Practical Tools for Artificial Intelligence

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Learning Objectives

After completing this lecture, you will be able to:-

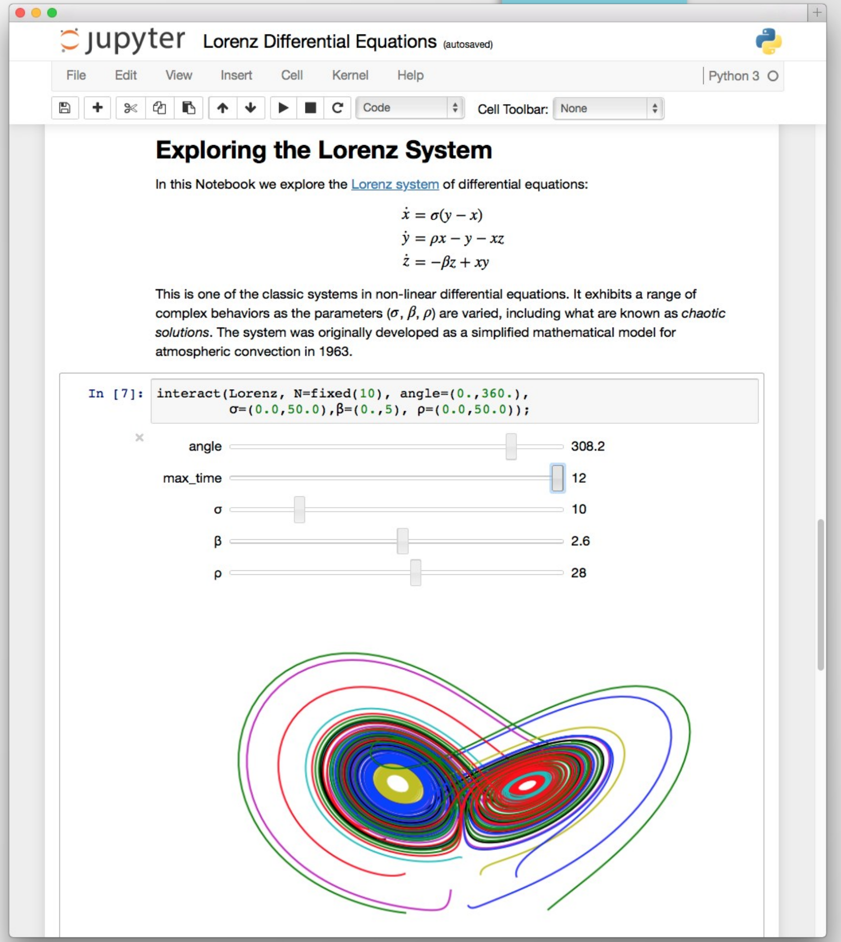
- Describe the primary software tools used in this course

Our Toolset

- Python (programming language, use py3!)
- Anaconda (with Intel's Math Kernel Library, MKL)
  - Intel distribution
- Jupyter notebooks (interactive coding)
- Numpy, SciPy, Pandas (numerical computation)
- Matplotlib, Seaborn (data visualization)
- Scikit-learn (machine learning)

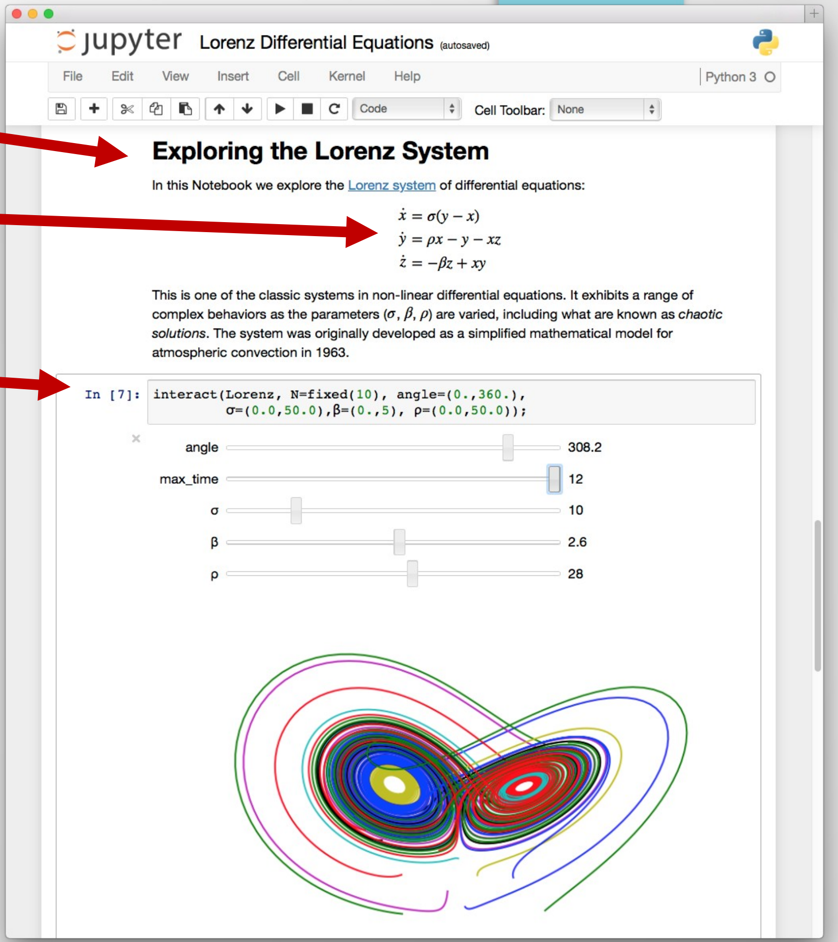
Jupyter Notebook

- Polyglot analysis environment—blends multiple languages
- Jupyter is an anagram of: Julia, Python, and R
- Supports multiple content types: code, narrative text, images, movies, etc.



