

Python For Data Science Cheat Sheet

NumPy Basics

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NumPy

The NumPy library is the core library for scientific computing in Python. It provides a high-performance multidimensional array object, and tools for working with these arrays.

Use the following import convention:

```
>>> import numpy as np
```



NumPy Arrays

1D array

```
[1 2 3]
```

2D array

axis 1
axis 0

```
[[1.5 2. 3.]  
 [4. 5. 6.]]
```

3D array

axis 2
axis 1
axis 0

Creating Arrays

```
>>> a = np.array([1,2,3])  
>>> b = np.array([(1.5,2,3), (4,5,6)], dtype = float)  
>>> c = np.array([(1.5,2,3), (4,5,6)], [(3,2,1), (4,5,6)]],  
                dtype = float)
```

Initial Placeholders

```
>>> np.zeros((3,4))  
>>> np.ones((2,3,4),dtype=np.int16)  
>>> d = np.arange(10,25,5)  
  
>>> np.linspace(0,2,9)  
  
>>> e = np.full((2,2),7)  
>>> f = np.eye(2)  
>>> np.random.random((2,2))  
>>> np.empty((3,2))
```

Create an array of zeros
Create an array of ones
Create an array of evenly spaced values (step value)
Create an array of evenly spaced values (number of samples)
Create a constant array
Create a 2X2 identity matrix
Create an array with random values
Create an empty array

I/O

Saving & Loading On Disk

```
>>> np.save('my_array', a)  
>>> np savez('array.npy', a, b)  
>>> np.load('my_array.npy')
```

Saving & Loading Text Files

```
>>> np.loadtxt("myfile.txt")  
>>> np.genfromtxt("my_file.csv", delimiter=',')  
>>> np.savetxt("myarray.txt", a, delimiter=" ")
```

Data Types

```
>>> np.int64  
>>> np.float32  
>>> np.complex  
>>> np.bool  
>>> np.object  
>>> np.string_  
>>> np.unicode_
```

Signed 64-bit integer types
Standard double-precision floating point
Complex numbers represented by 128 floats
Boolean type storing TRUE and FALSE values
Python object type
Fixed-length string type
Fixed-length unicode type

Inspecting Your Array

```
>>> a.shape  
>>> len(a)  
>>> b.ndim  
>>> e.size  
>>> b.dtype  
>>> b.dtype.name  
>>> b.astype(int)
```

Array dimensions
Length of array
Number of array dimensions
Number of array elements
Data type of array elements
Name of data type
Convert an array to a different type

Asking For Help

```
>>> np.info(np.ndarray.dtype)
```

Array Mathematics

Arithmetic Operations

```
>>> g = a - b  
array([[ -0.5,  0. ,  0. ],  
       [-3. , -3. , -3. ]])  
>>> np.subtract(a,b)  
>>> b + a  
array([[ 2.5,  4. ,  6. ],  
       [ 5. ,  7. ,  9. ]])  
  
>>> np.add(b,a)  
array([[ 0.66666667,  1. ,  1. ],  
       [ 0.25 ,  0.4 ,  0.5 ]])  
>>> a / b  
array([[ 0.66666667,  1. ,  1. ],  
       [ 0.25 ,  0.4 ,  0.5 ]])  
>>> np.divide(a,b)  
>>> a * b  
array([[ 1.5,  4. ,  9. ],  
       [ 4. , 10. , 18. ]])  
  
>>> np.multiply(a,b)  
>>> np.exp(b)  
>>> np.sqrt(b)  
>>> np.sin(a)  
>>> np.cos(b)  
>>> np.log(a)  
>>> e.dot(f)  
array([[ 7. ,  7. ],  
       [ 7. ,  7.]])
```

Subtraction
Subtraction
Addition
Addition
Division
Division
Multiplication
Exponentiation
Square root
Print sines of an array
Element-wise cosine
Element-wise natural logarithm
Dot product

Comparison

```
>>> a == b  
array([[False,  True,  True],  
       [False, False, False]], dtype=bool)  
>>> a < 2  
array([True, False, False], dtype=bool)  
>>> np.array_equal(a, b)
```

Element-wise comparison
Element-wise comparison
Array-wise comparison

Aggregate Functions

```
>>> a.sum()  
>>> a.min()  
>>> b.max(axis=0)  
>>> b.cumsum(axis=1)  
>>> a.mean()  
>>> b.median()  
>>> a.corrcoef()  
>>> np.std(b)
```

Array-wise sum
Array-wise minimum value
Maximum value of an array row
Cumulative sum of the elements
Mean
Median
Correlation coefficient
Standard deviation

Copying Arrays

```
>>> h = a.view()  
>>> np.copy(a)  
>>> h = a.copy()
```

Create a view of the array with the same data
Create a copy of the array
Create a deep copy of the array

Sorting Arrays

```
>>> a.sort()  
>>> c.sort(axis=0)
```

Sort an array
Sort the elements of an array's axis

Subsetting, Slicing, Indexing

Also see Lists

Subsetting

```
>>> a[2]  
3  
>>> b[1,2]  
6.0
```

Select the element at the 2nd index
Select the element at row 1 column 2 (equivalent to b[1][2])

