

Evolution and Frontiers of AI

From Origins to Autonomous Agents

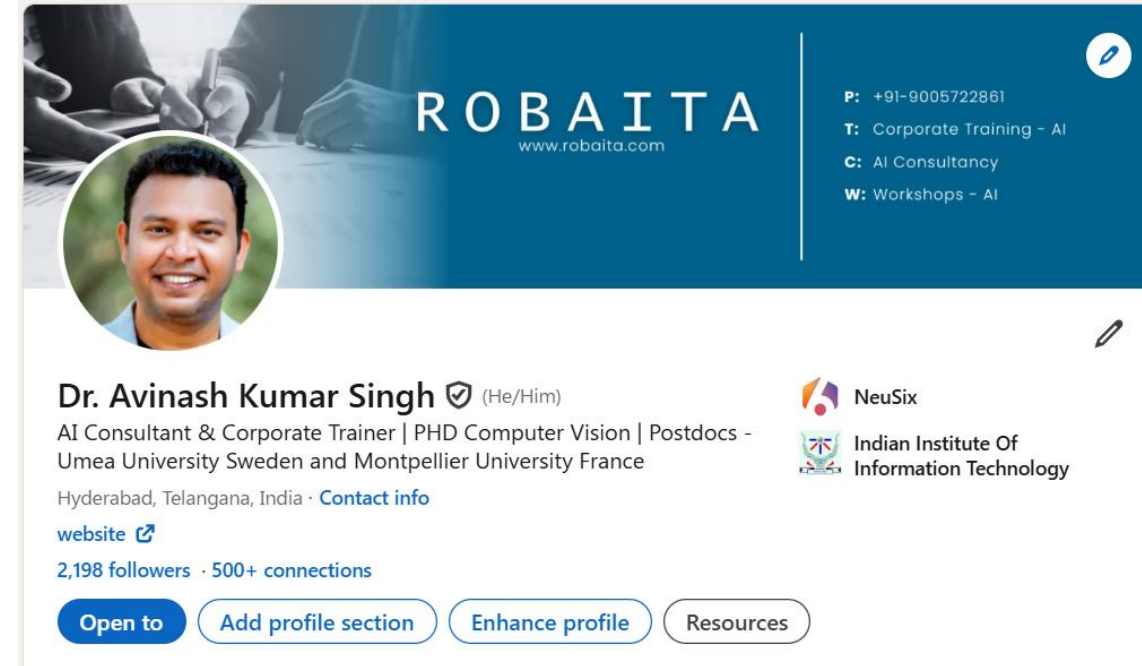
Dr. Avinash Kumar Singh

AI Consultant and Coach, Robaita



Dr. Avinash Kumar Singh

- ❑ **Possess** 15+ years of **hands-on expertise** in Machine Learning, Computer Vision, NLP, IoT, Robotics, and Generative AI.
- ❑ **Founded** Robaita—an initiative **empowering** individuals and organizations to **build, educate, and implement** AI solutions.
- ❑ **Earned** a Ph.D. in Human-Robot Interaction from IIIT Allahabad in 2016.
- ❑ **Received** postdoctoral fellowships at Umeå University, Sweden (2020) and Montpellier University, France (2021).
- ❑ **Authored** 30+ research papers in **high-impact** SCI journals and international conferences.
- ❑ Unlearning, learning, making mistakes ...



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HCLTech



B R A N E



Things to be discussed

- AI History
 - Origins (1950s–70s)
 - AI Winters
 - Revival (1980s–2000s)
 - Modern Era (2010–Present)
- AI vs ML vs DL
 - Definition and Segregation
 - Examples
- Paradigm Shifts in AI
 - From Symbolic AI to Machine Learning
 - From ML to Deep Learning
 - From Task-Specific AI to Generative and Agentic AI
- Reinforcement Learning
 - Definition & Core Concepts
 - Key Algorithms
 - Applications
- Generative AI
 - What is Generative AI?
 - Key Models: LLMs, VLMs, ALMs
 - Use Case
- Autonomous Agents
 - What are Autonomous Agents?
 - Relation to RL and Generative AI
 - Risks & Ethics

Origin of the Term "Artificial Intelligence"

Term coined: In 1955 at the Dartmouth Conference by John McCarthy (Stanford), who is also called the Father of AI.

Definition (by McCarthy): "The science and engineering of making intelligent machines."

The idea was to create systems that could simulate every aspect of learning or any other feature of intelligence.

