Introduction to Machine Learning – What is Machine Learning?

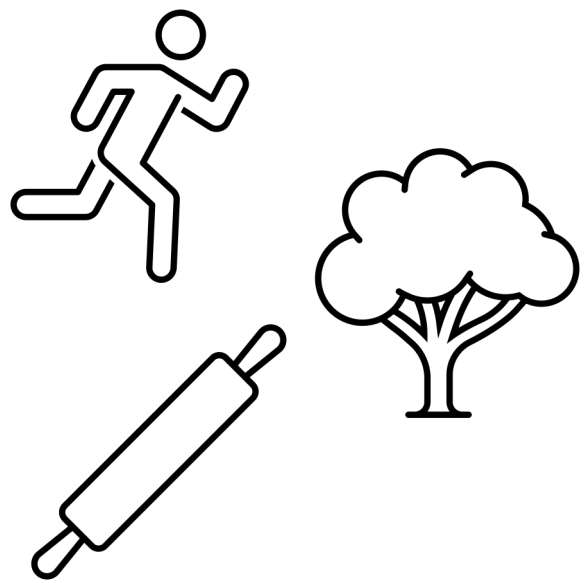
Dr. Ab Mosca (they/them)

Slides based off slides courtesy of Jordan Crouser (https://jcrouser.github.io/)

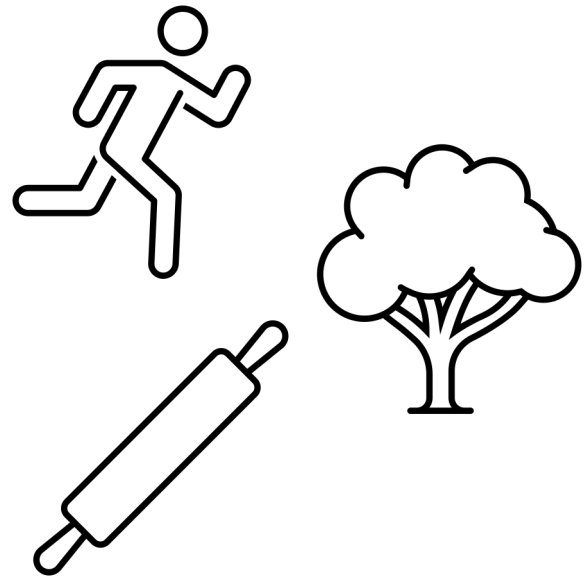
Plan for Today

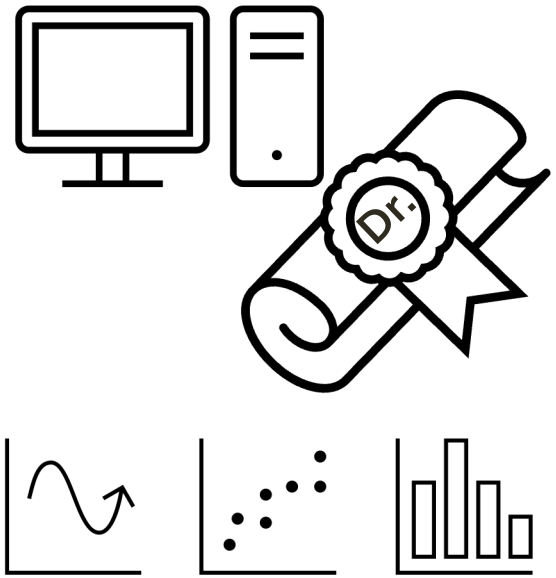
- Who am I?
- Who are you?
- What will we do in this class?
- What is Machine Learning?

Who Am I?



Who Am I?





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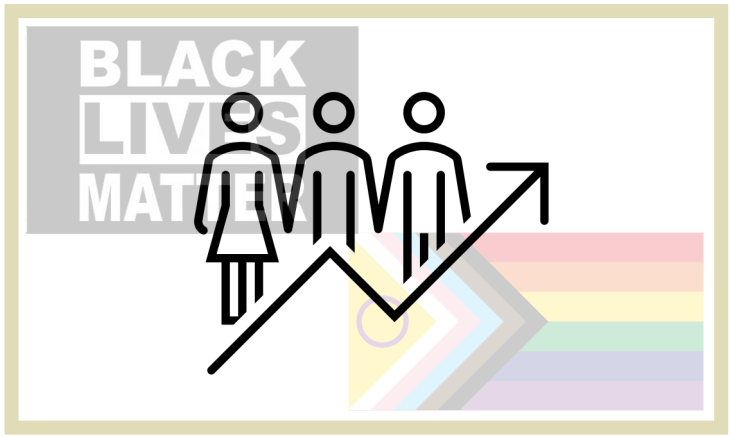
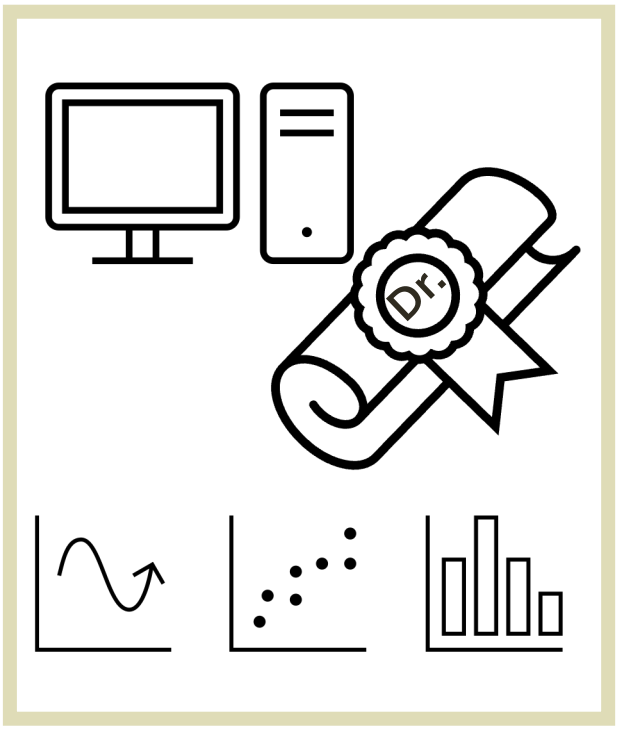




Who Are You?

