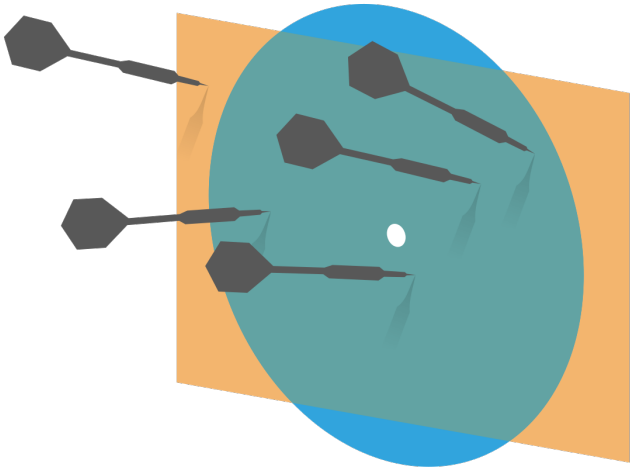
Probability and Statistics for Computer Science



Credit: wikipedia

"The eternal mystery of the world is its comprehensibility … The fact that it is comprehensible is a miracle." – Albert Einstein

Hongye Liu, Teaching Assistant Prof, Course CS361, UIUC, 8.25.2021

Objectives

- Welcome/Orientation
  - Expectations in mixed-mode lectures
- Big picture of the contents
- Lecture 1 - Data Visualization & Summary (I)

What to expect in the lecture?

Mixed-mode of teaching

Poll Everywhere

Activities using **Poll Everywhere** and **Canvas group**

CANVAS

What to expect in the lecture? (AL2)

- **AL2** online students' Video and Audio will be both muted during the lecture unless permitted by the instructor for questions.
- You can use the chatbox or Canvas "chat" to ask questions or write comments.
- Questions will be collected by the assistant for answers or summary.

What to expect in the lecture? (AL1)

- **AL1** in-person students should not log into Zoom.
- You can use Canvas “chat” to ask questions or write comments. You can also raise hands to ask questions.
- Questions from Canvas will be collected by the assistant for answers or summary.
- Wear face covering in the classroom

Vision (PCA)

- **P**assion for learning
- **C**ompassion for each other
- **A**uthentic understanding

How to succeed in this course?

- Factors that will hinder you from success
- Factors that will help you succeed

Avoid these that could cause failure

- Academic integrity infraction – by all means!
- Missing homeworks, project or quizzes
- Late/Poor homeworks or project
- Insufficient viewing of the contents
- Poor time management & Procrastination
- Too many challenging classes at the same time
- Not motivated/not interested in the topic

Factors that will help you succeed

- **Be engaged/motivated**,
- **Do not hesitate to ask** for help.
- Be **Active** in class participation
- Do as much practice as possible, not just the homework and project.
- Participate in the optional teamwork
- Clear your doubts/misconceptions **asap (every lecture/discussion is important)**

Interactions are important!

- Try to go to office hours as much as possible
- Try to meet or talk to the instructor as least once personally
- You are encouraged to join the teamwork (extra points opportunities)
- Show compassion via community service

Graded Teamwork

Extra Points

Quizzes

Course materials

- Canvas Course Site

  https://canvas.illinois.edu/courses/13954

- Public Website

  https://courses.grainger.illinois.edu/CS361/fa2021/

Lecture videos and ClassTranscribe

- Lecture and discussion will be recorded and accessible at https://mediaspace.illinois.edu/
- ClassTranscribe provides transcripts for these videos

  https://classtranscribe.illinois.edu/home
- The Zoom recording links and the specific links of the above two channels are all on Canvas

Ed policy and Gradescope submission

- Students are expected to follow the guidelines on how to use Ed (linked to the syllabus) in this course
- Students are expected to follow the guidelines of homework submissions (linked to the syllabus and on Canvas) in this course

Big picture of the content

- Probability and Statistics in action
- What does this course teach?

