

dm25s1

Topic 04 : Exploratory Data Analysis

Part 01 : EDA Pass1

Dr Bernard Butler

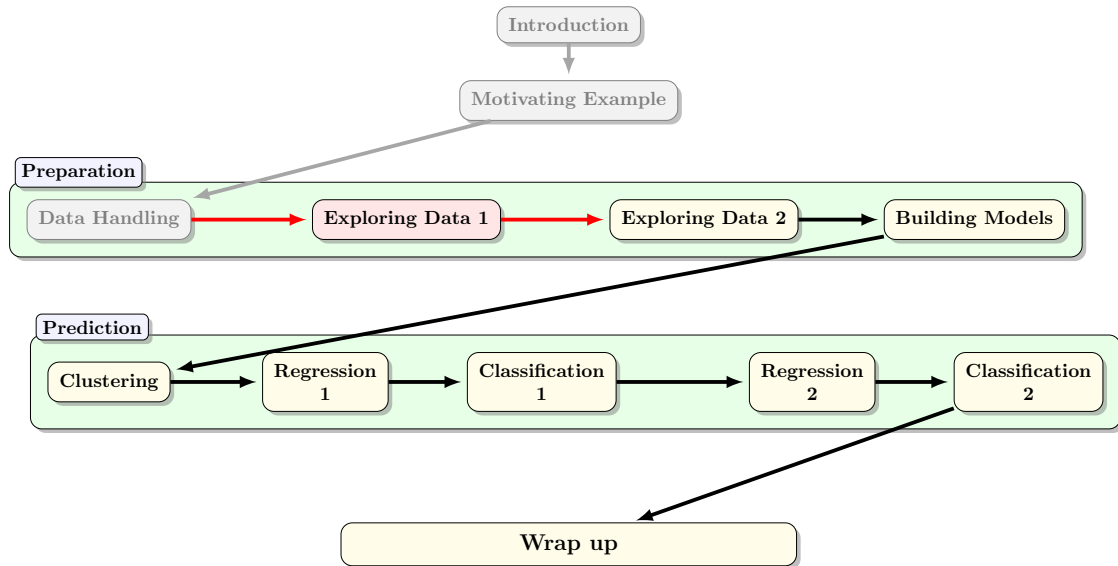
Department of Computing and Mathematics, WIT.
(bernard.butler@setu.ie)

Autumn Semester, 2025

Outline

- EDA Process
- Datasets = Tips, Titanic and Algae Blooms
- EDA Pass 1

Data Mining (Week 4)



EDA Pass1 — Summary

1. Introduction

1.1 Example Datasets

1.2 Before we start ...

2. First Pass — Load Dataset and Initial Clean

2.1 dtypes

2.2 Missing Values

2.3 What have we achieved?

Acknowledgment

A big thanks to Dr Kieran Murphy, who provided many of the slides for today's lecture.

Introduction

Exploratory Data Analysis (EDA)

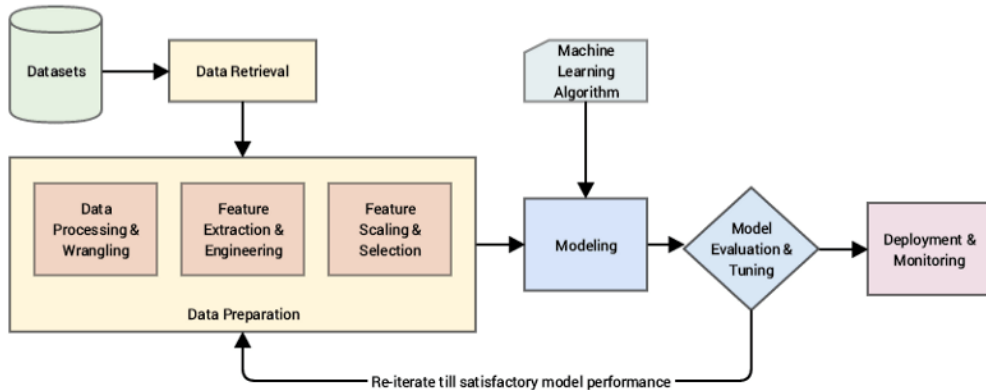
Aim

To understand and summarise a dataset to ensure that the features which are feed to machine learning algorithms are refined and that the results are valid and can correctly interpreted.

Benefits

- Develop insight about the dataset and understanding of the underlying structure.
- Extract important parameters and relationships that hold between them.
- Test underlying assumptions.
- Identify issues that affect model performance — outliers, missing values.

Data Pipeline



- Data preparation is the core of the data mining pipeline (typical estimates >50% of the time/effort).
- EDA is the data processing and wrangling.
- EDA informs the feature extraction, engineering, transformation and selection.

The Bad News — ‘The curse of choice’

What questions to ask?

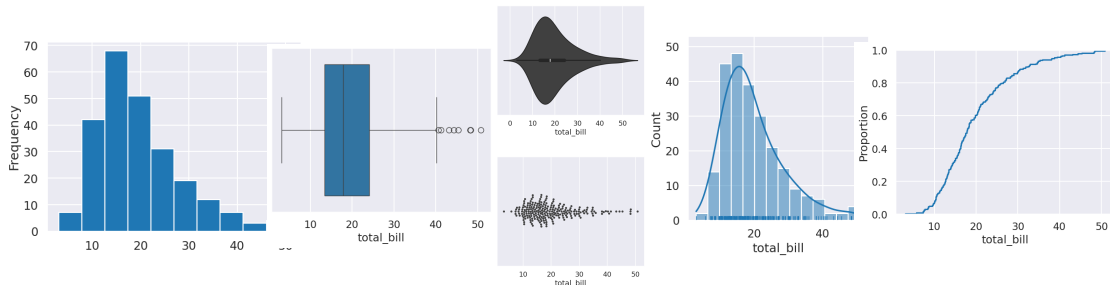
Dataset global questions: How many features? How many observations? What is the data type of each feature? Any null values? ... Feature specific questions: What is the distribution of each variable? Do there appear to be outliers? What features are related? ... Missing value questions: Are null value a result of the way data was recorded? Can we drop the rows with null values without it significantly affecting your analysis? Can we justify filling in the missing values with the mean or median for that variable? If the data is time-series data, can we fill the missing values with interpolation? Are there so many missing values for a variable that we should drop that variable from the dataset? ... Outlier questions: Why are outliers present? Do the outliers represent real observations (i.e. not errors)? Should we exclude these observations? If not, should we winsorise the values? ... Correlations/Relationships questions: Which variables are most correlated with your target variable? (If applicable) Is there multicollinearity? (Two features that have a correlation > 0.8) How will this affect your model? Do you have variables that represent the same information? Can one be dropped? ...

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What visualisations to build?

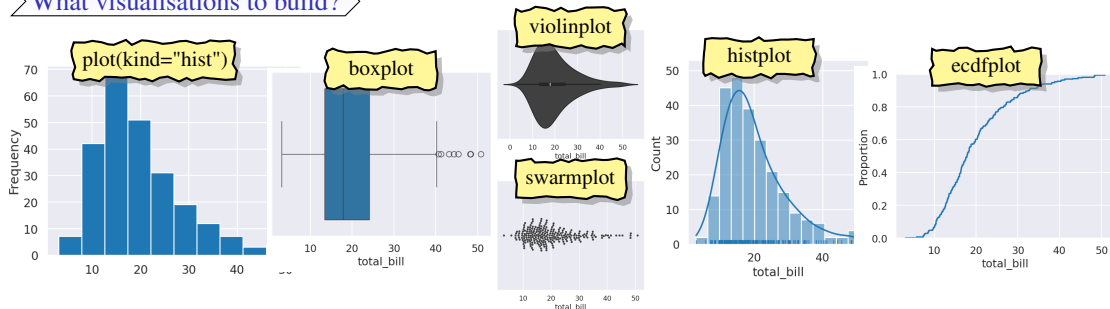


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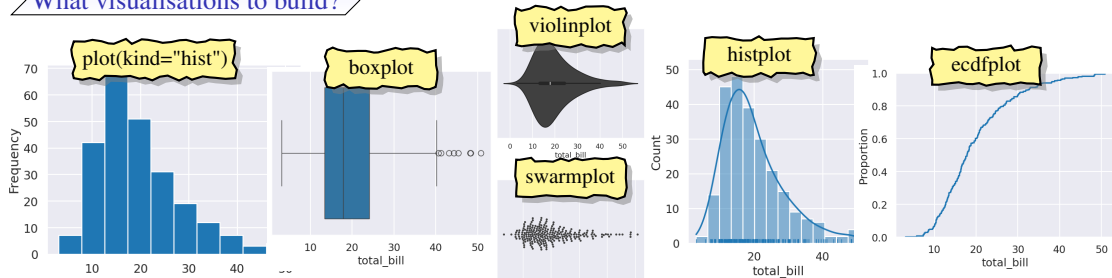


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What visualisations to build?



