Machine Learning

Dr Tamara Clelford

To download a copy of the slides go to
https://tamaraclelford.co.uk/iop.html

INTRODUCTION TO DATA SCIENCE

- What is data science
- Examples from my work
- Data science workflow walkthrough
- How can I learn more?

IS DATA SCIENCE: "THE SEXIEST JOB OF THE 21ST CENTURY"?

- In 2012 the Harvard Business Review described data science as being

  'The sexiest job of the 21st Century'

- 'Data will be the raw material of the 21st Century'

  Angela Merkel, German Chancellor, Davos 2018

WHAT IS THIS THING CALLED DATA SCIENCE?

https://en.wikipedia.org/wiki/Data_science

Not l

WIKIPEDIA
The Free Encyclopedia

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Data science

From Wikipedia, the free encyclopedia

Not to be confused with information science.

Data science is a multi-disciplinary field that uses scientific methods, processes, algorithms and systems to extract knowledge and insights from data in various forms, both structured and unstructured,[1][2] similar to data mining.

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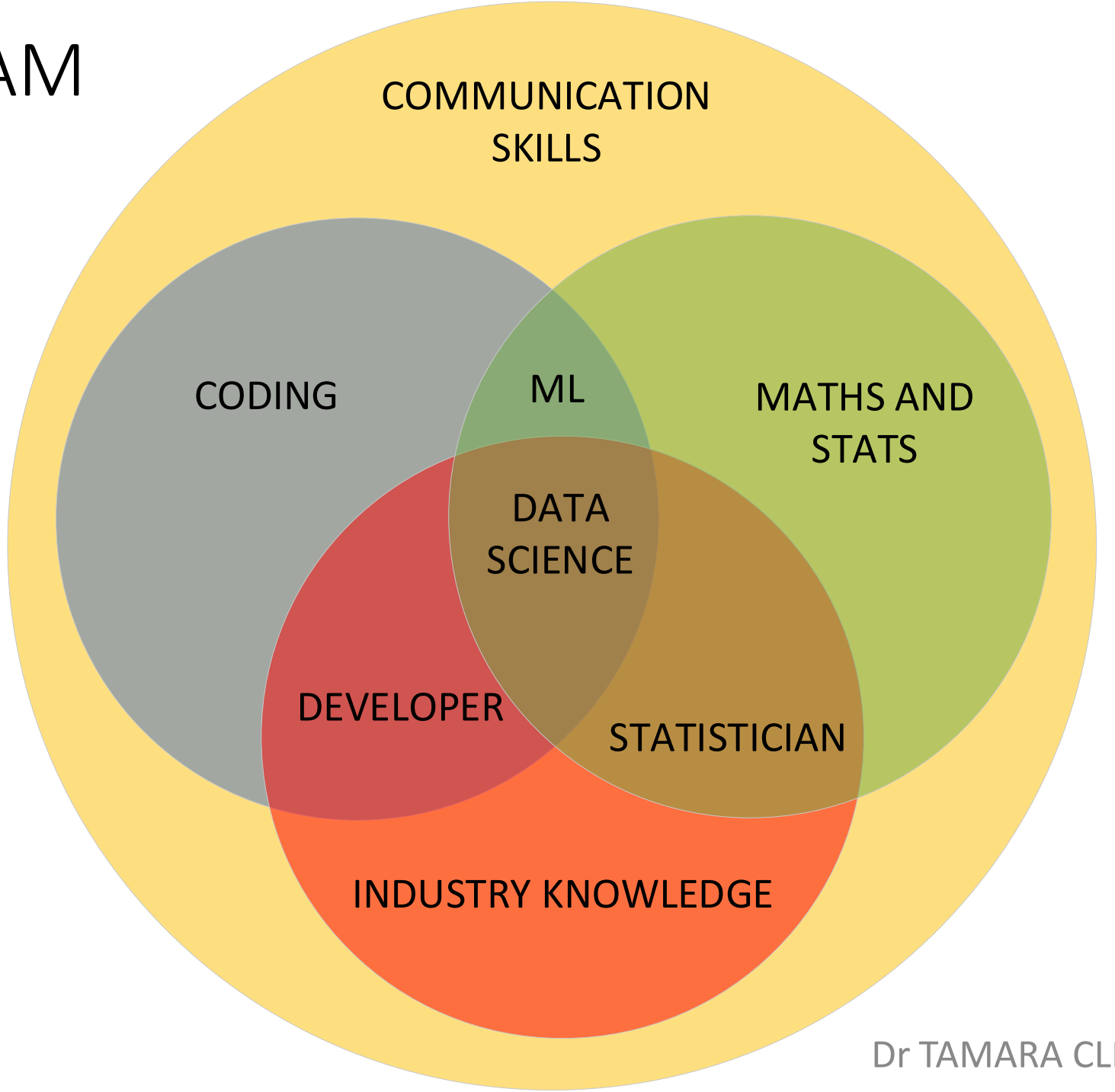
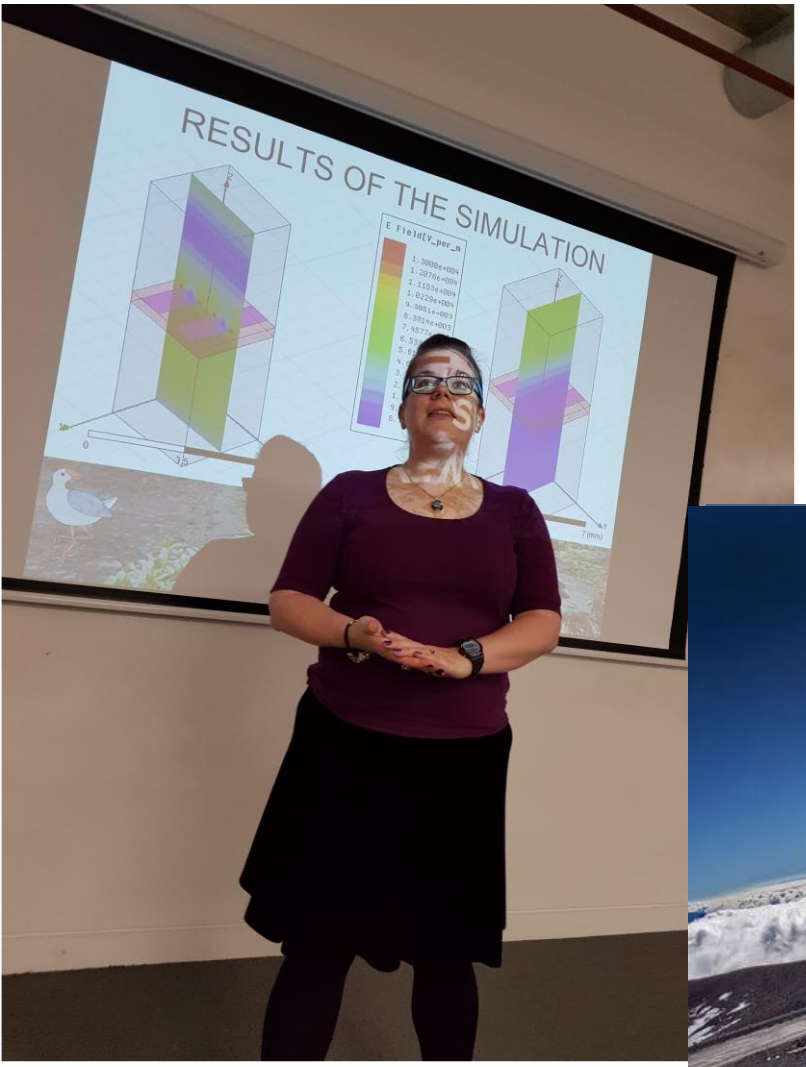
WHAT IS THIS THING CALLED DATA SCIENCE?

