Working with csv files in Python

Difficulty Level : Medium

Last Updated : 19 Feb, 2022

This article explains how to load and parse a CSV file in Python.

First of all, what is a CSV ?

CSV (Comma Separated Values) is a simple file format used to store tabular data, such as a spreadsheet or database. A CSV file stores tabular data (numbers and text) in plain text. Each line of the file is a data record. Each record consists of one or more fields, separated by commas. The use of the comma as a field separator is the source of the name for this file format.

For working CSV files in python, there is an inbuilt module called csv.

Reading a CSV file

```
# importing csv module

import csv


# csv file name

filename = "aapl.csv"


# initializing the titles and rows list

fields = []

rows = []


# reading csv file

with open(filename, 'r') as csvfile:

    # creating a csv reader object

    csvreader = csv.reader(csvfile)
```

```
    # extracting field names through first row
    fields = next(csvreader)

    # extracting each data row one by one
    for row in csvreader:
        rows.append(row)

    # get total number of rows
    print("Total no. of rows: %d"%(csvreader.line_num))

# printing the field names
print('Field names are:' + ', '.join(field for field in fields))

#  printing first 5 rows
print('\nFirst 5 rows are:\n')
for row in rows[:5]:
    # parsing each column of a row
    for col in row:
        print("%10s"%col,end=" "),
    print('\n')
```

The output of the above program looks like this:

The above example uses a CSV file aapl.csv which can be downloaded from here.

Run this program with the aapl.csv file in the same directory.

Let us try to understand this piece of code.

```
with open(filename, 'r') as csvfile:
    csvreader = csv.reader(csvfile)
```

Here, we first open the CSV file in READ mode. The file object is named as csvfile. The file object is converted to csv.reader object. We save the csv.reader object as csvreader.

```
fields = csvreader.next()
```

csvreader is an iterable object. Hence, .next() method returns the current row and advances the iterator to the next row. Since the first row of our csv file contains the headers (or field names), we save them in a list called fields.

```
for row in csvreader:
    rows.append(row)
```

Now, we iterate through the remaining rows using a for loop. Each row is appended to a list called rows. If you try to print each row, one can find that a row is nothing but a list containing all the field values.

```
print("Total no. of rows: %d"%(csvreader.line_num))
```

csvreader.line_num is nothing but a counter which returns the number of rows that have been iterated.

Writing to a CSV file

```
# importing the csv module
import csv

# field names
fields = ['Name', 'Branch', 'Year', 'CGPA']
```

```
# data rows of csv file
rows = [ ['Nikhil', 'COE', '2', '9.0'],
        ['Sanchit', 'COE', '2', '9.1'],
        ['Aditya', 'IT', '2', '9.3'],
        ['Sagar', 'SE', '1', '9.5'],
        ['Prateek', 'MCE', '3', '7.8'],
        ['Sahil', 'EP', '2', '9.1']]

# name of csv file
filename = "university_records.csv"

# writing to csv file
with open(filename, 'w') as csvfile:
    # creating a csv writer object
    csvwriter = csv.writer(csvfile)

    # writing the fields
    csvwriter.writerow(fields)

    # writing the data rows
    csvwriter.writerows(rows)
```

Let us try to understand the above code in pieces.

fields and rows have been already defined. fields is a list containing all the field names. rows is a list of lists. Each row is a list containing the field values of that row.

```
with open(filename, 'w') as csvfile:
    csvwriter = csv.writer(csvfile)
```

Here, we first open the CSV file in WRITE mode. The file object is named as csvfile. The file object is converted to csv.writer object. We save the csv.writer object as csvwriter.

csvwriter.writerow(fields)

Now we use writerow method to write the first row which is nothing but the field names.

csvwriter.writerows(rows)

We use writerows method to write multiple rows at once.

Writing a dictionary to a CSV file

```
# importing the csv module
import csv

# my data rows as dictionary objects
mydict =[{'branch': 'COE', 'cgpa': '9.0', 'name': 'Nikhil', 'year': '2'},
        {'branch': 'COE', 'cgpa': '9.1', 'name': 'Sanchit', 'year': '2'},
        {'branch': 'IT', 'cgpa': '9.3', 'name': 'Aditya', 'year': '2'},
        {'branch': 'SE', 'cgpa': '9.5', 'name': 'Sagar', 'year': '1'},
        {'branch': 'MCE', 'cgpa': '7.8', 'name': 'Prateek', 'year': '3'},
        {'branch': 'EP', 'cgpa': '9.1', 'name': 'Sahil', 'year': '2'}]

# field names
fields = ['name', 'branch', 'year', 'cgpa']

# name of csv file
filename = "university_records.csv"

# writing to csv file
with open(filename, 'w') as csvfile:
```

```
    # creating a csv dict writer object
    writer = csv.DictWriter(csvfile, fieldnames = fields)

    # writing headers (field names)
    writer.writeheader()

    # writing data rows
    writer.writerows(mydict)
```

In this example, we write a dictionary mydict to a CSV file.

```
with open(filename, 'w') as csvfile:
    writer = csv.DictWriter(csvfile, fieldnames = fields)
```

Here, the file object (csvfile) is converted to a DictWriter object.

Here, we specify the fieldnames as an argument.

```
writer.writeheader()
```

writeheader method simply writes the first row of your csv file using the pre-specified fieldnames.

```
writer.writerows(mydict)
```

writerows method simply writes all the rows but in each row, it writes only the values(not keys).

So, in the end, our CSV file looks like this:

Important Points:

In csv modules, an optional dialect parameter can be given which is used to define a set of parameters specific to a particular CSV format. By default, csv module uses excel dialect which makes them compatible with excel spreadsheets. You can define your own dialect using register_dialect method.

Here is an example:

Now, while defining a csv.reader or csv.writer object, we can specify the dialect like

this:

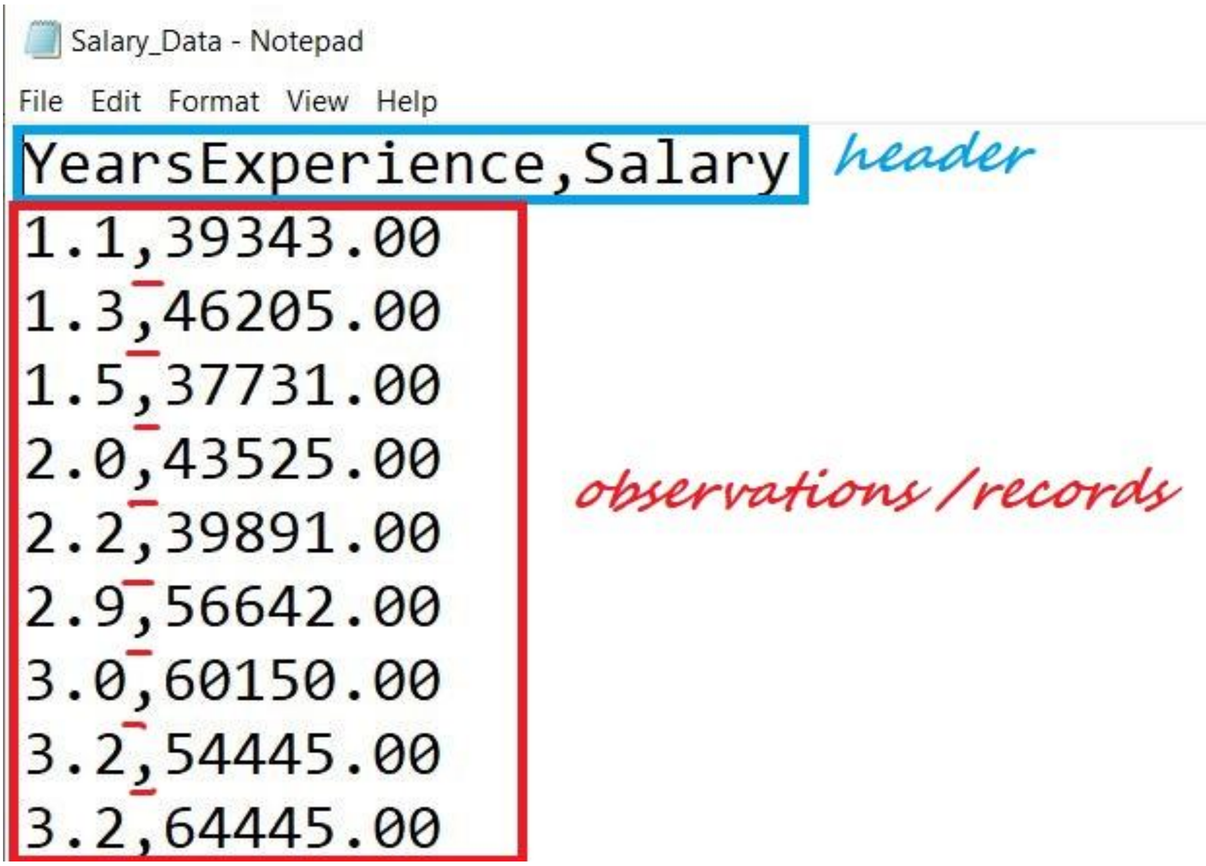
Now, consider that a CSV file looks like this in plain-text:

Working with CSV file

1. What is a CSV?

CSV stands for “Comma Separated Values.” It is the simplest form of storing data in tabular form as plain text. It is important to know to work with CSV because we mostly rely on CSV data in our day-to-day lives as data scientists.

Structure of CSV:



We have a file named “Salary_Data.csv.” The first line of a CSV file is the header and contains the names of the fields/features.

After the header, each line of the file is an observation/a record. The values of a record are separated by “comma.”

2. Reading a CSV

CSV files can be handled in multiple ways in Python.

2.1 Using csv.reader

Reading a CSV using Python's inbuilt module

called [csv](csv) using **csv.reader** object.

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Steps to read a CSV file:

1. Import the csv library

```
import csv
```

2. Open the CSV file

The .open() method in python is used to open files and return a file object.

```
file = open('Salary_Data.csv')


type(file)
```

The type of file is "**_io.TextIOWrapper**" which is a file object that is returned by the **open()** method.

3. Use the csv.reader object to read the CSV file

```
csvreader = csv.reader(file)
```

4. Extract the field names

Create an empty list called header. Use the next() method to obtain the header.

The .next() method returns the current row and moves to the next row.

The first time you run next() it returns the header and the next time you run it returns the first record and so on.

```
header = []
header = next(csvreader)
header
```

```
['YearsExperience', 'Salary']
```

5. Extract the rows/records

Create an empty list called rows and iterate through the csvreader object and append each row to the rows list.

```
rows = []
for row in csvreader:
        rows.append(row)
rows
```

```
[['1.1', '39343.00'],
 ['1.3', '46205.00'],
 ['1.5', '37731.00'],
 ['2.0', '43525.00'],
 ['2.2', '39891.00'],
 ['2.9', '56642.00'],
 ['3.0', '60150.00'],
 ['3.2', '54445.00'],
 ['3.2', '64445.00'],
 ['3.7', '57189.00'],
 ['3.9', '63218.00'],
 ['4.0', '55794.00'],
 ['4.0', '56957.00'],
 ['4.1', '57081.00'],
 ['4.5', '61111.00'],
 ['4.9', '67938.00'],
 ['5.1', '66029.00'],
 ['5.3', '83088.00'],
 ['5.9', '81363.00'],
 ['6.0', '93940.00'],
 ['6.8', '91738.00'],
 ['7.1', '98273.00'],
 ['7.9', '101302.00'],
 ['8.2', '113812.00'],
 ['8.7', '109431.00'],
 ['9.0', '105582.00'],
 ['9.5', '116969.00'],
 ['9.6', '112635.00'],
 ['10.3', '122391.00'],
 ['10.5', '121872.00']]
```

6. Close the file

.close() method is used to close the opened file. Once it is closed, we cannot perform any operations on it.

```
file.close()
```

Complete Code:

Python Code:

Naturally, we might forget to close an open file. To avoid that we can use the **with()** statement to automatically release the resources. In simple terms, there is no need to call the .close() method if we are using with() statement.

Implementing the above code using with() statement:

Syntax: with open(filename, mode) as alias_filename:

Modes:

'r' – to read an existing file,

'w' – to create a new file if the given file doesn't exist and write to it,

'a' – to append to existing file content,

'+' – to create a new file for reading and writing

```
import csv
rows = []
with open("Salary_Data.csv", 'r) as file:
    csvreader = csv.reader(file)
    header = next(csvreader)
    for row in csvreader:
        rows.append(row)
print(header)
print(rows)
```

```
['YearsExperience', 'Salary']
[['1.1', '39343.00'], ['1.3', '46205.00'], ['1.5', '37731.00'], ['2.0', '43525.00'], ['2.2', '39891.00'], ['2.9', '56642.0
0'], ['3.0', '60150.00'], ['3.2', '54445.00'], ['3.2', '64445.00'], ['3.7', '57189.00'], ['3.9', '63218.00'], ['4.0', '5579
4.00'], ['4.0', '56957.00'], ['4.1', '57081.00'], ['4.5', '61111.00'], ['4.9', '67938.00'], ['5.1', '66029.00'], ['5.3', '83
088.00'], ['5.9', '81363.00'], ['6.0', '93940.00'], ['6.8', '91738.00'], ['7.1', '98273.00'], ['7.9', '101302.00'], ['8.2',
'113812.00'], ['8.7', '109431.00'], ['9.0', '105582.00'], ['9.5', '116969.00'], ['9.6', '112635.00'], ['10.3', '122391.00'],
['10.5', '121872.00']]
```

2.2 Using .readlines()

Now the question is – "Is it possible to fetch the header, rows using only open() and with() statements and without the csv library?" Let's see…

.readlines() method is the answer. It returns all the lines in a file as a list. Each item of the list is a row of our CSV file.

The first row of the file.readlines() is the header and the rest of them are the records.

```
with open('Salary_Data.csv') as file:
    content = file.readlines()
header = content[:1]
rows = content[1:]
print(header)
print(rows)
```

```
['YearsExperience,Salary\n']
['1.1,39343.00\n', '1.3,46205.00\n', '1.5,37731.00\n', '2.0,43525.00\n', '2.2,39891.00\n', '2.9,56642.00\n', '3.0,60150.00
\n', '3.2,54445.00\n', '3.2,64445.00\n', '3.7,57189.00\n', '3.9,63218.00\n', '4.0,55794.00\n', '4.0,56957.00\n', '4.1,57081.
00\n', '4.5,61111.00\n', '4.9,67938.00\n', '5.1,66029.00\n', '5.3,83088.00\n', '5.9,81363.00\n', '6.0,93940.00\n', '6.8,9173
8.00\n', '7.1,98273.00\n', '7.9,101302.00\n', '8.2,113812.00\n', '8.7,109431.00\n', '9.0,105582.00\n', '9.5,116969.00\n',
'9.6,112635.00\n', '10.3,122391.00\n', '10.5,121872.00\n']
```

**The ‘n’ from the output can be removed using .strip() method.

What if we have a huge dataset with hundreds of features and thousands of records. Would it be possible to handle lists??

Here comes the pandas library into the picture.

