Demystifying

Generative Artificial Intelligence

WORKSHOP DETAILS

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- COURSE MATERIALS: GITHUB LINK - DATA-SCIENCE-WORKSHOP---SPRING-2025---NBL-
- WORKSHOP RECORDINGS: LIBGUIDES

WORKSHOPS SCHEDULE

Introduction to Python Programming	February 3, 2025; 2 - 3:30 PM
Mastering Data Analysis: Pandas and Numpy	February 10, 2025; 2 - 3:30 PM
Introduction to Tableau: Visualizing Data Made Easy	February 17, 2025; 2 - 3:30 PM
Introduction to Machine Learning: Supervised Learning	February 24, 2025; 2 - 3:30 PM
Introduction to Machine Learning: Unsupervised Learning	March 3, 2025; 2 - 3:30 PM
Data-Driven Decision Making: A/B Testing and Statistical Hypothesis Testing	March 10, 2025; 2 - 3:30 PM
Demystifying Generative AI	March 24, 2025; 2 - 3:30 PM
Large Language Models: From Theory to Implementation	March 31, 2025; 2 - 3:30 PM
Generative AI Applications with AI Agents	April 7, 2025; 2 - 3:30 PM
Building Intelligent Recommendation Systems	April 14, 2025; 2 - 3:30 PM

https://libcal.rutgers.edu/calendar/nblworkshops?cid=4537&t=d&d=0000-00-00&cal=4537&inc=0

WORKSHOP AGENDA

- INTRODUCTION TO GENERATIVE AI
- GENERATIVE AI APPLICATIONS
- EVOLUTION OF GENERATIVE AI
- HOW GENERATIVE AI WORKS
- RISKS, MYTHS & CHALLENGES OF GENERATIVE AI
- LIMITATIONS: WHAT GENERATIVE AI CAN’T DO (YET)
- THE FUTURE OF GENERATIVE AI
- PRACTICAL SESSION

Have you ever used a chatbot, seen a cool AI-made picture, or heard an AI song? That's Generative AI at work!

Generative AI is a type of artificial intelligence that can create new things—like text, images, music, or even ideas—by learning from examples. Unlike traditional AI which often detects or classifies, generative AI "creates".

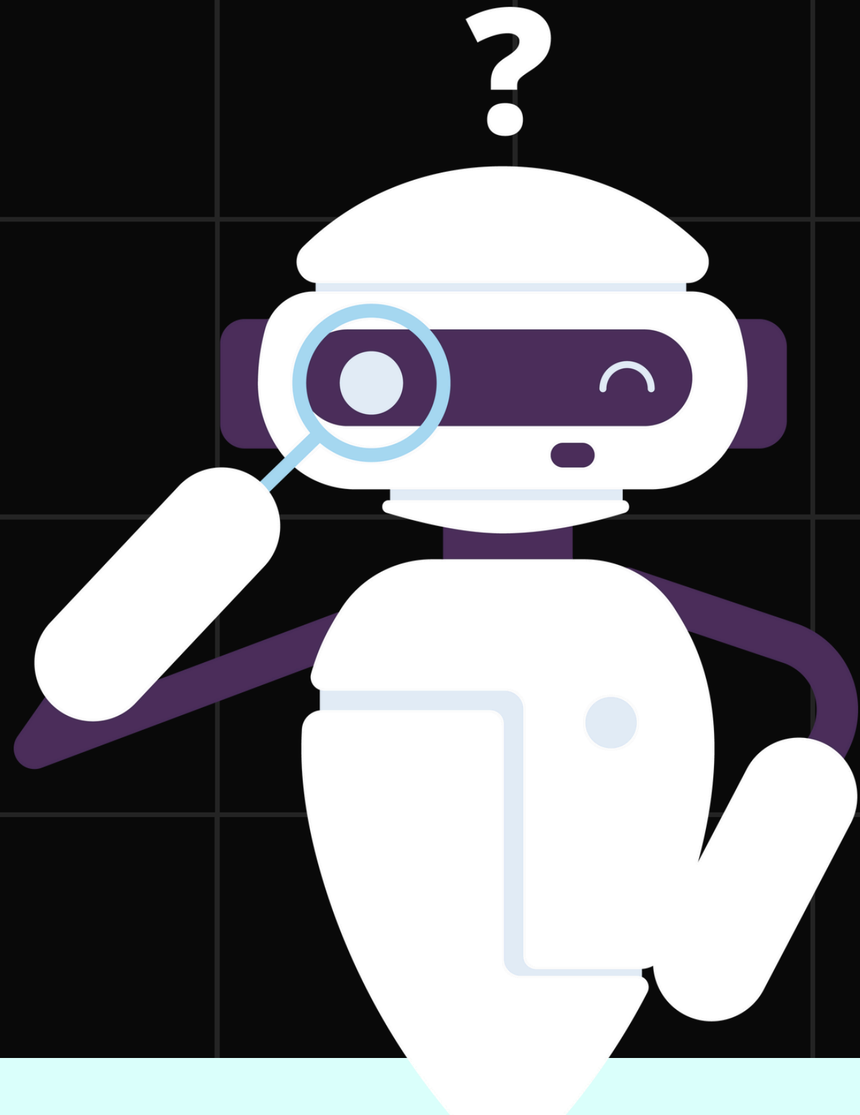
Traditional AI vs Generative AI

Traditional AI

It is designed to predict, detect, or sort things. Its output is usually a label or a score—like classifying an email as spam, detecting a face in a photo, or predicting a stock price. The main focus of traditional AI is decision-making based on patterns in data.