Have a plan, be selective, understand strengths/weaknesses of metrics/visualisations

Terminology / Notation

PassengerId	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked	Survived
1	3	Braund, Mr. Owen Harris	male	22.0	1	0	A/5 21171	7.2500	NaN	S	0
2	1	Cumings, Mrs. John Bradley (Florence Briggs Th...	female	38.0	1	0	PC 17599	71.2833	C85	C	1
3	3	Heikkinen, Miss. Laina	female	26.0	0	0	STON/O2. 3101282	7.9250	NaN	S	1
4	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35.0	1	0	113803	53.1000	C123	S	1
5	3	Allen, Mr. William Henry	male	35.0	0	0	373450	8.0500	NaN	S	0
6	3	Moran, Mr. James	male	NaN	0	0	330877	8.4583	NaN	Q	0
7	1	McCarthy, Mr. Timothy J	male	54.0	0	0	17463	51.8625	E46	S	0
8	3	Palsson, Master. Gosta Leonard	male	2.0	3	1	349909	21.0750	NaN	S	0
9	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27.0	0	2	347742	11.1333	NaN	S	1
10	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14.0	1	0	237736	30.0708	NaN	C	1
11	3	Sandstrom, Miss. Marguerite Rut	female	4.0	1	1	PP 9549	16.7000	G6	S	1

Terminology / Notation

$n + 1$ columns / variables

\mathbf{X}

n features / attributes / dimensions

y target

m observations / instances / cases / rows

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- Use bold to represent vectors and matrices.

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- So $x_j^{(i)}$ (or $x_{i,j}$) is the i -th observation in the j -th feature $x_j^{(i)}$

Example Datasets

We will use a few datasets today to illustrate the various features:

Tips

Titanic

Algae Blooms

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- Water quality study where samples were taken from different rivers over time.
- Recorded levels of (seven) chemical substances and population of (six) algae species and other information on the sample conditions.
- Task: regression — predict algae population level (7 separate populations).

Tips **dataset**

	total_bill	tip	sex	smoker	day	time	size
0	16.99	1.01	Female	No	Sun	Dinner	2
1	10.34	1.66	Male	No	Sun	Dinner	3
2	21.01	3.50	Male	No	Sun	Dinner	3
3	23.68	3.31	Male	No	Sun	Dinner	2
4	24.59	3.61	Female	No	Sun	Dinner	4
5	25.29	4.71	Male	No	Sun	Dinner	4
6	8.77	2.00	Male	No	Sun	Dinner	2
7	26.88	3.12	Male	No	Sun	Dinner	4
8	15.04	1.96	Male	No	Sun	Dinner	2
9	14.78	3.23	Male	No	Sun	Dinner	2

No target column, so mainly just an exploratory data analysis problem. But questions of interest:

- How do factors **sex**, **smoker**, **day**, **time**, or **size** affect tip / percentage tip?
- Does **size** vary with **day**, **time**, **smoker**?

But some questions don't make sense

- What is the relationship between **sex** and **smoker**? — why should they be related?

This is the downside of automatic EDA tools such as **pandas-profiling** — you will drown in statistics / charts.

Algae Blooms dataset

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a
0	winter	small	medium	8.00	9.8	60.800	6.238	578.00000	105.00000	170.00000	50.000	0.0	0.0	0.0
1	spring	small	medium	8.35	8.0	57.750	1.288	370.00000	428.75000	558.75000	1.300	1.4	7.6	4.8
2	autumn	small	medium	8.10	11.4	40.020	5.330	346.66699	125.66700	187.05701	15.600	3.3	53.6	1.9
3	spring	small	medium	8.07	4.8	77.364	2.302	98.18200	61.18200	138.70000	1.400	3.1	41.0	18.
4	autumn	small	medium	8.06	9.0	55.350	10.416	233.70000	58.22200	97.58000	10.500	9.2	2.9	7.5
5	winter	small	high	8.25	13.1	65.750	9.248	430.00000	18.25000	56.66700	28.400	15.1	14.6	1.4
6	summer	small	high	8.15	10.3	73.250	1.535	110.00000	61.25000	111.75000	3.200	2.4	1.2	3.2
7	autumn	small	high	8.05	10.6	59.067	4.990	205.66701	44.66700	77.43400	6.900	18.2	1.6	0.0
8	winter	small	medium	8.70	3.4	21.950	0.886	102.75000	36.30000	71.00000	5.544	25.4	5.4	2.5
9	winter	small	high	7.93	9.9	8.000	1.390	5.80000	27.25000	46.60000	0.800	17.0	0.0	0.0
10	spring	small	high	7.70	10.2	8.000	1.527	21.57100	12.75000	20.75000	0.800	16.6	0.0	0.0
11	summer	small	high	7.45	11.7	8.690	1.588	18.42900	10.66700	19.00000	0.600	32.1	0.0	0.0
12	winter	small	high	7.74	9.6	5.000	1.223	27.28600	12.00000	17.00000	41.000	43.5	0.0	2.1
13	summer	small	high	7.72	11.8	6.300	1.470	8.00000	16.00000	15.00000	0.500	31.1	1.0	3.4
14	winter	small	high	7.90	9.6	3.000	1.448	46.20000	13.00000	61.60000	0.300	52.2	5.0	7.8
15	autumn	small	high	7.55	11.5	4.700	1.320	14.75000	4.25000	98.25000	1.100	69.9	0.0	1.7
16	winter	small	high	7.78	12.0	7.000	1.420	34.33300	18.66700	50.00000	1.100	46.2	0.0	0.0
17	spring	small	high	7.61	9.8	7.000	1.443	31.33300	20.00000	57.83300	0.400	31.8	0.0	3.1
18	summer	small	high	7.35	10.4	7.000	1.718	49.00000	41.50000	61.50000	0.800	50.6	0.0	9.9
19	spring	small	medium	7.79	3.2	64.000	2.822	8777.59961	564.59998	771.59998	4.500	0.0	0.0	0.0

Algae Blooms dataset

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2	autumn	small	medium	8.10	11.4	40.020	5.330	346.66699	125.66700	187.05701	15.600	3.3	53.6	1.9
3	spring	small	medium	8.07	4.8	77.364	2.302	98.18200	61.18200	138.70000	1.400	3.1	41.0	18.1
4	autumn	small	medium	8.06	9.0	55.350	10.416	233.70000	58.22200	97.58000	10.500	9.2	2.9	7.5
5	winter	small	high	8.25	13.1	65.750	9.248	430.00000	18.25000	56.66700	28.400	15.1	14.6	1.4
6	summer	small	high	8.15	10.3	73.250	1.535	110.00000	61.25000	111.75000	3.200	2.4	1.2	3.2
7	autumn	small	high	8.05	10.6	59.067	4.990	205.66701	44.66700	77.43400	6.900	18.2	1.6	0.0
8	winter	small	medium	8.70	3.4	21.950	0.886	102.75000	36.30000	71.00000	5.544	25.4	5.4	2.5
9	winter	small	high	7.93	9.9	8.000	1.390	5.80000	27.25000	46.60000	0.800	17.0	0.0	0.0
10	spring	small	high	7.70	10.2	8.000	1.527	21.57100	12.75000	20.75000	0.800	16.6	0.0	0.0
11	summer	small	high	7.45	11.7	8.690	1.588	18.42900	10.66700	19.00000	0.600	32.1	0.0	0.0
12	winter	small	high	7.74	9.6	5.000	1.223	27.28600	12.00000	17.00000	41.000	43.5	0.0	2.1
13	summer	small	high	7.72	11.8	6.300	1.470	8.00000	16.00000	15.00000	0.500	31.1	1.0	3.4
14	winter	small	high	7.90	9.6	3.000	1.448	46.20000	13.00000	61.60000	0.300	52.2	5.0	7.8
15	autumn	small	high	7.55	11.5	4.700	1.320	14.75000	4.25000	98.25000	1.100	69.9	0.0	1.7
16	winter	small	high	7.78	12.0	7.000	1.420	34.33300	18.66700	50.00000	1.100	46.2	0.0	0.0
17	spring	small	high	7.61	9.8	7.000	1.443	31.33300	20.00000	57.83300	0.400	31.8	0.0	3.1
18	summer	small	high	7.35	10.4	7.000	1.718	49.00000	41.50000	61.50000	0.800	50.6	0.0	9.9
19	spring	small	medium	7.79	3.2	64.000	2.822	8777.59961	564.59998	771.59998	4.500	0.0	0.0	0.0