2.3 Using pandas

Steps of reading CSV files using pandas

1. Import pandas library

```
import pandas as pd
```

2. Load CSV files to pandas using [read_csv()]()

Basic Syntax: pandas.read_csv(filename, delimiter=’,’)

```
data= pd.read_csv("Salary_Data.csv")
data
```

	YearsExperience	Salary
0	1.1	39343.0
1	1.3	46205.0
2	1.5	37731.0
3	2.0	43525.0
4	2.2	39891.0
5	2.9	56642.0
6	3.0	60150.0
7	3.2	54445.0
8	3.2	64445.0
9	3.7	57189.0
10	3.9	63218.0
11	4.0	55794.0
12	4.0	56957.0
13	4.1	57081.0
14	4.5	61111.0
15	4.9	67938.0
16	5.1	66029.0
17	5.3	83088.0

3. Extract the field names

.columns is used to obtain the header/field names.

```
data.columns
```

```
Index(['YearsExperience', 'Salary'], dtype='object')
```

4. Extract the rows

All the data of a data frame can be accessed using the field names.

```
data.Salary
```

```
0      39343.0
1      46205.0
2      37731.0
3      43525.0
4      39891.0
5      56642.0
6      60150.0
7      54445.0
8      64445.0
9      57189.0
10     63218.0
11     55794.0
12     56957.0
13     57081.0
14     61111.0
15     67938.0
16     66029.0
17     83088.0
18     81363.0
19     93940.0
20     91738.0
21     98273.0
22    101302.0
23    113812.0
24    109431.0
25    105582.0
26    116969.0
27    112635.0
28    122391.0
29    121872.0
Name: Salary, dtype: float64
```

3. Writing to a CSV file

We can write to a CSV file in multiple ways.

3.1 Using csv.writer

Let’s assume we are recording 3 Students data(Name, M1 Score, M2 Score)

```
header = ['Name', 'M1 Score', 'M2 Score']
data = [['Alex', 62, 80], ['Brad', 45, 56], ['Joey', 85, 98]]
```

Steps of writing to a CSV file:

1. Import csv library

```
import csv
```

2. Define a filename and Open the file using open()

3. Create a csvwriter object using csv.writer()

4. Write the header

5. Write the rest of the data

code for steps 2-5

```
filename = 'Students_Data.csv'
with open(filename, 'w', newline="") as file:
    csvwriter = csv.writer(file) # 2. create a csvwriter object
    csvwriter.writerow(header) # 4. write the header
    csvwriter.writerows(data) # 5. write the rest of the data
```

Below is how our CSV file looks.

Students_Data - Notepad

File Edit Format View Help

```
Name,M1 Score,M2 Score
Alex,62,80
Brad,45,56
Joey,85,98
```

3.2 Using .writelines()

Iterate through each list and convert the list elements to a string and write to the csv file.

```
header = ['Name', 'M1 Score', 'M2 Score']
data = [['Alex', 62, 80], ['Brad', 45, 56], ['Joey', 85, 98]]
filename = 'Student_scores.csv'
with open(filename, 'w') as file:
    for header in header:
        file.write(str(header)+', ')
    file.write('n')
    for row in data:
        for x in row:
            file.write(str(x)+', ')
        file.write('n')
```

Student_scores - Notepad

File Edit Format View Help

```
Name, M1 Score, M2 Score,
Alex, 62, 80,
Brad, 45, 56,
Joey, 85, 98,
```

3.3. Using pandas

Steps to writing to a CSV using pandas

1. Import pandas library

```
import pandas as pd
```

2. Create a pandas dataframe using pd.DataFrame

Syntax: pd.DataFrame(data, columns)

The data parameter takes the records/observations and the columns parameter takes the columns/field names.

```
header = ['Name', 'M1 Score', 'M2 Score']
data = [['Alex', 62, 80], ['Brad', 45, 56], ['Joey', 85, 98]]
data = pd.DataFrame(data, columns=header)
```

3. Write to a CSV file using to_csv()

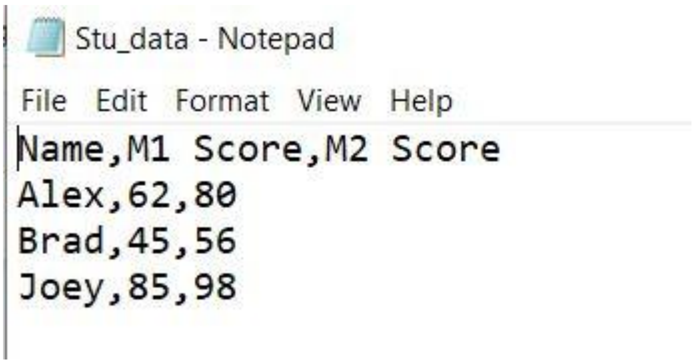
Syntax: DataFrame.to_csv(filename, sep=',', index=False)

**separator is ',' by default.

index=False to remove the index numbers.

```
data.to_csv('Stu_data.csv', index=False)
```

Below is how our CSV looks like



End Notes:

Thank you for reading till the conclusion. By the end of this article, we are familiar with different ways of handling CSV files in Python.

CSV File Reading and Writing¶

Source code: Lib/csv.py

The so-called CSV (Comma Separated Values) format is the most common import and export format for spreadsheets and databases. CSV format was used for many years prior to attempts to describe the format in a standardized way in **RFC 4180**. The lack of a well-defined standard means that subtle differences often exist in the data produced and consumed by different applications. These differences can make it annoying to process CSV files from multiple sources. Still, while the delimiters and quoting characters vary, the overall format is similar enough that it is possible to write a single module which can efficiently manipulate such data, hiding the details of reading and writing the data from the programmer.

The `csv` module implements classes to read and write tabular data in CSV format. It allows programmers to say, "write this data in the format preferred by Excel," or "read data from this file which was generated by Excel," without knowing the precise details of the CSV format used by Excel. Programmers can also describe the CSV formats understood by other applications or define their own special-purpose CSV formats.

The `csv` module's `reader` and `writer` objects read and write sequences. Programmers can also read and write data in dictionary form using the `DictReader` and `DictWriter` classes.

See also

PEP 305 - CSV File API

The Python Enhancement Proposal which proposed this addition to Python.

Module Contents

The `csv` module defines the following functions:

`csv.`**`reader`**(*csvfile*, *dialect*=`'excel'`, `**`*fmtparams*)

Return a reader object which will iterate over lines in the given *csvfile*. *csvfile* can be any object which supports the iterator protocol and returns a string each time its `__next__()` method is called — file objects and list objects are both suitable. If *csvfile* is a file object, it should be opened with `newline=''`. 1 An optional *dialect* parameter can be given which is used to define a set of parameters specific to a particular CSV dialect. It may be an instance of a subclass of the `Dialect` class or one of the strings returned by the `list_dialects()` function. The other optional *fmtparams* keyword arguments can be given to override individual formatting parameters in the current dialect. For full details about the dialect and formatting parameters, see section Dialects and Formatting Parameters.

Each row read from the csv file is returned as a list of strings. No automatic data type conversion is performed unless the `QUOTE_NONNUMERIC` format option is specified (in which case unquoted fields are transformed into floats).

A short usage example:

```
>>> import csv
>>> with open('eggs.csv', newline='') as csvfile:
...     spamreader = csv.reader(csvfile, delimiter=' ',
quotechar='|')
...     for row in spamreader:
...         print(', '.join(row))
Spam, Spam, Spam, Spam, Spam, Baked Beans
Spam, Lovely Spam, Wonderful Spam
```

`csv.`**`writer`**(*csvfile*, *dialect*=`'excel'`, `**`*fmtparams*)

Return a writer object responsible for converting the user's data into delimited strings on the given file-like object. *csvfile* can be any object with a `write()` method. If *csvfile* is a file object, it should be opened with `newline=''` [1]. An optional *dialect* parameter can be given which is used to define a set of parameters specific to a particular CSV dialect. It may be an instance of a subclass of the `Dialect` class or one of the strings returned by the `list_dialects()` function. The other optional *fmtparams* keyword arguments can be given to override individual formatting parameters in the current dialect. For full details about dialects and formatting parameters, see the Dialects and Formatting Parameters section. To make it as easy as possible to interface with modules which implement the DB API, the value `None` is written as the empty string. While this isn't a reversible transformation, it makes it easier to dump SQL NULL data values to CSV files without preprocessing the data returned from a `cursor.fetch*` call. All other non-string data are stringified with `str()` before being written.

A short usage example:

```
import csv
with open('eggs.csv', 'w', newline='') as csvfile:
    spamwriter = csv.writer(csvfile, delimiter=' ',
                            quotechar='|',
quoting=csv.QUOTE_MINIMAL)
    spamwriter.writerow(['Spam'] * 5 + ['Baked Beans'])
    spamwriter.writerow(['Spam', 'Lovely Spam', 'Wonderful
Spam'])
```

`csv.`**`register_dialect`**(*`name`*[, *`dialect`*[, `**`*`fmtparams`*]])

Associate *dialect* with *name*. *name* must be a string. The dialect can be specified either by passing a sub-class of `Dialect`, or by *fmtparams* keyword arguments, or both, with keyword arguments overriding parameters of the dialect. For full details about dialects and formatting parameters, see section Dialects and Formatting Parameters.

csv.**unregister_dialect**(*name*)

Delete the dialect associated with *name* from the dialect registry. An `Error` is raised if *name* is not a registered dialect name.

csv.**get_dialect**(*name*)

Return the dialect associated with *name*. An `Error` is raised if *name* is not a registered dialect name. This function returns an immutable `Dialect`.

csv.**list_dialects**()

Return the names of all registered dialects.

csv.**field_size_limit**([*new_limit*])

Returns the current maximum field size allowed by the parser. If *new_limit* is given, this becomes the new limit.

The `csv` module defines the following classes:

class csv.**DictReader**(*f*, *fieldnames=None*, *restkey=None*, *restval=None*, *dialect='excel'*, **args*, ***kwds*)

Create an object that operates like a regular reader but maps the information in each row to a `dict` whose keys are given by the optional *fieldnames* parameter.

The *fieldnames* parameter is a sequence. If *fieldnames* is omitted, the values in the first row of file *f* will be used as the fieldnames. Regardless of how the fieldnames are determined, the dictionary preserves their original ordering.

If a row has more fields than fieldnames, the remaining data is put in a list and stored with the fieldname specified by *restkey* (which defaults to `None`). If a non-blank row has fewer fields than fieldnames, the missing values are filled-in with the value of *restval* (which defaults to `None`).

All other optional or keyword arguments are passed to the underlying `reader` instance.

Changed in version 3.6: Returned rows are now of type `OrderedDict`.

Changed in version 3.8: Returned rows are now of type `dict`.

A short usage example:

>>>

```
>>> import csv
>>> with open('names.csv', newline='') as csvfile:
...     reader = csv.DictReader(csvfile)
```

```
...     for row in reader:
...         print(row['first_name'], row['last_name'])
...
Eric Idle
John Cleese

>>> print(row)
{'first_name': 'John', 'last_name': 'Cleese'}
```

class `csv.`**`DictWriter`**(*f*, *fieldnames*, *restval*='', *extrasaction*='raise', *dialect*='excel', **args*, ***kwds*)

Create an object which operates like a regular writer but maps dictionaries onto output rows. The *fieldnames* parameter is a `sequence` of keys that identify the order in which values in the dictionary passed to the `writerow()` method are written to file *f*. The optional *restval* parameter specifies the value to be written if the dictionary is missing a key in *fieldnames*. If the dictionary passed to the `writerow()` method contains a key not found in *fieldnames*, the optional *extrasaction* parameter indicates what action to take. If it is set to `'raise'`, the default value, a `ValueError` is raised. If it is set to `'ignore'`, extra values in the dictionary are ignored. Any other optional or keyword arguments are passed to the underlying `writer` instance.

Note that unlike the `DictReader` class, the *fieldnames* parameter of the `DictWriter` class is not optional.

A short usage example:

```
import csv

with open('names.csv', 'w', newline='') as csvfile:
    fieldnames = ['first_name', 'last_name']
    writer = csv.DictWriter(csvfile, fieldnames=fieldnames)

    writer.writeheader()
    writer.writerow({'first_name': 'Baked', 'last_name':
'Beans'})
    writer.writerow({'first_name': 'Lovely', 'last_name':
'Spam'})
    writer.writerow({'first_name': 'Wonderful', 'last_name':
'Spam'})
```

What is Pandas?

Pandas is defined as an open-source library that provides high-performance data manipulation in Python. It is built on top of the NumPy package, which means **Numpy** is required for operating the Pandas. The name of Pandas is derived from the word **Panel Data**, which means **an Econometrics from Multidimensional data**. It is used for data analysis in Python and developed by **Wes McKinney in 2008**.

Before Pandas, Python was capable for data preparation, but it only provided limited support for data analysis. So, Pandas came into the picture and enhanced the capabilities of data analysis. It can perform five significant steps required for processing and analysis of data irrespective of the origin of the data, i.e., **load, manipulate, prepare, model, and analyze**.

What is NumPy?

NumPy is mostly written in C language, and it is an extension module of Python. It is defined as a Python package used for performing the various numerical computations and processing of the multidimensional and single-dimensional array elements. The calculations using Numpy arrays are faster than the normal Python array.

The NumPy package is created by the **Travis Oliphant** in 2005 by adding the functionalities of the ancestor module Numeric into another module **Numarray**. It is also capable of handling a vast amount of data and convenient with Matrix multiplication and data reshaping.

Installing Pandas

The code in this tutorial is executed with CPython 3.7.4 and Pandas 0.25.1. It would be beneficial to make sure you have the latest versions of Python and Pandas on your machine. You might want to create a new virtual environment and install the dependencies for this tutorial.

First, you'll need the Pandas library. You may already have it installed. If you don't, then you can install it with pip:

```
$ pip install pandas
```

Once the installation process completes, you should have Pandas installed and ready.

Anaconda is an excellent Python distribution that comes with Python, many useful packages like Pandas, and a package and environment manager called Conda. To learn more about Anaconda, check out Setting Up Python for Machine Learning on Windows.

If you don't have Pandas in your virtual environment, then you can install it with Conda:

```
$ conda install pandas
```

Conda is powerful as it manages the dependencies and their versions. To learn more about working with Conda, you can check out the official documentation.

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Preparing Data

In this tutorial, you'll use the data related to 20 countries. Here's an overview of the data and sources you'll be working with:

- **Country** is denoted by the country name. Each country is in the top 10 list for either population, area, or gross domestic product (GDP). The row labels for the dataset are the three-letter country codes defined in ISO 3166-1. The column label for the dataset is `COUNTRY`.
- **Population** is expressed in millions. The data comes from a list of countries and dependencies by population on Wikipedia. The column label for the dataset is `POP`.
- **Area** is expressed in thousands of kilometers squared. The data comes from a list of countries and dependencies by area on Wikipedia. The column label for the dataset is `AREA`.
- **Gross domestic product** is expressed in millions of U.S. dollars, according to the United Nations data for 2017. You can find this data in the list of countries by nominal GDP on Wikipedia. The column label for the dataset is `GDP`.
- **Continent** is either Africa, Asia, Oceania, Europe, North America, or South America. You can find this information on Wikipedia as well. The column label for the dataset is `CONT`.
- **Independence day** is a date that commemorates a nation's independence. The data comes from the list of national independence days on Wikipedia. The dates are shown in ISO 8601 format. The first four digits represent the year, the next two numbers are

the month, and the last two are for the day of the month. The column label for the dataset is `IND_DAY`.