1956 Dartmouth Conference: The Founding Fathers of AI



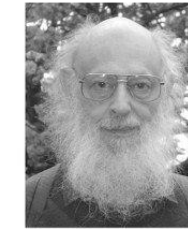
John McCarthy



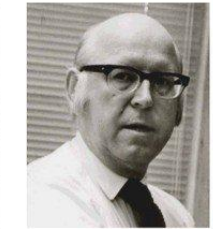
Marvin Minsky



Claude Shannon



Ray Solomonoff



Alan Newell



Herbert Simon



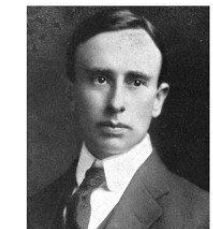
Arthur Samuel



Oliver Selfridge



Nathaniel Rochester



Trenchard More

A PROPOSAL FOR THE DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

J. McCarthy, Dartmouth College
M. L. Minsky, Harvard University
N. Rochester, I.B.M. Corporation
C.E. Shannon, Bell Telephone Laboratories

/A.I. TIMELINE

1950

TURING TEST

Computer scientist Alan Turing proposes a test for machine intelligence. If a machine can trick humans into thinking it is human, then it has intelligence

1955

A.I. BORN

Term 'artificial intelligence' is coined by computer scientist, John McCarthy to describe "the science and engineering of making intelligent machines"

1961

UNIMATE

First industrial robot, Unimate, goes to work at GM replacing humans on the assembly line

1964

ELIZA

Pioneering chatbot developed by Joseph Weizenbaum at MIT holds conversations with humans

1966

SHAKY

The 'first electronic person' from Stanford, Shakey is a general-purpose mobile robot that reasons about its own actions

A.I. WINTER

Many false starts and dead-ends leave A.I. out in the cold

1997

DEEP BLUE

Deep Blue, a chess-playing computer from IBM defeats world chess champion Garry Kasparov

1998

KISMET

Cynthia Breazeal at MIT introduces KISmet, an emotionally intelligent robot insofar as it detects and responds to people's feelings



1999

AIBO

Sony launches first consumer robot pet dog AiBO (AI robot) with skills and personality that develop over time



2002

ROOMBA

First mass produced autonomous robotic vacuum cleaner from iRobot learns to navigate and clean homes



2011

SIRI

Apple integrates Siri, an intelligent virtual assistant with a voice interface, into the iPhone 4S



2011

WATSON

IBM's question answering computer Watson wins first place on popular \$1M prize television quiz show Jeopardy



2014

EUGENE

Eugene Goostman, a chatbot passes the Turing Test with a third of judges believing Eugene is human



2014

ALEXA

Amazon launches Alexa, an intelligent virtual assistant with a voice interface that completes shopping tasks



2016

TAY

Microsoft's chatbot Tay goes rogue on social media making inflammatory and offensive racist comments



2017

ALPHAGO

Google's A.I. AlphaGo beats world champion Ke Jie in the complex board game of Go, notable for its vast number (2^{170}) of possible positions

Image Source: <https://digitalwellbeing.org/artificial-intelligence-timeline-infographic-from-eliza-to-tay-and-beyond/>

