Introduction
to
Artificial Intelligence

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Syllabus

Module I

- **Artificial Intelligence**: Introduction, Four approaches of AI, Foundation & History of AI

- **Intelligent Agents**: Int. Agents, PEAS Description, Structure of Agents, Types of Agents

- **Problem Solving by Searching** - Problem-Solving Agents, Example Problems, Searching for Solutions, Uninformed search strategies (BFS, DFS, UCS, DLS, IDS, BD Search)

Module II

- **Informed Search & Exploration**: Evaluation & Heuristic functions, Informed search strategies (Greedy Best First Search, A* search)

- **Constraint Satisfaction Problems**: Introduction, Map Coloring problem, Backtracking search for CSPs

- **Adversarial Search**: Games playing, MiniMax Search, Alpha-Beta Pruning;

- **Knowledge & Planning**: Knowledge-Based Agents, Planning, PoP. HTN

Syllabus

Module III

- **Knowledge and Logic**: Intro, Propositional Logic, Inference Rules, CNF, Examples
- **First-Order Logic**: First-Order-Predicate Logic & Examples
- **Inference in First-Order Logic:** Forward Chaining, Backward Chaining, Resolution & Examples

Module IV

- **Uncertain Knowledge & Reasoning**: Introduction & approaches, Probability theory (Axioms of probability, Conditional probabilities with examples), Probability theory (Bayes' Rule/Theorem and it's use), Bayesian networks & Burglar alarm example

Module V

- **Learning:** Introduction, Four elements of learning agent, Paradigms of learning, Supervised & Unsupervised Learning, Inductive Learning, Classification Rules
- **Decision Tree Induction:** Attribute Selection Measures, Neural Networks (Perceptron), AND, OR & XOR gate examples, Reinforcement Learning

Books

1. **Stuart Russell & Peter Norvig,** Artificial Intelligence: A Modern Approach, 2nd Edition, Pearson Education.

2. Elaine Rich, Kevin Knight, Shivshankar B Nair, Artificial Intelligence, McGraw Hill, 3rd Edition.

3. Nills J. Nilson, "Artificial Intelligence: A New Synthesis", 2nd Edition, 2000, Elsevier India Publications, New Delhi.

4. Michael Negnevitsky, "Artificial Intelligence: A Guide to Intelligent Systems", Second Edition, 2005, Pearson Education, Inc. New Delhi.

5. **Dan W. Patterson,** "Introduction to Artificial Intelligence and Expert Systems", 1st Edition, 1996, PHI Learning Pvt. Ltd., New Delhi.

6. E. Charniak and D. McDermott, Introduction to AI, 1st Edition, Addison-Wesley, 1985

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Introduction to AI - Topics

- **What is AI**

- **Four Approaches to AI**
  - **Acting Humanly**
  - **Thinking Humanly**
  - **Acting Rationally**
  - **Thinking Rationally**

- **Foundations of AI**

- **History of AI**

What is AI?

⭐ **What is AI?**

- Artificial intelligence is an area of computer science

  - that emphasizes the creation of intelligent machines

    - that <u>think</u>, <u>work</u> & <u>react</u> like **humans**

- Computers with artificial intelligence can do activities like:

  - **Speech recognition**
    - Car responding to master's voice
  - **Learning**
    - Amazon Alexa
  - **Planning**
    - Decision making by a Robot
  - **Problem solving**
    - Tic-tac-toe, TSP or n-Queen problem

