Machine Learning Algorithms

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Outline

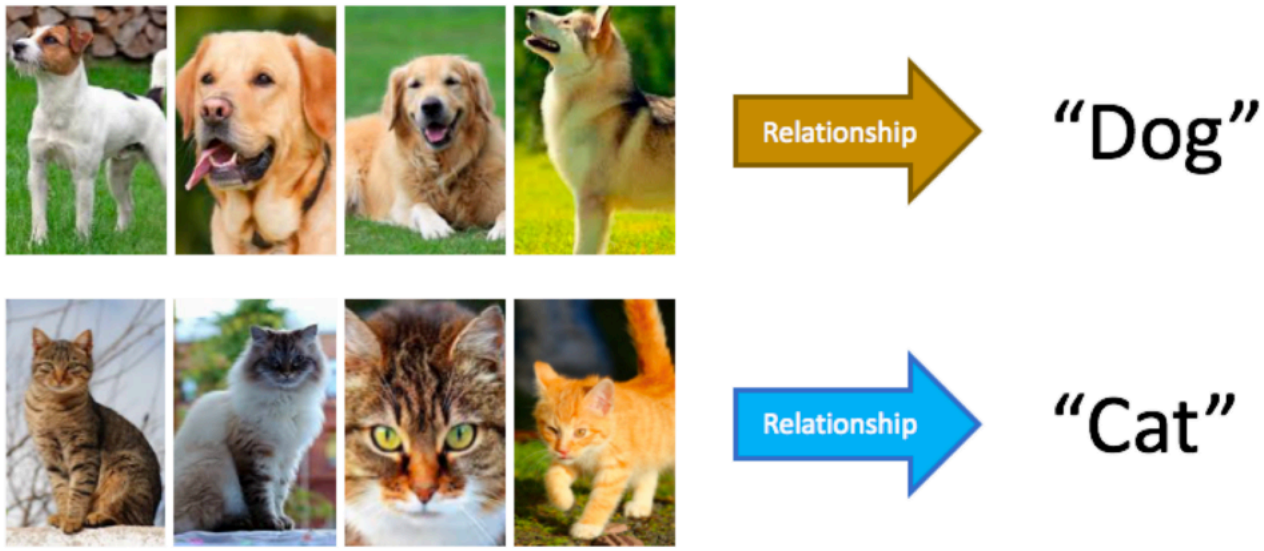
- Background
  - What is Machine Learning
- Examples of machine learning algorithms
  - Regression
  - Random Forest
- Code-along ML tutorial.

What is machine learning?

What is machine learning?

Machine Learning: Computer systems learning* input to produce predictions on never-before-seen data using statistical techniques

***Learn:** progressively improve performance on a specific task



Key Terminology

Label: What we are predicting

- IMDB score of a movie
- If a passenger survived Titanic
- If someone has colon cancer

Feature: Input variable

- # of Instagram likes of lead actor
- Age and gender of passenger
- Species abundances in the stool

Maybe just one feature in a simple machine learning project
Many features for a sophisticated machine learning project

Model learns the relationship between the features and the label

What are other examples where machine learning might be useful?

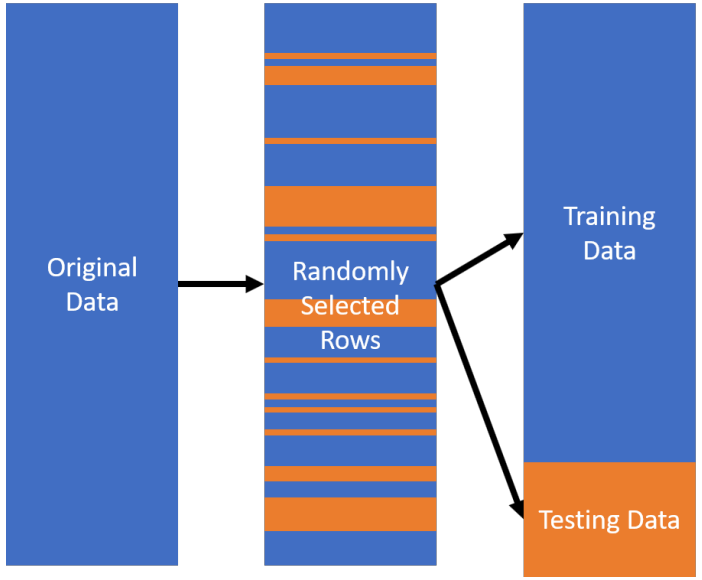
An example: Is this email spam or not?