Algae Blooms dataset

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a
0	winter	small	medium	8.00	9.8	60.800	6.238	578.00000	105.00000	170.00000	50.000	0.0	0.0	0.0
1	spring	small	medium	8.35	8.0	57.750	1.288	370.00000	428.75000	558.75000	1.300	1.4	7.6	4.8
2	autumn	small	medium	8.10	11.4	40.020	5.330	346.66699	125.66700	187.05701	15.600	3.3	53.6	1.9
3	spring	small	medium	8.07	4.8	77.364	2.302	98.18200	61.18200	138.70000	1.400	3.1	41.0	18.
4	autumn	small	medium	8.06	9.0	55.350	10.416	233.70000	58.22200	97.58000	10.500	9.2	2.9	7.5
5	winter	small	high	8.25	13.1	65.750	9.248	430.00000	18.25000	56.66700	28.400	15.1	14.6	1.4
6	summer	small	high	8.15	10.3	73.250	1.535	110.00000	61.25000	111.75000	3.200	2.4	1.2	3.2
7	autumn	small	high	8.05	10.6	59.067	4.990	205.66701	44.66700	77.43400	6.900	18.2	1.6	0.0
8	winter	small	medium	8.70	3.4	21.950	0.886	102.75000	36.30000	71.00000	5.544	25.4	5.4	2.5
9	winter	How well can we predict the (7) different algae population levels using water sample information?											0.0	0.0
10	spring	small	high	7.70	10.2	8.000	1.527	21.57100	12.75000	20.75000	0.800	16.6	0.0	0.0
11	summer	small	high	7.45	11.7	8.690	1.588	18.42900	10.66700	19.00000	0.600	32.1	0.0	0.0
12	winter	small	high	7.74	9.6	5.000	1.223	27.28600	12.00000	17.00000	41.000	43.5	0.0	2.1
13	summer	small	high	7.72	11.8	6.300	1.470	8.00000	16.00000	15.00000	0.500	31.1	1.0	3.4
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16	winter	small	high	7.78	12.0	7.000	1.420	34.33300	18.66700	50.00000	1.100	46.2	0.0	0.0
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19	spring	small	medium	7.79	3.2	64.000	2.822	8777.59961	564.59998	771.59998	4.500	0.0	0.0	0.0

Titanic dataset

	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked
0	1	0	3	Braund, Mr. Owen Harris	male	22.0	1	0	A/5 21171	7.2500	NaN	S
1	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Th...	female	38.0	1	0	PC 17599	71.2833	C85	C
2	3	1	3	Heikkinen, Miss. Laina	female	26.0	0	0	STON/O2. 3101282	7.9250	NaN	S
3	4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35.0	1	0	113803	53.1000	C123	S
4	5	0	3	Allen, Mr. William Henry	male	35.0	0	0	373450	8.0500	NaN	S
5	6	0	3	Moran, Mr. James	male	NaN	0	0	330877	8.4583	NaN	Q
6	7	0	1	McCarthy, Mr. Timothy J	male	54.0	0	0	17463	51.8625	E46	S
7	8	0	3	Palsson, Master. Gosta Leonard	male	2.0	3	1	349909	21.0750	NaN	S
8	9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27.0	0	2	347742	11.1333	NaN	S
9	10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14.0	1	0	237736	30.0708	NaN	C
10	11	1	3	Sandstrom, Miss. Marguerite Rut	female	4.0	1	1	PP 9549	16.7000	G6	S
11	12	1	1	Bonnell, Miss. Elizabeth	female	58.0	0	0	113783	26.5500	C103	S
12	13	0	3	Saunderscock, Mr. William Henry	male	20.0	0	0	A/5. 2151	8.0500	NaN	S
13	14	0	3	Andersson, Mr. Anders	male	39.0	1	5	347082	31.2750	NaN	S

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5	6	0	3	Moran, Mr. James	male	NaN	0	0	330877	8.4583	NaN	Q
6	7	0	1	McCarthy, Mr. Timothy J	male	54.0	0	0	17463	51.8625	E46	S
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How well can we predict a passenger's survival using information at time of departure?

Before we start ... Loading libraries

We start by loading in the core data science modules...

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
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Next, we import some statistical modules ...

```
import scipy.stats as stats
import statsmodels.api as sm
import pingouin as pg
```

`scipy.stats` has a large number of distributions, parametric and nonparametric statistical tests, and descriptive statistics.
`statsmodels` is more focused on estimating statistical models.
`pingouin` overlaps with bits of `scipy.stats` and `statsmodels` but generates more details and nicer visualisations.

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Finally we set options ...

```
plt.style.use("seaborn-v0_8-darkgrid")
```

Before we start ... auto EDA using ydata-profiling

```
from pandas_profiling import ProfileReport
profile = ProfileReport(df, title="Tips Report", html={"style": {"full_width": True}}, sort=None)
profile
```

Summarize dataset: 100%  21/21 [00:05<00:00, 4.00it/s, Completed]

Generate report structure: 100%  1/1 [00:02<00:00, 2.78s/it]

Render HTML: 100%  1/1 [00:00<00:00, 1.72it/s]

Tips Report

Overview

Variables

Interactions

Correlations

Missing values

Sample

Duplicate rows

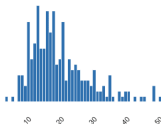
Variables

total_bill

Real number ($\mathbb{R}_{>0}$)

Distinct	229
Distinct (%)	93.9%
Missing	0
Missing (%)	0.0%
Infinite	0
Infinite (%)	0.0%

Mean	19.78594262
Minimum	3.07
Maximum	50.81
Zeros	0
Zeros (%)	0.0%
Memory size	1.9 KiB



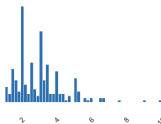
Toggle details

tip

Real number ($\mathbb{R}_{>0}$)

Distinct	123
Distinct (%)	50.4%
Missing	0
Missing (%)	0.0%
Infinite	0
Infinite (%)	0.0%

Mean	2.998278689
Minimum	1
Maximum	10
Zeros	0
Zeros (%)	0.0%
Memory size	1.9 KiB



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Summarize dataset: 100%  21/21 [00:05<00:00, 4.00it/s, Completed]

Generate report structure: 100%  1/1 [00:02<00:00, 2.78s/it]

Render HTML: 100%  1/1 [00:00<00:00, 1.72it/s]

ydata-profiling is nice, but see how slow it is on this tiny dataset. What would happen if we had 100K rows x 100 columns?

Tips Report

Overview

Variables

Interactions

Correlations

Missing values

Sample

Duplicate rows

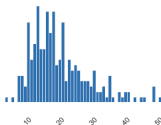
Variables

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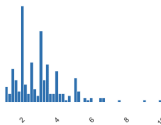
Toggle details

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Before we start ... zero-code EDA using dtale

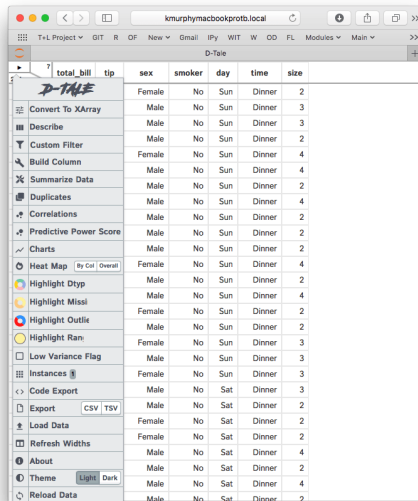
Well, almost zero code....

```
import pandas as pd
import dtale

# Read the Tips data into a dataframe, check it looks OK
df = pd.read_csv('tips.csv')
df.head()

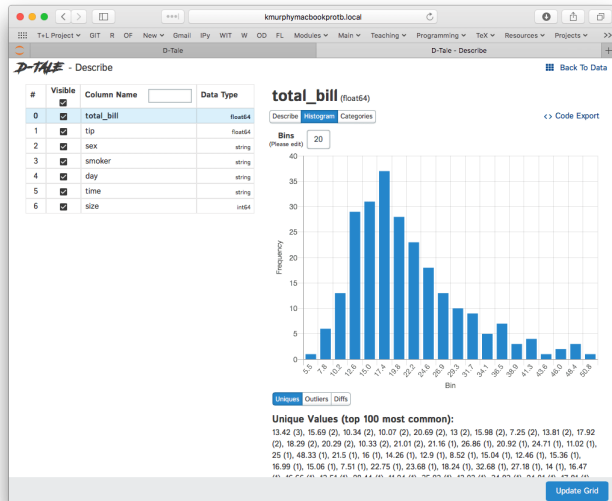
# Run dtale to visualize the structure of the dataframe
dtale.show(df)
```


