R/Python Cheatsheet

## Data Structures

### R

R offers quite a few data structures in base-R:

* Vector
* Matrix
* List
* Data frame

#### Vector in R

A vector is a collection of same type of elements and could assume any of the following types:

* character
* logical
* integer
* numeric

A vector is used to apply mathemathical techniques like vector algebra and are quite often used to implement mathematical and statistical procedures.

# Create a vector (numeric)  
vec\_1 <- c(2, 3, 5, 7)  
vec\_2 <- c(3, 5, 1, 4)  
  
# Vector one  
print(vec\_1)

## [1] 2 3 5 7

# Vector two  
print(vec\_2)

## [1] 3 5 1 4

# Vector Addition  
print(vec\_1 + vec\_2)

## [1] 5 8 6 11

Notice that the addition of two numeric vectors is the sum of individual numeric elements of each vector at the corresponding index.

#### Matrix in R

Matrices are an extension of numeric or character vector. They are similar to vector in the sense that they also store same data type elements but matrices has dimensions and vectors have only one dimension. They are useful in implementing the matrix algebra. They are commonly used for linear transformations. Below code creates a 2 dimensional matrix containing 2 rows and 2 columns.

# Create a matrix  
mtrx\_1 <- matrix(vec\_1, nrow = 2, ncol = 2)  
mtrx\_2 <- matrix(vec\_2, nrow = 2, ncol = 2)  
  
# Matrix one  
print(mtrx\_1)

## [,1] [,2]  
## [1,] 2 5  
## [2,] 3 7

# Matrix one  
print(mtrx\_2)

## [,1] [,2]  
## [1,] 3 1  
## [2,] 5 4

# Matrix Addition  
print(mtrx\_1 + mtrx\_2)

## [,1] [,2]  
## [1,] 5 6  
## [2,] 8 11

Notice that the addition of two matrices is the sum of individual numeric elements of each matrix at the corresponding 2 dimensional index.

#### List in R

Lists are similar to vector in a way that they are collection of elements, but with a difference that the elements can be a mixture of different data types. They are helpful when we need to bind together mulitple objects, to pass them as arguments to functions or when we need to return multiple objects from the functions.

# Create a mixed data type list  
list\_1 <- list(0, "j", TRUE, 1 + 4i)  
print(list\_1)

## [[1]]  
## [1] 0  
##   
## [[2]]  
## [1] "j"  
##   
## [[3]]  
## [1] TRUE  
##   
## [[4]]  
## [1] 1+4i

# Create a character vector  
names\_vec <- c("Jon", "Jane", "John", "Jean")  
  
# Create a named list of two vectors of different data types  
list\_2 <- list(id = vec\_1, name = names\_vec)  
print(list\_2)

## $id  
## [1] 2 3 5 7  
##   
## $name  
## [1] "Jon" "Jane" "John" "Jean"

#### Data-frame in R

A data frame is a tabular data structure in R and is the most commonly used data structure. It can be thought of as a rectangular list in which data is structured in rows and columns. It is infact a special type of list. For most of the statistical analysis, R datasets are created as data-frame.

# Create a data.frame  
customers\_df <- data.frame(id = vec\_1, name = names\_vec)  
  
# Print top 2 records  
head(customers\_df, 2)

## id name  
## 1 2 Jon  
## 2 3 Jane

#### Data-table in R

A data-table is essentially a data-frame but with added features. A data-frame is part of base R, while data-table was developed as an extension of data-frame. The key additional features built into data-table are speed of access and a cleaner syntax.

# Create a data.table  
customers\_dt <- data.table(id = vec\_1, name = names\_vec)  
  
# Print top 2 records  
head(customers\_dt, 2)

## id name  
## 1: 2 Jon  
## 2: 3 Jane

### Python

Python offers similar data structures as R. Python programming language has basically four types of built-in data structures:

* **List** is a collection which is ordered and changeable. Allows duplicate members.
* **Tuple** is a collection which is ordered and unchangeable. Allows duplicate members.
* **Set** is a collection which is unordered and unindexed. No duplicate members.
* **Dictionary** is a collection which is unordered, changeable and indexed. No duplicate members.

#### Vector in Python

**numpy** is a python library built specifically for large, multi-dimensionals arrays and matrices. It has large collection functions specially built for mathematical operations. A vector in Python is basically a one dimensional **numpy** array. Operations on vectors are pretty much similar to R.

import numpy as np  
# Create a vector (numeric)  
vec\_1 = np.array([2, 3, 5, 7])  
vec\_2 = np.array([3, 5, 1, 4])  
  
# Vector one  
print(vec\_1)  
  
# Vector two

## [2 3 5 7]

print(vec\_2)  
  
# Vector Addition

## [3 5 1 4]

print(vec\_1 + vec\_2)

## [ 5 8 6 11]

#### Matrix in Python

A matrix in Python is basically a multi-dimensional **numpy** array. Operations on matrices are pretty much similar to R. In the below example, the first matrix is created from a 1-dimensional array reshaped into a 2-dimensional array. To align with the R code, matrix transpose has been used. It’s just because the Python default reshapes the 1-d array row-wise while R reshapes the 1-d array column-wise. R’s default reshaping can be changed to row-wise as well. In this case, we have just taken the transpose of the 2x2 array to match with R version of the code.