- Labels:
  - Spam or Not Spam
- Features:
  - Sender’s email address
  - Time of the day it was sent
  - Email contains phrase “Nigeria” or “prince”.

- Model learns the relationship between features and label

Steps in Machine Learning

- Gather Data: Look at hundreds of thousands of emails
- Prepare/clean data: e.g. correct or remove SPAM labeled .edu emails
- Separate data into train and test sets

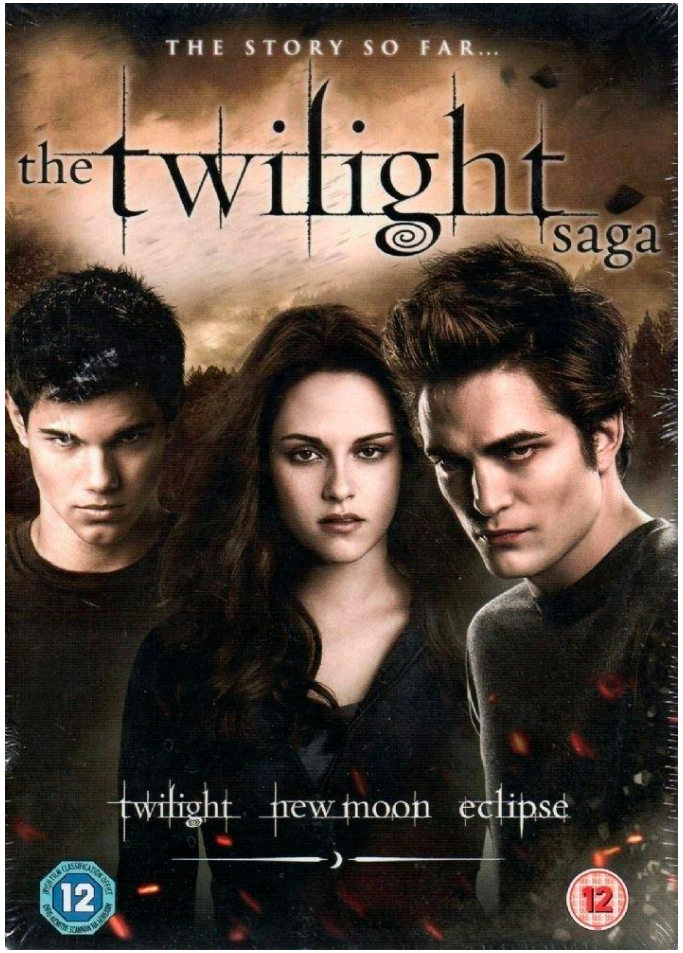


Steps in Machine Learning

- Choose a model: e.g. logistic regression
- Tune parameters: e.g. penalty for getting things too right
- Train (learning): show your model spam email examples, and enable the model to gradually learn the relationships between features and label
- Evaluate: Are we doing well, should we change model/parameters?
- Predict: Apply the trained model to unlabeled emails