Before we start ... zero-code EDA using dtale



The screenshot shows the dtale web interface in a browser window. The browser address bar shows 'kmurphymacbookprotb.local'. The interface has a sidebar on the left with various analysis tools, and a main table area on the right. The table has columns: total_bill, tip, sex, smoker, day, time, size. The data is as follows:

	total_bill	tip	sex	smoker	day	time	size
			Female	No	Sun	Dinner	2
			Male	No	Sun	Dinner	3
			Male	No	Sun	Dinner	3
			Male	No	Sun	Dinner	2
			Female	No	Sun	Dinner	4
			Male	No	Sun	Dinner	4
			Male	No	Sun	Dinner	2
			Male	No	Sun	Dinner	4
			Male	No	Sun	Dinner	2
			Male	No	Sun	Dinner	2
			Male	No	Sun	Dinner	2
			Female	No	Sun	Dinner	4
			Male	No	Sun	Dinner	2
			Male	No	Sun	Dinner	4
			Female	No	Sun	Dinner	2
			Male	No	Sun	Dinner	2
			Female	No	Sun	Dinner	3
			Male	No	Sun	Dinner	3
			Female	No	Sun	Dinner	3
			Male	No	Sat	Dinner	3
			Male	No	Sat	Dinner	2
			Female	No	Sat	Dinner	2
			Female	No	Sat	Dinner	2
			Male	No	Sat	Dinner	4
			Male	No	Sat	Dinner	2
			Male	No	Sat	Dinner	4
			Male	No	Sat	Dinner	2



Before we start ... zero-code EDA using dtale

kmurphymacbookprotb.local

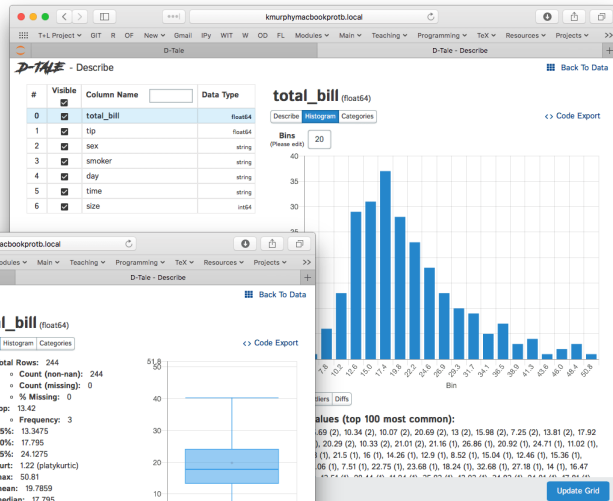
T+L Project ▾ GIT R OF New ▾ Gmail IPy WIT W OD FL Modules ▾ Main ▾ >>

D-Tale

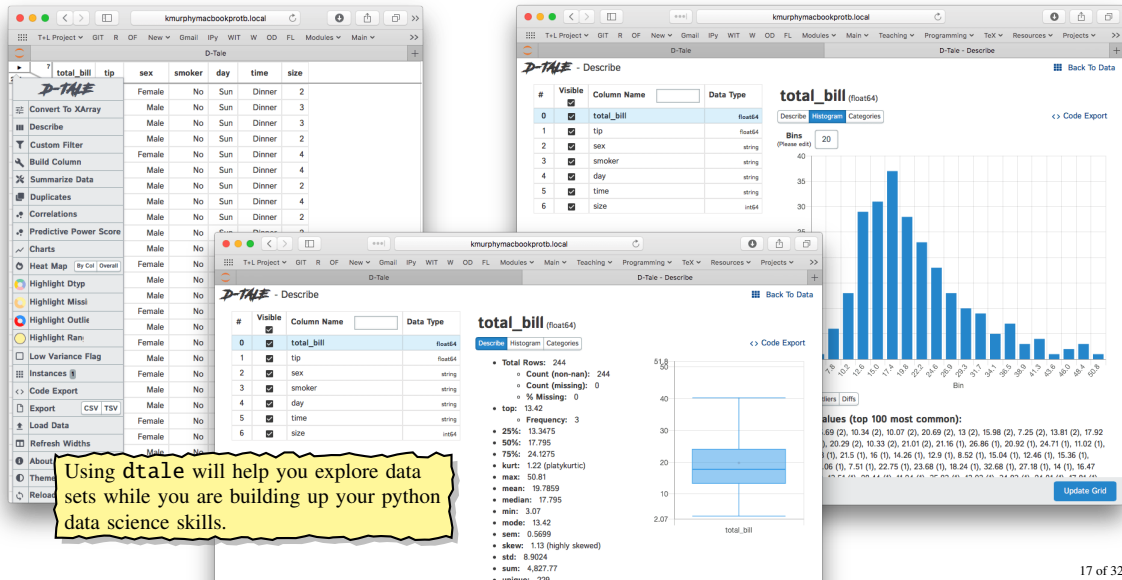
	total_bill	tip	sex	smoker	day	time	size
1	Female	No	Sun	Dinner	2		
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3	Male	No	Sun	Dinner	3		
4	Male	No	Sun	Dinner	2		
5	Female	No	Sun	Dinner	4		
6	Male	No	Sun	Dinner	4		
7	Male	No	Sun	Dinner	2		
8	Male	No	Sun	Dinner	4		
9	Male	No	Sun	Dinner	4		
10	Male	No	Sun	Dinner	2		
11	Male	No	Sun	Dinner	2		
12	Male	No	Sun	Dinner	2		
13	Male	No	Sun	Dinner	2		
14	Male	No	Sun	Dinner	2		
15	Male	No	Sun	Dinner	2		
16	Male	No	Sun	Dinner	2		
17	Male	No	Sun	Dinner	2		
18	Male	No	Sun	Dinner	2		
19	Male	No	Sun	Dinner	2		
20	Male	No	Sun	Dinner	2		

D-TALE

- Convert To XArray
- Describe
- Custom Filter
- Build Column
- Summarize Data
- Duplicates
- Correlations
- Predictive Power Score
- Charts
- Heat Map (By Col | Overall)
- Highlight Dtyp
- Highlight Missi
- Highlight Outlie
- Highlight Ran
- Low Variance Flag
- Instances
- Code Export
- Export CSV TSV
- Load Data
- Refresh Widths
- About
- Theme Light Dark
- Reload Data



Before we start ... zero-code EDA using dtale



Using dtale will help you explore data sets while you are building up your python data science skills.

First Pass — Load Dataset and Initial Clean

- Load dataset
- Check variables names
- Verify variable types
- Identify (and possibly address) missing values

Tips — Load

```
df = pd.read_csv("data/tips.csv")
print(df.shape)
df.head(10)
```

(244, 7)

	total_bill	tip	sex	smoker	day	time	size
0	16.99	1.01	Female	No	Sun	Dinner	2
1	10.34	1.66	Male	No	Sun	Dinner	3
2	21.01	3.50	Male	No	Sun	Dinner	3
3	23.68	3.31	Male	No	Sun	Dinner	2
4	24.59	3.61	Female	No	Sun	Dinner	4
5	25.29	4.71	Male	No	Sun	Dinner	4
6	8.77	2.00	Male	No	Sun	Dinner	2
7	26.88	3.12	Male	No	Sun	Dinner	4
8	15.04	1.96	Male	No	Sun	Dinner	2
9	14.78	3.23	Male	No	Sun	Dinner	2

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 244 entries, 0 to 243
```

```
Data columns (total 7 columns):
```

#	Column	Non-Null Count	Dtype
0	total_bill	244 non-null	float64
1	tip	244 non-null	float64
2	sex	244 non-null	object
3	smoker	244 non-null	object
4	day	244 non-null	object
5	time	244 non-null	object
6	size	244 non-null	int64

```
dtypes: float64(2), int64(1), object(4)
```

```
memory usage: 13.5+ KB
```

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(244, 7)

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2	21.01	3.50	Male	No	Sun	Dinner	3
3	23.68	3.31	Male	No	Sun	Dinner	2
4	24.59	3.61	Female	No	Sun	Dinner	4
5	25.29	4.71	Male	No	Sun	Dinner	4
6	8.77	2.00	Male	No	Sun	Dinner	2
7	26.88	3.12	Male	No	Sun	Dinner	4
8	15.04	1.96	Male	No	Sun	Dinner	2
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6	size	244 non-null	int64

```
dtypes: float64(2), int64(1), object(4)
```

```
memory usage: 13.5+ KB
```

Issue: categorical data treated as object (string).

Tips — Fix Data Types

- `df.sex.unique()`

```
array(['Female', 'Male'], dtype=object)
```

- `df.sex = pd.Categorical(df.sex)`
`df.sex.unique()`

```
['Female', 'Male']  
Categories (2, object): ['Female', 'Male']
```


Tips — Fix Data Types

- `df.sex.unique()`

```
array(['Female', 'Male'], dtype=object)
```

- `df.sex = pd.Categorical(df.sex)`
`df.sex.unique()`

```
['Female', 'Male']  
Categories (2, object): ['Female', 'Male']
```

- `df.smoker.unique()`

```
array(['No', 'Yes'], dtype=object)
```

- `df.smoker = pd.Categorical(df.smoker)`
`df.smoker.unique()`

```
['No', 'Yes']  
Categories (2, object): ['No', 'Yes']
```

Tips — Fix Data Types

