Chapter 1:
Intro to Artificial Intelligence

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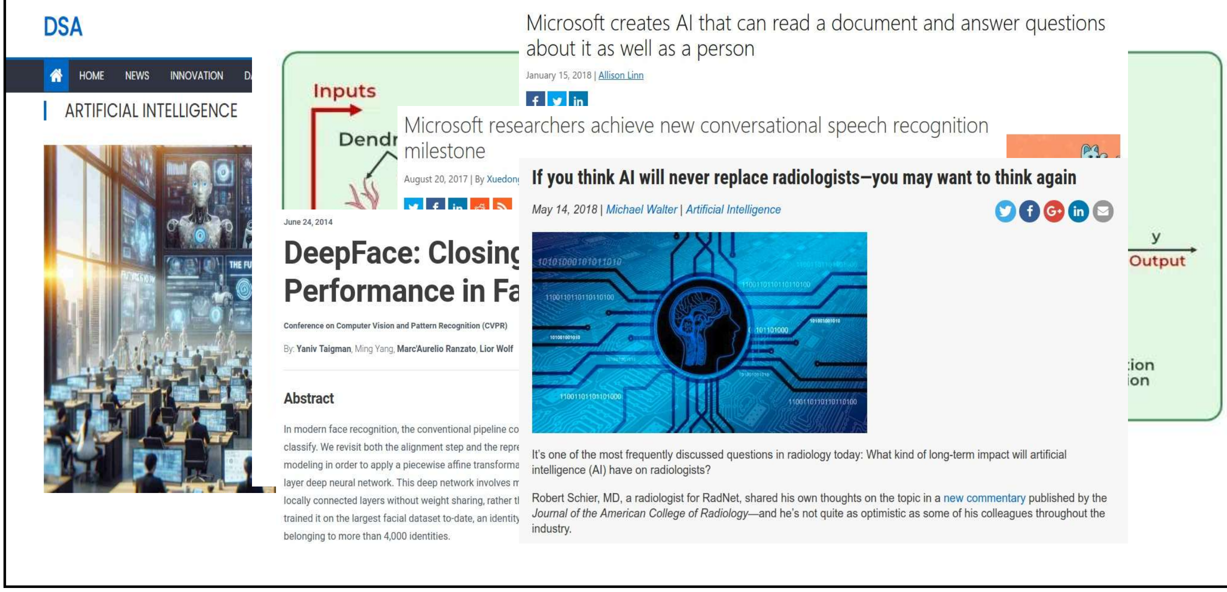
Contents

- Introduction to Artificial Intelligence (AI)
- The Foundations of AI
- History of AI
- Approaches
- Conclusion

Introduction to Artificial Intelligence



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ARTIFICIAL INTELLIGENCE

Microsoft creates AI that can read a document and answer questions about it as well as a person

January 15, 2018 | Allison Linn

Microsoft researchers achieve new conversational speech recognition milestone

August 20, 2017 | By Xuedong

June 24, 2014

DeepFace: Closing Performance in Fa

Conference on Computer Vision and Pattern Recognition (CVPR)

By: Yaniv Taigman, Ming Yang, Marc'Aurelio Ranzato, Lior Wolf

Abstract

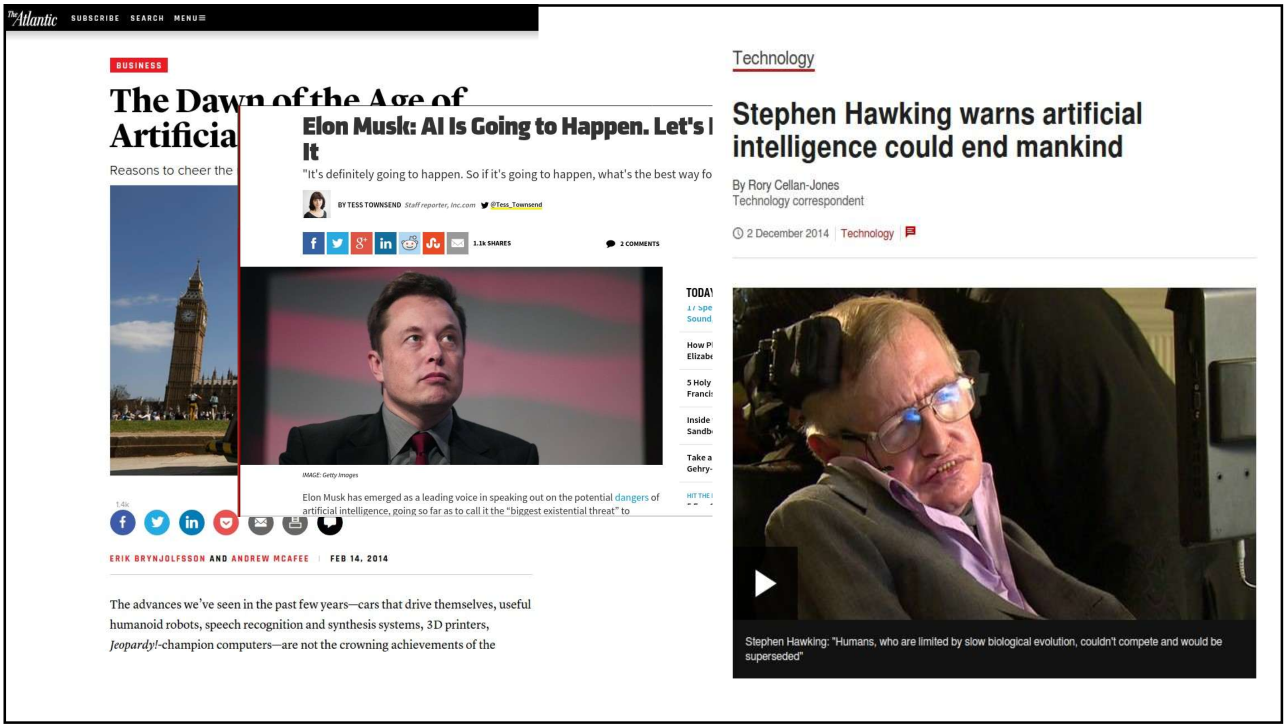
In modern face recognition, the conventional pipeline co classify. We revisit both the alignment step and the repre modeling in order to apply a piecewise affine transforma layer deep neural network. This deep network involves m locally connected layers without weight sharing, rather t trained it on the largest facial dataset to-date, an identity belonging to more than 4,000 identities.

If you think AI will never replace radiologists—you may want to think again

May 14, 2018 | Michael Walter | Artificial Intelligence

It's one of the most frequently discussed questions in radiology today: What kind of long-term impact will artificial intelligence (AI) have on radiologists?

Robert Schier, MD, a radiologist for RadNet, shared his own thoughts on the topic in a new commentary published by the *Journal of the American College of Radiology*—and he's not quite as optimistic as some of his colleagues throughout the industry.