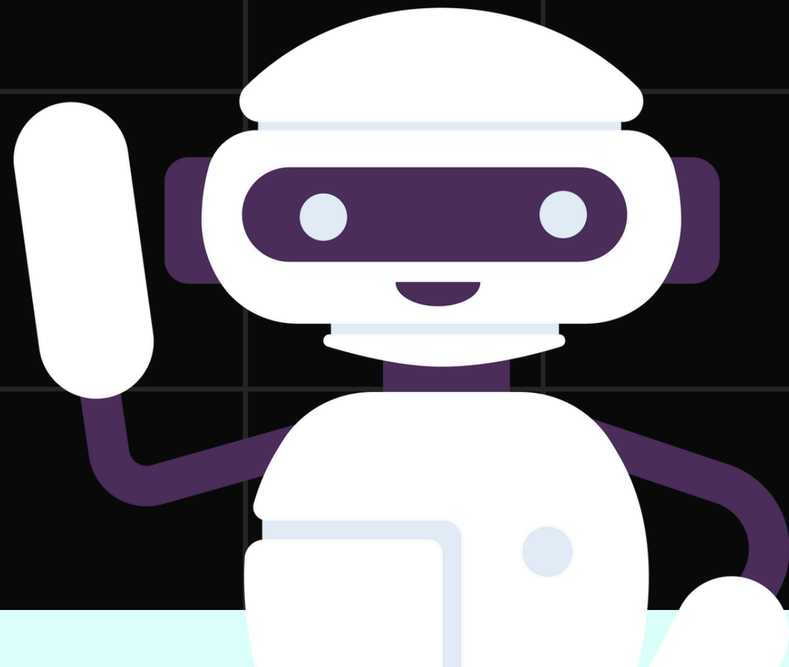
Generative AI

It is built to create new content. It can generate text, images, videos, audio, or even code that didn't exist before. Its output is not just a label, but something original, and its focus is on creativity, simulation, and human-like generation.

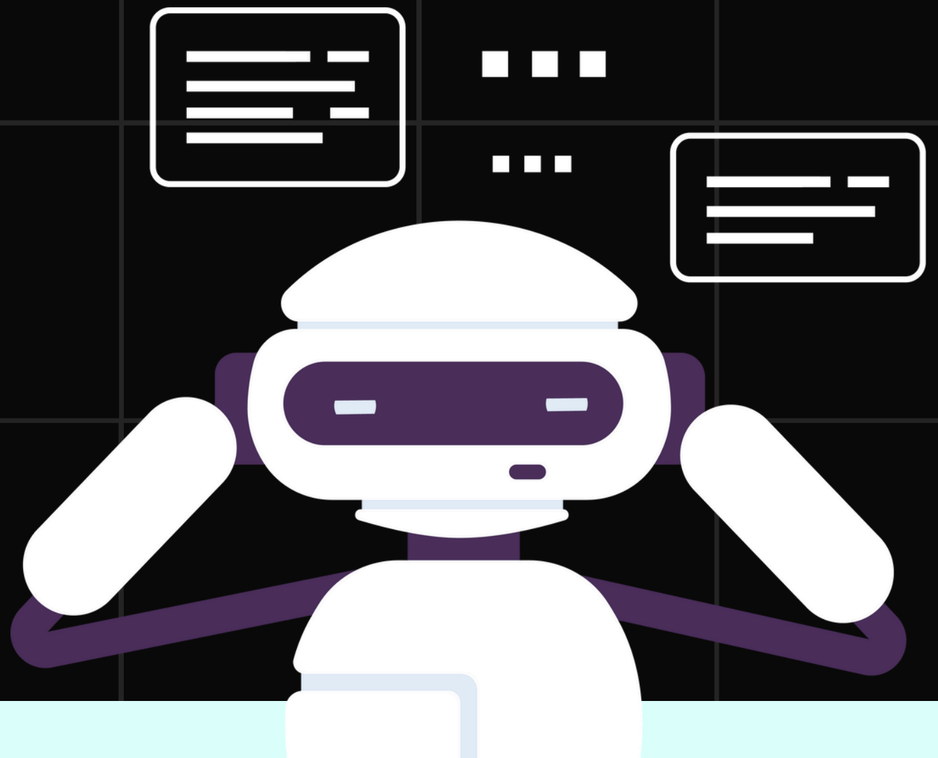


Why Gen AI Matters: Real-World Impact

- ***Productivity Improvements:*** Organizations using generative AI report a 30-40% increase in employee productivity. Knowledge workers, such as analysts or writers, save 2-3 hours daily on routine tasks.
- ***Economic Value:*** According to McKinsey, generative AI could contribute $2.6 to $4.4 trillion to the global economy each year.
- ***Cost Savings:*** Companies using generative AI for customer service see support costs decrease by 15-25% while also improving customer satisfaction.
- ***Content Creation Efficiency:*** Marketing teams using generative AI tools make content 70% quicker and create 3 times more options to try out.
- ***Software Development:*** Software engineers using AI coding assistants complete tasks 55% faster and reduce errors by 25%.
- ***Healthcare Accuracy:*** AI systems achieve over 90% accuracy in detecting certain medical conditions from images, matching the skill of specialists.
- ***Supply Chain Benefits:*** Companies using generative AI for demand forecasting reduce inventory costs by 20-30% and experience 15% fewer stock shortages
- ***Talent Recruitment:*** HR teams using Gen AI find good candidates 60% faster and improve hiring quality by 35%.
- ***Faster Medicine:*** AI speeds up finding new drugs, cutting early steps from years to months—some are ready for testing in under a year!