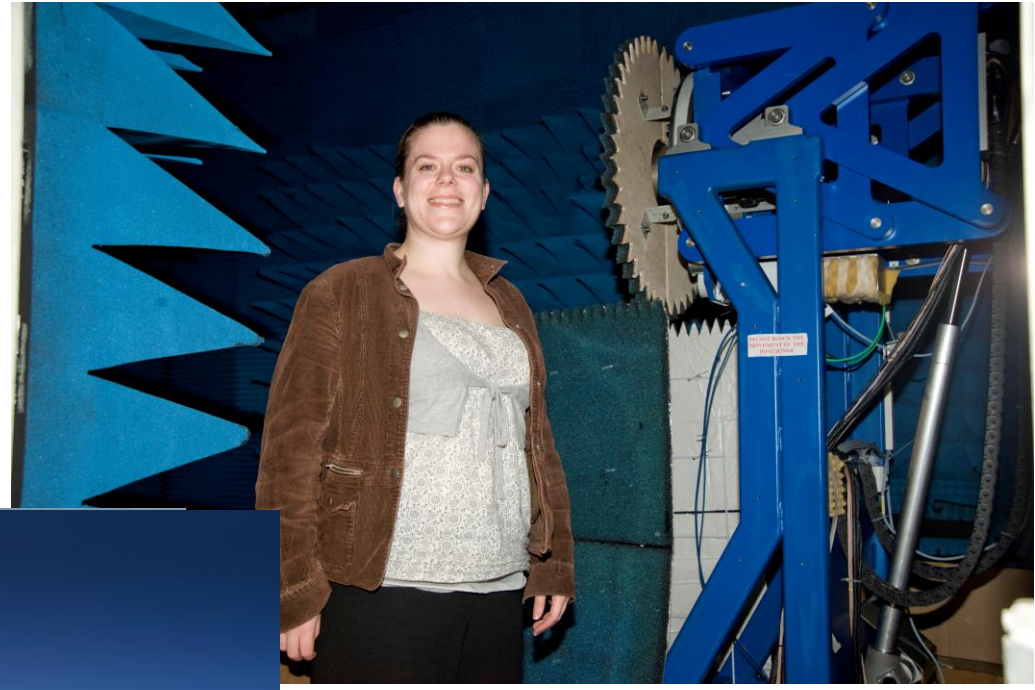
- Any data can be looked at, multiple data sets used
  - Structured, unstructured, numbers, words, clicks, actions, images
- Multi-disciplinary
  - Part physics, statistics, maths, computer science, coding, big data, business
- Clean data before use
  - Removes incorrect and partial data
- Uses scientific methods and algorithms
  - Coding, decision trees, machine learning, neural networks
- Extracts knowledge and insights from data
  - The output is verified as being plausible