  Textbook: Forsyth, D. A. "Probability and Statistics for Computer Science," Springer (2018)

- Why are there 4 sections? How are they related?

This field really started with gaming

- We are familiar with flipping a coin or throwing a dice, the result is uncertain!

Head
Or Tail?

Which side
is front?

Life is uncertain so aim for long-term average

- We repeat a lot of experiments and see if there is regularity

Head
Or Tail?

Which side
is front?

Throwing a lot of “coins” for many times in one touch

- Galton board, the Bead Machine

https://www.youtube.com/watch?v=Kq7e6cj2nDw

Probability and Statistics Experiment in action

Simulation of random draw of a picture on computer

- It's the same as

throwing a 4-sided die.

What does this course teach?

- Describing Datasets

  Summary & visualization

- Probability
- Inference – Statistical Inference
- Tools – Machine Learning tools

Describing datasets (Summary & visualization)

Descriptive & Graphical

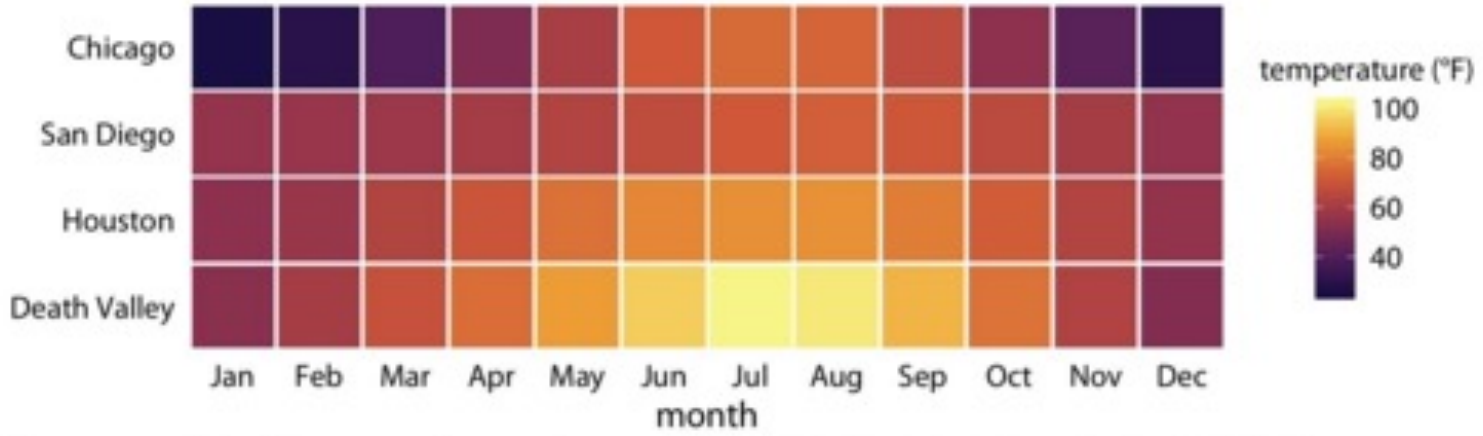


Figure 2-4. Monthly normal mean temperatures for four locations in the US. Data source: NOAA.

Summarization of 4 locations' annual mean temperature by month

Probability

- **Mathematical**

Romeo and Juliet have a date

Each arrives with a delay btw 0 and 1 hour. The first to arrive leaves after 1/4 hour. All pairs of delays are equally likely.

What's the probability that they will meet?