Regression

Example: predict IMDB score of a movie

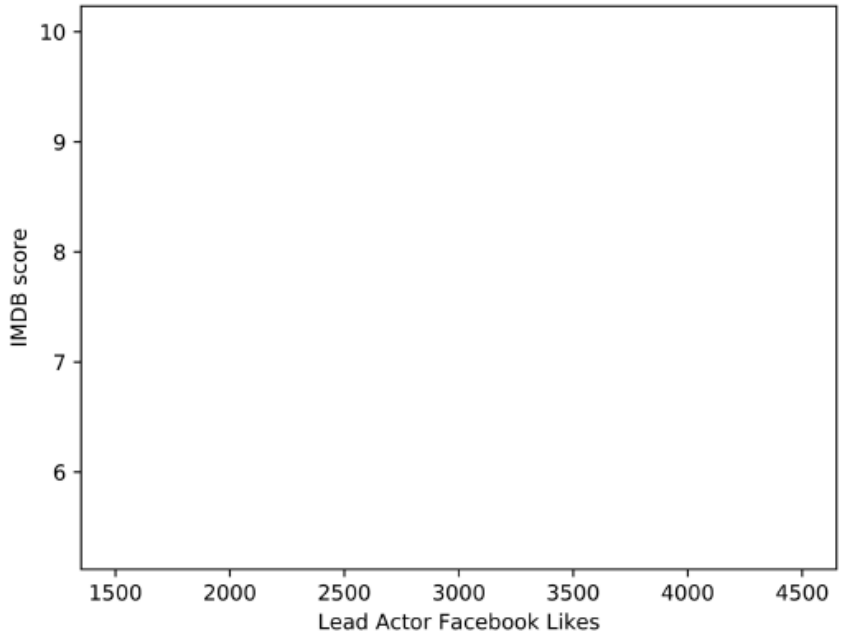


Regression: one feature (simple linear relationship)

$$y_i = \beta_0 + \beta_1 x_{i1} + \epsilon$$

Label of i^{th} sample
(ex: movie i)

Feature (input)
(ex. lead actor facebook likes)



Regression: one feature (simple linear relationship)

$$y_i = \beta_0 + \beta_1 x_{i1} + \epsilon$$

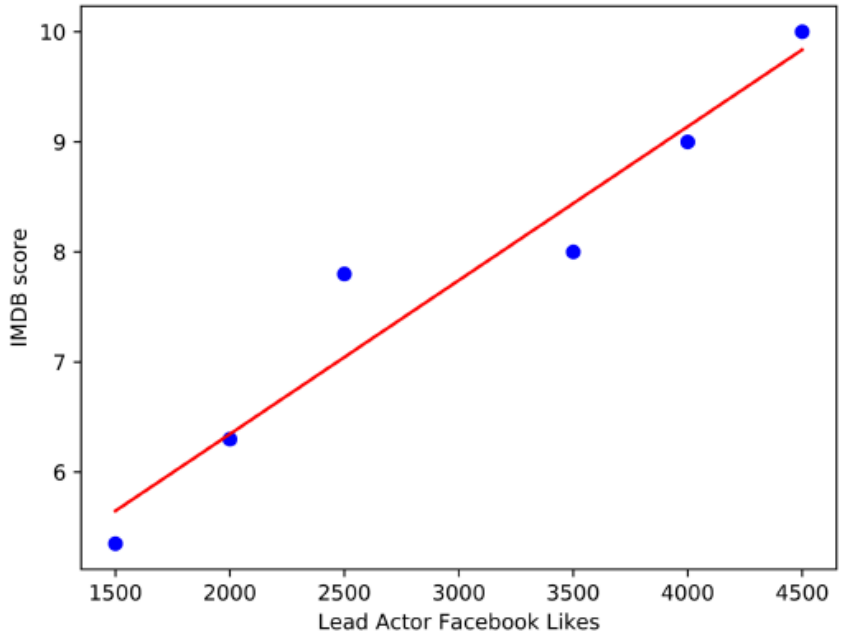
Label of i^{th} sample
(ex: movie i)

intercept

Weight of feature 1

Feature (input)
(ex. lead actor facebook likes)

