M-Lab CARTE AI Workshop 2025

AI Landscape Overview

https://2025.mlab.carte.training/

About me

- Alex Olson
- Centre for Analytics & AI Engineering (CARTE)
- 11 years in Artificial Intelligence, with a particular focus on applications

Myhal Centre for Engineering Innovation & Entrepreneurship

Your learning support

- Nakul Upadhya
- Deep Learning and Optimization: Interpretable Sequence Models
- Previously Industrial Engineering + Computer Science at Perdue University
- Academic interests include Optimization and its interactions with Machine Learning.

- Rahul Patel
- Stochastic and Multi-objective optimization problems using Machine Learning
- Previously Industrial Engineering at Polytechnique Montreal and Mila
- Studied under Yoshua Bengio – Nobel prizewinner and godfather of AI

Workshop aims

- Build practical AI understanding
- Learn how to evaluate AI technologies and startup proposals
- Get hands-on with modern tools and workflows
- Learn how to stay on top of new developments

Journey map

AI Foundation & Data Mastery

- Landscape Overview
- Exploratory Data Analysis
- Neural Networks & Optimization
- Advanced Data Processing

Generative AI

- Large Language Models
- Visual Workflow Building
- Multimodal AI
- Multimodal Content Creation

Technology Evaluation & Robotics

- Technology Evaluation & Investment
- Advanced Agents
- Robotics & AI

Agentic AI

- Agentic Systems Architecture
- AI Safety & Ethics
- Multi-Agent Orchestration
- 90-Day Implementation Roadmap

Questions & Interactivity

- Questions are highly encouraged throughout
- You can ask questions as they come to you, or wait to the end
- We encourage cross-collaboration on work
- Talk to people you may have not met before!

AI Terminology & Definitions

What is an example of AI?

More examples of AI

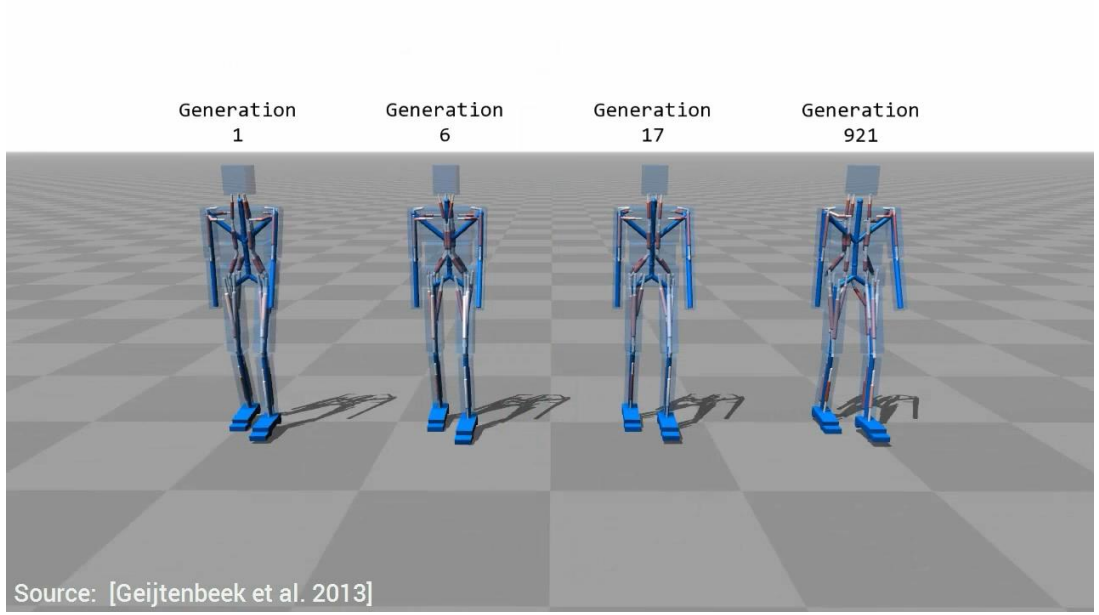
- Spam filters
- Netflix recommendations
- Google Maps directions
- Credit card fraud detection
- You likely rely on many of these daily without thinking ”I’m using AI”
- AI has been embedded in tools for years

So what is AI?