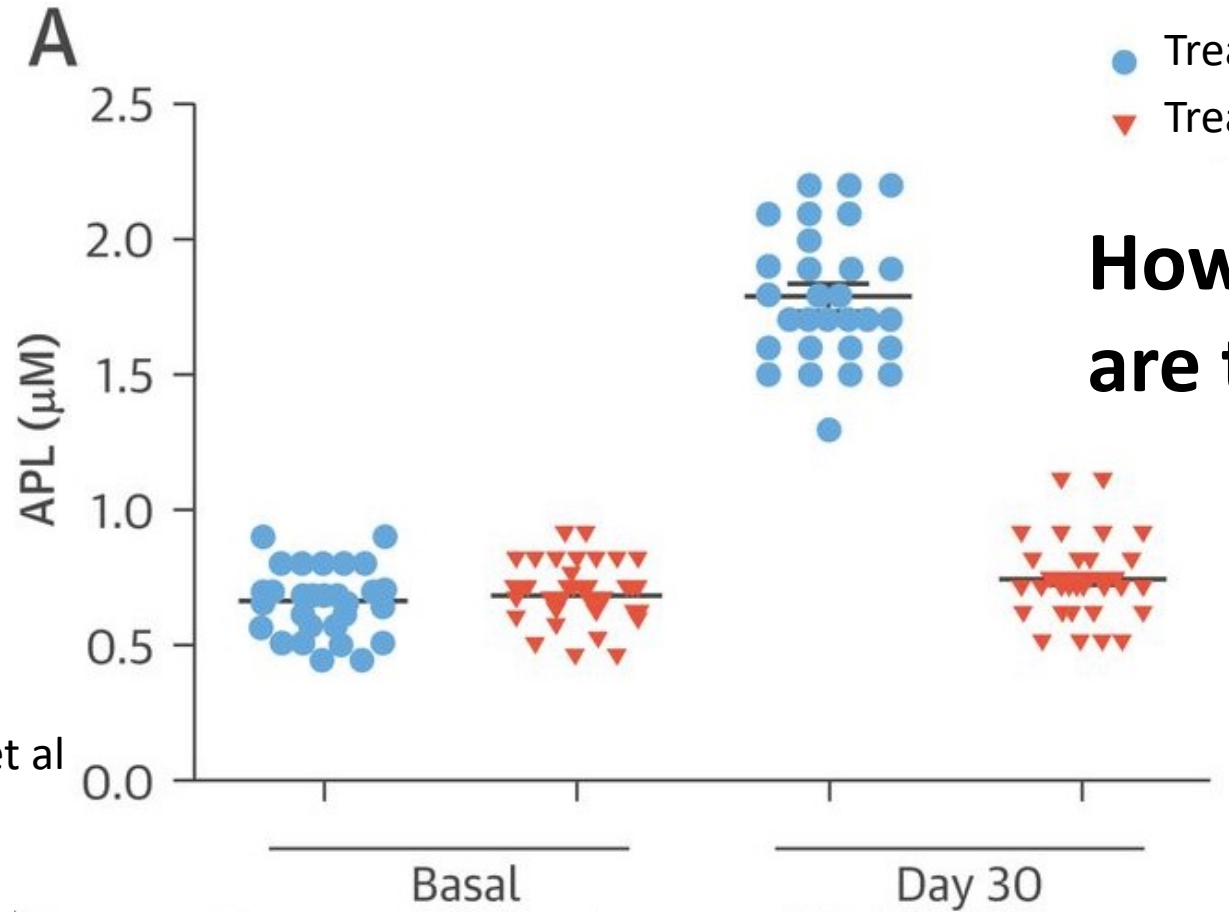
Probability

- **Mathematical**

How many slots are empty on average for a simple hashing table?

