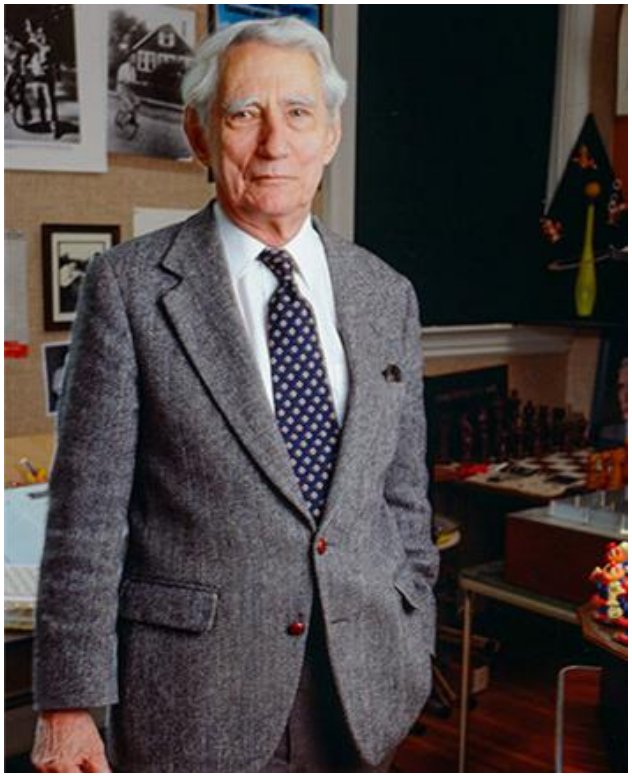
Introduction to Artificial Intelligence

Chapter 1

What is AI?

What is **AI**?

- The term “Artificial Intelligence” was coined by
  - John McCarthy in 1956 along with his colleagues
  - At Dartmouth College in New Hampshire
- To further elaborate the meaning of AI
  - John McCarthy defined sub-objectives which describe intelligent machines