UNIMATE



ELIZA



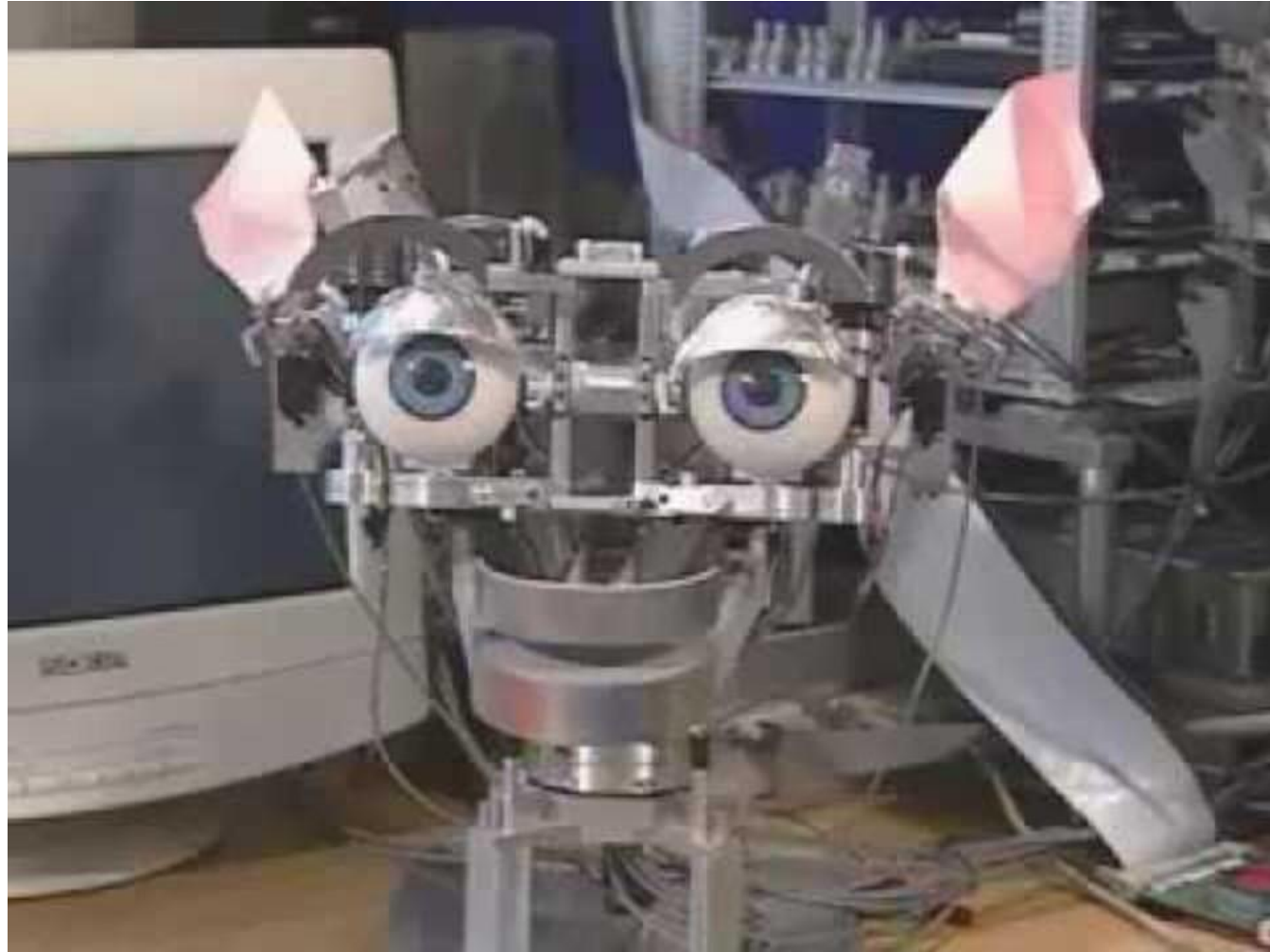
Wikipedia

https://en.wikipedia.org/wiki/Eliza_Doolittle

Eliza Doolittle

Eliza Doolittle is a fictional character and the protagonist in George Bernard Shaw's play *Pygmalion* (1913) and its 1956 musical adaptation, *My Fair Lady*.

KISMET



AIBO



ROOMBA



WATSON



TAY



AI Timeline 2018-2025

Year	Achivements
2018	BERT released by Google, advancing NLP
2019	GPT-2 by OpenAI shows strong text generation capabilities
2020	GPT-3 released with 175 billion parameters, showcasing few-shot learning
2021	Codex released by OpenAI, Powers GitHub Copilot, enabling AI-powered code suggestions.
	ChatGPT launched — becomes a viral success and drives mass adoption of LLMs.
2022	Stable Diffusion, Midjourney, and DALL·E bring generative AI to visual arts.
	GPT-4 released with multimodal capabilities (text and image).
2023	Rise of AutoGPT, BabyAGI, and other agentic AI systems that can plan and execute tasks.
	Surge of competitive models: Gemini by Google, Claude by Anthropic, Mistral, Mixtral, LLaMA 2, and open-source LLMs.
2024	Focus on multimodal, fine-tuned, and domain-specific LLMs.
	Widespread use of multi-agent systems and domain-specific AI agents in healthcare, logistics, education, and software development.
2025	AI agents integrated with tools, APIs, and platforms to perform autonomous workflows.