Inference

- **Analytical**

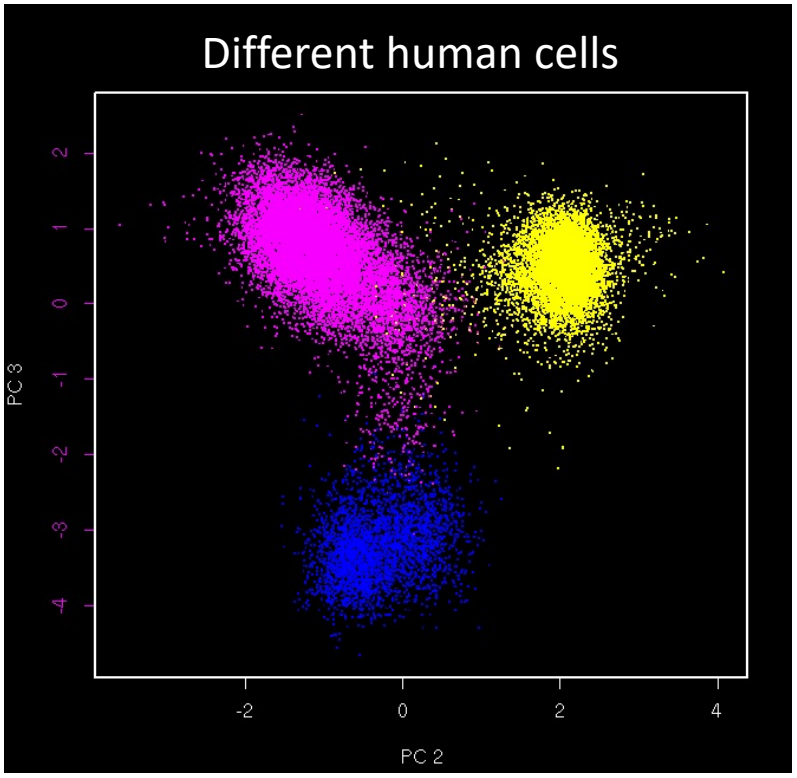


How different are they?

J Fromonot et al
JACC 2016

Tools (Machine learning)

- **Algorithmical**



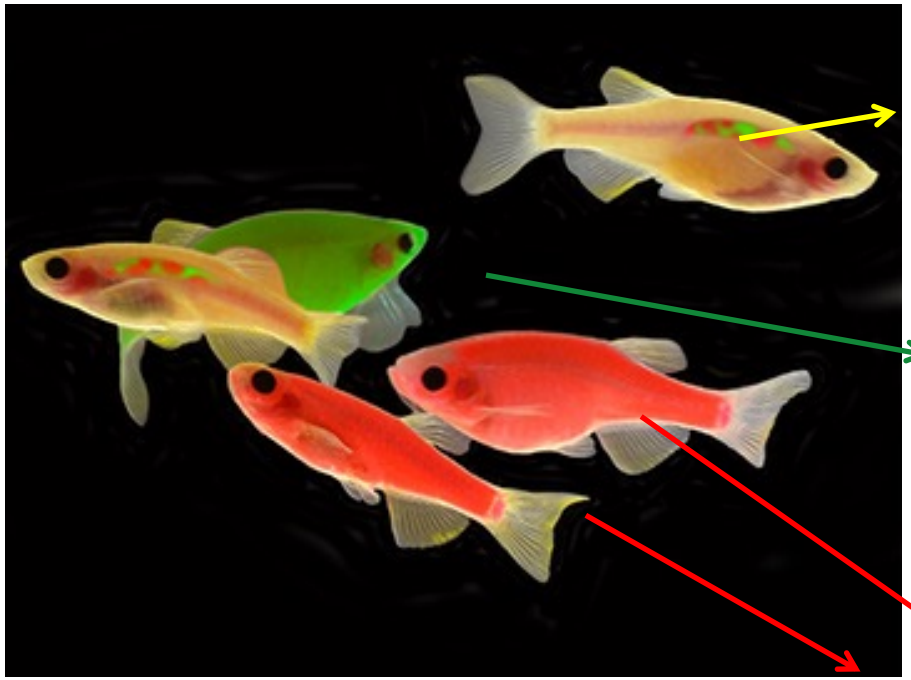
High-dimensional or complex shaped data sets need tools!
Humans are limited in 2-3D.
Machine learning is Highly desired!
Often depends on Statistics.

Why these 4 sections?