Slicing

```
>>> a[0:2]  
array([1, 2])  
>>> b[0:2,1]  
array([ 2.,  5.])  
  
>>> b[:1]  
array([[1.5, 2., 3.]])  
>>> c[:,...]  
array([[ 3.,  2.,  1.],  
       [ 4.,  5.,  6.]])
```

Select items at index 0 and 1
Select items at rows 0 and 1 in column 1
Select all items at row 0 (equivalent to b[0:1, :])
Same as [1, :, :]

Boolean Indexing

```
>>> a[a<2]  
array([1])  
  
>>> a[ : :-1]  
array([3, 2, 1])
```

Reversed array a

Fancy Indexing

```
>>> b[[1, 0, 1, 0],[0, 1, 2, 0]]  
array([ 4.,  2.,  6.,  1.5])  
>>> b[[1, 0, 1, 0]][:,[0,1,2,0]]  
array([[ 4.,  5.,  6.,  4.],  
       [ 1.5,  2.,  3.,  1.5],  
       [ 4.,  2.,  6.,  4.],  
       [ 1.5,  2.,  3.,  1.5]])
```

Select elements (1,0), (0,1), (1,2) and (0,0)
Select a subset of the matrix's rows and columns

Array Manipulation

Transposing Array

```
>>> i = np.transpose(b)  
>>> i.T
```

Permute array dimensions
Permute array dimensions

Changing Array Shape

```
>>> b.ravel()  
>>> g.reshape(3,-2)
```

Flatten the array
Reshape, but don't change data

Adding/Removing Elements

```
>>> h.resize((2,6))  
>>> np.append(h,g)  
>>> np.insert(a, 1, 5)  
>>> np.delete(a, [1])
```

Return a new array with shape (2,6)
Append items to an array
Insert items in an array
Delete items from an array

Combining Arrays

```
>>> np.concatenate((a,d),axis=0)  
array([ 1,  2,  3, 10, 15, 20])  
>>> np.vstack((a,b))  
array([[ 1.,  2.,  3. ],  
       [ 1.5,  2.,  3. ],  
       [ 4.,  5.,  6. ]])  
  
>>> np.r_[e,f]  
>>> np.hstack((e,f))  
array([[ 7.,  7.,  1.,  0.],  
       [ 7.,  7.,  0.,  1.]])  
>>> np.column_stack((a,d))  
array([[ 1, 10],  
       [ 2, 15],  
       [ 3, 20]])  
>>> np.c_[a,d]
```

Concatenate arrays
Stack arrays vertically (row-wise)
Stack arrays vertically (row-wise)
Stack arrays horizontally (column-wise)
Create stacked column-wise arrays
Create stacked column-wise arrays

Splitting Arrays

```
>>> np.hsplit(a,3)  
[array([1]), array([2]), array([3])]  
>>> np.vsplit(c,2)  
[array([[ 4.,  5.,  6. ]]),  
 array([[ 3.,  2.,  3.]])]
```

Split the array horizontally at the 3rd index
Split the array vertically at the 2nd index

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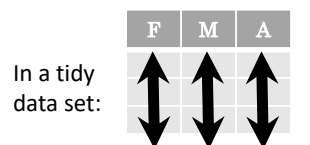
Data Wrangling

with pandas

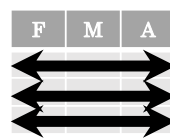
Cheat Sheet

<http://pandas.pydata.org>

Tidy Data – A foundation for wrangling in pandas

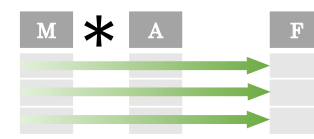


Each **variable** is saved in its own **column**



Each **observation** is saved in its own **row**

Tidy data complements pandas's **vectorized operations**. pandas will automatically preserve observations as you manipulate variables. No other format works as intuitively with pandas.



M * A

Syntax – Creating DataFrames

	a	b	c
1	4	7	10
2	5	8	11
3	6	9	12

```
df = pd.DataFrame(  
    {"a" : [4 ,5, 6],  
     "b" : [7, 8, 9],  
     "c" : [10, 11, 12]},  
    index = [1, 2, 3])  
Specify values for each column.
```

```
df = pd.DataFrame(  
    [[4, 7, 10],  
     [5, 8, 11],  
     [6, 9, 12]],  
    index=[1, 2, 3],  
    columns=['a', 'b', 'c'])  
Specify values for each row.
```

	a	b	c
n	1	4	7
d	2	5	8
e	2	6	9

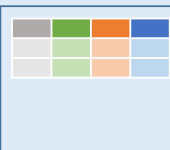
```
df = pd.DataFrame(  
    {"a" : [4 ,5, 6],  
     "b" : [7, 8, 9],  
     "c" : [10, 11, 12]},  
    index = pd.MultiIndex.from_tuples(  
        [('d',1),('d',2),('e',2)],  
        names=['n', 'v']))  
Create DataFrame with a MultiIndex
```

