Australian National University

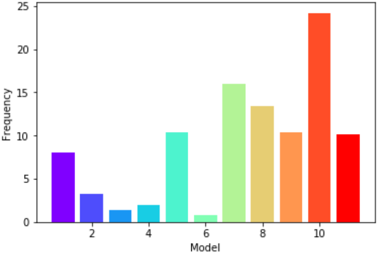
COMP1730/COMP6730

Programming for Scientists

Data science

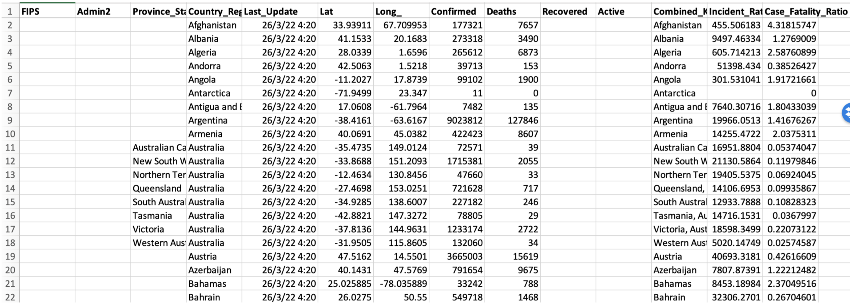
Data analysis

- Representing tables
- Reading data files
- Working with data: selecting, visualising
- Interpretation



Working example

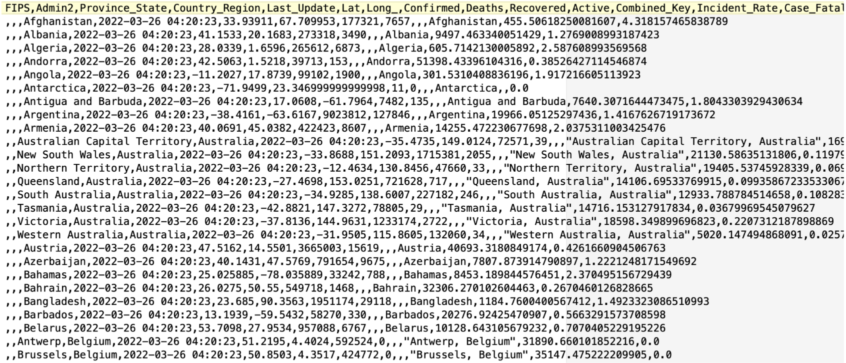
COVID-19 cases until 25th March 2022



1	FIPS	Admin2	Province_Sta	Country_Reg	Last_Update	Lat	Long_	Confirmed	Deaths	Recovered	Active	Combined_K	Incident_Rat	Case_Fatality_Ratio
2				Afghanistan	26/3/22 4:20	33.93911	67.709953	177321	7657			Afghanistan	455.506183	4.31815747
3				Albania	26/3/22 4:20	41.1533	20.1683	273318	3490			Albania	9497.46334	1.2769009
4				Algeria	26/3/22 4:20	28.0339	1.6596	265612	6873			Algeria	605.714213	2.58760899
5				Andorra	26/3/22 4:20	42.5063	1.5218	39713	153			Andorra	51398.434	0.38526427
6				Angola	26/3/22 4:20	-11.2027	17.8739	99102	1900			Angola	301.531041	1.91721661
7				Antarctica	26/3/22 4:20	-71.9499	23.347	11	0			Antarctica		0
8				Antigua and E	26/3/22 4:20	17.0608	-61.7964	7482	135			Antigua and E	7640.30716	1.80433039
9				Argentina	26/3/22 4:20	-38.4161	-63.6167	9023812	127846			Argentina	19966.0513	1.41676267
10				Armenia	26/3/22 4:20	40.0691	45.0382	422423	8607			Armenia	14255.4722	2.0375311
11			Australian Ca	Australia	26/3/22 4:20	-35.4735	149.0124	72571	39			Australian Ca	16951.8804	0.05374047
12			New South W	Australia	26/3/22 4:20	-33.8688	151.2093	1715381	2055			New South W	21130.5864	0.11979846
13			Northern Ter	Australia	26/3/22 4:20	-12.4634	130.8456	47660	33			Northern Ter	19405.5375	0.06924045
14			Queensland	Australia	26/3/22 4:20	-27.4698	153.0251	721628	717			Queensland,	14106.6953	0.09935867
15			South Austral	Australia	26/3/22 4:20	-34.9285	138.6007	227182	246			South Austral	12933.7888	0.10828323
16			Tasmania	Australia	26/3/22 4:20	-42.8821	147.3272	78805	29			Tasmania, Au	14716.1531	0.0367997
17			Victoria	Australia	26/3/22 4:20	-37.8136	144.9631	1233174	2722			Victoria, Aust	18598.3499	0.22073122
18			Western Aust	Australia	26/3/22 4:20	-31.9505	115.8605	132060	34			Western Aust	5020.14749	0.02574587
19				Austria	26/3/22 4:20	47.5162	14.5501	3665003	15619			Austria	40693.3181	0.42616609
20				Azerbaijan	26/3/22 4:20	40.1431	47.5769	791654	9675			Azerbaijan	7807.87391	1.22212482
21				Bahamas	26/3/22 4:20	25.025885	-78.035889	33242	788			Bahamas	8453.18984	2.37049516
22				Bahrain	26/3/22 4:20	26.0275	50.55	549718	1468			Bahrain	32306.2701	0.26704601

