kneed

Release 0.6.0

Jul 30, 2022

Contents

This is the documentation for the kneed Python package. Given x and y arrays, *kneed* attempts to identify the knee/elbow point of a line fit to the data. The knee/elbow is defined as the point of the line with maximum curvature. For more information about how each of the parameters affect identification of knee points, check out *Parameter Examples*. For a full reference of the API, head over to the *API Reference*.

CHAPTER 1

Parameter Examples

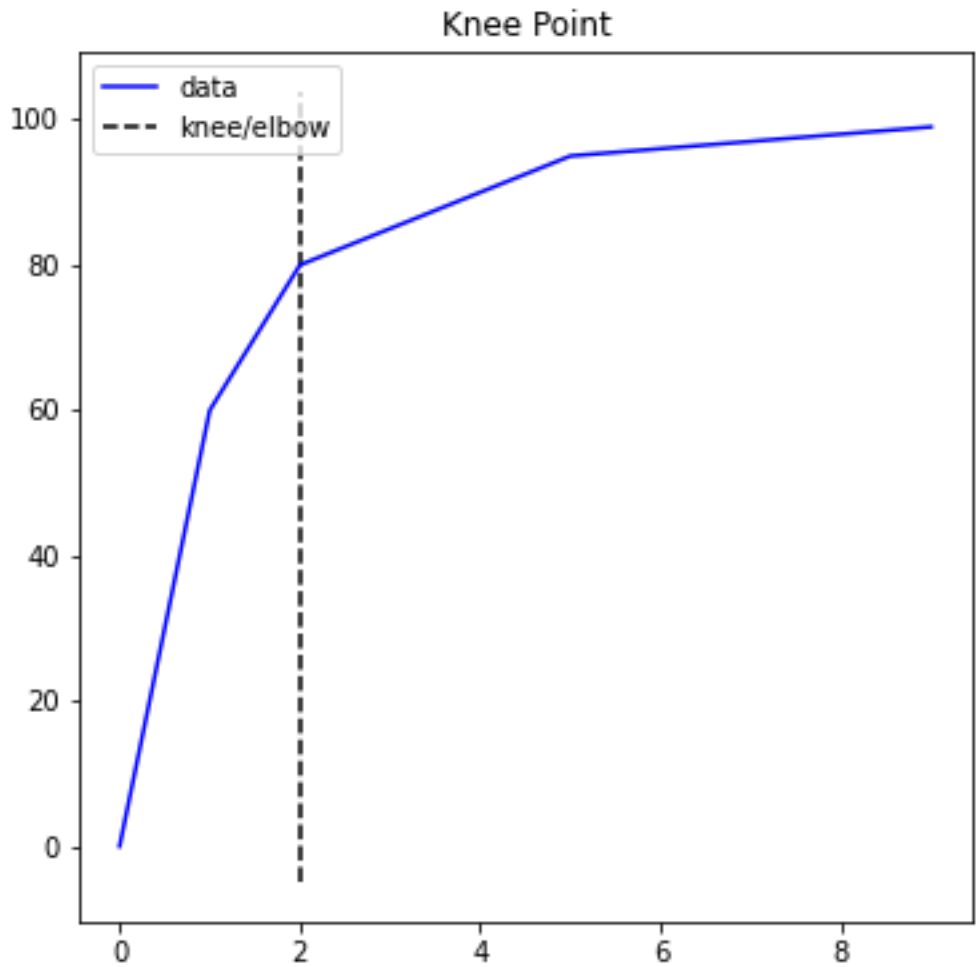
This page provides examples that outline the effect of tuning the parameters for *KneeLocator*.

1.1 curve

If *curve="concave"*, kneed will detect knees. If *curve="convex"*, it will detect elbows. Use the *DataGenerator* class to generate synthetic data:

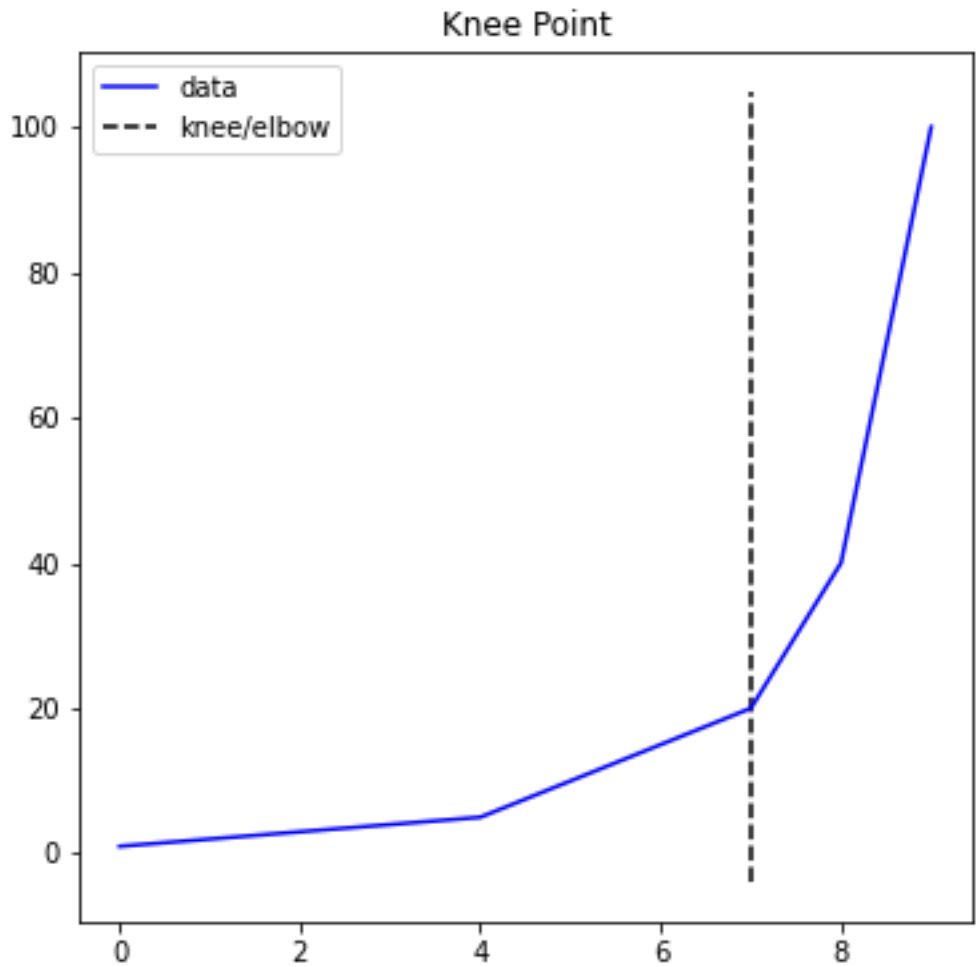
An concave curve example:

```
from kneed import KneeLocator, DataGenerator as dg
x, y = dg.concave_increasing()
kl = KneeLocator(x, y, curve="concave")
kl.plot_knee()
```



A convex curve example:

```
from kneed import KneeLocator, DataGenerator as dg
x, y = dg.convex_increasing()
kl = KneeLocator(x, y, curve="convex")
kl.plot_knee()
```