Method Chaining

Most pandas methods return a DataFrame so that another pandas method can be applied to the result. This improves readability of code.

```
df = (pd.melt(df)  
     .rename(columns={  
         'variable' : 'var',  
         'value' : 'val'})  
     .query('val >= 200'))
```

Reshaping Data – Change the layout of a data set



pd.melt(df)
Gather columns into rows.



df.pivot(columns='var', values='val')
Spread rows into columns.



pd.concat([df1,df2])
Append rows of DataFrames



pd.concat([df1,df2], axis=1)
Append columns of DataFrames

```
df.sort_values('mpg')  
Order rows by values of a column (low to high).  
  
df.sort_values('mpg', ascending=False)  
Order rows by values of a column (high to low).  
  
df.rename(columns = {'y':'year'})  
Rename the columns of a DataFrame  
  
df.sort_index()  
Sort the index of a DataFrame  
  
df.reset_index()  
Reset index of DataFrame to row numbers, moving  
index to columns.  
  
df.drop(columns=['Length', 'Height'])  
Drop columns from DataFrame
```

Subset Observations (Rows)



```
df[df.Length > 7]  
Extract rows that meet logical  
criteria.  
  
df.drop_duplicates()  
Remove duplicate rows (only  
considers columns).  
  
df.head(n)  
Select first n rows.  
  
df.tail(n)  
Select last n rows.
```

```
df.sample(frac=0.5)  
Randomly select fraction of rows.  
  
df.sample(n=10)  
Randomly select n rows.  
  
df.iloc[10:20]  
Select rows by position.  
  
df.nlargest(n, 'value')  
Select and order top n entries.  
  
df.nsmallest(n, 'value')  
Select and order bottom n entries.
```

Subset Variables (Columns)



```
df[['width', 'length', 'species']]  
Select multiple columns with specific names.  
  
df['width'] or df.width  
Select single column with specific name.  
  
df.filter(regex='regex')  
Select columns whose name matches regular expression regex.
```

regex (Regular Expressions) Examples

regex	Matches
'\.'	Matches strings containing a period '.'
'Length\$'	Matches strings ending with word 'Length'
'^Sepal'	Matches strings beginning with the word 'Sepal'
'^x[1-5]\$'	Matches strings beginning with 'x' and ending with 1,2,3,4,5
'^(?!Species\$).*\$'	Matches strings except the string 'Species'

```
df.loc[:, 'x2': 'x4']  
Select all columns between x2 and x4 (inclusive).  
  
df.iloc[:, [1,2,5]]  
Select columns in positions 1, 2 and 5 (first column is 0).  
  
df.loc[df['a'] > 10, ['a', 'c']]  
Select rows meeting logical condition, and only the specific columns.
```

Summarize Data

df['w'].value_counts()

Count number of rows with each unique value of variable

len(df)

of rows in DataFrame.

df['w'].nunique()

of distinct values in a column.

df.describe()

Basic descriptive statistics for each column (or GroupBy)



pandas provides a large set of **summary functions** that operate on different kinds of pandas objects (DataFrame columns, Series, GroupBy, Expanding and Rolling (see below)) and produce single values for each of the groups. When applied to a DataFrame, the result is returned as a pandas Series for each column. Examples:

sum()

Sum values of each object.

count()

Count non-NA/null values of each object.

median()

Median value of each object.

quantile([0.25,0.75])

Quantiles of each object.

apply(function)

Apply function to each object.

min()

Minimum value in each object.

max()

Maximum value in each object.

mean()

Mean value of each object.

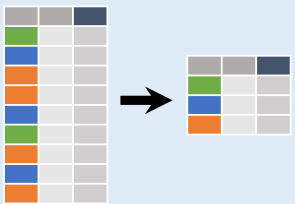
var()

Variance of each object.

std()

Standard deviation of each object.

Group Data



df.groupby(by="col")

Return a GroupBy object, grouped by values in column named "col".

df.groupby(level="ind")

Return a GroupBy object, grouped by values in index level named "ind".

All of the summary functions listed above can be applied to a group. Additional GroupBy functions:

size()

Size of each group.

agg(function)

Aggregate group using function.

Windows

df.expanding()

Return an Expanding object allowing summary functions to be applied cumulatively.

df.rolling(n)

Return a Rolling object allowing summary functions to be applied to windows of length n.

Handling Missing Data

df.dropna()

Drop rows with any column having NA/null data.

df.fillna(value)

Replace all NA/null data with value.

Make New Columns



df.assign(Area=lambda df: df.Length*df.Height)

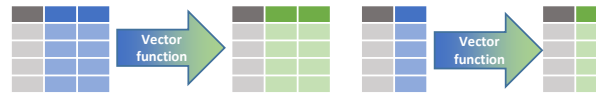
Compute and append one or more new columns.

df['Volume'] = df.Length*df.Height*df.Depth

Add single column.

pd.qcut(df.col, n, labels=False)

Bin column into n buckets.



pandas provides a large set of **vector functions** that operate on all columns of a DataFrame or a single selected column (a pandas Series). These functions produce vectors of values for each of the columns, or a single Series for the individual Series. Examples:

max(axis=1)

Element-wise max.

min(axis=1)

Element-wise min.

clip(lower=-10, upper=10) abs()

Trim values at input thresholds Absolute value.