import numpy as np  
# Create a matrix  
mtrx\_1 = np.array([2, 3, 5, 7])  
mtrx\_1 = mtrx\_1.reshape(2, 2)  
mtrx\_1 = mtrx\_1.T  
  
# Matrix one  
print(mtrx\_1)

## [[2 5]  
## [3 7]]

mtrx\_2 = np.array([[3, 5], [1, 4]])  
mtrx\_2 = mtrx\_2.T  
  
# Matrix two  
print(mtrx\_2)  
  
# Matrix Addition

## [[3 1]  
## [5 4]]

print(mtrx\_1 + mtrx\_2)

## [[ 5 6]  
## [ 8 11]]

#### List in Python

Lists in Python are similar to R except that the named lists in Python are actually called ‘dictionary’ type data structures. Dictionary does not allows duplicate members in Python while a list allows duplicates in both Python and R.

# Create a mixed data type list  
list\_1 = [0, "j", True, 1 + 4j]  
print(list\_1)  
  
# Create a list of list

## [0, 'j', True, (1+4j)]

id = [2, 3, 5, 7]  
names = ["Jon", "Jane", "John", "Jean"]  
list\_2 = [id, names]  
print(list\_2)

## [[2, 3, 5, 7], ['Jon', 'Jane', 'John', 'Jean']]

#### Data-frame in Python

**pandas** is a very popular Python library written for data manipulation and analysis. It provides a similar data structure like R data frame with built in indexation. It provides various functions for data manipulation, reshaping, slicing, grouping, merging, time-series and lot more. **pandas** dataframes can be initialized using a dictionary type object.

import numpy as np  
import pandas as pd  
# Create a dictonary (Named List)  
customers\_dct = {  
 "id":id,   
 "name":names  
 }  
   
# Print dictionary  
print(customers\_dct)  
  
# Data Frame

## {'id': [2, 3, 5, 7], 'name': ['Jon', 'Jane', 'John', 'Jean']}

customers\_df = pd.DataFrame(customers\_dct)  
  
# Print top 2 records  
customers\_df.head(2)

## id name  
## 0 2 Jon  
## 1 3 Jane

## Data Import and Export

Loading a dataset from a locally or remotely stored file into memory is the most common data science task. Similarly, often an analyst need to store the analytical outputs from memory to a local or remote storage location.

### R

Example below saves the customer details dataset, created earlier, to a file on a local disk. The code ensures that the local directory exists before writing the contents of data.table to a file. ‘fwrite’ is a function from **data.table** library which provides a fast function to write large data.tables to disk. ‘fread’ is a similar fast function to read large files, stored on a disk, into the memory.

# Check if directory exists, if not, create one  
output\_dir <- file.path(getwd(), "Data")  
  
if (!dir.exists(output\_dir)){  
 dir.create(output\_dir)  
} else {  
 print("Dir already exists!")  
}

## [1] "Dir already exists!"

#Write  
fwrite(customers\_dt, "Data/employees.csv")  
  
#Read  
customers\_dt <- fread("Data/employees.csv")  
  
#Print top 2 records   
head(customers\_dt, 2)

## id name  
## 1: 2 Jon  
## 2: 3 Jane

### Python

Similar to R, **pandas** has a method ‘to\_csv’ to write the data-frame contents to a csv file on disk. ‘read\_csv’ is used to import data from disk into memory. Note that the name of the imported dataframe has been suffixed with ‘dt’ just to be in sync with R data.table naming convention of a data.table object. It is essentially a **pandas** dataframe denoted by ‘dt’ suffixed name.

import os  
import pandas as pd  
# Check if directory exists, if not, create one  
output\_dir = os.getcwd() + "/Data"  
if not os.path.exists(output\_dir):  
 os.makedirs(output\_dir)  
else:  
 print("Dir already exists!")  
  
#Write

## Dir already exists!

customers\_df.to\_csv("Data/employees.csv", index=False)  
  
#Read  
customers\_dt = pd.read\_csv("Data/employees.csv")   
  
#Print top 2 records  
customers\_dt.head(2)

## id name  
## 0 2 Jon  
## 1 3 Jane

## Data Binding

Some of the data science tasks requires calculations that end up generating additional information that needs to be appended/binded to the original dataset. Example, a function generates a list calculated from one or more columns from the original dataset. The returned list needs to be appended back to the original dataset. Another example could be aggregating numbers across multiple datasets of same shape, in which case you will bind all of them togethers rows by rows.

### R

‘cbind’ is a function in base R to bind together datasets by column. ‘rbind’ is a function in base R to bind together datasets by rows. Example below adds additional information about customer, ‘age’ and ‘height’ of customer. Also, another customer is added as a new row to the original customer data.table.