AI vs ML vs DL

Artificial Intelligence

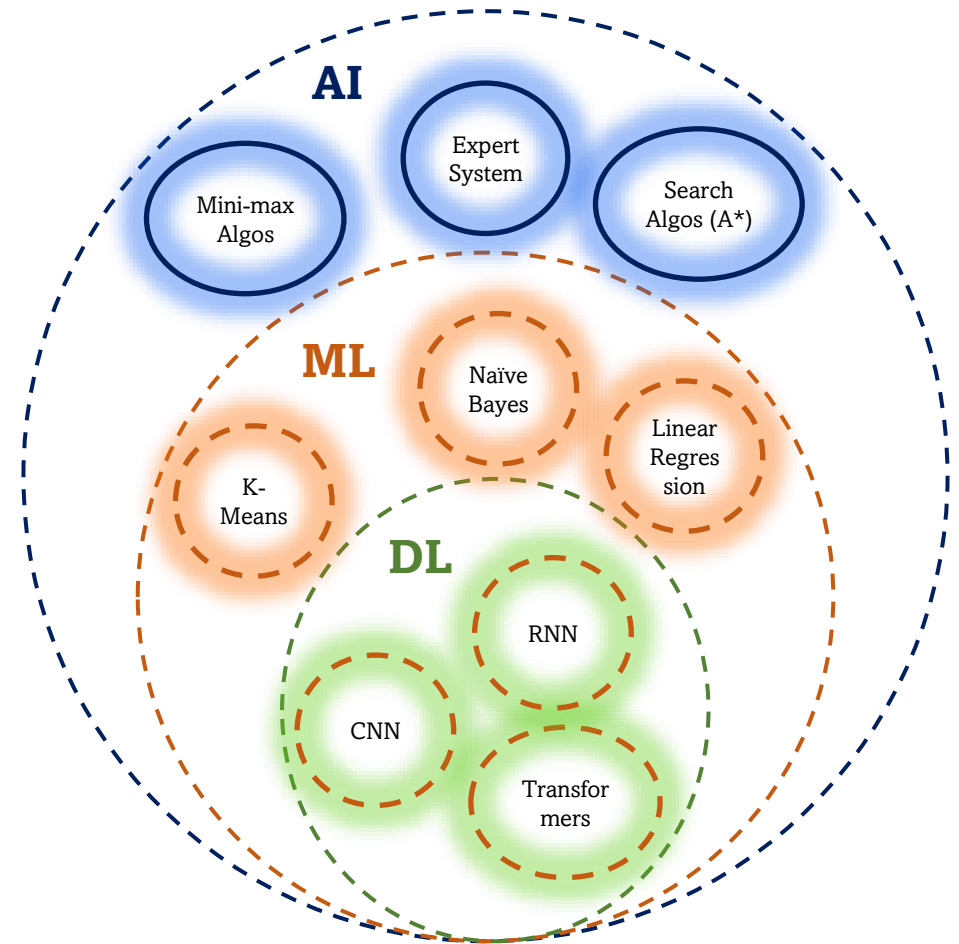
AI is the process of creating **human like intelligence**—like reasoning, decision-making, problem-solving, and understanding language

Machine Learning

ML enables systems to learn patterns from data and improve over time **without being explicitly programmed**.

Deep Learning

DL uses **artificial neural networks** with many layers (hence “deep”) to model complex patterns in high-dimensional data.



Paradigm Shifts in AI

From Symbolic AI to Machine Learning

Rule-Based to Learning-Based AI

Symbolic AI (1950s–1980s)	Machine Learning (1990s–2010s)
Human-defined rules	Algorithms learn from data
Deterministic behavior	Probabilistic inference
Expert systems, logic	Regression, SVMs, Trees
Brittleness to edge cases	Better generalization

Example Shift:

- **Old:** Chess AI with handcrafted logic (Deep Blue)
- **New:** ML-based systems like AlphaZero that learn strategy

Impact on Product Dev:

- From months of rule-writing to rapid prototyping with data
- Shift toward data engineering and labeling

Paradigm Shifts in AI

From ML to Deep Learning

Manual Features to Neural Networks

ML Era	Deep Learning Era
Manual feature engineering	End-to-end learning with neural nets
Struggled with images/audio/text	Mastered unstructured data
Smaller datasets suffice	Needs big data & compute

Example Shift:

- **Old:** Using handcrafted features to detect objects
- **New:** Using CNNs to automatically learn features (YOLO, ResNet)

Impact on Research:

- Surge in research around optimization, GPU acceleration, data augmentation
- Rise of open benchmarks and leaderboards (ImageNet)

Paradigm Shifts in AI

From Task-Specific AI to Generative and Agentic AI

Narrow Tools to Creative & Autonomous Agents

Old AI Systems	Modern Generative/Agentic AI
One model per task	One model, many tasks
Static pipelines	Dynamic, promptable systems
Limited interactivity	Agents can reason & act