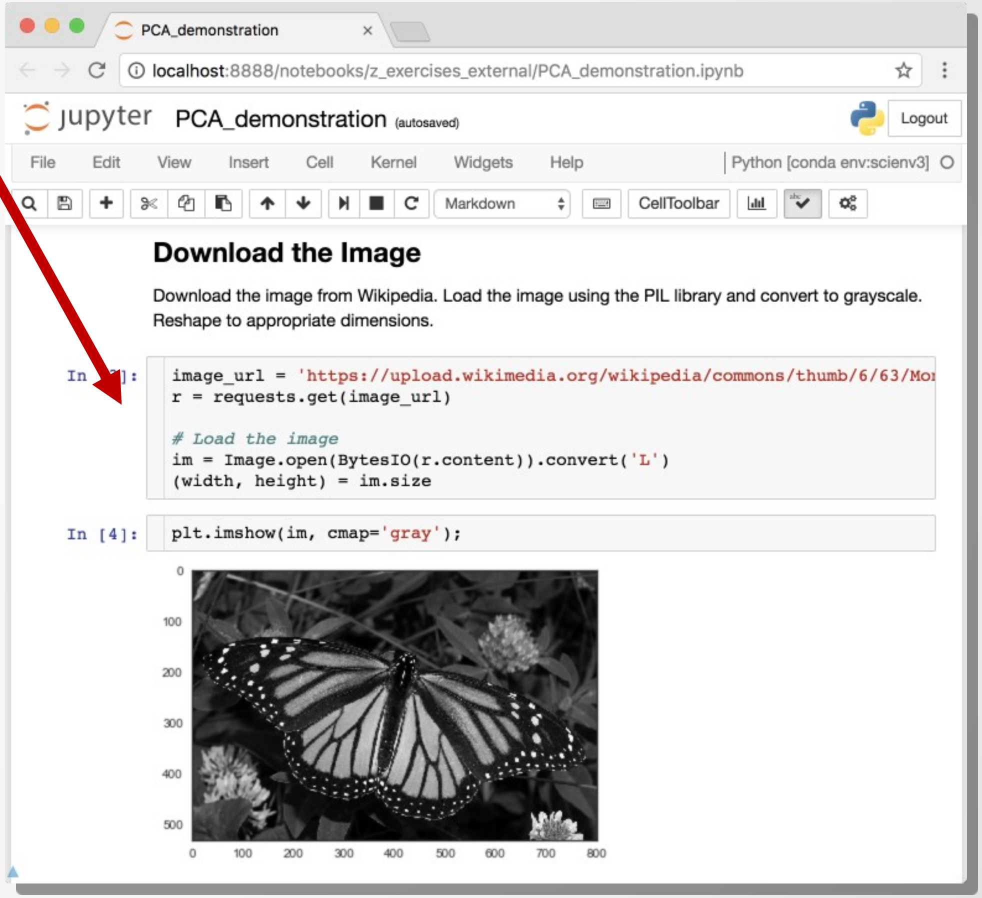
Jupyter Notebook

- HTML & Markdown
- LaTeX (equations)
- Code



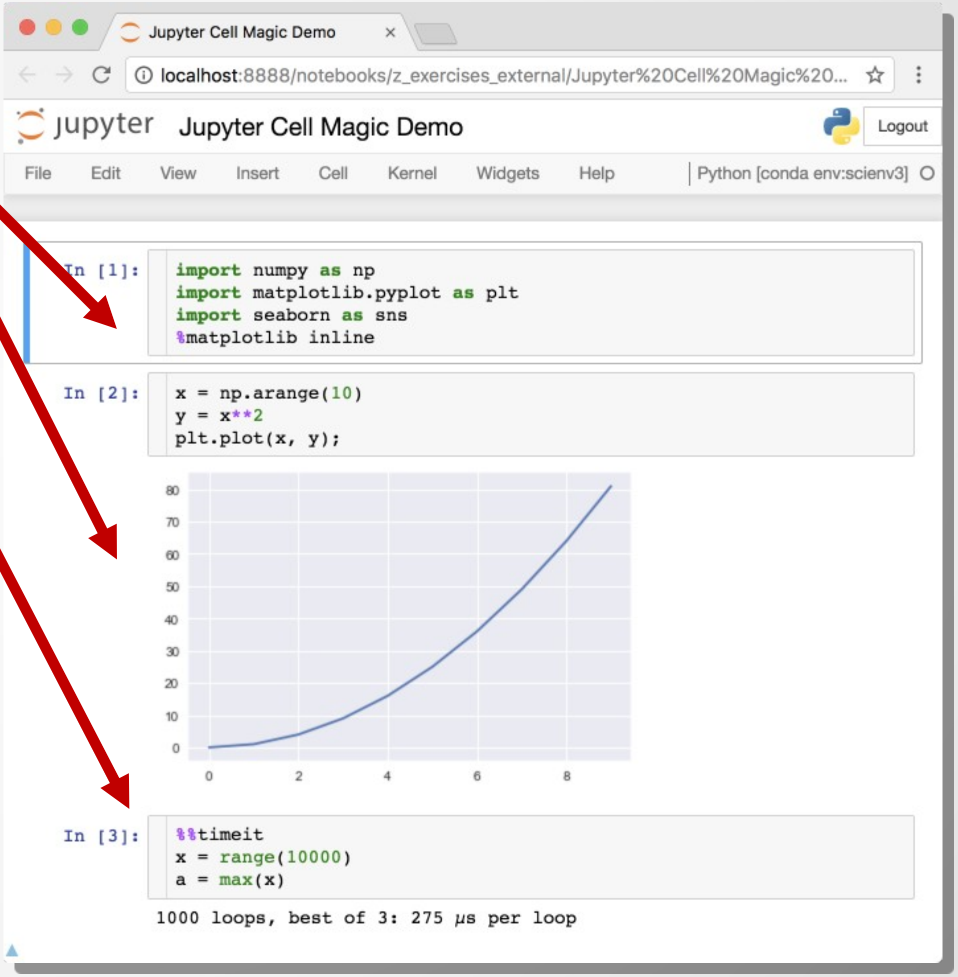
Jupyter Notebook

- Code is divided into cells to control execution
- Enables interactive development
- Ideal for exploratory analysis and model building



Jupyter Notebook – Cell Magic

- %matplotlib inline: display plots inline in Jupyter notebook
- %%timeit: time how long a cell takes to execute
- %run filename.ipynb: execute code from another notebook or python file
- %load filename.py: copy contents of the file and paste into the cell



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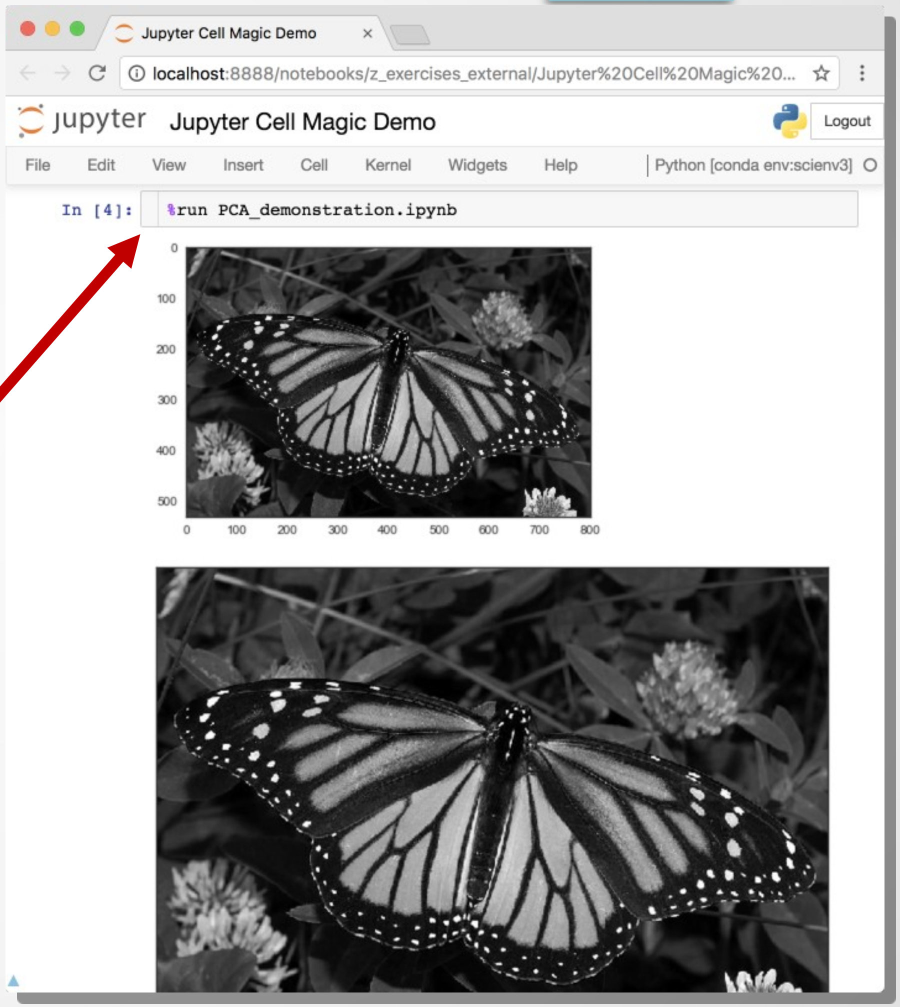


Jupyter Notebook Keyboard Shortcuts

Keyboard shortcuts

The Jupyter Notebook has two different keyboard input modes. **Edit mode** allows you to type code/text into a cell and is indicated by a green cell border. **Command mode** binds the keyboard to notebook level actions and is indicated by a grey cell border with a blue left margin.

Command Mode (press `Esc` to enable)

- `F` : find and replace
- `Ctrl-Shift-P` : open the command palette
- `Enter` : enter edit mode
- `Shift-Enter` : run cell, select below
- `Ctrl-Enter` : run selected cells
- `Alt-Enter` : run cell, insert below
- `Shift-J` : extend selected cells below
- `A` : insert cell above
- `B` : insert cell below
- `X` : cut selected cells
- `C` : copy selected cells
- `Shift-V` : paste cells above