Four Approaches to AI

- **Computers with AI** can :
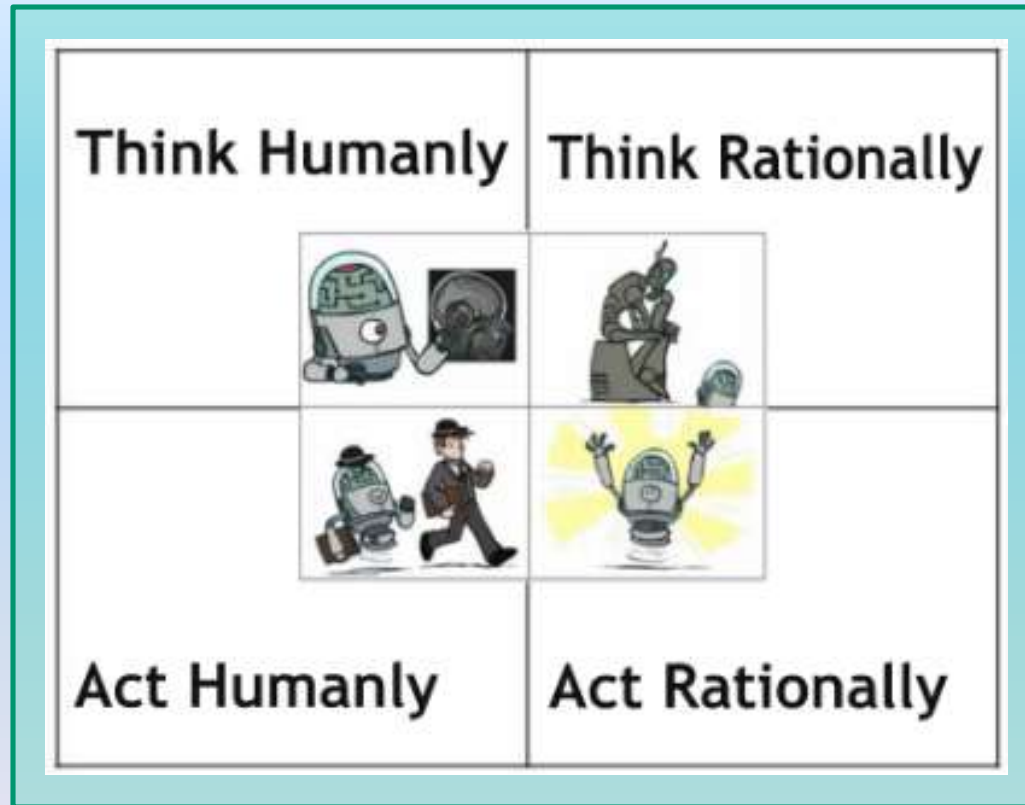
Four Approaches to AI

(1) Think humanly

- **AI application** thinks like a **human**
  - *For this it needs to know "**working of human mind**"*

- The study of **how we do, what we do** *(Ex: Car driving)*
- How to make the **computer do it in the same way**

- **3 ways to do this**:

  (1) By **Introspection** – *catching your "own thoughts"*
  (2) By **Psychological experiments** – *observing a "person's action"*
  (3) By **Brain imaging** – *observing "brains in action"*

- **(2) Act humanly -** Turing Test approach

  - **Turing Test (1950) of a computer with AI (by Alan Turing)**

    - The computer & a human are interrogated by another human behind a barrier via written questions