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BUSINESS

The Dawn of the Age of Artificia

Reasons to cheer the

1.4k

ERIK BRYNJOLFSSON AND ANDREW MCAFEE | FEB 14, 2014

The advances we've seen in the past few years—cars that drive themselves, useful humanoid robots, speech recognition and synthesis systems, 3D printers, *Jeopardy!*-champion computers—are not the crowning achievements of the

Elon Musk: AI Is Going to Happen. Let's I It

"It's definitely going to happen. So if it's going to happen, what's the best way fo

BY TESS TOWNSEND *Staff reporter, Inc.com* @Tess_Townsend

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IMAGE: Getty Images

Elon Musk has emerged as a leading voice in speaking out on the potential dangers of artificial intelligence, going so far as to call it the "biggest existential threat" to

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Technology

Stephen Hawking warns artificial intelligence could end mankind

By Rory Cellan-Jones
Technology correspondent

2 December 2014 | Technology

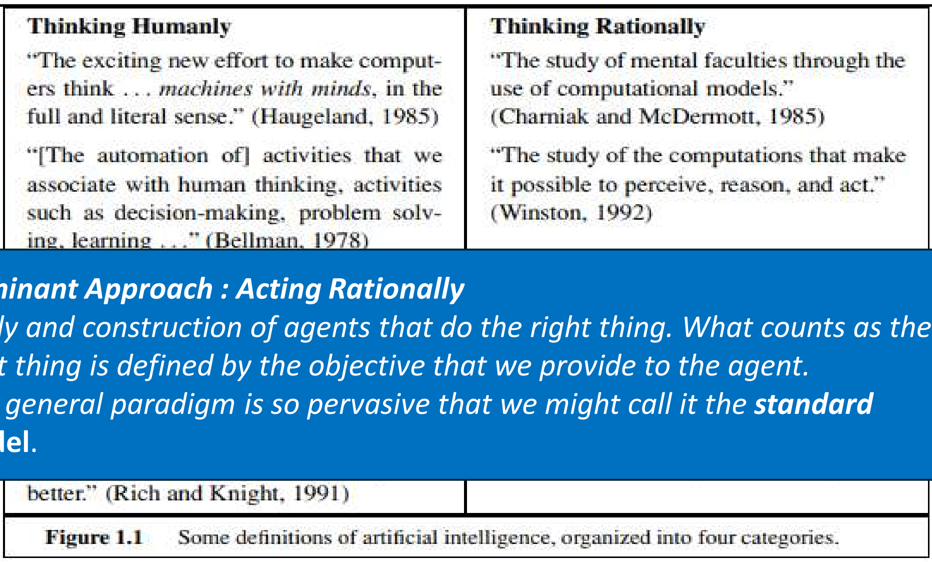
Stephen Hawking: "Humans, who are limited by slow biological evolution, couldn't compete and would be superseded"

What is AI?

“The area of computer science that studies how machines can perform tasks that would normally require a sentient agent.“

It could be argued from such a definition that something as simple as a computer multiplying two numbers is "artificial intelligence." This is because we have designed a machine capable of taking an input and independently producing a logical output that usually would require a living entity to process.

A more skeptical definition might be more narrow, for example: **"the area of computer science that studies how machines can closely imitate human intelligence."** From such definition skeptics may argue that what we have today is not artificial intelligence.



Thinking Humanly	Thinking Rationally
“The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense.” (Haugeland, 1985) “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . .” (Bellman, 1978)	“The study of mental faculties through the use of computational models.” (Charniak and McDermott, 1985) “The study of the computations that make it possible to perceive, reason, and act.” (Winston, 1992)

better.” (Rich and Knight, 1991)

Figure 1.1 Some definitions of artificial intelligence, organized into four categories.

Dominant Approach : Acting Rationally

Study and construction of agents that do the right thing. What counts as the right thing is defined by the objective that we provide to the agent.

*This general paradigm is so pervasive that we might call it the **standard model**.*

"Artificial Intelligence (AI) is the simulation of human intelligence in machines that are programmed to think and act like humans." – *Russell & Norvig*

Key Aspects of AI:

1. **Perception:** Understanding the environment (e.g., Computer Vision, Speech Recognition).
2. **Reasoning:** Logical decision-making (e.g., Expert Systems).
3. **Learning:** Improving performance over time (e.g., Machine Learning).
4. **Interaction:** Communicating with users (e.g., Chatbots, Virtual Assistants).

Examples:

- Virtual assistants like Siri or Alexa understanding voice commands.
- AI-powered fraud detection in banking using transaction analysis.

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Why do we need to study AI?

- AI can impact every aspect of our lives. The field of AI tries to understand patterns and behaviors of entities. With AI, we want to build smart systems and understand the concept of intelligence as well. The intelligent systems that we construct are very useful in understanding how an intelligent system like our brain goes about constructing another intelligent system.
- Compared to some other fields such as mathematics or physics that have been around for centuries, AI is relatively in its infancy. Over the last couple of decades, AI has produced some spectacular products such as self-driving cars and intelligent robots that can walk. Based on the direction in which we are heading, it's obvious that achieving intelligence will have a great impact on our lives in the coming years.

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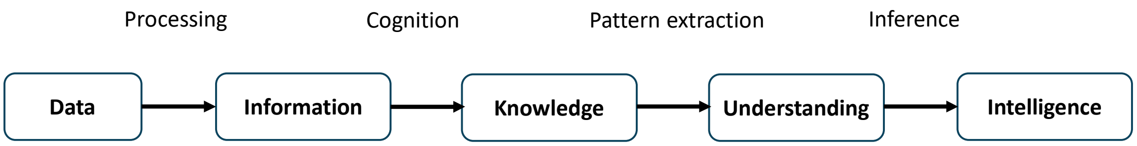
Conversion of Data into Intelligence



- **For example**, a restaurant collects data from every customer order. That information may be analyzed to produce knowledge that is put to use when the business subsequently wants to identify the most popular or least popular dish. This will eventually be used for decision-making in the final step.

One of the main reasons we want to study AI is to automate things. We live in a world where:

- We deal with huge amounts of data. The human brain can't keep track of so much data.
- Data originates from multiple sources simultaneously. The data is unorganized and chaotic.
- Knowledge derived from this data must be updated constantly because the data itself keeps changing.
- The sensing and actuation must happen in real-time with high precision.

Even though the human brain is great at analyzing things around us, it cannot keep up with the preceding conditions. Hence, we need to design and develop intelligent machines that can do this. We need AI systems that can:

- Handle large amounts of data in an efficient way. With the advent of Cloud Computing, we are now able to store huge amounts of data.
- Ingest data simultaneously from multiple sources without any lag. Index and organize data in a way that allows us to derive insights.
- Learn from new data and update constantly using the right learning algorithms. Think and respond to situations based on the conditions in real time.
- Continue with tasks without getting tired or needing breaks.