THE VENN DIAGRAM OF DATA SCIENCE



ABOUT ME





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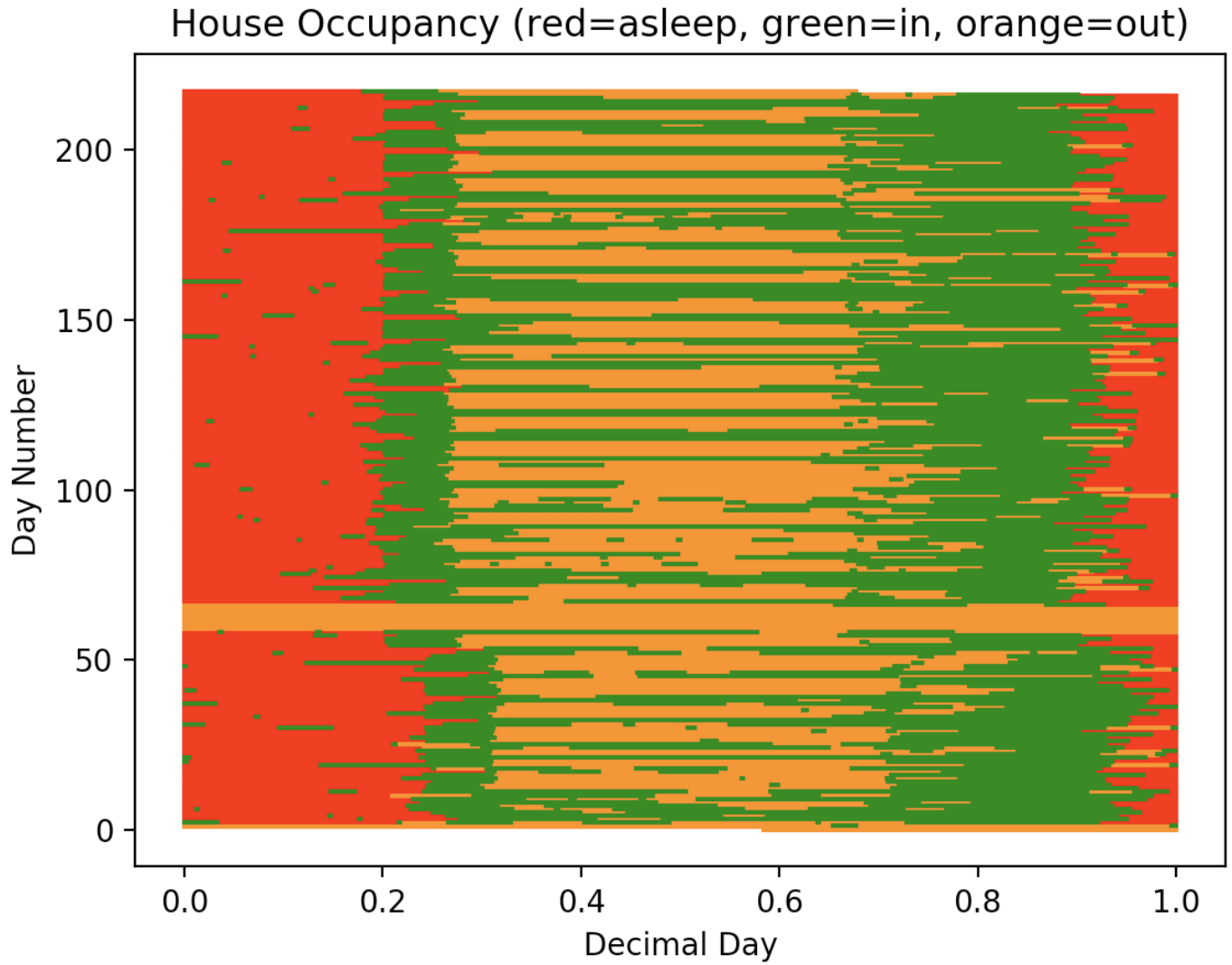
HOUSE OCCUPANCY CALCULATIONS



COMMERCIAL EXAMPLES OF DATA SCIENCE

- Business analytics
- Recommender engines
- Online advertisements
- Financial predictions
- Internet of Things
- Diagnostics
- Kaggle competitions

THE RISE OF DATA SCIENCE

- As more data is collected in all walks of life the need to analyse this data and find it's hidden secrets becomes increasingly important

- Blurred line between engineer, statistician, data analyst, data scientist, data engineer, business analyst

- People from different backgrounds are re-training and becoming data scientists

DATA SCIENCE FLOW

1. Identify requirement
2. Setup data science tools
3. Get data
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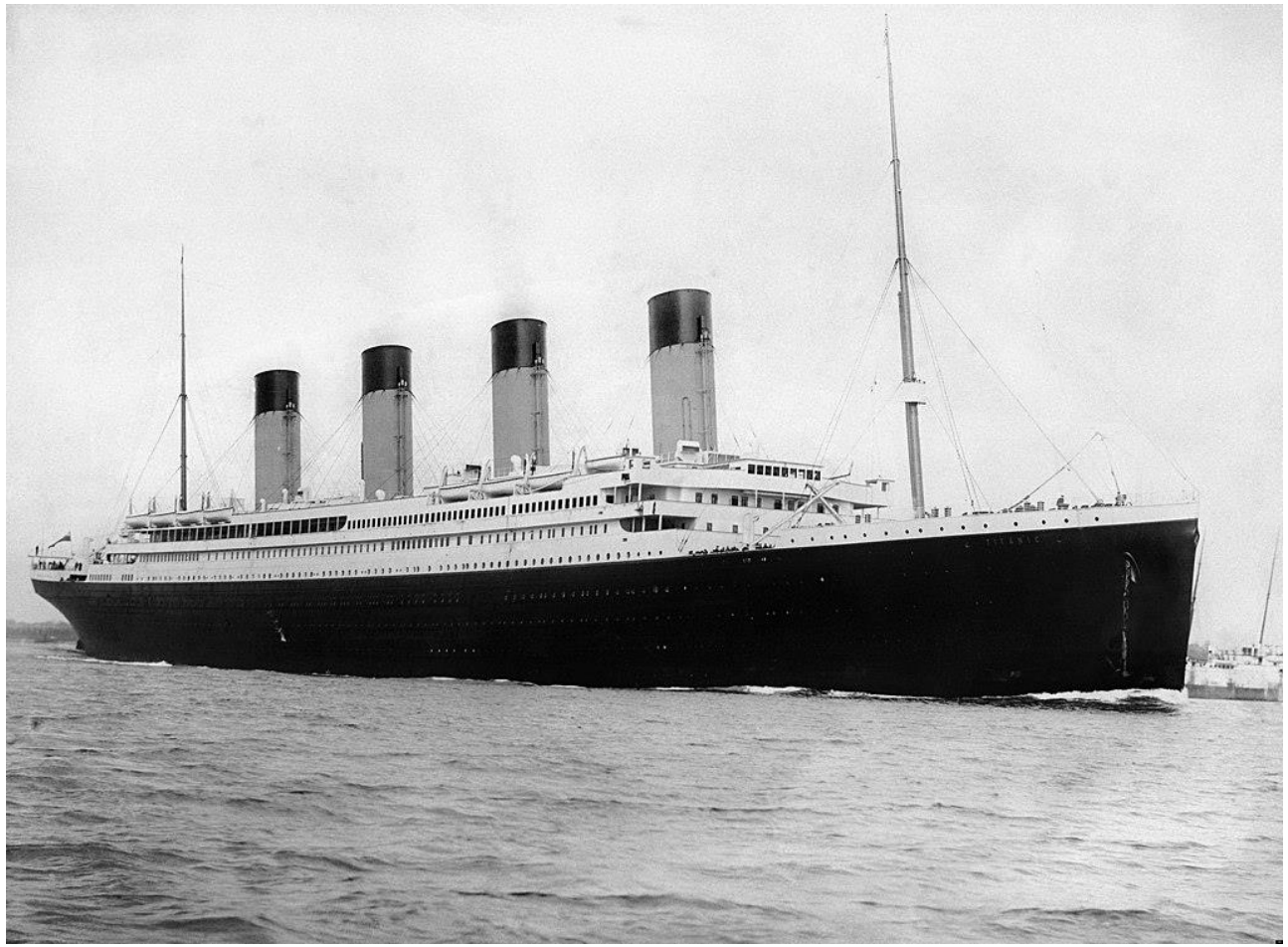
SURVIVAL OF THE BEST DATA