```
df.sex.unique()
```

```
array(['Female', 'Male'], dtype=object)
```

```
df.sex = pd.Categorical(df.sex)  
df.sex.unique()
```

```
['Female', 'Male']  
Categories (2, object): ['Female', 'Male']
```

```
df.smoker.unique()
```

```
array(['No', 'Yes'], dtype=object)
```

```
df.smoker = pd.Categorical(df.smoker)  
df.smoker.unique()
```

```
['No', 'Yes']  
Categories (2, object): ['No', 'Yes']
```

```
df.day.unique()
```

```
array(['Sun', 'Sat', 'Thur', 'Fri'], dtype=object)
```

```
df.day = pd.Categorical(df.day, categories=['Thur', 'Fri', 'Sun', 'Sat'], ordered=True)  
df.day.unique()
```

```
['Sun', 'Sat', 'Thur', 'Fri']  
Categories (4, object): ['Thur' < 'Fri' < 'Sun' < 'Sat']
```

Tips — fix datatypes

```
df.time = pd.Categorical(df.time, categories=['Lunch', 'Dinner'], ordered=True)  
df.time.unique()
```

```
['Dinner', 'Lunch']
```

```
Categories (2, object): ['Lunch' < 'Dinner']
```

Tips — fix datatypes

```
df.time = pd.Categorical(df.time, categories=['Lunch', 'Dinner'], ordered=True)
df.time.unique()
```

```
['Dinner', 'Lunch']
Categories (2, object): ['Lunch' < 'Dinner']
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 244 entries, 0 to 243
```

```
Data columns (total 7 columns):
```

#	Column	Non-Null Count	Dtype
0	total_bill	244 non-null	float64
1	tip	244 non-null	float64
2	sex	244 non-null	category
3	smoker	244 non-null	category
4	day	244 non-null	category
5	time	244 non-null	category
6	size	244 non-null	int64

```
dtypes: category(4), float64(2), int64(1)
```

```
memory usage: 7.4 KB
```

Tips — fix datatypes

```
df.time = pd.Categorical(df.time, categories=['Lunch', 'Dinner'], ordered=True)
df.time.unique()
```

```
['Dinner', 'Lunch']
Categories (2, object): ['Lunch' < 'Dinner']
```

```
df.info()
```

Converting to category will:

- Simplify visualisation (order can be preserved).
 - Reduce memory usage (not that big a deal for us).
 - Speed up I/O (depending on file format).
- ⇒ Convert to category is a bigger deal for features where the levels have an order.

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 244 entries, 0 to 243
```

```
Data columns (total 7 columns):
```

#	Column	Non-Null Count	Dtype
0	total_bill	244 non-null	float64
1	tip	244 non-null	float64
2	sex	244 non-null	category
3	smoker	244 non-null	category
4	day	244 non-null	category
5	time	244 non-null	category
6	size	244 non-null	int64

```
dtypes: category(4), float64(2), int64(1)
```

```
memory usage: 7.4 KB
```

Titanic — load

- Dataset is split into two parts:
 - `train.csv` — 891 rows with `Survived` column, used in EDA and model training.
 - `test.csv` — 418 rows without the `Survived` column, used in competition scoring.

Titanic — load

- Dataset is split into two parts:
 - `train.csv` — 891 rows with Survived column, used in EDA and model training.
 - `test.csv` — 418 rows without the Survived column, used in competition scoring.

```
df = pd.read_csv("data/train.csv")
print(df.shape)
df.head(25)
```

	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked
0	1	0	3	Braund, Mr. Owen Harris	male	22.0	1	0	A/5 21171	7.2500	NaN	S
1	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Th...	female	38.0	1	0	PC 17599	71.2833	C85	C
2	3	1	3	Heikkinen, Miss. Laina	female	26.0	0	0	STON/O2. 3101282	7.9250	NaN	S
3	4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35.0	1	0	113803	53.1000	C123	S
4	5	0	3	Allen, Mr. William Henry	male	35.0	0	0	373450	8.0500	NaN	S
5	6	0	3	Moran, Mr. James	male	NaN	0	0	330877	8.4583	NaN	Q
6	7	0	1	McCarthy, Mr. Timothy J	male	54.0	0	0	17463	51.8625	E46	S
7	8	0	3	Paisson, Master. Gosta Leonard	male	2.0	3	1	349909	21.0750	NaN	S
8	9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27.0	0	2	347742	11.1333	NaN	S
9	10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14.0	1	0	237736	30.0708	NaN	C
10	11	1	3	Sandstrom, Miss. Marguerite Rut	female	4.0	1	1	PP 9549	16.7000	G6	S
11	12	1	1	Bonnell, Miss. Elizabeth	female	58.0	0	0	113783	26.5500	C103	S
12	13	0	3	Saunderscock, Mr. William Henry	male	20.0	0	0	A/S. 2151	8.0500	NaN	S
13	14	0	3	Andersson, Mr. Anders Johan	male	39.0	1	5	347082	31.2750	NaN	S
14	15	0	3	Vestrom, Miss. Hulda Amanda Adolfina	female	14.0	0	0	350406	7.8542	NaN	S
15	16	1	2	Hewlett, Mrs. (Mary D Kingcome)	female	55.0	0	0	248706	16.0000	NaN	S
16	17	0	3	Rice, Master. Eugene	male	2.0	4	1	382652	29.1250	NaN	Q
17	18	1	2	Williams, Mr. Charles Eugene	male	NaN	0	0	244373	13.0000	NaN	S
18	19	0	3	Vander Planke, Mrs. Julius (Emelia Maria Vande...	female	31.0	1	0	345763	18.0000	NaN	S
19	20	1	3	Masabiani, Mrs. Estima	female	NaN	0	0	2649	7.2750	NaN	C

Titanic — load

- Dataset is split into two parts:
 - `train.csv` — 891 rows with Survived column, used in EDA and model training.
 - `test.csv` — 418 rows without the Survived column, used in competition scoring.

```
df = pd.read_csv("data/train.csv")
print(df.shape)
df.head(25)
```

	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked
0	1	0	3	Braund, Mr. Owen Harris	male	22.0	1	0	A/5 21171	7.2500	NaN	S
1	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Th...)	female	38.0	1	0	PC 17599	71.2833	C85	C
2	3	1	3	Heikkinen, Miss. Laina	female	26.0	0	0	STON/O2. 3101282	7.9250	NaN	S
3	4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35.0	1	0	113803	53.1000	C123	S
4	5	0	3	Allen, Mr. William Henry	male	35.0	0	0	373450	8.0500	NaN	S
5	6	0	3	Moran, Mr. James	male	NaN	0	0	330877	8.4583	NaN	Q
6	7	0	1	McCarthy, Mr. Timothy J	male	54.0	0	0	17463	51.8625	E46	S
7	8	0	3	Palsson, Master. Gosta Leonard	male	2.0	3	1	349909	21.0750	NaN	S
8	9	1	3	Johnson, Mrs. Oscar W (Elisabeth Vilhelmina Berg)	female	27.0	0	2	347742	11.1333	NaN	S
9	10	1	2	Nasser, Mrs. Nicholas (Adele Achem)	female	14.0	1	0	237736	30.0708	NaN	C
10	11	1	3	Sandstrom, Miss. Marguerite Rut	female	4.0	1	1	PP 9549	16.7000	G6	S
11	12	1	1	Bonnell, Miss. Elizabeth	female	58.0	0	0	113783	26.5500	C103	S
12	13	0	3	Saunderscock, Mr. William Henry	male	20.0	0	0	A/5. 2151	8.0500	NaN	S
13	14	0	3	Andersson, Mr. Anders Johan	male	39.0	1	5	347082	31.2750	NaN	S
14	15	0	3	Vestrom, Miss. Hulda Amanda Adolfina	female	14.0	0	0	350406	7.8542	NaN	S
15	16	1	2	Hewlett, Mrs. (Mary D Kingcome)	female	55.0	0	0	248706	16.0000	NaN	S
16	17	0	3	Rice, Master. Eugene	male	2.0	4	1	382652	29.1250	NaN	Q
17	18	1	2	Williams, Mr. Charles Eugene	male	NaN	0	0	244373	13.0000	NaN	S
18	19	0	3	Vander Planke, Mrs. Julius (Emelia Maria Vande...)	female	31.0	1	0	345763	18.0000	NaN	S
19	20	1	3	Masela, Mrs. Estima...	female	NaN	0	0	2649	7.7250	NaN	C

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
```

#	Column	Non-Null Count	Dtype
0	PassengerId	891 non-null	int64
1	Survived	891 non-null	int64
2	Pclass	891 non-null	int64
3	Name	891 non-null	object
4	Sex	891 non-null	object
5	Age	714 non-null	float64
6	SibSp	891 non-null	int64
7	Parch	891 non-null	int64
8	Ticket	891 non-null	object
9	Fare	891 non-null	float64
10	Cabin	204 non-null	object
11	Embarked	889 non-null	object

```
dtypes: float64(2), int64(5), object(5)
```


Titanic — load

- Dataset is split into two parts:
 - `train.csv` — 891 rows with Survived column, used in EDA and model training.
 - `test.csv` — 418 rows without the Survived column, used in competition scoring.