- Form groups of 3
- Introduce yourselves (name, pronouns)
- Share:
  - A highlight of your winter break
- Find 1 thing that your entire group has in common (favorite color? hometown? left-handed? Be creative!)
- After about 5 minutes we will go around, introduce ourselves, and share what each group has in common

Who Are You?

- Form **new groups** of 3 (move around!)
- Introduce yourselves (name, pronouns)
- Share:
  - Would you rather be able to touch a book and instantly read it OR remember everything you've ever read?
- After about 5 minutes we will go around, introduce ourselves, and share our would you rather answers

Who Are You?

- Form **new new groups** of 3 (move around!)
- Introduce yourselves (name, pronouns)
- Share:
  - Would you rather have your dishes wash themselves or your laundry wash itself?
- After about 5 minutes we will go around, introduce ourselves, and share our would you rather answers

- Name tags!

What You Will Learn & Logistics

What is this class?

1. Understand what ML is (and isn't)

2. Learn some foundational methods / tools

3. Be able to choose methods that make sense

Important Info

- Course website (**write this down**!): https://amosca01.github.io/CAIS380ML-S24/

- Office Hours
  - Wilson Hall 325
    - Wednesday 09:30 - 11:00
    - Thursday 14:30 - 16:30
    - By Appointment

Important Info

- Textbook: *An Introduction to Statistical Learning*
  - See course website for instructions
- Assignments:
  - Turn in on Gradescope – Demo! (https://help.gradescope.com/article/ccbpppziu9-student-submit-work)
- Due Dates: As listed on course schedule.
  - 24hr grace period; no late submissions
  - Lowest homework dropped
  - See syllabus for revise and resubmit policy

Important Info

Assignments

- Homework
  - Pair assignments
  - Graded on effort and correctness
- Quizzes (on PLATO)
  - Individual assignments
  - Can re-take as many times as wanted before deadline
- In-class Activities
  - Graded on effort
- Final Project
  - Small group
  - Graded on creativity and correctness

Important Info

- I’m here to help you succeed
- Please come to office hours or reach out if you need any additional support

Now the good stuff

What is machine learning?

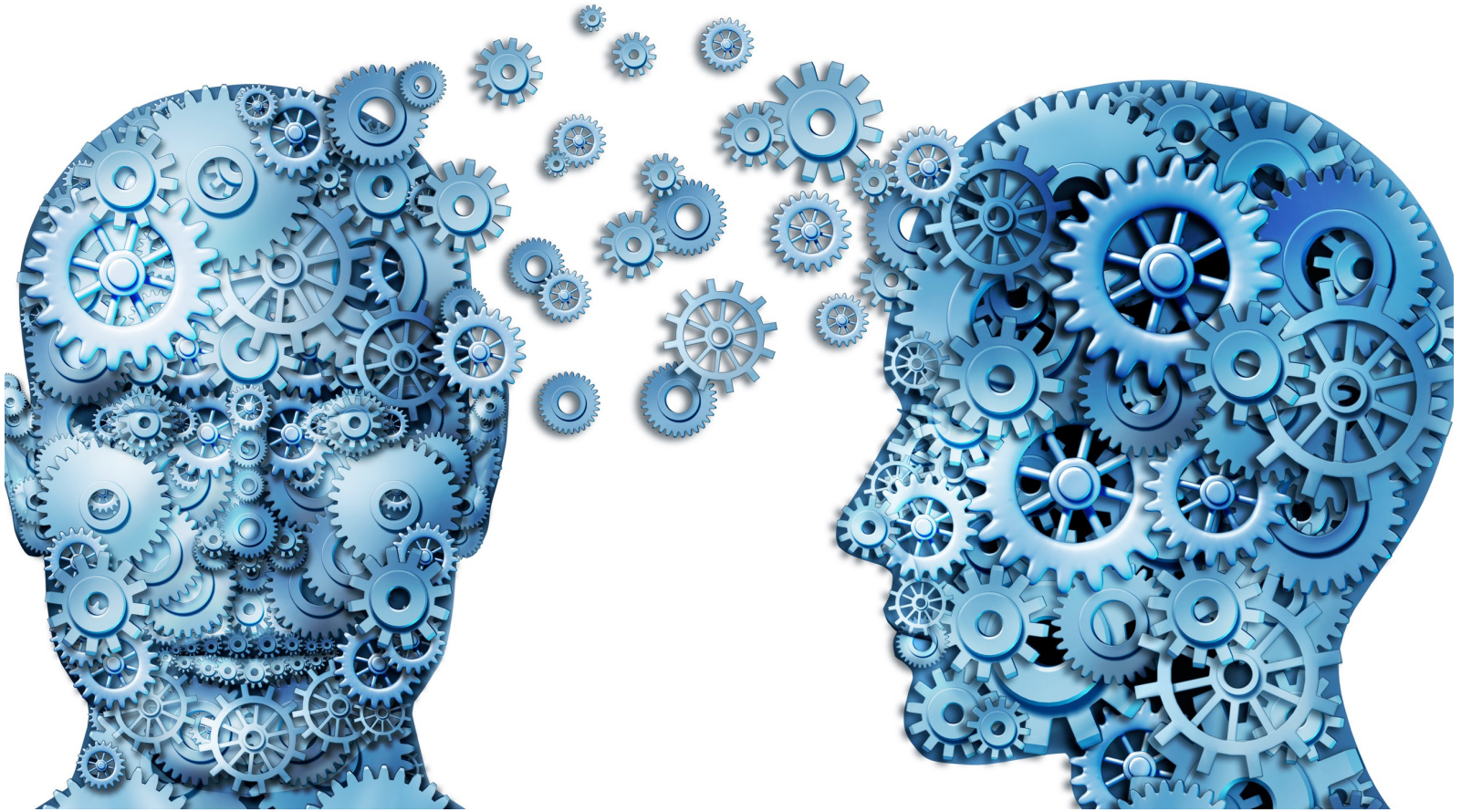


Image credit: Coursera

What is ~~machine~~ learning?