By F.G.O. Stuart (1843-1923) - http://www.uwants.com/viewthread.php?tid=3817223&extra=page%3D1, Public Domain, https://commons.wikimedia.org/w/index.php?curid=2990792

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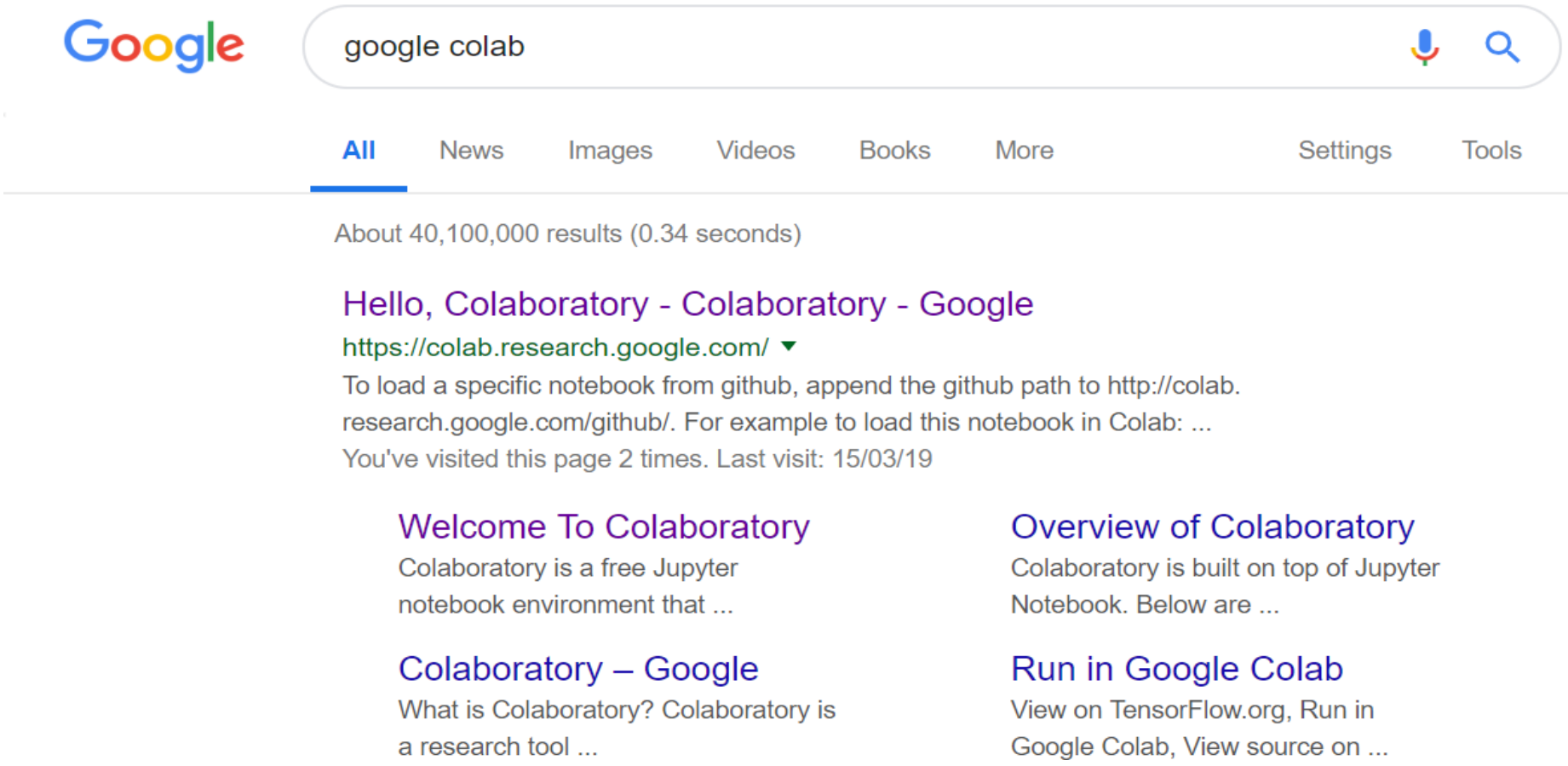
2) SET UP DATA SCIENCE TOOLS