```
df = pd.read_csv("data/train.csv")
print(df.shape)
df.head(25)
```

	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked
0	1	0	3	Braund, Mr. Owen Harris	male	22.0	1	0	A/5 21171	7.2500	NaN	S
1	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Th...)	female	38.0	1	0	PC 17599	71.2833	C85	C
2	3	1	3	Heikkinen, Miss. Laina	female	26.0	0	0	STON/O2. 3101282	7.9250	NaN	S

- We could convert `Sex` or `Embarked`, to a category, but since their levels are not ordered there is no big advantage.
- We don't want to convert `Name`, `Ticket` and `Cabin` since we want to perform further text processing on these columns. For example, extracting title (Capt, Mr, Miss, etc.) out of `Name`.
- We have missing values (**that are plausibly linked to target**) that we need to deal with.

18	19	0	3	Vander Planke, Mrs. Julius (Emelia Maria Vande...)	female	31.0	1	0	345763	18.0000	NaN	S
19	20	1	3	Mascekman, Mrs. Estima	female	NaN	0	0	2649	7.2250	NaN	C

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 891 entries, 0 to 890
Data columns (total 12 columns):
```

#	Column	Non-Null Count	Dtype
0	PassengerId	891 non-null	int64
1	Survived	891 non-null	int64
2	Pclass	891 non-null	int64
3	Name	891 non-null	object
4	Sex	891 non-null	object
5	Age	714 non-null	float64
6	SibSp	891 non-null	int64
7	Parch	891 non-null	int64
8	Ticket	891 non-null	object
9	Fare	891 non-null	float64
10	Cabin	204 non-null	object
11	Embarked	889 non-null	object

```
dtypes: float64(2), int64(5), object(5)
```

Algae_Blooms — load

I

<https://archive.ics.uci.edu/ml/datasets/Coil+1999+Competition+Data>

Read instructions.txt, and
download the *.data files.

UCI Machine Learning Repository
Center for Machine Learning and Intelligent Systems

Coil 1999 Competition Data Data Set
Download: [Data Folder](#) [Data Set Description](#)

Abstract: This data set is from the 1999 Computational Intelligence and Learning (COIL) competition. The data contains measurements of river chemical concentrations and algae densities.

Data Set Characteristics:	Multivariate	Number of Instances:	340	Area:	Physical
Attribute Characteristics:	Categorical, Real	Number of Attributes:	17	Date Donated	1999-09-09
Associated Tasks:	N/A	Missing Values?	No	Number of Web Hits:	52986

Source:

Original Owner:

ERUDIT
European Network for Fuzzy Logic and Uncertainty Modelling
<http://www.erudit.de/>

Donor:

Jens Strackeljan
Technical University Clausthal
Institute of Applied Mechanics
Graupenstr. 3, 38678 Clausthal-Zellerfeld, Germany
jmx@im.tu-clausthal.de

Data Set Information:

This data comes from a water quality study where samples were taken from a river. The samples contain chemical substances including: nitrogen in the form of nitrates, nitrites, and ammonia.

The competition involved the prediction of algal frequency density when the sample was taken, the river size and its flow velocity.

Index of /ml/machine-learning-databases/coil-mld

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- [analysis.data](#)
- [coil.data.html](#)
- [coil.html](#)
- [eval.data](#)
- [instructions.txt](#)
- [r2](#)
- [results.data](#)
- [results.htm](#)
- [results.txt](#)

Apache/2.4.6 (CentOS) OpenSSL/1.0.2k-fips SVN/1.7.14 Phusion_Passenger/4.0.53 mod_perl/2.0.11 Perl/v5.16.3 Server at archive.ics.uci.edu Port 443

Pandas function `pd.read_table`, is a more general function than `read_csv`.

```
df = pd.read_table('src/Analysis.txt')
print(df.shape)
df.head()
```

(199, 1)

	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.00000	0.00000	0.00000	0.00000
0	spring	small	medium	8.35000	...										
1	autumn	small	medium	8.10000	1...										
2	spring	small	medium	8.07000	...										
3	autumn	small	medium	8.06000	...										
4	winter	small	high	8.25000	13....										

Pandas function `pd.read_table`, is a more general function than `read_csv`.

```
df = pd.read_table('src/Analysis.txt')
print(df.shape)
df.head()
```

(199, 1)

	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.00000	0.00000	0.00000	0.00000
0	spring	small	medium	8.35000	...										
1	autumn	small	medium	8.10000	1...										
2	spring	small	medium	8.07000	...										
3	autumn	small	medium	8.06000	...										
4	winter	small	high	8.25000	13....										

Two problems, first row was treated as column headers, and we need to specify the character(s) used to separate columns

Algae_Blooms — load (2nd attempt)

III

```
df = pd.read_table('src/Analysis.txt', sep=r'\s+', header=None)
print(df.shape)
df.head()
```

(200, 18)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.0	0.0	0.0	0.0	34.2	8.3
1	spring	small	medium	8.35000	8.00000	57.75000	1.28800	370.00000	428.75000	558.75000	1.30000	1.4	7.6	4.8	1.9	6.7	0.0
2	autumn	small	medium	8.10000	11.40000	40.02000	5.33000	346.66699	125.66700	187.05701	15.60000	3.3	53.6	1.9	0.0	0.0	0.0
3	spring	small	medium	8.07000	4.80000	77.36400	2.30200	98.18200	61.18200	138.70000	1.40000	3.1	41.0	18.9	0.0	1.4	0.0
4	autumn	small	medium	8.06000	9.00000	55.35000	10.41600	233.70000	58.22200	97.58000	10.50000	9.2	2.9	7.5	0.0	7.5	4.1

Algae_Blooms — load (2nd attempt)

```
df = pd.read_table('src/Analysis.txt', sep=r'\s+', header=None)
print(df.shape)
df.head()
```

(200, 18)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.0	0.0	0.0	0.0	34.2	8.3
1	spring	small	medium	8.35000	8.00000	57.75000	1.28800	370.00000	428.75000	558.75000	1.30000	1.4	7.6	4.8	1.9	6.7	0.0
2	autumn	small	medium	8.10000	11.40000	40.02000	5.33000	346.66699	125.66700	187.05701	15.60000	3.3	53.6	1.9	0.0	0.0	0.0
3	spring	small	medium	8.07000	4.80000	77.36400	2.30200	98.18200	61.18200	138.70000	1.40000	3.1	41.0	18.9	0.0	1.4	0.0
4	autumn	small	medium	8.06000	9.00000	55.35000	10.41600	233.70000	58.22200	97.58000	10.50000	9.2	2.9	7.5	0.0	7.5	4.1

- Now, notice that the number of data rows changed from 199 to 200 since the first row is now counted as a data row. And now we are using default columns names.
- The "\s+" matches one or more spaces. This is an example of a regex.

Algae_Blooms — load (2nd attempt)

```
df = pd.read_table('src/Analysis.txt', sep=r'\s+', header=None)
print(df.shape)
df.head()
```

(200, 18)

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.0	0.0	0.0	0.0	34.2	8.5
1	spring	small	medium	8.35000	8.00000	57.75000	1.28800	370.00000	428.75000	558.75000	1.30000	1.4	7.6	4.8	1.9	6.7	0.0
2	autumn	small	medium	8.10000	11.40000	40.02000	5.33000	346.66699	125.66700	187.05701	15.60000	3.3	53.6	1.9	0.0	0.0	0.0
3	spring	small	medium	8.07000	4.80000	77.36400	2.30200	98.18200	61.18200	138.70000	1.40000	3.1	41.0	18.9	0.0	1.4	0.0
4	autumn	small	medium	8.06000	9.00000	55.35000	10.41600	233.70000	58.22200	97.58000	10.50000	9.2	2.9	7.5	0.0	7.5	4.1

- Now, notice that the number of data rows changed from 199 to 200 since the first row is now counted as a data row. And now we are using default columns names.
- The "\s+" matches one or more spaces. This is an example of a regex.
- We need to name the columns.