Branches of AI

- Supervised learning vs. unsupervised learning vs. reinforcement learning
- Artificial general intelligence vs. narrow intelligence

By human function:

- Machine vision
- Machine learning
- Natural language processing
- Natural language generation

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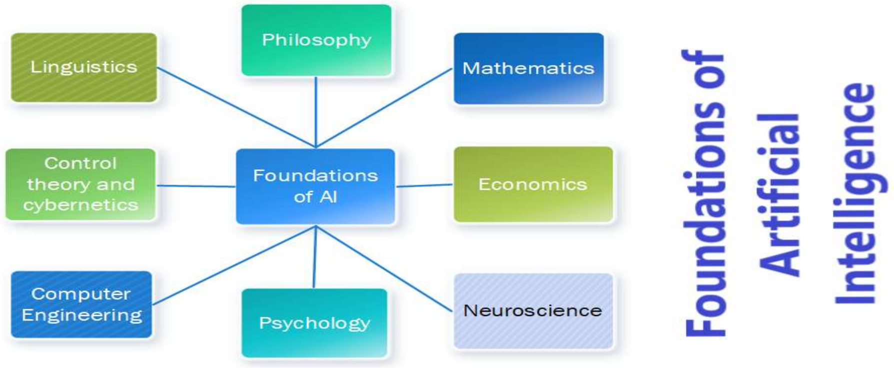
The Foundations of AI



In this section, we see the disciplines that contributed ideas, viewpoints, and techniques to AI. Like any history, this one is forced to concentrate on a small number of people, events, and ideas and to ignore others that also were important.

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Philosophy

- Can formal rules be used to draw valid conclusions?
- How does the mind arise from a physical brain?
- Where does knowledge come from?
- How does knowledge lead to action?

Ethics in AI, Privacy, Right and Wrong

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Mathematics

- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

Probability, statistics, linear algebra (used in ML algorithms).

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Economics

- How should we make decisions so as to maximize payoff?
- How should we do this when others may not go along?
- How should we do this when the payoff may be far in the future?

Trading through artificial intelligence

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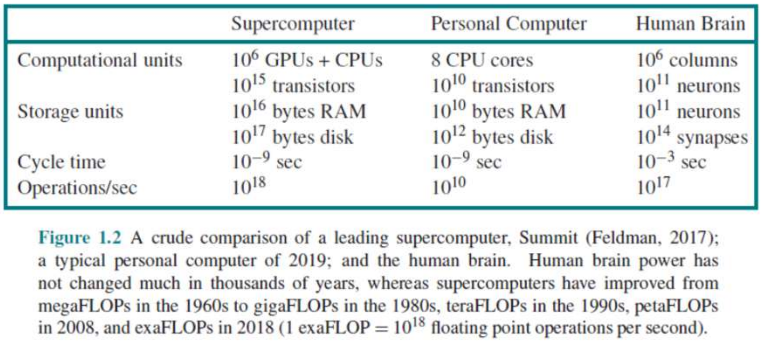
Neuroscience

- How does brain processes information?



	Supercomputer	Personal Computer	Human Brain
Computational units	10^6 GPUs + CPUs 10^{15} transistors	8 CPU cores 10^{10} transistors	10^6 columns 10^{11} neurons
Storage units	10^{16} bytes RAM 10^{17} bytes disk	10^{10} bytes RAM 10^{12} bytes disk	10^{11} neurons 10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{18}	10^{10}	10^{17}

Figure 1.2 A crude comparison of a leading supercomputer, Summit (Feldman, 2017); a typical personal computer of 2019; and the human brain. Human brain power has not changed much in thousands of years, whereas supercomputers have improved from megaFLOPs in the 1960s to gigaFLOPs in the 1980s, teraFLOPs in the 1990s, petaFLOPs in 2008, and exaFLOPs in 2018 (1 exaFLOP = 10^{18} floating point operations per second).

Brain-inspired neural networks for learning

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Cognitive Psychology & Computer engineering

- How do humans and animals think and act?
- How can we build an efficient computer?

Understanding human intelligence to replicate it.

Algorithms, data structures, and computation power.

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Linguistics

- How does language relate to thought?

Natural language processing (NLP) for understanding human speech.

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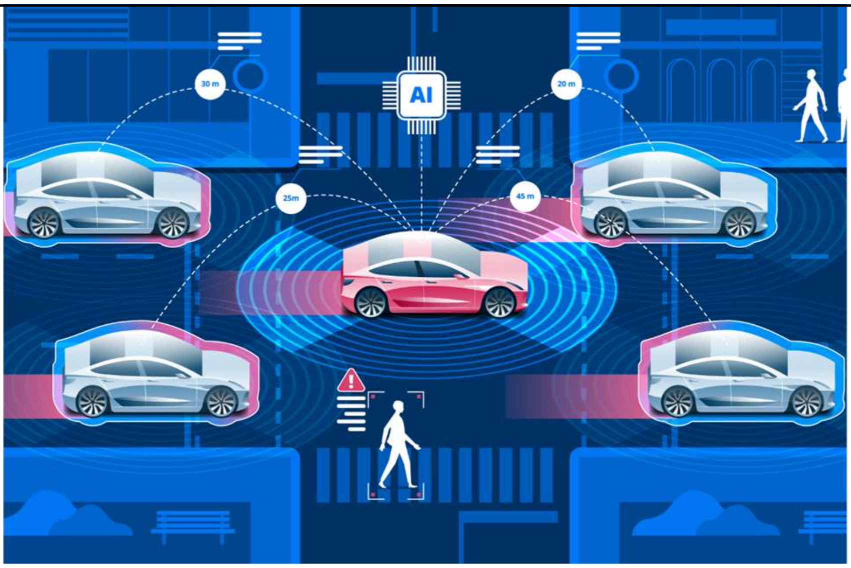

AI in **autonomous vehicles** relies on mathematics (sensor fusion), computer vision (image processing), and cognitive science (decision-making).

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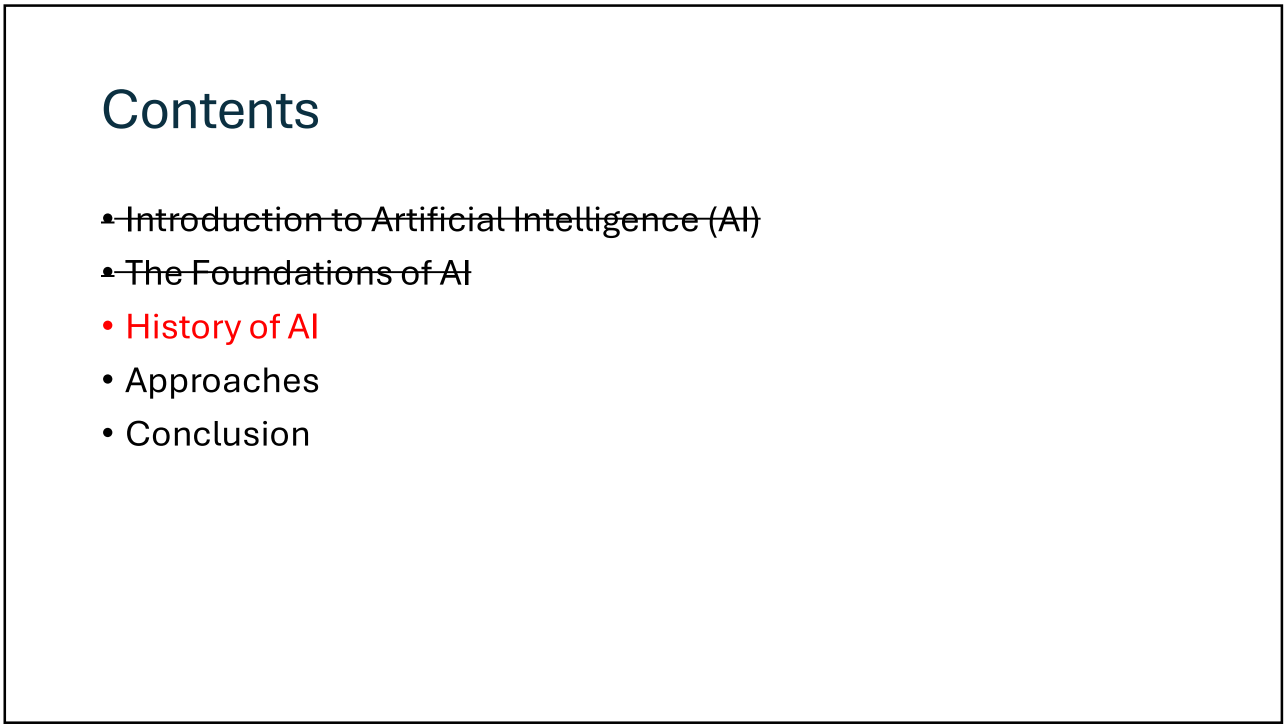