- Summary & visualization
  Graphical
- Probability
  Mathematical
- Inference – Statistical Inference
  Analytical
- Tools – Machine Learning tools
  Algorithmical

Why these 4 sections?

- The common thread is **Data.**
- We are doing computer science and so are like these yellow fish



What is special of Data? For Data?

Why these 4 sections?

- Real world data is often high dimensional and complex
- These 4 parts of knowledge or techniques are inseparably/organically connected in many real world applications.

What do we emphasize?

- Mathematical principle
- Critical thinking
- Working with real world data

LECTURE 1

Q. What do you feel about it when we speak of data visualization?

Example 1: Black hole

Constructed image using data collected from many different telescopes' view of the same object

This project received a 3million-dollar award

Credit: NASA

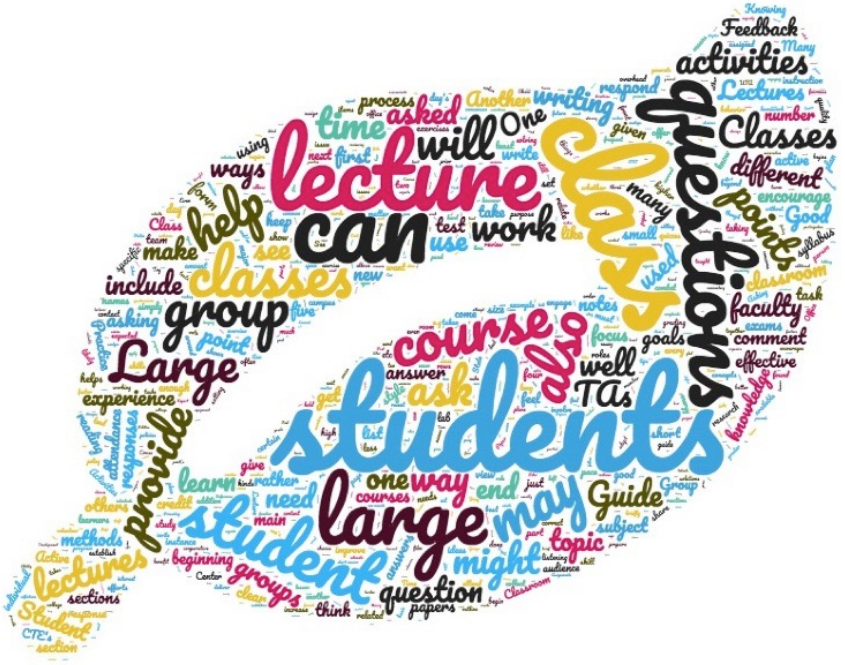
Example 2: Four seasons by Vivaldi

Pitch is shown by the distance from center;
Length of the note is the size of dot
Instrument is shown by the color's shade

https://medium.com/future-today/off-the-staff-an-experiment-in-visualizing-notes-from-music-scores-58f6ee9f0cef