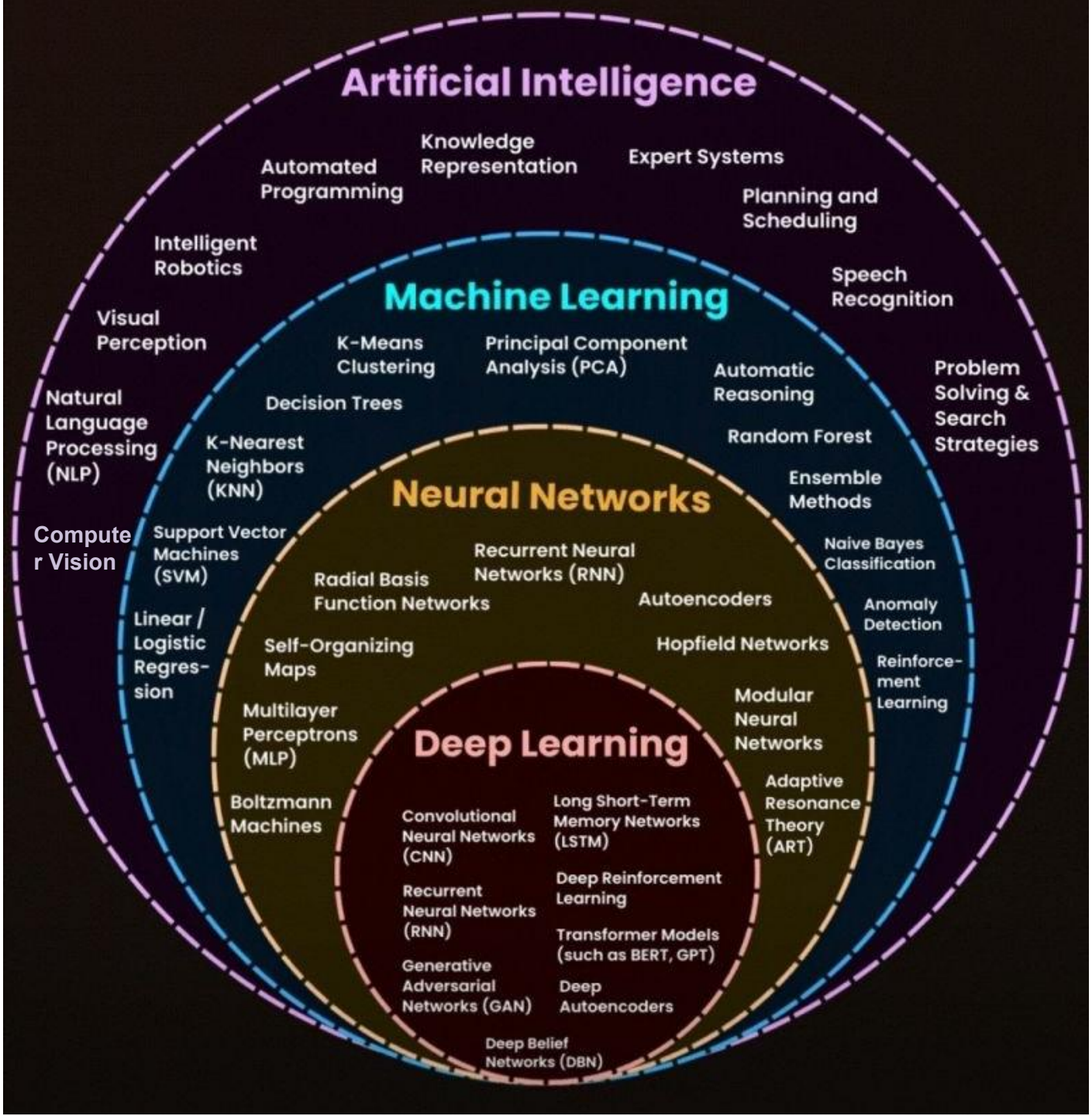


John McCarthy

Name	Timeline	Contribution
Alan Turing	1912-1954	Pioneered the concept of machine intelligence, developed the Turing test to determine if a machine can exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human.
John McCarthy	1927-2011	Coined the term "artificial intelligence," organized the Dartmouth Conference in 1956, and developed the Lisp programming language.
Marvin Minsky	1927-2016	Contributed to cognitive science, artificial intelligence, and computer science. He was a co-founder of the MIT Artificial Intelligence Laboratory.
Herbert A. Simon	1916-2001	Pioneered research in artificial intelligence, cognitive psychology, and decision-making. He received the Nobel Prize in Economics in 1978.
Allen Newell	1927-1992	Collaborated with Herbert A. Simon to develop the first artificial intelligence program, the Logic Theorist.
Yann LeCun	1960-Present	A pioneer in deep learning, particularly convolutional neural networks. His work has led to significant advancements in computer vision and image recognition.
Geoffrey Hinton	1947-Present	A leading figure in deep learning, known for his work on backpropagation and neural networks. He has made significant contributions to the development of neural networks and their applications.
Andrew Ng	1976-Present	A prominent figure in machine learning and artificial intelligence. He has made significant contributions to the development of deep learning algorithms and their applications.
Demis Hassabis	1976-Present	A computer scientist, neuroscientist, and entrepreneur. He is the co-founder and CEO of DeepMind, a leading AI research company.

