libraries_data_management

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1 Python Libraries

Python, like other programming languages, has an abundance of additional modules or libraries that augument the base framework and functionality of the language.

Think of a library as a collection of functions that can be accessed to complete certain programming tasks without having to write your own algorithm.

For this course, we will focus primarily on the following libraries:

- **Numpy** is a library for working with arrays of data.
- **Pandas** provides high-performance, easy-to-use data structures and data analysis tools.
- **Scipy** is a library of techniques for numerical and scientific computing.
- **Matplotlib** is a library for making graphs.
- **Seaborn** is a higher-level interface to Matplotlib that can be used to simplify many graphing tasks.
- **Statsmodels** is a library that implements many statistical techniques.

2 Documentation

Reliable and accesible documentation is an absolute necessity when it comes to knowledge transfer of programming languages. Luckily, python provides a significant amount of detailed documentation that explains the ins and outs of the language syntax, libraries, and more.

Understanding how to read documentation is crucial for any programmer as it will serve as a fantastic resource when learning the intricacies of python.

Here is the link to the documentation of the python standard library: Python Standard Library

2.0.1 Importing Libraries

When using Python, you must always begin your scripts by importing the libraries that you will be using.

The following statement imports the numpy and pandas library, and gives them abbreviated names:

```
In [2]: import numpy as np
        import pandas as pd
```

2.0.2 Utilizing Library Functions

After importing a library, its functions can then be called from your code by prepending the library name to the function name. For example, to use the '`dot`' function from the '`numpy`' library, you would enter '`numpy.dot`'. To avoid repeatedly having to type the libary name in your scripts, it is conventional to define a two or three letter abbreviation for each library, e.g. '`numpy`' is usually abbreviated as '`np`'. This allows us to use '`np.dot`' instead of '`numpy.dot`'. Similarly, the Pandas library is typically abbreviated as '`pd`'.

The next cell shows how to call functions within an imported library:

```
In [4]: a = np.array([0,1,2,3,4,5,6,7,8,9,10])
        np.mean(a)

Out[4]: 5.0
```

As you can see, we used the mean() function within the numpy library to calculate the mean of the numpy 1-dimensional array.

3 Data Management

Data management is a crucial component to statistical analysis and data science work. The following code will show how to import data via the pandas library, view your data, and transform your data.

The main data structure that Pandas works with is called a **Data Frame**. This is a two-dimensional table of data in which the rows typically represent cases (e.g. Cartwheel Contest Participants), and the columns represent variables. Pandas also has a one-dimensional data structure called a **Series** that we will encounter when accesing a single column of a Data Frame.

Pandas has a variety of functions named '`read_xxx`' for reading data in different formats. Right now we will focus on reading '`csv`' files, which stands for comma-separated values. However the other file formats include excel, json, and sql just to name a few.

This is a link to the .csv that we will be exploring in this tutorial: Cartwheel Data (Link goes to the dataset section of the Resources for this course)

There are many other options to '`read_csv`' that are very useful. For example, you would use the option `sep='\t'` instead of the default `sep=','` if the fields of your data file are delimited by tabs instead of commas. See here for the full documentation for '`read_csv`'.

3.0.1 Importing Data

```
In [3]: # Store the url string that hosts our .csv file (note that this is a different url tha
        url = "Cartwheeldata.csv"

        # Read the .csv file and store it as a pandas Data Frame
        df = pd.read_csv(url)

        # Output object type
        type(df)

Out[3]: pandas.core.frame.DataFrame
```

3.0.2 Viewing Data

```
In [5]: # We can view our Data Frame by calling the head() function
        df.head()

Out[5]:    ID  Age Gender  GenderGroup Glasses  GlassesGroup  Height  Wingspan  \
        0   1   56      F            1       Y             1    62.0      61.0
        1   2   26      F            1       Y             1    62.0      60.0
        2   3   33      F            1       Y             1    66.0      64.0
        3   4   39      F            1       N             0    64.0      63.0
        4   5   27      M            2       N             0    73.0      75.0

           CWDistance Complete  CompleteGroup  Score
        0          79        Y              1      7
        1          70        Y              1      8
        2          85        Y              1      7
        3          87        Y              1     10
        4          72        N              0      4
```