- No one universally agreed answer
- A system is artificially intelligent if it performs a task we normally associate with intelligence
  - As we associate more tasks with AI, we stop thinking of them as requiring intelligence!
- Turing Test: Can a computer fool you into thinking it's a person through conversation?
  - Used to be the most popular test for AI capability
  - Now there are a million tools that can beat this

Machine Learning

- Machine Learning is a technique to develop AI
- Instead of telling a system how to perform a task, we give it examples
- Over time, the system refines its own rules, and improves its performance
- This requires:
  - Enough examples
  - Enough time
  - A system that has enough capability!



Digital Creatures Learn To Walk | Two Minute Papers #8

Deep Learning

- Deep Learning is Machine Learning applied to neural networks
- Modern neural networks are far too complex to develop by hand
- A significant part of the field works to improve techniques for neural networks to improve their performance
- Neural networks are so successful that they have become synonymous with both AI and Machine Learning
  - But other kinds of AI and Machine Learning do exist!

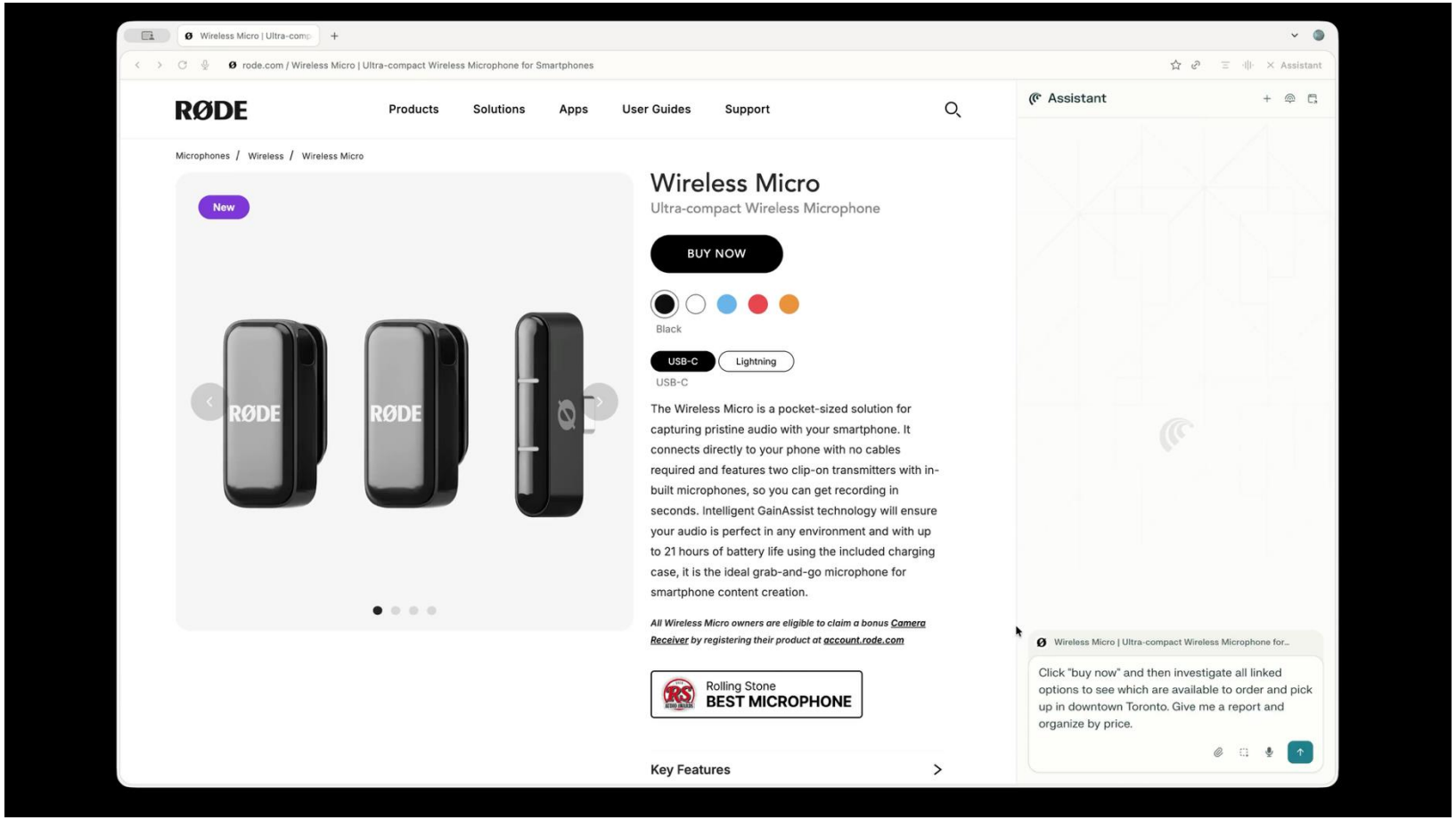
Generative AI

- Refers specifically to models that produce “new” content in response to a description (or *prompt*)
- Models learn underlying patterns in the type of data they specialize in: text, image, sound
- Cannot create anything *truly* new as they learn to replicate what they have been shown already

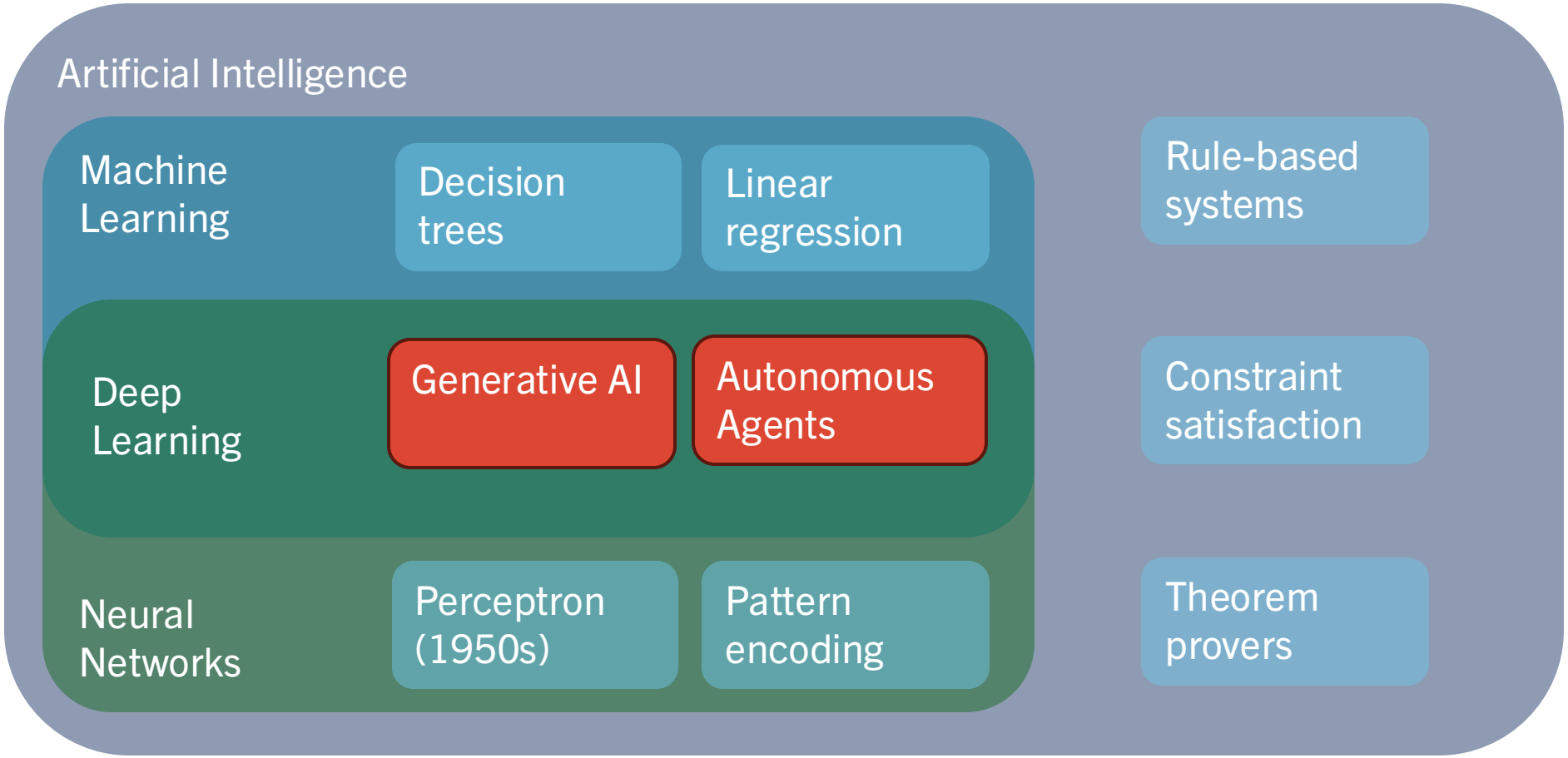
Autonomous Agents

- AI systems that can take actions toward a goal, not just recommend them
- They plan, use tools, make decisions and adjust based on results
- Agents can break down complex tasks and execute multi-step workflows independently
- This is a key frontier of AI right now!