learn·ing

/ˈlərniNG/

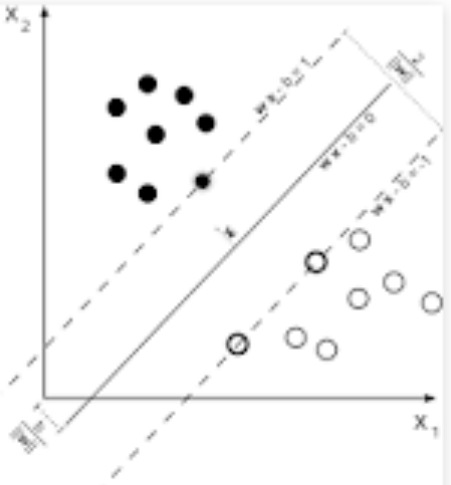
noun

the acquisition of knowledge or skills through experience, study, or by being taught.
"these children experienced difficulties in learning"
synonyms: study, studying, education, schooling, tuition, teaching, academic work; research
"a center of learning"

Translations, word origin, and more definitions

Machine learning: Wikipedia

Machine learning is a subfield of computer science that evolved from the study of pattern recognition and computational **learning** theory in artificial intelligence. **Machine learning** explores the study and construction of algorithms that can learn from and make predictions on data.

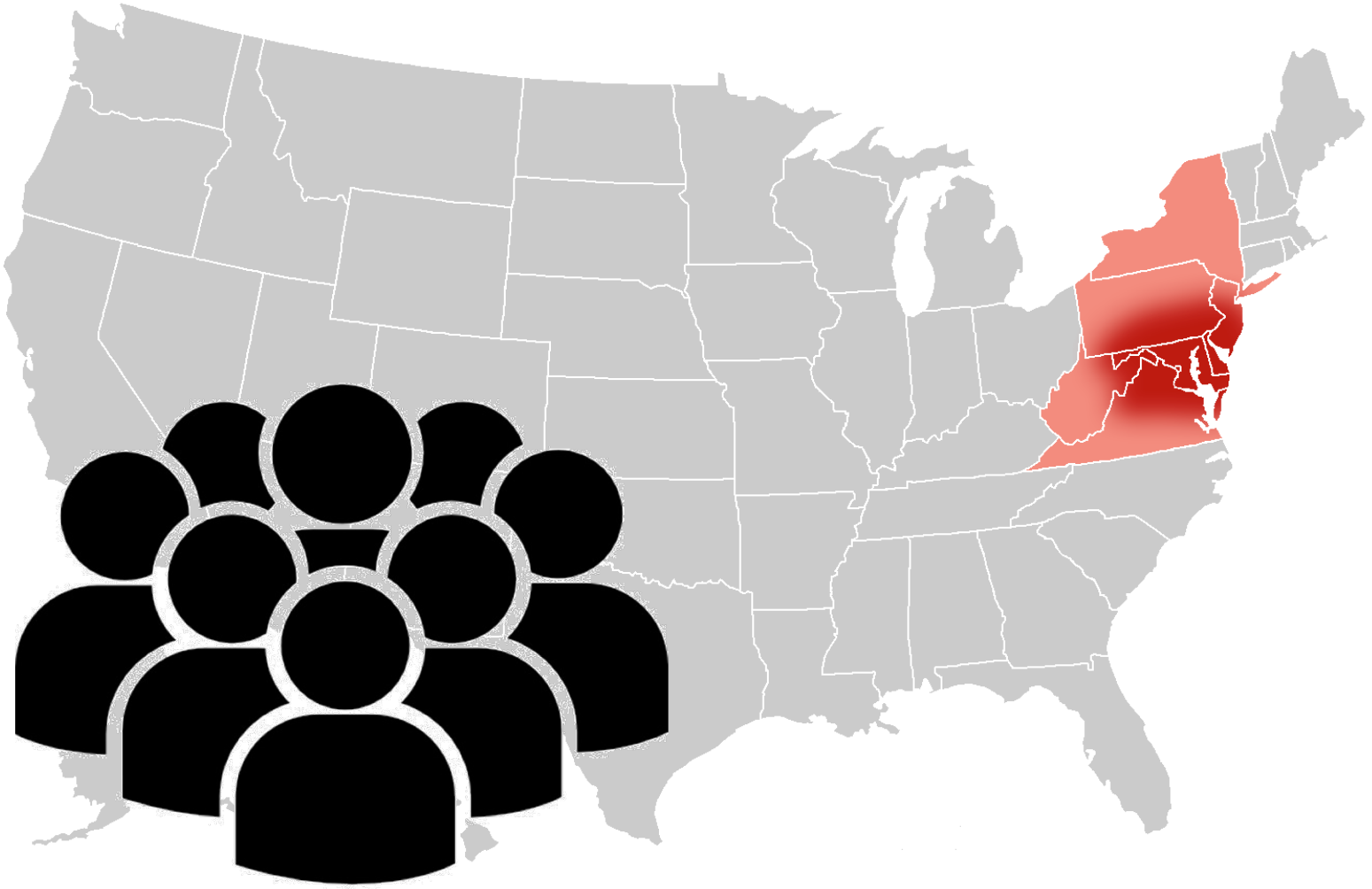


Machine learning - Wikipedia, the free encyclopedia
https://en.wikipedia.org/wiki/**Machine_learning** Wikipedia

Machine learning: a working definition

- Machine learning is a set of **computational tools** for building **statistical models**
- These models can be used to:
  - **Group** similar data points together (*clustering*)
  - **Assign** new data points to the correct group (*classification*)
  - Identify the **relationships** between variables (*regression*)
  - Draw conclusions about the **population** (*density estimation*)
  - Figure out **which variables** are important (*dimension reduction*)

Example: men & money in the mid-Atlantic



Example: men & money in the mid-Atlantic

- `Wage` dataset available in the `ISLR` package
- **Sample**: 3000 male earners from the mid-Atlantic, surveyed between 2003 and 2009
- Dimensions:
  - Year each datapoint was collected
  - Age of respondent
  - Martial status
  - Race
  - Educational attainment
  - Job class
  - Health
  - Whether or not they have health insurance
  - Wage