The head() function simply shows the first 5 rows of our Data Frame. If we wanted to show the entire Data Frame we would simply write the following:

```
In [6]: # Output entire Data Frame
        df

Out[6]:     ID  Age Gender  GenderGroup Glasses  GlassesGroup  Height  Wingspan  \
        0    1   56      F            1       Y             1   62.00      61.0
        1    2   26      F            1       Y             1   62.00      60.0
        2    3   33      F            1       Y             1   66.00      64.0
        3    4   39      F            1       N             0   64.00      63.0
        4    5   27      M            2       N             0   73.00      75.0
        5    6   24      M            2       N             0   75.00      71.0
        6    7   28      M            2       N             0   75.00      76.0
        7    8   22      F            1       N             0   65.00      62.0
        8    9   29      M            2       Y             1   74.00      73.0
        9   10   33      F            1       Y             1   63.00      60.0
        10  11   30      M            2       Y             1   69.50      66.0
        11  12   28      F            1       Y             1   62.75      58.0
        12  13   25      F            1       Y             1   65.00      64.5
        13  14   23      F            1       N             0   61.50      57.5
        14  15   31      M            2       Y             1   73.00      74.0
        15  16   26      M            2       Y             1   71.00      72.0
        16  17   26      F            1       N             0   61.50      59.5
        17  18   27      M            2       N             0   66.00      66.0
        18  19   23      M            2       Y             1   70.00      69.0
        19  20   24      F            1       Y             1   68.00      66.0
        20  21   23      M            2       Y             1   69.00      67.0
        21  22   29      M            2       N             0   71.00      70.0
        22  23   25      M            2       N             0   70.00      68.0
```

```
23  24   26      M            2       N            0   69.00       71.0
24  25   23      F            1       Y            1   65.00       63.0

    CWDistance Complete  CompleteGroup  Score
0           79        Y              1      7
1           70        Y              1      8
2           85        Y              1      7
3           87        Y              1     10
4           72        N              0      4
5           81        N              0      3
6          107        Y              1     10
7           98        Y              1      9
8          106        N              0      5
9           65        Y              1      8
10          96        Y              1      6
11          79        Y              1     10
12          92        Y              1      6
13          66        Y              1      4
14          72        Y              1      9
15         115        Y              1      6
16          90        N              0     10
17          74        Y              1      5
18          64        Y              1      3
19          85        Y              1      8
20          66        N              0      2
21         101        Y              1      8
22          82        Y              1      4
23          63        Y              1      5
24          67        N              0      3
```

As you can see, we have a 2-Dimensional object where each row is an independent observation of our cartwheel data.

To gather more information regarding the data, we can view the column names and data types of each column with the following functions:

```
In [8]: df.columns
```

```
Out[8]: Index([u'ID', u'Age', u'Gender', u'GenderGroup', u'Glasses', u'GlassesGroup',
               u'Height', u'Wingspan', u'CWDistance', u'Complete', u'CompleteGroup',
               u'Score'],
              dtype='object')
```

Lets say we would like to splice our data frame and select only specific portions of our data. There are three different ways of doing so.

1. .loc()
2. .iloc()
3. .ix()

We will cover the .loc() and .iloc() splicing functions.