This is how the data looks as a table:

	COUNTRY	POP	AREA	GDP	CONT	IND_DAY
CHN	China	1398.72	9596.96	12234.78	Asia	
IND	India	1351.16	3287.26	2575.67	Asia	1947-08-15
USA	US	329.74	9833.52	19485.39	N.America	1776-07-04
IDN	Indonesia	268.07	1910.93	1015.54	Asia	1945-08-17
BRA	Brazil	210.32	8515.77	2055.51	S.America	1822-09-07
PAK	Pakistan	205.71	881.91	302.14	Asia	1947-08-14
NGA	Nigeria	200.96	923.77	375.77	Africa	1960-10-01
BGD	Bangladesh	167.09	147.57	245.63	Asia	1971-03-26
RUS	Russia	146.79	17098.25	1530.75		1992-06-12
MEX	Mexico	126.58	1964.38	1158.23	N.America	1810-09-16
JPN	Japan	126.22	377.97	4872.42	Asia	
DEU	Germany	83.02	357.11	3693.20	Europe	
FRA	France	67.02	640.68	2582.49	Europe	1789-07-14
GBR	UK	66.44	242.50	2631.23	Europe	
ITA	Italy	60.36	301.34	1943.84	Europe	
ARG	Argentina	44.94	2780.40	637.49	S.America	1816-07-09
DZA	Algeria	43.38	2381.74	167.56	Africa	1962-07-05
CAN	Canada	37.59	9984.67	1647.12	N.America	1867-07-01
AUS	Australia	25.47	7692.02	1408.68	Oceania	
KAZ	Kazakhstan	18.53	2724.90	159.41	Asia	1991-12-16

You may notice that some of the data is missing. For example, the continent for Russia is not specified because it spreads across both Europe and Asia. There are also several missing independence days because the data source omits them.

You can organize this data in Python using a nested dictionary:

```
data = {
```

```
    'CHN': {'COUNTRY': 'China', 'POP': 1_398.72, 'AREA': 9_596.96,
            'GDP': 12_234.78, 'CONT': 'Asia'},
    'IND': {'COUNTRY': 'India', 'POP': 1_351.16, 'AREA': 3_287.26,
            'GDP': 2_575.67, 'CONT': 'Asia', 'IND_DAY': '1947-08-15'},
    'USA': {'COUNTRY': 'US', 'POP': 329.74, 'AREA': 9_833.52,
            'GDP': 19_485.39, 'CONT': 'N.America',
            'IND_DAY': '1776-07-04'},
    'IDN': {'COUNTRY': 'Indonesia', 'POP': 268.07, 'AREA': 1_910.93,
            'GDP': 1_015.54, 'CONT': 'Asia', 'IND_DAY': '1945-08-17'},
    'BRA': {'COUNTRY': 'Brazil', 'POP': 210.32, 'AREA': 8_515.77,
            'GDP': 2_055.51, 'CONT': 'S.America', 'IND_DAY': '1822-09-07'},
    'PAK': {'COUNTRY': 'Pakistan', 'POP': 205.71, 'AREA': 881.91,
            'GDP': 302.14, 'CONT': 'Asia', 'IND_DAY': '1947-08-14'},
    'NGA': {'COUNTRY': 'Nigeria', 'POP': 200.96, 'AREA': 923.77,
            'GDP': 375.77, 'CONT': 'Africa', 'IND_DAY': '1960-10-01'},
    'BGD': {'COUNTRY': 'Bangladesh', 'POP': 167.09, 'AREA': 147.57,
            'GDP': 245.63, 'CONT': 'Asia', 'IND_DAY': '1971-03-26'},
    'RUS': {'COUNTRY': 'Russia', 'POP': 146.79, 'AREA': 17_098.25,
            'GDP': 1_530.75, 'IND_DAY': '1992-06-12'},
    'MEX': {'COUNTRY': 'Mexico', 'POP': 126.58, 'AREA': 1_964.38,
            'GDP': 1_158.23, 'CONT': 'N.America', 'IND_DAY': '1810-09-16'},
    'JPN': {'COUNTRY': 'Japan', 'POP': 126.22, 'AREA': 377.97,
            'GDP': 4_872.42, 'CONT': 'Asia'},
    'DEU': {'COUNTRY': 'Germany', 'POP': 83.02, 'AREA': 357.11,
            'GDP': 3_693.20, 'CONT': 'Europe'},
    'FRA': {'COUNTRY': 'France', 'POP': 67.02, 'AREA': 640.68,
            'GDP': 2_582.49, 'CONT': 'Europe', 'IND_DAY': '1789-07-14'},
    'GBR': {'COUNTRY': 'UK', 'POP': 66.44, 'AREA': 242.50,
            'GDP': 2_631.23, 'CONT': 'Europe'},
    'ITA': {'COUNTRY': 'Italy', 'POP': 60.36, 'AREA': 301.34,
            'GDP': 1_943.84, 'CONT': 'Europe'},
    'ARG': {'COUNTRY': 'Argentina', 'POP': 44.94, 'AREA': 2_780.40,
            'GDP': 637.49, 'CONT': 'S.America', 'IND_DAY': '1816-07-09'},
    'DZA': {'COUNTRY': 'Algeria', 'POP': 43.38, 'AREA': 2_381.74,
            'GDP': 167.56, 'CONT': 'Africa', 'IND_DAY': '1962-07-05'},
    'CAN': {'COUNTRY': 'Canada', 'POP': 37.59, 'AREA': 9_984.67,
            'GDP': 1_647.12, 'CONT': 'N.America', 'IND_DAY': '1867-07-01'},
    'AUS': {'COUNTRY': 'Australia', 'POP': 25.47, 'AREA': 7_692.02,
```

```
            'GDP': 1_408.68, 'CONT': 'Oceania'},
    'KAZ': {'COUNTRY': 'Kazakhstan', 'POP': 18.53, 'AREA': 2_724.90,
            'GDP': 159.41, 'CONT': 'Asia', 'IND_DAY': '1991-12-16'}
}

columns = ('COUNTRY', 'POP', 'AREA', 'GDP', 'CONT', 'IND_DAY')
```

Each row of the table is written as an inner dictionary whose keys are the column names and values are the corresponding data. These dictionaries are then collected as the values in the outer `data` dictionary. The corresponding keys for `data` are the three-letter country codes.

You can use this `data` to create an instance of a Pandas `DataFrame`. First, you need to import Pandas:

>>>

```
>>> import pandas as pd
```

Now that you have Pandas imported, you can use the [`DataFrame` constructor]() and `data` to create a `DataFrame` object.

`data` is organized in such a way that the country codes correspond to columns. You can reverse the rows and columns of a `DataFrame` with the property `.T`:

>>>

```
>>> df = pd.DataFrame(data=data).T
>>> df
       COUNTRY      POP     AREA      GDP       CONT     IND_DAY
CHN      China  1398.72  9596.96  12234.8       Asia         NaN
IND      India  1351.16  3287.26  2575.67       Asia  1947-08-15
USA         US   329.74  9833.52  19485.4  N.America  1776-07-04
IDN  Indonesia   268.07  1910.93  1015.54       Asia  1945-08-17
BRA     Brazil   210.32  8515.77  2055.51  S.America  1822-09-07
PAK   Pakistan   205.71   881.91   302.14       Asia  1947-08-14
NGA    Nigeria   200.96   923.77   375.77     Africa  1960-10-01
BGD Bangladesh   167.09   147.57   245.63       Asia  1971-03-26
RUS     Russia   146.79  17098.2  1530.75        NaN  1992-06-12
MEX     Mexico   126.58  1964.38  1158.23  N.America  1810-09-16
JPN      Japan   126.22   377.97  4872.42       Asia         NaN
DEU    Germany    83.02   357.11   3693.2     Europe         NaN
FRA     France    67.02   640.68  2582.49     Europe  1789-07-14
GBR         UK    66.44    242.5  2631.23     Europe         NaN
ITA      Italy    60.36   301.34  1943.84     Europe         NaN
ARG  Argentina    44.94   2780.4   637.49  S.America  1816-07-09
```

```
DZA     Algeria    43.38  2381.74   167.56     Africa  1962-07-05
CAN      Canada    37.59  9984.67  1647.12  N.America  1867-07-01
AUS   Australia    25.47  7692.02  1408.68    Oceania         NaN
KAZ  Kazakhstan    18.53   2724.9   159.41       Asia  1991-12-16
```
Now you have your `DataFrame` object populated with the data about each country.

Note: You can use `.transpose()` instead of `.T` to reverse the rows and columns of your dataset. If you use `.transpose()`, then you can set the optional parameter `copy` to specify if you want to copy the underlying data. The default behavior is `False`.

Versions of Python older than 3.6 did not guarantee the order of keys in dictionaries. To ensure the order of columns is maintained for older versions of Python and Pandas, you can specify `index=columns`:

\>>>

```
>>> df = pd.DataFrame(data=data, index=columns).T
```
Now that you've prepared your data, you're ready to start working with files!

Using the Pandas `read_csv()` and `.to_csv()` Functions

A comma-separated values (CSV) file is a plaintext file with a `.csv` extension that holds tabular data. This is one of the most popular file formats for storing large amounts of data. Each row of the CSV file represents a single table row. The values in the same row are by default separated with commas, but you could change the separator to a semicolon, tab, space, or some other character.

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Write a CSV File

You can save your Pandas `DataFrame` as a CSV file with `.to_csv()`:

\>>>

```
>>> df.to_csv('data.csv')
```
That's it! You've created the file `data.csv` in your current working directory. You can expand the code block below to see how your CSV file should look:

data.csvShow/Hide

This text file contains the data separated with **commas**. The first column contains the row labels. In some cases, you'll find them irrelevant. If you don't want to keep them, then you can pass the argument `index=False` to `.to_csv()`.

Read a CSV File

Once your data is saved in a CSV file, you'll likely want to load and use it from time to time. You can do that with the Pandas `read_csv()` function:

\>>>

```
>>> df = pd.read_csv('data.csv', index_col=0)
>>> df
        COUNTRY      POP      AREA       GDP       CONT     IND_DAY
CHN       China  1398.72   9596.96  12234.78       Asia         NaN
IND       India  1351.16   3287.26   2575.67       Asia  1947-08-15
USA          US   329.74   9833.52  19485.39  N.America  1776-07-04
IDN   Indonesia   268.07   1910.93   1015.54       Asia  1945-08-17
BRA      Brazil   210.32   8515.77   2055.51  S.America  1822-09-07
PAK    Pakistan   205.71    881.91    302.14       Asia  1947-08-14
NGA     Nigeria   200.96    923.77    375.77     Africa  1960-10-01
BGD  Bangladesh   167.09    147.57    245.63       Asia  1971-03-26
RUS      Russia   146.79  17098.25   1530.75        NaN  1992-06-12
MEX      Mexico   126.58   1964.38   1158.23  N.America  1810-09-16
JPN       Japan   126.22    377.97   4872.42       Asia         NaN
DEU     Germany    83.02    357.11   3693.20     Europe         NaN
FRA      France    67.02    640.68   2582.49     Europe  1789-07-14
GBR          UK    66.44    242.50   2631.23     Europe         NaN
ITA       Italy    60.36    301.34   1943.84     Europe         NaN
ARG   Argentina    44.94   2780.40    637.49  S.America  1816-07-09
DZA     Algeria    43.38   2381.74    167.56     Africa  1962-07-05
CAN      Canada    37.59   9984.67   1647.12  N.America  1867-07-01
AUS   Australia    25.47   7692.02   1408.68    Oceania         NaN
KAZ  Kazakhstan    18.53   2724.90    159.41       Asia  1991-12-16
```

In this case, the Pandas `read_csv()` function returns a new `DataFrame` with the data and labels from the file `data.csv`, which you specified with the first argument. This string can be any valid path, including URLs.

The parameter `index_col` specifies the column from the CSV file that contains the row labels. You assign a zero-based column index to this parameter. You should determine the value of `index_col` when the CSV file contains the row labels to avoid loading them as data.

You'll learn more about using Pandas with CSV files later on in this tutorial. You can also check out Reading and Writing CSV Files in Python to see how to handle CSV files with the built-in Python library csv as well.

Using Pandas to Write and Read Excel Files

Microsoft Excel is probably the most widely-used spreadsheet software. While older versions used binary `.xls` files, Excel 2007 introduced the new XML-based `.xlsx` file. You can read and write Excel files in Pandas, similar to CSV files. However, you'll need to install the following Python packages first:

- xlwt to write to `.xls` files
- openpyxl or XlsxWriter to write to `.xlsx` files

- xlrd to read Excel files

You can install them using pip with a single command:

```
$ pip install xlwt openpyxl xlsxwriter xlrd
```

You can also use Conda:

```
$ conda install xlwt openpyxl xlsxwriter xlrd
```

Please note that you don't have to install *all* these packages. For example, you don't need both openpyxl and XlsxWriter. If you're going to work just with `.xls` files, then you don't need any of them! However, if you intend to work only with `.xlsx` files, then you're going to need at least one of them, but not `xlwt`. Take some time to decide which packages are right for your project.

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Write an Excel File

Once you have those packages installed, you can save your `DataFrame` in an Excel file with `.to_excel()`:

>>>

```
>>> df.to_excel('data.xlsx')
```

The argument `'data.xlsx'` represents the target file and, optionally, its path. The above statement should create the file `data.xlsx` in your current working directory. That file should look like this:

	A	B	C	D	E	F	G
1		**COUNTRY**	**POP**	**AREA**	**GDP**	**CONT**	**IND_DAY**
2	**CHN**	China	1398.72	9596.96	12234.78	Asia	
3	**IND**	India	1351.16	3287.26	2575.67	Asia	1947-08-15
4	**USA**	US	329.74	9833.52	19485.39	N.America	1776-07-04
5	**IDN**	Indonesia	268.07	1910.93	1015.54	Asia	1945-08-17
6	**BRA**	Brazil	210.32	8515.77	2055.51	S.America	1822-09-07
7	**PAK**	Pakistan	205.71	881.91	302.14	Asia	1947-08-14
8	**NGA**	Nigeria	200.96	923.77	375.77	Africa	1960-10-01
9	**BGD**	Bangladesh	167.09	147.57	245.63	Asia	1971-03-26
10	**RUS**	Russia	146.79	17098.25	1530.75		1992-06-12
11	**MEX**	Mexico	126.58	1964.38	1158.23	N.America	1810-09-16
12	**JPN**	Japan	126.22	377.97	4872.42	Asia	
13	**DEU**	Germany	83.02	357.11	3693.2	Europe	
14	**FRA**	France	67.02	640.68	2582.49	Europe	1789-07-14
15	**GBR**	UK	66.44	242.5	2631.23	Europe	
16	**ITA**	Italy	60.36	301.34	1943.84	Europe	
17	**ARG**	Argentina	44.94	2780.4	637.49	S.America	1816-07-09
18	**DZA**	Algeria	43.38	2381.74	167.56	Africa	1962-07-05
19	**CAN**	Canada	37.59	9984.67	1647.12	N.America	1867-07-01
20	**AUS**	Australia	25.47	7692.02	1408.68	Oceania	
21	**KAZ**	Kazakhstan	18.53	2724.9	159.41	Asia	1991-12-16

The first column of the file contains the labels of the rows, while the other columns store data.