# Data Binding  
  
#Print top 2 records  
head(customers\_dt,2)

## id name  
## 1: 2 Jon  
## 2: 3 Jane

# Bind new columns  
age <- c(30, 25, 35, 29)  
customers\_dt <- cbind(customers\_dt, age)  
  
height <- c(1.7, 1.8, 1.65, 1.85)  
customers\_dt <- cbind(customers\_dt, height)  
  
#Print top 2 records  
head(customers\_dt,2)

## id name age height  
## 1: 2 Jon 30 1.7  
## 2: 3 Jane 25 1.8

# Bind new rows  
# new row is defined as a new data.table  
new\_row <- data.table(id = 9, name = "Jen", age = 31, height = 1.6)  
  
# Must be of same shape  
customers\_dt <- rbind(customers\_dt, new\_row)  
  
#Print all records  
print(customers\_dt)

## id name age height  
## 1: 2 Jon 30 1.70  
## 2: 3 Jane 25 1.80  
## 3: 5 John 35 1.65  
## 4: 7 Jean 29 1.85  
## 5: 9 Jen 31 1.60

### Python

In Python, the assignment operator binds new columns and name of the new column is specified by the name enclosed in the square brackets of the **pandas** dataframe. If the column with the same name already exists, then the column gets updated otherwise it gets created. Adding a new row can be done using ‘concat’ funtion of **pandas** library.

import pandas as pd  
  
#Print top 2 records  
customers\_dt.head(2)  
  
# Bind new columns

## id name  
## 0 2 Jon  
## 1 3 Jane

age = [30, 25, 35, 29]  
customers\_dt["age"] = age  
  
height = [1.7, 1.8, 1.65, 1.85]  
customers\_dt["height"] = height  
  
#Print top 2 records  
customers\_dt.head(2)  
  
# Bind new rows  
# new row is defined as a dict first (each item as a list) and then as pandas dataframe

## id name age height  
## 0 2 Jon 30 1.7  
## 1 3 Jane 25 1.8

new\_row = {  
 "id":[9],   
 "name":["Jen"],   
 "age":[31],   
 "height":[1.6]  
 }  
   
customers\_dt = pd.concat([customers\_dt, pd.DataFrame(new\_row)], ignore\_index=True)  
  
#Print all records  
print(customers\_dt)

## id name age height  
## 0 2 Jon 30 1.70  
## 1 3 Jane 25 1.80  
## 2 5 John 35 1.65  
## 3 7 Jean 29 1.85  
## 4 9 Jen 31 1.60

## Data Wrangling

Data wrangling includes a variety of commonly performed data science tasks such as cleansing, standardizing, augmenting and are often applied on rows, columns, subset of rows and columns etc.

### R

The very first task is to look at the shape, size, data types and distribution of data in the dataset under investigation. Below examples show how to look at the some of the descriptive statistics of dataset, removing NAs, removing duplicates, subsetting data by rows & columns, aggregating data. ‘summary’ function proivdes basic stastics about the data types and distribution of data. ‘is.na’ checks for any NAs in the data. ‘unique’ returns the dataset by removing row level duplicates across all columns.Rows can be subset by using indexes of the datatable or by specifying a condition as ‘i’ of the data.table[i,j,by]. ‘’i’ is basically telling the data.table to filter records by the specified condition (like a WHERE clause in SQL), ‘j’ tell data.table what columns to select or what functions to apply on the selected columns, ‘by’ is used to group together columns to calculate aggregate functions. Example below shows how to count all customers whose weight is greater than 60 grouped into males/female and order by descending count of customers.

# Data Wrangling  
  
## Descriptive statistics  
summary(customers\_dt)

## id name age height   
## Min. :2.0 Length:5 Min. :25 Min. :1.60   
## 1st Qu.:3.0 Class :character 1st Qu.:29 1st Qu.:1.65   
## Median :5.0 Mode :character Median :30 Median :1.70   
## Mean :5.2 Mean :30 Mean :1.72   
## 3rd Qu.:7.0 3rd Qu.:31 3rd Qu.:1.80   
## Max. :9.0 Max. :35 Max. :1.85

## Removing NULLS  
customers\_dt[!is.na(name)]

## id name age height  
## 1: 2 Jon 30 1.70  
## 2: 3 Jane 25 1.80  
## 3: 5 John 35 1.65  
## 4: 7 Jean 29 1.85  
## 5: 9 Jen 31 1.60

## Removing Duplicates  
# Add a duplicate  
customers\_dt <- rbind(customers\_dt, new\_row)  
customers\_dt

## id name age height  
## 1: 2 Jon 30 1.70  
## 2: 3 Jane 25 1.80  
## 3: 5 John 35 1.65  
## 4: 7 Jean 29 1.85  
## 5: 9 Jen 31 1.60  
## 6: 9 Jen 31 1.60

# Remove the duplicate  
customers\_dt <- unique(customers\_dt)  
customers\_dt

## id name age height  
## 1: 2 Jon 30 1.70  
## 2: 3 Jane 25 1.80  
## 3: 5 John 35 1.65  
## 4: 7 Jean 29 1.85  
## 5: 9 Jen 31 1.60

## Select rows/columns  
### Rows  
customers\_dt[1:2, ]

## id name age height  
## 1: 2 Jon 30 1.7  
## 2: 3 Jane 25 1.8

customers\_dt[name=="Jon", ]

## id name age height  
## 1: 2 Jon 30 1.7

### Columns  
customers\_dt[, 1:2]

## id name  
## 1: 2 Jon  
## 2: 3 Jane  
## 3: 5 John  
## 4: 7 Jean  
## 5: 9 Jen

customers\_dt[, .(name, id)]

## name id  
## 1: Jon 2  
## 2: Jane 3  
## 3: John 5  
## 4: Jean 7  
## 5: Jen 9

### Rows & Columns  
customers\_dt[name=="Jon", .(name, id)]

## name id  
## 1: Jon 2

## Aggregate by group and order the resulting output  
weight <- c(75, 60, 70, 65, 50)  
customers\_dt <- cbind(customers\_dt, weight)  
  
gender <- c("M", "F", "M", "F", "F")  
customers\_dt <- cbind(customers\_dt, gender)  
  
customers\_dt[weight>60, .N, by = gender][order(-N)]