Generative AI Applications



Education

- AI Tutors: Personalized learning experiences, adaptive content
- Summarization Tools: Quickly digest complex academic papers
- Research Assistants: Automatically generate hypotheses or assist in data analysis

Entertainment & Media

- AI Art Creation: Generating original artwork, illustrations, and designs
- AI Music Composition: Creating melodies and harmonies based on user input
- Text Generation for Stories/Screenplays: Writing novels, poems, or even movie scripts

Healthcare

- Drug Discovery: AI models generate potential drug molecules
- Medical Imaging: AI helps create synthetic medical images for training and diagnosis
- Patient Interaction: Virtual assistants to support patients with personalized advice

Business & Marketing

- Automated Content Generation: Writing blog posts, social media content, product descriptions
- Customer Service AI: Chatbots for instant responses and feedback
- Market Analysis: Generative AI for creating product mockups, logos, and branding

Evolution of Generative AI

1950s–1980s: The Foundations

- **1950s:** Alan Turing poses the question "*Can machines think?*"
  - (Alan Turing was a British mathematician and computer scientist, widely regarded as the father of artificial intelligence and theoretical computer science.)
- **1960s–70s**: Rule-based AI (expert systems) – followed fixed rules, no learning
  - (These systems used if-then rules to mimic human decision-making but couldn't adapt or learn from data.)
- **1980s:** Neural networks emerge with basic learning capability
  - (Neural networks are computing systems inspired by the human brain that learn patterns from data. Pioneers like Geoffrey Hinton played a major role in bringing them back into the spotlight.)

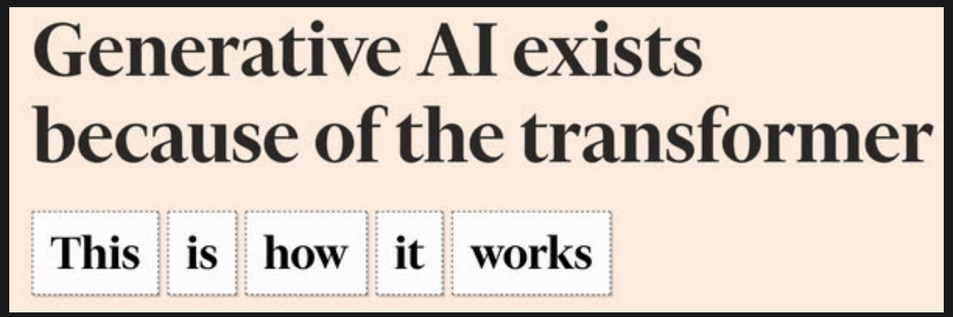
1990s–2010: Learning Begins

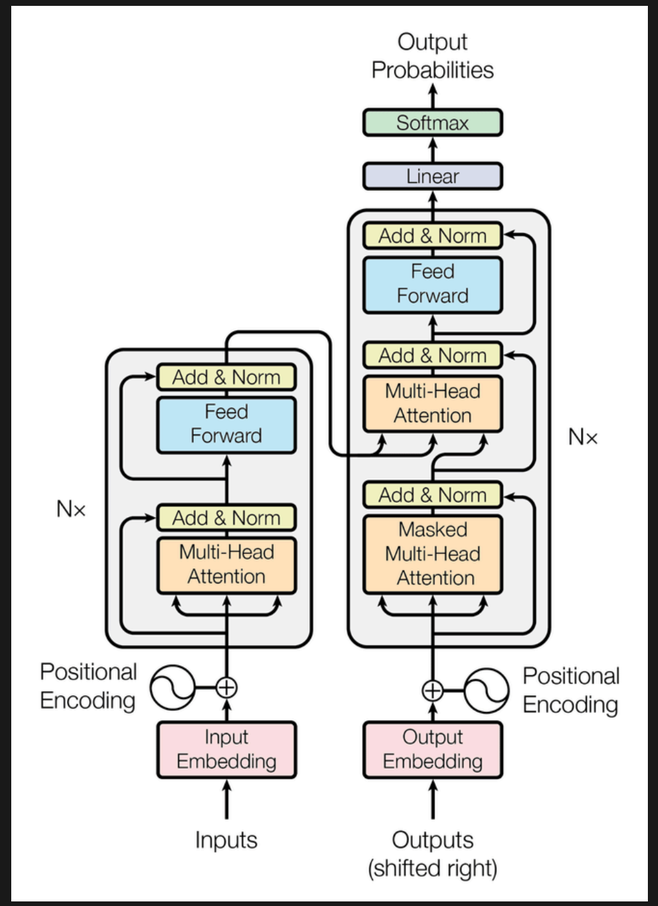
- Rise of machine learning – (Machine Learning allows computers to learn from examples rather than following hard-coded rules. It enabled smarter predictions and pattern recognition.)
- Early generative models like Naive Bayes and Markov Chains (Naive Bayes and Markov Chains were early tools used to generate simple text, like predicting the next word in a sentence based on the ones before it.)
- Autoencoders introduced – (Autoencoders are neural networks trained to compress input into a smaller representation (encoding), then reconstruct it. This helped computers understand patterns in data.***)***
- GAN concept starts brewing (Goodfellow's work begins ~2010) (GANs—short for Generative Adversarial Networks—use two AIs: one creates images, and the other judges them. They improve by competing, like an artist and a critic.)