Attributions

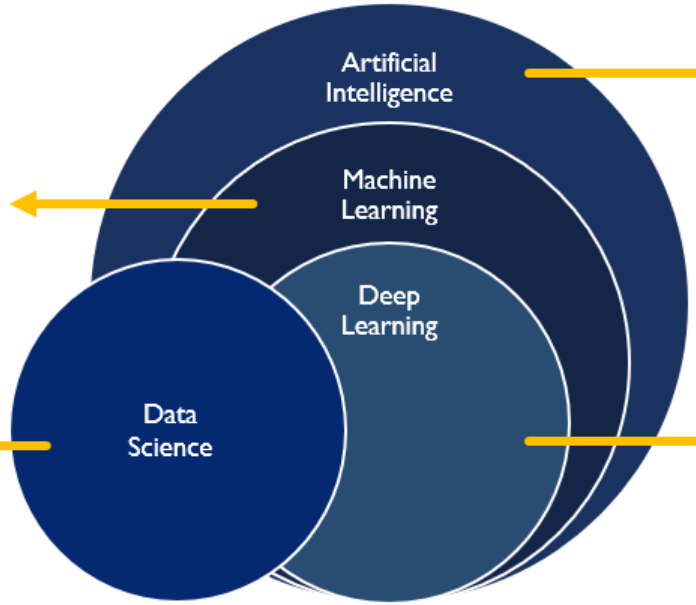
- John McCarthy – Father of AI, coined the term “Artificial Intelligence" and organized the Dartmouth Conference in 1956, which is considered the birth of AI as a field of study. He also developed the Lisp programming language, which became a cornerstone of AI research.
- Godfather of AI' Geoffrey Hinton


Artificial Intelligence
Automated Programming
Knowledge Representation
Expert Systems
Planning and Scheduling
Intelligent Robotics
Speech Recognition
Visual Perception
Machine Learning
K-Means Clustering
Principal Component Analysis (PCA)
Automatic Reasoning
Problem Solving & Search Strategies
Natural Language Processing (NLP)
Decision Trees
Random Forest
K-Nearest Neighbors (KNN)
Ensemble Methods
Neural Networks
Compute r Vision
Support Vector Machines (SVM)
Recurrent Neural Networks (RNN)
Naive Bayes Classification
Radial Basis Function Networks
Autoencoders
Anomaly Detection
Linear / Logistic Regres-sion
Self-Organizing Maps
Hopfield Networks
Reinforce-ment Learning
Modular Neural Networks
Multilayer Perceptrons (MLP)
Deep Learning
Adaptive Resonance Theory (ART)
Boltzmann Machines
Convolutional Neural Networks (CNN)
Long Short-Term Memory Networks (LSTM)
Deep Reinforcement Learning
Recurrent Neural Networks (RNN)
Transformer Models (such as BERT, GPT)
Generative Adversarial Networks (GAN)
Deep Autoencoders
Deep Belief Networks (DBN)

DS vs AI vs ML vs DL

Machine Learning is a subset of AI, and builds a model based on training data to make predictions

Data Science is a subset of AI. It is an area of statistics, scientific methods, etc. to extract meaning and insights from data..



Artificial Intelligence means creating smart machines to mimic human behavior

Deep learning is a subset of ML, a class of ML algorithms to solve complex problems.

What is AI?