Data files

- Many data file formats (e.g., excel, csv, json, binary). We'll use the following csv file.



```
FIPS,Admin2,Province_State,Country_Region,Last_Update,Lat,Long_,Confirmed,Deaths,Recovered,Active,Combined_Key,Incident_Rate,Case_Fatal
,,,Afghanistan,2022-03-26 04:20:23,33.93911,67.709953,177321,7657,,,Afghanistan,455.5061825008l607,4.318157465838789
,,,Albania,2022-03-26 04:20:23,41.1533,20.1683,273318,3490,,,Albania,9497.463340051429,1.2769008993187423
,,,Algeria,2022-03-26 04:20:23,28.0339,1.6596,265612,6873,,,Algeria,605.7142130005892,2.587608993569568
,,,Andorra,2022-03-26 04:20:23,42.5063,1.5218,39713,153,,,Andorra,51398.43396104316,0.38526427114546874
,,,Angola,2022-03-26 04:20:23,-11.2027,17.8739,99102,1900,,,Angola,301.5310408836196,1.917216605113923
,,,Antarctica,2022-03-26 04:20:23,-71.9499,23.346999999999998,11,0,,,Antarctica,,0.0
,,,Antigua and Barbuda,2022-03-26 04:20:23,17.0608,-61.7964,7482,135,,,Antigua and Barbuda,7640.3071644473475,1.804330392943063 4
,,,Argentina,2022-03-26 04:20:23,-38.4161,-63.6167,9023812,127846,,,Argentina,19966.05125297436,1.4167626719173672
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,,Australian Capital Territory,Australia,2022-03-26 04:20:23,-35.4735,149.0124,72571,39,,,"Australian Capital Territory, Australia",169
,,New South Wales,Australia,2022-03-26 04:20:23,-33.8688,151.2093,1715381,2055,,,"New South Wales, Australia",21130.58635131806,0.1197
,,Northern Territory,Australia,2022-03-26 04:20:23,-12.4634,130.8456,47660,33,,,"Northern Territory, Australia",19405.53745928339,0.069
,,Queensland,Australia,2022-03-26 04:20:23,-27.4698,153.0251,721628,717,,,"Queensland, Australia",14106.69533769915,0.0993586723353306
,,South Australia,Australia,2022-03-26 04:20:23,-34.9285,138.6007,227182,246,,,"South Australia, Australia",12933.788784514658,0.10828
,,Tasmania,Australia,2022-03-26 04:20:23,-42.8821,147.3272,78805,29,,,"Tasmania, Australia",14716.153127917834,0.03679969545079627
,,Victoria,Australia,2022-03-26 04:20:23,-37.8136,144.9631,1233174,2722,,,"Victoria, Australia",18598.349899696823,0.2207312187898869
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,,,Bahrain,2022-03-26 04:20:23,26.0275,50.55,549718,1468,,,Bahrain,32306.270102604463,0.2670460126828665
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,,Antwerp,Belgium,2022-03-26 04:20:23,51.2195,4.4024,592524,0,,,"Antwerp, Belgium",31890.660101852216,0.0
,,Brussels,Belgium,2022-03-26 04:20:23,50.8503,4.3517,424772,0,,,"Brussels, Belgium",35147.475222209905,0.0
```