Evolution of Generative AI

2014–2018: The Breakthrough Years

- **2014**: Ian Goodfellow introduces GANs (Generative Adversarial Networks)
- **2015–2017:** Sequence models like LSTM and Attention open new doors
  - (LSTMs helped AI understand and generate long sequences of text. Attention allowed the model to focus on the most important words—like highlighting key parts of a sentence.)
- **2017:** Google releases "Attention is All You Need" → foundation for Transformers
  - (This paper changed everything. It showed that attention alone could handle language tasks—no need for older complex models. This led to powerful models like GPT and BERT.)





Evolution of Generative AI

2018–2022: Transformers Take Over

- **2018:** OpenAI's GPT-1 shows potential in generating human-like text (This was one of the first AI models that could write short paragraphs that made sense—like writing a news headline or a short email.)
- **2019–2020:** GPT-2 and GPT-3 launch, shocking the world with fluency
- (These models could write full articles, poems, or answer questions. They had seen a massive amount of text from books, websites, and more—so they became really good at mimicking how humans write.)
- **2021**: DALL·E and CLIP combine vision + language (DALL·E can draw images based on descriptions like "an astronaut riding a horse." CLIP helps the AI understand both pictures and words at the same time—like being able to look and read together.)
- Code Generators like Codex emerge (Now, you could tell the AI something like "make a calculator" in plain English, and it would write the code for you. Codex became the brain behind tools like GitHub Copilot.)

2023–Present: Multimodal and Democratized

- AI models like GPT-4, Gemini, Claude, and LLaMA now have multimodal powers (This means they can work with text, images, audio, and more—not just typing back answers. You can show them a picture and ask questions about it.)
- These models can now see, hear, and interact (You can upload an image, speak into a mic, or even combine text and images—and the AI understands it all. It's like talking to an assistant that understands everything you share, not just your words.)
- Open-source models make this tech available to everyone (Tools like Mistral, LLaMA, and Stable Diffusion are free to use and share. This means students, researchers, and developers around the world can build their own AI tools without needing huge budgets.)

How Generative AI Works

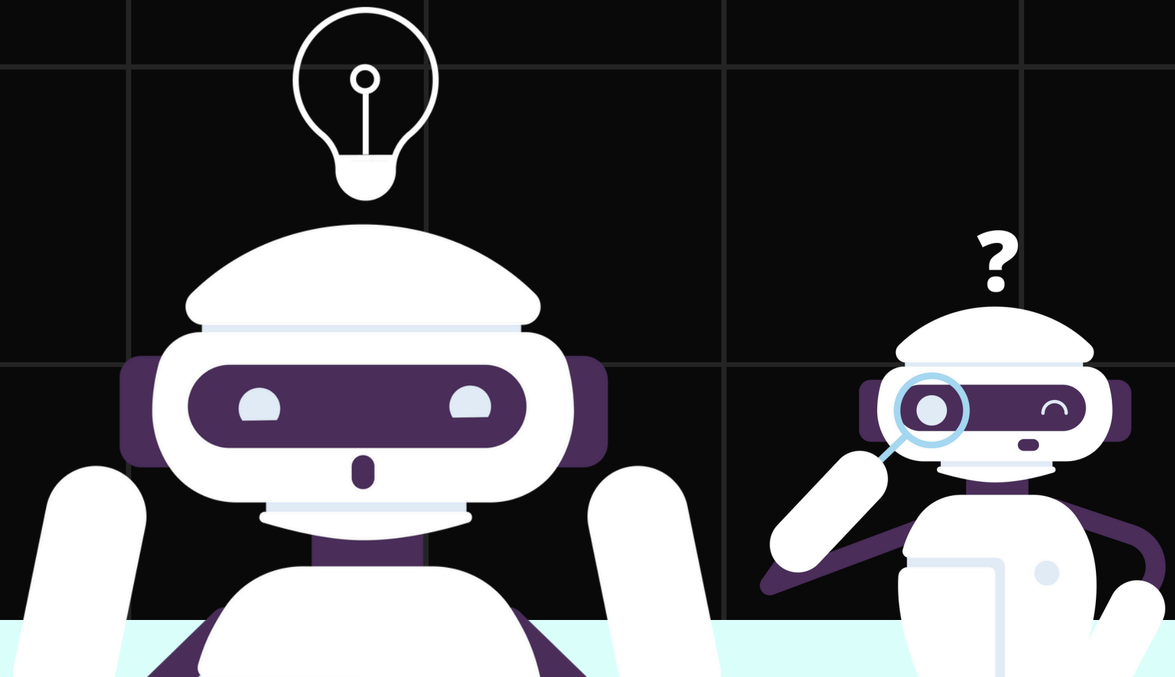
- Learns patterns from huge amounts of data (like text, images, or audio)
- Uses those patterns to generate new content that looks or sounds real
- Needs three things:

1. A training dataset
2. A model architecture (like a Transformer or GAN)
3. A way to generate new content from what it has learned

How Text Generation Works

- You type a prompt: "Tell me a story about a dog."
- The AI looks at the prompt and asks: “What word usually comes next?”
- It chooses the next word based on probabilities
- It keeps repeating this step—word by word—until it finishes your story

"Prompt → AI thinks → Word 1 → Word 2 → Word 3 → Full sentence"



How Generative AI Works

How Does AI Make Choices?

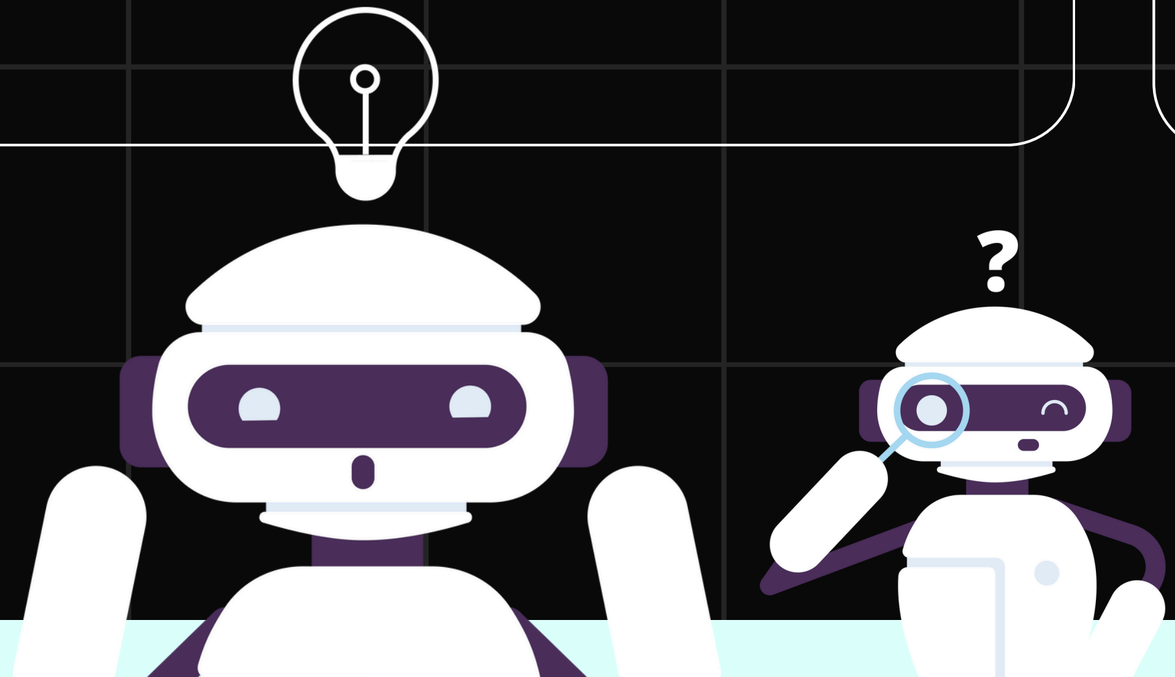
- Training: AI reads millions of examples to learn grammar, tone, style, structure
- Attention Mechanism: Helps AI focus on the most important parts of the input
- (e.g., knowing that “dog” is more important than “the” in your prompt)
- Sampling Techniques:
- Greedy: Always picks the top choice (safe, but boring)
- Top-k / Top-p: Adds randomness for more creativity

How Image Generation Works

1. You give a prompt: "A cat wearing sunglasses at the beach"
2. AI turns that text into a visual concept
3. It generates pixels step by step to bring your idea to life

Behind the scenes:

- Uses **diffusion** (starts with noise, then removes it step-by-step to form a clear image)
- Trained on millions of image-text pairs