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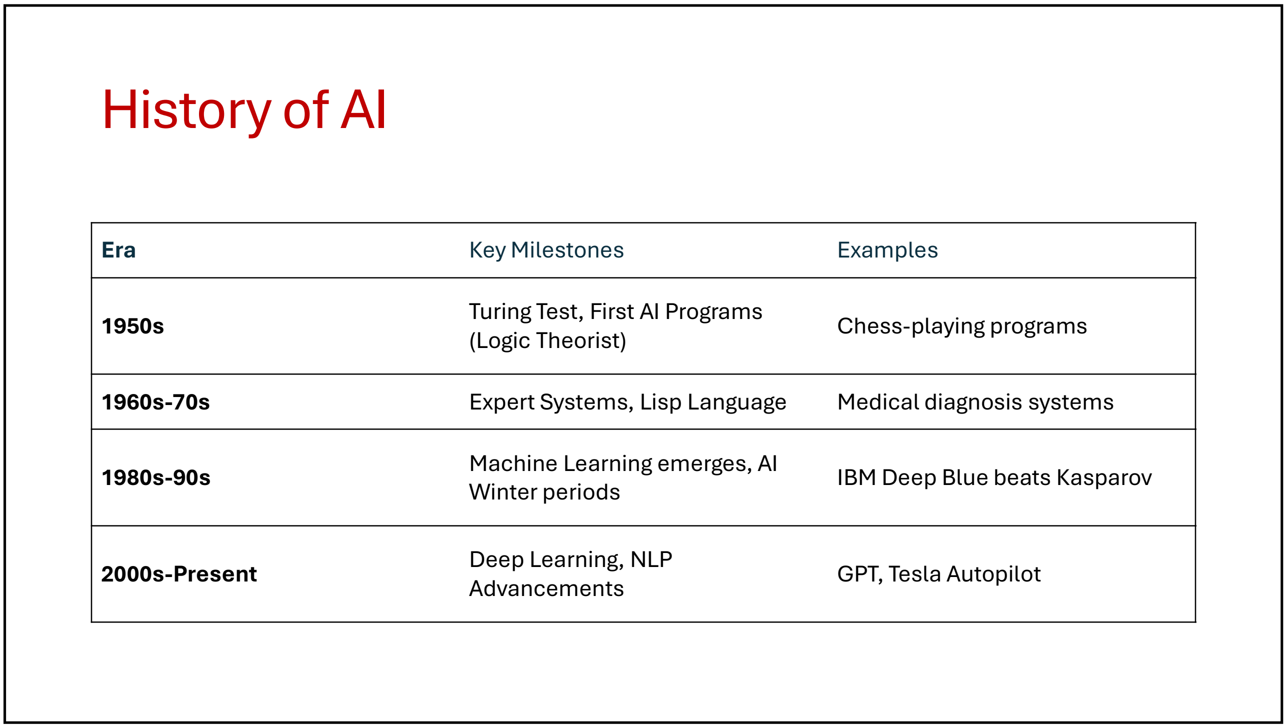

History of AI

Era	Key Milestones	Examples
1950s	Turing Test, First AI Programs (Logic Theorist)	Chess-playing programs
1960s-70s	Expert Systems, Lisp Language	Medical diagnosis systems
1980s-90s	Machine Learning emerges, AI Winter periods	IBM Deep Blue beats Kasparov
2000s-Present	Deep Learning, NLP Advancements	GPT, Tesla Autopilot

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Important Events

- **1950:** Alan Turing proposes the Turing Test.

Computer scientist and mathematician, Alan Turing, proposed the Turing test to provide a definition of intelligence. It is a test to see if a computer can learn to mimic human behavior. He defined intelligent behavior as the ability to achieve human-level intelligence during a conversation. This performance should be enough to trick an interrogator into thinking that the answers are coming from a human. To see if a machine can do this, he proposed a test setup: he proposed that a **human should interrogate the machine through a text interface.** Another constraint is that the human cannot know who's on the other side of the interrogation, which means it can either be a machine or a human. To enable this setup, a human will be interacting with two entities through a text interface. These two entities are called respondents. One of them will be a human and the other one will be the machine

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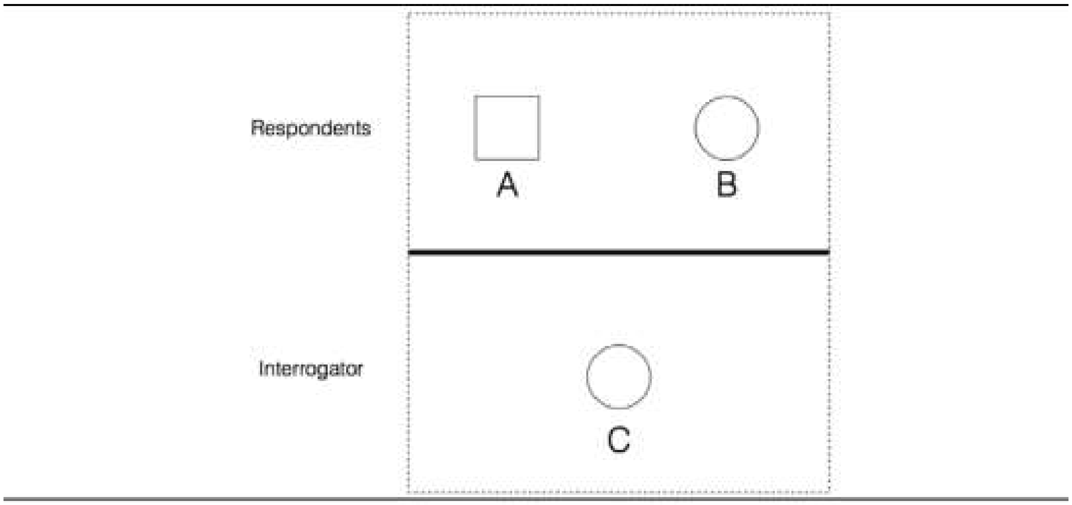

Figure 5: The Turing Test

The respondent machine passes the test if the interrogator is unable to tell whether the answers are coming from a machine or a human.

