CS 107, Probability, Spring 2020
Lecture 01

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AUA

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Welcome to the 2020 AUA Probability Course!

Happy New Year and Semester ☺

Content

- Syllabus Highlights
- Intro to Probability

What is Randomness? Does it exist? How to define it?

Example: Is the following sequence of numbers Random:

$$1,\ 4,\ 1,\ 5,\ 9,\ 2,\ 6,\ 5,\ 3,\ 5,\ 9,\ \ldots\ ?$$

Answer: Well, that depends on how these numbers are obtained, how the sequence is built. In fact, I took the consecutive digits of

$$\pi = 3,14159265359\ldots$$

Idea: A string of bits is Random iff it cannot be produced by a computer program shorter than that string itself, i.e., if it is uncompressible.

Example: The string $0,1,0,1,0,1,0,1,\ldots.$ can be described easily, because the alternating 0-1 pattern exists. But think of the result of a coin toss (write 0 for Tails and 1 for Heads): we need to specify all terms one by one, because no pattern exists.

Syllabus Highlights

- Course name: **CS 107, Probability, Section A**
- No. of Credits: **3**
- Instructor: **MP**
- Instructor's Office: $\#336$**W, PAB**
- Instructor's OH: Wed, 11:30 - 13:30
- Teaching Associate: **Gayane Tonoyan**
- PSS day/time: **TBD**
- TA's OH: **TBD**
- Supplementary: Do we need a Slack Channel for our course?

Course Materials

- Moodle Page: yeah, we have a one
- Moodle Enrollment Key: **RTLProb**
- Syllabus: uploaded to our Moodle page
- Textbooks: uploaded to our Moodle page
- Software: **R** and **R Studio** (freeware)
- Software 2: Maybe we can use Python ?

Syllabus Highlights, Cont'd

- Exams: **2 Midterms** and a **Final Exam**
- Homework: **(almost) weekly**, due on **Fridays**
- Quizzes: Yeah, we will have them! At most once a week.
- Q and HW: The lowest Quiz grade will be dropped. No HW grade will be dropped.
- Final Grade Formula:

$$Total = 0.1 \cdot (HW + Q) + 0.2 \cdot (M1 + M2) + 0.4 \cdot F$$

- **No Makeups for Quizzes**! Sorry!
- No late HWs (except in some veeery special cases)
- No Grades Curving. ☹
- Advice: Always ask your questions, attend OHs, solve HW by yourself!

QA Session

Questions?

Your expectations?

Course Topics at a glance

- Random Experiments, Events, Probability Axioms and Properties
- Basic Probability Models
- Conditional Probability and Independence
- Repeated Trials Models
- Random Variables (RVs), their Characteristics
- Important Discrete and Continuous RVs
- Random Vectors (Jointly Distributed RVs)
- Partial Numerical Characteristics of RVs
- Limit Theorems
- Conditional Distributions
- Markov Chains

Intro to Probability

Q: What is Probability (theory)?
A: It is a Mathematical Theory to model the uncertainty. We will consider *Experiments* with more than one outcomes. The uncertainty can be because:

- the Experiment is not performed yet, it will be performed in the future;
- the Experiment is already done, but we do not know the result, outcome.

Example: What is the Probability that the closing price of 1 Apple Stock tomorrow will be greater than 320$?
Example: What is the Probability that there is a life in our Universe, besides our planet?
Note: Even the outcome of the Experiment is not known, still we want to (and usually, we can) get some information, assess some Probabilities.

Intro to Probability

Q: Why we need to study the Probability (theory)?

A: Because of its use in different aspects of life and science:

- in Statistics
- in Medicine and Biology
- in Insurance
- in Finance
- in Data Science and Machine Learning
- in Computer Science
- in Physics
- as a core course in our Curriculum ☺

Intro to Probability

Q: What are doing Probabilists most of the time?
A: They are

- Tossing a coin;
- Tossing a coin several times (or tossing several coins at once);
- Rolling a die (or dice);
- Picking a ball at random from a box with different colored balls;
- Picking a playing card from a deck of cards;
- Sometimes throwing a Darts missile;
- rarely proving Theorems or giving Lectures ◡̈

Note: Important is that many random phenomena can be modeled by these simple models.

Examples

Example: When we talk that the probability is 55% that

- the first child will be a boy;
- the customer will prefer "Ashtarak Kat" to "Geghi Matsoon";
- the person is a smoker;
- the patient will develop some illness;
- the candidate A will be elected;
- your favorite team will win the next game;
- you will not fail the course,

then these can be "modeled" as

- we are tossing a coin, and the probability of Heads is 55%.

Examples

Example: If we solve problems like this:

- A family has 3 children. The Probability of having a boy child is 0.55. What is the Probability that the family has exactly 2 boys?
- 3 customers are entering a market. The Probability that a customer will buy something is 0.55. What is the Probability that exactly 2 customers will buy something?
- 3 CS students are chosen randomly. The Probability that a CS student knows the MVT is 0.55. What is the Probability that exactly 2 students from that 3 know MVT?

Then we can think about the following model problem:

- We are tossing a coin 3 times. The Probability of a coin to land on Heads is 0.55. What is the Probability that we will have exactly 2 Heads in that 3 tosses?

Supplement: R Code

This code is to simulate coin tossing and die rolling Experiments:

```
#creating a vector (array)
x <- c(1,3,4) #in R, we use "<-" instead of "=" usually
x = c(1,3,4) #the same thing as above

#Simulating one Fair Coin Toss
coin <- c(0,1) #coin a vector with coordinates 0 and 1
sample(coin, 1)

#Tossing a Fair Coin 10 times
sample(coin, size = 10, replace = TRUE)

#Tossing a Biasaed Coin 10 times
sample(coin, size = 10, replace = TRUE, prob = c(0.1, 0.9))

#Rolling a Fair Die 3 times
die <- 1:6 #the same as die <- c(1,2,3,4,5,6)
result <- sample(die, 3, replace = TRUE)
result
```

Supplement: Python Code

This code is to simulate coin tossing and die rolling Experiments:

```
#Importing necessary libraries
import numpy as np #numpy is for working with numerical arrays

#Creating a vector (array)
x  = np.array([1,3,4])  #as above defined, np stands for numpy
x #the same as print(x)

#Tossing a fair coin 10 times
coin = np.arange(2) #np.arange(2) is an object like np.array([0,1])
np.random.choice(coin, size = 10, replace = True)

#Tossing a biased coin 10 times
np.random.choice(coin, size = 10, replace = True, p = np.array([0.1,0.9]))

#Rolling a fair die 3 times
die = np.array([1,2,3,4,5,6]) # or die = np.arange(1,7)
result = np.random.choice(die, size = 3, replace = True)
result
```