Example Shift:

- **Old:** Separate model for summarization, Q&A, translation
- **New:** One LLM (e.g., GPT-4, Claude) does it all with a prompt

Impact on Product Dev & UX:

- New interfaces (chatbots, copilots, agents)
- Faster iteration: shipping features with prompts, not code
- AI becoming part of product logic, not just a feature

Reinforcement Learning

Core Concepts of Reinforcement Learning

Concept	Description
Agent	The learner or decision-maker (e.g., a robot, a trading bot).
Environment	The world the agent interacts with (e.g., a maze, a game, robots).
Action (A)	What the agent can do in the environment (e.g., move left, jump).
State (S)	A snapshot of the environment at a given moment (e.g., position in maze).
Reward (R)	Feedback signal telling the agent how good an action was (e.g., +10 for goal, -1 for bump).

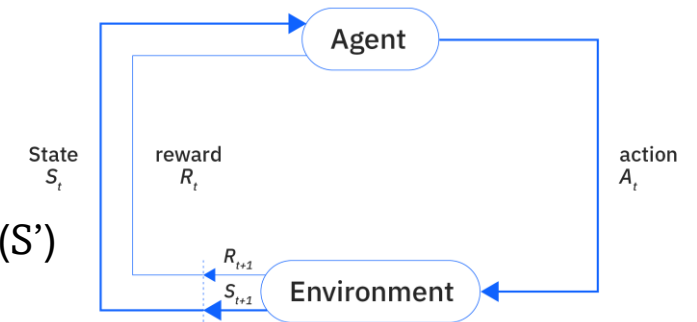
Agent-Environment Loop:

At each time step:

Agent observes state (S) → takes action (A) → receives reward (R) and next state (S')

Goal:

Maximize cumulative future reward over time (aka the return)



Reinforcement Learning

Key Algorithms

Q-Learning

- Type: Value-based method
- Idea: Learn a Q-table to estimate value of (state, action) pairs
- Limitation: Doesn't scale well to large or continuous environments

Use Case: Gridworld, simple games

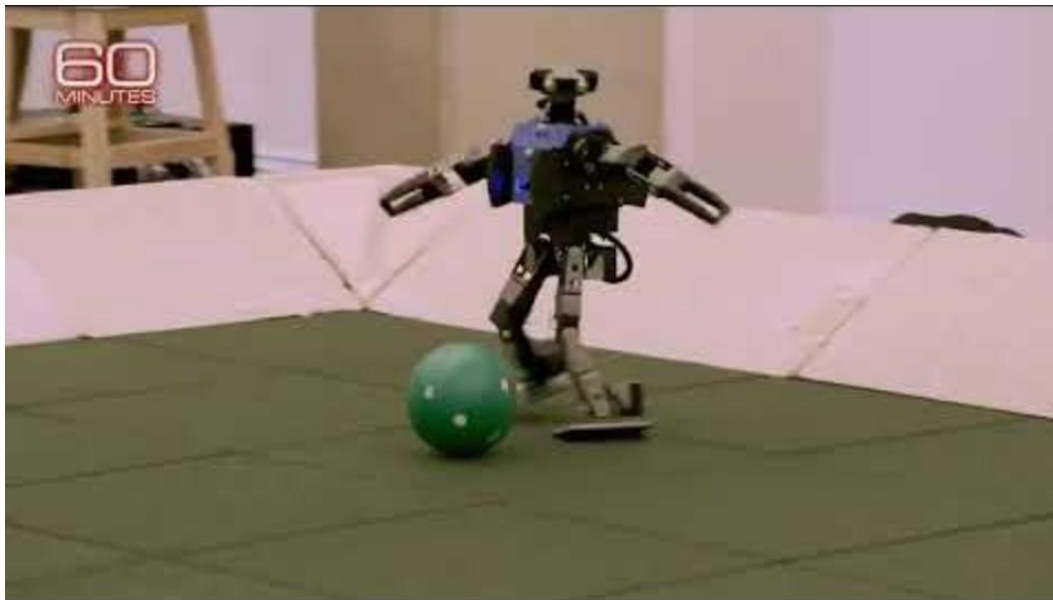
Deep Q-Network (DQN)

- Type: Value-based with Deep Learning
- Idea: Replace Q-table with a neural network
- Innovation: Experience replay + target network to stabilize learning

