
    - Configurable ray steps for volume rendering (Volume.ray_steps)
    - Better transparency support, premultiplied colors used consistently, colors can now be of shape *(..., 3 or 4)* to allow alpha channel (note: no proper rendering yet, this is a difficult problem).
    - Panoramic modes: 180 and 360 degrees for dome projection or VR video creations.
    - Maximum intensity volume rendering.
    - Progressive loading of large volumetric cubes.
    - ipyvolume.moviemaker: simple UI for making movies, and keyframes settings for the camera.
    - ipyvolume.astro: (experiment) as domain specific module for astronomy.
    - New example male head volume rendering `ipyvolume.examples.head`
  - Changes
    - 100x faster mesh generation
    - Fixes/improvements for headless rendering
    - Selection method in the kernel, see `ipyvolume.pylab.selector_default`.
    - Fixed memory leak issues in the browser
    - Scatter supports 2d sprites,see `ipyvolume.pylab.scatter`.
    - Pythreejs integration, Camera, Scene and ShaderMaterial are now exposed.
    - 'sphere' marker was double the size as the others, now halved in size/

        - *ipyvolume.pylab.view* can control distance, and returns currents values.
    - New contributors
        - Casper van Leeuwen
        - Oleh Kozynets
        - Oliver Evans
        - Jean-Rémi KING
        - Mathieu Carette
        - Saul (saulthu)
        - Timo Friedri
        - WANG Aiyong
        - mpu-creare
        - xavArtley
        - Eric Larson
        - Hans Moritz Günther
        - Jackie Leng
- 0.4
    - plotting
        - lines
        - wireframes
        - meshes/surfaces
        - isosurfaces
        - texture (animated) support, gif image and MediaStream (movie, camera, canvas)
    - camera control (angles from the python side), FoV
    - movie creation
    - eye separation for VR
    - better screenshot support (can be to a PIL Image), and higher resolution possible
    - mouse lasso (a bit rough), selections can be made from the Python side.
    - icon bar for common operations (fullscreen, stereo, screenshot, reset etc)
    - offline support for embedding/saving to html
    - Jupyter lab support
    - New contributors
        - Chris Sewell
        - Satrajit Ghosh
        - Sylvain Corlay
        - stonebig
        - Matt McCormick

        * Jean Michel Arbona
- 0.3
  - new
    * axis with labels and ticklabels
    * styling
    * animation (credits also to https://github.com/jeammimi)
    * binary transfers
    * default camera control is trackball
  - changed
    * s and ss are now spelled out, size and size_selected

CHAPTER 6

Indices and tables

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Python Module Index

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