Error

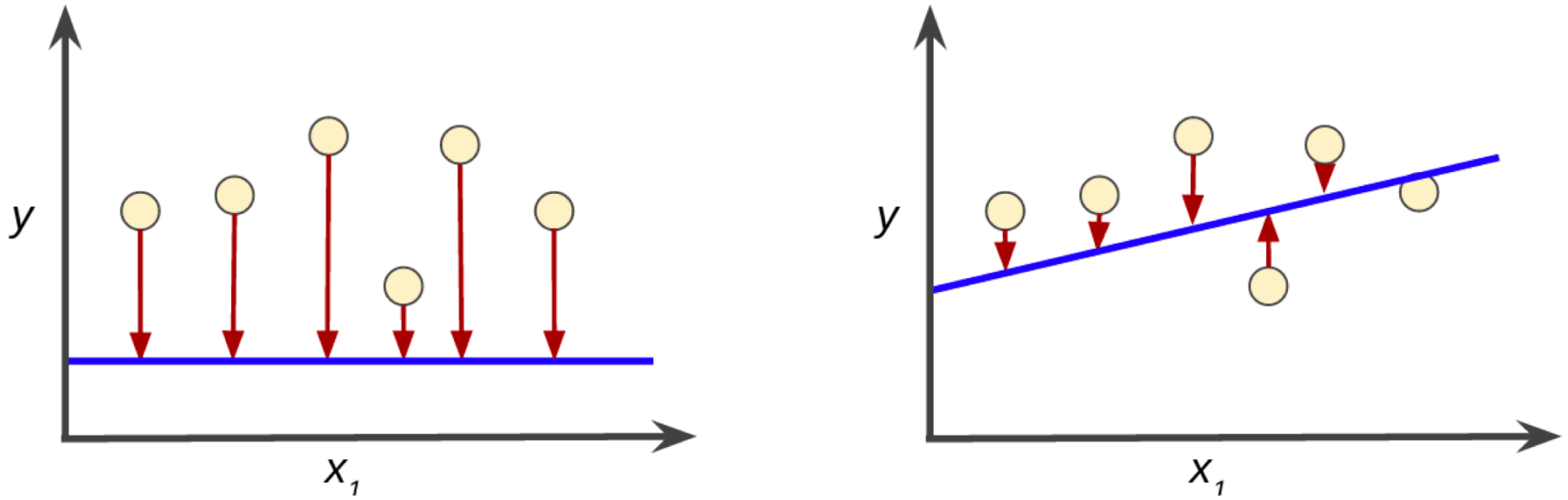


Regression: many feature (more sophisticated model)

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_m x_{im} + \epsilon$$

- Features: Country of the movie, genre, duration, plot keywords, budget etc.
- Each of these features will have different weights.
- Training a model simply means learning (determining) good values for all the weights from labeled examples.
- How does a model do that?

The model learns by making bad predictions and getting a penalty for the bad prediction



- The goal of training a model is to find a set of weights that have low loss, on average, across all examples (minimize the total error).

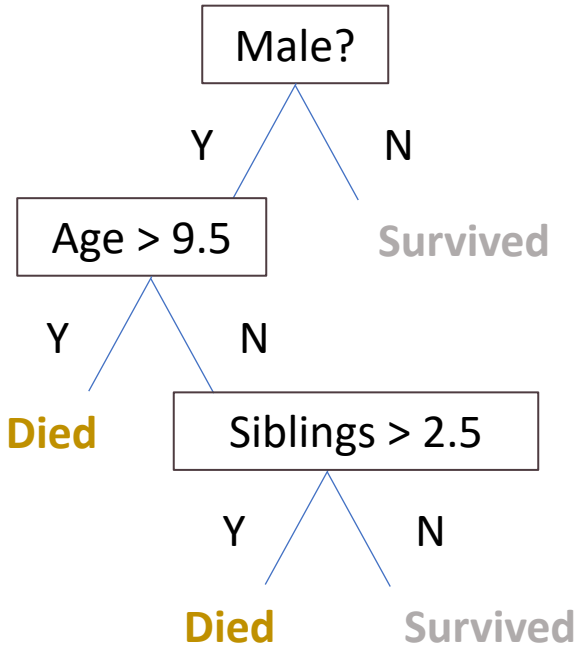
Be careful of overfitting!