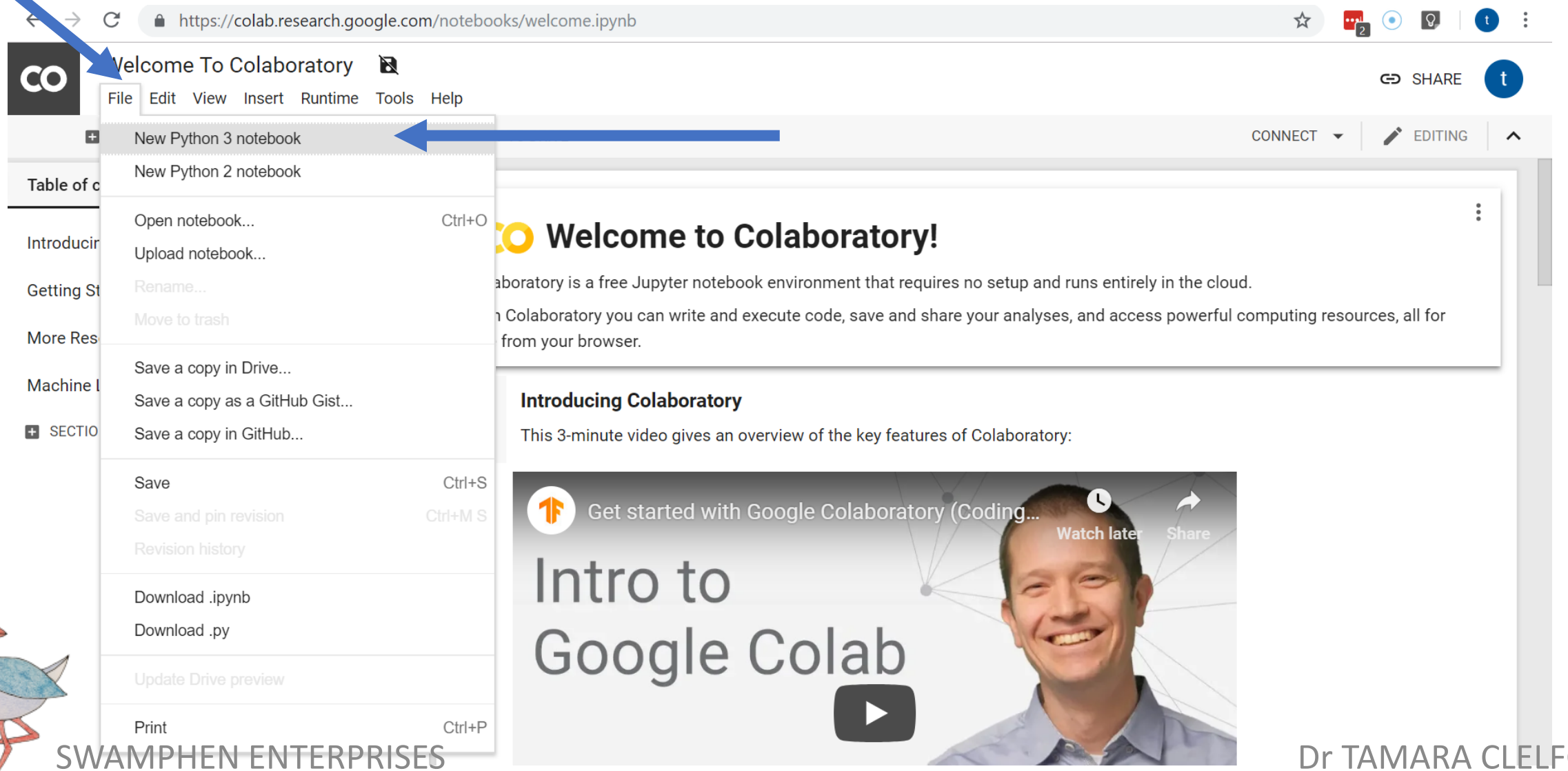
- Python programming language
  - Toolboxes such as NumPy, pandas and scikit-learn

- Integrated Development Environment (IDE)
  - Jupyter notebook style
  - Google Colab

GO TO GOOGLE COLAB
https://colab.research.google.com



OPEN A NEW PYTHON 3 NOTEBOOK



2) SETUP DATA SCIENCE TOOLS

```
1  # open up google colab
2  # open a python 3 notebook and rename to 'Titanic_analysis'
3  # import packages going to use
4  import numpy as np
5  import pandas as pd
6  import matplotlib.pyplot as plt
```

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3) GET DATA

```
# import the data to google colab
from google.colab import files
uploaded = files.upload()
```

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4) LOOK AT YOUR DATA SET

- Important step to get an understanding of the data
  - If you don’t understand your data set it will be hard to get insights from it
- Check that is has been read in correctly
- Look at raw data and plot things to help understanding

TITANIC DATA INVESTIGATION

```
# import data set
raw_data = pd.read_csv('titanic.csv')
```

```
# print out the headder
raw_data.head()
# try putting a number in the brackets
# what does .tail() do?
```

```
# how many rows in the data set
len(raw_data)
```

```
# get basic shape information
raw_data.shape
```

```
# print out a selection of the data
raw_data[20:25][['Name']]
```

```
# sort wrt one column
raw_data.sort_values('Fare')
```

```
# calculate average fare
np.mean(raw_data['Fare'])
```

```
# describe data set - nothing with letters in the result
raw_data.describe()
```

```
# get the range of ages on board
age_female = raw_data.loc[raw_data['Sex'] == 'female', 'Age']
age_male = raw_data.loc[raw_data['Sex'] == 'male', 'Age']
print(age_female)
print(age_male)
```

```
# look at the range of ages on board, often scatter graph, but not in this case
fig, graph = plt.subplots()
graph.hist([age_female, age_male])
```

```
# graph options
fig, graph = plt.subplots()
graph.hist([age_female, age_male], color = ['b','g'], label = ['female', 'male'])
# pick any colours to use from b, g, k, r, c, m, y, w
# print out the axis labels
graph.set_ylabel("number of people")
graph.set_xlabel("age (y)")
# add the legend
plt.legend(loc = 'best')
# move the legend around, options are:
# upper left, upper right, lower left, lower right, best, upper center, lower center,
# center left, center right
```