Which data type can we use to represent tables?

Representing tables

- Lists are 1-dimensional, but a list can contain values of any type, including lists.
- A table can be stored as a list of lists, by row, for example:

```
data[i]     # i:th row
data[i][j]  # j:th column of i:th row
```

- Indexing (and slicing) are *operators*
- Indexing (and slicing) associate to the left:

```
data[i][j] == (data[i])[j]
```

- (later we will cover pandas.DataFrame which is a higher level data structure for data processing)

Reading data files

- We will use a python module that helps with reading the file format:

```
import csv
with open("filename.csv") as csvfile:
    reader = csv.reader(csvfile)
    next(reader) # skip the header
    data = [ row for row in reader ]
```

- More about (reading and writing) files later in the course.

List comprehension

- Typically we will initialise a list variable with data when created:

```
first_col = []
for row in data:
    first_col.append(row[0])
```

- Python offers a shorter syntax for this called a *list comprehension* which creates a list by evaluating an expression for each value in an iterable collection (e.g., a sequence) using syntax:

```
[ expression for item in a_sequence ]
```

- Example: selecting columns of the table

```
first_col = [ row[0] for row in data ]
last_two_cols = [ row[-2:] for row in data ]
```

Conditional list comprehension

- Syntax:

```
[ expression for item in a_sequence if boolean_expression ]
```

- Example: select rows where column-1 is > 10

```
sel_rows = [ row for row in data if int(row[1]) > 10 ]
```

- Equivalent to:

```
sel_rows = []
for row in data:
    if int(row[1]) > 10:
        sel_rows.append(row)
```

Sorting

- `sorted(seq)` returns a list with values in `seq` sorted in default order (<).
  - We can sort the rows in a table.
  - Reminder: comparison of sequences is lexicographic.
- `sorted(seq, key=`*fun*`)` sorts value `x` by *fun*`(x)`.

```python
def new_order(row):
    return -row[-1]  # decreasing on last col

sd = sorted(data, key=new_order)
```

Descriptive statistics

- min(*seq*);
- max(*seq*);
- mean (sum(*seq*) / len(*seq*));
- variance.
- No built-in function for median.

```
def median(seq):
    if len(seq) % 2 == 1:
        return sorted(seq)[len(seq) // 2]
    else:
        return sum(sorted(seq)[(len(seq)//2-1):(len(seq)//2+1)])/2
```

Visualisation

- The purpose of visualisation is to see or show information – not drawing pretty pictures!
- Different kinds of plots show different things:
  - barplot
  - histogram or cumulative distribution
  - scatterplot
  - line and area plot
- Depends on relation between variables and whether they are continuous or discrete.
- Choose your dimensions carefully.
- Label axes, lines, etc.

Matplotlib

- Matplotlib is a Python 2D plotting library, which produces publication quality figures.
- “*Matplotlib makes easy things easy and hard things possible*”.
- Documentation: `matplotlib.org`

Take home message

- Python is powerful in data analysis.
- Think carefully about visualisation: How can people quickly interpret the results?
- We have only scratched the surface of Matplotlib. Extensive documentation: `https://matplotlib.org` or just **google it**.
- Other useful plotting libraries Seaborn (based on Matplotlib and includes more complex plots such as heatmaps); and Plotnine (based on a "grammar of graphics" and similar to the R ggplot graphics library).