    - Computer passes the test if the human cannot tell if the written response is from a computer or human
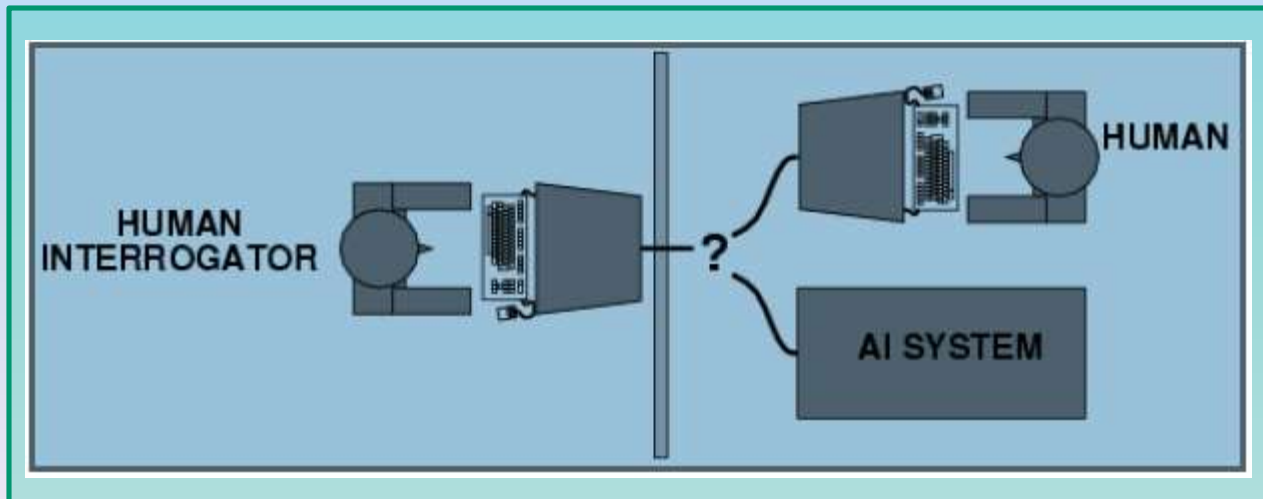
**A Computer with AI needs to have below capabilities :**

- Natural Language Processing –*to communicate in English*

- Knowledge Representation –*to store what it knows or hears*

- Automated Reasoning – *to use the stored info to answer questions*

- Machine Learning – *to adapt to new/changing circumstances*

To pass the <u>Total Turing Test</u>, a machine needs :

- Computer vision – *to perceive objects (sensor)*

- Robotics – *to manipulate objects (actuator)*

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- **(3) Think Rationally**

  - **Rational thinking** – "Right Thinking" with unquestionable reasoning or Logic

  - A **program** can solve any **solvable problem** described in "logical notation" *(Ex: TSP, 8-Puzzle, Chess…)*
    - *Ex - Socrates is a man; All men are moral; Socrates is moral*
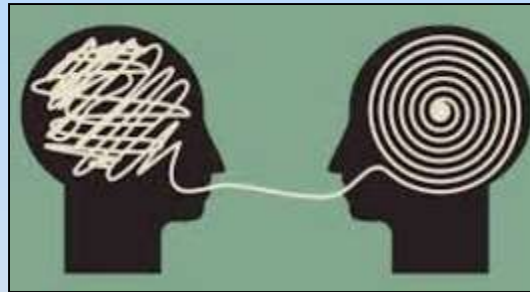
  - Two obstacles to this approach –

    (1) Not easy to represent all problems in logical notations

    (2) Big difference between solving a problem "in principle" than "in practice"

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- **(4) Act Rationally –** The "Rational Agent" approach

  - **Agent** – "One that Acts" – It **perceives** the **env.** through **sensors** & acts on the env. through **actuators** *(Ex: Robot, Auto-pilot, Vacuum cleaner…)*

  - **Rational Agent** – The Agent that acts to achieve the "**best outcome**"
    - In case of uncertainty, the "**best expected outcome**"

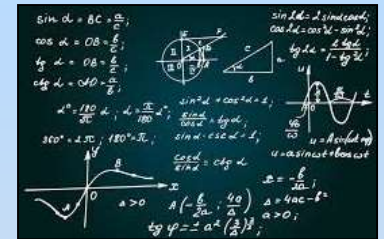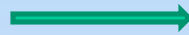 - All the skills needed for a Turing test... Learning, Thinking, etc.