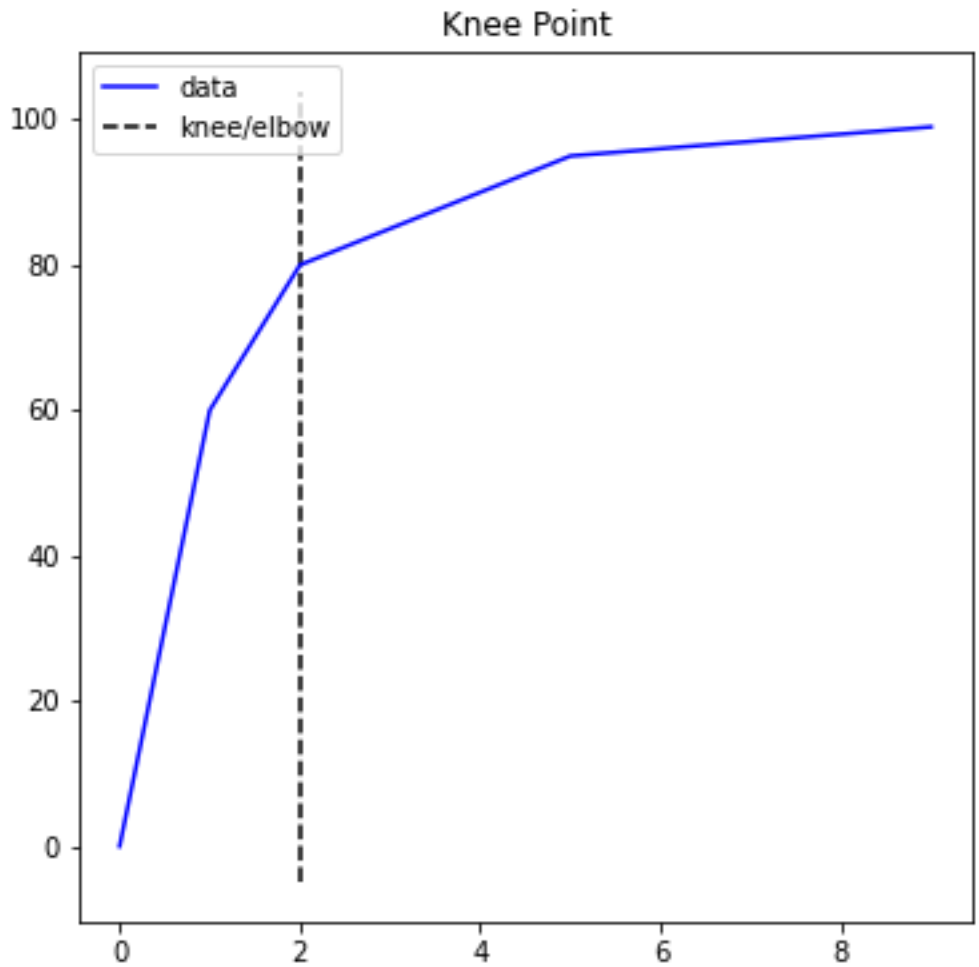


1.2 direction

The direction parameter describes the line from left to right on the x-axis. If the knee/elbow you are trying to identify is on a positive slope use *direction="increasing"*, if the knee/elbow you are trying to identify is on a negative slope, use *direction="decreasing"*. Use the *DataGenerator* class to generate synthetic data.

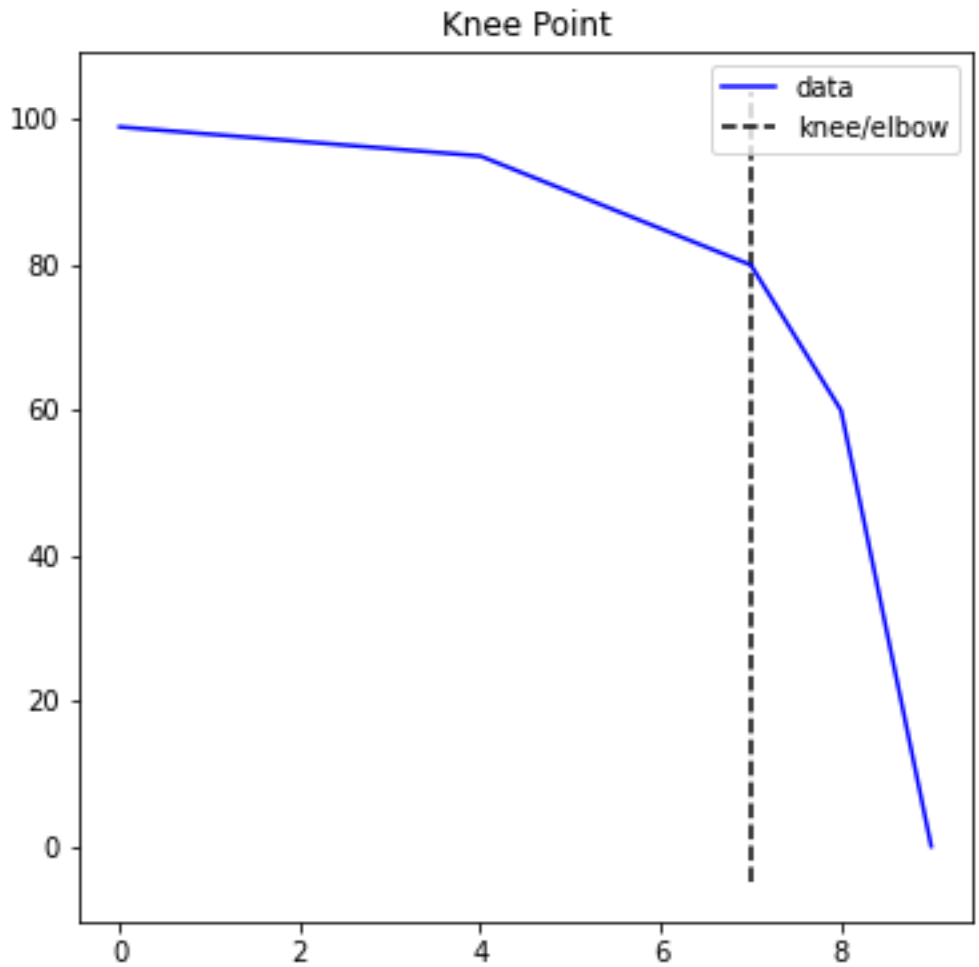
An example of an increasing curve:

```
from kneed import KneeLocator, DataGenerator as dg
x, y = dg.concave_increasing()
kl = KneeLocator(x, y, curve="concave", direction="increasing")
kl.plot_knee()
```