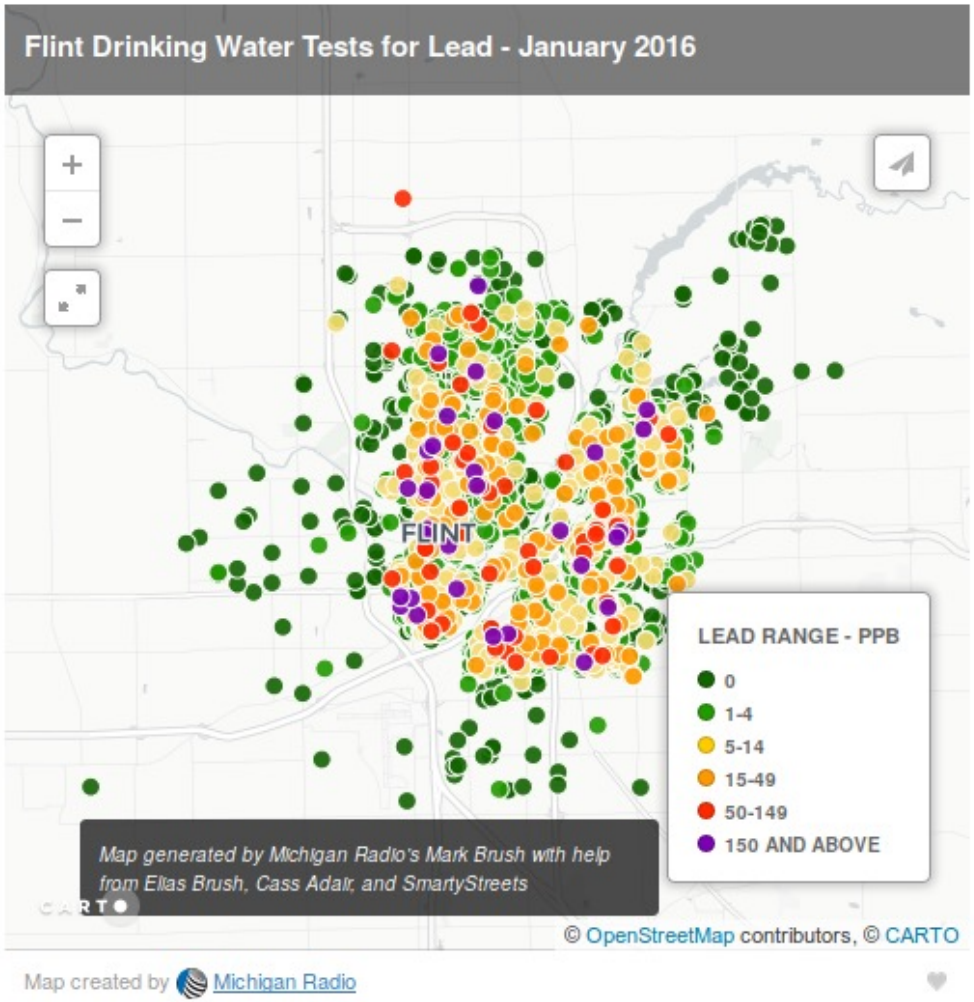
Example 3: Word cloud

Frequency of words of a document in novel visual presentation



Example 4: GIS map

Color scaled dots show the lead level in water in an area in Michigan



Lecture I: Data Visualization &Summary

- Datasets {x} – a set of N items x_i, i=1…N, each of which is a tuple

Proteins →

Cells ↓

Cell ID	CD45	CD3e	CD19	CD11b	Ki67
1	7.10543765	1.99490875	2.13073358	7.82894178	2.57289058
2	6.5957055	4.65342077	1.62918585	0.88137359	0.88137359
3	6.81991147	1.76259579	4.63429706	2.74452653	0.88137359
4	6.90112651	1.41502227	4.54593607	0.88137359	0.88137359
5	6.75571436	2.87597714	2.18671075	6.72464322	0.91192661
6	7.39538689	2.55285118	4.55845203	1.57273629	0.88137359
7	6.50181654	0.9030504	0.88137359	6.55459538	1.61883699
8	6.60986569	2.1753298	1.52779681	6.44086205	1.5347653
9	6.97651408	2.38246511	1.90249637	3.41580053	1.85303806
10	7.14397512	3.36924119	9.23325502	4.79035059	0.88137359

Each row is a tuple

Lecture I: Data Visualization &Summary

- Convention: columns are the ***features***; the number of features is ***dimension.***

Proteins →

Cells ↓

Cell ID	CD45	CD3e	CD19	CD11b	Ki67
1	7.10543765	1.99490875	2.13073358	7.82894178	2.57289058
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Each row is a tuple with dimension =5

Data types

- Categorical
- Ordinal
- Continuous

Data types

- Categorical

  Smoker or non-Smoker, Female or Male etc.