Autonomous Agent Example - Comet



Putting it all together



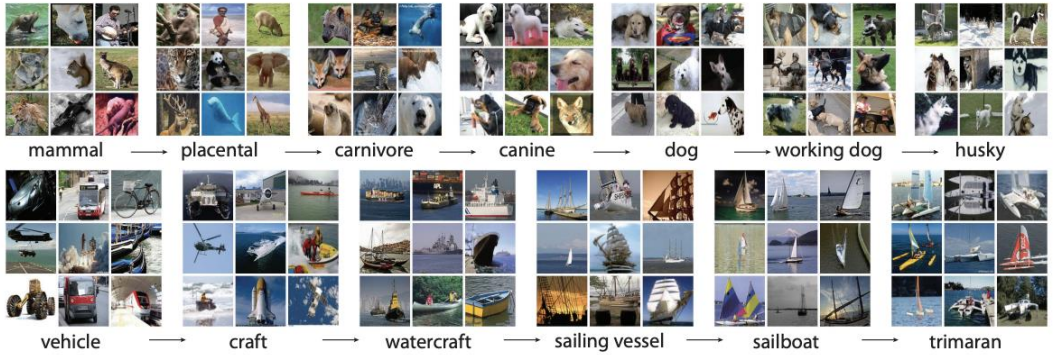
How did we get here?

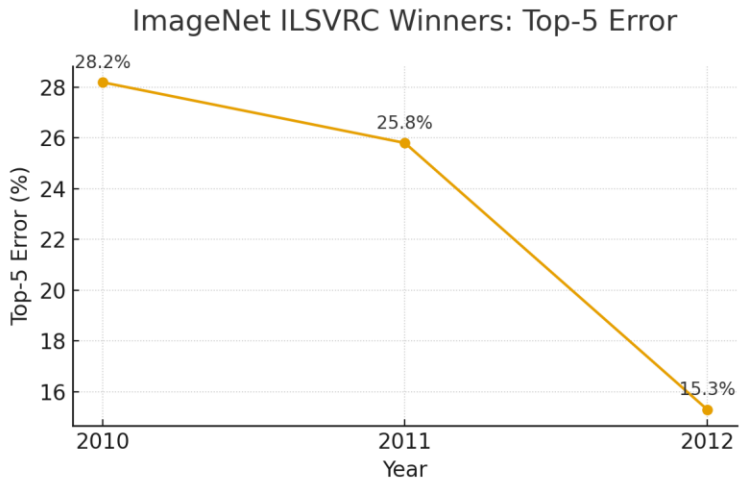
AI springs and winters

- AI research has gone through multiple boom and bust cycles since the 1950s
  - “AI Spring”: Excitement, funding, bold promises about what’s possible
  - “AI Winter”: Disappointment when promises don’t materialize, funding dries up
- Major winters: mid-1970s, late 1980s–early 1990s
- Each time, the hype outpaced what the technology could deliver
- Key problem: not enough data, not enough computing power, techniques didn't scale
- By the 2000s, many researchers avoided even calling their work "AI"
- Then everything changed...