Keyboard shortcuts can be viewed from Help → Keyboard Shortcuts

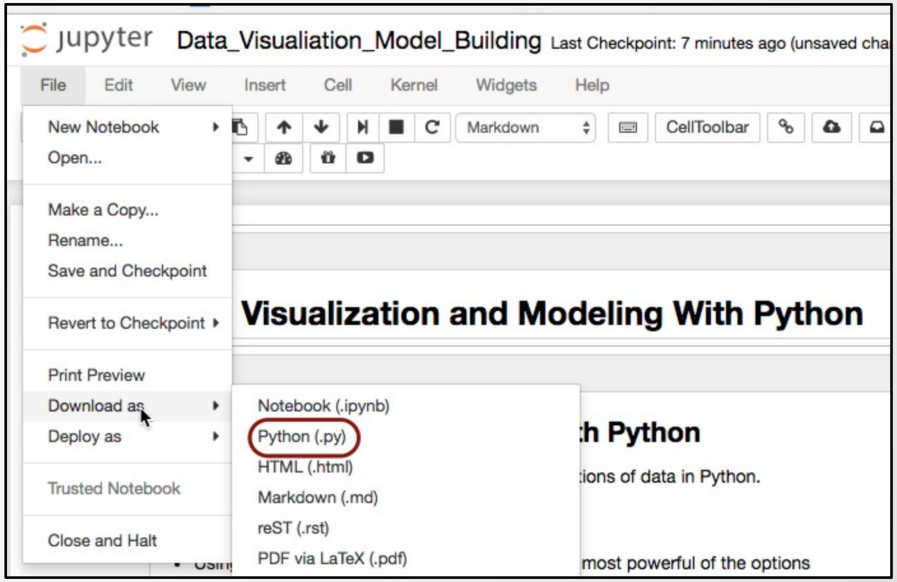
Jupyter Notebook Re-use

Extracting code from a Jupyter notebook

Convert from command-line

```
>>> jupyter nbconvert --to python notebook.ipynb
```

Export from Notebook

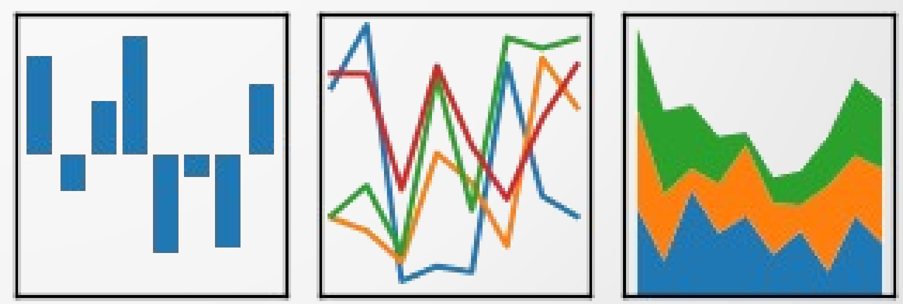


Pandas

- Library for computation with tabular data
- Mixed types of data allowed in a single table
- Columns and rows of data can be named
- Advanced data aggregation and statistical functions

pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$



Pandas Basic Data Structures

Type	Pandas Name
Vector (1 Dimension)	Series
Array (2 Dimensions)	DataFrame

Pandas Series

Creating a Pandas Series

Code

```
import pandas as pd

step_data = [3620, 7891, 9761,
             3907, 4338, 5373]

step_counts = pd.Series(step_data,
                        name='steps')

print(step_counts)
```

Output

```
>>> 0 3620
    1 7891
    2 9761
    3 3907
    4 4338
    5 5373
    Name: steps, dtype: int64
```

Pandas Series

Add a date range to a Series

Code

```
step_counts.index = pd.date_range(
        '20150329', periods=6)

print(step_counts)
```

Output

```
>>> 2015-03-29 3620
    2015-03-30 7891
    2015-03-31 9761
    2015-04-01 3907
    2015-04-02 4338
    2015-04-03 5373
    Freq: D, Name: steps,
    dtype: int64
```

Pandas Series

Select data by the index values

Code

```
# Just like a dictionary
print(step_counts['2015-04-01'])

# Or by index position--like an array
print(step_counts[3])

# Select all of April
print(step_counts['2015-04'])
```

Output

```
>>> 3907

>>> 3907

>>> 2015-04-01 3907
    2015-04-02 4338
    2015-04-03 5373
    Freq: D, Name: steps,
    dtype: int64
```

Pandas Datatypes

Data types can be viewed and converted

Code

```
# View the data type
print(step_counts.dtypes)

# Convert to a float
step_counts = step_counts.astype(np.float)

# View the data type
print(step_counts.dtypes)
```

Output

```
>>> int64

>>> float64
```

Pandas Datatypes

Data types can be viewed and converted

Code

```
# Create invalid data
step_counts[1:3] = np.NaN

# Now fill it in with zeros
step_counts = step_counts.fillna(0.)
# equivalently,
# step_counts.fillna(0., inplace=True)

print(step_counts[1:3])
```

Output

```
>>> 2015-03-30 0.0
    2015-03-31 0.0
    Freq: D, Name: steps,
dtype: float64
```

Pandas DataFrame

DataFrames can be created from lists, dictionaries, and Pandas Series

Code

```
# Cycling distance
cycling_data = [10.7, 0, None, 2.4, 15.3,
                10.9, 0, None]

# Create a tuple of data
joined_data = list(zip(step_data,
                       cycling_data))

# The dataframe
activity_df = pd.DataFrame(joined_data)

print(activity_df)
```

Output

```
>>>
```

	0	1
0	3620	10.7
1	7891	0.0
2	9761	NaN
3	3907	2.4
4	4338	15.3
5	5373	10.9

Pandas DataFrame

Labeled columns and an index can be added

Code

```
# Add column names to dataframe
activity_df = pd.DataFrame(joined_data,
         index=pd.date_range('20150329',
         periods=6),
         columns=['Walking','Cycling'])

print(activity_df)
```