Read an Excel File

You can load data from Excel files with `read_excel()`:

\>>>

```
>>> df = pd.read_excel('data.xlsx', index_col=0)
>>> df
        COUNTRY      POP     AREA       GDP       CONT     IND_DAY
CHN       China  1398.72  9596.96  12234.78       Asia         NaN
IND       India  1351.16  3287.26   2575.67       Asia  1947-08-15
USA          US   329.74  9833.52  19485.39  N.America  1776-07-04
IDN   Indonesia   268.07  1910.93   1015.54       Asia  1945-08-17
BRA      Brazil   210.32  8515.77   2055.51  S.America  1822-09-07
PAK    Pakistan   205.71   881.91    302.14       Asia  1947-08-14
NGA     Nigeria   200.96   923.77    375.77     Africa  1960-10-01
```

```
BGD  Bangladesh   167.09    147.57    245.63        Asia  1971-03-26
RUS      Russia   146.79  17098.25   1530.75         NaN  1992-06-12
MEX      Mexico   126.58   1964.38   1158.23  N.America  1810-09-16
JPN       Japan   126.22    377.97   4872.42        Asia         NaN
DEU     Germany    83.02    357.11   3693.20      Europe         NaN
FRA      France    67.02    640.68   2582.49      Europe  1789-07-14
GBR          UK    66.44    242.50   2631.23      Europe         NaN
ITA       Italy    60.36    301.34   1943.84      Europe         NaN
ARG   Argentina    44.94   2780.40    637.49  S.America  1816-07-09
DZA     Algeria    43.38   2381.74    167.56      Africa  1962-07-05
CAN      Canada    37.59   9984.67   1647.12  N.America  1867-07-01
AUS   Australia    25.47   7692.02   1408.68     Oceania         NaN
KAZ  Kazakhstan    18.53   2724.90    159.41        Asia  1991-12-16
```
read_excel() returns a new DataFrame that contains the values from data.xlsx. You can also use read_excel() with OpenDocument spreadsheets, or .ods files.

You'll learn more about working with Excel files later on in this tutorial. You can also check out Using Pandas to Read Large Excel Files in Python.

Understanding the Pandas IO API

Pandas IO Tools is the API that allows you to save the contents of Series and DataFrame objects to the clipboard, objects, or files of various types. It also enables loading data from the clipboard, objects, or files.

Write Files

Series and DataFrame objects have methods that enable writing data and labels to the clipboard or files. They're named with the pattern **.to_<file-type>()**, where <file-type> is the type of the target file.

You've learned about .to_csv() and .to_excel(), but there are others, including:

- .to_json()
- .to_html()
- .to_sql()
- .to_pickle()

There are still more file types that you can write to, so this list is not exhaustive.

Note: To find similar methods, check the official documentation about serialization, IO, and conversion related to Series and DataFrame objects.

These methods have parameters specifying the target file path where you saved the data and labels. This is mandatory in some cases and optional in others. If this option is available and you choose to omit it, then the methods return the objects (like strings or iterables) with the contents of DataFrame instances.

The optional parameter `compression` decides how to compress the file with the data and labels. You'll learn more about it later on. There are a few other parameters, but they're mostly specific to one or several methods. You won't go into them in detail here.

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Read Files

Pandas functions for reading the contents of files are named using the pattern **`.read_<file-type>()`**, where `<file-type>` indicates the type of the file to read. You've already seen the Pandas `read_csv()` and `read_excel()` functions. Here are a few others:

- `read_json()`
- `read_html()`
- `read_sql()`
- `read_pickle()`

These functions have a parameter that specifies the target file path. It can be any valid string that represents the path, either on a local machine or in a URL. Other objects are also acceptable depending on the file type.

The optional parameter `compression` determines the type of decompression to use for the compressed files. You'll learn about it later on in this tutorial. There are other parameters, but they're specific to one or several functions. You won't go into them in detail here.

Working With Different File Types

The Pandas library offers a wide range of possibilities for saving your data to files and loading data from files. In this section, you'll learn more about working with CSV and Excel files. You'll also see how to use other types of files, like JSON, web pages, databases, and Python pickle files.

CSV Files

You've already learned how to read and write CSV files. Now let's dig a little deeper into the details. When you use `.to_csv()` to save your `DataFrame`, you can provide an argument for the parameter `path_or_buf` to specify the path, name, and extension of the target file.

`path_or_buf` is the first argument `.to_csv()` will get. It can be any string that represents a valid file path that includes the file name and its extension. You've seen this in a previous example. However, if you omit `path_or_buf`, then `.to_csv()` won't create any files. Instead, it'll return the corresponding string:

>>>

```
>>> df = pd.DataFrame(data=data).T
>>> s = df.to_csv()
>>> print(s)
,COUNTRY,POP,AREA,GDP,CONT,IND_DAY
CHN,China,1398.72,9596.96,12234.78,Asia,
```

```
IND,India,1351.16,3287.26,2575.67,Asia,1947-08-15
USA,US,329.74,9833.52,19485.39,N.America,1776-07-04
IDN,Indonesia,268.07,1910.93,1015.54,Asia,1945-08-17
BRA,Brazil,210.32,8515.77,2055.51,S.America,1822-09-07
PAK,Pakistan,205.71,881.91,302.14,Asia,1947-08-14
NGA,Nigeria,200.96,923.77,375.77,Africa,1960-10-01
BGD,Bangladesh,167.09,147.57,245.63,Asia,1971-03-26
RUS,Russia,146.79,17098.25,1530.75,,1992-06-12
MEX,Mexico,126.58,1964.38,1158.23,N.America,1810-09-16
JPN,Japan,126.22,377.97,4872.42,Asia,
DEU,Germany,83.02,357.11,3693.2,Europe,
FRA,France,67.02,640.68,2582.49,Europe,1789-07-14
GBR,UK,66.44,242.5,2631.23,Europe,
ITA,Italy,60.36,301.34,1943.84,Europe,
ARG,Argentina,44.94,2780.4,637.49,S.America,1816-07-09
DZA,Algeria,43.38,2381.74,167.56,Africa,1962-07-05
CAN,Canada,37.59,9984.67,1647.12,N.America,1867-07-01
AUS,Australia,25.47,7692.02,1408.68,Oceania,
KAZ,Kazakhstan,18.53,2724.9,159.41,Asia,1991-12-16
```

Now you have the string `s` instead of a CSV file. You also have some **missing values** in your `DataFrame` object. For example, the continent for Russia and the independence days for several countries (China, Japan, and so on) are not available. In data science and machine learning, you must handle missing values carefully. Pandas excels here! By default, Pandas uses the NaN value to replace the missing values.

Note: `nan`, which stands for “not a number,” is a particular floating-point value in Python.

You can get a `nan` value with any of the following functions:

- `float('nan')`
- `math.nan`
- `numpy.nan`

The continent that corresponds to Russia in `df` is `nan`:

```
>>>
```

```
>>> df.loc['RUS', 'CONT']
nan
```

This example uses `.loc[]` to get data with the specified row and column names.

When you save your `DataFrame` to a CSV file, empty strings (`''`) will represent the missing data. You can see this both in your file `data.csv` and in the string `s`. If you want to change this behavior, then use the optional parameter `na_rep`:

```
>>>
```

```
>>> df.to_csv('new-data.csv', na_rep='(missing)')
```

This code produces the file `new-data.csv` where the missing values are no longer empty strings. You can expand the code block below to see how this file should look:

new-data.csvShow/Hide

Now, the string `'(missing)'` in the file corresponds to the `nan` values from `df`.

When Pandas reads files, it considers the empty string (`''`) and a few others as missing values by default:

- `'nan'`
- `'-nan'`
- `'NA'`
- `'N/A'`
- `'NaN'`
- `'null'`

If you don't want this behavior, then you can pass `keep_default_na=False` to the Pandas `read_csv()` function. To specify other labels for missing values, use the parameter `na_values`:

```
>>>
```

```
>>> pd.read_csv('new-data.csv', index_col=0, na_values='(missing)')
        COUNTRY      POP      AREA       GDP       CONT     IND_DAY
CHN       China  1398.72   9596.96  12234.78       Asia         NaN
IND       India  1351.16   3287.26   2575.67       Asia  1947-08-15
USA          US   329.74   9833.52  19485.39  N.America  1776-07-04
IDN   Indonesia   268.07   1910.93   1015.54       Asia  1945-08-17
BRA      Brazil   210.32   8515.77   2055.51  S.America  1822-09-07
PAK    Pakistan   205.71    881.91    302.14       Asia  1947-08-14
NGA     Nigeria   200.96    923.77    375.77     Africa  1960-10-01
BGD  Bangladesh   167.09    147.57    245.63       Asia  1971-03-26
RUS      Russia   146.79  17098.25   1530.75        NaN  1992-06-12
MEX      Mexico   126.58   1964.38   1158.23  N.America  1810-09-16
JPN       Japan   126.22    377.97   4872.42       Asia         NaN
DEU     Germany    83.02    357.11   3693.20     Europe         NaN
FRA      France    67.02    640.68   2582.49     Europe  1789-07-14
GBR          UK    66.44    242.50   2631.23     Europe         NaN
ITA       Italy    60.36    301.34   1943.84     Europe         NaN
ARG   Argentina    44.94   2780.40    637.49  S.America  1816-07-09
DZA     Algeria    43.38   2381.74    167.56     Africa  1962-07-05
CAN      Canada    37.59   9984.67   1647.12  N.America  1867-07-01
```

```
AUS    Australia     25.47    7692.02    1408.68     Oceania          NaN
KAZ   Kazakhstan     18.53    2724.90     159.41        Asia  1991-12-16
```

Here, you've marked the string `'(missing)'` as a new missing data label, and Pandas replaced it with `nan` when it read the file.

When you load data from a file, Pandas assigns the [data types](https://docs.scipy.org/doc/numpy/user/basics.types.html) to the values of each column by default. You can check these types with `.dtypes`:

>>>

```
>>> df = pd.read_csv('data.csv', index_col=0)
>>> df.dtypes
COUNTRY      object
POP         float64
AREA        float64
GDP         float64
CONT         object
IND_DAY      object
dtype: object
```

The columns with strings and dates (`'COUNTRY'`, `'CONT'`, and `'IND_DAY'`) have the data type `object`. Meanwhile, the numeric columns contain 64-bit floating-point numbers (`float64`).

You can use the parameter `dtype` to specify the desired data types and `parse_dates` to force use of [datetimes](https://docs.python.org/3/library/datetime.html):

>>>

```
>>> dtypes = {'POP': 'float32', 'AREA': 'float32', 'GDP': 'float32'}
>>> df = pd.read_csv('data.csv', index_col=0, dtype=dtypes,
...                  parse_dates=['IND_DAY'])
>>> df.dtypes
COUNTRY              object
POP                 float32
AREA                float32
GDP                 float32
CONT                 object
IND_DAY     datetime64[ns]
dtype: object
>>> df['IND_DAY']
CHN            NaT
IND     1947-08-15
USA     1776-07-04
```

```
IDN   1945-08-17
BRA   1822-09-07
PAK   1947-08-14
NGA   1960-10-01
BGD   1971-03-26
RUS   1992-06-12
MEX   1810-09-16
JPN          NaT
DEU          NaT
FRA   1789-07-14
GBR          NaT
ITA          NaT
ARG   1816-07-09
DZA   1962-07-05
CAN   1867-07-01
AUS          NaT
KAZ   1991-12-16
Name: IND_DAY, dtype: datetime64[ns]
```

Now, you have 32-bit floating-point numbers (`float32`) as specified with `dtype`. These differ slightly from the original 64-bit numbers because of smaller **precision**. The values in the last column are considered as dates and have the data type `datetime64`. That's why the `NaN` values in this column are replaced with `NaT`.

Now that you have real dates, you can save them in the format you like:

>>>

```
>>> df = pd.read_csv('data.csv', index_col=0, parse_dates=['IND_DAY'])
>>> df.to_csv('formatted-data.csv', date_format='%B %d, %Y')
```

Here, you've specified the parameter `date_format` to be `'%B %d, %Y'`. You can expand the code block below to see the resulting file:

formatted-data.csvShow/Hide

The format of the dates is different now. The format `'%B %d, %Y'` means the date will first display the full name of the month, then the day followed by a comma, and finally the full year.

There are several other optional parameters that you can use with `.to_csv()`:

- **`sep`** denotes a values separator.
- **`decimal`** indicates a decimal separator.
- **`encoding`** sets the file encoding.
- **`header`** specifies whether you want to write column labels in the file.

Here's how you would pass arguments for `sep` and `header`:

>>>

```
>>> s = df.to_csv(sep=';', header=False)
>>> print(s)
CHN;China;1398.72;9596.96;12234.78;Asia;
IND;India;1351.16;3287.26;2575.67;Asia;1947-08-15
USA;US;329.74;9833.52;19485.39;N.America;1776-07-04
IDN;Indonesia;268.07;1910.93;1015.54;Asia;1945-08-17
BRA;Brazil;210.32;8515.77;2055.51;S.America;1822-09-07
PAK;Pakistan;205.71;881.91;302.14;Asia;1947-08-14
NGA;Nigeria;200.96;923.77;375.77;Africa;1960-10-01
BGD;Bangladesh;167.09;147.57;245.63;Asia;1971-03-26
RUS;Russia;146.79;17098.25;1530.75;;1992-06-12
MEX;Mexico;126.58;1964.38;1158.23;N.America;1810-09-16
JPN;Japan;126.22;377.97;4872.42;Asia;
DEU;Germany;83.02;357.11;3693.2;Europe;
FRA;France;67.02;640.68;2582.49;Europe;1789-07-14
GBR;UK;66.44;242.5;2631.23;Europe;
ITA;Italy;60.36;301.34;1943.84;Europe;
ARG;Argentina;44.94;2780.4;637.49;S.America;1816-07-09
DZA;Algeria;43.38;2381.74;167.56;Africa;1962-07-05
CAN;Canada;37.59;9984.67;1647.12;N.America;1867-07-01
AUS;Australia;25.47;7692.02;1408.68;Oceania;
KAZ;Kazakhstan;18.53;2724.9;159.41;Asia;1991-12-16
```

The data is separated with a semicolon (`';'`) because you've specified `sep=';'`. Also, since you passed `header=False`, you see your data without the header row of column names.

The Pandas `read_csv()` function has many additional options for managing missing data, working with dates and times, quoting, encoding, handling errors, and more. For instance, if you have a file with one data column and want to get a `Series` object instead of a `DataFrame`, then you can pass `squeeze=True` to `read_csv()`. You'll learn later on about data compression and decompression, as well as how to skip rows and columns.

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JSON Files

JSON stands for JavaScript object notation. JSON files are plaintext files used for data interchange, and humans can read them easily. They follow the ISO/IEC

21778:2017 and ECMA-404 standards and use the `.json` extension. Python and Pandas work well with JSON files, as Python's json library offers built-in support for them.

