COGS 300 **control 04** ~~sep~~ oct 7/25

Before class: "Leaders of Tomorrow" song.

- Labs have been great! Very creative
- To continue the good work, time to address group conflict.

- Not just one person doing the work. If you are that person, back off. If you believe you "can't" time to learn. Po-mo's. Plagiarism.

- You are all volunteers. Define your purpose.

- Be sensitive culturally. Might be Arts vs. Sci, might be this or that language. Group unity comes before personality. You succeed only if your group succeeds.

- Respectful language and conduct. No sexual commentary, race jokes, etc. Plenty of places you can do that, not here, + actions. This is not the internet, your words have an impact. These ppl are colleagues for life.

- We will intervene. I've been on both sides and Univ. agrees.

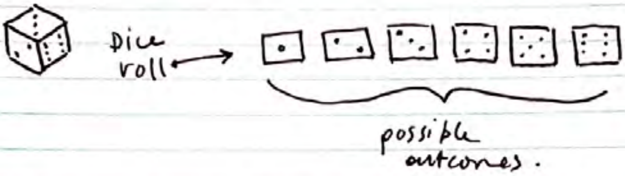
- CSJ will do a review of lab conduct. Jurisdiction: we have responsibility

- Class rep.

Probability

while it's "possible" to have a robot run without modeling probability, it's best to use it.

The core of probability is modeling possible outcomes of actions over sets.



only 7 can happen. $\frac{1}{6}$ event I care about
possible

dice comes up even? $\frac{3}{6}$

$$P(D = 2 \text{ or } D = 4 \text{ or } D = 6)$$

0 for dice.
↓

$$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$$

↑ chain: A or (B or C)

Analytical vs. experimental: ☆ ask

you can test this. The claim of the model is that the test will approximate at the limit.

↗
subtle but important!

analyze.
↓
Design a fair 1-die gambling game

- every player rolls the die once. per round
- win condition is once per round.
- Betting required!

Dice game brings up expected value.

Let's say we have a payout

$1 - 5 = \$1$ $\qquad P(D = 1-5) = \frac{5}{6} \times \$1$

$\$6 = \$5$ $\qquad P(D = 6) = 1/6. \times \$5$

$$\frac{\$5}{6} + \frac{\$5}{6} = \frac{\$10}{6} = \$1.\overline{66}$$

If it's \$1/game, you'll come out on top.

If it's \$2/game, the house comes out on top.

Robots use expected value all the time!

We need to find a way to quantify good/bad outcomes.

every action has a cost.

energy, time, money ...etc.

2 Dice: joint outcomes for independent events.

$\overbrace{\qquad\qquad\qquad}^{N=6}$ with weight

$N \times M$

	1	2	3	4	5	6
1	1,1	2,1	3,1	4,1	5,1	6,1
2	1,2	2,2	$\cdot$			
3	1,3	$\vdots$		$\ddots$		
4	1,4	$\cdot$				
5	1,5					
6	1,6					6,6

$M = 6$

If the dice are distinguishable (red + blue), each outcome is 1/36

If not (yellow + yellow) or it doesn't matter, it depends on counts.

$$\underset{P(A=1,\,B=6)}{\frac{1}{36}} + \underset{P(B=1,\,A=6)}{\frac{1}{36}} = \frac{2}{36} \leftarrow \cancel{p(A=1, B=6 \text{ or}} \; P([A=1, B=6] \text{ or } [A=6, B=1])$$

$$P(A \text{ and } B) = \underset{\uparrow\ 1/36}{P(A)} \times P(B) \leftarrow \text{independent}$$

$$\cancel{\text{[illegible]}} \quad P(\underset{\substack{\uparrow \\ \text{all cases} \\ \text{where} \\ A=1}}{A=1}, \underset{\substack{\uparrow \\ \text{all cases} \\ \text{where} \\ B=6.}}{B=6}) = \frac{6}{36} \overset{\times}{\cancel{*}} \frac{6}{36} = \frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$$

Application to your robot.

A-priori

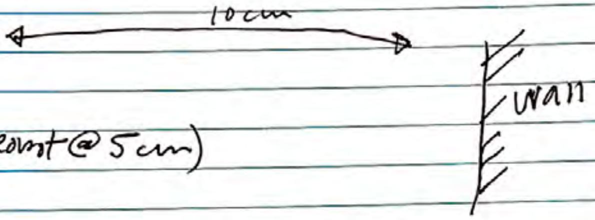
P(potentiometer = sensor = 123) ? ★ Ask.

