

DSI Notes

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April 12, 2022

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Setting things up

This section is about how to install python and jupyter notebook. I will update it later. Hopefully will be easily followed.

In the past, computers didn't have graphical user interface (GUI, pronounced "gooey"). Instead, everyone interacted with the computer using text commands in what we call a command-line interface (CLI). DOS and MS-DOS are perhaps the most well known command line interface operating system. Some Linux distribution still lack GUI and operated text based.

[illegible]

A shell (or terminal) is a type of command-line program that contains a simple, text-based user interface, enabling us to access all of an operating

system's services. It is, put simply, a program that accepts text as an input and translates that text into the appropriate functions you want your computer to run.

It might look cumbersome but everything we can do with GUI can also be done with command line, often faster. It just doesn't look pretty.

1.2.1 How to Access Terminal

It is extremely simple for Linux users, you can just type "terminal" on your program search.

Windows users have several options:

- **Windows Command Prompt:** Also known as cmd. A legacy DOS-based shell.
- **Windows PowerShell:** The official Windows-native shell and scripting language, intended to replace the antiquated Command Prompt.

Alternatively, there are several others third party programs available, such as GitBash and the built in cmd-prompt and PowerShell in Anaconda.

1.2.2 Shell Commands

Here is a list of commonly used shell commands.

Commands	
ls	list directory
cd	change directory
cat	read, create, concatenate files
mv	move or rename directory
echo	print text to terminal window
touch	create files
mkdir	make directory
man	print manual or get help
pwd	print working directory
rmdir	remove directory
cp	copy data or file
head	read the start of file
tail	read the end of file
exit	exit out of a directory
kill	terminate a process

1.2.3 Navigating with Terminal

1.2.4 Shell Demonstrations

image intensive

1.3 GIT

ALWAYS DOUBLE CHECK BEFORE MERGE. Reverting a merge can be a real pain.

Chapter 2

Python Variables and Data Types

A Variable is a mathematical object whose value might change. For example, $x = 3$. In this statement, x is the *variable* and 3 is its *value*. Python has several data types and these values could be any of them. For example 'Hello world' is a *string*. If you are not sure what type the values are, you could use `type()`.

```
In [1]: type('hello world')
```

```
Out[1]: str
```

```
In [2]: type(3)
```

```
Out[2]: int
```

```
In [4]: type(3.0)
```

```
Out[4]: float
```

Figure 2.1: Using `type()` to check data type

Chapter 3

Control Flow

3.1 Conditional Statement

3.2 Loop

Chapter 4

List and Dictionary

Chapter 5

Numpy and Matplotlib

5.1 Linear Algebra

This section would only have very basic of linear algebra, adapted from Artin's algebra textbook[1]. This is not intended for mathematics course which is why we would keep it to bare minimum

Let m and n be positive integers. An $m \times n$ matrix is a collection of mn numbers arranged in rectangular array.

$$\begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix}$$

Figure 5.1: $m \times n$ matrix.

For example, $\begin{bmatrix} 2 & 1 & 0 \\ 1 & 3 & 5 \end{bmatrix}$ is a 2×3 matrix.

Numbers in a matrix are the *matrix entries*. They are usually denoted as a_{ij} where i and j are indices with $1 \leq i \leq m$ and $1 \leq j \leq n$.

An $n \times n$ matrix is called *square matrix*. An $1 \times n$ matrix is an n -dimensional row vector.

Let $A = (a_{ij})$ and $B = (b_{ij})$ be two $m \times n$ matrix. Their sum $A + B$ is the $m \times n$ matrix $S = (s_{ij})$ defined by:

$$s_{ij} = a_{ij} + b_{ij} \tag{5.1}$$

Thus

$$\begin{bmatrix} 2 & 1 & 0 \\ 1 & 3 & 5 \end{bmatrix} + \begin{bmatrix} 1 & 0 & 3 \\ 4 & -3 & 1 \end{bmatrix} = \begin{bmatrix} 3 & 1 & 3 \\ 5 & 0 & 6 \end{bmatrix} \tag{5.2}$$

Scalar multiplication of an $m \times n$ matrix A by a number c is another $m \times n$ matrix $B = (b_{ij})$, where $(b_{ij} = ca_{ij})$ for all i, j . Thus

$$2 \begin{bmatrix} 2 & 1 & 0 \\ 1 & 3 & 5 \end{bmatrix} = \begin{bmatrix} 4 & 2 & 0 \\ 2 & 6 & 10 \end{bmatrix} \quad (5.3)$$

Things start to get nasty when we come to Matrix multiplication. Before we get there, it's imperative to first learn about the most basic form of matrix, vectors.