You can save the data from your `DataFrame` to a JSON file with `.to_json()`. Start by creating a `DataFrame` object again. Use the dictionary `data` that holds the data about countries and then apply `.to_json()`:

>>>

```
>>> df = pd.DataFrame(data=data).T
>>> df.to_json('data-columns.json')
```

This code produces the file `data-columns.json`. You can expand the code block below to see how this file should look:

data-columns.jsonShow/Hide

`data-columns.json` has one large dictionary with the column labels as keys and the corresponding inner dictionaries as values.

You can get a different file structure if you pass an argument for the optional parameter `orient`:

>>>

```
>>> df.to_json('data-index.json', orient='index')
```

The `orient` parameter defaults to `'columns'`. Here, you've set it to `index`.

You should get a new file `data-index.json`. You can expand the code block below to see the changes:

data-index.jsonShow/Hide

`data-index.json` also has one large dictionary, but this time the row labels are the keys, and the inner dictionaries are the values.

There are few more options for `orient`. One of them is `'records'`:

>>>

```
>>> df.to_json('data-records.json', orient='records')
```

This code should yield the file `data-records.json`. You can expand the code block below to see the content:

data-records.jsonShow/Hide

`data-records.json` holds a list with one dictionary for each row. The row labels *are not* written.

You can get another interesting file structure with `orient='split'`:

>>>

```
>>> df.to_json('data-split.json', orient='split')
```

The resulting file is `data-split.json`. You can expand the code block below to see how this file should look:

data-split.jsonShow/Hide

`data-split.json` contains one dictionary that holds the following lists:

- **The names** of the columns
- **The labels** of the rows
- **The inner lists** (two-dimensional sequence) that hold data values

If you don't provide the value for the optional parameter `path_or_buf` that defines the file path, then `.to_json()` will return a JSON string instead of writing the results to a file. This behavior is consistent with `.to_csv()`.

There are other optional parameters you can use. For instance, you can set `index=False` to forgo saving row labels. You can manipulate precision with `double_precision`, and dates with `date_format` and `date_unit`. These last two parameters are particularly important when you have time series among your data:

\>>>

```
>>> df = pd.DataFrame(data=data).T
>>> df['IND_DAY'] = pd.to_datetime(df['IND_DAY'])
>>> df.dtypes
COUNTRY              object
POP                  object
AREA                 object
GDP                  object
CONT                 object
IND_DAY      datetime64[ns]
dtype: object

>>> df.to_json('data-time.json')
```

In this example, you've created the `DataFrame` from the dictionary `data` and used `to_datetime()` to convert the values in the last column to `datetime64`. You can expand the code block below to see the resulting file:

data-time.jsonShow/Hide

In this file, you have large integers instead of dates for the independence days. That's because the default value of the optional parameter `date_format` is `'epoch'` whenever `orient` isn't `'table'`. This default behavior expresses dates as an epoch in milliseconds relative to midnight on January 1, 1970.

However, if you pass `date_format='iso'`, then you'll get the dates in the ISO 8601 format. In addition, `date_unit` decides the units of time:

\>>>

```
>>> df = pd.DataFrame(data=data).T
>>> df['IND_DAY'] = pd.to_datetime(df['IND_DAY'])
>>> df.to_json('new-data-time.json', date_format='iso', date_unit='s')
```

This code produces the following JSON file:

new-data-time.jsonShow/Hide

The dates in the resulting file are in the ISO 8601 format.

You can load the data from a JSON file with `read_json()`:

```
>>>

>>> df = pd.read_json('data-index.json', orient='index',
...                   convert_dates=['IND_DAY'])
```

The parameter `convert_dates` has a similar purpose as `parse_dates` when you use it to read CSV files. The optional parameter `orient` is very important because it specifies how Pandas understands the structure of the file.

There are other optional parameters you can use as well:

- **Set the encoding** with `encoding`.
- **Manipulate dates** with `convert_dates` and `keep_default_dates`.
- **Impact precision** with `dtype` and `precise_float`.
- **Decode numeric data** directly to NumPy arrays with `numpy=True`.

Note that you might lose the order of rows and columns when using the JSON format to store your data.

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HTML Files

An HTML is a plaintext file that uses hypertext markup language to help browsers render web pages. The extensions for HTML files are `.html` and `.htm`. You'll need to install an HTML parser library like lxml or html5lib to be able to work with HTML files:

```
$pip install lxml html5lib
```

You can also use Conda to install the same packages:

```
$ conda install lxml html5lib
```

Once you have these libraries, you can save the contents of your `DataFrame` as an HTML file with `.to_html()`:

```
>>>

df = pd.DataFrame(data=data).T
df.to_html('data.html')
```

This code generates a file `data.html`. You can expand the code block below to see how this file should look:

data.htmlShow/Hide

This file shows the `DataFrame` contents nicely. However, notice that you haven't obtained an entire web page. You've just output the data that corresponds to `df` in the HTML format.

`.to_html()` won't create a file if you don't provide the optional parameter `buf`, which denotes the buffer to write to. If you leave this parameter out, then your code will return a string as it did with `.to_csv()` and `.to_json()`.

Here are some other optional parameters:

- **`header`** determines whether to save the column names.
- **`index`** determines whether to save the row labels.
- **`classes`** assigns cascading style sheet (CSS) classes.
- **`render_links`** specifies whether to convert URLs to HTML links.
- **`table_id`** assigns the CSS `id` to the `table` tag.
- **`escape`** decides whether to convert the characters `<`, `>`, and `&` to HTML-safe strings.

You use parameters like these to specify different aspects of the resulting files or strings.

You can create a `DataFrame` object from a suitable HTML file using `read_html()`, which will return a `DataFrame` instance or a list of them:

```
>>>

>>> df = pd.read_html('data.html', index_col=0, parse_dates=['IND_DAY'])
```

This is very similar to what you did when reading CSV files. You also have parameters that help you work with dates, missing values, precision, encoding, HTML parsers, and more.

Excel Files

You've already learned how to read and write Excel files with Pandas. However, there are a few more options worth considering. For one, when you use `.to_excel()`, you can specify the name of the target worksheet with the optional parameter `sheet_name`:

```
>>>

>>> df = pd.DataFrame(data=data).T
>>> df.to_excel('data.xlsx', sheet_name='COUNTRIES')
```

Here, you create a file `data.xlsx` with a worksheet called `COUNTRIES` that stores the data. The string `'data.xlsx'` is the argument for the parameter `excel_writer` that defines the name of the Excel file or its path.

The optional parameters `startrow` and `startcol` both default to `0` and indicate the upper left-most cell where the data should start being written:

```
>>>

>>> df.to_excel('data-shifted.xlsx', sheet_name='COUNTRIES',
```

```
...                startrow=2, startcol=4)
```

Here, you specify that the table should start in the third row and the fifth column. You also used zero-based indexing, so the third row is denoted by `2` and the fifth column by `4`.

Now the resulting worksheet looks like this:

	A	B	C	D	E	F	G	H	I	J	K
1											
2											
3						**COUNTRY**	**POP**	**AREA**	**GDP**	**CONT**	**IND_DAY**
4					**CHN**	China	1398.72	9596.96	12234.78	Asia	
5					**IND**	India	1351.16	3287.26	2575.67	Asia	1947-08-15
6					**USA**	US	329.74	9833.52	19485.39	N.America	1776-07-04
7					**IDN**	Indonesia	268.07	1910.93	1015.54	Asia	1945-08-17
8					**BRA**	Brazil	210.32	8515.77	2055.51	S.America	1822-09-07
9					**PAK**	Pakistan	205.71	881.91	302.14	Asia	1947-08-14
10					**NGA**	Nigeria	200.96	923.77	375.77	Africa	1960-10-01
11					**BGD**	Bangladesh	167.09	147.57	245.63	Asia	1971-03-26
12					**RUS**	Russia	146.79	17098.25	1530.75		1992-06-12
13					**MEX**	Mexico	126.58	1964.38	1158.23	N.America	1810-09-16
14					**JPN**	Japan	126.22	377.97	4872.42	Asia	
15					**DEU**	Germany	83.02	357.11	3693.2	Europe	
16					**FRA**	France	67.02	640.68	2582.49	Europe	1789-07-14
17					**GBR**	UK	66.44	242.5	2631.23	Europe	
18					**ITA**	Italy	60.36	301.34	1943.84	Europe	
19					**ARG**	Argentina	44.94	2780.4	637.49	S.America	1816-07-09
20					**DZA**	Algeria	43.38	2381.74	167.56	Africa	1962-07-05
21					**CAN**	Canada	37.59	9984.67	1647.12	N.America	1867-07-01
22					**AUS**	Australia	25.47	7692.02	1408.68	Oceania	
23					**KAZ**	Kazakhstan	18.53	2724.9	159.41	Asia	1991-12-16

As you can see, the table starts in the third row `2` and the fifth column `E`.

`.read_excel()` also has the optional parameter `sheet_name` that specifies which worksheets to read when loading data. It can take on one of the following values:

- **The zero-based index** of the worksheet
- **The name** of the worksheet
- **The list** of indices or names to read multiple sheets
- **The value** `None` to read all sheets

Here's how you would use this parameter in your code:

>>>

```
>>> df = pd.read_excel('data.xlsx', sheet_name=0, index_col=0,
...                    parse_dates=['IND_DAY'])
>>> df = pd.read_excel('data.xlsx', sheet_name='COUNTRIES', index_col=0,
...                    parse_dates=['IND_DAY'])
```

Both statements above create the same `DataFrame` because the `sheet_name` parameters have the same values. In both cases, `sheet_name=0` and `sheet_name='COUNTRIES'` refer to the same worksheet. The argument `parse_dates=['IND_DAY']` tells Pandas to try to consider the values in this column as dates or times.

There are other optional parameters you can use with `.read_excel()` and `.to_excel()` to determine the Excel engine, the encoding, the way to handle missing values and infinities, the method for writing column names and row labels, and so on.

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SQL Files

Pandas IO tools can also read and write databases. In this next example, you'll write your data to a database called `data.db`. To get started, you'll need the SQLAlchemy package. To learn more about it, you can read the official ORM tutorial. You'll also need the database driver. Python has a built-in driver for SQLite.

You can install SQLAlchemy with pip:

```
$ pip install sqlalchemy
```

You can also install it with Conda:

```
$ conda install sqlalchemy
```

Once you have SQLAlchemy installed, import `create_engine()` and create a database engine:

>>>

```
>>> from sqlalchemy import create_engine
>>> engine = create_engine('sqlite:///data.db', echo=False)
```

Now that you have everything set up, the next step is to create a `DataFrame` object. It's convenient to specify the data types and apply `.to_sql()`.

>>>

```
>>> dtypes = {'POP': 'float64', 'AREA': 'float64', 'GDP': 'float64',
...           'IND_DAY': 'datetime64'}
>>> df = pd.DataFrame(data=data).T.astype(dtype=dtypes)
>>> df.dtypes
COUNTRY            object
POP               float64
AREA              float64
GDP               float64
CONT               object
IND_DAY    datetime64[ns]
dtype: object
```

`.astype()` is a very convenient method you can use to set multiple data types at once.

Once you've created your `DataFrame`, you can save it to the database with `.to_sql()`:

```
>>>

>>> df.to_sql('data.db', con=engine, index_label='ID')
```

The parameter `con` is used to specify the database connection or engine that you want to use. The optional parameter `index_label` specifies how to call the database column with the row labels. You'll often see it take on the value `ID`, `Id`, or `id`.

You should get the database `data.db` with a single table that looks like this:

	ID	COUNTRY	POP	AREA	GDP	CONT	IND_DAY
	...	Filter	Filter	Filter	Filter	Filter	Filter
1		China	1398.72	9596.96	12234.78	Asia	NULL
2	IND	India	1351.16	3287.26	2575.67	Asia	1947-08-15 00:00:00.000000
3	USA	US	329.74	9833.52	19485.39	N.America	1776-07-04 00:00:00.000000
4	IDN	Indonesia	268.07	1910.93	1015.54	Asia	1945-08-17 00:00:00.000000
5	BRA	Brazil	210.32	8515.77	2055.51	S.America	1822-09-07 00:00:00.000000
6	PAK	Pakistan	205.71	881.91	302.14	Asia	1947-08-14 00:00:00.000000
7	NGA	Nigeria	200.96	923.77	375.77	Africa	1960-10-01 00:00:00.000000
8	BGD	Bangladesh	167.09	147.57	245.63	Asia	1971-03-26 00:00:00.000000
9	RUS	Russia	146.79	17098.25	1530.75	NULL	1992-06-12 00:00:00.000000
10	MEX	Mexico	126.58	1964.38	1158.23	N.America	1810-09-16 00:00:00.000000
11	JPN	Japan	126.22	377.97	4872.42	Asia	NULL
12	DEU	Germany	83.02	357.11	3693.2	Europe	NULL
13	FRA	France	67.02	640.68	2582.49	Europe	1789-07-14 00:00:00.000000
14	GBR	UK	66.44	242.5	2631.23	Europe	NULL
15	ITA	Italy	60.36	301.34	1943.84	Europe	NULL
16	ARG	Argentina	44.94	2780.4	637.49	S.America	1816-07-09 00:00:00.000000
17	DZA	Algeria	43.38	2381.74	167.56	Africa	1962-07-05 00:00:00.000000
18	CAN	Canada	37.59	9984.67	1647.12	N.America	1867-07-01 00:00:00.000000
19	AUS	Australia	25.47	7692.02	1408.68	Oceania	NULL
20	KAZ	Kazakhstan	18.53	2724.9	159.41	Asia	1991-12-16 00:00:00.000000

The first column contains the row labels. To omit writing them into the database, pass `index=False` to `.to_sql()`. The other columns correspond to the columns of the `DataFrame`.

There are a few more optional parameters. For example, you can use `schema` to specify the database schema and `dtype` to determine the types of the database columns. You can also use `if_exists`, which says what to do if a database with the same name and path already exists:

- `if_exists='fail'` raises a [ValueError](#) and is the default.
- `if_exists='replace'` drops the table and inserts new values.
- `if_exists='append'` inserts new values into the table.