1024 levels of sensitivity → 1/1024

20 holes

P(motor = 18°) ? 1/20 ★ Ask

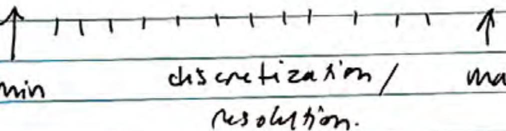
P(ultrasonic = 10 cm) ? ★ Ask.



P(Robot @ 5cm)

low res $\frac{1}{10}$

high res $\frac{1}{1000000}$



4. 6.

Robot between ~~4.5~~ cm and ~~5.5~~ cm

← better question.

Strict = 4.5 or 5.0 or 5.5 @ .5 cm res.

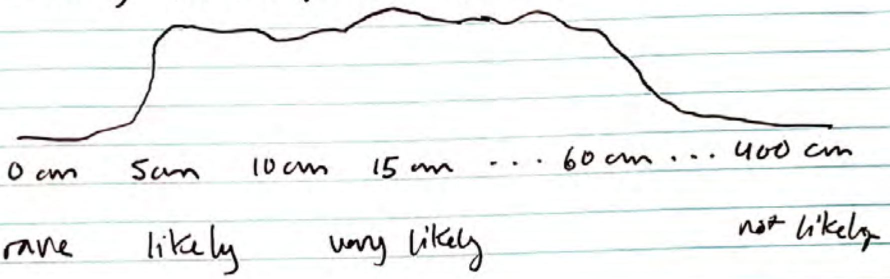
4.1, 4.2, 4.3, 4.4 ... 5.9 @ .1 cm

$\frac{3}{20}$ vs. $\frac{19}{100}$ ← close!

0.15 0.19

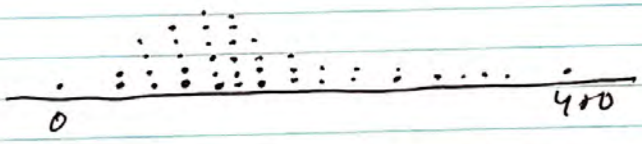
Weighted probabilities.

From experiment, you know that the real liklihood of a sensor isn't exactly what's given a priori. Eg:



histogram.

build up observations.



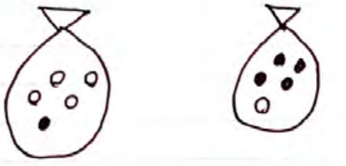
now it's just a lookup table:

$P(u=10cm)$?

$$\frac{u[10] = 5}{sum(u)} \quad \frac{\text{\# of obs. per item}}{\text{total \# of obs.}}$$

conditional probabilities.

$$P(A \mid B) = \frac{P(A \text{ and } B)}{P(B)}, \quad P(B) \neq 0$$



$P(\text{marble} = \text{Black}) = 1/2$

... if you dump them out.

$$P(m = \text{Black} \mid \text{Bag} = 1) = \frac{1}{5}$$

$$P(m = \text{Black} \mid \text{Bag} = 2) = \frac{4}{5}$$

$$P(A \text{ and } B) = P(A) \times P(B \mid A)$$ dependent events.

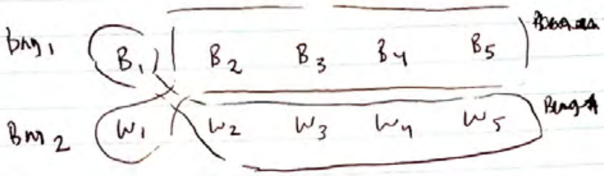
$P(\text{Bag} = 1 \mid m = \text{Black})$?

↳ next time. preview →

$$P(M = B_1) = \frac{1}{10}$$

$$P(M = B) = P(m = B_1 \text{ or} \ldots B_n)$$

$$= \frac{5}{10}$$



$$P(Bag = Bag\ 1) = \frac{1}{2}$$

$$P(M = B) = 5/10 = 1/2$$

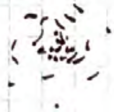
$$P(Bag = 1) = 1/2$$

$$P(Bag = 1 \mid m = B) = \frac{1}{5}$$

COGS 300 **Control 04** Oct 2/25

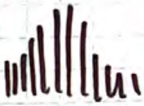
Warm up: Draw something "random" Then something less "random". What's the difference?