## gender N  
## 1: M 2  
## 2: F 1

### Python

In Python, ‘describe’ function provides a nice summary statistics about the data. ‘isnull’ is used to check nulls. ~ is the **not** operator in **pandas** whereas ! is the equivalent in R. ‘drop\_duplicates’ is the method to eliminate row-wise duplicates across all columns. ‘iloc’ method is to subset rows/columns using index. ‘value\_counts’ is a method to aggregate counts across the selected columns. In the example below it counts all the customers whose weight is greater than 60 grouped into males/female and order by descending count of customers.

import pandas as pd  
# Data Wrangling  
  
## Descriptive statistics  
customers\_dt.describe(include = "all")  
  
## Removing NULLS

## id name age height  
## count 5.000000 5 5.000000 5.000000  
## unique NaN 5 NaN NaN  
## top NaN Jane NaN NaN  
## freq NaN 1 NaN NaN  
## mean 5.200000 NaN 30.000000 1.720000  
## std 2.863564 NaN 3.605551 0.103682  
## min 2.000000 NaN 25.000000 1.600000  
## 25% 3.000000 NaN 29.000000 1.650000  
## 50% 5.000000 NaN 30.000000 1.700000  
## 75% 7.000000 NaN 31.000000 1.800000  
## max 9.000000 NaN 35.000000 1.850000

customers\_dt[~customers\_dt["name"].isnull()]

## id name age height  
## 0 2 Jon 30 1.70  
## 1 3 Jane 25 1.80  
## 2 5 John 35 1.65  
## 3 7 Jean 29 1.85  
## 4 9 Jen 31 1.60

customers\_dt.isnull().values.any()  
  
## Removing Duplicates  
# Add a duplicate

## False

customers\_dt = pd.concat([customers\_dt, pd.DataFrame(new\_row)], ignore\_index=True)  
customers\_dt  
  
# Drop duplicate

## id name age height  
## 0 2 Jon 30 1.70  
## 1 3 Jane 25 1.80  
## 2 5 John 35 1.65  
## 3 7 Jean 29 1.85  
## 4 9 Jen 31 1.60  
## 5 9 Jen 31 1.60

customers\_dt = customers\_dt.drop\_duplicates()  
customers\_dt  
  
## Select rows/columns  
### Rows

## id name age height  
## 0 2 Jon 30 1.70  
## 1 3 Jane 25 1.80  
## 2 5 John 35 1.65  
## 3 7 Jean 29 1.85  
## 4 9 Jen 31 1.60

customers\_dt.iloc[0:2]

## id name age height  
## 0 2 Jon 30 1.7  
## 1 3 Jane 25 1.8

customers\_dt[customers\_dt["name"]=="Jon"]  
  
### Columns

## id name age height  
## 0 2 Jon 30 1.7

customers\_dt.iloc[:, 0:2]

## id name  
## 0 2 Jon  
## 1 3 Jane  
## 2 5 John  
## 3 7 Jean  
## 4 9 Jen

customers\_dt[["name", "id"]]  
  
### Rows & Columns

## name id  
## 0 Jon 2  
## 1 Jane 3  
## 2 John 5  
## 3 Jean 7  
## 4 Jen 9

customers\_dt.loc[customers\_dt["name"]=="Jon", ["name", "id"]]  
  
## Where clause  
## group by  
## order by

## name id  
## 0 Jon 2

weight = [75, 60, 70, 65, 50]  
customers\_dt["weight"] = weight

## /Users/anuj/.virtualenvs/cs\_proj/bin/python:1: SettingWithCopyWarning:   
## A value is trying to be set on a copy of a slice from a DataFrame.  
## Try using .loc[row\_indexer,col\_indexer] = value instead  
##   
## See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#indexing-view-versus-copy

gender = ["M", "F", "M", "F", "F"]  
customers\_dt["gender"] = gender  
  
# Default sorts on frequencies and order in descending  
customers\_dt.loc[customers\_dt["weight"]>60, "gender"].value\_counts()

## M 2  
## F 1  
## Name: gender, dtype: int64

# Data Transformation

This section specifically talks about transforming and reshaping the data to compute additional features or to convert it into more meaningful shape to perform analytical functions. Some complex datasets come in multi-dimensions and does not necessary confirm to the rectangular structure of row and columns. In such cases, the dataset is reshaped in such a way that single subjects information is stored in multiple rows to perform some meaningful analysis.

### R

Examples below show how to transform a column from one scale to another and store as an additional information. ‘melt’ is a function from **data.table** library to reshape/transpose the data from a wide format to a long format. In the example, the wide format variable ‘id’, ‘age’, ‘height’, ‘weight’ are collapsed into a measure/value pair for each ‘id’, ‘name’ (subject). ‘dcast’ is the another function to convert a long form data to a wide form data.