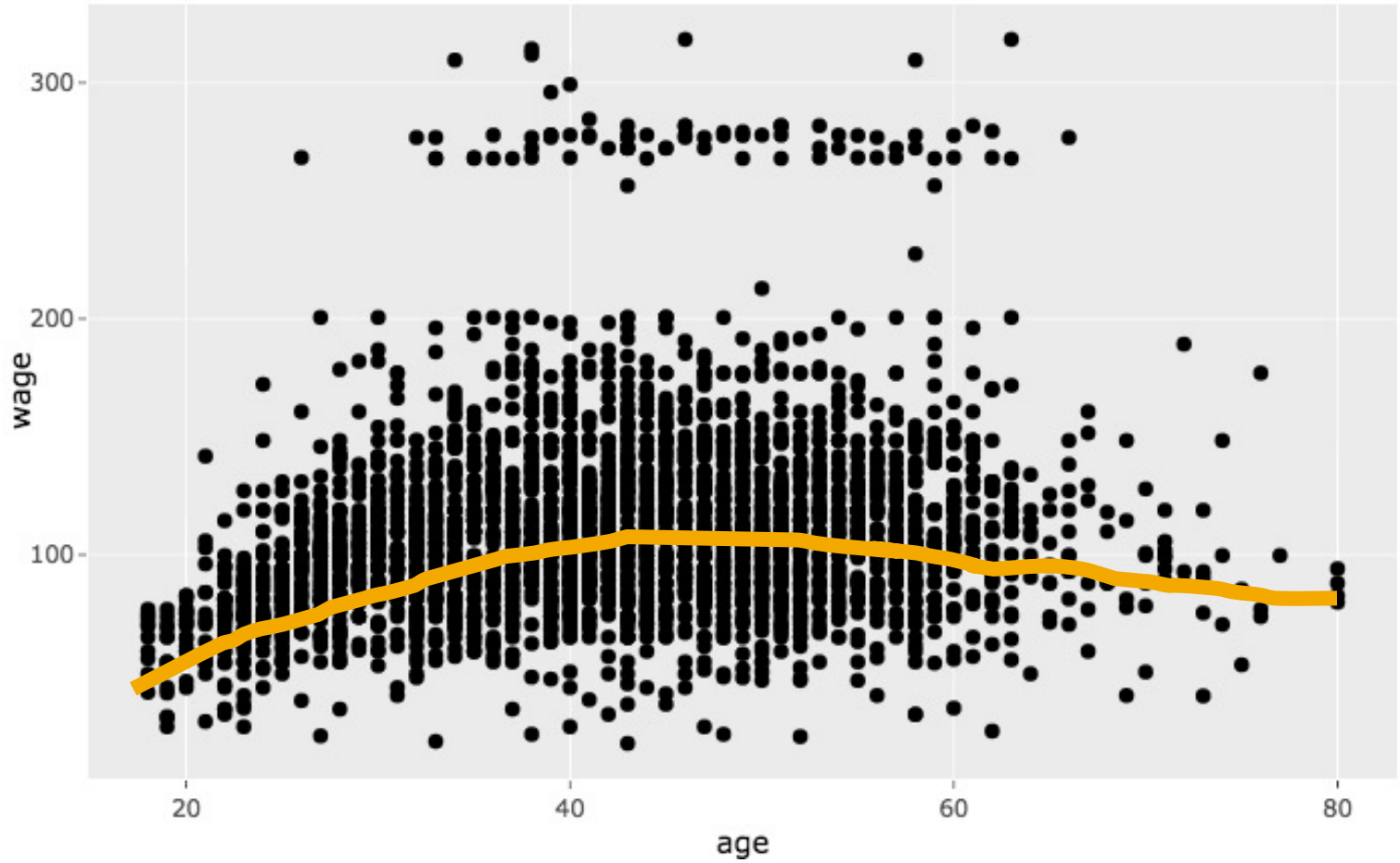
Example: men & money in the mid-Atlantic

- **Question**: what is the effect of an earner's `age`, `education`, and the `year` on his `wage`?
- Find some friends, then go explore the data at: https://amosca01.github.io/CAIS380ML-S24/ under the Example tab

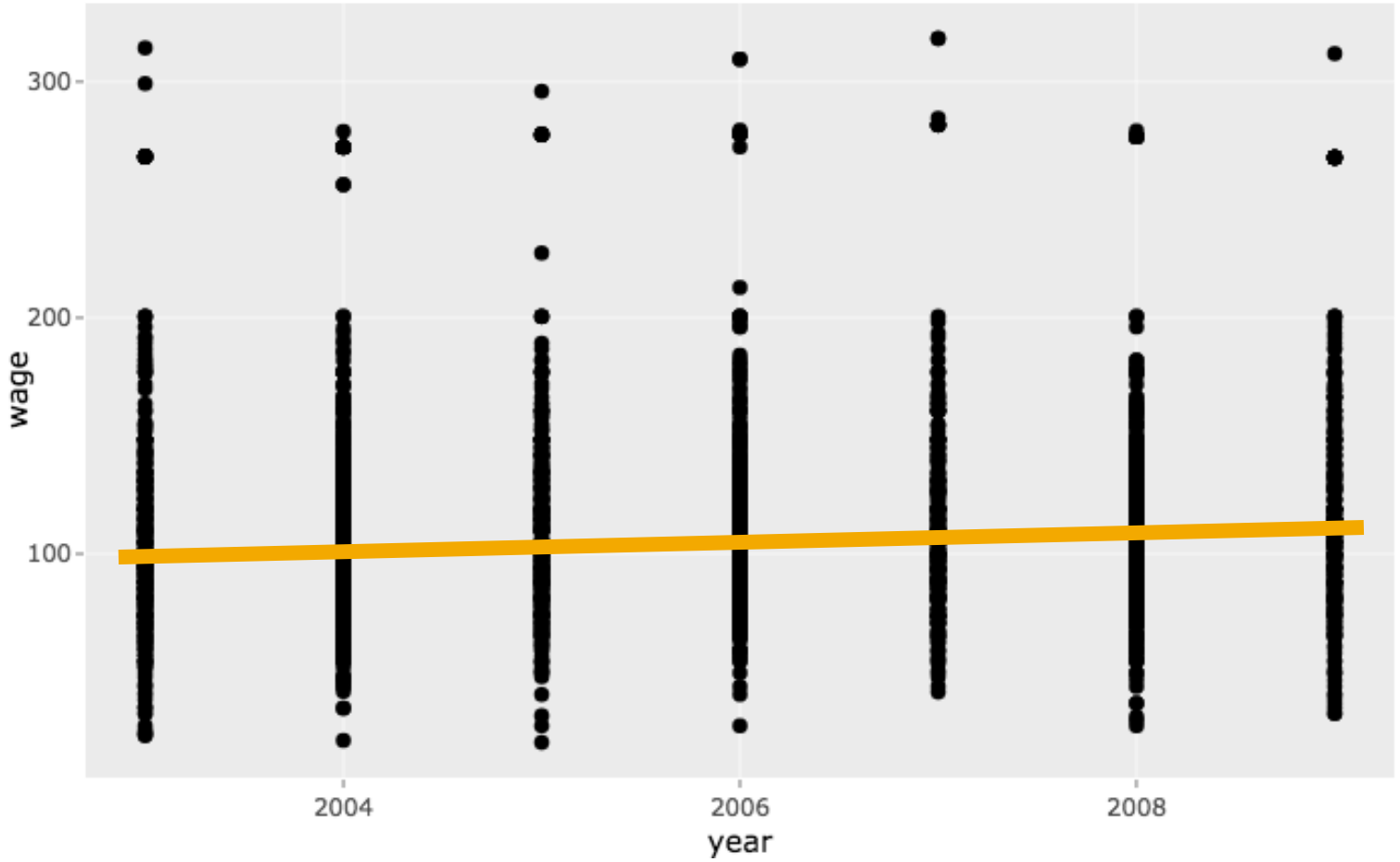
Example: men & money in the mid-Atlantic