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- As you can imagine, this is quite a difficult task for the respondent machine. There are a lot of things going on during a conversation. At the very minimum, the machine needs to be well versed with the following things:
- **Natural language processing:** The machine needs this to communicate with the interrogator. The machine needs to parse the sentence, extract the context, and give an appropriate answer.
- **Knowledge representation:** The machine needs to store the information provided before the interrogation. It also needs to keep track of the information being provided during the conversation so that it can respond appropriately if it comes up again.
- **Reasoning:** It's important for the machine to understand how to interpret the information that gets stored. Humans tend to do this automatically in order to draw conclusions in real time.
- **Machine learning:** This is needed so that the machine can adapt to new conditions in real time. The machine needs to analyze and detect patterns so that it can draw inferences. You must be wondering why the human is communicating with a text interface. According to Turing, physical simulation of a person is unnecessary for intelligence. That's the reason the Turing test avoids direct physical interaction between the human and the machine

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1956: The Dartmouth Conference - birth of AI as a field.

Workshop at Dartmouth College; attendees: John McCarthy, Marvin Minsky, Claude Shannon, etc.

- Aim for general principles:

“Proposal was that every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it.”

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Overwhelming optimism…

- *Machines will be capable, within twenty years, of doing any work a man can do* —**Herbert Simon**
- *Within 10 years the problems of artificial intelligence will be substantially solved* —**Marvin Minsky**
- *I visualize a time when we will be to robots what dogs are to humans, and I'm rooting for the machines* —**Claude Shannon**

What went wrong? It turns out that the real world is very complex and most AI problems require a lot of **compute** and **data**. The hardware at the time was simply too limited both compared to the human brain and computers available now. Also, casting problems as general logical reasoning meant that the approaches fell prey to the exponential search space, which no possible amount of compute could really fix.

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Knowledge-based systems (70-80s)

- Expert systems: elicit specific domain knowledge from experts in form of rules:
  - `if [premises] then [conclusion]`

In the seventies and eighties, AI researchers looked to knowledge as a way to combat both the limited computation and information problems. If we could only figure out a way to encode prior knowledge in these systems, then they would have the necessary information and also have to do less compute.

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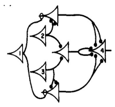
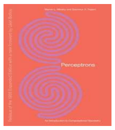
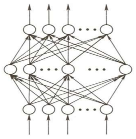
Artificial neural networks



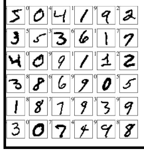
1943: introduced artificial neural networks, connect neural circuitry and logic (McCulloch/Pitts)



1969: Perceptrons book showed that linear models could not solve XOR, killed neural nets research (Minsky/Papert)



1986: Popularization of backpropagation for training multi-layer networks (Rumelhardt, Hinton, Williams)



1989: applied convolutional neural networks for recognizing handwritten digits for USPS (LeCun)

Deep learning

- AlexNet (2012): Huge gains in object recognition; transformed computer vision community overnight
- AlphaGo (2016): Deep reinforcement-learning, world champion Lee Sedol

History in a nutshell

- The gestation of artificial intelligence (1943–1955)
- The birth of artificial intelligence (1956)
- Early enthusiasm, great expectations (1952–1969)
- A dose of reality (1966–1973)
- Knowledge-based systems: The key to power? (1969–1979)
- AI becomes an industry (1980–present)
- The return of neural networks (1986–present)
- AI adopts the scientific method (1987–present)
- The emergence of intelligent agents (1995–present)
- The availability of very large data sets (2001–present)

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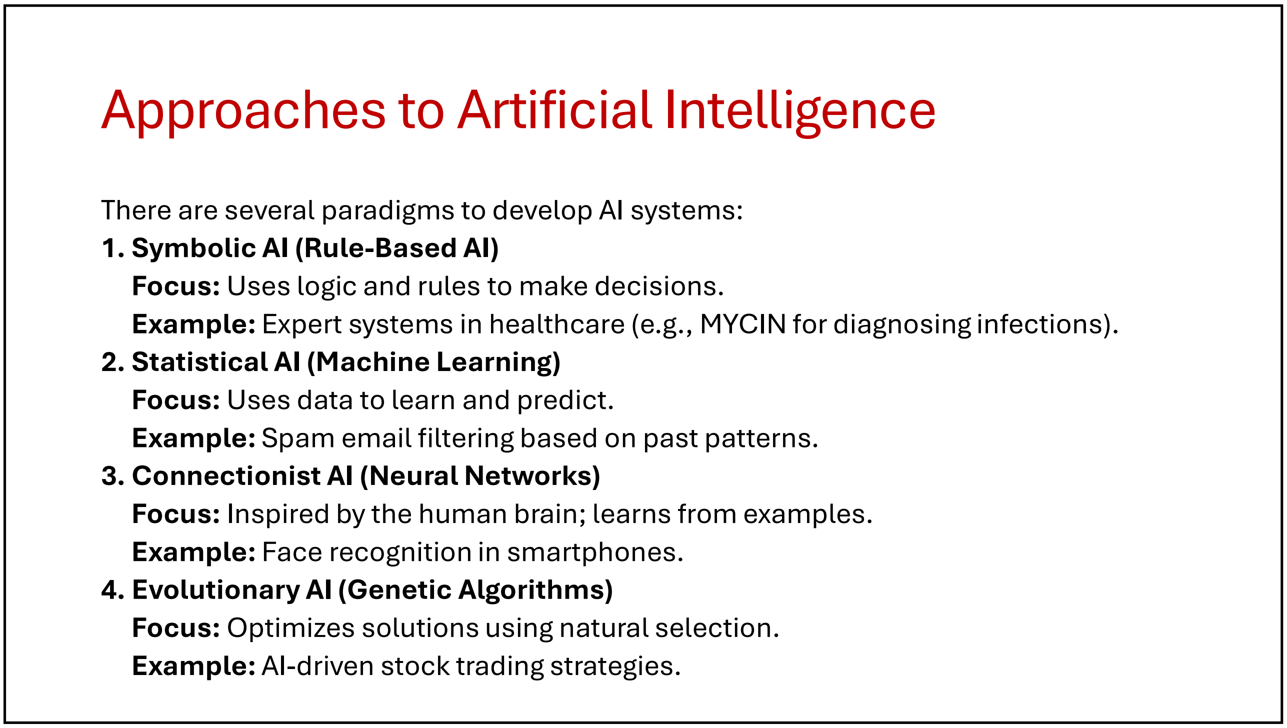

Approaches to Artificial Intelligence

There are several paradigms to develop AI systems:

1. **Symbolic AI (Rule-Based AI)**
   Focus: Uses logic and rules to make decisions.
   Example: Expert systems in healthcare (e.g., MYCIN for diagnosing infections).
2. **Statistical AI (Machine Learning)**
   Focus: Uses data to learn and predict.
   Example: Spam email filtering based on past patterns.
3. **Connectionist AI (Neural Networks)**
   Focus: Inspired by the human brain; learns from examples.
   Example: Face recognition in smartphones.
4. **Evolutionary AI (Genetic Algorithms)**
   Focus: Optimizes solutions using natural selection.
   Example: AI-driven stock trading strategies.