- Ordinal

  Satisfaction (Not satisfied, satisfied, very satisfied)

- Continuous (any real number within a range)

  Temperature

Q. Which of the following data is not categorical?

A. Number of enrolled students in a class
B. Weight of apples in a grocery store
C. Instruments played by an orchestra
D. Type of chemical reagents in a lab
E. A & B

Simple Visualization of Data

- General principles
- Bar chart
- Histogram
- Conditional histogram

Simple Visualization of Data

- General principles

  Must not mislead or distort;

  Aesthetically pleasing;

  Clear, Attractive, Convincing;

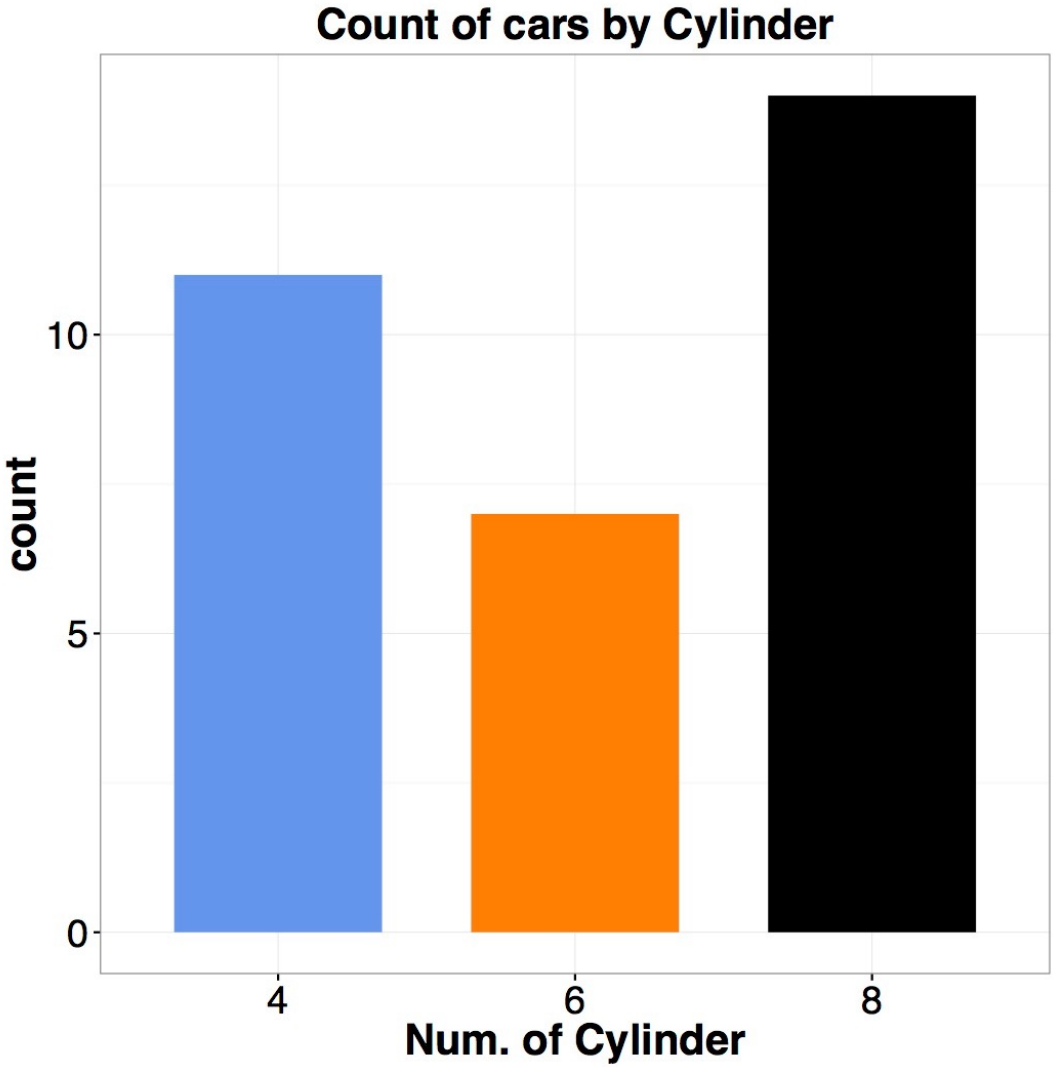
  Show message/significance.