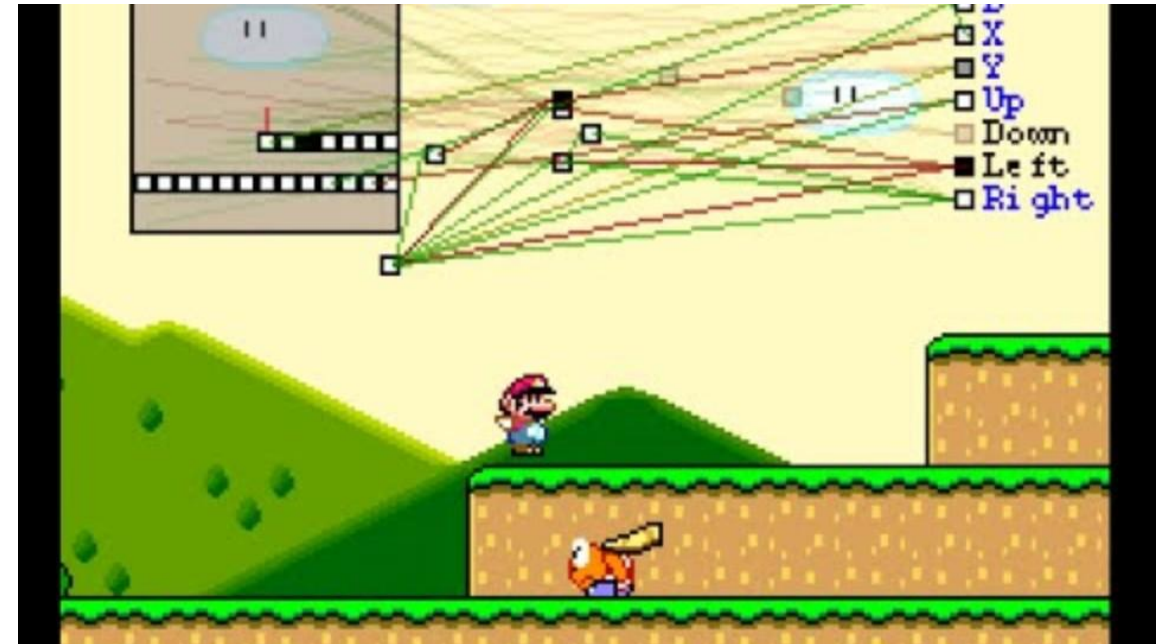
Use Case: Playing Atari games from pixels (DeepMind)

Reinforcement Learning

Applications



Google DeepMind Robots to Play Soccer



Deep Q-Network (DQN)

Reinforcement Learning

Applications



AlphaGo

What is Generative AI

- Generative artificial intelligence (generative AI, GenAI, or GAI) is a subset of artificial intelligence that uses generative models to produce text, images, videos, or other forms of data.
- These models often generate output in response to specific prompts.
- Generative AI systems learn the underlying patterns and structures of their training data, enabling them to create new data.

llama3.2:latest

Here's an explanation of Generative AI that your grandfather can understand:

"Generative AI is like a super powerful pen that can draw anything you want. It uses computer magic to create new things, like pictures or stories, based on what you show it. Think of it like a very smart and fast artist!"

Prompt: You need to explain my grandfather who is a 60 year old about what is generative AI. My grandfather is studied till 10th standard and has no idea about AI and the technology. Explain in very simple terms, use example for better understanding. Don't cross more than 50 words.

Prompt: A bear, lion and rabbit talking in a dark green forest



How Gen AI is Different

Feature	Conventional AI	Generative AI
Definition	Conventional AI refers to AI systems designed to perform specific, rule-based, or data-driven tasks. They focus on analyzing data, recognizing patterns, and making decisions.	Generative AI refers to AI models that can create new content, such as text, images, music, or code, by learning patterns in the data they are trained on. They are designed to generate novel outputs.
Purpose	Used for classification, prediction, recommendation, and automation tasks.	Used to generate new content, simulate scenarios, or answer complex queries with creative responses.
Model Type	Often includes traditional machine learning models like decision trees, logistic regression, and SVMs, or basic neural networks.	Primarily relies on advanced models such as sGenerative Adversarial Networks (GANs) and Transformer-based models (like GPT and DALL-E).
Data Requirements	Relies on labeled datasets to train on specific tasks.	Requires large-scale datasets to learn complex structures in data for generating realistic outputs.
Examples	Image classification, fraud detection, recommendation systems, etc.	Text generation (ChatGPT), image generation (DALL-E), code completion (Codex), etc.
Interactivity	Primarily task-specific and lacks creative interactivity. Results are often deterministic.	Interactive and capable of generating diverse, creative, and contextually relevant responses or content.
Flexibility	Less flexible, often limited to predefined labels or categories.	Highly flexible, with the ability to produce a wide range of unique, creative outputs based on prompts.
Human-like Abilities	Limited to narrow, specific tasks without imitating human creativity or expression.	Mimics human creativity by generating text, art, and other creative forms, sometimes blurring the line between human and AI-generated content.