Random Forest

Titanic Data Set

Name	Class	Sex	Age	Siblings/ Spouses Aboard	Parents/ Children Aboard	Fare	Survived
Mr. Owen Harris Braund	3	male	22	1	0	7.25	0
Mrs. John Bradley (Florence Briggs Thayer) Cumings	1	female	38	1	0	71.2833	1
Miss. Laina Heikkinen	3	female	26	0	0	7.925	1
Mrs. Jacques Heath (Lily May Peel) Futrelle	1	female	35	1	0	53.1	1
Mr. William Henry Allen	3	male	35	0	0	8.05	0
Mr. James Moran	3	male	27	0	0	8.4583	0
Mr. Timothy J McCarthy	1	male	54	0	0	51.8625	0
Master. Gosta Leonard Palsson	3	male	2	3	1	21.075	0
Mrs. Oscar W (Elisabeth Vilhelmina Berg) Johnson	3	female	27	0	2	11.1333	1
Mrs. Nicholas (Adele Achem) Nasser	2	female	14	1	0	30.0708	1
Miss. Marguerite Rut Sandstrom	3	female	4	1	1	16.7	1
Miss. Elizabeth Bonnell	1	female	58	0	0	26.55	1
Mr. William Henry Saundercock	3	male	20	0	0	8.05	0
Mr. Anders Johan Andersson	3	male	39	1	5	31.275	0
Miss. Hulda Amanda Adolfina Vestrom	3	female	14	0	0	7.8542	0
Mrs. (Mary D Kingcome) Hewlett	2	female	55	0	0	16	1
…	…	…	…	…	…	…	…

Decision Tree



Overfitting

Random Forest

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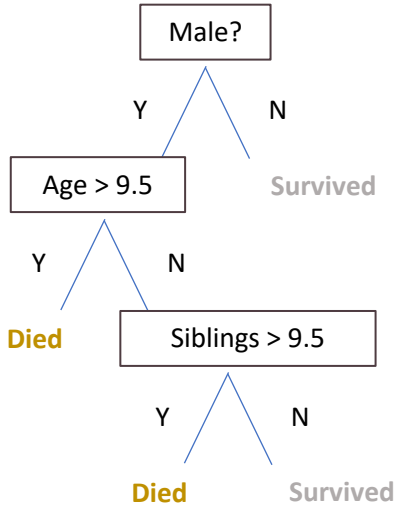

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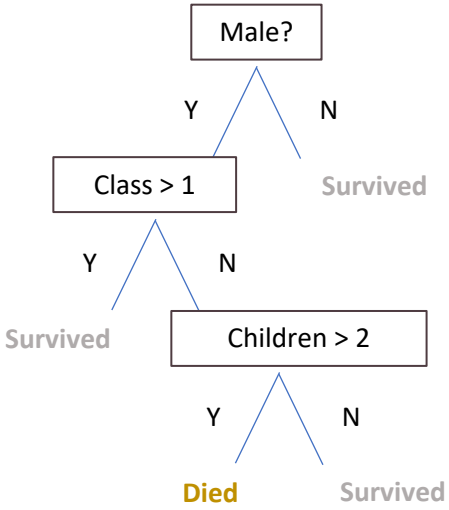