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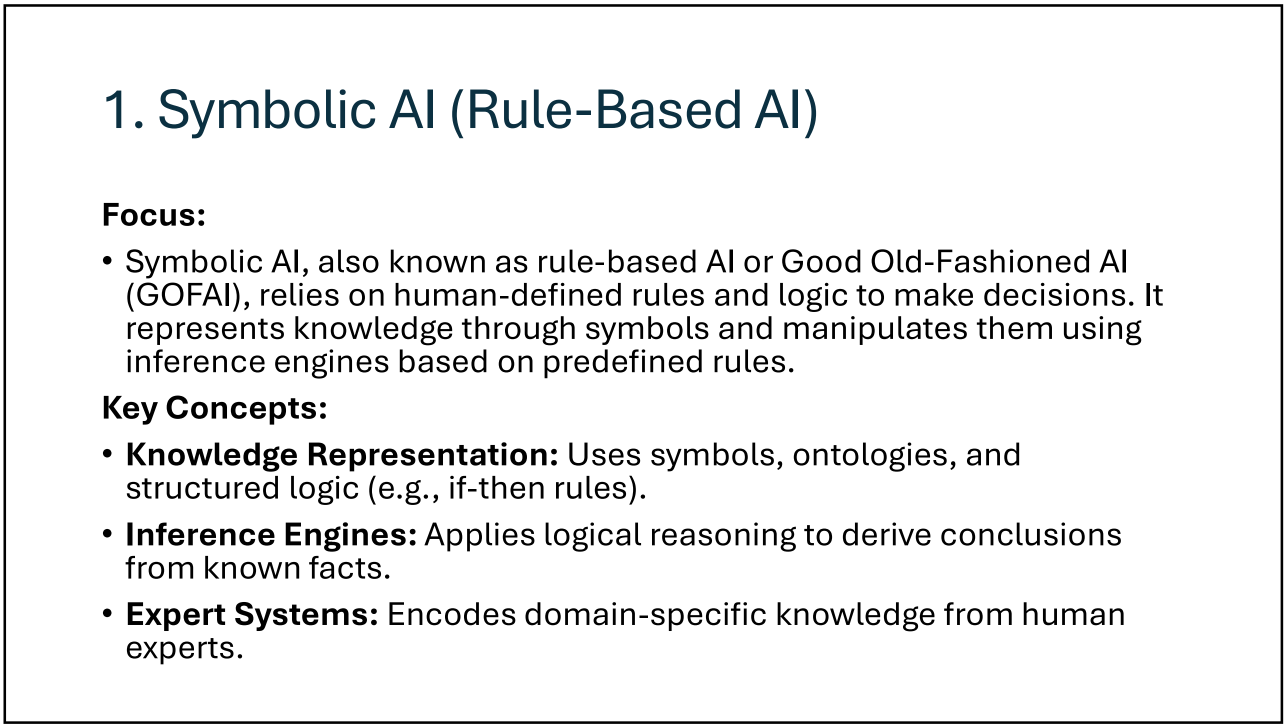

1. Symbolic AI (Rule-Based AI)

Focus:

- Symbolic AI, also known as rule-based AI or Good Old-Fashioned AI (GOFAI), relies on human-defined rules and logic to make decisions. It represents knowledge through symbols and manipulates them using inference engines based on predefined rules.

Key Concepts:

- **Knowledge Representation:** Uses symbols, ontologies, and structured logic (e.g., if-then rules).
- **Inference Engines:** Applies logical reasoning to derive conclusions from known facts.
- **Expert Systems:** Encodes domain-specific knowledge from human experts.

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Symbolic AI

Advantages

- Transparent decision making
- Easy to explain and debug
- Works well in structured environments with clear rules
- High precision in domains with well defined processed

Challenges

- Struggles with ambiguity and uncertainty
- Difficult to scale for complex, real world problems
- Requires extensive manual rule formation

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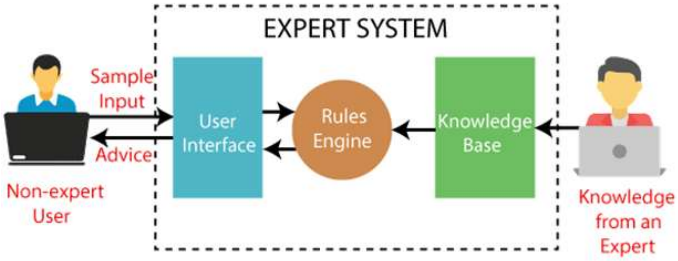
Example Use Case:



Healthcare Expert Systems (e.g., MYCIN)
MYCIN was an early AI system that diagnosed bacterial infections based on patient symptoms and prescribed antibiotics based on expert-defined rules. It worked by asking questions and applying inference rules to determine potential treatments.

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2. Statistical AI (Machine learning)

Focus:

- Statistical AI leverages large amounts of data to identify patterns and make predictions without explicit programming. It uses mathematical models to analyze relationships between data points and generalize to unseen instances.

Key Concepts:

- **Supervised Learning:** Learns from labeled data (e.g., spam classification).
- **Unsupervised Learning:** Identifies patterns in unlabeled data (e.g., customer segmentation).
- **Reinforcement Learning:** Learns through trial and error using rewards (e.g., game-playing bots).
- **Probabilistic Models:** Uses statistical techniques like Bayesian networks.

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Statistical AI

Advantages:

•Scales well with big data and complex patterns.

•Adaptable to various domains with different data types.

•Can continuously improve with new data (self-learning).

Challenges:

•Requires large datasets and computational resources.

•Model interpretability can be challenging (black-box behavior).

•Data quality significantly impacts performance.

•Examples: Decision Trees, Support vector machines etc

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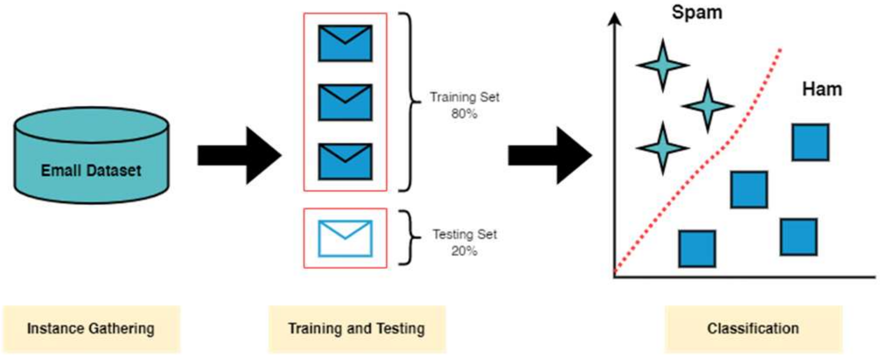
Example Use Case:



Spam Email Filtering
Email services use machine learning algorithms to classify emails as spam or not based on patterns in previous data, such as words used in the message, sender reputation, and metadata features.

3. Connectionist AI (Neural Networks)

Focus:

- Connectionist AI, based on artificial neural networks (ANNs), is inspired by the workings of the human brain. It consists of interconnected layers of artificial neurons that process information through weighted connections.

Key Concepts:

- **Deep Learning:** Multi-layered neural networks (e.g., CNNs for image processing, RNNs for sequential data).
- **Backpropagation:** A training method to adjust weights based on errors.
- **Activation Functions:** Introduce non-linearity (e.g., ReLU, Sigmoid).
- **Transfer Learning:** Leveraging pre-trained models for different tasks.