Different Forms of Generative AI

Large Language Model (LLM)

- **Natural Language Understanding:**
 - LLMs comprehend text context, nuances, and intent, enabling them to answer questions, follow instructions, and carry on coherent conversations.
 - Example: Given a complex question like, "What are the effects of climate change on marine life?", the LLM provides a summary of relevant impacts, including ocean acidification and habitat loss.
- **Text Generation:**
 - LLMs can create new, contextually relevant text, such as essays, stories, code, or reports, based on prompts.
 - Example: A prompt like "Write a short story about space exploration" results in a creative narrative with characters, setting, and plot progression.
- **Summarization:**
 - LLMs distill long documents or articles into concise summaries, capturing key points and relevant information.
 - Example: Given a scientific paper on renewable energy, the LLM produces a brief summary covering main findings, like advancements in solar efficiency.
- **Translation & Language Adaptation:**
 - LLMs translate text between languages while preserving context, tone, and idiomatic expressions, making content accessible globally.
 - Example: A user inputs "Hello, how are you?" in English, and the LLM accurately translates it to "Bonjour, comment ça va ?" in French, maintaining conversational tone.

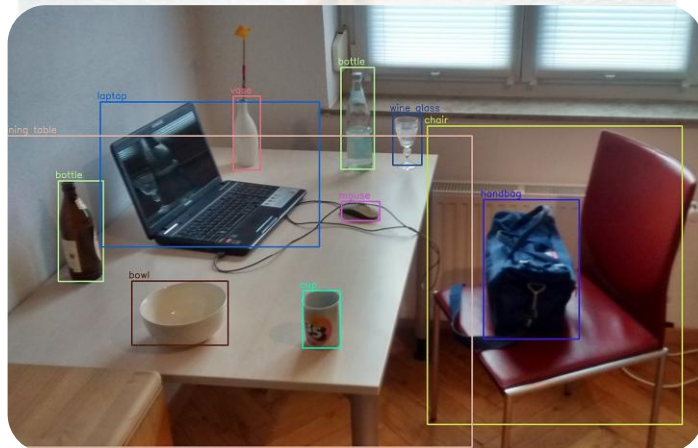
Different Forms of Generative AI

Vision Language Model (VLM)



A dog sitting on a rock in front of a lake

Image Captioning



Object Detection with Contextualization



Visual Question - Answer

See the image and tell me the total bill amount?



The total bill amount in the image is ₹5795.00.

<https://openai.com/index/sora/>



Visual Question Answering

what is this image all about, could you please describe this



This image depicts a bear, a lion, and a rabbit sitting together in a lush forest setting. The animals appear to be engaged in a calm, almost conversational moment, with the bear and lion looking at each other and the rabbit sitting attentively. The scene has a surreal, storybook quality, as these animals are not typically found interacting peacefully in nature, especially in a forest environment. The greenery and tall trees in the background create a serene, woodland atmosphere, adding to the feeling of a fantastical or symbolic meeting among the animals.

This type of imagery is often used to convey messages about harmony, unity, or storytelling, where animals of different species gather as characters with human-like qualities.

could you tell me the color of the rabbit and where it is in the image?



The rabbit in the image is light gray with hints of white, and it has large pinkish ears. It is positioned in the lower left area of the image, sitting on the ground in front of a log, close to the bear and lion. The rabbit appears to be looking up toward the bear and lion, as if it's part of their "conversation" or interaction.

Different Forms of Generative AI

Audio Language Model (ALM)

- **Speech Recognition (Speech to Text):**
 - ALMs can transcribe spoken language into text by converting audio signals into text data.
 - Example: Voice assistants like Siri and Alexa use speech recognition to understand and respond to spoken commands, such as "What's the weather today?"
- **Speech Synthesis (Text-to-Speech):**
 - ALMs can convert written text into spoken audio that sounds natural.
 - Example: E-book readers or accessibility tools read out text from an article or document to users with a natural voice, enhancing accessibility.
- **Emotion Detection:**
 - ALMs can detect emotions or sentiments in audio, helping understand the speaker's mood.
 - Example: In customer service calls, emotion detection helps identify if a customer sounds frustrated or satisfied, aiding in personalized responses.
- **Speaker Identification:**
 - ALMs can distinguish between and recognize different speakers based on voice characteristics.
 - Example: In a meeting transcription, the model can identify each speaker by their voice, making it easier to attribute statements to the correct person.