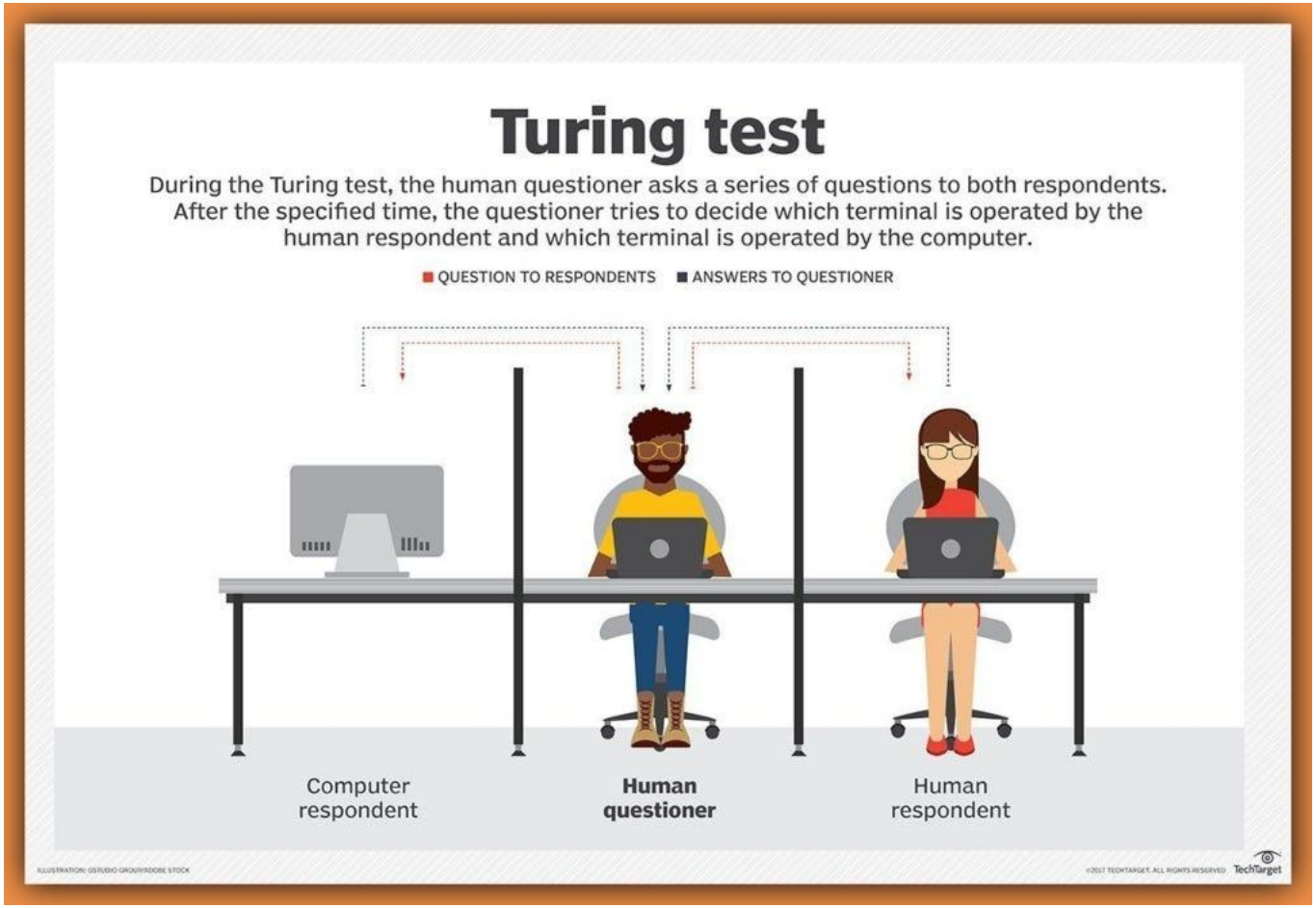
- "The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning…" (Bellman ,1978)
- "The study of mental faculties through the use of computational models" (Charniak + McDermott, 1985)
- "The study of how to make computers do things at which, at the moment, people are better" (Rich & Knight, 1991)
- "The branch of computer science that is concerned with automation of intelligent behavior" (Luger & Stubblefield, 1993)

What is AI?

- Views of AI falls into four categories:

Systems that think like humans.	Systems that think rationally.
Systems that act like humans.	Systems that act rationally

Acting Humanly: The Turing Test



How Turing Test is used to evaluate the intelligence of a machine?

- The Turing Test, proposed by Alan Turing in 1950, is a method to evaluate a machine's ability to exhibit intelligent behavior equivalent to, or indistinguishable from, that of a human. Here's how it works and what it entails:

How the Turing Test Works

- **Setup**: The test involves three participants: a human evaluator, a human respondent, and a machine. The evaluator is separated from the other two and communicates with them through text-only channels.
- **Objective**: The evaluator engages in natural language conversations with both the human and the machine, without knowing which is which.
- **Evaluation**: If the evaluator cannot reliably distinguish the machine from the human based on their responses, the machine is said to have passed the Turing Test.

What properties a machine should have to pass the total Turing Test?