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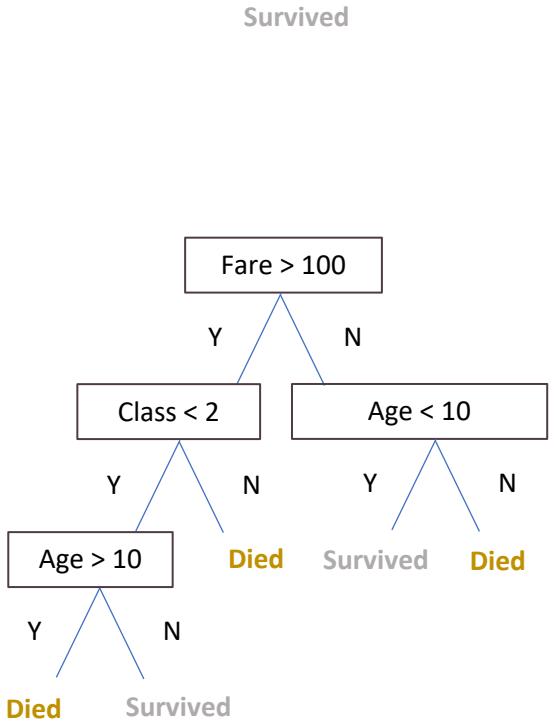