You can load the data from the database with `read_sql()`:

>>>

```
>>> df = pd.read_sql('data.db', con=engine, index_col='ID')
>>> df
        COUNTRY      POP      AREA       GDP       CONT    IND_DAY
ID
CHN       China  1398.72   9596.96  12234.78       Asia        NaT
IND       India  1351.16   3287.26   2575.67       Asia 1947-08-15
USA          US   329.74   9833.52  19485.39  N.America 1776-07-04
IDN   Indonesia   268.07   1910.93   1015.54       Asia 1945-08-17
BRA      Brazil   210.32   8515.77   2055.51  S.America 1822-09-07
PAK    Pakistan   205.71    881.91    302.14       Asia 1947-08-14
NGA     Nigeria   200.96    923.77    375.77     Africa 1960-10-01
BGD  Bangladesh   167.09    147.57    245.63       Asia 1971-03-26
RUS      Russia   146.79  17098.25   1530.75       None 1992-06-12
MEX      Mexico   126.58   1964.38   1158.23  N.America 1810-09-16
JPN       Japan   126.22    377.97   4872.42       Asia        NaT
DEU     Germany    83.02    357.11   3693.20     Europe        NaT
FRA      France    67.02    640.68   2582.49     Europe 1789-07-14
GBR          UK    66.44    242.50   2631.23     Europe        NaT
ITA       Italy    60.36    301.34   1943.84     Europe        NaT
ARG   Argentina    44.94   2780.40    637.49  S.America 1816-07-09
DZA     Algeria    43.38   2381.74    167.56     Africa 1962-07-05
CAN      Canada    37.59   9984.67   1647.12  N.America 1867-07-01
AUS   Australia    25.47   7692.02   1408.68    Oceania        NaT
KAZ  Kazakhstan    18.53   2724.90    159.41       Asia 1991-12-16
```

The parameter `index_col` specifies the name of the column with the row labels. Note that this inserts an extra row after the header that starts with `ID`. You can fix this behavior with the following line of code:

>>>

```
>>> df.index.name = None
>>> df
        COUNTRY      POP      AREA       GDP       CONT    IND_DAY
CHN       China  1398.72   9596.96  12234.78       Asia        NaT
```

```
IND       India  1351.16   3287.26   2575.67       Asia 1947-08-15
USA          US   329.74   9833.52  19485.39  N.America 1776-07-04
IDN   Indonesia   268.07   1910.93   1015.54       Asia 1945-08-17
BRA      Brazil   210.32   8515.77   2055.51  S.America 1822-09-07
PAK    Pakistan   205.71    881.91    302.14       Asia 1947-08-14
NGA     Nigeria   200.96    923.77    375.77     Africa 1960-10-01
BGD  Bangladesh   167.09    147.57    245.63       Asia 1971-03-26
RUS      Russia   146.79  17098.25   1530.75       None 1992-06-12
MEX      Mexico   126.58   1964.38   1158.23  N.America 1810-09-16
JPN       Japan   126.22    377.97   4872.42       Asia        NaT
DEU     Germany    83.02    357.11   3693.20     Europe        NaT
FRA      France    67.02    640.68   2582.49     Europe 1789-07-14
GBR          UK    66.44    242.50   2631.23     Europe        NaT
ITA       Italy    60.36    301.34   1943.84     Europe        NaT
ARG   Argentina    44.94   2780.40    637.49  S.America 1816-07-09
DZA     Algeria    43.38   2381.74    167.56     Africa 1962-07-05
CAN      Canada    37.59   9984.67   1647.12  N.America 1867-07-01
AUS   Australia    25.47   7692.02   1408.68    Oceania        NaT
KAZ  Kazakhstan    18.53   2724.90    159.41       Asia 1991-12-16
```

Now you have the same `DataFrame` object as before.

Note that the continent for Russia is now `None` instead of `nan`. If you want to fill the missing values with `nan`, then you can use `.fillna()`:

>>>

```
>>> df.fillna(value=float('nan'), inplace=True)
```

`.fillna()` replaces all missing values with whatever you pass to `value`. Here, you passed `float('nan')`, which says to fill all missing values with `nan`.

Also note that you didn't have to pass `parse_dates=['IND_DAY']` to `read_sql()`. That's because your database was able to detect that the last column contains dates. However, you can pass `parse_dates` if you'd like. You'll get the same results.

There are other functions that you can use to read databases, like `read_sql_table()` and `read_sql_query()`. Feel free to try them out!

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Pickle Files

Pickling is the act of converting Python objects into byte streams. Unpickling is the inverse process. Python pickle files are the binary files that keep the data and hierarchy of Python objects. They usually have the extension `.pickle` or `.pkl`.

You can save your `DataFrame` in a pickle file with `.to_pickle()`:

>>>

```
>>> dtypes = {'POP': 'float64', 'AREA': 'float64', 'GDP': 'float64',
...           'IND_DAY': 'datetime64'}
>>> df = pd.DataFrame(data=data).T.astype(dtype=dtypes)
>>> df.to_pickle('data.pickle')
```

Like you did with databases, it can be convenient first to specify the data types. Then, you create a file `data.pickle` to contain your data. You could also pass an integer value to the optional parameter `protocol`, which specifies the protocol of the pickler.

You can get the data from a pickle file with `read_pickle()`:

>>>

```
>>> df = pd.read_pickle('data.pickle')
>>> df
       COUNTRY      POP      AREA       GDP       CONT    IND_DAY
CHN      China  1398.72   9596.96  12234.78       Asia        NaT
IND      India  1351.16   3287.26   2575.67       Asia 1947-08-15
USA         US   329.74   9833.52  19485.39  N.America 1776-07-04
IDN  Indonesia   268.07   1910.93   1015.54       Asia 1945-08-17
BRA     Brazil   210.32   8515.77   2055.51  S.America 1822-09-07
PAK   Pakistan   205.71    881.91    302.14       Asia 1947-08-14
NGA    Nigeria   200.96    923.77    375.77     Africa 1960-10-01
BGD Bangladesh   167.09    147.57    245.63       Asia 1971-03-26
RUS     Russia   146.79  17098.25   1530.75        NaN 1992-06-12
MEX     Mexico   126.58   1964.38   1158.23  N.America 1810-09-16
JPN      Japan   126.22    377.97   4872.42       Asia        NaT
DEU    Germany    83.02    357.11   3693.20     Europe        NaT
FRA     France    67.02    640.68   2582.49     Europe 1789-07-14
GBR         UK    66.44    242.50   2631.23     Europe        NaT
ITA      Italy    60.36    301.34   1943.84     Europe        NaT
ARG  Argentina    44.94   2780.40    637.49  S.America 1816-07-09
DZA    Algeria    43.38   2381.74    167.56     Africa 1962-07-05
CAN     Canada    37.59   9984.67   1647.12  N.America 1867-07-01
AUS  Australia    25.47   7692.02   1408.68    Oceania        NaT
```

```
KAZ   Kazakhstan     18.53    2724.90     159.41        Asia 1991-12-16
```
`read_pickle()` returns the `DataFrame` with the stored data. You can also check the data types:

```
>>>
```

```
>>> df.dtypes
COUNTRY              object
POP                 float64
AREA                float64
GDP                 float64
CONT                 object
IND_DAY      datetime64[ns]
dtype: object
```
These are the same ones that you specified before using `.to_pickle()`.

As a word of caution, you should always beware of loading pickles from untrusted sources. **This can be dangerous!** When you unpickle an untrustworthy file, it could execute arbitrary code on your machine, gain remote access to your computer, or otherwise exploit your device in other ways.

Working With Big Data

If your files are too large for saving or processing, then there are several approaches you can take to reduce the required disk space:

- **Compress** your files
- **Choose** only the columns you want
- **Omit** the rows you don't need
- **Force** the use of less precise data types
- **Split** the data into chunks

You'll take a look at each of these techniques in turn.

Compress and Decompress Files

You can create an archive file like you would a regular one, with the addition of a suffix that corresponds to the desired compression type:

- `'.gz'`
- `'.bz2'`
- `'.zip'`
- `'.xz'`

Pandas can deduce the compression type by itself:

```
>>>
```

```
>>> df = pd.DataFrame(data=data).T
```

```
>>> df.to_csv('data.csv.zip')
```

Here, you create a compressed `.csv` file as an archive. The size of the regular `.csv` file is 1048 bytes, while the compressed file only has 766 bytes.

You can open this compressed file as usual with the Pandas `read_csv()` function:

```
>>>
```

```
>>> df = pd.read_csv('data.csv.zip', index_col=0,
...                  parse_dates=['IND_DAY'])
>>> df
        COUNTRY      POP      AREA       GDP       CONT    IND_DAY
CHN       China  1398.72   9596.96  12234.78       Asia        NaT
IND       India  1351.16   3287.26   2575.67       Asia 1947-08-15
USA          US   329.74   9833.52  19485.39  N.America 1776-07-04
IDN   Indonesia   268.07   1910.93   1015.54       Asia 1945-08-17
BRA      Brazil   210.32   8515.77   2055.51  S.America 1822-09-07
PAK    Pakistan   205.71    881.91    302.14       Asia 1947-08-14
NGA     Nigeria   200.96    923.77    375.77     Africa 1960-10-01
BGD  Bangladesh   167.09    147.57    245.63       Asia 1971-03-26
RUS      Russia   146.79  17098.25   1530.75        NaN 1992-06-12
MEX      Mexico   126.58   1964.38   1158.23  N.America 1810-09-16
JPN       Japan   126.22    377.97   4872.42       Asia        NaT
DEU     Germany    83.02    357.11   3693.20     Europe        NaT
FRA      France    67.02    640.68   2582.49     Europe 1789-07-14
GBR          UK    66.44    242.50   2631.23     Europe        NaT
ITA       Italy    60.36    301.34   1943.84     Europe        NaT
ARG   Argentina    44.94   2780.40    637.49  S.America 1816-07-09
DZA     Algeria    43.38   2381.74    167.56     Africa 1962-07-05
CAN      Canada    37.59   9984.67   1647.12  N.America 1867-07-01
AUS   Australia    25.47   7692.02   1408.68    Oceania        NaT
KAZ  Kazakhstan    18.53   2724.90    159.41       Asia 1991-12-16
```

`read_csv()` decompresses the file before reading it into a `DataFrame`.

You can specify the type of compression with the optional parameter `compression`, which can take on any of the following values:

- `'infer'`
- `'gzip'`
- `'bz2'`
- `'zip'`
- `'xz'`
- `None`

The default value `compression='infer'` indicates that Pandas should deduce the compression type from the file extension.

Here's how you would compress a pickle file:

>>>

```
>>> df = pd.DataFrame(data=data).T
>>> df.to_pickle('data.pickle.compress', compression='gzip')
```

You should get the file `data.pickle.compress` that you can later decompress and read:

>>>

```
>>> df = pd.read_pickle('data.pickle.compress', compression='gzip')
```

`df` again corresponds to the `DataFrame` with the same data as before.

You can give the other compression methods a try, as well. If you're using pickle files, then keep in mind that the `.zip` format supports reading only.

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Choose Columns

The Pandas `read_csv()` and `read_excel()` functions have the optional parameter `usecols` that you can use to specify the columns you want to load from the file. You can pass the list of column names as the corresponding argument:

>>>

```
>>> df = pd.read_csv('data.csv', usecols=['COUNTRY', 'AREA'])
>>> df
       COUNTRY      AREA
0        China   9596.96
1        India   3287.26
2           US   9833.52
3    Indonesia   1910.93
4       Brazil   8515.77
5     Pakistan    881.91
6      Nigeria    923.77
7   Bangladesh    147.57
8       Russia  17098.25
9       Mexico   1964.38
10       Japan    377.97
11     Germany    357.11
```

```
12       France    640.68
13           UK    242.50
14        Italy    301.34
15    Argentina   2780.40
16      Algeria   2381.74
17       Canada   9984.67
18    Australia   7692.02
19   Kazakhstan   2724.90
```

Now you have a `DataFrame` that contains less data than before. Here, there are only the names of the countries and their areas.

Instead of the column names, you can also pass their indices:

>>>

```
>>> df = pd.read_csv('data.csv',index_col=0, usecols=[0, 1, 3])
>>> df
        COUNTRY      AREA
CHN       China   9596.96
IND       India   3287.26
USA          US   9833.52
IDN   Indonesia   1910.93
BRA      Brazil   8515.77
PAK    Pakistan    881.91
NGA     Nigeria    923.77
BGD  Bangladesh    147.57
RUS      Russia  17098.25
MEX      Mexico   1964.38
JPN       Japan    377.97
DEU     Germany    357.11
FRA      France    640.68
GBR          UK    242.50
ITA       Italy    301.34
ARG   Argentina   2780.40
DZA     Algeria   2381.74
CAN      Canada   9984.67
AUS   Australia   7692.02
KAZ  Kazakhstan   2724.90
```

Expand the code block below to compare these results with the file `'data.csv'`:

data.csvShow/Hide

You can see the following columns:

- The column at **index `0`** contains the row labels.
- The column at **index `1`** contains the country names.
- The column at **index `3`** contains the areas.

Simlarly, `read_sql()` has the optional parameter `columns` that takes a list of column names to read:

>>>

```
>>> df = pd.read_sql('data.db', con=engine, index_col='ID',
...                  columns=['COUNTRY', 'AREA'])
>>> df.index.name = None
>>> df
        COUNTRY      AREA
CHN       China   9596.96
IND       India   3287.26
USA          US   9833.52
IDN   Indonesia   1910.93
BRA      Brazil   8515.77
PAK    Pakistan    881.91
NGA     Nigeria    923.77
BGD  Bangladesh    147.57
RUS      Russia  17098.25
MEX      Mexico   1964.38
JPN       Japan    377.97
DEU     Germany    357.11
FRA      France    640.68
GBR          UK    242.50
ITA       Italy    301.34
ARG   Argentina   2780.40
DZA     Algeria   2381.74
CAN      Canada   9984.67
AUS   Australia   7692.02
KAZ  Kazakhstan   2724.90
```

Again, the `DataFrame` only contains the columns with the names of the countries and areas. If `columns` is `None` or omitted, then all of the columns will be read, as [you saw before](). The default behavior is `columns=None`.

Omit Rows

When you test an algorithm for data processing or machine learning, you often don't need the entire dataset. It's convenient to load only a subset of the data to speed up the process. The

Pandas `read_csv()` and `read_excel()` functions have some optional parameters that allow you to select which rows you want to load:

- **`skiprows`:** either the number of rows to skip at the beginning of the file if it's an integer, or the zero-based indices of the rows to skip if it's a list-like object
- **`skipfooter`:** the number of rows to skip at the end of the file
- **`nrows`:** the number of rows to read

Here's how you would skip rows with odd zero-based indices, keeping the even ones:

>>>

```
>>> df = pd.read_csv('data.csv', index_col=0, skiprows=range(1, 20, 2))
>>> df
        COUNTRY      POP     AREA      GDP       CONT     IND_DAY
IND       India  1351.16  3287.26  2575.67       Asia  1947-08-15
IDN   Indonesia   268.07  1910.93  1015.54       Asia  1945-08-17
PAK    Pakistan   205.71   881.91   302.14       Asia  1947-08-14
BGD  Bangladesh   167.09   147.57   245.63       Asia  1971-03-26
MEX      Mexico   126.58  1964.38  1158.23  N.America  1810-09-16
DEU     Germany    83.02   357.11  3693.20     Europe         NaN
GBR          UK    66.44   242.50  2631.23     Europe         NaN
ARG   Argentina    44.94  2780.40   637.49  S.America  1816-07-09
CAN      Canada    37.59  9984.67  1647.12  N.America  1867-07-01
KAZ  Kazakhstan    18.53  2724.90   159.41       Asia  1991-12-16
```

In this example, `skiprows` is `range(1, 20, 2)` and corresponds to the values `1`, `3`, …, `19`. The instances of the Python built-in class `range` behave like sequences. The first row of the file `data.csv` is the header row. It has the index `0`, so Pandas loads it in. The second row with index `1` corresponds to the label `CHN`, and Pandas skips it. The third row with the index `2` and label `IND` is loaded, and so on.

If you want to choose rows randomly, then `skiprows` can be a list or NumPy array with pseudo-random numbers, obtained either with pure Python or with NumPy.