https://amosca01.github.io/CAIS380ML-S24/examples/Wage.html

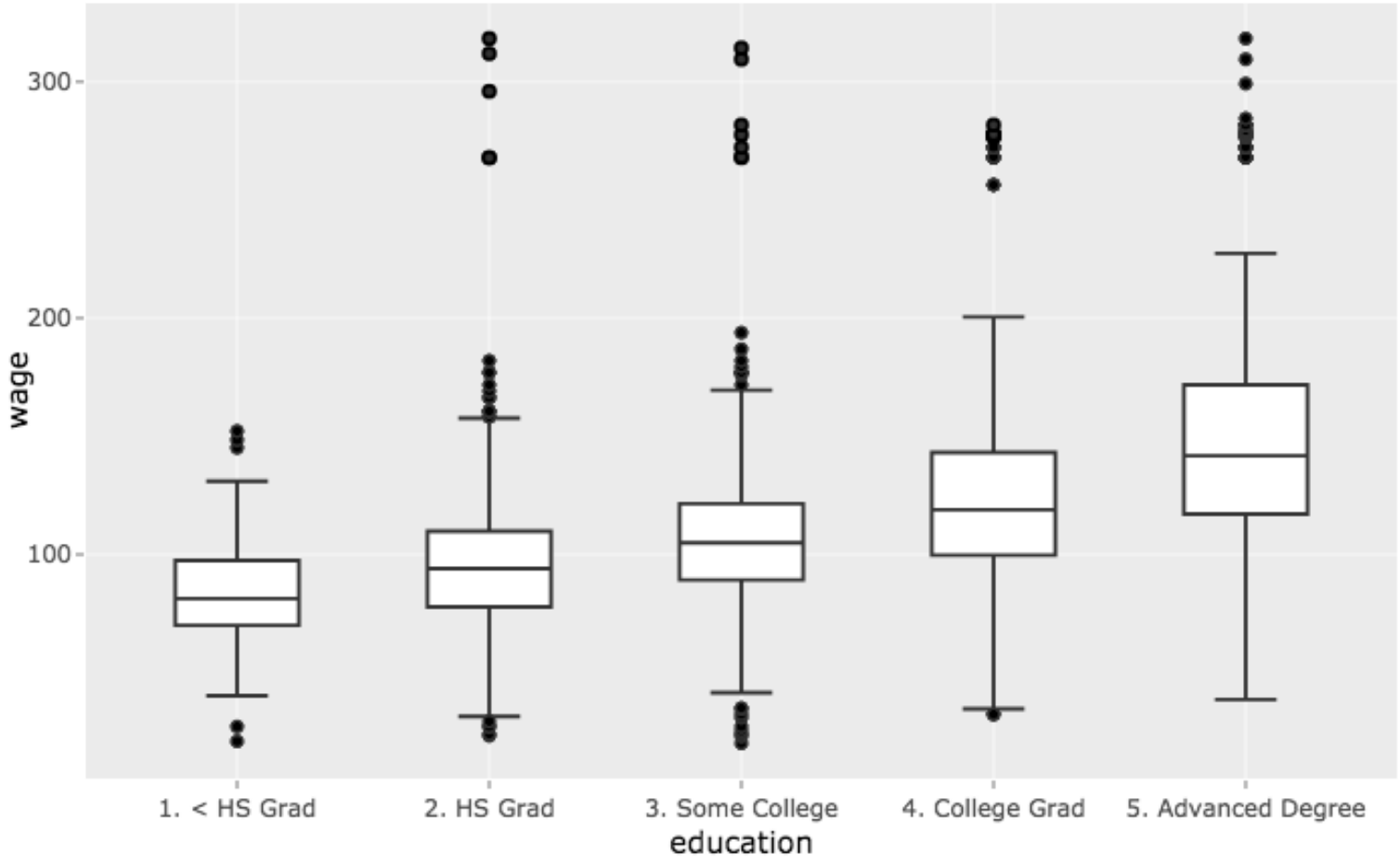
wage vs. age



`wage` vs. `year`

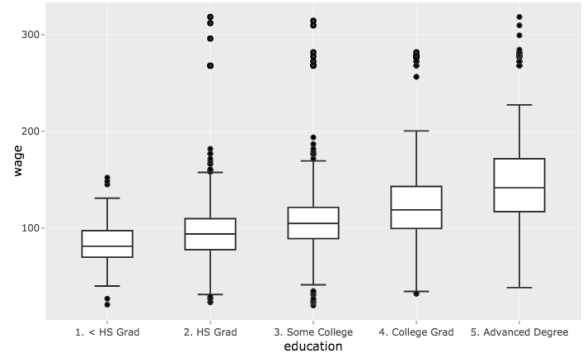


wage vs. education

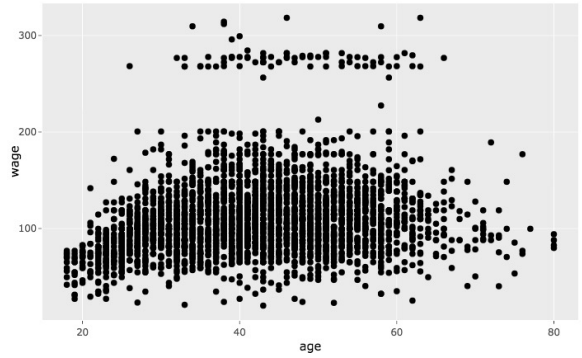


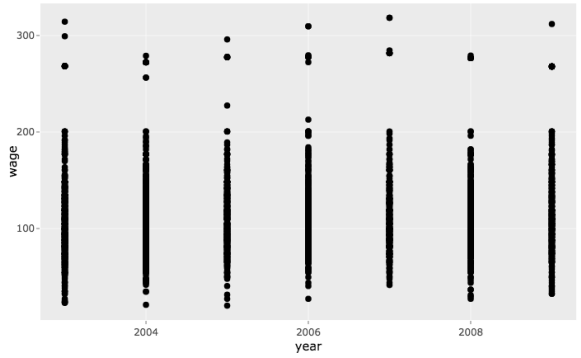
Example: men & money in the mid-Atlantic

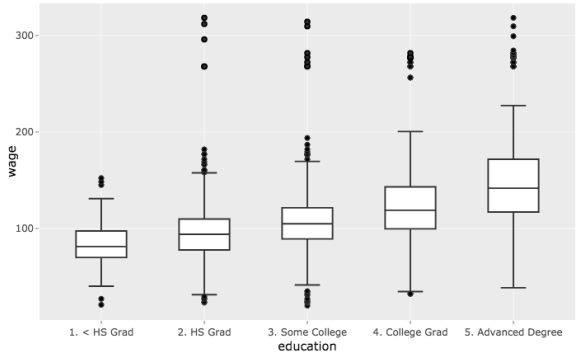
- If we had to pick **just one**, we should probably use `education`



- In reality, the **best predictor** is probably a **combination** of all three







Supervised machine learning

- In this example, we used the value of **input variables** to predict the value of **output variables**
- Another way to think about this:

Supervised machine learning

- **Goal**: explain some observable phenomenon *Y* as a function of some set of predictors *X*:

$$Y = f(X) + \epsilon$$