Types of Generative Models

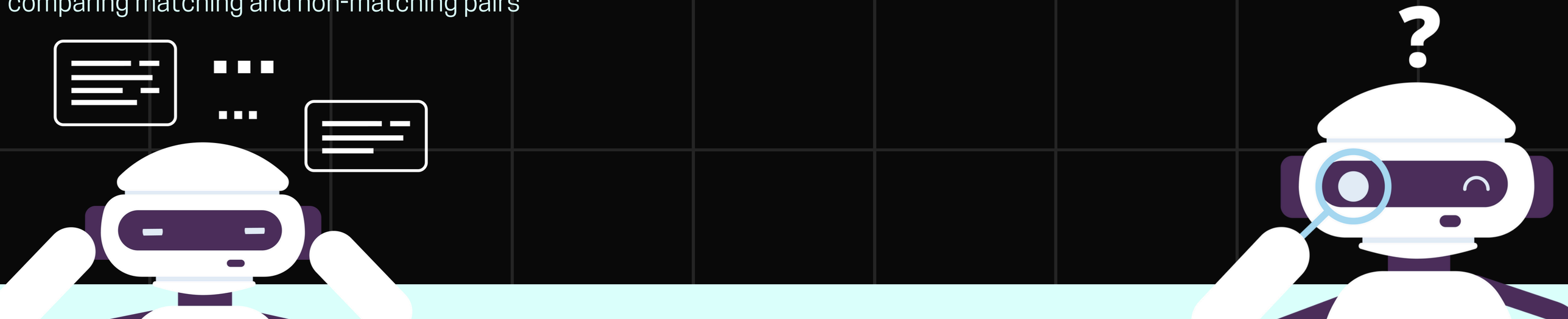
📄 Text → Large Language Models (Use large datasets and transformers to generate text by predicting the next word in a sequence—this process is called token prediction.)

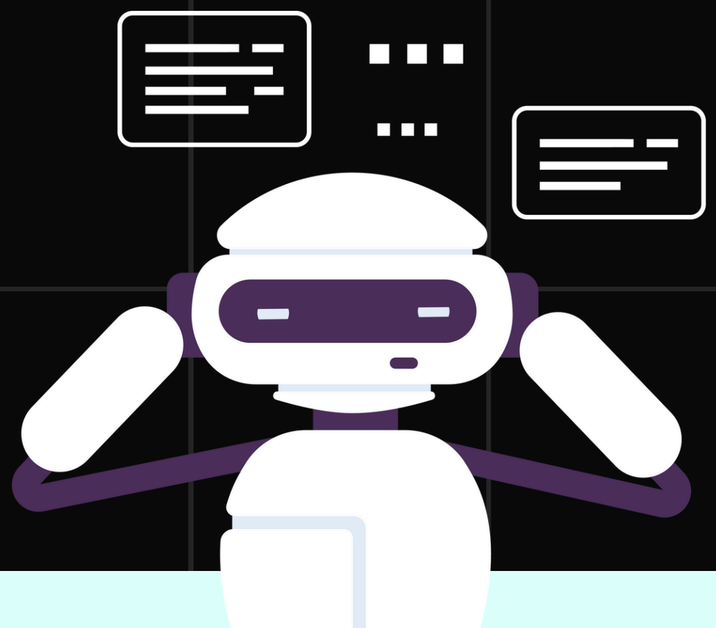
🌄 Images → Image Generation Models (Use GANs or Diffusion models to generate visuals. They learn image patterns through compressed “latent spaces.” - compressed representation of image concepts. A compressed representation is like a tiny summary of an image that captures its key ideas—like colors, shapes, or objects—without keeping all the details.)

🎧 Audio → Music & Speech Models (Generate waveforms (raw sound signals) or spectrograms (visual audio maps) to produce realistic music or speech. Can mimic tone and emotion.)

👨‍💻 Code → AI Programming Assistants (Trained on open-source code. Can translate natural language prompts into working code.)

🎬 Multimodal → Models that combine input types (e.g., text + images) (Use joint embeddings [represent different inputs (text/image) in the same space] and cross-attention [lets the model “look” at text while generating from an image, or vice versa] to process and respond across modalities.) - CLIP (OpenAI): Learns connections between images and captions using contrastive learning: trains by comparing matching and non-matching pairs





Language Models

- Generate human-like responses by predicting the next token (word or sub-word)
- Trained using transformer architectures, which use attention mechanisms to understand context
- Learn language from massive datasets in a process called pretraining, and then refined for specific tasks via fine-tuning
- GPT-3/4 – Autoregressive: predicts next word based on previous ones, BERT – Bidirectional: understands context from both sides of a sentence, LLaMA – Lightweight, open-source language model from Meta

Audio Generation Models

- Turn text or melodies into waveforms (raw sound signals) or spectrograms (visual audio maps)
- Generate voice with emotion, music, or realistic background audio
- WaveNet (DeepMind): High-fidelity speech synthesis, Jukebox (OpenAI): Music creation with lyrics and style, AudioLM / VALL-E: Generate speech with emotion and accent based on short input

Image Generation Models

- GANs (Generative Adversarial Networks): Two neural networks compete—generator creates fake images, discriminator evaluates if they’re real
- Diffusion Models: Start with pure noise and remove it step-by-step to form a realistic image (denoising)
- DALL·E 2, Stable Diffusion, Midjourney, Imagen