An example of a decreasing curve:

```
from kneed import KneeLocator, DataGenerator as dg
x, y = dg.concave_decreasing()
kl = KneeLocator(x, y, curve="concave", direction="decreasing")
kl.plot_knee()
```



1.3 S

The selected knee point is tunable by setting the sensitivity parameter *S*. From the kneedle manuscript:

> The sensitivity parameter allows us to adjust how aggressive we want Kneedle to be when detecting knees. Smaller values for S detect knees quicker, while larger values are more conservative. Put simply, S is a measure of how many "flat" points we expect to see in the unmodified data curve before declaring a knee.

```
import numpy as np

np.random.seed(23)

sensitivity = [1, 3, 5, 10, 100, 200, 400]
knees = []
norm_knees = []
```

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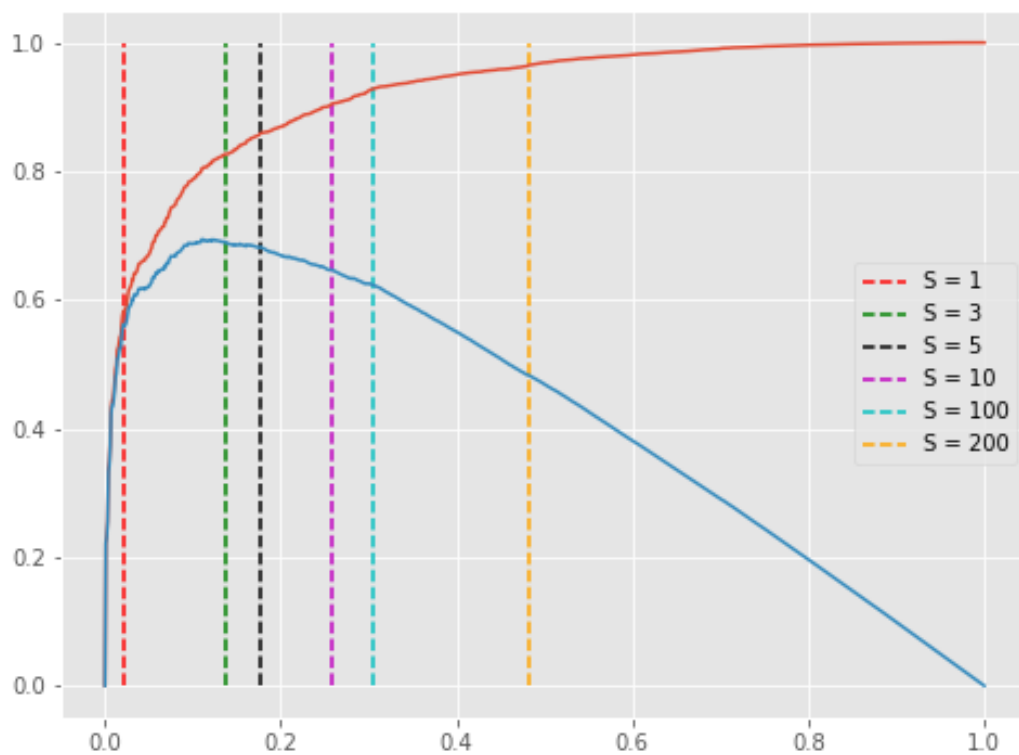
```
n = 1000
x = range(1, n + 1)
y = sorted(np.random.gamma(0.5, 1.0, n), reverse=True)
for s in sensitivity:
    kl = KneeLocator(x, y, curve="convex", direction="decreasing", S=s)
    knees.append(kl.knee)
    norm_knees.append(kl.norm_knee)

print(knees)
[43, 137, 178, 258, 305, 482, 482]

print([nk.round(2) for nk in norm_knees])
[0.04, 0.14, 0.18, 0.26, 0.3, 0.48, 0.48]

import matplotlib.pyplot as plt

plt.style.use("ggplot")
plt.figure(figsize=(8, 6))
plt.plot(kl.x_normalized, kl.y_normalized)
plt.plot(kl.x_difference, kl.y_difference)
colors = ["r", "g", "k", "m", "c", "orange"]
for k, c, s in zip(norm_knees, colors, sensitivity):
    plt.vlines(k, 0, 1, linestyles="--", colors=c, label=f"S = {s}")
plt.legend()
```