The examples below can also be applied to groups. In this case, the function is applied on a per-group basis, and the returned vectors are of the length of the original DataFrame.

shift(1)

Copy with values shifted by 1.

rank(method='dense')

Ranks with no gaps.

rank(method='min')

Ranks. Ties get min rank.

rank(pct=True)

Ranks rescaled to interval [0, 1].

rank(method='first')

Ranks. Ties go to first value.

shift(-1)

Copy with values lagged by 1.

cumsum()

Cumulative sum.

cummax()

Cumulative max.

cumin()

Cumulative min.

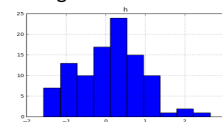
cumprod()

Cumulative product.

Plotting

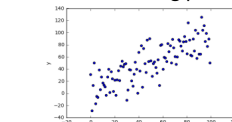
df.plot.hist()

Histogram for each column

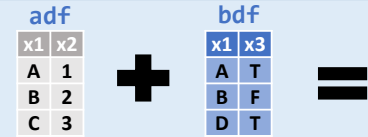


df.plot.scatter(x='w', y='h')

Scatter chart using pairs of points



Combine Data Sets



Standard Joins

x1	x2	x3
A	1	T
B	2	F
C	3	NaN

pd.merge(adf, bdf, how='left', on='x1')
Join matching rows from bdf to adf.

x1	x2	x3
A	1.0	T
B	2.0	F
D	NaN	T

pd.merge(adf, bdf, how='right', on='x1')
Join matching rows from adf to bdf.

x1	x2	x3
A	1	T
B	2	F

pd.merge(adf, bdf, how='inner', on='x1')
Join data. Retain only rows in both sets.

x1	x2	x3
A	1	T
B	2	F
C	3	NaN
D	NaN	T

pd.merge(adf, bdf, how='outer', on='x1')
Join data. Retain all values, all rows.

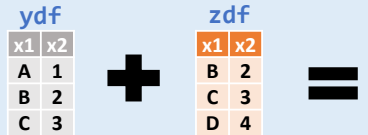
Filtering Joins

x1	x2
A	1
B	2

adf[adf.x1.isin(bdf.x1)]
All rows in adf that have a match in bdf.

x1	x2
C	3

adf[~adf.x1.isin(bdf.x1)]
All rows in adf that do not have a match in bdf.



Set-like Operations

x1	x2
B	2
C	3

pd.merge(ydf, zdf)
Rows that appear in both ydf and zdf (Intersection).

x1	x2
A	1
B	2
C	3
D	4

pd.merge(ydf, zdf, how='outer')
Rows that appear in either or both ydf and zdf (Union).

x1	x2
A	1

pd.merge(ydf, zdf, how='outer', indicator=True)
.query('_merge == "left_only"')
.drop(columns=['_merge'])
Rows that appear in ydf but not zdf (Setdiff).

Python For Data Science Cheat Sheet 3 Plotting With Seaborn

Seaborn

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Statistical Data Visualization With Seaborn

The Python visualization library **Seaborn** is based on **matplotlib** and provides a high-level interface for drawing attractive statistical graphics.

Make use of the following aliases to import the libraries:

```
>>> import matplotlib.pyplot as plt
>>> import seaborn as sns
```

The basic steps to creating plots with Seaborn are:

1. Prepare some data
2. Control figure aesthetics
3. Plot with Seaborn
4. Further customize your plot

```
>>> import matplotlib.pyplot as plt
>>> import seaborn as sns
>>> tips = sns.load_dataset("tips")
>>> sns.set_style("whitegrid")
>>> g = sns.lmplot(x="tip",
>>>               y="total_bill",
>>>               data=tips,
>>>               aspect=2)
>>> g = (g.set_axis_labels("Tip", "Total bill (USD)").
>>>      set(xlim=(0,10),ylim=(0,100)))
>>> plt.title("Title")
>>> plt.show(g)
```

1 Data

Also see [Lists](#), [NumPy](#) & [Pandas](#)

```
>>> import pandas as pd
>>> import numpy as np
>>> uniform_data = np.random.rand(10, 12)
>>> data = pd.DataFrame({'x':np.arange(1,101),
>>>                     'y':np.random.normal(0,4,100)})
```

Seaborn also offers built-in data sets:

```
>>> titanic = sns.load_dataset("titanic")
>>> iris = sns.load_dataset("iris")
```

2 Figure Aesthetics

Also see [Matplotlib](#)

```
>>> f, ax = plt.subplots(figsize=(5,6))
```

Create a figure and one subplot

Seaborn styles

```
>>> sns.set()
>>> sns.set_style("whitegrid")
>>> sns.set_style("ticks",
>>>               {'xtick.major.size':8,
>>>                'ytick.major.size':8})
>>> sns.axes_style("whitegrid")
```