- **Problem**: we don't know what the function actually looks like; we have to *estimate* it
- **Machine learning**: computational tools for estimating *f*

Unsupervised machine learning

- We sometimes have only **input variables**, but no clearly defined "response"
- Can't check ("supervise") our analysis: **unsupervised**
- Can't fit a regression model (why?)
- What **can** we do?

Example: personalized marketing

Example: personalized marketing

amazon

Example: personalized marketing

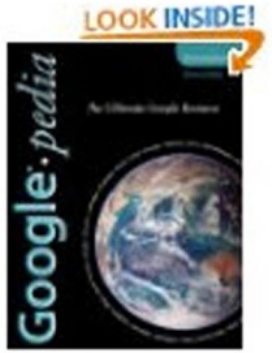
amazon.com

Recommended for You

Amazon.com has new recommendations for you based on items you purchased or told us you own.

Google Apps Deciphered: Compute in the Cloud to Streamline Your Desktop

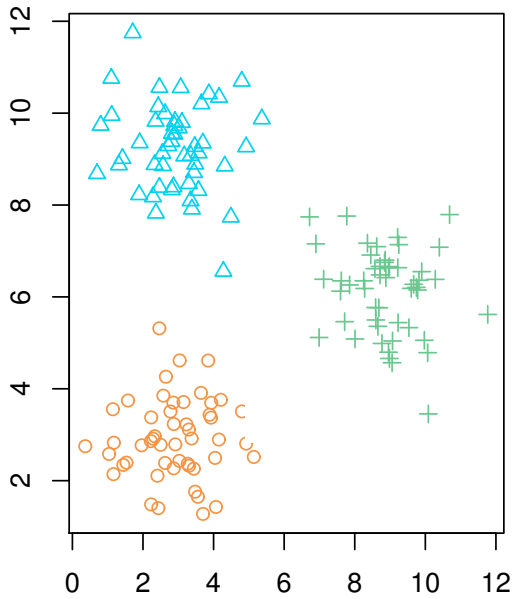
Google Apps Administrator Guide: A Private-Label Web Workspace

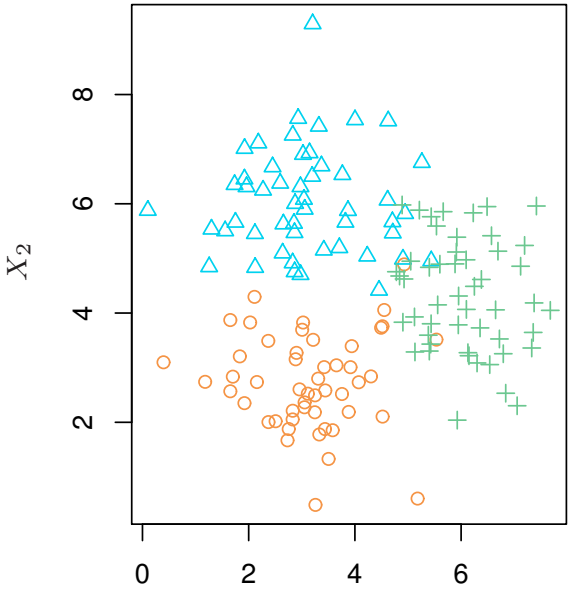


Googlepedia: The Ultimate Google Resource (3rd Edition)