Connectionist AI

Advantages

- Excels at tasks requiring pattern recognition like speech and vision
- Can generalize well with enough training data
- End to end learning without manual feature extraction

Challenges

- Computationally expensive training and inference
- Requires large labeled datasets to perform well
- Difficult to interpret and troubleshoot

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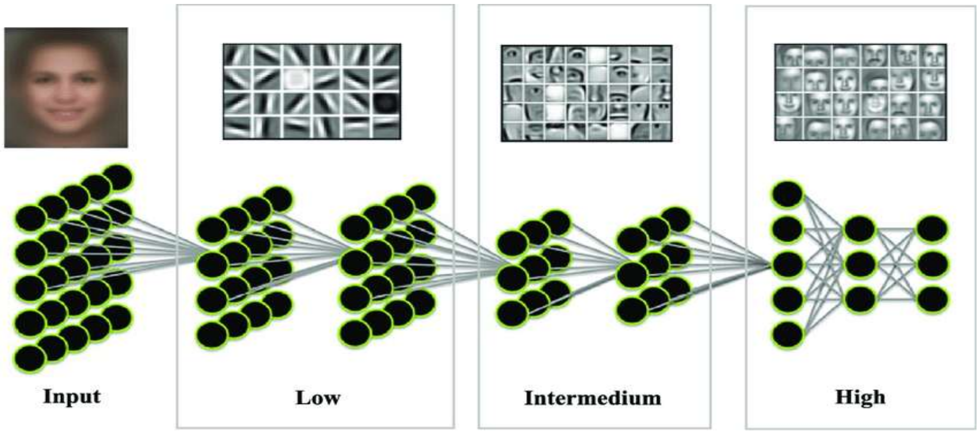
Example Use Case:



Face Recognition in Smartphones
Deep learning-based neural networks analyze facial features such as eyes, nose, and mouth position to unlock smartphones securely.

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4. Evolutionary AI (Genetic Algorithms)

Focus:

- Evolutionary AI is inspired by biological evolution and natural selection. It optimizes solutions iteratively by evolving populations of potential solutions through mechanisms like mutation, crossover, and selection.

Key Concepts:

- **Genetic Algorithms (GA):** Mimics evolution through selection and mutation.
- **Fitness Function:** Evaluates how well a solution performs.
- **Selection Mechanisms:** Chooses the best-performing individuals for reproduction.
- **Mutation & Crossover:** Introduces diversity and combines features of parent solutions.

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Evolutionary AI

Advantages:

- Effective for optimization problems without clear solutions.
- Can handle complex, non-linear problems.
- Does not require gradient-based optimization.

Challenges:

- Computationally expensive due to large solution space.
- Convergence to optimal solutions can be slow.
- Requires careful tuning of evolutionary parameters.

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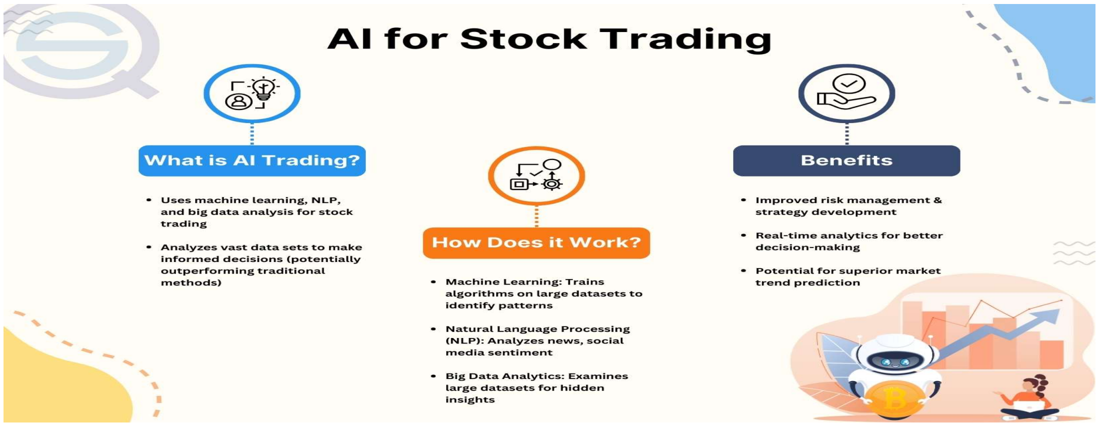
Example Use Case:



AI for Stock Trading

What is AI Trading?

- Uses machine learning, NLP, and big data analysis for stock trading
- Analyzes vast data sets to make informed decisions (potentially outperforming traditional methods)

How Does it Work?

- Machine Learning: Trains algorithms on large datasets to identify patterns
- Natural Language Processing (NLP): Analyzes news, social media sentiment
- Big Data Analytics: Examines large datasets for hidden insights

Benefits

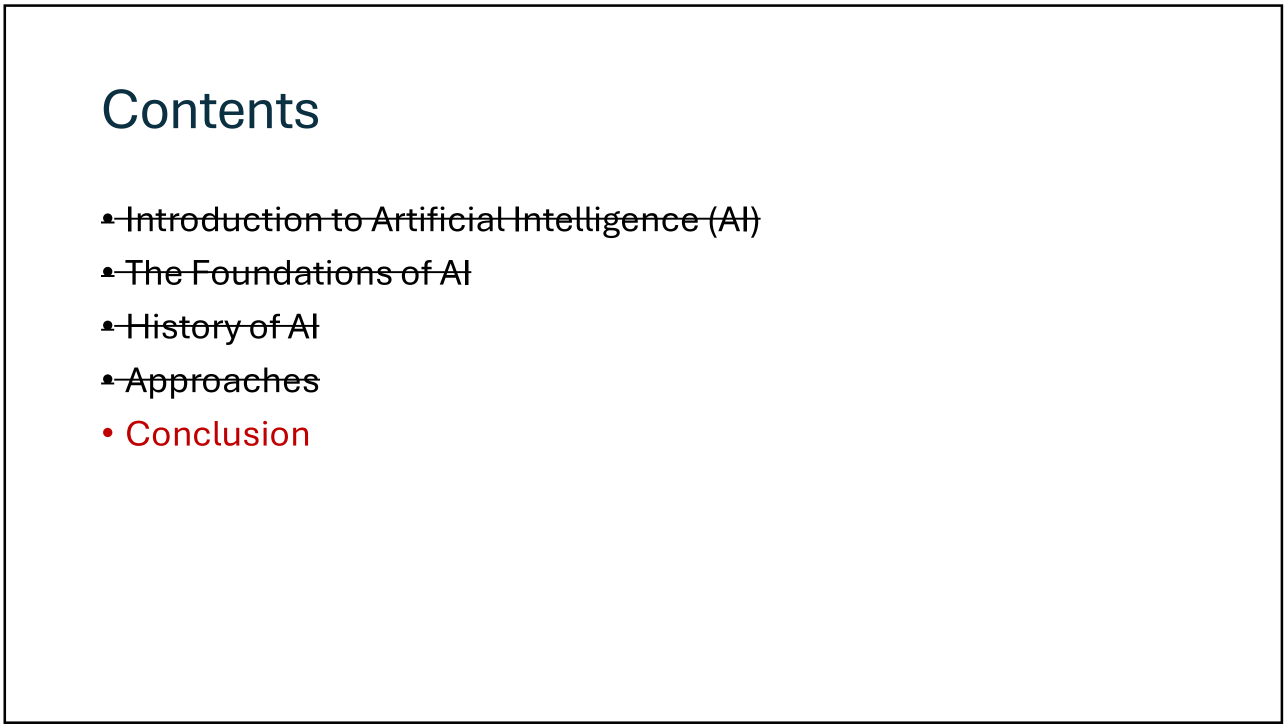
- Improved risk management & strategy development
- Real-time analytics for better decision-making
- Potential for superior market trend prediction

AI-Driven Stock Trading Strategies

Genetic algorithms are used to evolve trading strategies by selecting the best-performing rules and improving them through iteration, optimizing for profit and risk management.