Algae_Blooms — load (3rd attempt)

IV

```
names = ('Season', 'Size', 'Speed', 'max_pH', 'min_O2', 'mean_Cl', 'mean_NO3', 'mean_NH4', 'mean_oPO4',
         'mean_PO4', 'mean_Chlor', 'a1', 'a2', 'a3', 'a4', 'a5', 'a6', 'a7')
```

```
df = pd.read_table('src/Analysis.txt', sep=r'\s+', names=names)
```

```
print(df.shape)
```

```
df.head()
```

(200, 18)

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a3
0	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.0	0.0	0.0
1	spring	small	medium	8.35000	8.00000	57.75000	1.28800	370.00000	428.75000	558.75000	1.30000	1.4	7.6	4.8
2	autumn	small	medium	8.10000	11.40000	40.02000	5.33000	346.66699	125.66700	187.05701	15.60000	3.3	53.6	1.9
3	spring	small	medium	8.07000	4.80000	77.36400	2.30200	98.18200	61.18200	138.70000	1.40000	3.1	41.0	18.9
4	autumn	small	medium	8.06000	9.00000	55.35000	10.41600	233.70000	58.22200	97.58000	10.50000	9.2	2.9	7.5

Algae_Blooms — load (3rd attempt)

```
names = ('Season', 'Size', 'Speed', 'max_pH', 'min_O2', 'mean_Cl', 'mean_NO3', 'mean_NH4', 'mean_oPO4',
         'mean_PO4', 'mean_Chlor', 'a1', 'a2', 'a3', 'a4', 'a5', 'a6', 'a7')
```

```
df = pd.read_table('src/Analysis.txt', sep=r'\s+', names=names)
```

```
print(df.shape)
```

```
df.head()
```

(200, 18)

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a3
0	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.0	0.0	0.0
1	spring	small	medium	8.35000	8.00000	57.75000	1.28800	370.00000	428.75000	558.75000	1.30000	1.4	7.6	4.8
2	autumn	small	medium	8.10000	11.40000	40.02000	5.33000							
3	spring	small	medium	8.07000	4.80000	77.36400	2.30200							
4	autumn	small	medium	8.06000	9.00000	55.35000	10.41600							

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 200 entries, 0 to 199
```

```
Data columns (total 18 columns):
```

#	Column	Non-Null Count	Dtype
0	Season	200 non-null	object
1	Size	200 non-null	object
2	Speed	200 non-null	object
3	max_pH	200 non-null	object
4	min_O2	200 non-null	object
5	mean_Cl	200 non-null	object
6	mean_NO3	200 non-null	object
7	mean_NH4	200 non-null	object
8	mean_oPO4	200 non-null	object

Algae_Blooms — load (3rd attempt)

```
names = ('Season', 'Size', 'Speed', 'max_pH', 'min_O2', 'mean_Cl', 'mean_NO3', 'mean_NH4', 'mean_oPO4',
         'mean_PO4', 'mean_Chlor', 'a1', 'a2', 'a3', 'a4', 'a5', 'a6', 'a7')
```

```
df = pd.read_table('src/Analysis.txt', sep=r'\s+', names=names)
```

```
print(df.shape)
```

```
df.head()
```

(200, 18)

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a3
0	winter	small	medium	8.00000	9.80000	60.80000	6.23800	578.00000	105.00000	170.00000	50.00000	0.0	0.0	0.0
1	spring	small	medium	8.35000	8.00000	57.75000	1.28800	370.00000	428.75000	558.75000	1.30000	1.4	7.6	4.8
2	autumn	small	medium	8.10000	11.40000	40.02000	5.33000							
3	spring	small	medium	8.07000	4.80000	77.36400	2.30200							
4	autumn	small	medium	8.06000	9.00000	55.35000	10.41600							

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 200 entries, 0 to 199
```

```
Data columns (total 18 columns):
```

#	Column	Non-Null Count	Dtype
0	Season	200 non-null	object
1	Size	200 non-null	object
2	Speed	200 non-null	object
3	max_pH	200 non-null	object
4	min_O2	200 non-null	object
5	mean_Cl	200 non-null	object
6	mean_NO3	200 non-null	object
7	mean_NH4	200 non-null	object
8	mean_oPO4	200 non-null	object

Dataframe looks a bit better, but why are numeric columns converted as **object**?
Reading instructions.txt we see that missing values are indicated by XXXXXXXX.

Algae_Blooms — load (4th attempt)

```
names = ('Season','Size','Speed','max_pH','min_O2','mean_Cl','mean_NO3','mean_NH4','mean_oPO4',
         'mean_PO4','mean_Chlor','a1','a2','a3','a4','a5','a6','a7')
```

```
df = pd.read_table('src/Analysis.txt', sep='\s+', names=names, na_values='XXXXXX')
```

```
print(df.shape)
```

(200, 18)

```
df.head()
```

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a3	a4
0	winter	small	medium	8.00	9.8	60.800	6.238	578.00000	105.000	170.00000	50.0	0.0	0.0	0.0	0
1	spring	small	medium	8.35	8.0	57.750	1.288	370.00000	428.750	558.75000	1.3	1.4	7.6	4.8	1
2	autumn	small	medium	8.10	11.4	40.020	5.330	346.66699	125.667	187.05701	15.6	3.3	53.6	1.9	0
3	spring	small	medium	8.07	4.8	77.364	2.302	98.18200	61.182	138.70000	1.4	3.1	41.0	18.9	0
4	autumn	small	medium	8.06	9.0	55.350	10.416	233.70000	58.222	97.58000	10.5	9.2	2.9	7.5	0

Algae_Blooms — load (4th attempt)

```
names = ('Season','Size','Speed','max_pH','min_O2','mean_Cl', 'mean_NO3', 'mean_NH4', 'mean_oPO4',
         'mean_PO4', 'mean_Chlor', 'a1', 'a2', 'a3', 'a4', 'a5', 'a6', 'a7')
```

```
df = pd.read_table('src/Analysis.txt', sep='\s+', names=names, na_values='XXXXXXX')
```

```
print(df.shape)
```

```
df.head()
```

(200, 18)

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a3	a4	a5	a6	a7
0	winter	small	medium	8.00	9.8	60.800	6.238	578.00000	105.000	170.00000	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	spring	small	medium	8.35	8.0	57.750	1.288	370.00000	428.750	558.75000	1.3	1.4	7.6	4.8	1.0	0.0	0.0	0.0
2	autumn	small	medium	8.10	11.4	40.020	5.330	50.00000	10.000	10.00000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3	spring	small	medium	8.07	4.8	77.364	2.302	50.00000	10.000	10.00000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4	autumn	small	medium	8.06	9.0	55.350	10.416	50.00000	10.000	10.00000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 200 entries, 0 to 199
```

```
Data columns (total 18 columns):
```

#	Column	Non-Null Count	Dtype
0	Season	200 non-null	object
1	Size	200 non-null	object
2	Speed	200 non-null	object
3	max_pH	199 non-null	float64
4	min_O2	198 non-null	float64
5	mean_Cl	190 non-null	float64
6	mean_NO3	198 non-null	float64
7	mean_NH4	198 non-null	float64
8	mean_oPO4	198 non-null	float64

Algae_Blooms — load (4th attempt)

```
names = ('Season', 'Size', 'Speed', 'max_pH', 'min_O2', 'mean_Cl', 'mean_NO3', 'mean_NH4', 'mean_oPO4',
         'mean_PO4', 'mean_Chlor', 'a1', 'a2', 'a3', 'a4', 'a5', 'a6', 'a7')
```

```
df = pd.read_table('src/Analysis.txt', sep='\s+', names=names, na_values='XXXXXXX')
```

```
print(df.shape)
```

```
df.head()
```

(200, 18)

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor	a1	a2	a3	a4	a5	a6	a7
0	winter	small	medium	8.00	9.8	60.800	6.238	578.00000	105.000	170.00000	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	spring	small	medium	8.35	8.0	57.750	1.288	370.00000	428.750	558.75000	1.3	1.4	7.6	4.8	1.0	0.0	0.0	0.0
2	autumn	small	medium	8.10	11.4	40.020	5.330	50.00000	10.000	10.00000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3	spring	small	medium	8.07	4.8	77.364	2.302	50.00000	10.000	10.00000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4	autumn	small	medium	8.06	9.0	55.350	10.416	50.00000	10.000	10.00000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 200 entries, 0 to 199
```

```
Data columns (total 18 columns):
```

#	Column	Non-Null Count	Dtype
0	Season	200 non-null	object
1	Size	200 non-null	object
2	Speed	200 non-null	object
3	max_pH	199 non-null	float64
4	min_O2	198 non-null	float64
5	mean_Cl	190 non-null	float64
6	mean_NO3	198 non-null	float64
7	mean_NH4	198 non-null	float64
8	mean_oPO4	198 non-null	float64

Now some variables have missing values

Also we should convert Season, Size and Speed to category and ensure the levels are ordered.