Any *S*>200 will result in a knee at 482 (0.48, normalized) in the plot above.

1.4 online

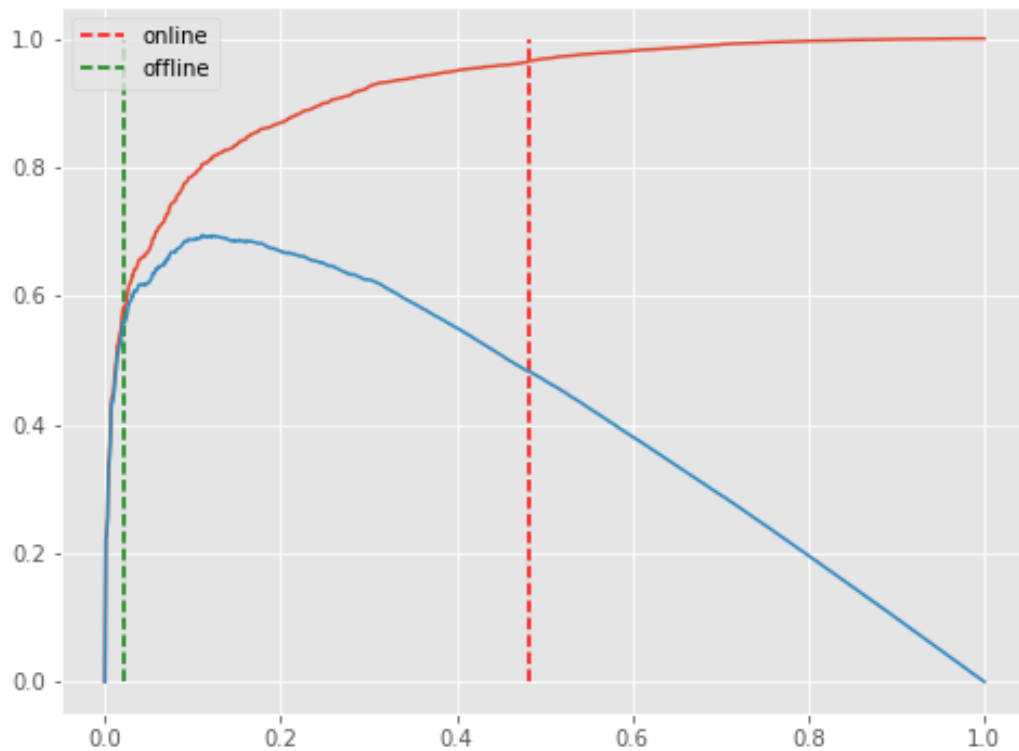
The knee point can be corrected if the parameter online is *True* (default). This mode will step through each element in x. In contrast, if online is False, kneed will run in offline mode and return the first knee point identified. When *online=False* the first knee point identified is returned regardless of whether it's the local maxima on the difference curve or the global maxima. So the algorithm stops early. When *online=True*, kneed runs in online mode and "corrects" itself by continuing to overwrite any previously identified knees.