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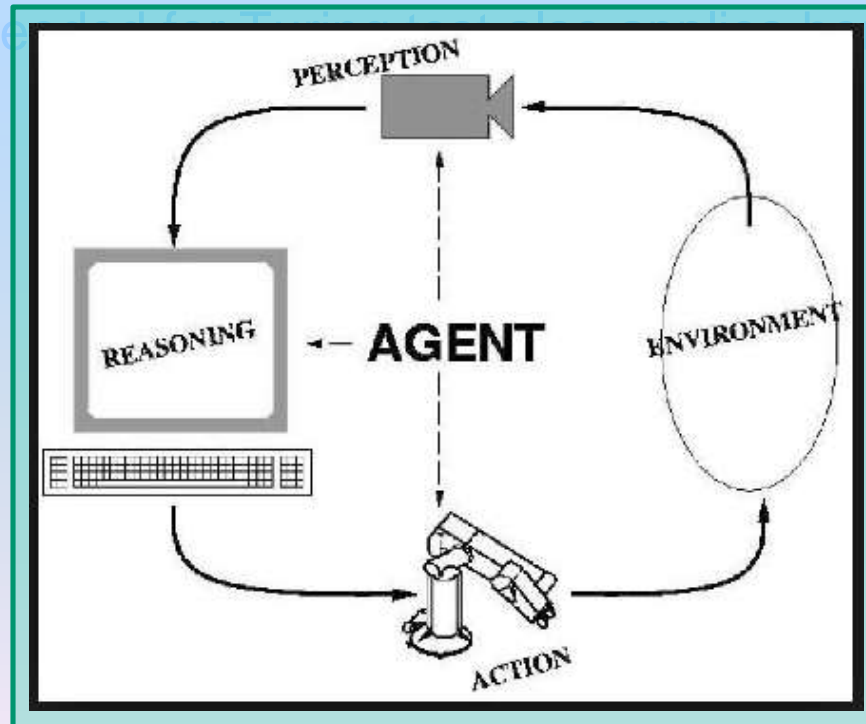
Foundations of AI

- **Following disciplines** have contributed to ideas, viewpoints & techniques to AI

- **Philosophy**
    - Made AI conceivable with the idea that "Mind is in someway like a machine"
    - It operates based on "knowledge"
    - "Thought" can be used to choose "action"

- **Mathematics**
    - Provided "tools" to represent & manipulate logically certain or uncertain statements
    - Provided algorithms & computations

- **Economics**
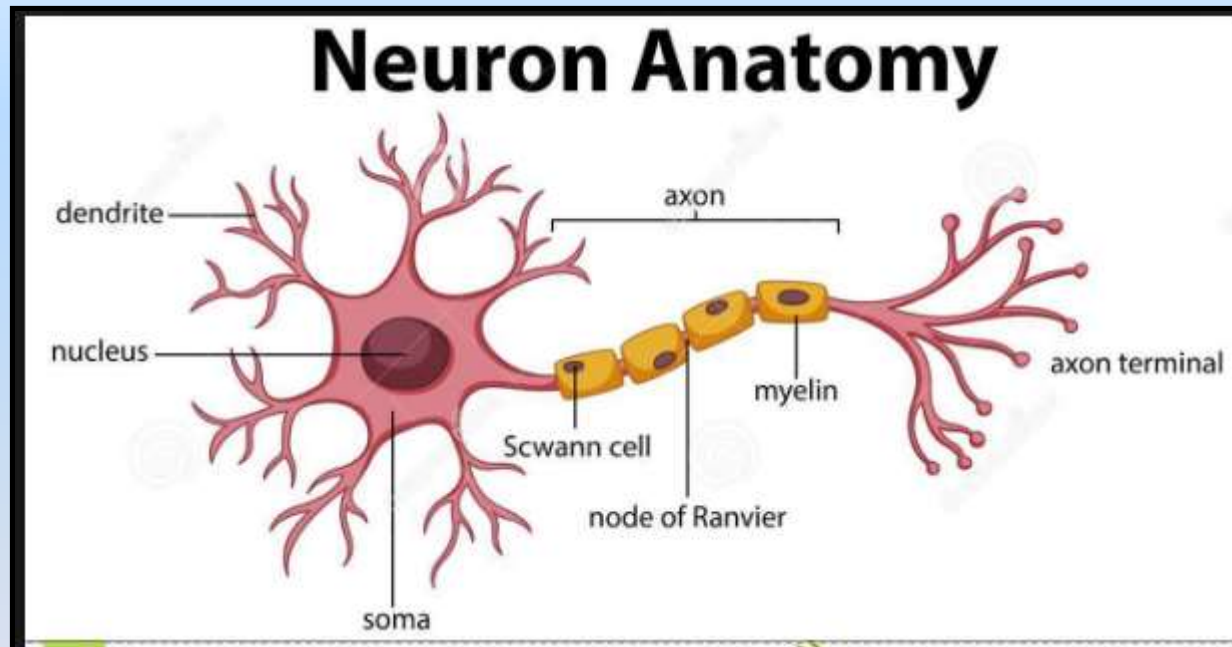   - Helped in making decision that Maximize the expected outcome