To pass the Turing Test, a machine must demonstrate several key properties:

- **Natural Language Processing (NLP):** The machine must understand and generate human language convincingly.
- **Knowledge Representation:** It should have a robust knowledge base to provide accurate and contextually relevant responses.
- **Reasoning and Problem-Solving:** The machine must be able to reason logically and solve problems as a human would.
- **Learning Ability:** It should learn from interactions and improve over time.
- **Emotional Intelligence:** While not a strict requirement, the ability to recognize and respond to human emotions can enhance the machine's conversational abilities.

Passing the Turing Test is a significant milestone in AI, indicating that a machine can mimic human-like intelligence in conversation. However, it's important to note that passing the Turing Test doesn't necessarily mean the machine possesses true understanding or consciousness.

Acting Humanly: The Turing Test

- Act-Humanly is the Turing Test Approach.
- The Turing Test, proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of Artificial Intelligence.
- A computer passes the Turing Test if a human interrogator after posing some written questions, cannot tell whether the written responses come from a person or from a computer.

Acting Humanly: The Turing Test

A computer would need to possess the following minimum capabilities to pass this test:

- **natural language processing** to communicate successfully in a human language;
- **knowledge representation** to store what it knows or hears;
- **automated reasoning** to answer questions and to draw new conclusions;
- **machine learning** to adapt to new circumstances and to detect and extrapolate patterns.

Acting Humanly: The Turing Test

- Turing viewed the physical simulation of a person as unnecessary to demonstrate intelligence.
- However, other researchers have proposed a total Turing test, which requires interaction with objects and people in the real world.
- To pass the total Turing test, a robot will need
  - **computer vision** and speech recognition to perceive the world;
  - **robotics** to manipulate objects and move about.

Thinking humanly: The cognitive modeling approach

- Think-Humanly is the Cognitive-Modelling-Approach.
- It basically says if we're going to design an algorithm that thinks like a human, then we must have some way to determine how humans think.

Thinking humanly: The cognitive modeling approach

There are 3 ways of doing this:-

- **introspection**—trying to catch our own thoughts as they go by;
- **psychological experiments**—observing a person in action;
- **brain imaging**—observing the brain in action.

Thinking humanly: The cognitive modeling approach

- The interdisciplinary field of cognitive science brings together computer models from AI and experimental techniques from psychology to construct precise and testable theories of the mind.

- There have been notable strides in the use of cognitive-modeling-approach, one that comes to mind is Control labs. A team of researchers have partnered with Facebook and are building a non-invasive neural-interface-technology called intention-capture, that can help you control objects with only your brain signals.

Thinking rationally: The “laws of thought” approach

- Think-Rationally is the Laws-of-Thought-Approach to AI.
- The Greek philosopher Aristotle, was one of the first to attempt to codify “right-thinking”.
- He used **syllogisms** that provided patterns for argument structures.
- For example:-

  Socrates is a man; All men are mortal => Therefore, Socrates is mortal.

Thinking rationally: The “laws of thought” approach

- These laws of thought were supposed to govern the operations of the mind, their study initiated the field called Logic.
- The so-called **Logiscist** tradition within AI tries to build computer programs that can solve any solvable problem described in logical notation.
- This approach was popular during the late ’60s and ’70s.

Thinking rationally: The “laws of thought” approach

- The theory of **probability** fills this gap, allowing rigorous reasoning with uncertain information.
- In principle, it allows the construction of a comprehensive model of rational thought, leading from raw perceptual information to an understanding of how the world works to predictions about the future.
- What it does not do, is generate intelligent behavior. For that, we need a theory of rational action.
- Rational thought, by itself, is not enough.

Acting rationally: The rational agent approach

- Act-Rationally is the Rational-Agent-Approach.
- A rational agent is one that acts so as to achieve the best outcome, or when there's uncertainty, the best expected outcome.