Let A be a row vector and B a column vector of the same size, let say m . If the entries of A and B are denoted by a_i and b_i respectively, the (dot) product of AB is a 1×1 matrix or scalar.

$$\begin{bmatrix} a_1 & a_2 & \cdots & a_m \end{bmatrix} \times \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_m \end{bmatrix} = a_1b_1 + a_2b_2 + \cdots + a_mb_m \quad (5.4)$$

Thus

$$\begin{bmatrix} 1 & 3 & 5 \end{bmatrix} \times \begin{bmatrix} 1 \\ -1 \\ 4 \end{bmatrix} = 1 - 3 + 20 = 18 \quad (5.5)$$

The entries of product matrix are computed by multiplying all rows of A by all columns of B . If we denote the product matrix AB by $P = (p_{ij})$, then

$$p_{ij} = a_{i1}b_{1j} + a_{i2}b_{2j} + \cdots + a_{im}b_{mj} \quad (5.6)$$

For example,

$$\begin{bmatrix} 2 & 1 & 0 \\ 1 & 3 & 5 \end{bmatrix} \begin{bmatrix} 1 \\ -1 \\ 4 \end{bmatrix} = \begin{bmatrix} 1 \\ 18 \end{bmatrix} \quad (5.7)$$

Care should be taken that the product of matrix multiplication is non-commutative, $AB \neq BA$.

Transpose of a matrix A is a matrix A^T with it's row and column flipped.

$$\begin{bmatrix} 2 & 1 & 0 \\ 1 & 3 & 5 \end{bmatrix}^T = \begin{bmatrix} 2 & 1 \\ 1 & 3 \\ 0 & 5 \end{bmatrix} \quad (5.8)$$

Matrix A is called invertible if there is $n \times n$ square matrix B such that $AB = BA = I_n$ where I_n is $n \times n$ identity matrix. For example,

$$\begin{bmatrix} 2 & 1 \\ 5 & 3 \end{bmatrix} \begin{bmatrix} 3 & -1 \\ -5 & 2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \quad (5.9)$$

Matrices could also be used to solve systems of equation. Let us solve this systems of equation with matrix operation.

$$\begin{aligned} 2x_1 + 1x_2 &= 3 \\ 5x_1 + 3x_2 &= 8 \end{aligned} \quad (5.10)$$

Which we can rewrite as

$$\begin{pmatrix} 2 & 1 \\ 5 & 3 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 3 \\ 8 \end{pmatrix} \quad (5.11)$$

Using inverse matrix, we get

$$\begin{aligned} \begin{pmatrix} 2 & 1 \\ 5 & 3 \end{pmatrix}^{-1} \begin{pmatrix} 3 \\ 8 \end{pmatrix} &= \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \\ \begin{pmatrix} 2 & 1 \\ 5 & 3 \end{pmatrix}^{-1} \begin{pmatrix} 3 \\ 8 \end{pmatrix} &= \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} \end{aligned} \quad (5.12)$$

And thus

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = \begin{pmatrix} 1 \\ 1 \end{pmatrix} \quad (5.13)$$

5.2 Numpy

Numpy is a python library for handling large, multi-dimensional arrays and matrices, along with a large collection of high-level mathematical functions to operate on these arrays.

5.3 Matplotlib

will be image intensive, set a folder for that

5.4 Seaborn

Chapter 6

Pandas

6.1 Introduction to Pandas

Pandas is a popular python library for dealing with database. It is one of our primary tool in this course. Let us first import Pandas.

```
import pandas as pd
import numpy as np
```

Figure 6.1: Importing Pandas as pd

We would then load our dataset and import them as Pandas dataset.

```
drug = pd.read_csv('../resource-datasets/drug_use_by_age/drug-use-by-age.csv')
```

Figure 6.2: Importing data

We can simply call the data by typing it's name (in this case *drug*).