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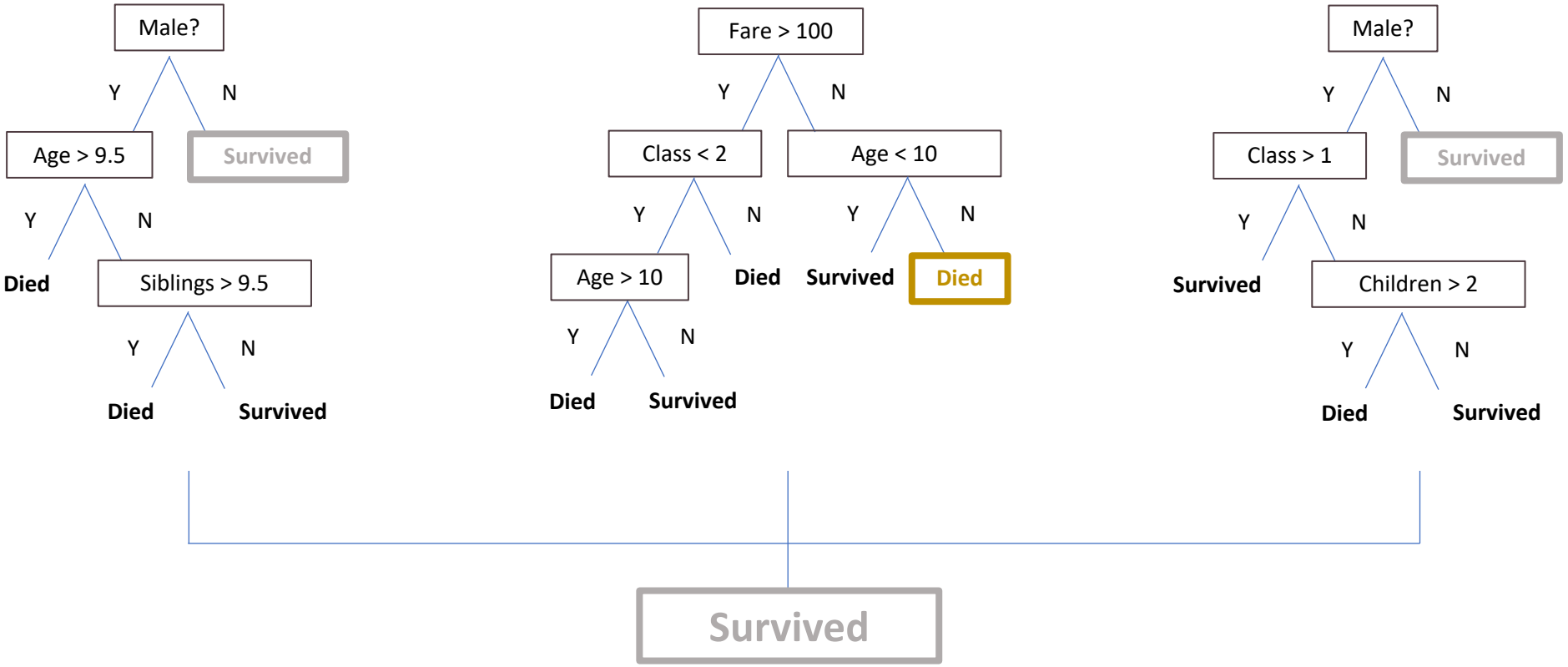
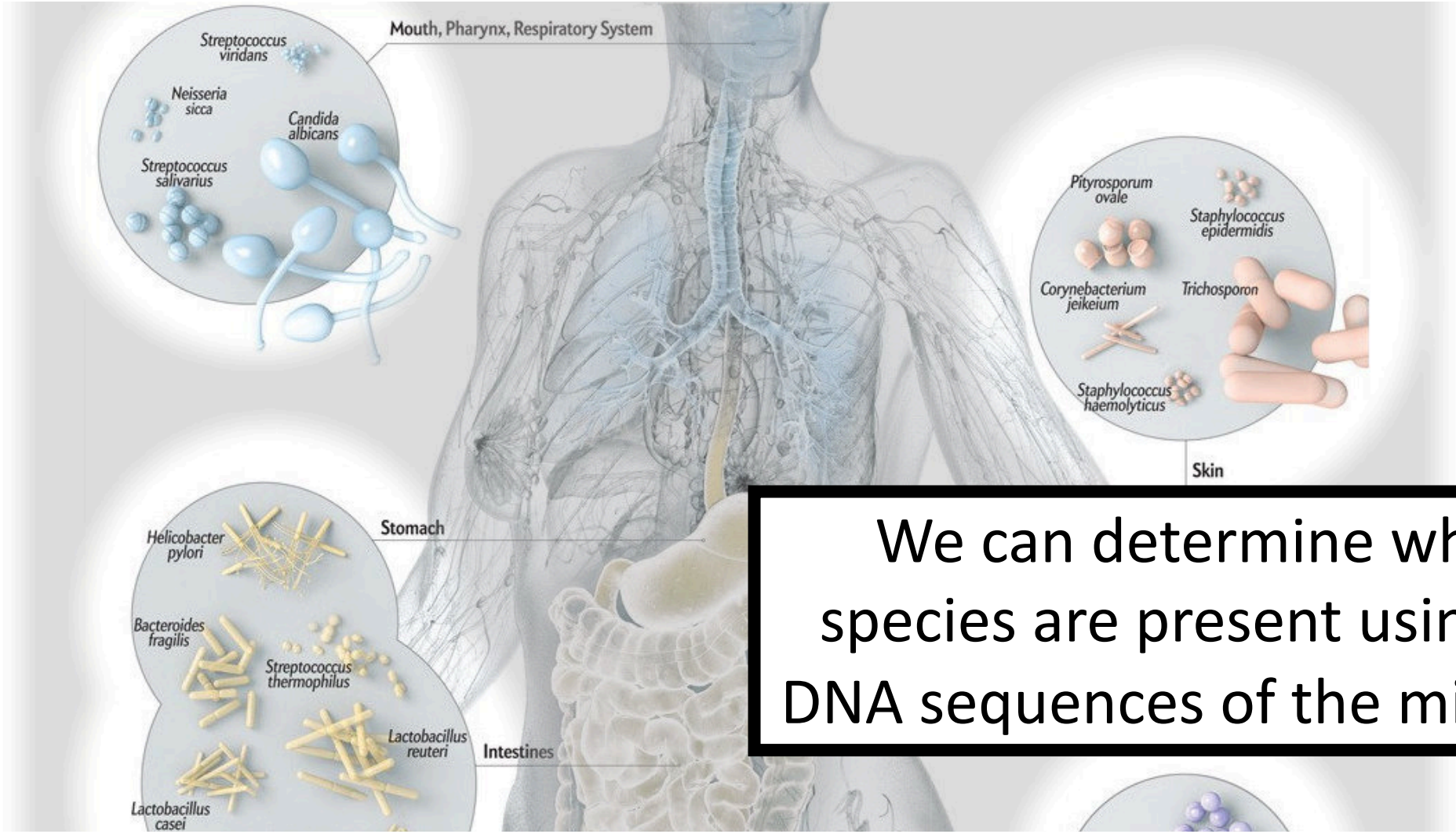


Example: Predict if lesion is cancerous (we'll be doing this in the lab!)