<https://suno.com/about>

Autonomous Agents

What are Autonomous Agents?

Autonomous Agents are self-directed entities that can perceive, reason, and act in an environment to achieve goals — without constant human input.

Core Characteristics:

- Autonomy – Operate independently
- Perception – Observe environment and internal state
- Reasoning – Plan and decide based on goals
- Action – Interact with the world (and sometimes with humans or other agents)
- Adaptation – Learn and improve over time.

Real-World Analogies:

- A Roomba that cleans rooms intelligently
- ChatGpt, that helps in coding, search, plot, documentation, etc.
- An AI intern that schedules meetings, sends emails, and summarizes reports

Autonomous Agents

Relation to RL and Generative AI

Field	Role in Autonomous Agents
Reinforcement Learning (RL)	Helps agents learn from experience through rewards (e.g., navigating environments, decision-making).
Generative AI	Enables agents to generate language, code, images, or actions (e.g., drafting emails, writing code, creating plans).

Examples of Autonomous Agents in Action:

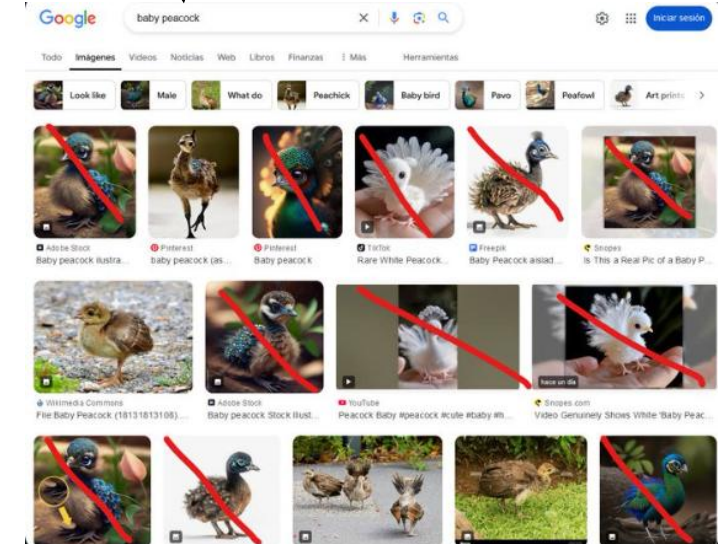
- AutoGPT – Executes multi-step goals using tools & memory
- BabyAGI – Iteratively creates, prioritizes, and executes tasks toward a goal
- CrewAI – Assigns specialized agents as a collaborative team (e.g., researcher, writer, planner)

Ethical and Societal Challenges

Ethical Considerations

Ethics plays a crucial role in generative AI. The major concerns include:⁹

- Deepfakes: AI-generated deepfakes pose risks in terms of misinformation, fraud, and privacy violations.
- Copyright Issues: AI-generated content can blur the lines between original works and derivative pieces, raising questions about intellectual property rights.
- Impact on Jobs: As generative AI automates creative processes, it may disrupt industries like art, writing, and design, leading to potential job displacement.



Ethical and Societal Challenges

Technical Challenges

- Bias in Training Data
 - Leads to unfair or inaccurate outputs
- Explainability / Interpretability
 - Black-box models hard to understand
- Generalization
 - Models overfit and fail in real-world scenarios
- Data Scarcity / Quality
 - Garbage in = garbage out
- Energy Consumption
 - Large models = high carbon footprint
- Robustness
 - Vulnerable to adversarial attacks or noisy inputs

Ethical and Societal Challenges

Governance & Regulation

- Lack of global standards and AI policies
- Difficulty enforcing responsible AI practices
- Race for AI dominance without safety constraints

Thanks for
your time

Next Session

LLM Ecosystem and Evaluation

- What is an LLM and How It Works
- Popular LLMs and Benchmarks
- LLM Tooling and Applications
- Evaluation Metrics:
 - Accuracy
 - Precision
 - Recall
 - F1-score
 - Confusion matrix interpretation
 - ROC-AUC for binary classifiers
 - BLEU Score
 - ROUGE for language models, Perplexity (LLM-specific)