3.0.3 .loc()

.loc() takes two single/list/range operator separated by ','. The first one indicates the row and the second one indicates columns.

```
In [9]: # Return all observations of CWDistance
        df.loc[:,"CWDistance"]

Out[9]: 0      79
        1      70
        2      85
        3      87
        4      72
        5      81
        6     107
        7      98
        8     106
        9      65
        10     96
        11     79
        12     92
        13     66
        14     72
        15    115
        16     90
        17     74
        18     64
        19     85
        20     66
        21    101
        22     82
        23     63
        24     67
        Name: CWDistance, dtype: int64
```

```
In [10]: # Select all rows for multiple columns, ["CWDistance", "Height", "Wingspan"]
         df.loc[:,["CWDistance", "Height", "Wingspan"]]

Out[10]:     CWDistance  Height  Wingspan
         0           79   62.00      61.0
         1           70   62.00      60.0
         2           85   66.00      64.0
         3           87   64.00      63.0
         4           72   73.00      75.0
         5           81   75.00      71.0
         6          107   75.00      76.0
         7           98   65.00      62.0
         8          106   74.00      73.0
         9           65   63.00      60.0
```

```
10           96   69.50      66.0
11           79   62.75      58.0
12           92   65.00      64.5
13           66   61.50      57.5
14           72   73.00      74.0
15          115   71.00      72.0
16           90   61.50      59.5
17           74   66.00      66.0
18           64   70.00      69.0
19           85   68.00      66.0
20           66   69.00      67.0
21          101   71.00      70.0
22           82   70.00      68.0
23           63   69.00      71.0
24           67   65.00      63.0
```

```
In [11]: # Select few rows for multiple columns, ["CWDistance", "Height", "Wingspan"]
         df.loc[:9, ["CWDistance", "Height", "Wingspan"]]
```

```
Out[11]:    CWDistance  Height  Wingspan
         0          79    62.0      61.0
         1          70    62.0      60.0
         2          85    66.0      64.0
         3          87    64.0      63.0
         4          72    73.0      75.0
         5          81    75.0      71.0
         6         107    75.0      76.0
         7          98    65.0      62.0
         8         106    74.0      73.0
         9          65    63.0      60.0
```

```
In [12]: # Select range of rows for all columns
         df.loc[10:15]
```

```
Out[12]:     ID  Age Gender  GenderGroup Glasses  GlassesGroup  Height  Wingspan  \
         10  11   30      M            2       Y             1   69.50      66.0
         11  12   28      F            1       Y             1   62.75      58.0
         12  13   25      F            1       Y             1   65.00      64.5
         13  14   23      F            1       N             0   61.50      57.5
         14  15   31      M            2       Y             1   73.00      74.0
         15  16   26      M            2       Y             1   71.00      72.0

             CWDistance Complete  CompleteGroup  Score
         10          96        Y              1      6
         11          79        Y              1     10
         12          92        Y              1      6
         13          66        Y              1      4
         14          72        Y              1      9
         15         115        Y              1      6
```

The .loc() function requires to arguments, the indices of the rows and the column names you wish to observe.

In the above case **:** specifies all rows, and our column is **CWDistance**. df.loc[**:**,**"CWDistance"**]

Now, let's say we only want to return the first 10 observations:

```
In [13]: df.loc[:9, "CWDistance"]

Out[13]: 0     79
         1     70
         2     85
         3     87
         4     72
         5     81
         6    107
         7     98
         8    106
         9     65
         Name: CWDistance, dtype: int64
```

3.0.4 .iloc()

