INTRO TO PROBABILITY

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CMSC 671

By the end of class today, you will be able to:

- Internalize the core aspects & vocabulary of probability
- Distinguish between conditional and joint distributions
- Consider when you would use probability in AI

Modified from slides by Dr. Chris Callison-Burch

COURSE SCHEDULE

- HW 3 is due 11/14
- All project milestones are released (see website)
  - First milestone due 11/16
- Module 4 Presentations are 11/16
  - Summaries due 11/15

FINAL PROJECT TEAMS

- Figure out what you want to work on
- Come up with cute team names (if you want)
- Project Milestone 1: Project Proposal is due **11/16**
  - Includes:
    1. Meeting with me or Aydin
    2. Writing a proposal

Name	Team Name	Topic Preference
Aja, Richard	1	search,logic,planning,rl,bayes,probability,NN,transformer
Breitmeyer, Max	1	NN,transformer,rl,logic,probability,planning,bayes,search
May, An	1	bayes,probability,transformer,NN,rl,logic,search,planning
Rubinstein, Jacob Spencer	1	search,logic,planning,rl,bayes,probability,NN,transformer
Anand, Aaditya	2	transformer,NN,probability,bayes,rl,planning,logic,search
Konagalla, Ashish Gupta	2	
Kumar, Akshay	2	search,logic,planning,rl,bayes,probability,NN,transformer
Patel, Neel R	2	
Choudhury, Shadab Hafiz	3	logic,probability,bayes,NN,transformer,planning,search,rl
Gopal, Bharath	3	probability,search,rl,transformer,NN,planning,bayes,logic
Hossain, Shahin	3	transformer,NN,probability,bayes,rl,planning,logic,search
Bollineni, Prerana	4	
Honraopatil, Arya M	4	
Poyekar, Bhargavi	4	
Vidam, Mukesh Kumar	4	
Bansal, Apoorv	5	logic,rl,bayes,probability,NN,transformer,search,planning
Jagabathina, Lakshmi Vivek	5	rl,search,planning,logic,bayes,probability,NN,transformer
Sharma, Saksham Kumar	5	probability,search,logic,planning,rl,bayes,NN,transformer
Athimamula, Ashish	6	
Changal, Mahesh Reddy	6	probability,NN,transformer,search,logic,planning,rl,bayes
Changal, Ramesh	6	
Pendem, Saieesh	6	
Samudrala, Hanuma Sashank	6	
Bhande, Siddhesh Laxman	7	search,logic,planning,rl,bayes,probability,NN,transformer
Muthunooru, Aksheetha	7	transformer,NN,probability,bayes,rl,planning,logic,search
Oruganti, Seetaram	7	NN,probability,bayes,rl,planning,logic,search,transformer
Shah, Pratvi Dhananjay	7	search,logic,planning,rl,bayes,probability,NN,transformer
Abili, Chris	8	
Kadasani, Dayakar Reddy	8	logic,transformer,bayes,rl,probability,planning,NN,search
Kochar, Pravar Aditya	8	planning,bayes,probability,search,logic,rl,transformer,NN
Young, Jo	8	search,logic,planning,rl,bayes,probability,NN,transformer
Sivakumar, Naren	9	transformer,NN,rl,probability,bayes,search,planning,logic
Ugwuabonyi, Emmanuel Chinonyelu	9	search,NN,transformer,probability,bayes,logic,planning,rl
bray, Shawn	9	NN,transformer,search,rl,probability,logic,planning,bayes

BIGGER PICTURE

THE COURSE SO FAR

- Module 0: Introduction to AI & Agents → building basic vocabulary, intro to agent paradigm
- Module 1: Search → Reaching a goal by "exploring" & using task-specific information (heuristics)
- Module 2: Logical Agents → Reaching a goal by "reasoning"
  - Planning is search with logic
- Module 3: Sequential Decision Making → Reaching a goal by "learning" the environment
- Module 4: Probability & Stochastic Reasoning → Reaching a goal by modeling it with probability from data
- Module 5: Machine Learning → Reaching a goal by modeling it from learning patterns in data

PROBABILITY

How comfortable are you with probability?

Consider the probability P(X). A distribution is...

SIMILARITIES TO LOGIC

Like logical assertions, probabilities are about **possible worlds**. Instead of strictly ruling out possibilities (where a logical assertion is false), probabilities quantify how likely a particular possible world is.

In probability theory, the possible worlds are called the **sample space**.

REASONING UNDER UNCERTAINTY

- **Observed variables (evidence):** Agent knows certain things about the state of the world (e.g., sensor readings or symptoms)
- **Unobserved variables (states):** Agent needs to reason about other aspects they can't sense (e.g. where an object is or what disease is present)
- **Model:** Agent knows something about how the known/observed variables relate to the unknown/unobserved variables

RANDOM VARIABLES

- Capture some aspect of the world we might have uncertainty about
- Notation: capital letter
- E.g., R = Is it raining?

  U = Is Dr. Martin carrying an umbrella?
- Unobserved random variables refer to a distribution

DISTRIBUTIONS

- A distribution is an exhaustive list of all possible values a random variable can contain AND how likely each is
- Any value listed must be possible i.e., have a probability ≥ 0

$P(W)$

W	Probability
Rain	0.3
Fog	0.1
Sun	0.6

$P(U)$

U	Probability
Umbrella	0.2
No Umbrella	0.8

Notice that these sum to 1!

$$\sum_{u} P(U=u) = 1$$

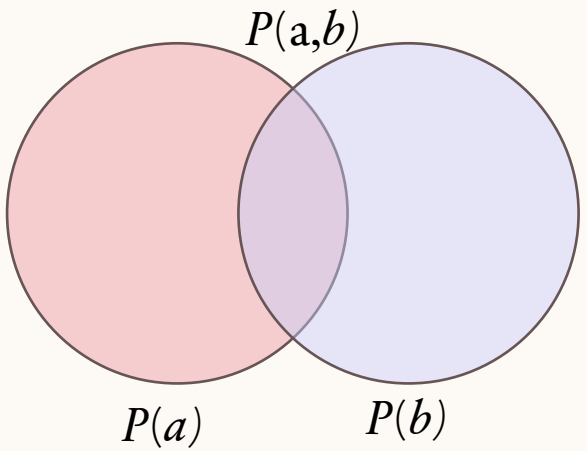
JOINT DISTRIBUTIONS

- A joint distribution over a set of random variables $X_1, X_2, \ldots X_n$ is a distribution where both values would be true

$$P(X_1 = x_1, X_2 = x_2, \ldots X_n = x_n)$$

or

$$P(x_1, x_2, \ldots x_n)$$



Where $P(x_1, x_2, \ldots x_n) \geq 0$ and $\sum_{x_1, x_2, \ldots x_n} P(x_1, x_2, \ldots x_n) = 1$

JOINT DISTRIBUTIONS

$$P(W,U)$$

W	U	Probability
Rain	Umbrella	0.3
Rain	No Umbrella	0.2
Sun	Umbrella	0.1
Sun	No Umbrella	0.4

CONDITIONAL DISTRIBUTIONS

- A conditional distribution is a distribution where a probability is being calculated *given* some other fixed values

$$P(U \mid W = rain)$$

W	U	Probability
Rain	Umbrella	0.8
Rain	No Umbrella	0.2

CLASS DISCUSSION

- What types of agents use probability?
- Can you think of any AI that uses probability?
- When would you *not* want to use probability?