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5) NEED MORE DATA?

```
# we want to be able to include gender information
# change female = 1, male = 0
raw_data['GenderNumerical'] = raw_data.apply(lambda row:1 if row.Sex == 'female' else 0, axis = 1)
raw_data.head()
```

```
# describe the data set again
raw_data.describe()
```

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6) CLEAN DATA SET

- This is where most of your time is spent as a data scientist
- Need to ensure you do not introduce bias or errors to the data set during cleaning
- Examples of cleaning practices:
  - Remove lines with missing data
  - Use an average to fill missing data
  - Use a different data set to fill missing data
  - Interpolate between points

6) CLEAN DATA SET

```
raw_data.head(7)
```

```
# pick data want to include
include = ['Survived', 'Pclass', 'Age', 'GenderNumerical', 'Fare']
```

```
# check include
raw_data[include]
```

```
# remove nans
data_set = raw_data[include].dropna()
```

```
# check removal of nans
data_set.head(7)
data_set[-5:]
```

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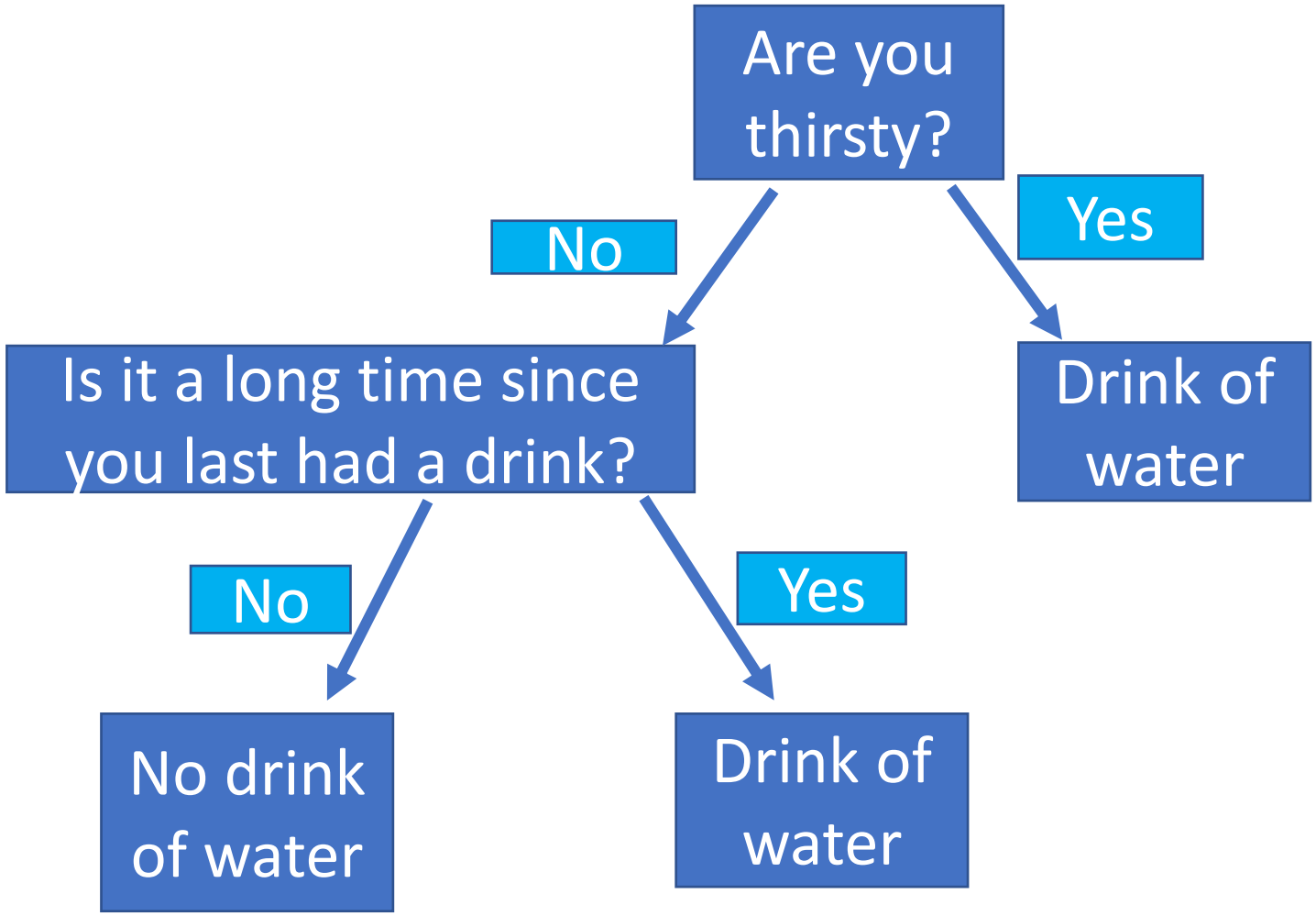
MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE

- AI is getting computers to behave like humans
- ML is an application of AI
  - gives the ML code access to data and lets it learn for itself
- Two categories of ML:
  - Supervised
    - decision trees, random forests, linear regression, Gaussian regression, Bayesian statistics
  - Unsupervised
    - clustering, k-means, anomaly detection, neural networks, method of moments

DECISION TREE



7) SET UP MODEL

```
# select data for random forest
data_chosen = include[1:]
data = data_set[data_chosen]
answer = data_set['Survived']
```

```
# import decision tree
from sklearn import tree
```

```
# set up the model
tree_model = tree.DecisionTreeClassifier(random_state = 42)
```

```
# run the model on our data
titanic_tree = tree_model.fit(data, answer)
print(titanic_tree)
```