The deep learning breakthrough

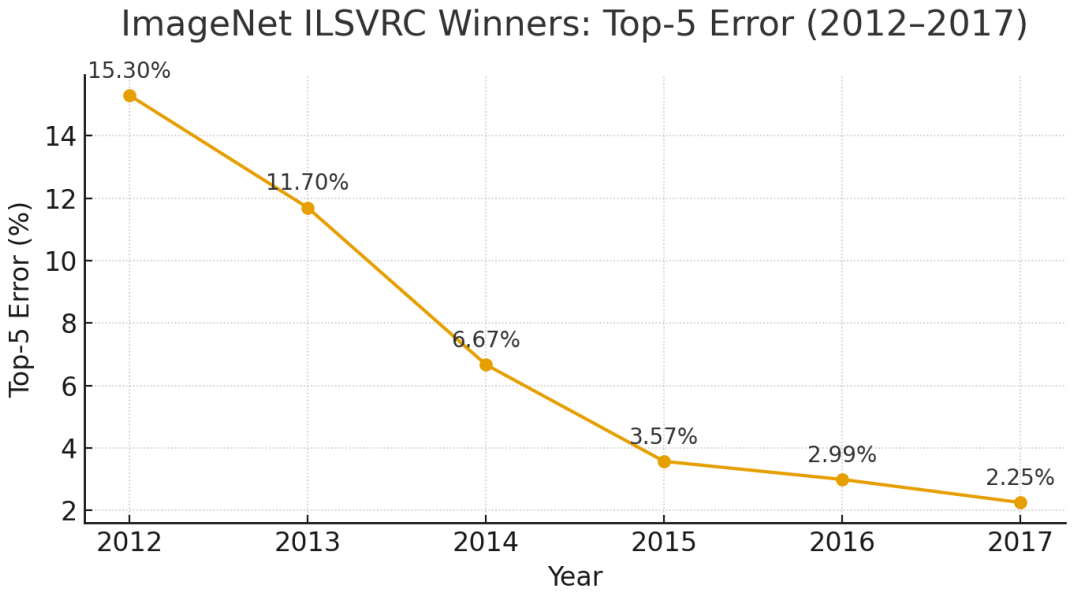
- 2012: University of Toronto team wins the ImageNet competition with a deep neural network
- First time deep learning dramatically outperformed traditional methods on a major benchmark
- GPUs for parallel processing
- This moment convinced the world that deep learning actually worked at scale





GPU acceleration & big data

- Neural Networks require massive amounts of computation
  - Millions or billions of calculations
- CPUs process instructions sequentially
  - Too slow for training large networks!
- Graphics Processing Units were originally designed for computer graphics, but turn out to be perfect for neural networks
- At the same time, the internet gave us unprecedented amounts of data
- ImageNet: 14 million labeled images. Before this, datasets had thousands



The transformer revolution

- 2017: Google researchers publish "Attention is All You Need"
- Introduced the transformer architecture: a new way to process sequences like text
- Key innovation: attention mechanism lets the model focus on relevant parts of the input
- Transformers process all words at once, understanding relationships between any words regardless of distance
- Much faster to train, scales better with more data and compute
- This architecture is the foundation for everything that came next

The ChatGPT moment

- November 2022: OpenAI releases ChatGPT to the public
- Reached 1 million users in 5 days
  - Fastest product adoption in history
- First time most people directly interacted with powerful AI
- Not the most advanced model at the time, but the most accessible
- Simple chat interface made AI feel conversational and useful, not academic
- Sparked massive investment and competition: Google, Microsoft, Meta, Anthropic all racing to catch up

Where we are today

- Major players:
  - OpenAI (ChatGPT)
  - Anthropic (Claude)
  - Google (Gemini)
  - Meta (Llama)
  - Microsoft (Copilot)
- Open-source models are catching up fast
- Competition is fierce

Current frontiers

- Multimodal AI: handling text, images, video, audio together
- Reasoning models: systems that can "think" through complex problems step-by-step
- Agentic AI: systems that use tools, plan, and execute multi-step tasks autonomously
- Longer context: models that can work with entire books or codebases at once
- AI safety: making these systems reliable, aligned, and secure