Using the *x* and *y* from the sensitivity example above, this time, keep *S=1* but modify *online*.

```
kl_online = KneeLocator(x, y, curve="convex", direction="decreasing", online=True)
kl_offline = KneeLocator(x, y, curve="convex", direction="decreasing", online=False)

import matplotlib.pyplot as plt

plt.style.use("ggplot")
plt.figure(figsize=(8, 6))
plt.plot(kl_online.x_normalized, kl_online.y_normalized)
plt.plot(kl_online.x_difference, kl_online.y_difference)
colors = ["r", "g"]
for k, c, o in zip(
    [kl_online.norm_knee, kl_offline.norm_knee], ["r", "g"], ["online", "offline"]
):
    plt.vlines(k, 0, 1, linestyles="--", colors=c, label=o)
plt.legend()
```



1.5 interp_method

This parameter controls the interpolation method for fitting a spline to the input *x* and *y* data points. Valid arguments are *"interp1d"* and *"polynomial"*.

If *interp_method="interp1d"*, then *x* and *y* will be fit using scipy.interpolate.interp1d.

```
x = list(range(90))
y = [
    7304, 6978, 6666, 6463, 6326, 6048, 6032, 5762, 5742,
    5398, 5256, 5226, 5001, 4941, 4854, 4734, 4558, 4491,
    4411, 4333, 4234, 4139, 4056, 4022, 3867, 3808, 3745,
    3692, 3645, 3618, 3574, 3504, 3452, 3401, 3382, 3340,
    3301, 3247, 3190, 3179, 3154, 3089, 3045, 2988, 2993,
    2941, 2875, 2866, 2834, 2785, 2759, 2763, 2720, 2660,
    2690, 2635, 2632, 2574, 2555, 2545, 2513, 2491, 2496,
    2466, 2442, 2420, 2381, 2388, 2340, 2335, 2318, 2319,
    2308, 2262, 2235, 2259, 2221, 2202, 2184, 2170, 2160,
    2127, 2134, 2101, 2101, 2066, 2074, 2063, 2048, 2031
]

kneedle = KneeLocator(
    x, y, S=1.0, curve="convex", direction="decreasing", interp_method="interp1d"
```