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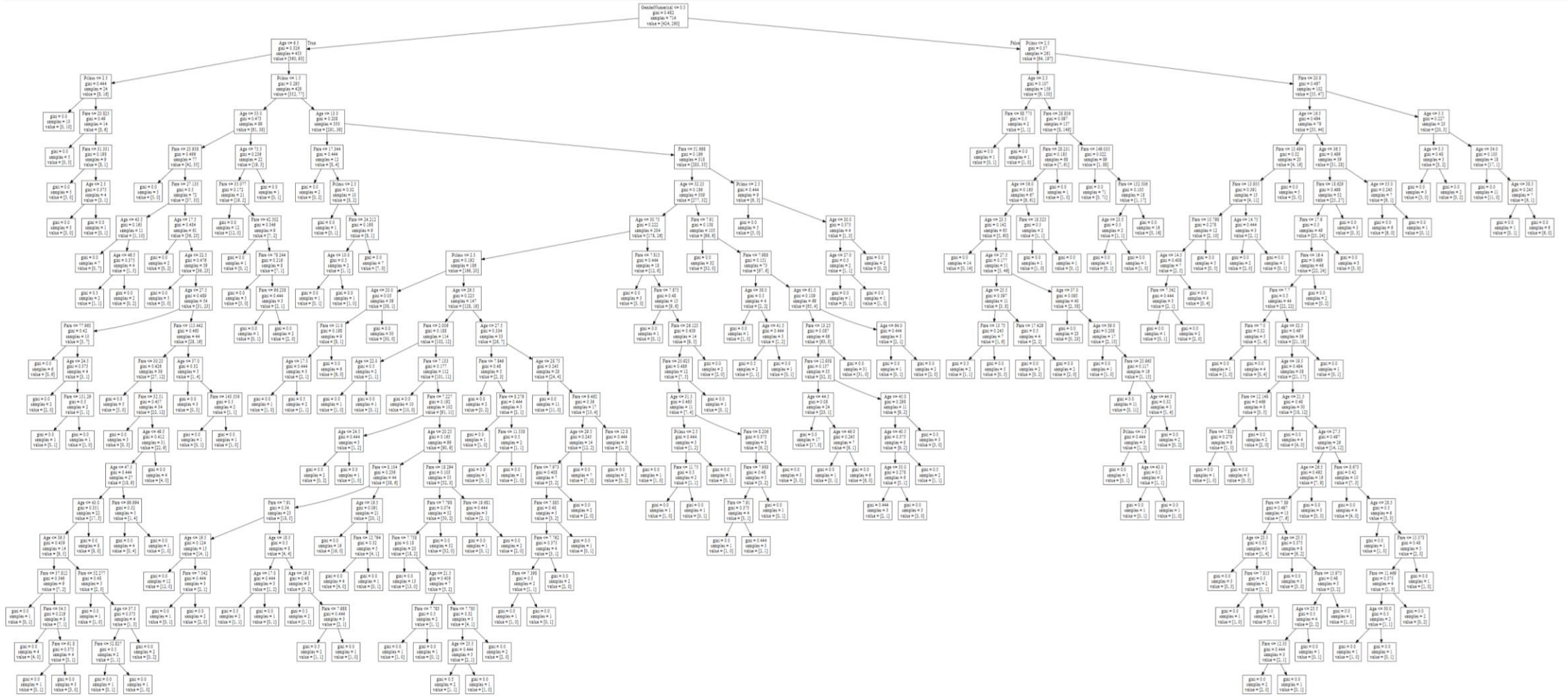
8) EVALUATE MODEL

```
1  # see how good model is at predicting survival
2  from sklearn.model_selection import cross_val_score as CVS
3  scores_tree = CVS(titanic_tree, data, answer)
4  print(scores_tree)
5  print(np.mean(scores_tree))
```

DECISION TREE



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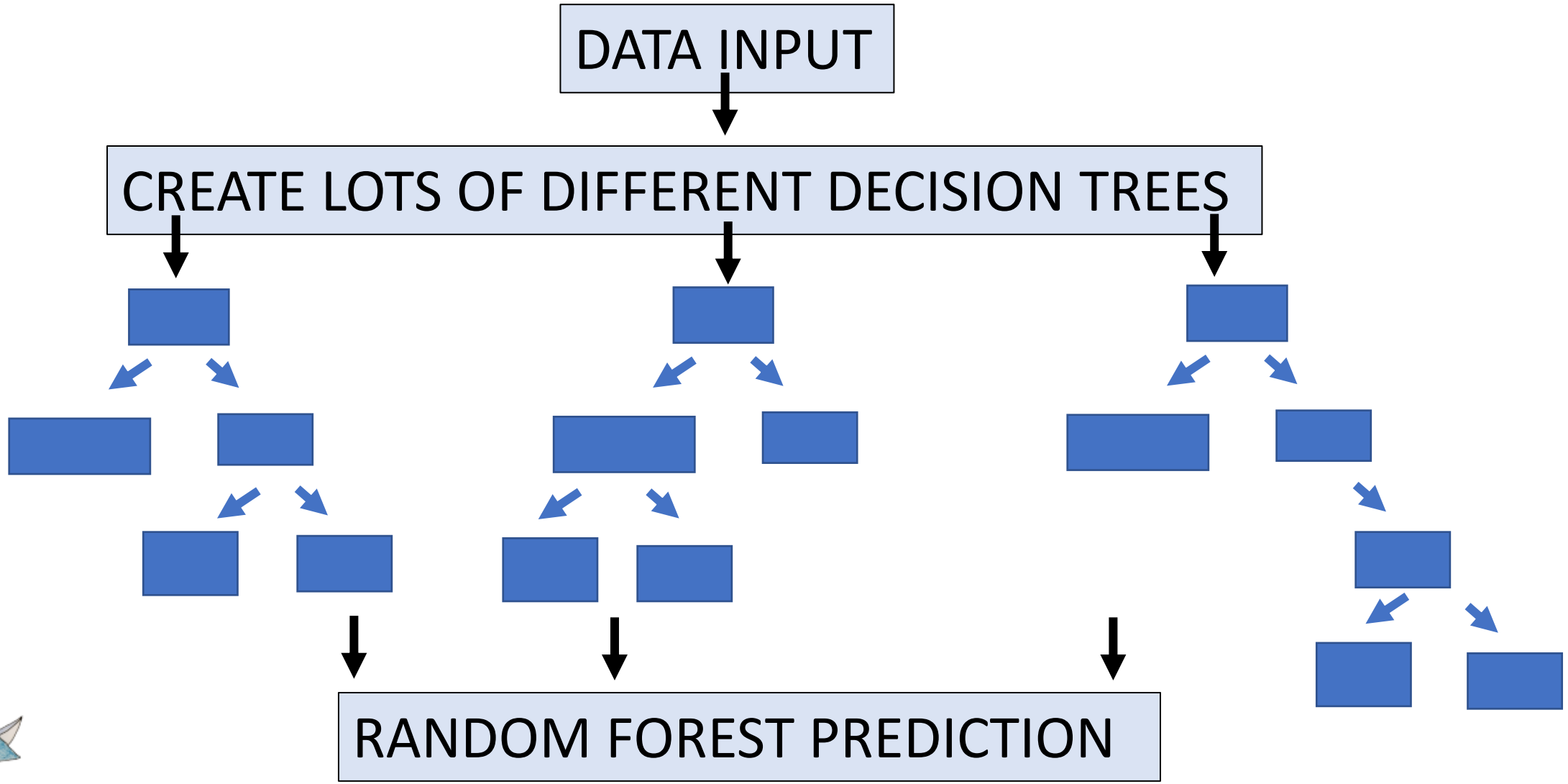
RANDOM FORESTS