Output

\>>>

	Walking	Cycling
2015-03-29	3620	10.7
2015-03-30	7891	0.0
2015-03-31	9761	NaN
2015-04-01	3907	2.4
2015-04-02	4338	15.3
2015-04-03	5373	10.9

Pandas DataFrame

DataFrame rows can be indexed by row using the ‘loc’ and ‘iloc’ methods

Code	Output

`# Select row of data by index name`
`print(activity_df.loc['2015-04-01'])`
	`>>> Walking 3907.0`
	`Cycling 2.4`
	`Name: 2015-04-01,`
	`dtype: float64`

`# Select row of data by integer position`
`print(activity_df.iloc[-3])`
	`>>> Walking 3907.0`
	`Cycling 2.4`
	`Name: 2015-04-01,`
	`dtype: float64`

Pandas DataFrame

DataFrame columns can be indexed by name

Code

```
# Name of column
print(activity_df['Walking'])
```

Output

```
>>> 2015-03-29 3620
    2015-03-30 7891
    2015-03-31 9761
    2015-04-01 3907
    2015-04-02 4338
    2015-04-03 5373
    Freq: D, Name: Walking,
    dtype: int64
```

Pandas DataFrame

DataFrame columns can be indexed as properties

Code

```
# Object-oriented approach
print(activity_df.Walking)
```

Output

```
>>> 2015-03-29 3620
    2015-03-30 7891
    2015-03-31 9761
    2015-04-01 3907
    2015-04-02 4338
    2015-04-03 5373
    Freq: D, Name: Walking,
    dtype: int64
```

Pandas DataFrame

DataFrame columns can be indexed by integer

Code

```
# First column
print(activity_df.iloc[:,0])
```

Output

```
>>> 2015-03-29 3620
    2015-03-30 7891
    2015-03-31 9761
    2015-04-01 3907
    2015-04-02 4338
    2015-04-03 5373
    Freq: D, Name: Walking,
    dtype: int64
```

Pandas DataFrame

CSV and other common filetypes can be read with a single command

Code

```
# The location of the data file
filepath = 'data/Iris_Data/Iris_Data.csv'

# Import the data
data = pd.read_csv(filepath)

# Print a few rows
print(data.iloc[:5])
```

Output

>>>

	sepal_length	sepal_width	petal_length	petal_width	species
0	5.1	3.5	1.4	0.2	Iris-setosa
1	4.9	3.0	1.4	0.2	Iris-setosa
2	4.7	3.2	1.3	0.2	Iris-setosa
3	4.6	3.1	1.5	0.2	Iris-setosa
4	5.0	3.6	1.4	0.2	Iris-setosa

Pandas DataFrame

Data can be (re-)assigned to a DataFrame column

Code

```
# Create a new column that is a product
# of both measurements
data['sepal_area'] = data.sepal_length *
            data.sepal_width

# Print a few rows and columns
print(data.iloc[:5, -3:])
```

Output

>>>

	petal_width	species	sepal_area
0	0.2	Iris-setosa	17.85
1	0.2	Iris-setosa	14.70
2	0.2	Iris-setosa	15.04
3	0.2	Iris-setosa	14.26
4	0.2	Iris-setosa	18.00

Pandas DataFrame

Functions can be applied to columns or rows of a DataFrame or Series

Code

```
# The lambda function applies what
# follows it to each row of data
data['abbrev'] = (data
                  .species
                  .apply(lambda x:
        x.replace('Iris-','')))

# Note that there are other ways to
# accomplish the above

print(data.iloc[:5, -3:])
```

Output

```
>>>
```

	petal_width	species	abbrev
0	0.2	Iris-setosa	setosa
1	0.2	Iris-setosa	setosa
2	0.2	Iris-setosa	setosa
3	0.2	Iris-setosa	setosa
4	0.2	Iris-setosa	setosa

Pandas DataFrame

Two DataFrames can be concatenated along either dimension

Code

```
# Concatenate the first two and
# last two rows
small_data = pd.concat([data.iloc[:2],
                        data.iloc[-2:]])


print(small_data.iloc[:,-3:])

# See the 'join' method for
# SQL style joining of dataframes
```

Output

```
>>>
```

	petal_length	petal_width	species
0	1.4	0.2	Iris-setosa
1	1.4	0.2	Iris-setosa
148	5.4	2.3	Iris-virginica
149	5.1	1.8	Iris-virginica

Pandas DataFrame

Using the groupby method to calculate aggregated DataFrame statistics

Code

```
# Use the size method with a
# DataFrame to get count
# For a Series, use the .value_counts
# method
group_sizes = (data
              .groupby('species')
              .size())

print(group_sizes)
```

Output

```
>>> species
    Iris-setosa        50
    Iris-versicolor    50
    Iris-virginica     50
    dtype: int64
```

Pandas Statistical Calculations

Pandas contains a variety of statistical methods – mean, median, and mode

Code

```
# Mean calculated on a DataFrame
print(data.mean())
```

```
# Median calculated on a Series
print(data.petal_length.median())
```

```
# Mode calculated on a Series
print(data.petal_length.mode())
```

Output

```
>>> sepal_length 5.843333
    sepal_width 3.054000
    petal_length 3.758667
    petal_width 1.198667
    dtype: float64
```

```
>>> 4.35
```

```
>>> 0 1.5
    dtype: float64
```

Pandas Statistical Calculations

Standard deviation, variance, SEM and quantiles can also be calculated

Code

```
# Standard dev, variance, and SEM
print(data.petal_length.std(),
      data.petal_length.var(),
      data.petal_length.sem())

# As well as quantiles
print(data.quantile(0))
```