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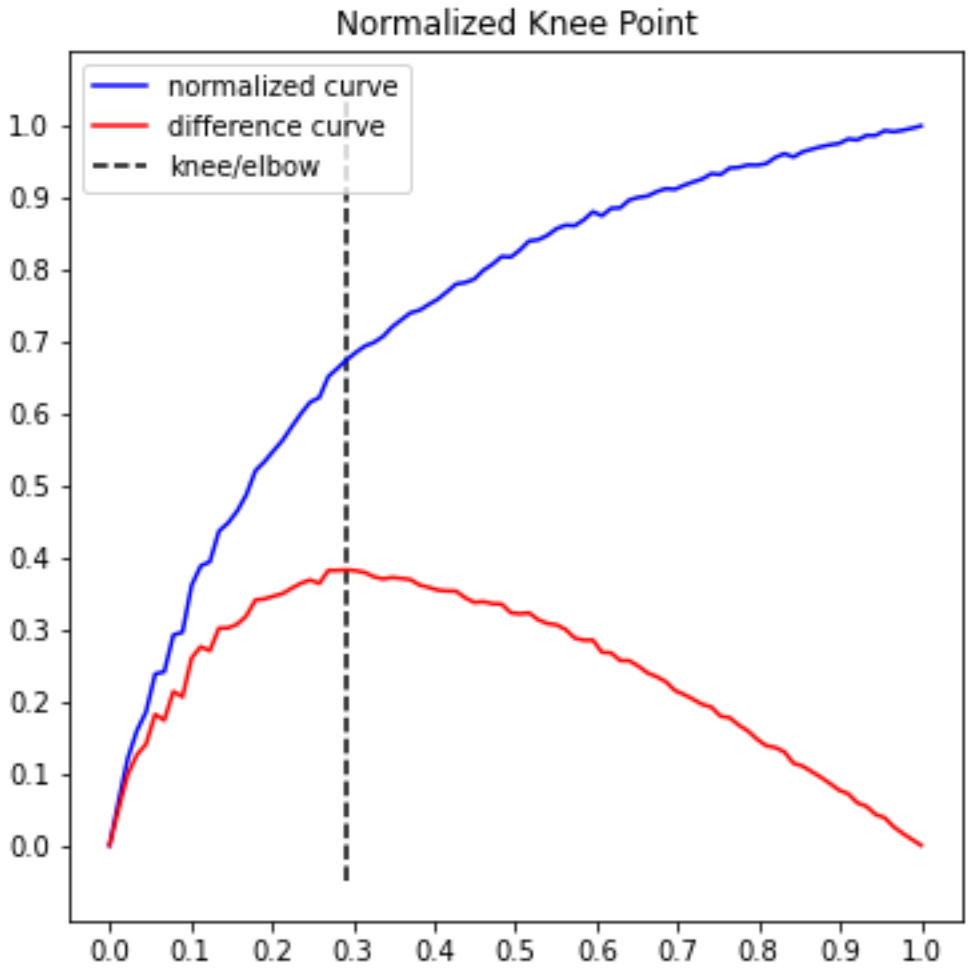
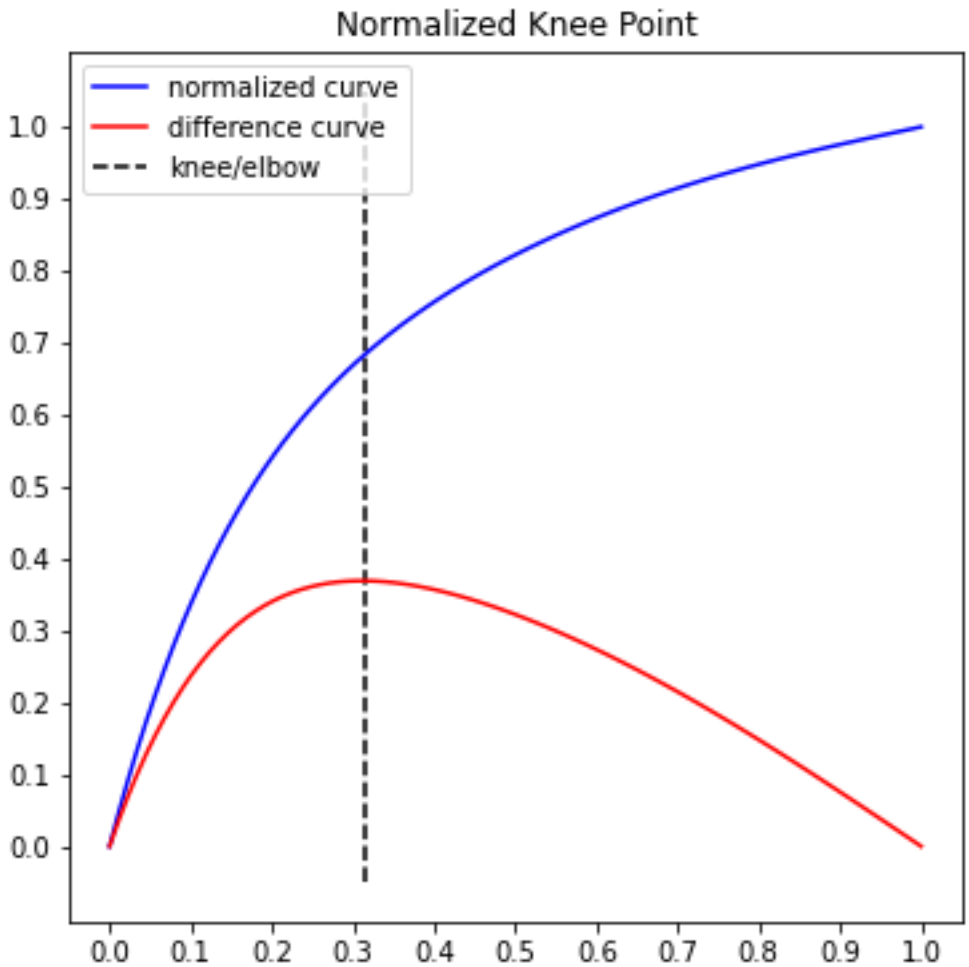
```
)
kneedle.plot_knee_normalized()
```



If *interp_method="polynomial"*, then *x* and *y* will be fit using numpy.polyfit. Using the same data, change *interp_method* and note that the line is smoother.

```
kneedle = KneeLocator(
    x, y, S=1.0, curve="convex", direction="decreasing", interp_method="polynomial",
)
kneedle.plot_knee_normalized()
```