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Force Less Precise Data Types

If you're okay with less precise data types, then you can potentially save a significant amount of memory! First, get the data types with `.dtypes` again:

>>>

```
>>> df = pd.read_csv('data.csv', index_col=0, parse_dates=['IND_DAY'])
>>> df.dtypes
```

```
COUNTRY            object
POP               float64
AREA              float64
GDP               float64
CONT               object
IND_DAY    datetime64[ns]
dtype: object
```

The columns with the floating-point numbers are 64-bit floats. Each number of this type `float64` consumes 64 bits or 8 bytes. Each column has 20 numbers and requires 160 bytes. You can verify this with `.memory_usage()`:

```
>>>

>>> df.memory_usage()
Index       160
COUNTRY     160
POP         160
AREA        160
GDP         160
CONT        160
IND_DAY     160
dtype: int64
```

`.memory_usage()` returns an instance of `Series` with the memory usage of each column in bytes. You can conveniently combine it with `.loc[]` and `.sum()` to get the memory for a group of columns:

```
>>>

>>> df.loc[:, ['POP', 'AREA', 'GDP']].memory_usage(index=False).sum()
480
```

This example shows how you can combine the numeric columns `'POP'`, `'AREA'`, and `'GDP'` to get their total memory requirement. The argument `index=False` excludes data for row labels from the resulting `Series` object. For these three columns, you'll need 480 bytes.

You can also extract the data values in the form of a NumPy array with `.to_numpy()` or `.values`. Then, use the `.nbytes` attribute to get the total bytes consumed by the items of the array:

```
>>>

>>> df.loc[:, ['POP', 'AREA', 'GDP']].to_numpy().nbytes
480
```

The result is the same 480 bytes. So, how do you save memory?

In this case, you can specify that your numeric columns 'POP', 'AREA', and 'GDP' should have the type float32. Use the optional parameter dtype to do this:

>>>

```
>>> dtypes = {'POP': 'float32', 'AREA': 'float32', 'GDP': 'float32'}
>>> df = pd.read_csv('data.csv', index_col=0, dtype=dtypes,
...                  parse_dates=['IND_DAY'])
```

The dictionary dtypes specifies the desired data types for each column. It's passed to the Pandas read_csv() function as the argument that corresponds to the parameter dtype.

Now you can verify that each numeric column needs 80 bytes, or 4 bytes per item:

>>>

```
>>> df.dtypes
COUNTRY            object
POP               float32
AREA              float32
GDP               float32
CONT               object
IND_DAY    datetime64[ns]
dtype: object
>>> df.memory_usage()
Index      160
COUNTRY    160
POP         80
AREA        80
GDP         80
CONT       160
IND_DAY    160
dtype: int64
>>> df.loc[:, ['POP', 'AREA', 'GDP']].memory_usage(index=False).sum()
240
>>> df.loc[:, ['POP', 'AREA', 'GDP']].to_numpy().nbytes
240
```

Each value is a floating-point number of 32 bits or 4 bytes. The three numeric columns contain 20 items each. In total, you'll need 240 bytes of memory when you work with the type float32. This is half the size of the 480 bytes you'd need to work with float64.

In addition to saving memory, you can significantly reduce the time required to process data by using float32 instead of float64 in some cases.

Use Chunks to Iterate Through Files

Another way to deal with very large datasets is to split the data into smaller **chunks** and process one chunk at a time. If you use `read_csv()`, `read_json()` or `read_sql()`, then you can specify the optional parameter `chunksize`:

```
>>>
```

```
>>> data_chunk = pd.read_csv('data.csv', index_col=0, chunksize=8)
>>> type(data_chunk)
<class 'pandas.io.parsers.TextFileReader'>
>>> hasattr(data_chunk, '__iter__')
True
>>> hasattr(data_chunk, '__next__')
True
```

`chunksize` defaults to `None` and can take on an integer value that indicates the number of items in a single chunk. When `chunksize` is an integer, `read_csv()` returns an iterable that you can use in a [`for` loop]() to get and process only a fragment of the dataset in each iteration:

```
>>>
```

```
>>> for df_chunk in pd.read_csv('data.csv', index_col=0, chunksize=8):
...     print(df_chunk, end='\n\n')
...     print('memory:', df_chunk.memory_usage().sum(), 'bytes',
...           end='\n\n\n')
...
        COUNTRY     POP     AREA       GDP       CONT     IND_DAY
CHN       China  1398.72  9596.96  12234.78       Asia         NaN
IND       India  1351.16  3287.26   2575.67       Asia  1947-08-15
USA          US   329.74  9833.52  19485.39  N.America  1776-07-04
IDN   Indonesia   268.07  1910.93   1015.54       Asia  1945-08-17
BRA      Brazil   210.32  8515.77   2055.51  S.America  1822-09-07
PAK    Pakistan   205.71   881.91    302.14       Asia  1947-08-14
NGA     Nigeria   200.96   923.77    375.77     Africa  1960-10-01
BGD  Bangladesh   167.09   147.57    245.63       Asia  1971-03-26

memory: 448 bytes



       COUNTRY     POP      AREA      GDP       CONT     IND_DAY
RUS     Russia  146.79  17098.25  1530.75        NaN  1992-06-12
MEX     Mexico  126.58   1964.38  1158.23  N.America  1810-09-16
JPN      Japan  126.22    377.97  4872.42       Asia         NaN
```

```
DEU    Germany   83.02    357.11  3693.20     Europe         NaN
FRA     France   67.02    640.68  2582.49     Europe  1789-07-14
GBR         UK   66.44    242.50  2631.23     Europe         NaN
ITA      Italy   60.36    301.34  1943.84     Europe         NaN
ARG  Argentina   44.94   2780.40   637.49  S.America  1816-07-09

memory: 448 bytes



        COUNTRY    POP     AREA      GDP       CONT     IND_DAY
DZA     Algeria  43.38  2381.74   167.56     Africa  1962-07-05
CAN      Canada  37.59  9984.67  1647.12  N.America  1867-07-01
AUS   Australia  25.47  7692.02  1408.68    Oceania         NaN
KAZ  Kazakhstan  18.53  2724.90   159.41       Asia  1991-12-16

memory: 224 bytes
```
In this example, the `chunksize` is `8`. The first iteration of the `for` loop returns a `DataFrame` with the first eight rows of the dataset only. The second iteration returns another `DataFrame` with the next eight rows. The third and last iteration returns the remaining four rows.

Select Rows from Pandas DataFrame

May 29, 2021

Need to select rows from Pandas DataFrame?

If so, you'll see the full steps to select rows from Pandas DataFrame based on the conditions specified.

Steps to Select Rows from Pandas DataFrame

Step 1: Gather your data

Firstly, you'll need to gather your data. Here is an example of a data gathered about *boxes:*

Color	**Shape**
Green	Rectangle
Green	Rectangle
Green	Square
Blue	Rectangle
Blue	Square
Red	Square
Red	Square
Red	Rectangle

Step 2: Create a DataFrame

Once you have your data ready, you'll need to create a DataFrame to capture that data in Python.
For our example, you may use the code below to create a DataFrame:

```
import pandas as pd



boxes = {'Color':
['Green','Green','Green','Blue','Blue','Red','Red','Red']
,

         'Shape':
['Rectangle','Rectangle','Square','Rectangle','Square','S
quare','Square','Rectangle'],

         'Price': [10,15,5,5,10,15,15,5]

        }



df = pd.DataFrame(boxes, columns=
['Color','Shape','Price'])

print (df)
```

Run the code in Python and you'll see this DataFrame:

```
   Color      Shape  Price
0  Green  Rectangle     10
1  Green  Rectangle     15
2  Green     Square      5
3   Blue  Rectangle      5
4   Blue     Square     10
5    Red     Square     15
6    Red     Square     15
7    Red  Rectangle      5
```

Step 3: Select Rows from Pandas DataFrame

You can use the following logic to select rows from Pandas DataFrame based on specified conditions:

df.loc[df['column name'] condition]

For example, if you want to get the rows where the *color is green*, then you'll need to apply:

df.loc[df['Color'] == 'Green']

Where:

- **Color** is the column name
- **Green** is the condition

And here is the full Python code for our example:

```
import pandas as pd



boxes = {'Color':
['Green','Green','Green','Blue','Blue','Red','Red','Red']
,

         'Shape':
['Rectangle','Rectangle','Square','Rectangle','Square','S
quare','Square','Rectangle'],

         'Price': [10,15,5,5,10,15,15,5]

        }



df = pd.DataFrame(boxes, columns=
['Color','Shape','Price'])



select_color = df.loc[df['Color'] == 'Green']

print (select_color)
```

Once you run the code, you'll get the rows where the color is green:

```
   Color      Shape  Price
0  Green  Rectangle     10
1  Green  Rectangle     15
2  Green     Square      5
```

Additional Examples of Selecting Rows from Pandas DataFrame

Let's now review additional examples to get a better sense of selecting rows from Pandas DataFrame.

Example 1: Select rows where the price is equal or greater than 10

To get all the rows where the price is equal or greater than 10, you'll need to apply this condition:

df.loc[df['Price'] >= 10]

And this is the complete Python code:

```
import pandas as pd



boxes = {'Color':
['Green','Green','Green','Blue','Blue','Red','Red','Red']
,

         'Shape':
['Rectangle','Rectangle','Square','Rectangle','Square','S
quare','Square','Rectangle'],

         'Price': [10,15,5,5,10,15,15,5]

        }
```

```
df = pd.DataFrame(boxes, columns=
['Color','Shape','Price'])



select_price = df.loc[df['Price'] >= 10]

print (select_price)
```

Run the code, and you'll get all the rows where the price is equal or greater than 10:

```
   Color      Shape  Price
0  Green  Rectangle     10
1  Green  Rectangle     15
4   Blue     Square     10
5    Red     Square     15
6    Red     Square     15
```

Example 2: Select rows where the color is green AND the shape is rectangle

Now the goal is to select rows based on *two* conditions:

- Color is green; *and*
- Shape is rectangle

You may then use the **&** symbol to apply multiple conditions. In our example, the code would look like this:

df.loc[(df['Color'] == 'Green') & (df['Shape'] == 'Rectangle')]

Putting everything together:

```
import pandas as pd



boxes = {'Color':
['Green','Green','Green','Blue','Blue','Red','Red','Red']
,
```

```
         'Shape':
['Rectangle','Rectangle','Square','Rectangle','Square','S
quare','Square','Rectangle'],

         'Price': [10,15,5,5,10,15,15,5]

        }



df = pd.DataFrame(boxes, columns=
['Color','Shape','Price'])



color_and_shape = df.loc[(df['Color'] == 'Green') &
(df['Shape'] == 'Rectangle')]

print (color_and_shape)
```

Run the code and you'll get the rows with the green color *and* rectangle shape:

```
   Color      Shape  Price
0  Green  Rectangle     10
1  Green  Rectangle     15
```

Example 3: Select rows where the color is green OR the shape is rectangle

You can also select the rows based on one condition *or* another. For instance, you can select the rows if the color is green *or* the shape is rectangle.

To achieve this goal, you can use the | symbol as follows:

df.loc[(df['Color'] == 'Green') | (df['Shape'] == 'Rectangle')]

And here is the complete Python code:

```
import pandas as pd
```

```
boxes = {'Color':
['Green','Green','Green','Blue','Blue','Red','Red','Red']
,

         'Shape':
['Rectangle','Rectangle','Square','Rectangle','Square','S
quare','Square','Rectangle'],

         'Price': [10,15,5,5,10,15,15,5]

        }



df = pd.DataFrame(boxes, columns=
['Color','Shape','Price'])



color_or_shape = df.loc[(df['Color'] == 'Green') |
(df['Shape'] == 'Rectangle')]

print (color_or_shape)
```

Here is the result, where the color is green or the shape is rectangle:

```
   Color      Shape  Price
0  Green  Rectangle     10
1  Green  Rectangle     15
2  Green     Square      5
3   Blue  Rectangle      5
7    Red  Rectangle      5
```

Example 4: Select rows where the price is not equal to 15

You can use the combination of symbols **!=** to select the rows where the price is *not equal* to 15:

df.loc[df['Price'] != 15]

```
import pandas as pd
```

```
boxes = {'Color':
['Green','Green','Green','Blue','Blue','Red','Red','Red']
,

         'Shape':
['Rectangle','Rectangle','Square','Rectangle','Square','S
quare','Square','Rectangle'],

         'Price': [10,15,5,5,10,15,15,5]

        }



df = pd.DataFrame(boxes, columns=
['Color','Shape','Price'])



not_eqaul_to = df.loc[df['Price'] != 15]

print (not_eqaul_to)
```

Once you run the code, you'll get all the rows where the price is not equal to 15:

```
   Color      Shape  Price
0  Green  Rectangle     10
2  Green     Square      5
3   Blue  Rectangle      5
4   Blue     Square     10
7    Red  Rectangle      5
```

Statistical Language - Measures of Central Tendency

Calculate the average, variance and standard deviation in Python using NumPy

Difficulty Level : Basic

Last Updated : 08 Oct, 2021

Numpy in Python is a general-purpose array-processing package. It provides a high-performance multidimensional array object and tools for working with these arrays. It is the fundamental package for scientific computing with Python. Numpy provides very easy methods to calculate the average, variance, and standard deviation.

Average

Average a number expressing the central or typical value in a set of data, in particular the mode, median, or (most commonly) the mean, which is calculated by dividing the sum of the values in the set by their number. The basic formula for the average of n numbers x1, x2, ……xn is

$A = (x_1 + x_2 .... + x_n)/ n$

Example:

Suppose there are 8 data points,

$2,\ 4,\ 4,\ 4,\ 5,\ 5,\ 7,\ 9$

The average of these 8 data points is,

$A = \frac{2 + 4 + 4 + 4 + 5 + 5 + 7 + 9}{8} = 5$

Average in Python Using Numpy:

One can calculate the average by using numpy.average() function in python.

Syntax:

numpy.average(a, axis=None, weights=None, returned=False)

Parameters:

a: Array containing data to be averaged

axis: Axis or axes along which to average a

weights: An array of weights associated with the values in a

returned: Default is False. If True, the tuple is returned, otherwise only the average is returned

Example 1:

```
# Python program to get average of a list

# Importing the NumPy module
import numpy as np
```

```
# Taking a list of elements
list = [2, 4, 4, 4, 5, 5, 7, 9]

# Calculating average using average()
print(np.average(list))
```

Output:

```
5.0
```

Example 2:

```
# Python program to get average of a list

# Importing the NumPy module
import numpy as np

# Taking a list of elements
list = [2, 40, 2, 502, 177, 7, 9]

# Calculating average using average()
print(np.average(list))
```

Output:

```
105.57142857142857
```

Variance

Variance is the sum of squares of differences between all numbers and means. The mathematical formula for variance is as follows,

Formula: \sigma^{2}= \frac { \sum_{i=1}^{N} (x_{i}-\mu)^{2}}{N}

Where,

? is Mean,

N is the total number of elements or frequency of distribution.

Example:

Let’s consider the same dataset that we have taken in average. First, calculate the deviations of each data point from the mean, and square the result of each,

$$\begin{array}{lll} (2-5)^2 = (-3)^2 = 9 && (5-5)^2 = 0^2 = 0 \\ (4-5)^2 = (-1)^2 = 1 && (5-5)^2 = 0^2 = 0 \\ (4-5)^2 = (-1)^2 = 1 && (7-5)^2 = 2^2 = 4 \\ (4-5)^2 = (-1)^2 = 1 && (9-5)^2 = 4^2 = 16. \\ \end{array}$$

$$variance = \frac{9 + 1 + 1 + 1 + 0 + 0 + 4 + 16}{8} = 4$$

Variance in Python Using Numpy:

One can calculate the variance by using numpy.var() function in python.