(Re)set the seaborn default
Set the matplotlib parameters
Set the matplotlib parameters

Return a dict of params or use with
with to temporarily set the style

Context Functions

```
>>> sns.set_context("talk")
>>> sns.set_context("notebook",
>>>                 font_scale=1.5,
>>>                 rc={'Lines.linewidth':2.5})
```

Set context to "talk"
Set context to "notebook",
scale font elements and
override param mapping

Color Palette

```
>>> sns.set_palette("husl",3)
>>> sns.color_palette("husl")
>>> flatui = ["#9b59b6","#3498db","#95a5a6","#e74c3c","#34495e","#2ecc71"]
>>> sns.set_palette(flatui)
```

Define the color palette
Use with with to temporarily set palette
Set your own color palette

Axis Grids

```
>>> g = sns.FacetGrid(titanic,
>>>                   col="survived",
>>>                   row="sex")
>>> g = g.map(plt.hist,"age")
>>> sns.factorplot(x="pclass",
>>>               y="survived",
>>>               hue="sex",
>>>               data=titanic)
>>> sns.lmplot(x="sepal_width",
>>>            y="sepal_length",
>>>            hue="species",
>>>            data=iris)
```

Subplot grid for plotting conditional
relationships

Draw a categorical plot onto a
Facetgrid

Plot data and regression model fits
across a FacetGrid

Categorical Plots

```
Scatterplot
>>> sns.stripplot(x="species",
>>>               y="petal_length",
>>>               data=iris)
>>> sns.swarmplot(x="species",
>>>               y="petal_length",
>>>               data=iris)

Bar Chart
>>> sns.barplot(x="sex",
>>>              y="survived",
>>>              hue="class",
>>>              data=titanic)
```

Scatterplot with one
categorical variable

Categorical scatterplot with
non-overlapping points

Show point estimates and
confidence intervals with
scatterplot glyphs

```
Count Plot
>>> sns.countplot(x="deck",
>>>               data=titanic,
>>>               palette="Greens_d")

Point Plot
>>> sns.pointplot(x="class",
>>>               y="survived",
>>>               hue="sex",
>>>               data=titanic,
>>>               palette={"male":"g",
>>>                        "female":"m"},
>>>               markers=["^","o"],
>>>               linestyle=["-","-"])
```

Show count of observations

Show point estimates and
confidence intervals as
rectangular bars

```
Boxplot
>>> sns.boxplot(x="alive",
>>>              y="age",
>>>              hue="adult_male",
>>>              data=titanic)
>>> sns.boxplot(data=iris,orient="h")

Violinplot
>>> sns.violinplot(x="age",
>>>                 y="sex",
>>>                 hue="survived",
>>>                 data=titanic)
```

Boxplot

Boxplot with wide-form data

Violin plot

```
>>> h = sns.PairGrid(iris)
>>> h = h.map(plt.scatter)
>>> sns.pairplot(iris)
>>> i = sns.JointGrid(x="x",
>>>                  y="y",
>>>                  data=data)
>>> i = i.plot(sns.regplot,
>>>            sns.distplot)
>>> sns.jointplot("sepal_length",
>>>               "sepal_width",
>>>               data=iris,
>>>               kind='kde')
```

Subplot grid for plotting pairwise
relationships
Plot pairwise bivariate distributions
Grid for bivariate plot with marginal
univariate plots

Plot bivariate distribution

Regression Plots

```
>>> sns.regplot(x="sepal_width",
>>>              y="sepal_length",
>>>              data=iris,
>>>              ax=ax)
```

Plot data and a linear regression
model fit

Distribution Plots

```
>>> plot = sns.distplot(data.y,
>>>                      kde=False,
>>>                      color="b")
```

Plot univariate distribution

Matrix Plots

```
>>> sns.heatmap(uniform_data,vmin=0,vmax=1)
```

Heatmap

4 Further Customizations

Also see [Matplotlib](#)

Axisgrid Objects

```
>>> g.despine(left=True)
>>> g.set_ylabels("Survived")
>>> g.set_xticklabels(rotation=45)
>>> g.set_axis_labels("Survived",
>>>                  "Sex")
>>> h.set(xlim=(0,5),
>>>        ylim=(0,5),
>>>        xticks=[0,2.5,5],
>>>        yticks=[0,2.5,5])
```

Remove left spine
Set the labels of the y-axis
Set the tick labels for x
Set the axis labels

Set the limit and ticks of the
x-and y-axis

Plot

```
>>> plt.title("A Title")
>>> plt.ylabel("Survived")
>>> plt.xlabel("Sex")
>>> plt.ylim(0,100)
>>> plt.xlim(0,10)
>>> plt.setp(ax,yticks=[0,5])
>>> plt.tight_layout()
```

Add plot title
Adjust the label of the y-axis
Adjust the label of the x-axis
Adjust the limits of the y-axis
Adjust the limits of the x-axis
Adjust a plot property
Adjust subplot params

5 Show or Save Plot

Also see [Matplotlib](#)

```
>>> plt.show()
>>> plt.savefig("foo.png")
>>> plt.savefig("foo.png",
>>>             transparent=True)
```

Show the plot
Save the plot as a figure
Save transparent figure

Close & Clear

Also see [Matplotlib](#)

```
>>> plt.cla()
>>> plt.clf()
>>> plt.close()
```

Clear an axis
Clear an entire figure
Close a window

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Scikit-Learn

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Scikit-learn

Scikit-learn is an open source Python library that implements a range of machine learning, preprocessing, cross-validation and visualization algorithms using a unified interface.