Unsupervised machine learning

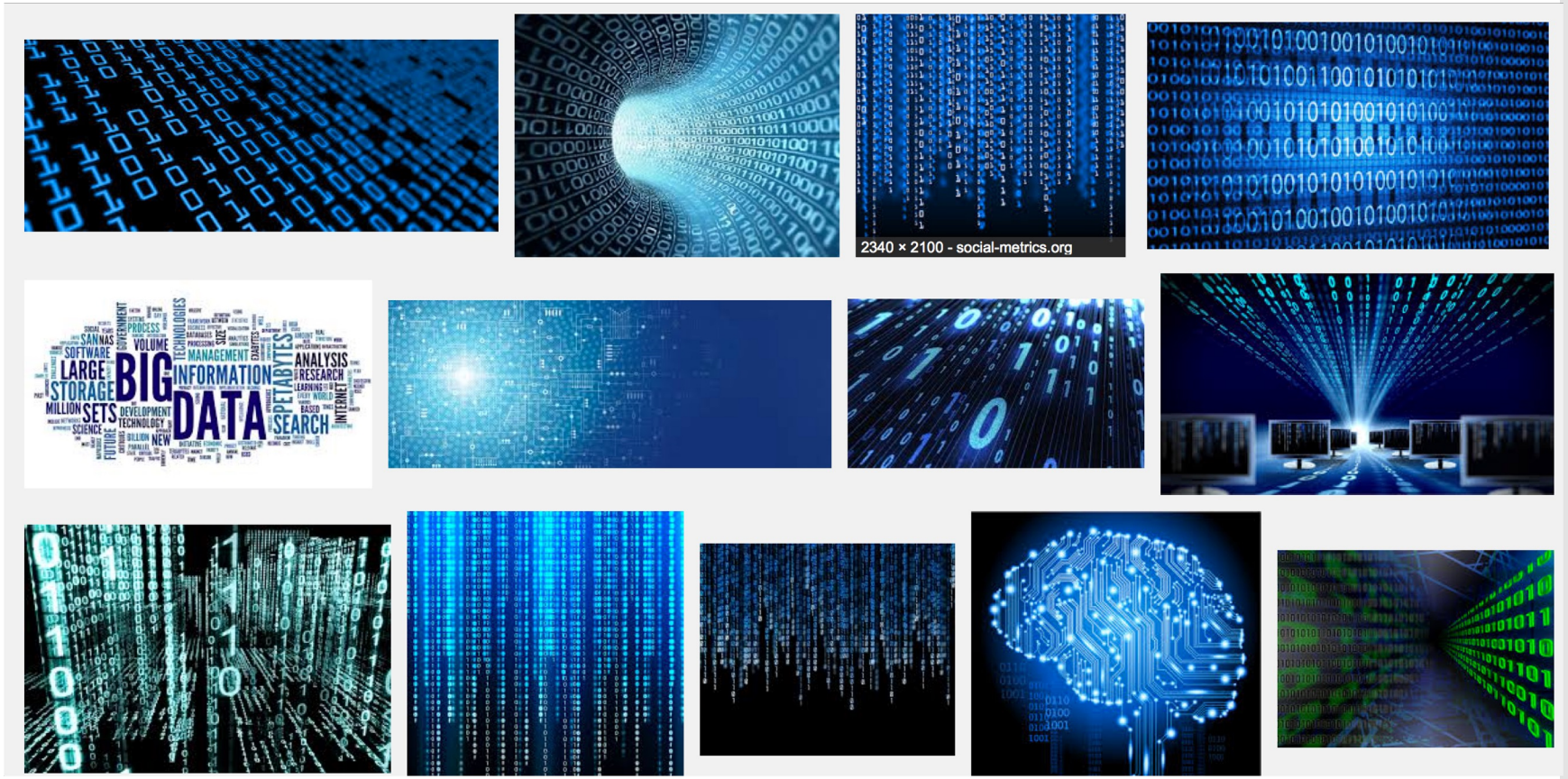
- **Challenge**: identify whether the data separates into (relatively) distinct groups





- This kind of problem is called **cluster analysis** (Ch. 10)

Data science refresher: what is “data”?



Data: a definition

A dataset has some set of *variables* available for making predictions. For example:

Tuition rates, enrollment numbers, public vs. private, etc.

Data: a definition

Each variable may be either *independent* or *dependent*:

- An *independent variable (iv)* is not controlled or affected by another variable (e.g., time in a time-series dataset)
- A *dependent variable (dv)* is affected by a variation in one or more associated independent variables (e.g., temperature in a region)

Data: a definition

A dataset also contains a set of **observations** (also called *records)* over these variables. For example:

tuition = $26,978, *enrollment* = 4,239, *public, etc.*

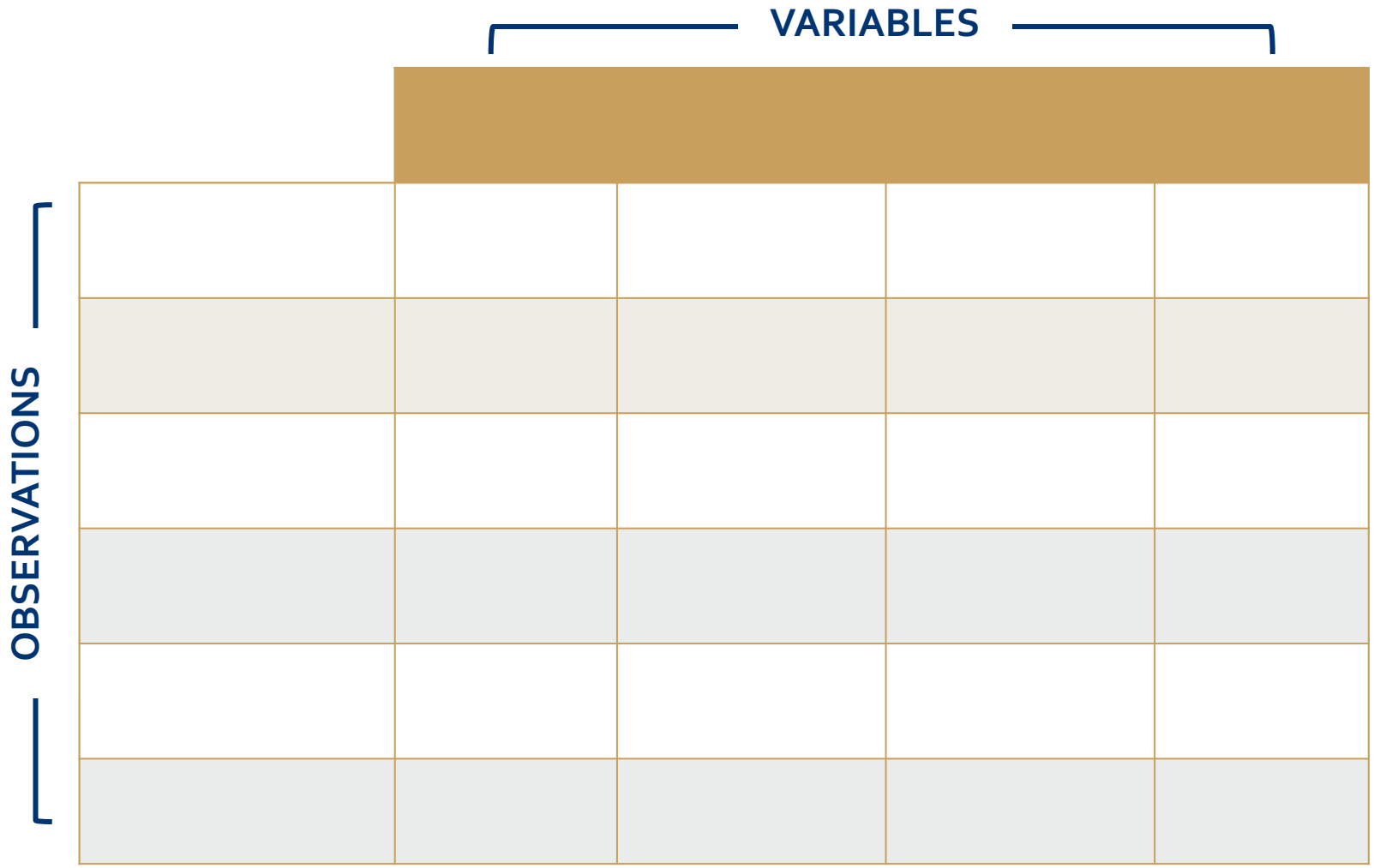
Data: a definition

A dataset also contains a set of **observations** (also called *records)* over these variables. For example:

tuition = $32,434,
enrollment = 28,635,
public, etc.

tuition = $78,438,
enrollment = 2,600
private, etc.

One way to think about this:



Basic data types

- Nominal
- Ordinal
- Scale / Quantitative
  - Ratio
  - Interval

An **unordered** set {…}

of non-numeric values

For example:

- Categorical (finite) data

  {apple, orange, pear}

  {red, green, blue}

- Arbitrary (infinite) data

  {"12 Main St. Boston MA", "45 Wall St. New York NY", …}

  {"John Smith", "Jane Doe", …}

Basic data types

- Nominal
- Ordinal
- Scale / Quantitative
  - Ratio
  - Interval

An **ordered set** <…>

(also known as a tuple)

For example:

- Numeric: <2, 4, 6, 8>
- Binary: <0, 1>
- Non-numeric:

  <G, PG, PG-13, R>

Basic data types

- Nominal
- Ordinal
- Scale / Quantitative
  - Ratio
  - Interval

A **numeric range** […]

Ratios

- Distance from "absolute zero"
- Can be compared mathematically using division
- For example: height, weight

Intervals

- Ordered numeric elements that can be mathematically manipulated, but cannot be compared as ratios
- E.g.: date, current time

Converting between basic data types

- Q → O [0, 100] → <F, D, C, B, A>
- O → N <F, D, C, B, A> → {C, B, F, D, A}
- N → O (??)
  - {John, Mike, Bob} → <Bob, John, Mike>
  - {red, green, blue} → <blue, green, red>
- O → Q (??)
  - Hashing?
  - Bob + John = ??

Discussion: what do you notice?

Readings in Information Visualization: Using Vision To Think. Card, Mackinglay, Schneiderman, 1999

Basic operations

- Nominal (N)
  - Equality: = and ≠
  - Frequency: how often does *x* appear?
- Ordinal (O)
  - Relation to other points: >, <, ≥, ≤
  - Distribution: inference on relative frequency
- Quantitative (Q)
  - Other mathematical operations: (+, -, *, /, etc.)
  - Descriptive statistics: *average, standard deviation, etc.*

(Hopefully) familiar statistical concepts

- We tend to refer to problems with a **quantitative** response as *regression* problems
- When the response is **qualitative** (i.e. nominal or ordinal), we're usually talking about a *classification* problem
- **Caveat**: the distinction isn't always that crisp. For example:
  - K-nearest neighbors (Ch. 2 and Ch. 4), which works with either
  - Logistic regression (Ch. 4), which estimates the probabilities of a qualitative response

What we'll cover in this class

- Ch. 2: Statistical Learning Overview (next class)
- Ch. 3: Linear Regression
- Ch. 4: Classification
- Ch. 5: Resampling Methods
- Ch. 6: Linear Model Selection
- Ch. 7: Beyond Linearity
- Ch. 8: Tree-Based Methods
- Ch. 9: Support Vector Machines
- Ch. 10: Unsupervised Learning

Backgrounds

- Who has experience coding?
- Who has experience with statistics?

Preparing for labs in R

You can install R Studio on your own machine: rstudio.com

Preparing for labs in python

You can install Anaconda here: https://www.anaconda.com/download

I recommend developing in Spyder (which comes with the anaconda download)

You'll need to know how to **install packages**

What I expect from you

- You like difficult problems and you're excited about "**figuring stuff out**"
- You have a solid foundation in **introductory statistics**
- You are proficient in **coding and debugging** (or are ready to work to get there)
- You're comfortable asking **questions**