Acting rationally: The rational agent approach

- The Rational-Agent-Approach has two advantages over the other approaches:-

- First, a Rational-Agent is more general than the rest. Take for example the “Laws-of-thoughts” approach that places emphasis on making correct inferences. Well, making correct inferences is often part of a Rational-Agent. Besides, there are other ways of acting rationally without inference, for example, recoiling from a hot stove is a rational reflex action devoid of inferences.
- Secondly, Rational-Agent-Approach is more amenable to scientific developments than are approaches based on human behavior or human thought.

Foundation of AI

Philosophy	logic, methods of reasoning mind as physical system foundations of learning, language, rationality
Mathematics	formal representation and proof algorithms computation, (un)decidability, (in)tractability probability
Psychology	adaptation phenomena of perception and motor control experimental techniques (psychophysics, etc.)
Linguistics	knowledge representation grammar
Neuroscience	physical substrate for mental activity
Control theory	homeostatic systems, stability simple optimal agent designs
Economics	
Computer Engineering	

History of AI

1. **The inception of artificial intelligence (1943–1956)**

- 1943: McCulloch and Pitts propose a mathematical model of artificial neurons (Boolean circuit model of brain).
- 1950: Alan Turing publishes "Computing Machinery and Intelligence," outlining the Turing test to determine machine intelligence.
- 1956: The Dartmouth Conference is held, marking the birth of AI as a field.

2. **Early enthusiasm, great expectations (1952–1969)**

- Look, Ma, no hands!
- 1952: Arthur Samuel develops the first self-learning program for checkers.
- 1957: Herbert Simon and Allen Newell develop the General Problem Solver (GPS) program.
- 1961: Noam Chomsky's work on generative grammar sparks interest in natural language processing.

History of AI

3. **Dose of reality (1966–1973)**

- The first kind of difficulty arose because most early programs knew nothing of their subject matter; they succeeded by means of simple **syntactic manipulations**.
- A typical story occurred in early machine translation efforts, which were generously funded by the U.S. National Research Council in an attempt to speed up the translation of Russian scientific papers in the wake of the Sputnik launch in 1957.
- In 1966, a report by an advisory committee found that “there has been no machine translation of general scientific text, and none is in immediate prospect.” All U.S. government funding for academic translation projects was canceled.
- 1973: The **Lighthill Report** criticizes the progress of AI research, leading to funding cuts.

History of AI

4. **Expert systems (1969–1986)**

- 1969: The first expert system, DENDRAL, is developed.
- 1970s and 1980s: Expert systems become increasingly popular in various industries.
- 1986: The rise of commercial expert systems leads to a renewed interest in AI.

Expert System

- An expert system is a computer program that emulates the decision-making ability of a human expert.
- It is designed to solve complex problems by applying knowledge and rules within a specific domain.
- Expert systems are used in various fields such as medicine, engineering, and finance.
- It is the subset of AI.

Expert System

An expert system typically consists of the following components:

1**. Knowledge Base:**

- Stores domain-specific knowledge, facts, and rules.
- Includes both declarative knowledge (facts) and procedural knowledge (rules).
- The knowledge is acquired from human experts through knowledge engineering techniques.

2**. Inference Engine:**

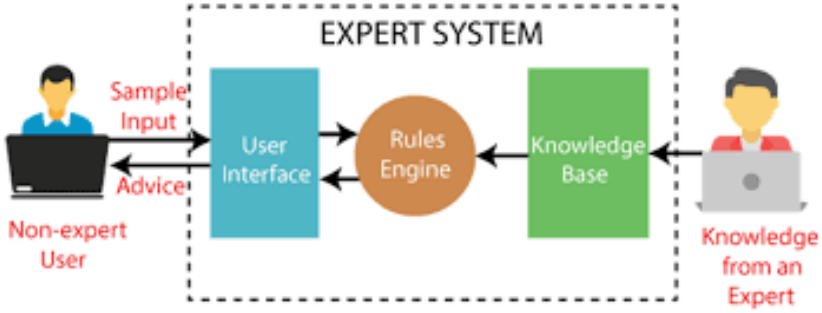
- The "brain" of the expert system.
- Applies logical reasoning to the knowledge base to draw conclusions and make decisions.
- Uses inference techniques like forward chaining and backward chaining to derive solutions.