# Data Transformation  
  
# Convert height in metres to inches and save as another column  
customers\_dt[, height\_inch:=height\*39.37]  
  
# Drop a column  
customers\_dt[, height\_inch:= NULL]  
  
# Long form  
customers\_dt\_l <- melt(customers\_dt, id.vars = c("id", "name"), measure.vars = c("id", "age", "height", "weight"))  
  
# Print top 5 records  
head(customers\_dt\_l, 5)

## id name variable value  
## 1: 2 Jon id 2  
## 2: 3 Jane id 3  
## 3: 5 John id 5  
## 4: 7 Jean id 7  
## 5: 9 Jen id 9

# Wide form  
customers\_dt\_w <- dcast(customers\_dt\_l, name ~ variable, value.var = "value")  
  
# Print top 2 records  
head(customers\_dt\_w, 2)

## name id age height weight  
## 1: Jane 3 25 1.80 60  
## 2: Jean 7 29 1.85 65

### Python

‘del’ is a keyword in Python to delete objects. Example below shows how to delete a column in **pandas** dataframe. ‘melt’ function in **pandas** transpose the data from a wide form to a long form. ‘pivot\_table’ method does the opposite of melt and helps to transpose data from long form to wide form.

import pandas as pd  
  
# Data Transformation  
  
# Convert height in metres to inches and save as another column  
customers\_dt["height\_inch"] = customers\_dt["height"]\*39.37  
  
# Drop columns  
del customers\_dt["height\_inch"]  
  
# Long form  
customers\_dt\_l = pd.melt(customers\_dt, id\_vars=["name"], value\_vars=["id", "age", "height", "weight"])  
  
# Print top 5 records  
customers\_dt\_l.head(5)  
  
# Wide form

## name variable value  
## 0 Jon id 2.0  
## 1 Jane id 3.0  
## 2 John id 5.0  
## 3 Jean id 7.0  
## 4 Jen id 9.0

customers\_dt\_w = customers\_dt\_l.pivot\_table(values="value", index="name", columns="variable").reset\_index()  
  
# Print top 2 records  
customers\_dt\_w.head(2)

## variable name age height id weight  
## 0 Jane 25.0 1.80 3.0 60.0  
## 1 Jean 29.0 1.85 7.0 65.0

# Data Joins

Often an analyst needs to join two or more datasets to collate disparate sets of information. Example, join customer transactions with the customer’s demographic information to analyse the frequency of transactions by a geographical region.

### R

**data.table** library in R provides a nice and easy way of joining two datasets. One simply needs to set the keys (like SQL primary keys) on the columns in both the tables on which one wants to join the two datasets. In the example below, we have customers’ personal details in one data.table and address details in another data.table. Now, we need to enhance the customer’s personal details dataset with the location information. Both the datasets have a common key called the ‘address\_id’. We set keys on both the data.tables and simply enclose one data.table inside the square brackets of another data.table. The position of data.table being on the right (inside the square brackets) or left (outside the square brackets) is important as that is the way to distinguish the type of join we want apply. A right outer join (misnomer in this context) is a join where in the resulting joined data.table contains all the rows from data.table that is enclosed within the square bracket and all the matched rows of the data.table outside the square brackets. In the example below of right join, all the rows of address details will be in the resulting joined dataset whether or not that matches with the customer details dataset rows and only the matching rows from the customer details table. An inner join is a join where the resulting joined dataset contains only the matching rows from both the datasets.

# Define addresses dataset  
address\_id <- c(1, 2, 3, 4, 5)  
address\_array <- c("1640 Riverside Drive, Hill Valley, California"  
 , "344 Clinton St., Apt. 3B, Metropolis, USA"  
 , "12 Grimmauld Place, London, UK"  
 , "221B Baker Street, London, UK"  
 , "1313 Webfoot Walk, Duckburg, Calisota")  
  
address\_dt <- data.table(address\_id = address\_id, address = address\_array)  
  
# Set the address ids in the customer details dataset  
address\_id <- c(1, 2, 6, 5, 5)  
customers\_dt <- cbind(customers\_dt, address\_id)  
  
# Set the keys/columns to join on  
setkey(customers\_dt, address\_id)  
setkey(address\_dt, address\_id)  
  
# Outer join (Right- All addresses + matching customers)  
customers\_dt[address\_dt]

## id name age height weight gender address\_id  
## 1: 2 Jon 30 1.70 75 M 1  
## 2: 3 Jane 25 1.80 60 F 2  
## 3: NA <NA> NA NA NA <NA> 3  
## 4: NA <NA> NA NA NA <NA> 4  
## 5: 7 Jean 29 1.85 65 F 5  
## 6: 9 Jen 31 1.60 50 F 5  
## address  
## 1: 1640 Riverside Drive, Hill Valley, California  
## 2: 344 Clinton St., Apt. 3B, Metropolis, USA  
## 3: 12 Grimmauld Place, London, UK  
## 4: 221B Baker Street, London, UK  
## 5: 1313 Webfoot Walk, Duckburg, Calisota  
## 6: 1313 Webfoot Walk, Duckburg, Calisota

# Inner join (Only the matched rows from customer and addresses)  
customers\_dt[address\_dt, nomatch=0]

## id name age height weight gender address\_id  
## 1: 2 Jon 30 1.70 75 M 1  
## 2: 3 Jane 25 1.80 60 F 2  
## 3: 7 Jean 29 1.85 65 F 5  
## 4: 9 Jen 31 1.60 50 F 5  
## address  
## 1: 1640 Riverside Drive, Hill Valley, California  
## 2: 344 Clinton St., Apt. 3B, Metropolis, USA  
## 3: 1313 Webfoot Walk, Duckburg, Calisota  
## 4: 1313 Webfoot Walk, Duckburg, Calisota