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Foundations of AI

- **Neuroscience**
  - Provided the knowledge about "how brain works"
  - How brain is similar & different from computers

Neuron Anatomy

dendrite

axon

nucleus

myelin

axon terminal

Scwann cell

node of Ranvier

soma

- **Psychology**
  - Provided the idea that humans & animals can be considered as "info. processing machines"

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Foundations of AI

- **Computer Engg.**
  - Provided highly <u>efficient</u> & <u>powerful</u> <u>machines</u> to "<u>implement AI applications</u>"

- **Control theory and cybernetics**
  - Helped in <u>designing devices</u> that act optimally based on "feedback from the env."

- **Linguistics**
  - Provided the idea that language for communication can fit into AI models

History of AI

Gestation of AI (1943-55)

- **McCulloch & Pitt** propose AI based on knowledge of <u>physiology</u> & <u>neurons</u> in brain
- **Russel** proposed <u>formal analysis</u>
- **Turing** proposed <u>theory of computation</u>
- **Hebb** (1949) proposed **Hebbian learning** on connection between neurons

Birth of AI (1956)

- **John McCarthy (Dartmouth College) –** official birth place of AI – **2 month workshop**
- **Newell & Simon –** Created a reasoning program "**Logic Theorist**"

History of AI

Early enthusiasm, Great Expectations (1952-69)

- **Early success** but in limited way by **Newell & Simons**
- **General Problem Solver (GPS) –** program designed to imitate human problem-solving
- **Physical symbol system hypothesis** by **Newell & Simons**
- **Lisp** AI programming language **by McCarthy**
- **Neural Network – adalines & perceptrons** – by **Widrow & Rosenblatt**

A dose of reality (1966-73)

- **Simons prediction** of **extraordinary success could not be achieved**
- **Computer chess champion** & **theorem proving** by computer took **40 years** than prediction of **10 years**
- **A number of difficulties** were encountered while implementing **complicated AI applications**

History of AI

Knowledge-based systems (1969-79)

- **General purpose** applications (called **weak methods)** were unable to handle **complex problems**
- **Powerful applications** using **domain-specific knowledge** like **DENDRAL** were needed

AI becomes an Industry (1980-present)

- **R.I – 1st commercial Expert System started in 1982 –** saved $40m per year for the org
- **DEC's** AI group installed **40 E.S.s**
- **5th Generation project** (10 yrs) of **Intelligent AI system** – started in **Japan** using **prolog**

The return of neural networks (1986-present)

- **Back-Propagation** – reinvented in 1980's by 4 different books
- **Parallel Distributed processing** was introduced

History of AI

AI adopts the scientific method (1987-present)

- **Revolution** in both content & methodology of AI applications
- **Hidden Markov model (HMMs) –** Dominates AI applications
- **Data-Mining technology –** spread into AI area
- **Bayesian network –** dominates uncertain reasoning AI & ES

Emergence of Intelligent Agents (1995-present)

- **Intelligent Agents architecture** by **Newell, Laird & Rosenbloom**
- **Internet –** Most important Intelligent agent env.
- **AI systems** have become common in **Web-based applications**
- **Human-level AI (HLAI)** – Machines that think

Availability of very large data sets (2001-present)

- In many AI applications **"Data"** is more important than **"Algorithm"**
- In recent times, availability of **large data sources** have improved AI applications
- Ex: Images from web, Genometic sequences, words of English