- Labels:
  - Colorectal lesions of patients
  - Defined as cancer or not

- Features:
  - 16S rRNA gene sequences in stool

We all have microbes in us: *the human microbiome*



We can determine which species are present using the DNA sequences of the microbes

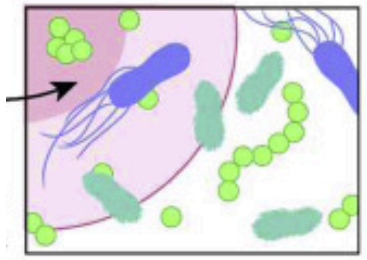
Can you use the microbes in you to predict if you have/will get colorectal cancer?

Can you use the microbes in you to predict if you have/will get colorectal cancer?

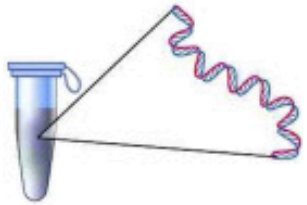
Cancer

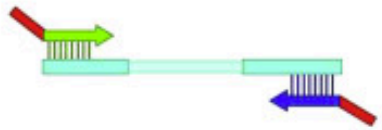
No cancer

}

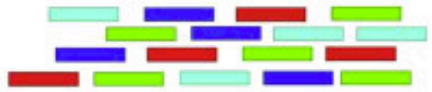


DNA isolation from sample

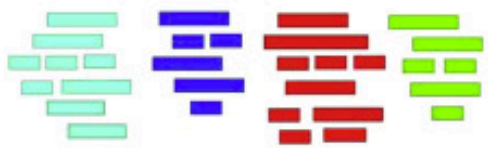




PCR amplification of bacterial 16S rRNA gene



High-throughtput sequencing of amplified 16S rRNA genes



Data processing, quality control and analysis using bioinformatic tools

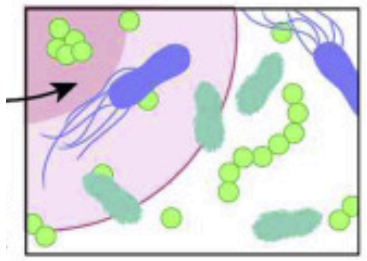
Species abundance

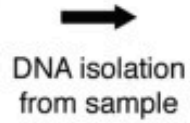
Can you use the microbes in you to predict if you have/will get colorectal cancer?

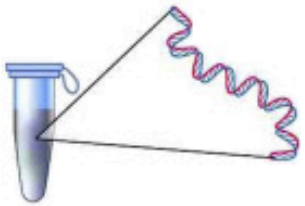
Cancer

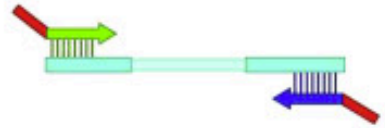
No cancer

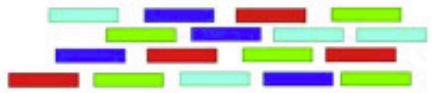
Label

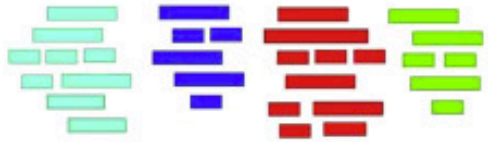












Species abundance

Features

Download data

- Download this data:
  - **https://tinyurl.com/yyqywozj**
- Make a folder on your Desktop called machine-learning-pipelines-r
- Make a folder in machine-learning-pipelines-r called data
- Move data.tsv to the data folder