# Outer join (Left - All customers + matching addresses)  
address\_dt[customers\_dt]

## address\_id address id name age  
## 1: 1 1640 Riverside Drive, Hill Valley, California 2 Jon 30  
## 2: 2 344 Clinton St., Apt. 3B, Metropolis, USA 3 Jane 25  
## 3: 5 1313 Webfoot Walk, Duckburg, Calisota 7 Jean 29  
## 4: 5 1313 Webfoot Walk, Duckburg, Calisota 9 Jen 31  
## 5: 6 <NA> 5 John 35  
## height weight gender  
## 1: 1.70 75 M  
## 2: 1.80 60 F  
## 3: 1.85 65 F  
## 4: 1.60 50 F  
## 5: 1.65 70 M

### Python

**pandas** ‘merge’ function does exactly the similar thing as the enclosing of one data.table with the square brackets of another data.table in R. We do not need to set any keys, however we can specify the column names as functiom arguments on which we want to apply the join. By default, it joins on the matching column names. Another argument that we can specify is ‘how’ we want to apply the join. Default is ‘inner’ join and we can change that to be either ‘left’ or ‘right’ join.

import pandas as pd  
# Define addresses dataset  
address\_dt = pd.DataFrame()  
  
address\_id = [1, 2, 3, 4, 5]  
address\_array = ["1640 Riverside Drive, Hill Valley, California"  
 , "344 Clinton St., Apt. 3B, Metropolis, USA"  
 , "12 Grimmauld Place, London, UK"  
 , "221B Baker Street, London, UK"  
 , "1313 Webfoot Walk, Duckburg, Calisota"]  
  
address\_dt["address\_id"] = address\_id  
address\_dt["address"] = address\_array  
  
# Set the address ids in the customer details dataset  
address\_id = [1, 2, 6, 5, 5]  
customers\_dt["address\_id"] = address\_id  
  
# Outer join (Right- All addresses + matching customers)  
customers\_dt.merge(address\_dt, how="right")  
  
# Inner join (Only the matched rows from customer and addresses)

## id name ... address\_id address  
## 0 2.0 Jon ... 1 1640 Riverside Drive, Hill Valley, California  
## 1 3.0 Jane ... 2 344 Clinton St., Apt. 3B, Metropolis, USA  
## 2 7.0 Jean ... 5 1313 Webfoot Walk, Duckburg, Calisota  
## 3 9.0 Jen ... 5 1313 Webfoot Walk, Duckburg, Calisota  
## 4 NaN NaN ... 3 12 Grimmauld Place, London, UK  
## 5 NaN NaN ... 4 221B Baker Street, London, UK  
##   
## [6 rows x 8 columns]

customers\_dt.merge(address\_dt)  
  
# Outer join (Left - All customers + matching addresses)

## id name ... address\_id address  
## 0 2 Jon ... 1 1640 Riverside Drive, Hill Valley, California  
## 1 3 Jane ... 2 344 Clinton St., Apt. 3B, Metropolis, USA  
## 2 7 Jean ... 5 1313 Webfoot Walk, Duckburg, Calisota  
## 3 9 Jen ... 5 1313 Webfoot Walk, Duckburg, Calisota  
##   
## [4 rows x 8 columns]

customers\_dt.merge(address\_dt, how="left")

## id name ... address\_id address  
## 0 2 Jon ... 1 1640 Riverside Drive, Hill Valley, California  
## 1 3 Jane ... 2 344 Clinton St., Apt. 3B, Metropolis, USA  
## 2 5 John ... 6 NaN  
## 3 7 Jean ... 5 1313 Webfoot Walk, Duckburg, Calisota  
## 4 9 Jen ... 5 1313 Webfoot Walk, Duckburg, Calisota  
##   
## [5 rows x 8 columns]

# String Manipulation

When dealing with strings, most of the times analyst need to manipulate, transform, search, match and append strings to extract information/features or to convert data into meaningful form. For example, an analyst want to filter customer transactions by type of transaction as ‘Return’ or wants to search for a particular customer name.

### R

**stringr** is special library dedicated to string operations and manipulation. ‘str\_replace’ from the **stringr** library is used to replace a specified substring with another string pattern. %like% is a special function in R that provides the feature to search for any substring in a string irrespective of the position of the substring in the original string. ‘str\_detect’ from **stringr** package is similar to %like% function but in example below has been implemented to check the existence of a substring rather than filtering the dataset. ‘str\_sub’ function is used to subset the original string. The function accepts the original string, a start index and a stop index which tells the function to extract a substring with the specified starting position and ending position. Regular expressions can be used to find/replace/filter a string pattern. Example below filters the names that starts with ‘J’ and another example with filters names that ends with ‘n’. ‘^’ is the regular expression that signifies the beginning of the string characters and ‘$’ signifies the end of the string characters.