3**. User Interface:**

- Provides a user-friendly interface for interaction with the system.
- Allows users to input queries, receive explanations, and view results.

4. **Knowledge Acquisition Facility:**

- Facilitates the acquisition and integration of new knowledge into the knowledge base.
- Involves knowledge engineers working with domain experts to capture and formalize knowledge.



History of AI

5. The return of neural networks (1986–present)

- 1986: Backpropagation algorithm is developed, enabling efficient training of neural networks.
- 1990s: Neural networks are applied to a variety of tasks, including speech recognition and image processing.
- 2000s: Deep learning frameworks are developed, further advancing the field of neural networks.

6. Probabilistic reasoning and machine learning (1987–present)

- 1987: Bayesian networks are introduced as a powerful tool for probabilistic reasoning.
- 1990s: Support vector machines (SVMs) become popular for classification tasks.
- 2000s: The rise of machine learning algorithms, such as random forests and gradient boosting, for a wide range of applications.

History of AI

7. Big data (2001–present)

- 2001: The advent of the internet and the rise of big data create new opportunities for AI research.
- 2010s: Machine learning algorithms are applied to large-scale datasets, leading to significant advancements in various fields.

8. Deep learning (2011–present)

- 2011: Deep learning models achieve breakthrough results in speech recognition and image classification.
- 2012: AlexNet, a deep convolutional neural network, wins the ImageNet Large Scale Visual Recognition Challenge.
- 2015: AlphaGo, a deep reinforcement learning system, defeats a human world champion in the game of Go.

Application of AI

- Robotic Vehicles
- Autonomous Planning And Scheduling
- Machine Translation
- Speech Recognition
- Recommendations
- Image Understanding
- Medicine
- Climate Science

Application of AI

- Healthcare
- Finance
- Transportation
- Entertainment
- Customer Service
- Retail

Application of AI

- Healthcare: AI in medical imaging, virtual health assistants, predictive analytics for patient care.
- Finance: AI-driven credit scoring, robo-advisors for investment, chatbots for customer support.
- Transportation: Self-driving cars, AI for route optimization, predictive maintenance for vehicles.
- Entertainment: Netflix recommendation algorithm, AI-generated music or art, deepfake technology.
- Customer Service: Automated phone systems, AI-driven customer feedback analysis, virtual shopping assistants.
- Retail: Amazon's personalized recommendations, automated checkout systems, demand forecasting.

Risks and Benefits of AI

- Surveillance And Persuasion
- Lethal Autonomous Weapons
- Biased Decision Making
- Impact On Employment
- Safety-critical Applications
- Cybersecurity

Characteristics of AI

- **Learning**: AI systems can learn from data and experiences, improving their performance over time. This includes machine learning and deep learning techniques.
- **Reasoning**: AI can make decisions based on available data, using logical reasoning to solve problems and make predictions.
- **Problem-Solving**: AI can identify problems and develop solutions, often in real-time.
- **Perception**: AI systems can interpret sensory data, such as visual, auditory, and tactile inputs, to understand and interact with their environment.
- **Language Understanding**: AI can process and understand human languages, enabling natural language processing (NLP) applications like chatbots and virtual assistants.

Characteristics of AI

- **Planning**: AI can set goals and develop strategies to achieve them, often optimizing for efficiency and effectiveness.
- **Autonomy**: AI systems can operate independently, making decisions and taking actions without human intervention.
- **Adaptability**: AI can adapt to new situations and environments, learning from changes and adjusting its behavior accordingly.
- **Creativity**: Some AI systems can generate new ideas, designs, or solutions, demonstrating a form of creativity.
- **Social Intelligence**: AI can recognize and respond to human emotions, enhancing interactions and providing more personalized experiences

End of Chapter 1