Simple Visualization of Data

- Bar chart

A set of bars that are organized by categorical or ordinal feature

Data: “mtcars”



An example of good, ugly, bad, wrong

Dr. Wilke illustrated the difference between ***good***, ***ugly, bad and wrong visualization***

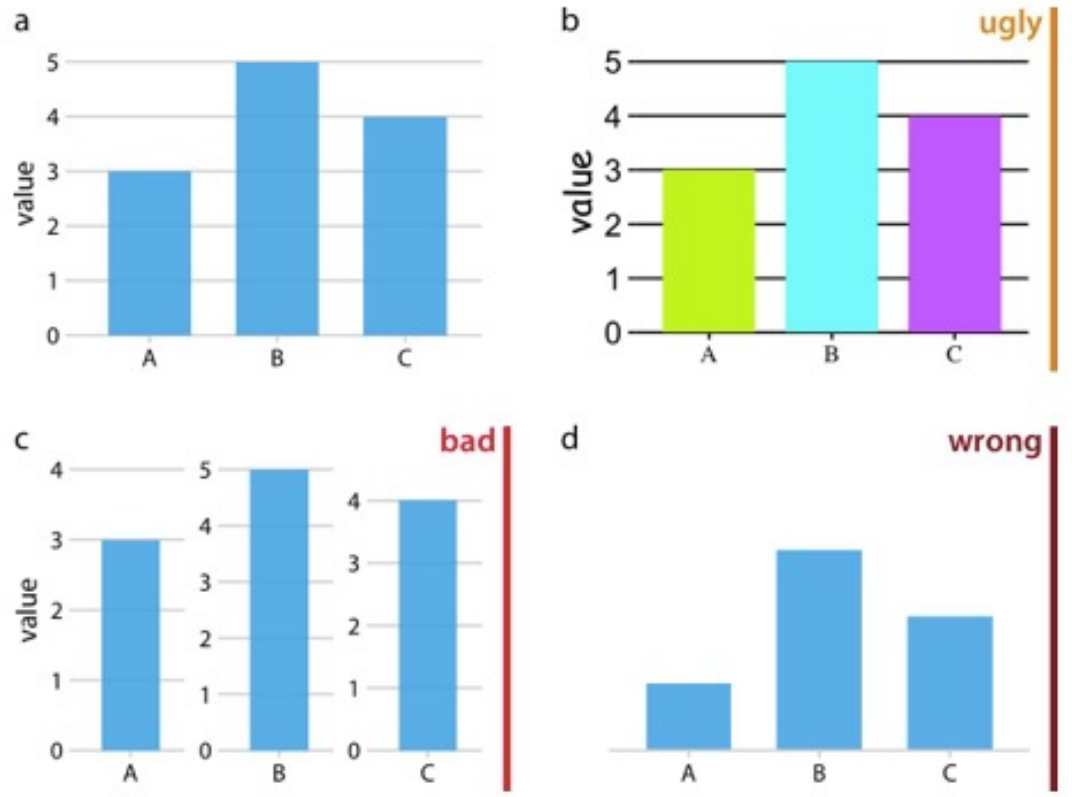


Figure 1-1. Examples of ugly, bad, and wrong

C. Wilke “Fundamentals of Data Visualization”

Assignments

- Finish the Orientation module on Canvas
- Submit HW0 to Gradescope to test it
- Start week1 module on Canvas
- Start discussion #1 on Python

Additional References

- Charles M. Grinstead and J. Laurie Snell "Introduction to Probability”
- Morris H. Degroot and Mark J. Schervish "Probability and Statistics”

See you next time

See you!