Algae_Blooms — Fix Data Types

II

The three categorical variables have levels with a natural order \Rightarrow convert to category and specify order:

```
df.Season = pd.Categorical(df.Season, categories=['spring', 'summer', 'autumn', 'winter'], ordered=True)
print(df.Season.unique())
```

```
['winter', 'spring', 'autumn', 'summer']
Categories (4, object): ['spring' < 'summer' < 'autumn' < 'winter']
```

Algae_Blooms — Fix Data Types

II

The three categorical variables have levels with a natural order \Rightarrow convert to category and specify order:

```
df.Season = pd.Categorical(df.Season, categories=['spring', 'summer', 'autumn', 'winter'], ordered=True)
print(df.Season.unique())
```

```
['winter', 'spring', 'autumn', 'summer']
Categories (4, object): ['spring' < 'summer' < 'autumn' < 'winter']
```

```
df.Size = pd.Categorical(df.Size, categories=['small', 'medium', 'large'], ordered=True)
print(df.Size.unique())
```

```
['small', 'medium', 'large']
Categories (3, object): ['small' < 'medium' < 'large']
```

Algae_Blooms — Fix Data Types

II

The three categorical variables have levels with a natural order \Rightarrow convert to category and specify order:

```
df.Season = pd.Categorical(df.Season, categories=['spring', 'summer', 'autumn', 'winter'], ordered=True)
print(df.Season.unique())
```

```
['winter', 'spring', 'autumn', 'summer']
Categories (4, object): ['spring' < 'summer' < 'autumn' < 'winter']
```

```
df.Size = pd.Categorical(df.Size, categories=['small', 'medium', 'large'], ordered=True)
print(df.Size.unique())
```

```
['small', 'medium', 'large']
Categories (3, object): ['small' < 'medium' < 'large']
```

```
df.Speed = pd.Categorical(df.Speed, categories=['low', 'medium', 'high'], ordered=True)
print(df.Speed.unique())
```

```
['medium', 'high', 'low']
Categories (3, object): ['low' < 'medium' < 'high']
```


Algae_Blooms — Identification of Missing Values (NA)

1 Which columns have missing values?

2 Which rows have missing values?
How many NAs per row?

4 Rows / Cols to drop?

Algae_Blooms — Identification of Missing Values (NA)

1 Which columns have missing values?

```
df.isna().sum()
```

```
Season      0
Size        0
Speed       0
max_pH      1
min_O2      2
mean_Cl     10
mean_NO3    2
mean_NH4    2
mean_oP04   2
mean_P04    2
mean_Chlor  12
a1          0
a2          0
a3          0
a4          0
a5          0
a6          0
a7          0
dtype: int64
```

2 Which rows have missing values?
How many NAs per row?

4 Rows / Cols to drop?

Algae_Blooms — Identification of Missing Values (NA)

1 Which columns have missing values?

```
df.isna().sum()
```

```
Season      0
Size        0
Speed       0
max_pH      1
min_O2      2
mean_Cl     10
mean_NO3    2
mean_NH4    2
mean_oP04   2
mean_P04    2
mean_Chlor  12
a1          0
a2          0
a3          0
a4          0
a5          0
a6          0
a7          0
dtype: int64
```

2 Which rows have missing values?
How many NAs per row?

```
df.isna().sum(axis=1).value_counts()
```

```
0    184
1      7
2      7
6      2
Name: count, dtype: int64
```

4 Rows / Cols to drop?

Algae_Blooms — Identification of Missing Values (NA)

1 Which columns have missing values?

```
df.isna().sum()
```

```
Season      0
Size        0
Speed       0
max_pH      1
min_O2      2
mean_Cl     10
mean_NO3    2
mean_NH4    2
mean_oP04   2
mean_P04    2
mean_Chlor  12
a1          0
a2          0
a3          0
a4          0
a5          0
a6          0
a7          0
dtype: int64
```

- Two columns (features) account for 22 NAs, but cannot just drop them as will lose a lot of information.
- Two rows (observations) account for 12 NAs ⇒ remove.
- Removing other rows with a NA will result in a loss of 14 rows (7% of the data), instead will impute later.

2 Which rows have missing values?
How many NAs per row?

```
df.isna().sum(axis=1).value_counts()
```

```
0    184
1      7
2      7
6      2
Name: count, dtype: int64
```

4 Rows / Cols to drop?

Algae_Blooms — Identification of Missing Values (NA)

1 Which columns have missing values?

```
df.isna().sum()
```

```
Season      0
Size        0
Speed       0
max_pH      1
min_O2      2
mean_Cl     10
mean_NO3    2
mean_NH4    2
mean_oPO4   2
mean_PO4    2
mean_Chlor  12
a1          0
a2          0
a3          0
a4          0
a5          0
a6          0
a7          0
dtype: int64
```

- Two columns (features) account for 22 NAs, but cannot just drop them as will lose a lot of information.
- Two rows (observations) account for 12 NAs \Rightarrow remove.
- Removing other rows with a NA will result in a loss of 14 rows (7% of the data), instead will impute later.

2 Which rows have missing values?
How many NAs per row?

```
df.isna().sum(axis=1).value_counts()
```

```
0    184
1      7
2      7
6      2
Name: count, dtype: int64
```

4 Rows / Cols to drop?

```
df.loc[df.isna().sum(axis=1)==6]
```

	Season	Size	Speed	max_pH	min_O2	mean_Cl	mean_NO3	mean_NH4	mean_oPO4	mean_PO4	mean_Chlor
61	summer	small	medium	6.4	NaN	NaN	NaN	NaN	NaN	14.0	NaN
198	winter	large	medium	8.0	7.6	NaN	NaN	NaN	NaN	NaN	NaN

```
df = df.loc[df.isna().sum(axis=1)<6].copy()
print(df.shape)
```

```
(198, 18)
```

Handling missing values using pandas

- Step 1: Replace missing values with marked values. Examples:
`df[col].replace('XXXXXX', np.nan)` or `df[col].replace("", None)`
- Step 2: Count the missing values by row and by column.
- Step 3: If a row or a column has **too many(?)** missing values, either drop it or add an extra boolean-valued feature `df[hasCol]`
- Step 4: If future processing can handle data with missing values, skip to step 7.
- Step 5: Otherwise, replace the missing values with **representative(?)** values...
- Step 5a: If the data is categorical, use a **safe** value such as its mode (the most commonly occurring value)
- Step 5b: If the column is numeric, unsorted, symmetrically distributed, without outliers, try
`df[col].fillna(df[col].mean(), inplace=True)`
- Step 5c: If the column is numeric, unsorted, but is unsymmetrically distributed and/or has outliers, try
`df[col].fillna(df[col].median(), inplace=True)`
- Step 6: If the column is numeric and sorted by row index, `df[col].interpolate()` can fill in values, so **1,3,,7,8** becomes **1,3,5,7,8**.
- Step 7: Proceed to EDA Pass 2

After Loading and Initial Clean — Where are we?

I

Tips

- ✓ Loaded data, corrected dtypes (categorical with order levels)
- ✓ Sanitised column names — not needed, but note column name `size` shadows pandas dataframe function `size` \Rightarrow so use `df["size"]` instead of `df.size`.
- ✓ No missing values

After Loading and Initial Clean — Where are we?

I

Tips

- ✓ Loaded data, corrected dtypes (categorical with order levels)
- ✓ Sanitised column names — not needed, but note column name size shadows pandas dataframe function size \Rightarrow so use `df["size"]` instead of `df.size`.
- ✓ No missing values

Titanic

- ✓ Loaded data — no conversion of dtypes needed (but if you don't plots/crosstab order won't agree)
- ✓ Sanitised column names — not needed,
 - Missing values in Age (177/891=20%), Cabin (687/891=77%), and Embarked (2/891=0.2%).
 - A feature with 77% missing values should be considered for deletion, but what if the presence of a missing value actually tells us something? \Rightarrow convert to a boolean feature.

After Loading and Initial Clean — Where are we?

I

Tips

- ✓ Loaded data, corrected dtypes (categorical with order levels)
- ✓ Sanitised column names — not needed, but note column name size shadows pandas dataframe function size \Rightarrow so use `df["size"]` instead of `df.size`.
- ✓ No missing values

Titanic

- ✓ Loaded data — no conversion of dtypes needed (but if you don't plots/crosstab order won't agree)
- ✓ Sanitised column names — not needed,
 - Missing values in Age (177/891=20%), Cabin (687/891=77%), and Embarked (2/891=0.2%).
 - A feature with 77% missing values should be considered for deletion, but what if the presence of a missing value actually tells us something? \Rightarrow convert to a boolean feature.

Algae Blooms

- ✓ Loaded data, corrected dtypes (categorical with ordered levels)
- ✓ Sanitised column names.
 - Missing values
 - Removed two rows with 6 NA each, accounted for 12/33=36% of the missing values.
 - Remaining, 21 NAs are concentrated in `mean_CL` (8) and `mean_Chlor` (10). EDA will suggest options.

After Loading and Initial Clean — Where are we?

II

Next we might

- Save result of initial clean:
 - To either a CSV (if we don't mind losing dtype metadata)

```
df.to_csv('data/Analysis.csv', index=False)
```

- To (say) pickle format (to keep dtype metadata)

```
df.to_pickle('data/Analysis.pkl')
```

Later can read dataframe back in using

```
df = pd.read_pickle('data/Analysis.pkl')  
print(df.shape)  
df.head(1)
```

- If the dataset is large (>100K rows), save a (reproducible) sample of the dataset for later EDA to speed up calculations (especially visualisations).

```
df.sample(frac=.25, random_state=42).to_pickle('data/Analysis_sample.pkl')
```

End of Pass 1...