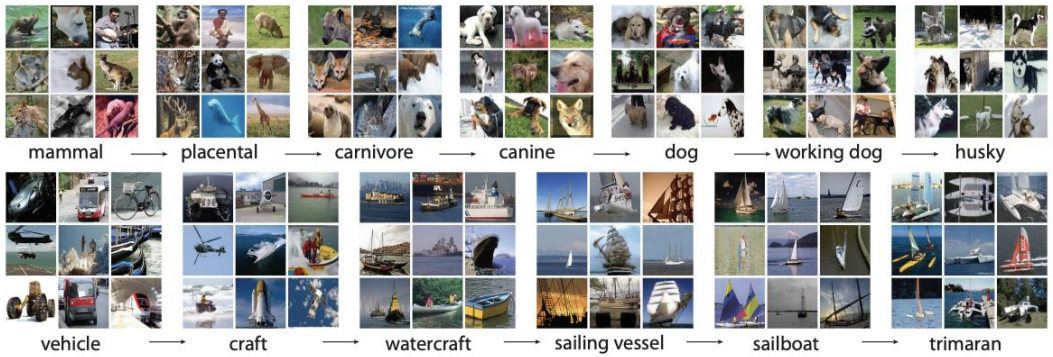
ML101: The Fundamentals

Types of data

- Real vs Symbolic
  - Whether data is directly comparable (like temperatures, or prices); or it requires deeper understanding (like words, or product categories)
- Structured vs Unstructured
  - Whether data is organized in rows and columns with clear labels (like spreadsheets); or has no predefined format and needs preprocessing (like text documents, images, audio)

Prediction Tasks: Classification

- **Classification** models predict which category an input belongs to
- ImageNet is used for image classification tasks
- Other examples include product tagging, medical diagnoses and fraud detection



Prediction Tasks: Regression

- **Regression** models predict a real value based on input
- GPT is a regression model: it predicts the probability that a word might come next in the sentence
- Regression models can also predict stock prices, weather, or sports results

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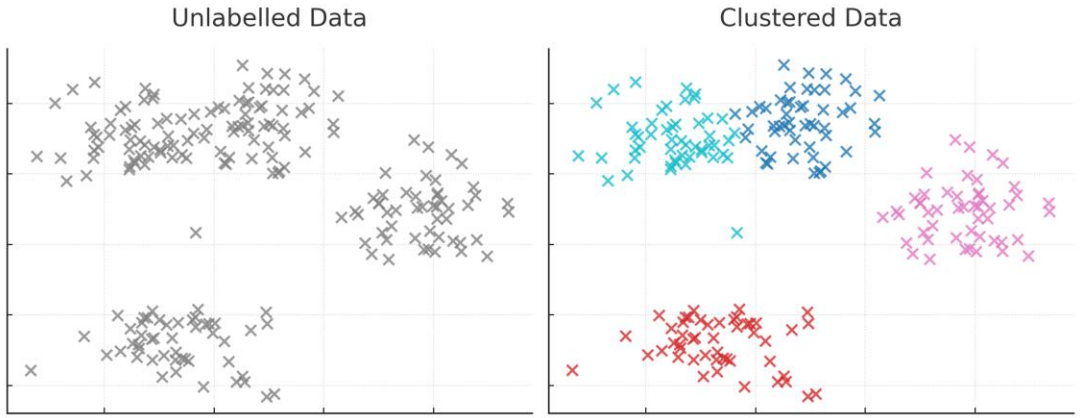
Prediction

#	probs	next token ID	predicted next token
0	22.93% …	10211	mouse
1	17.36% …	3290	dog
2	2.94%	6842	bear
3	2.26%	22746	rabbit
4	1.79%	3797	cat
5	1.21%	5935	egg
6	1.15%	4227	rat
7	1.14%	26241	tiger
8	1.00%	21657	monkey
9	0.84%	21831	fox

Prediction Tasks: Clustering

- **Clustering** models group together input examples by identifying underlying patterns
- **Unlike** classification and regression models, there is no set answer of how to cluster some group of data



Prediction Tasks: Generation

- **Generation** models create new content based on patterns learned from training data
- Unlike classification or clustering, the output is an entirely new piece of data, not a label or group
- As we said, generation is a type of **regression** task
  - The model predicts the likelihood of what could come next

From prediction to action

- So far we've talked about AI systems that make predictions
  - What category, what number, what word comes next
- **Agents** combine prediction with action
- Example:
  - Predicting "the user wants to schedule a meeting" is classification
  - Actually checking calendars, finding times, and sending invites is *agentic*
- Agents use tools (search engines, calculators, databases, APIs) to accomplish goals

Multi-agent systems & tool protocols

- Agents can work together
  - Multi-agent systems where specialized agents collaborate on complex tasks
- Example: one agent researches, another writes, another fact-checks
- New protocols like MCP (Model Context Protocol) are standardizing how agents connect to tools and data sources
- Makes it easier to build reliable agent workflows that can access your company's systems

Workshop Format

Structure

- Alternating lectures with interactive sessions
- One lecture and one session in morning; same in afternoon
- Day 3: half-day robotics session
- Breaks between each component

Today's path

- Today is the only day we will work directly with code
- This is to give you a comprehensive overview
- Next: Lab 1, in Google Colab

Questions?