Output

```
>>> 1.76442041995
    3.11317941834
    0.144064324021

>>> sepal_length 4.3
    sepal_width 2.0
    petal_length 1.0
    petal_width 0.1
    Name: 0, dtype: float64
```

Pandas Statistical Calculations

Multiple calculations can be presented in a DataFrame

Code

```
print(data.describe())
```

Output

	sepal_length	sepal_width	petal_length	petal_width
count	150.000000	150.000000	150.000000	150.000000
mean	5.843333	3.054000	3.758667	1.198667
std	0.828066	0.433594	1.764420	0.763161
min	4.300000	2.000000	1.000000	0.100000
25%	5.100000	2.800000	1.600000	0.300000
50%	5.800000	3.000000	4.350000	1.300000
75%	6.400000	3.300000	5.100000	1.800000
max	7.900000	4.400000	6.900000	2.500000

Pandas DataFrames Samples

DataFrames can be randomly sampled from

Code

```
# Sample 5 rows without replacement
sample = (data
          .sample(n=5,
                  replace=False,
                  random_state=42))


print(sample.iloc[:,-3:])
```

Output

```
>>>
```

	petal_length	petal_width	species
73	4.7	1.2	Iris-versicolor
18	1.7	0.3	Iris-setosa
118	6.9	2.3	Iris-virginica
78	4.5	1.5	Iris-versicolor
76	4.8	1.4	Iris-versicolor

SciPy and NumPy also contain a variety of statistical functions.

Visualization Libraries

Visualizations can be created in multiple ways:-

- Matplotlib
- Pandas (via Matplotlib)
- Seaborn
  - Statistically-focused plotting methods
  - Global preferences incorporated by Matplotlib

Basic Scatter Plots with Matplotlib

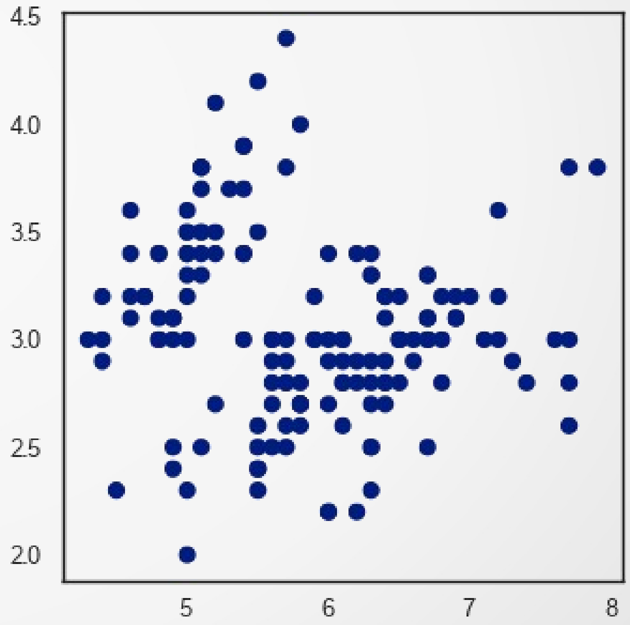
Scatter plots can be created from Pandas Series

Code

```
import matplotlib.pyplot as plt


plt.plot(data.sepal_length,
         data.sepal_width,
         ls ='', marker='o')
```

Output



Basic Scatter Plots with Matplotlib

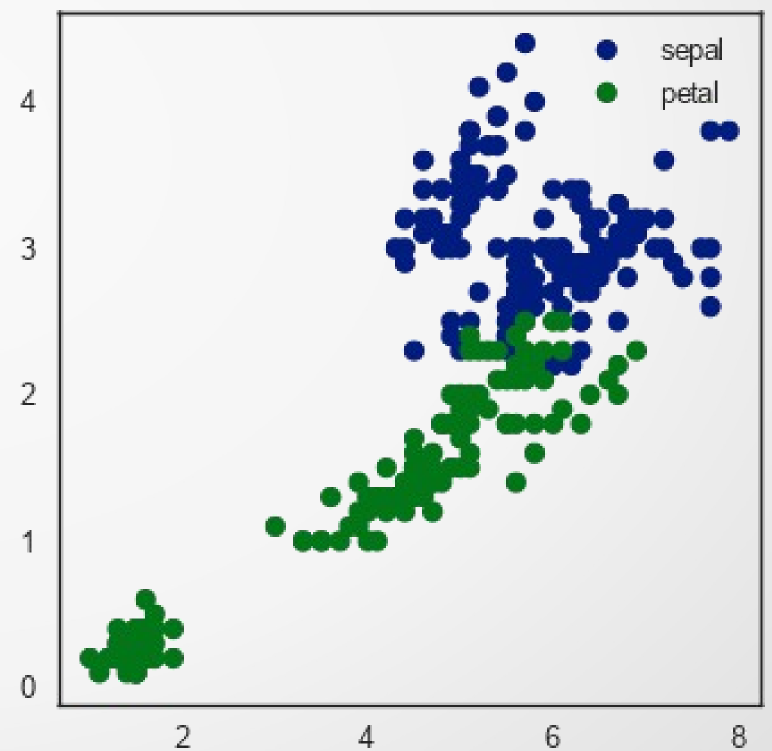
Multiple layers of data can also be added

Code

```
plt.plot(data.sepal_length,
         data.sepal_width,
         ls ='', marker='o',
         label='sepal')

plt.plot(data.petal_length,
         data.petal_width,
         ls ='', marker='o',
         label='petal')
```