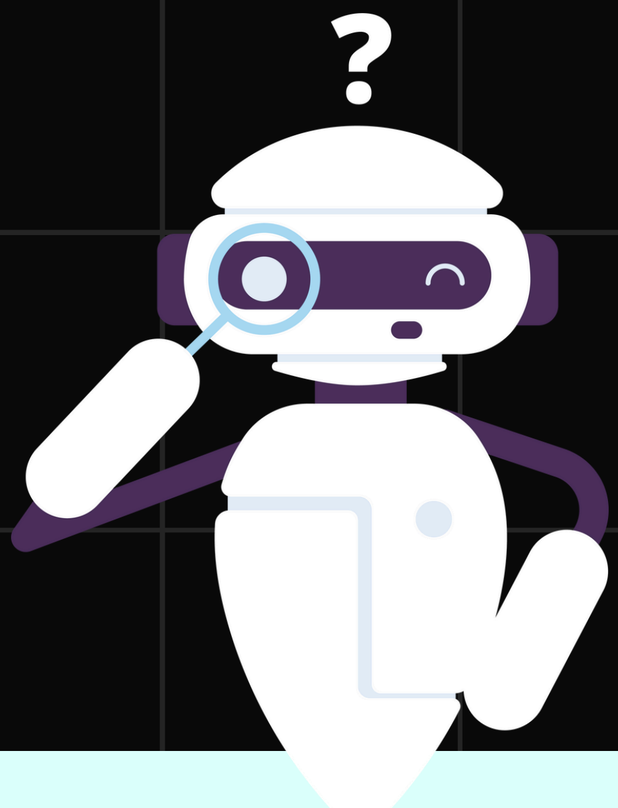
Code Generation Models

- Generate full code snippets from natural language prompts
- Understand programming syntax (structure) and semantics (meaning)
- Codex (OpenAI): Powers GitHub Copilot
- Code LLaMA (Meta): Fine-tuned for multiple programming languages
- CodeGen, StarCoder, Gemini Code Assist
- Build websites; Debug code; Convert logic into working scripts

⚠ Risks, Myths & Challenges of *Generative AI*

Generative AI is powerful—but it's not perfect. It comes with technical, ethical, legal, and environmental risks that we must understand and address.

- 🤯 ***Hallucination & Misinformation:*** When AI generates false or made-up content that sounds convincing. Example: Citing fake research papers, inventing facts, or giving incorrect medical advice. Why It Happens: The model doesn't "know" facts—it predicts the next word/token based on patterns in training data. If it hasn't seen accurate info during training, it may "fill in the blanks" incorrectly. AI doesn't think—it mimics. Even confident-sounding answers might be false. This is dangerous in areas like health, law, or education.
- 🕵️ **Deepfakes & Copyright Concerns:** AI-generated images, audio, or videos that mimic real people. Example: Fake videos of politicians or celebrities doing or saying things they never did. AI trained on content (images, code, writing) from the internet may unknowingly copy or remix copyrighted work. Can be used maliciously: misinformation, fraud, reputational harm.
- ⚖️ **Bias, Fairness & Ethical Dilemmas:** Generative AI can reflect or even amplify biases in the data it was trained on. Example: Stereotyping in job application text or image generation. Training data comes from the internet, which includes human bias - if biased examples dominate, AI learns and reproduces them.
- 🌍 **Environmental Impact – The Carbon Footprint: Training large models requires massive computing power. Example: Training GPT-3 reportedly used as much electricity as 100+ U.S. homes in a year. Energy-intensive data centers contribute to global carbon emissions. As models grow (billions of parameters), so does their environmental cost.**



🚫 Limitations: What Generative AI Can’t Do (Yet)

AI can write, paint, compose—but it doesn’t feel. The spark of creativity? That’s still human.

1️⃣ No Real Understanding or Reasoning

“It talks like it understands—but it doesn’t.”

- AI doesn’t understand meaning like humans do—it predicts what sounds likely; It lacks common sense reasoning, real-world experience, or emotions.

Ask it “Can I eat stones if I’m hungry?” — it might say yes unless trained to know better.

2️⃣ Struggles with Factual Accuracy (Hallucinations)

“It can make things up—confidently.”

- AI sometimes generates fake facts, URLs, references, or math; It doesn’t "know" truth—it works by pattern prediction.

Citing a fake study or giving wrong medical/legal advice with confident wording.

3️⃣ Poor at Real-Time or Up-to-Date Info

“It doesn’t know what happened yesterday.”

- Most models are trained on static datasets (up to a cutoff date); They don't automatically browse the web or stay current unless specifically designed for that (like RAG or web-enabled models).

4️⃣ Context Limitations (Short Memory)

“It forgets the conversation if it gets too long.”

- Language models have a token limit—meaning they can only remember a certain number of words at a time; Long conversations or documents might confuse or be forgotten.

5️⃣ Can’t Think Logically or Abstractly Like Humans

“AI doesn’t innovate. It mimics.”

- AI is excellent at remixing existing ideas but can’t yet: Form original insights; Understand deep emotions; Create ethical judgment from first principles

6️⃣ Can't Truly See, Hear, or Feel

“Even multimodal AI doesn’t experience the world.”

- Multimodal models can analyze images or sounds, but they don’t see or hear as humans do; No perception, no consciousness, no physical awareness.

🛡️ Guardrails and Governance

As AI becomes more powerful, we need guardrails to ensure it's used ethically, safely, and legally. This includes design principles, safety layers, and government policies that promote Responsible AI.

1️⃣ Responsible AI Principles (Responsible AI isn't just about how we build it—it's about how we use it.)