7) SET UP MODEL

```
# select data for random forest
include
include[1:]
data = data_set[include[1:]]
answer = data_set['Survived']
```

```
# import random forest
from sklearn.ensemble import RandomForestClassifier as RFC
```

```
# create the model
forest_model = RFC(n_estimators=100)
```

```
# run the model on the data
titanic_forest = forest_model.fit(data, answer)
print(titanic_forest)
```

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CROSS VALIDATION SCORE

- Splits data randomly into k sections (fold)
- Model is fitted on k-1 of sections – training data
- Model is evaluated on remaining section – testing data
- Repeated k times

CROSS VALIDATION SCORE

	DATA SET SPLIT		
FOLD 1	1	2	3
FOLD 2	1	2	3
FOLD 3	1	2	3

TRAINING DATA

TESTING DATA

8) EVALUATE

```
# see how good model is at predicting survival
from sklearn.model_selection import cross_val_score as CVS
scores_forest = CVS(titanic_forest, data, answer)
print(scores_forest)
print(np.mean(scores_forest))
```

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9) CALCULATE RESULTS

```
# choose a person to see if they survived
pclass = np.mean(data_set['Pclass'])           # 2.5
age = np.mean(data_set['Age'])                 # 29.7 years
gender = np.mean(data_set['GenderNumerical']) # 0.37
fare = np.mean(data_set['Fare'])               # £34.69
```

```
# put person data into an array
person = np.array([[pclass, age, gender, fare]])
print(person)
```

```
# calculate survival score
survival_score = titanic_forest.predict_proba(person)
print(survival_score)
```

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10) PRESENT RESULTS

```
# did the person survive the sinking of the titanic?
print({'survival chances': survival_score[0,1]*100, 'death chances': survival_score[0,0]*100})
```

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9) CALCULATE RESULTS

```
# how does age and gender alter survival chances
# create a list covering all ages on the titanic
age_max = int(np.max(data_set['Age']))
print(age_max)
age_list = list(range(0, age_max + 1))
print(age_list)
```

```
# to look at survival probability
survival = []
selected_class = 1
average_fare = np.mean(data_set['Fare'])
gender = 1
for i in age_list:
    person = np.array([[selected_class, i, gender, average_fare]])
    survival_chances = titanic_forest.predict_proba(person)
    survival.append(survival_chances[0,1]*100)
```

```
# to look at male and female survival probability
survival_female = []
survival_male = []
selected_class = 2
average_fare = np.mean(data_set['Fare'])
gender_list = [0,1]
for i in age_list:
    for j in gender_list:
        if j == 1:
            array = survival_female
        else:
            array = survival_male
        person = np.array([[selected_class, i, j, average_fare]])
        survival_chances = titanic_forest.predict_proba(person)
        array.append(survival_chances[0,1]*100)
len(survival_female)
```

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10) PRESENT RESULTS

```
# plot just survival
plt.plot(age_list, survival)
plt.title('survival in ' + str(selected_class) + ' class')
plt.xlabel('age (y)')
plt.ylabel('survival chances (%)')
```

```
# plot male and female survival chances
plt.plot(age_list, survival_female, label = 'female')
plt.plot(age_list, survival_male, label = 'male')
plt.title('survival in ' + str(selected_class) + ' class')
plt.xlabel('age (y)')
plt.ylabel('survival chances (%)')
plt.legend()
```

SO, IS DATA SCIENCE: "THE SEXIEST JOB OF THE 21ST CENTURY"?

- It is certainly a job with its profile on the rise
- Analytical role with varied and interesting work
- Data Science is a well paid and sought-after skill set
  - a lot of people are re-training or re-branding
- It covers a skill set desperately needed in this new digital world
- It needs people with good analytical skills to champion its evolution as a numerical science

HOW DO I LEARN MORE?

- Learn to program in Python
- Get to grips with the data science packages
  - NumPy, pandas and scikit-learn
- Brush up on your stats
- Understand the business you want to work in
- Practice!!

QUESTIONS!

- Dr Tamara Clelford

https://tamaraclelford.co.uk/online_courses.html