Syntax:

numpy.var(a, axis=None, dtype=None, out=None, ddof=0, keepdims=<no value>)

Parameters:

a: Array containing data to be averaged

axis: Axis or axes along which to average a

dtype: Type to use in computing the variance.

out: Alternate output array in which to place the result.

ddof: Delta Degrees of Freedom

keepdims: If this is set to True, the axes which are reduced are left in the result as dimensions with size one

Example 1:

```
# Python program to get variance of a list

# Importing the NumPy module
import numpy as np

# Taking a list of elements
list = [2, 4, 4, 4, 5, 5, 7, 9]

# Calculating variance using var()
```

```
print(np.var(list))
```

Output:

```
4.0
```

Example 2:

```
# Python program to get variance of a list

# Importing the NumPy module
import numpy as np

# Taking a list of elements
list = [212, 231, 234, 564, 235]

# Calculating variance using var()
print(np.var(list))
```

Output:

```
18133.359999999997
```

Standard Deviation

Standard Deviation is the square root of variance. It is a measure of the extent to which data varies from the mean. The mathematical formula for calculating standard deviation is as follows,

Standard Deviation = \sqrt{ variance }

Example:

Standard Deviation for the above data,

Standard Deviation = \sqrt{ 4 } = 2

Standard Deviation in Python Using Numpy:

One can calculate the standard deviation by using numpy.std() function in python.

Syntax:

numpy.std(a, axis=None, dtype=None, out=None, ddof=0, keepdims=<no value>)

Parameters:

a: Array containing data to be averaged

axis: Axis or axes along which to average a

dtype: Type to use in computing the variance.

out: Alternate output array in which to place the result.

ddof: Delta Degrees of Freedom

keepdims: If this is set to True, the axes which are reduced are left in the result as dimensions with size one

Example 1:

```
# Python program to get
# standard deviation of a list

# Importing the NumPy module
import numpy as np

# Taking a list of elements
list = [2, 4, 4, 4, 5, 5, 7, 9]

# Calculating standard
# deviation using var()
print(np.std(list))
```

Output:

2.0

Example 2:

```
# Python program to get
# standard deviation of a list

# Importing the NumPy module
import numpy as np

# Taking a list of elements
```

```
list = [290, 124, 127, 899]

# Calculating standard
# deviation using var()
print(np.std(list))
```

Output:

```
318.35750344541907
```

Pandas head

Pandas DataFrame head() method returns the top n rows of a **DataFrame** or **Series** where n is a user input value. The **head()** function is used to get the first n rows. It is helpful for quickly testing if your object has the right type of data in it. For negative values of *n*, the head() function returns all rows except the last *n* rows, equivalent to df[:-n].

Syntax

```
DataFrame.head(n=5)  (n=5 is default we can set any value)
```

Parameters

The head() method in python contains only one parameter, n. It is an optional parameter. By setting it, we fix the number of rows we want from the **DataFrame**.

Return Value

The head() function returns n rows from the **DataFrame**.

Example

Write a program to show the working of the head().

PLAY

UNMUTE

%1.01 :Loaded

FULLSCREEN

```
import pandas as pd

import numpy as np


data_set = pd.DataFrame({'Name': ['Rohit', 'Mohit', 'Shubh', 'Pranav', 'Shivam',
'Prince'],

                         'Class': ['10', '09', '11', '12', '05', '07']})

print(data_set.head(5))
```

Output

```
Name Class
```

```
0   Rohit    10
1   Mohit    09
2   Shubh    11
3  Pranav    12
4  Shivam    05
```

Here we can see that we have created a DataFrame data_set, which holds the values as names of 6 students and their respective classes in which they study.

Suppose we want to extract the data of only the top 5 students and not all the students. When this problem arises, we can use the head() method, defined in the Pandas library, to extract the top n rows of a dataset.

Write a program to use the head() function when the DataFrame consists of 5 columns.

```
import pandas as pd

import numpy as np

data_frame = pd.DataFrame({'Name': ['Rohit', 'Mohit', 'Shubh', 'Pranav', 'Shivam', 'Prince'],

                           'Class': ['10', '09', '11', '12', '05', '07'], 'Roll no': ['25', '37', '48', '47', '46', '35'], 'Fav Subject': ['C++', 'Python', 'Kotlin', 'C', 'Java', 'C#'], 'Favourite Sports': ['Football', 'Basketball', 'Hockey', 'Cricket', 'Handball', 'Soccer']})

print("DataFrame::\n")

print(data_frame)

print("\n")

print("Top 3 students::")

print("\n")

print(data_frame.head(3))
```

Output

```
DataFrame::


     Name Class Roll no Fav Subject Favourite Sports
0   Rohit    10      25         C++         Football
1   Mohit    09      37      Python       Basketball
2   Shubh    11      48      Kotlin           Hockey
3  Pranav    12      47           C          Cricket
4  Shivam    05      46        Java         Handball
5  Prince    07      35          C#           Soccer
```

```
Top 3 students::

    Name Class Roll no Fav Subject Favourite Sports
0  Rohit    10      25         C++         Football
1  Mohit    09      37      Python       Basketball
2  Shubh    11      48      Kotlin           Hockey
```

Here we can see five columns in the **DataFrame,** and with the help of the head function, we are showing the data of the top 3 students.

Passing no arguments to head() Function

If you don't pass any argument to the **DataFrame head()** function, you will get the default first five rows in return.

```
import pandas as pd
import numpy as np

data_frame = pd.DataFrame({'Name': ['Rohit', 'Mohit', 'Shubh', 'Pranav', 'Shivam', 'Prince'],
                           'Class': ['10', '09', '11', '12', '05', '07'], 'Roll no': ['25', '37', '48', '47', '46', '35'], 'Fav Subject': ['C++', 'Python', 'Kotlin', 'C', 'Java', 'C#'], 'Favourite Sports': ['Football', 'Basketball', 'Hockey', 'Cricket', 'Handball', 'Soccer']})

print("DataFrame::\n")
print(data_frame)
print("\n")
print(data_frame.head())
```

Output

```
DataFrame::

     Name Class Roll no Fav Subject Favourite Sports
0    Rohit    10      25         C++         Football
1    Mohit    09      37      Python       Basketball
2    Shubh    11      48      Kotlin           Hockey
3   Pranav    12      47           C          Cricket
4   Shivam    05      46        Java         Handball
```

```
5   Prince     07       35           C#           Soccer



     Name  Class  Roll  no  Fav  Subject  Favourite  Sports
0    Rohit     10       25          C++           Football
1    Mohit     09       37       Python         Basketball
2    Shubh     11       48       Kotlin             Hockey
3   Pranav     12       47            C            Cricket
4   Shivam     05       46         Java           Handball
```

Passing negative arguments to head() Function

Let's pass the negative arguments to the head() function and see the result.

```
import pandas as pd
import numpy as np


data_frame = pd.DataFrame({'Name': ['Rohit', 'Mohit', 'Shubh', 'Pranav', 'Shivam', 'Prince'],
                           'Class': ['10', '09', '11', '12', '05', '07'], 'Roll no': ['25', '37', '48', '47', '46', '35'], 'Fav Subject': ['C++', 'Python', 'Kotlin', 'C', 'Java', 'C#'], 'Favourite Sports': ['Football', 'Basketball', 'Hockey', 'Cricket', 'Handball', 'Soccer']})


print("DataFrame::\n")
print(data_frame)
print("\n")
print(data_frame.head(-4))
```

Output

```
DataFrame::


     Name  Class  Roll  no  Fav  Subject  Favourite  Sports
0    Rohit     10       25          C++           Football
1    Mohit     09       37       Python         Basketball
2    Shubh     11       48       Kotlin             Hockey
3   Pranav     12       47            C            Cricket
4   Shivam     05       46         Java           Handball
```

```
5  Prince    07      35          C#           Soccer



    Name Class Roll no Fav Subject Favourite Sports
0  Rohit    10      25          C++          Football
1  Mohit    09      37       Python        Basketball
```

From the output, you can see that it returns the first two rows. That means it won't count the last four rows. So, if you have passed **-5,** it won't count the last five rows and returns the first row.

Pandas Series head()

Pandas Series head() method is called on series with custom input of n parameter to return the top n rows of the series.

```
import pandas as pd
import numpy as np


df = pd.DataFrame({'Name': ['Rohit', 'Mohit', 'Shubh', 'Pranav', 'Shivam', 'Prince'],
                   'Class': ['10', '09', '11', '12', '05', '07'],
                   'Roll no': ['25', '37', '48', '47', '46', '35'],
                   'Fav Subject': ['C++', 'Python', 'Kotlin', 'C', 'Java', 'C#'],
                   'Favourite Sports': ['Football', 'Basketball', 'Hockey', 'Cricket', 'Handball', 'Soccer']})


series = df['Favourite Sports']
top5 = series.head()
print(top5)
```

Output

```
0      Football
1    Basketball
2        Hockey
3       Cricket
4      Handball
Name: Favourite Sports, dtype: object
```

DataFrame - tail() function

The tail() function is used to get the last n rows.

This function returns last n rows from the object based on position. It is useful for quickly verifying data, for example, after sorting or appending rows.

Syntax:

```
DataFrame.tail(self, n=5)
```

Parameters:

Name	Description	Type/Default Value	Required / Optional
n	Number of rows to select.	int Default Value: 5	Required

Returns: type of caller
The last n rows of the caller object.

Example:

DataFrame - loc property

The loc property is used to access a group of rows and columns by label(s) or a boolean array.

.loc[] is primarily label based, but may also be used with a boolean array.

Allowed inputs are:

- A single label, e.g. 5 or 'a', (note that 5 is interpreted as a label of the index, and never as an integer position along the index).
- A list or array of labels, e.g. ['a', 'b', 'c'].
- A slice object with labels, e.g. 'a':'f'.
- A boolean array of the same length as the axis being sliced, e.g. [True, False, True].

- A callable function with one argument (the calling Series or DataFrame) and that returns valid output for indexing (one of the above)

Syntax:

```
DataFrame.loc
```

Raises: KeyError

when any items are not found

Example:

Dataframe.iloc[] method is used when the index label of a data frame is something other than numeric series of 0, 1, 2, 3….n or in case the user doesn't know the index label. Rows can be extracted using an imaginary index position which isn't visible in the data frame.

Syntax: pandas.DataFrame.iloc[]

Parameters:

Index Position: Index position of rows in integer or list of integer.

Return type: Data frame or Series depending on parameters

To download the CSV used in code, click here.

Example #1: Extracting single row and comparing with .loc[] In this example, same index number row is extracted by both .iloc[] and.loc[] method and compared. Since the index column by default is numeric, hence the index label will also be integers.

```
# importing pandas package

import pandas as pd


# making data frame from csv file

data = pd.read_csv("nba.csv")


# retrieving rows by loc method

row1 = data.loc[3]
```

retrieving rows by iloc method

row2 = data.iloc[3]

checking if values are equal

row1 == row2

Output:

As shown in the output image, the results returned by both methods are the same.

Example #2: Extracting multiple rows with index In this example, multiple rows are extracted, first by passing a list and then by passing integers to extract rows between that range. After that, both the values are compared.

importing pandas package

import pandas as pd

making data frame from csv file

data = pd.read_csv("nba.csv")

retrieving rows by loc method

row1 = data.iloc[[4, 5, 6, 7]]

retrieving rows by loc method

row2 = data.iloc[4:8]

comparing values

row1 == row2

Output:

As shown in the output image, the results returned by both methods are the same. All values are True except values in the college column since those were NaN values.

DataFrame - values property

The values property is used to get a Numpy representation of the DataFrame.

Only the values in the DataFrame will be returned, the axes labels will be removed.

Syntax:

```
DataFrame.values
```

Returns: numpy.ndarray
The values of the DataFrame.

Example:

pandas.DataFrame.to_numpy

DataFrame.to_numpy(*dtype=None*, *copy=False*, *na_value=NoDefault.no_default*)[source]

Convert the DataFrame to a NumPy array.

By default, the dtype of the returned array will be the common NumPy dtype of all types in the DataFrame. For example, if the dtypes are `float16` and `float32`, the results dtype will be `float32`. This may require copying data and coercing values, which may be expensive.

Parameters

dtypestr or numpy.dtype, optional

The dtype to pass to **`numpy.asarray()`**.

copybool, default False

Whether to ensure that the returned value is not a view on another array. Note that `copy=False` does not *ensure* that `to_numpy()` is no-copy. Rather, `copy=True` ensure that a copy is made, even if not strictly necessary.

na_valueAny, optional

The value to use for missing values. The default value depends on *dtype* and the dtypes of the DataFrame columns.

New in version 1.1.0.

Returns

numpy.ndarray

See also

Series.to_numpy
Similar method for Series.

Examples

```
>>> pd.DataFrame({"A": [1, 2], "B": [3, 4]}).to_numpy()
array([[1, 3],
       [2, 4]])
```

With heterogeneous data, the lowest common type will have to be used.

```
>>> df = pd.DataFrame({"A": [1, 2], "B": [3.0, 4.5]})
>>> df.to_numpy()
array([[1. , 3. ],
       [2. , 4.5]])
```

For a mix of numeric and non-numeric types, the output array will have object dtype.

```
>>> df['C'] = pd.date_range('2000', periods=2)
>>> df.to_numpy()
array([[1, 3.0, Timestamp('2000-01-01 00:00:00')],
       [2, 4.5, Timestamp('2000-01-02 00:00:00')]], dtype=object)
```

Pandas DataFrame describe() Method

❮ DataFrame Reference

Example

Multiply the values for each row with the values from the previous row:

```
import pandas as pd
```

```
data = [[10, 18, 11], [13, 15, 8], [9, 20, 3]]

df = pd.DataFrame(data)

print(df.describe())
```

Try it Yourself »

Definition and Usage

The `describe()` method returns description of the data in the DataFrame.

If the DataFrame contains numerical data, the description contains these information for each column:

count - The number of not-empty values.
mean - The average (mean) value.
std - The standard deviation.
min - the minimum value.
25% - The 25% percentile*.
50% - The 50% percentile*.
75% - The 75% percentile*.
max - the maximum value.

*Percentile meaning: how many of the values are less than the given percentile. Read more about percentiles in our Machine Learning Percentile chapter.

Syntax

```
dataframe.describe(percentiles, include, exclude, datetime_is_numeric)
```

Parameters

The `percentile`, `include`, `exclude`, `datetime_is_numeric` parameters are keyword arguments.

Parameter	Value	Description
percentile	*numbers between: 0 and 1*	Optional, a list of percentiles to include in the `[.25, .50, .75]`.

include	`None`
	`'all'`
	datatypes
		Optional, a list of the data types to allow in t

exclude	`None`
	`'all'`
	datatypes
		Optional, a list of the data types to disallow i

datetime_is_numeric	`True` `False`	Optional, default False. Set to True to treat d numeric

Return Value

A DataFrame object with statistics for each row.