Output



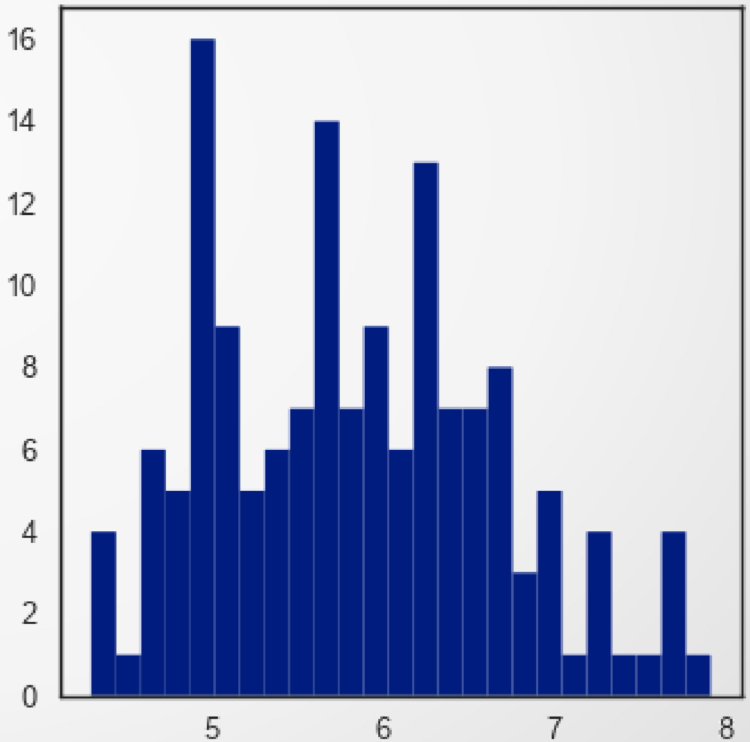
Histograms with Matplotlib

Histograms can be created from Pandas Series

Code

```
plt.hist(data.sepal_length, bins=25)
```

Output



Customizing Matplotlib Plots

Every feature of Matplotlib plots can be customized

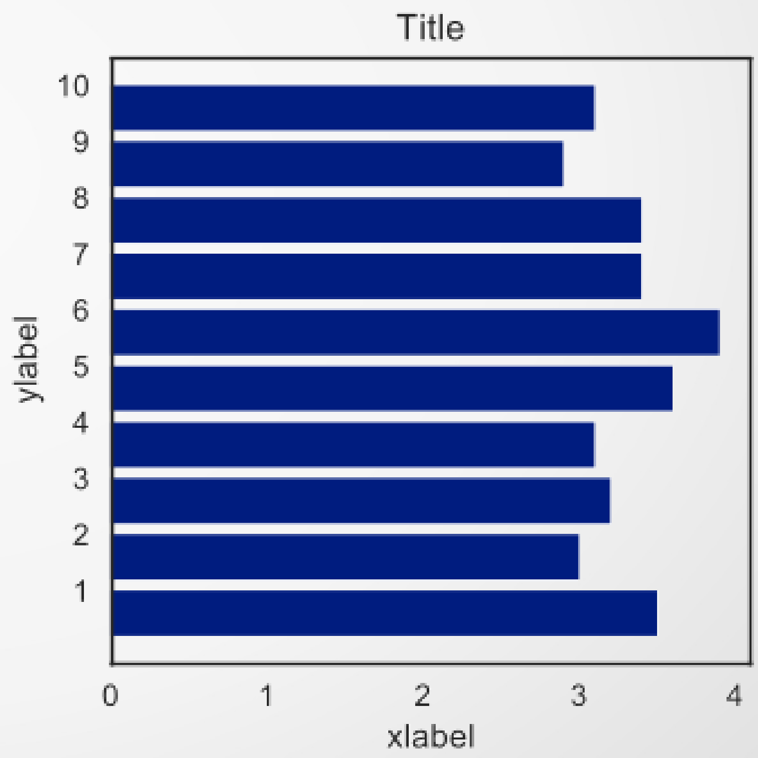
Code

```
fig, ax = plt.subplots()

ax.barh(np.arange(10),
        data.sepal_width.iloc[:10])

# Set position of ticks and tick labels
ax.set_yticks(np.arange(0.4,10.4,1.0))
ax.set_yticklabels(np.arange(1,11))
ax.set(xlabel='xlabel', ylabel='ylabel',
       title='Title')
```