A Basic Example

```
>>> from sklearn import neighbors, datasets, preprocessing
>>> from sklearn.model_selection import train_test_split
>>> from sklearn.metrics import accuracy_score
>>> iris = datasets.load_iris()
>>> X, y = iris.data[:, :2], iris.target
>>> X_train, X_test, y_train, y_test = train_test_split(X, y, random_state=33)
>>> scaler = preprocessing.StandardScaler().fit(X_train)
>>> X_train = scaler.transform(X_train)
>>> X_test = scaler.transform(X_test)
>>> knn = neighbors.KNeighborsClassifier(n_neighbors=5)
>>> knn.fit(X_train, y_train)
>>> y_pred = knn.predict(X_test)
>>> accuracy_score(y_test, y_pred)
```

Loading The Data

Also see NumPy & Pandas

Your data needs to be numeric and stored as NumPy arrays or SciPy sparse matrices. Other types that are convertible to numeric arrays, such as Pandas DataFrame, are also acceptable.

```
>>> import numpy as np
>>> X = np.random.random((10,5))
>>> y = np.array(['M', 'M', 'F', 'F', 'M', 'F', 'M', 'F', 'F', 'F'])
>>> X[X < 0.7] = 0
```

Training And Test Data

```
>>> from sklearn.model_selection import train_test_split
>>> X_train, X_test, y_train, y_test = train_test_split(X,
                                                    y,
                                                    random_state=0)
```

Preprocessing The Data

Standardization

```
>>> from sklearn.preprocessing import StandardScaler
>>> scaler = StandardScaler().fit(X_train)
>>> standardized_X = scaler.transform(X_train)
>>> standardized_X_test = scaler.transform(X_test)
```

Normalization

```
>>> from sklearn.preprocessing import Normalizer
>>> scaler = Normalizer().fit(X_train)
>>> normalized_X = scaler.transform(X_train)
>>> normalized_X_test = scaler.transform(X_test)
```

Binarization

```
>>> from sklearn.preprocessing import Binarizer
>>> binarizer = Binarizer(threshold=0.0).fit(X)
>>> binary_X = binarizer.transform(X)
```

Encoding Categorical Features

```
>>> from sklearn.preprocessing import LabelEncoder
>>> enc = LabelEncoder()
>>> y = enc.fit_transform(y)
```

Imputing Missing Values

```
>>> from sklearn.preprocessing import Imputer
>>> imp = Imputer(missing_values=0, strategy='mean', axis=0)
>>> imp.fit_transform(X_train)
```

Generating Polynomial Features

```
>>> from sklearn.preprocessing import PolynomialFeatures
>>> poly = PolynomialFeatures(5)
>>> poly.fit_transform(X)
```

Create Your Model

Supervised Learning Estimators

Linear Regression

```
>>> from sklearn.linear_model import LinearRegression
>>> lr = LinearRegression(normalize=True)
```

Support Vector Machines (SVM)

```
>>> from sklearn.svm import SVC
>>> svc = SVC(kernel='linear')
```

Naive Bayes

```
>>> from sklearn.naive_bayes import GaussianNB
>>> gnb = GaussianNB()
```

KNN

```
>>> from sklearn import neighbors
>>> knn = neighbors.KNeighborsClassifier(n_neighbors=5)
```

Unsupervised Learning Estimators

Principal Component Analysis (PCA)

```
>>> from sklearn.decomposition import PCA
>>> pca = PCA(n_components=0.95)
```

K Means

```
>>> from sklearn.cluster import KMeans
>>> k_means = KMeans(n_clusters=3, random_state=0)
```

Model Fitting

Supervised learning

```
>>> lr.fit(X, y)
>>> knn.fit(X_train, y_train)
>>> svc.fit(X_train, y_train)
```

Fit the model to the data

Unsupervised Learning

```
>>> k_means.fit(X_train)
>>> pca_model = pca.fit_transform(X_train)
```

Fit the model to the data
Fit to data, then transform it

Prediction

Supervised Estimators

```
>>> y_pred = svc.predict(np.random.random((2,5)))
>>> y_pred = lr.predict(X_test)
>>> y_pred = knn.predict_proba(X_test)
```