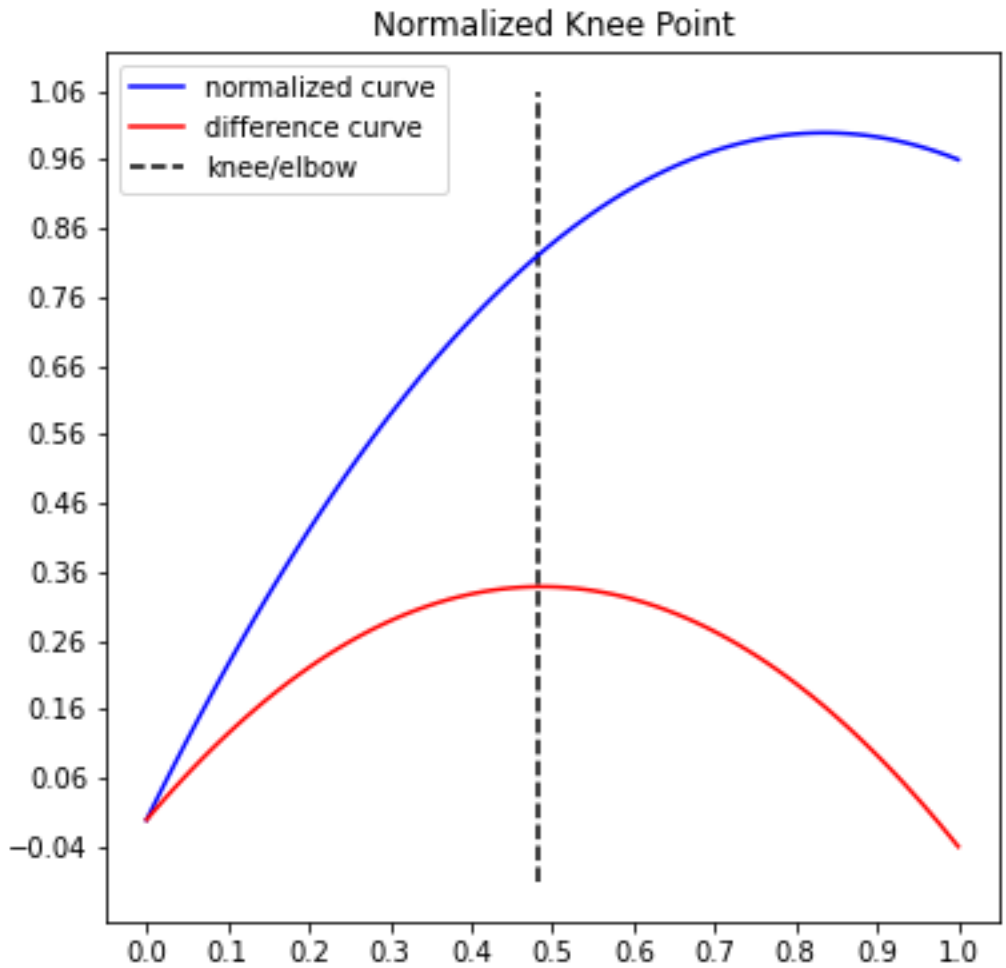


1.6 polynomial_degree

This parameter controls the degree of the polynomial fit. This parameter is passed as the argument to the *deg* parameter in numpy.polyfit.

Using the same data from the *interp_method* example, note how the line (and knee point) change when *polynomial_degree=2* instead of the default value, *7*:

```
kneedle = KneeLocator(
    x, y, S=1.0, curve="convex", direction="decreasing", interp_method="polynomial",
    polynomial_degree=2
)
kneedle.plot_knee_normalized()
```


Normalized Knee Point
normalized curve
difference curve
knee/elbow
1.06
0.96
0.86
0.76
0.66
0.56
0.46
0.36
0.26
0.16
0.06
−0.04
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

CHAPTER 2

API Reference

There are two classes in *kneed*: *KneeLocator* identifies the knee/elbow point(s) and and *DataGenerator* creates synthetic *x* and *y* numpy arrays to explore *kneed*.

2.1 KneeLocator

2.1.1 Plotting methods

There are two methods for basic visualizations of the knee/elbow point(s).

2.2 DataGenerator

CHAPTER 3

Interactive Streamlit App

An interactive streamlit app was developed to help users explore the effect of tuning the parameters. There are two sites where you can test out kneed by copy-pasting your own data:

1. https://share.streamlit.io/arvkevi/ikneed/main/ikneed.py
2. https://ikneed.herokuapp.com/

You can also run your own version – head over to the source code for ikneed.

CHAPTER 4

Indices and tables

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