Output



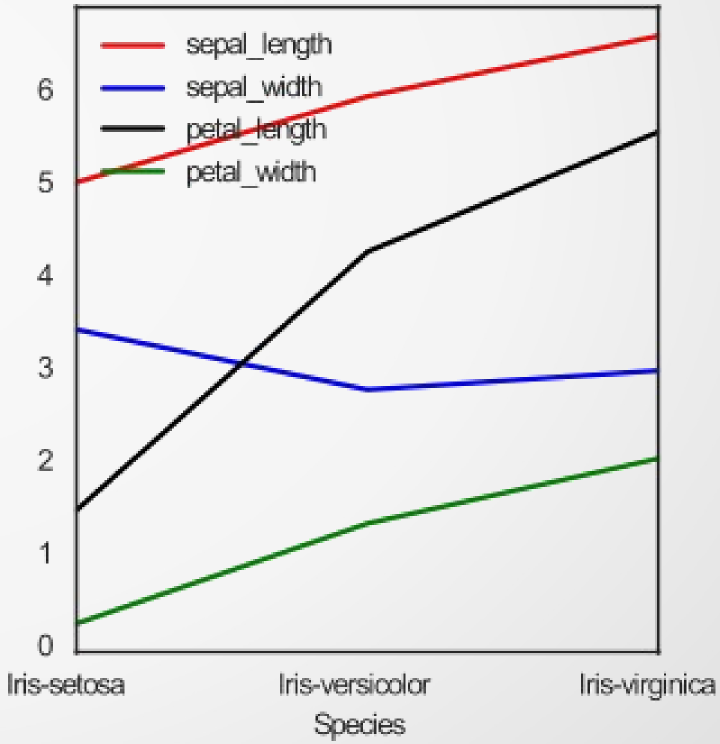
Incorporating Statistical Calculations

Statistical calculations can be included with Pandas methods

Code

```
(data
 .groupby('species')
 .mean()
 .plot(color=['red','blue',
          'black','green'],
       fontsize=10.0, figsize=(4,4)))
```

Output



Statistical Plotting with Seaborn

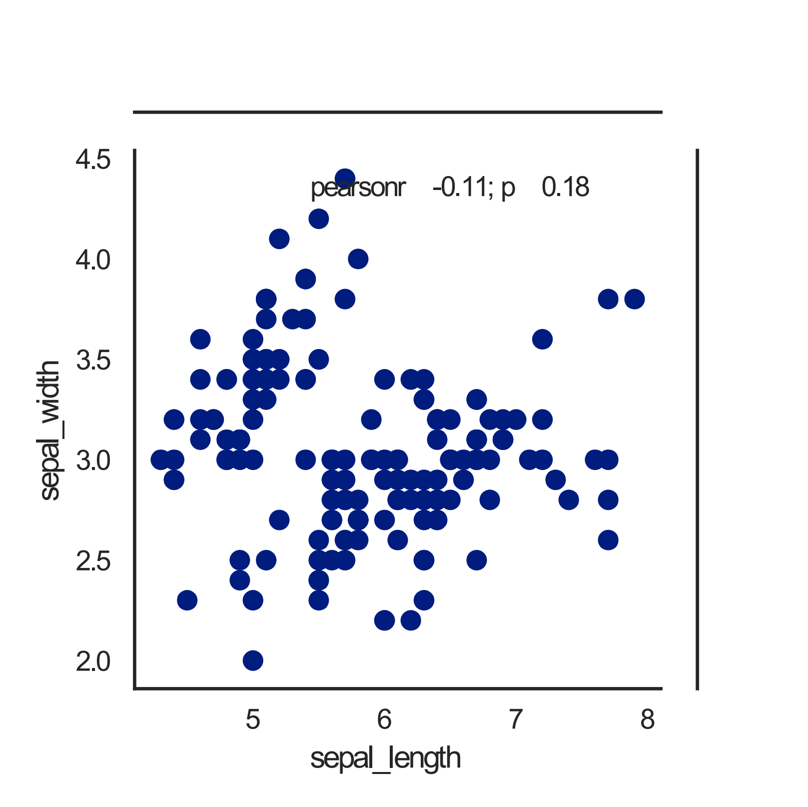
Joint distribution and scatter plots can be created

Code

```
import seaborn as sns

sns.jointplot(x='sepal_length',
         y='sepal_width',
         data=data, size=4)
```

Output



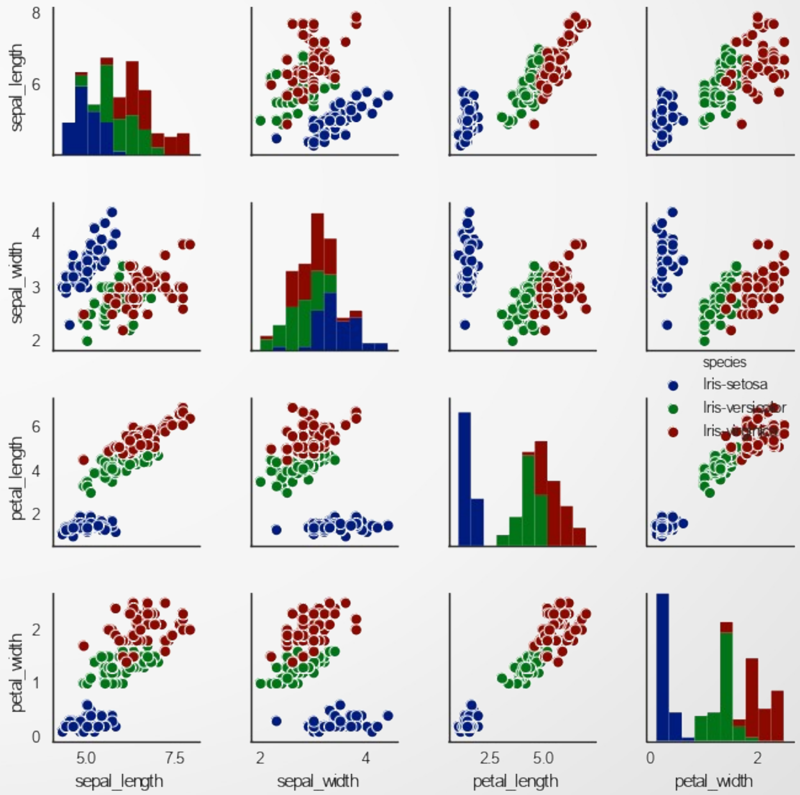
Statistical Plotting with Seaborn

Correlation plots of all variable pairs can also be made with Seaborn

Code

```
sns.pairplot(data, hue='species',
             size=3)
```

Output



End of Lecture

Many thanks to Intel Software for providing a variety of resources for this lecture series