Predict labels
Predict labels
Estimate probability of a label

Unsupervised Estimators

```
>>> y_pred = k_means.predict(X_test)
```

Predict labels in clustering algos

Evaluate Your Model's Performance

Classification Metrics

Accuracy Score

```
>>> knn.score(X_test, y_test)
>>> from sklearn.metrics import accuracy_score
>>> accuracy_score(y_test, y_pred)
```

Estimator score method
Metric scoring functions

Classification Report

```
>>> from sklearn.metrics import classification_report
>>> print(classification_report(y_test, y_pred))
```

Precision, recall, f1-score and support

Confusion Matrix

```
>>> from sklearn.metrics import confusion_matrix
>>> print(confusion_matrix(y_test, y_pred))
```

Regression Metrics

Mean Absolute Error

```
>>> from sklearn.metrics import mean_absolute_error
>>> y_true = [3, -0.5, 2]
>>> mean_absolute_error(y_true, y_pred)
```

Mean Squared Error

```
>>> from sklearn.metrics import mean_squared_error
>>> mean_squared_error(y_test, y_pred)
```

R² Score

```
>>> from sklearn.metrics import r2_score
>>> r2_score(y_true, y_pred)
```

Clustering Metrics

Adjusted Rand Index

```
>>> from sklearn.metrics import adjusted_rand_score
>>> adjusted_rand_score(y_true, y_pred)
```

Homogeneity

```
>>> from sklearn.metrics import homogeneity_score
>>> homogeneity_score(y_true, y_pred)
```

V-measure

```
>>> from sklearn.metrics import v_measure_score
>>> metrics.v_measure_score(y_true, y_pred)
```

Cross-Validation

```
>>> from sklearn.cross_validation import cross_val_score
>>> print(cross_val_score(knn, X_train, y_train, cv=4))
>>> print(cross_val_score(lr, X, y, cv=2))
```

Tune Your Model

Grid Search

```
>>> from sklearn.grid_search import GridSearchCV
>>> params = {'n_neighbors': np.arange(1,3),
            'metric': ['euclidean', 'cityblock']}
>>> grid = GridSearchCV(estimator=knn,
                    param_grid=params)
>>> grid.fit(X_train, y_train)
>>> print(grid.best_score_)
>>> print(grid.best_estimator_.n_neighbors)
```

Randomized Parameter Optimization

```
>>> from sklearn.grid_search import RandomizedSearchCV
>>> params = {'n_neighbors': range(1,5),
            'weights': ['uniform', 'distance']}
>>> rsearch = RandomizedSearchCV(estimator=knn,
                    param_distributions=params,
                    cv=4,
                    n_iter=8,
                    random_state=5)
>>> rsearch.fit(X_train, y_train)
>>> print(rsearch.best_score_)
```

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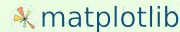
Matplotlib

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Matplotlib

Matplotlib is a Python 2D plotting library which produces publication-quality figures in a variety of hardcopy formats and interactive environments across platforms.



1 Prepare The Data

Also see Lists & NumPy

1D Data

```
>>> import numpy as np
>>> x = np.linspace(0, 10, 100)
>>> y = np.cos(x)
>>> z = np.sin(x)
```

2D Data or Images

```
>>> data = 2 * np.random.random((10, 10))
>>> data2 = 3 * np.random.random((10, 10))
>>> Y, X = np.mgrid[-3:3:100j, -3:3:100j]
>>> U = -1 - Y**2 + Y
>>> V = 1 + X - Y**2
>>> from matplotlib.cbook import get_sample_data
>>> img = np.load(get_sample_data('axes_grid/bivariate_normal.npy'))
```

2 Create Plot

```
>>> import matplotlib.pyplot as plt
```

Figure

```
>>> fig = plt.figure()
>>> fig2 = plt.figure(figsize=plt.figaspect(2.0))
```

Axes

All plotting is done with respect to an Axes. In most cases, a subplot will fit your needs. A subplot is an axes on a grid system.

```
>>> fig.add_axes()
>>> ax1 = fig.add_subplot(221) # row-col-num
>>> ax3 = fig.add_subplot(212)
>>> fig3, axes = plt.subplots(nrows=2,ncols=2)
>>> fig4, axes2 = plt.subplots(ncols=3)
```

3 Plotting Routines

1D Data

```
>>> lines = ax.plot(x,y)
>>> ax.scatter(x,y)
>>> axes[0,0].bar([1,2,3],[3,4,5])
>>> axes[1,0].barh([0.5,1.2,5],[0,1,2])
>>> axes[1,1].axhline(0.45)
>>> axes[0,1].axvline(0.65)
>>> ax.fill(x,y,color='blue')
>>> ax.fill_between(x,y,color='yellow')
```

Draw points with lines or markers connecting them
Draw unconnected points, scaled or colored
Plot vertical rectangles (constant width)
Plot horizontal rectangles (constant height)
Draw a horizontal line across axes
Draw a vertical line across axes
Draw filled polygons
Fill between y-values and 0

2D Data or Images

```
>>> fig, ax = plt.subplots()
>>> im = ax.imshow(img,
                  cmap='gist_earth',
                  interpolation='nearest',
                  vmin=-2,
                  vmax=2)
```