Comparison of AI Paradigms

Feature	**Symbolic AI**	**Statistical AI**	**Connectionist AI**	**Evolutionary AI**
Approach	Rule-based	Data-driven	Brain-inspired	Nature-inspired
Learning Type	No learning	Supervised/Unsupervised	Deep learning	Evolutionary
Strengths	Explainability	Generalization	Pattern recognition	Optimization
Weaknesses	Scalability	Data dependency	Black-box nature	Computational cost
Example	Expert systems	Spam filters	Face recognition	Stock trading



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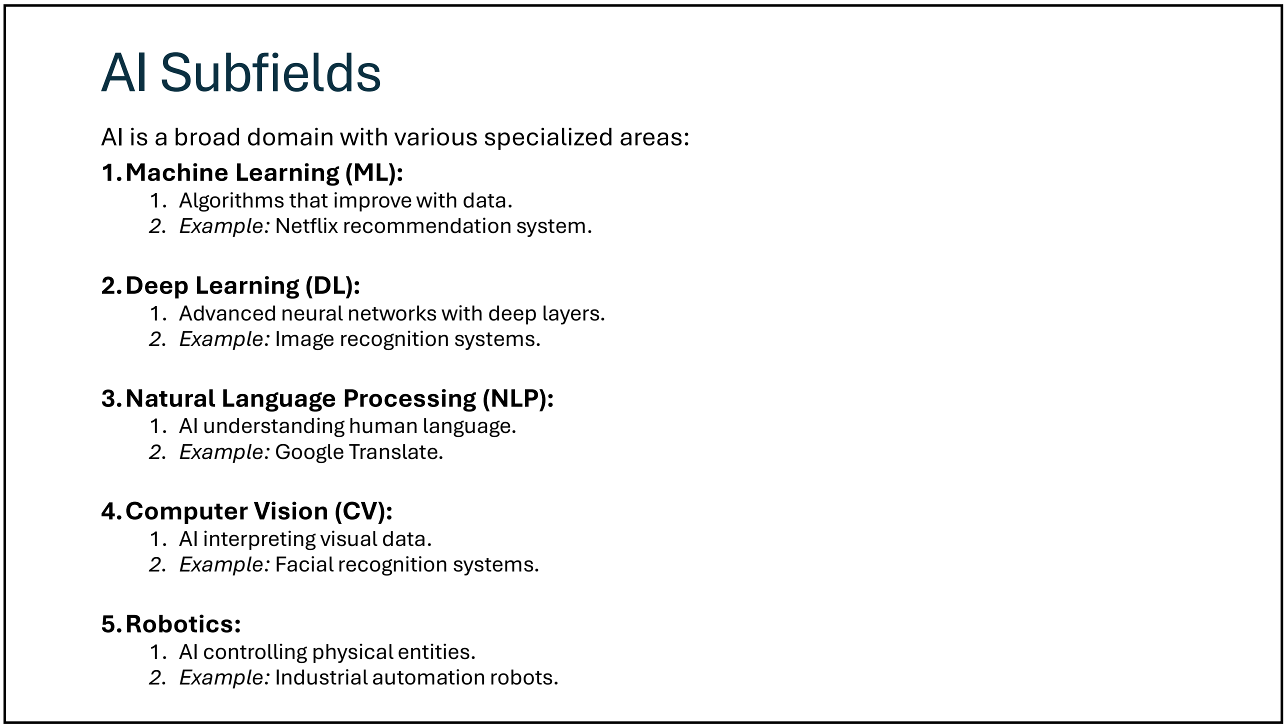

AI Subfields

AI is a broad domain with various specialized areas:

1. **Machine Learning (ML):**
   1. Algorithms that improve with data.
   2. *Example:* Netflix recommendation system.
2. **Deep Learning (DL):**
   1. Advanced neural networks with deep layers.
   2. *Example:* Image recognition systems.
3. **Natural Language Processing (NLP):**
   1. AI understanding human language.
   2. *Example:* Google Translate.
4. **Computer Vision (CV):**
   1. AI interpreting visual data.
   2. *Example:* Facial recognition systems.
5. **Robotics:**
   1. AI controlling physical entities.
   2. *Example:* Industrial automation robots.

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AI Applications

Industry	**Applications**
Healthcare	Disease diagnosis, drug discovery
Finance	Fraud detection, automated trading
Retail	Personalized recommendations
Autonomous Systems	Self-driving cars, drones
Security	Cyber threat detection

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Challenges in AI

- **Technical Challenges:**
- Data privacy and security.
- Model interpretability (black-box models).
- High computational power requirements.
- Adversarial attacks tricking AI models.

- **Ethical and Societal Challenges:**
- Job displacement due to automation.
- Bias and fairness issues in AI decisions.
- Misuse of AI in surveillance and misinformation.
- AI bias in hiring decisions.

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Future of AI

Emerging Trends:

1. **Explainable AI (XAI):** Making AI decisions more transparent.
2. **General AI:** Towards AI with human-like cognitive abilities.
3. **AI Ethics:** Developing guidelines for responsible AI usage.
4. **AI & IoT Integration:** Smart cities and smart homes.

Example:

- AI-driven medical assistants improving healthcare access.

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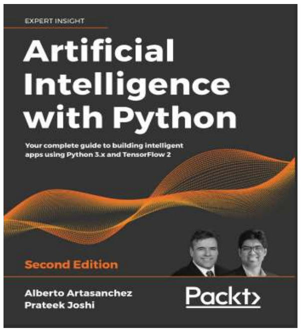
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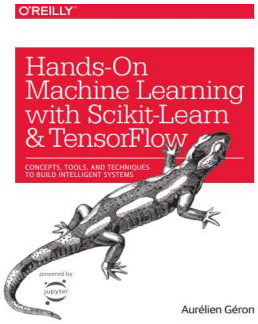
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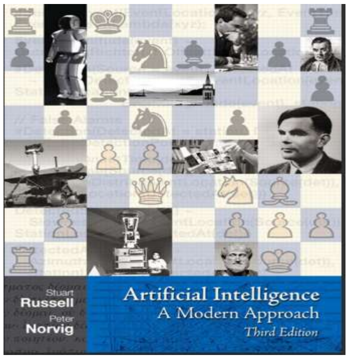

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