# String Replacement  
customers\_dt[, .(name, new\_name = str\_replace(name, "o", "e"))]

## name new\_name  
## 1: Jon Jen  
## 2: Jane Jane  
## 3: Jean Jean  
## 4: Jen Jen  
## 5: John Jehn

# Filter by pattern  
customers\_dt[name %like% "o"]

## id name age height weight gender address\_id  
## 1: 2 Jon 30 1.70 75 M 1  
## 2: 5 John 35 1.65 70 M 6

# Search by pattern  
customers\_dt[, .(name, o\_exists = str\_detect(name, "o"))]

## name o\_exists  
## 1: Jon TRUE  
## 2: Jane FALSE  
## 3: Jean FALSE  
## 4: Jen FALSE  
## 5: John TRUE

# Extract substring  
customers\_dt[, .(name, first\_letter = str\_sub(name, 1, 1), last\_letter = str\_sub(name, -1, -1))]

## name first\_letter last\_letter  
## 1: Jon J n  
## 2: Jane J e  
## 3: Jean J n  
## 4: Jen J n  
## 5: John J n

# Filter using Regex  
# Names starting with 'J'  
customers\_dt[name %like% "^J", .(name)]

## name  
## 1: Jon  
## 2: Jane  
## 3: Jean  
## 4: Jen  
## 5: John

# Names ending with 'n'  
customers\_dt[name %like% "n$", .(name)]

## name  
## 1: Jon  
## 2: Jean  
## 3: Jen  
## 4: John

### Python

**pandas** contains similar ‘str’ string operation functions. ‘str.replace’ replaces a specified substring with a replacement string. ‘str.contains’ is used to detect and filter the matching substring patterns. Extracting the substring is done by speciying the ‘str’ string index. Similar to R, ‘^’ is the regular expression that signifies the beginning of the string characters and ‘$’ signifies the end of the string characters.

import pandas as pd  
# String Replacement  
pd.DataFrame({"name":customers\_dt["name"], "new\_name":customers\_dt["name"].str.replace('o', 'e')})  
  
# Filter by pattern

## name new\_name  
## 0 Jon Jen  
## 1 Jane Jane  
## 2 John Jehn  
## 3 Jean Jean  
## 4 Jen Jen

customers\_dt[customers\_dt["name"].str.contains("o")]  
  
# Search by pattern

## id name age height weight gender address\_id  
## 0 2 Jon 30 1.70 75 M 1  
## 2 5 John 35 1.65 70 M 6

pd.DataFrame({"name":customers\_dt["name"], "o\_exists":customers\_dt["name"].str.contains("o")})  
  
# Extract substring

## name o\_exists  
## 0 Jon True  
## 1 Jane False  
## 2 John True  
## 3 Jean False  
## 4 Jen False

pd.DataFrame({"name":customers\_dt["name"], "first\_letter":customers\_dt["name"].str[:1], "last\_letter":customers\_dt["name"].str[-2:-1]})  
  
# Filter using Regex  
# Names starting with 'J'

## name first\_letter last\_letter  
## 0 Jon J o  
## 1 Jane J n  
## 2 John J h  
## 3 Jean J a  
## 4 Jen J e

customers\_dt.loc[customers\_dt["name"].str.contains("^J"), ["name"]]  
  
# Names ending with 'n'

## name  
## 0 Jon  
## 1 Jane  
## 2 John  
## 3 Jean  
## 4 Jen

customers\_dt.loc[customers\_dt["name"].str.contains("n$"), ["name"]]

## name  
## 0 Jon  
## 2 John  
## 3 Jean  
## 4 Jen

# Date and Time

Often datasets include dates and times and different data sources encode dates and time in a format they find the most efficient. There are number of ways to format dates and times, but quite often the dates are saved as a string of characters or the import tool encodes them as string of characters while loading the dataset. To properly utilise the dates in a statistical analysis, often the analyst needs to convert the strings to date format. Date format provides easy access to extract some useful information like day, month, year, day of the week etc. Another popular format of dates is the days since the epoch (1970-01-01). The dates in this format are stored as integers and are really fast to access and takes up less memory and storage.

### R

Let’s assume a bunch of dates are stored and loaded as strings in R. One can use the **data.table** packages ‘as.IDate’ function to easily convert them to a date format. ‘as.IDate’ can also convert the days since epoch to a date format. Dates are useful in R to peform time-series analysis. **lubridate** is another useful library in R packed with powerful date manipulation functions.

# Date and Time  
birth\_date <- c("1989-03-01", "1994-09-09", "1984-07-15", "1990-05-01", "1988-06-03")  
  
# Add as a String data type  
customers\_dt <- cbind(customers\_dt, birth\_date)  
# Check data type  
class(customers\_dt$birth\_date)

## [1] "character"

# Convert data type from character to Date  
customers\_dt[, birth\_date:= as.IDate(birth\_date)]  
# Check data type  
class(customers\_dt$birth\_date)

## [1] "IDate" "Date"

# Convert data type from Date to numeric  
customers\_dt[, birth\_date:= as.numeric(birth\_date)]  
# Check data type  
class(customers\_dt$birth\_date)

## [1] "numeric"

### Python

**pandas** provide powerful functions for time-series functionality. ‘to\_datetime’ converts the dates from string format to datetime. Subtracting another date (1970-01-01) from the original date returns the days since 1970-01-01.

import pandas as pd  
  
# Date and Time  
birth\_date = ["1989-03-01", "1994-09-09", "1984-07-15", "1990-05-01", "1988-06-03"]  
  
# Add as a String data type (stored as object type)  
customers\_dt["birth\_date"] = birth\_date  
# Check data type  
customers\_dt.dtypes  
  