- Transparency – Users should know when content is AI-generated
- Fairness – Models should avoid bias and treat all groups equitably
- Accountability – There should be a clear way to address harm
- Privacy – Data used to train or generate should be protected
- Safety – Models must not cause harm, intentionally or unintentionally

2️⃣ Constitutional AI

- A method where AI is trained to follow a "constitution"—a set of ethical rules and values (e.g., be helpful, harmless, honest)
- Used in models like Anthropic's Claude

How It Works:

1. Define a list of principles (the "constitution")
2. Train the model to self-critique and improve responses
3. Avoids harmful, toxic, or biased outputs

Why It Matters:

- Reduces the need for human moderators
- Makes AI safer and more consistent in tone

🛡️ Guardrails and Governance

🤝 AI + human judgment = better outcomes
As future creators, developers, or users of AI—you play a role in making it safer, fairer, and smarter for everyone.

3️⃣ Safety Layers in AI Models

1. RLHF (Reinforcement Learning from Human Feedback):
   - Trains AI using human-approved answers
   - Helps align responses with human values
2. Moderation Tools:
   - Filter out harmful content like hate speech, violence, illegal advice
3. Prompt Shields / Output Filters:
   - Prevent misuse (e.g., asking AI to generate malware or disinformation)

Why It's Important:

Without safety layers, generative AI could be exploited for fraud, propaganda, or misinformation.

4️⃣ Global Regulations & Policy Landscape

- There's no single global law yet—but momentum is building. The U.S. is balancing innovation with regulation.
- Over 893 AI-related bills introduced in 48 states in just the first 80 days of 2025 (Some promote AI, others regulate its use—privacy, bias, surveillance, etc.)
- EU AI Act (2024): Classifies AI by risk level—strictest rules for high-risk applications.
- 🇺🇸 Trump's AI Policy Shift (2025): Innovation vs. Regulation
  - Less Government Control - Would repeal Biden's Executive Order 14110, which focused on AI safety - Believes companies should self-regulate, not the government - Fewer rules = more innovation (but also more risk)
  - Competition with China - Sees AI as key to national security and global dominance - Plans to: Limit AI exports to China; Ramp up infrastructure, semiconductor manufacturing, and data centers - Goal: Outpace China, which currently leads in AI patents
  - Favors open-source AI projects to fuel rapid development - Risk: Open models can be adapted by foreign adversaries -Likely to relax constraints on how AI is trained and deployed - Emphasis on free speech and human flourishing over strict oversight
  - Supports continuing the AI Safety Institute (a bipartisan initiative) - Acknowledges that some risks need oversight - But prefers market-driven solutions over government-enforced regulations

The Future of Generative AI

Generative AI is evolving faster than any previous tech wave. What started as chatbots and art tools is now shaping work, education, creativity, and daily life.

Emerging Trends and Innovations

- Multimodality: AI that understands and combines text + image + audio + video + code. Example: GPT-4V, Gemini
- Agentic Systems: AI that can act on your behalf—automating tasks, browsing, sending emails, booking appointments. Example: AutoGPT, Devin (AI software engineer)
- Personal AI: Models trained on your data for tutoring, therapy, planning, etc. Think of it as your AI twin or lifelong assistant
- On-Device Models: Smaller, privacy-friendly AIs running directly on your laptop or phone. Example: LLaMA, Mistral
- Open-Source Acceleration: Anyone can build or modify models → faster innovation, but also risks

Societal Implications – Opportunities & Challenges

Opportunities:

- Personalized education, tutoring, and accessibility tools; Enhanced productivity and creativity; AI-assisted healthcare, mental wellness, and support

Challenges:

- Deepfakes, misinformation, and manipulation; Privacy loss and surveillance risks; Widening inequality (access to AI benefits)

AI can amplify the good—but it can also scale the bad. The way we design and govern it will shape its future.

Impact on Jobs and Society

Title: AI Won't Just Change Jobs—It Will Change How We Work

Likely Effects:

- Job transformation, not just replacement; Routine tasks automated; creativity and judgment more valued; New jobs in AI ethics, auditing, prompt design, AI psychology; Roles that didn't exist 5 years ago; Reskilling & Lifelong Learning becomes critical - Everyone from marketers to lawyers will need AI literacy

The AI revolution is less about taking jobs—and more about changing them. Learning to use AI will be as important as learning to write.

How to Stay Informed & Involved

💡 Learn AI. Question AI. Use AI.

But never forget: You are the thinker, the creator, the decision-maker.

- Learn Continuously: Follow communities like Hugging Face, DeepLearning.AI, Google AI Blog
- Experiment: Try hands-on tools (ChatGPT, DALL·E, Runway, Poe, Notion AI)
- Join the Conversation: Attend webinars, join local AI clubs, take courses
- Stay Policy-Aware: Follow developments from NIST, White House, UNESCO, EU AI Act
- Ask Better Questions: Don’t just consume AI—critique it, test it, guide it

🔍 Use AI, But Stay Alert

- AI is not intelligent in the human sense — it imitates, not thinks.
- It's a pattern machine, not a source of truth.
- Always verify its output — don’t hand over full control.

🧠 “More artificial than intelligent.”

👫 AI: Your Assistant, Not Your Replacement

- Use AI to support your creativity — not replace it.
- It can help brainstorm, summarize, suggest — but the intent and meaning must still come from you.

🤖 Beware the Hype

- Don’t adopt AI out of fear of missing out.
- Many narratives are profit-driven, not people-first.
- The best users are those who use AI mindfully, not mindlessly.