.iloc() is integer based slicing, whereas .loc() used labels/column names. Here are some examples:

```
In [14]: df.iloc[:4]

Out[14]:    ID  Age Gender  GenderGroup Glasses  GlassesGroup  Height  Wingspan  \
         0   1   56      F            1       Y             1    62.0      61.0
         1   2   26      F            1       Y             1    62.0      60.0
         2   3   33      F            1       Y             1    66.0      64.0
         3   4   39      F            1       N             0    64.0      63.0

            CWDistance Complete  CompleteGroup  Score
         0          79        Y              1      7
         1          70        Y              1      8
         2          85        Y              1      7
         3          87        Y              1     10

In [15]: df.iloc[1:5, 2:4]

Out[15]:   Gender  GenderGroup
         1      F            1
         2      F            1
         3      F            1
         4      M            2

In [17]: df.iloc[1:5, ["Gender", "GenderGroup"]]
```

```
    TypeErrorTraceback (most recent call last)

    <ipython-input-17-38420b6cd49e> in <module>()
----> 1 df.iloc[1:5, ["Gender", "GenderGroup"]]


    /opt/conda/envs/python2/lib/python2.7/site-packages/pandas/core/indexing.pyc in __geti
   1470             except (KeyError, IndexError):
   1471                 pass
-> 1472             return self._getitem_tuple(key)
   1473         else:
   1474             # we by definition only have the 0th axis


    /opt/conda/envs/python2/lib/python2.7/site-packages/pandas/core/indexing.pyc in _getit
   2011     def _getitem_tuple(self, tup):
   2012
-> 2013         self._has_valid_tuple(tup)
   2014         try:
   2015             return self._getitem_lowerdim(tup)


    /opt/conda/envs/python2/lib/python2.7/site-packages/pandas/core/indexing.pyc in _has_va
    220                 raise IndexingError('Too many indexers')
    221             try:
--> 222                 self._validate_key(k, i)
    223             except ValueError:
    224                 raise ValueError("Location based indexing can only have "


    /opt/conda/envs/python2/lib/python2.7/site-packages/pandas/core/indexing.pyc in _valida
   1965             l = len(self.obj._get_axis(axis))
   1966
-> 1967             if len(arr) and (arr.max() >= l or arr.min() < -l):
   1968                 raise IndexError("positional indexers are out-of-bounds")
   1969         else:


    /opt/conda/envs/python2/lib/python2.7/site-packages/numpy/core/_methods.pyc in _amax(a
     26 def _amax(a, axis=None, out=None, keepdims=False,
     27           initial=_NoValue):
---> 28     return umr_maximum(a, axis, None, out, keepdims, initial)
     29
     30 def _amin(a, axis=None, out=None, keepdims=False,


    TypeError: cannot perform reduce with flexible type
```

We can view the data types of our data frame columns with by calling .dtypes on our data frame:

```
In [18]: df.dtypes
```

```
Out[18]: ID                     int64
         Age                    int64
         Gender                object
         GenderGroup            int64
         Glasses               object
         GlassesGroup           int64
         Height               float64
         Wingspan             float64
         CWDistance             int64
         Complete              object
         CompleteGroup          int64
         Score                  int64
         dtype: object
```

The output indicates we have integers, floats, and objects with our Data Frame.
We may also want to observe the different unique values within a specific column, lets do this for Gender:

```
In [21]: # List unique values in the df['Gender'] column
         df['Gender'].unique()
```

```
Out[21]: array(['F', 'M'], dtype=object)
```

```
In [20]: # Lets explore df["GenderGroup] as well
         df.GenderGroup.unique()
```

```
Out[20]: array([1, 2])
```

It seems that these fields may serve the same purpose, which is to specify male vs. female. Lets check this quickly by observing only these two columns:

```
In [22]: # Use .loc() to specify a list of mulitple column names
         df.loc[:,["Gender", "GenderGroup"]]
```

```
Out[22]:    Gender  GenderGroup
         0       F            1
         1       F            1
         2       F            1
         3       F            1
         4       M            2
         5       M            2
         6       M            2
         7       F            1
```

```
8       M           2
9       F           1
10      M           2
11      F           1
12      F           1
13      F           1
14      M           2
15      M           2
16      F           1
17      M           2
18      M           2
19      F           1
20      M           2
21      M           2
22      M           2
23      M           2
24      F           1
```

From eyeballing the output, it seems to check out. We can streamline this by utilizing the groupby() and size() functions.

```
In [23]: df.groupby(['Gender','GenderGroup']).size()

Out[23]: Gender  GenderGroup
         F       1              12
         M       2              13
         dtype: int64
```

This output indicates that we have two types of combinations.

- Case 1: Gender = F & Gender Group = 1
- Case 2: Gender = M & GenderGroup = 2.

This validates our initial assumption that these two fields essentially portray the same information.