Random



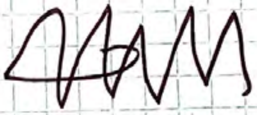
less

random

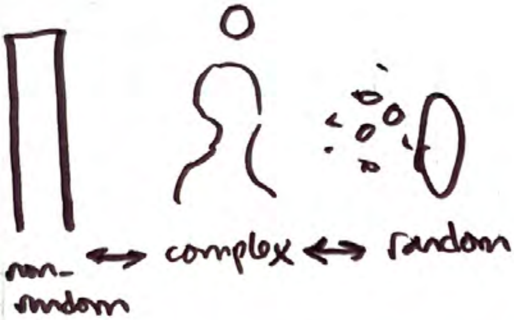


less

random



less.



$$\frac{1}{6} = \frac{\text{\# of outcomes you care about}}{\text{\# of possible outcomes}}$$

$$p(\text{even}) \qquad \frac{1}{2} = \frac{3}{6}$$

$$P(A \text{ or } B) = \underline{\underline{P(A) + P(B)}} - P(A \text{ and } B)$$

↑

analytical

experimental

1. Gamble 2. Fair 3. 1 round

Expected Value

$1 - 5 = \$1$ $\quad p(d = 1\text{-}5) = \frac{5}{6} \times \$1$

$6 = \$5$ $\quad p(d = 6) = \frac{1}{6} \times \$5$

$$\frac{\$5}{6} + \frac{\$5}{6} = \frac{\$10}{6} = \$1.\overline{66}$$

Joint out com come for independent events.

	1	2	3	4	5	6	yellow
1	1,1	2,1	3,1	···		6,1	
2	1,2	2,2	···			6,2	
3							
4							
5							
6	1,6					6,6	
orange							

$6 \times 6 = 36$

$p(y=1, o=6)$

$P(A \text{ and } B) = P(A) \times P(B)$

$$P(\cancel{A}\ A = Y = 1, B = O = 6) = \frac{6}{36} \times \frac{6}{36}$$

$$= 1/36$$

W, W $\frac{1}{4}$ $Bet

L, L $\frac{1}{4}$ 4 −$Bet

W, L } $\frac{2}{4}$ $0

L, W $0

P(pot. = 123) $\frac{1}{1024}$

analogRead(pot)

←1024→

0—1023

P(pot = 120−150) $\frac{31}{1024}$

p(motor = 18°)

$\frac{1}{360}$

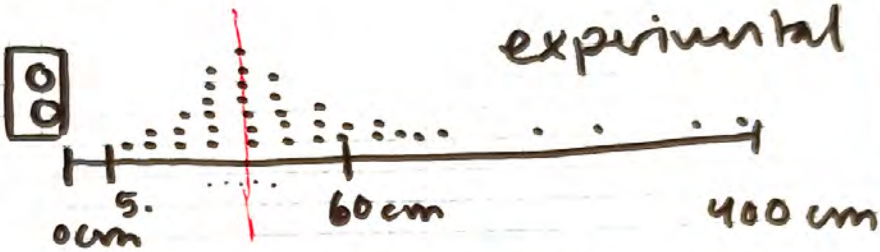
$\frac{1}{20}$

$\boxed{15^\circ}$

p(ultrasonic = 10cm)?

P(ultrasonic = 10cm)? Histogram

experimental



Appox.

$1/1024$

— normal dist

— "bell curve"

— gaussian

arr[400]

1 cm

0	1	2	3	~~4~~	5	. . . . →	39
0	0	0	0	6	10		1

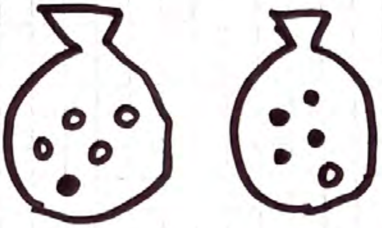
P(u = 25-30)

arr[24] + arr[25]...

... arr[29]

conditional probability

$$P(A|B) = \frac{P(A \text{ and } B)}{P(B)}, \quad P(B) \neq 0$$



$P(m=w) = 1/5$

$P(m=w)$
$=$
$4/5$