drug																
	age	n	alcohol-use	alcohol-frequency	marijuana-use	marijuana-frequency	cocaine-use	cocaine-frequency	crack-use	crack-frequency	...	oxycontin-use	oxycontin-frequency	tranquilizer-use	tranquilizer-frequency	stimulants
0	12	2798	3.9	3.0	1.1	4.0	0.1	5.0	0.0	-	...	0.1	24.5	0.2	52.0	
1	13	2757	8.5	6.0	3.4	15.0	0.1	1.0	0.0	3.0	...	0.1	41.0	0.3	25.5	
2	14	2792	18.1	5.0	8.7	24.0	0.1	5.5	0.0	-	...	0.4	4.5	0.9	5.0	
3	15	2956	29.2	6.0	14.5	25.0	0.5	4.0	0.1	9.5	...	0.8	3.0	2.0	4.5	

Figure 6.3: Calling the data

If we only want to see the first few rows, we use the *head* method. Which is 5 by default.

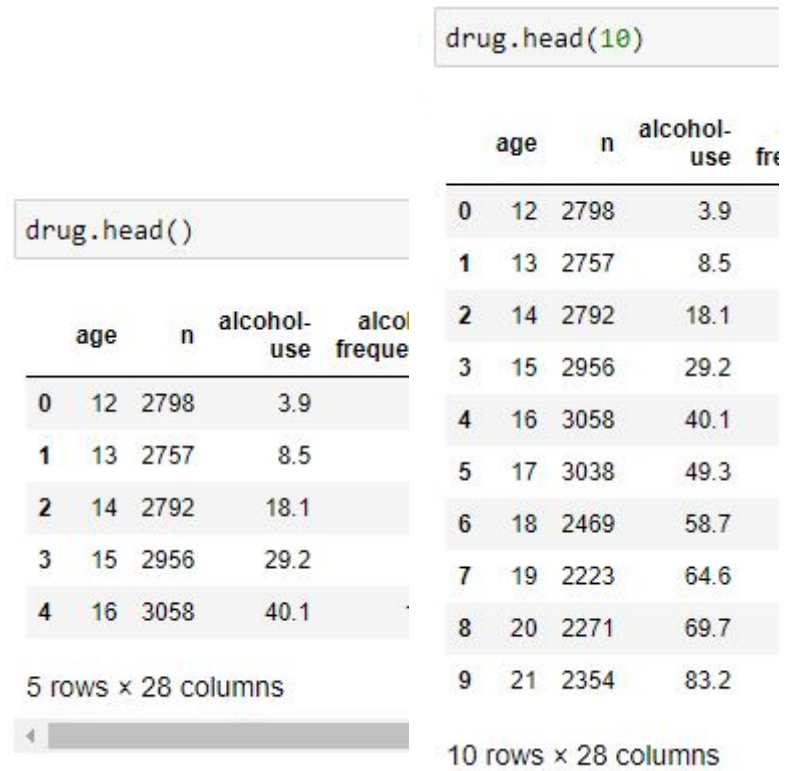


Figure 6.4: Using head method

Likewise, the *tail* method for last few rows.

drug.tail()				drug.tail(11)			
	age	n	alcohol-use				
12	26-29	2628	80.7	10	22-23	4707	84.2
13	30-34	2864	77.5	11	24-25	4591	83.1
14	35-49	7391	75.0	12	26-29	2628	80.7
15	50-64	3923	67.2	13	30-34	2864	77.5
16	65+	2448	49.3	14	35-49	7391	75.0
5 rows × 28 columns				15	50-64	3923	67.2
				16	65+	2448	49.3
				11 rows × 28 columns			

Figure 6.5: Using tail method

The *index* method is used to examine index which could be handy to detect duplicates

```
In [11]: drug.index.has_duplicates
Out[11]: False
```

Figure 6.6: Using index method

We can use *shape* method to examine the dimensions of our data.

```
In [59]: drug.shape  
Out[59]: (17, 28)
```

Figure 6.7: Using shape method

Chapter 7

Object Oriented Programming

7.1 Python Class

Classes are used to create user-defined data structures. Classes define functions called methods, which identify the behaviours and actions that an object created from the class can perform with its data.

Chapter 8

Linear Regression

Bibliography

- [1] M. Artin, *Algebra*. Pearson, 2010.