# Convert data type from character to Date

## id int64  
## name object  
## age int64  
## height float64  
## weight int64  
## gender object  
## address\_id int64  
## birth\_date object  
## dtype: object

customers\_dt["birth\_date"] = pd.to\_datetime(customers\_dt["birth\_date"])  
# Check data type  
customers\_dt.dtypes  
  
# Convert data type from Date to numeric

## id int64  
## name object  
## age int64  
## height float64  
## weight int64  
## gender object  
## address\_id int64  
## birth\_date datetime64[ns]  
## dtype: object

customers\_dt["birth\_date"] = pd.to\_datetime(customers\_dt["birth\_date"]) - pd.datetime(1970, 1, 1)  
# Check data type  
customers\_dt.dtypes

## id int64  
## name object  
## age int64  
## height float64  
## weight int64  
## gender object  
## address\_id int64  
## birth\_date timedelta64[ns]  
## dtype: object

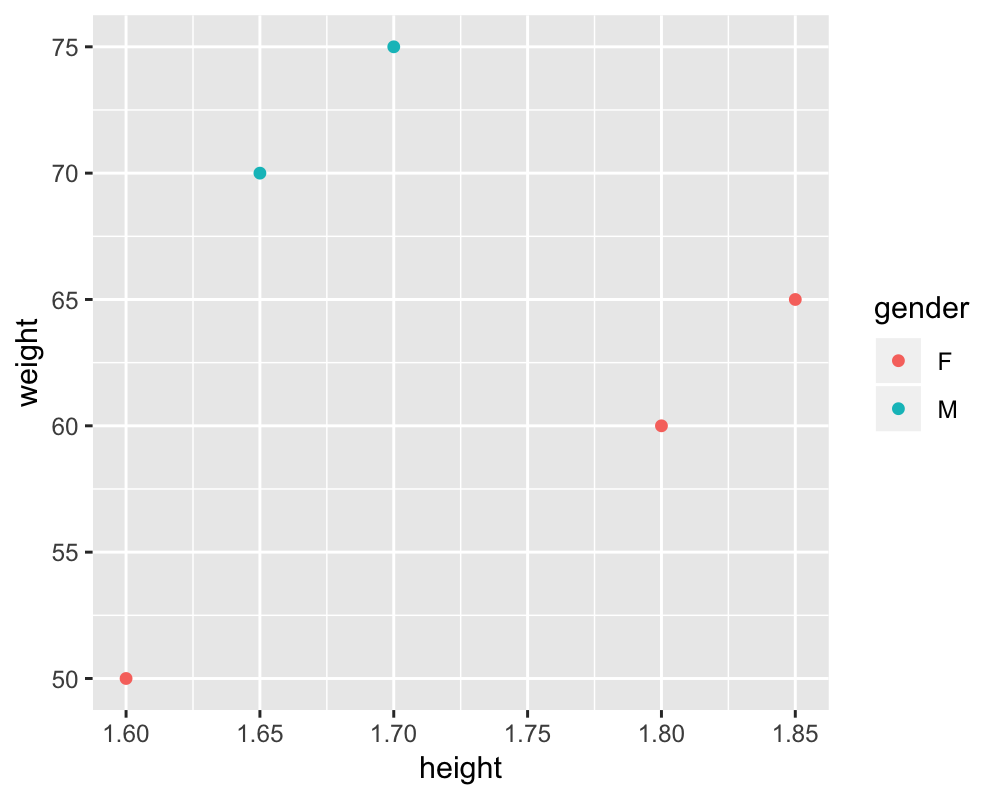
# Data Visualization

Graphically presenting the data is a key data science task. It not only helps the analyst to visually inspect the data but also helps to communicate insights about the data to the veiwers.

### R

**ggplot2** is the commonly used library in R for general purpose plotting of various types of charts. Here is an example of a scatter plot to understand the relationship between height and weight and is split into two categories of gender to assess if they two groups follow the same pattern or not. In the first argument of the ‘ggplot’ function we handover the entire dataset. The second argument is a set of ‘aes’ aesthetic instructions to the ‘ggplot’ function to tell it to plot ‘height’ along the x-cordinates of the plot and ‘weight’ along the y-cordinates. The ‘color’ adds a third dimenion to the 2-dimensional x-y plot and encode the ‘gender’ information.

# Scatter plot of height and weight, grouped into gender  
ggplot(customers\_dt, aes(x=height, y=weight, color = gender))+  
 geom\_point()



### Python

In Python, **matplotlib** is the most commonly used package for visualization. **seaborn** is an extension or wrapper around **matplotlib**, which has all the powerful features of **matplotlib** with additional easy to use functions. Using the same example as used in R for plotting a scatter plot to show the relationship between height and weight categorised into gender, we see that **seaborn** provides a very similar **ggplot** function capability. The first two arguments of the ‘pairplot’ function sets the x and y cordinates of the plot. In the third argument, we pass the entire dataset to the function. The fourth argument adds a third dimenion to the 2-dimensional x-y plot and encode the ‘gender’ information as color. The fifth and sixth arguments are to control the size of the resulting chart. ‘plt.show()’ is required to print the plot.

import seaborn as sb  
import matplotlib.pyplot as plt  
  
# Scatter plot of height and weight, grouped into gender  
sb.pairplot(x\_vars=["height"], y\_vars=["weight"], data=customers\_dt, hue="gender", height=5, aspect=1)

## <seaborn.axisgrid.PairGrid object at 0x132b40eb8>

plt.show()