Colormapped or RGB arrays

Vector Fields

```
>>> axes[0,1].arrow(0,0,0.5,0.5)
>>> axes[1,1].quiver(y,z)
>>> axes[0,1].streamplot(X,Y,U,V)
```

Add an arrow to the axes
Plot a 2D field of arrows
Plot 2D vector fields

Data Distributions

```
>>> ax1.hist(y)
>>> ax3.boxplot(y)
>>> ax3.violinplot(z)
```

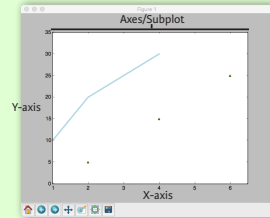
Plot a histogram
Make a box and whisker plot
Make a violin plot

```
>>> axes2[0].pcolor(data2)
>>> axes2[0].pcolormesh(data)
>>> CS = plt.contour(Y,X,U)
>>> axes2[2].contourf(data1)
>>> axes2[2] = ax.clabel(CS)
```

Pseudocolor plot of 2D array
Pseudocolor plot of 2D array
Plot contours
Plot filled contours
Label a contour plot

Plot Anatomy & Workflow

Plot Anatomy



Workflow

The basic steps to creating plots with matplotlib are:

1 Prepare data 2 Create plot 3 Plot 4 Customize plot 5 Save plot 6 Show plot

```
>>> import matplotlib.pyplot as plt
>>> x = [1,2,3,4]
>>> y = [10,20,25,30]
>>> fig = plt.figure()
>>> ax = fig.add_subplot(111)
>>> ax.plot(x, y, color='lightblue', linewidth=3)
>>> ax.scatter([2,4,6],
              [15,25],
              color='darkgreen',
              marker='^')
>>> ax.set_xlim(1, 6.5)
>>> plt.savefig('foo.png')
>>> plt.show()
```

4 Customize Plot

Colors, Color Bars & Color Maps

```
>>> plt.plot(x, x, x, x**2, x, x**3)
>>> ax.plot(x, y, alpha = 0.4)
>>> ax.plot(x, y, c='k')
>>> fig.colorbar(im, orientation='horizontal')
>>> im = ax.imshow(img, cmap='seismic')
```

Markers

```
>>> fig, ax = plt.subplots()
>>> ax.scatter(x,y,marker=".")
>>> ax.plot(x,y,marker="o")
```

Linestyles

```
>>> plt.plot(x,y,linewidth=4.0)
>>> plt.plot(x,y,ls='solid')
>>> plt.plot(x,y,ls='--')
>>> plt.plot(x,y,'--',x**2,y**2,'-.')
>>> plt.setp(lines,color='r',linewidth=4.0)
```

Text & Annotations

```
>>> ax.text(1, -2.1,
          'Example Graph',
          style='italic')
>>> ax.annotate("Sine",
              xy=(8, 0),
              xycoords='data',
              xytext=(10.5, 0),
              textcoords='data',
              arrowprops=dict(arrowstyle="->",
                              connectionstyle="arc3"),)
```

Mathtext

```
>>> plt.title(r'$\sigma_i=15$', fontsize=20)
```

Limits, Legends & Layouts

Limits & Autoscaling

```
>>> ax.margins(x=0,y=0.1)
>>> ax.axis('equal')
>>> ax.set_xlim([0,10.5],ylim=[-1.5,1.5])
>>> ax.set_xlim(0,10.5)
```

Legends

```
>>> ax.set(title='An Example Axes',
          ylabel='Y-Axis',
          xlabel='X-Axis')
>>> ax.legend(loc='best')
```

Ticks

```
>>> ax.xaxis.set(ticks=range(1,5),
               ticklabels=[3,100,-12,"foo"])
>>> ax.tick_params(axis='y',
                  direction='inout',
                  length=10)
```

Subplot Spacing

```
>>> fig3.subplots_adjust(wspace=0.5,
                        hspace=0.3,
                        left=0.125,
                        right=0.9,
                        top=0.9,
                        bottom=0.1)
```

Axis Spines

```
>>> fig.tight_layout()
>>> ax1.spines['top'].set_visible(False)
>>> ax1.spines['bottom'].set_position(('outward',10))
```

Add padding to a plot
Set the aspect ratio of the plot to 1
Set limits for x-and y-axis
Set limits for x-axis

Set a title and x-and y-axis labels

No overlapping plot elements

Manually set x-ticks

Make y-ticks longer and go in and out

Adjust the spacing between subplots

Fit subplot(s) in to the figure area

Make the top axis line for a plot invisible
Move the bottom axis line outward

5 Save Plot

Save figures

```
>>> plt.savefig('foo.png')
```

Save transparent figures

```
>>> plt.savefig('foo.png', transparent=True)
```

6 Show Plot

```
>>> plt.show()
```

Close & Clear

```
>>> plt.cla()
>>> plt.clf()
>>> plt.close()
```

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scikit-learn algorithm cheat-sheet

