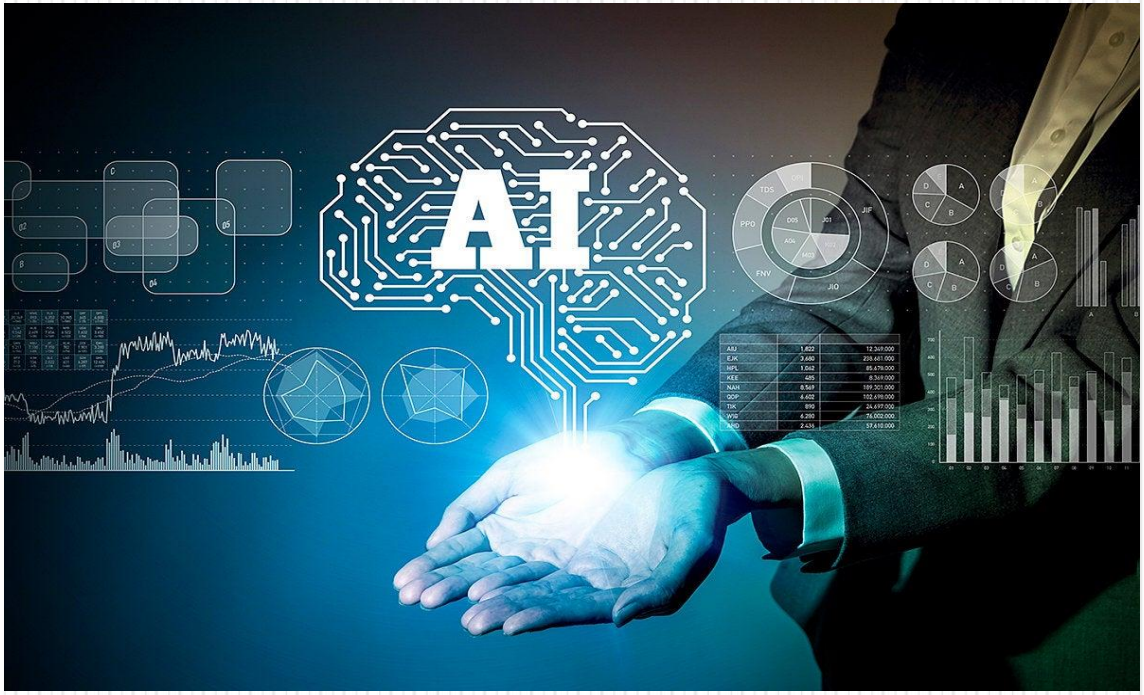
# TCS 421: Fundamental of Statistics and AI

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# Course Details

**Pre-requisite:** Basics of Mathematics, Basic knowledge of computer programming and data structure and algorithm design.

**Course Outcomes:** After completion of the course students will be able to

1. Demonstrate knowledge of statistical and exploratory data analysis data analysis techniques utilized in decision making.
2. Apply principles of Data Science to the analysis of business problems.
3. To use Machine Learning Algorithms to solve real-world problems.
4. To provide data science solution to business problems and visualization.
5. To learn the basic concepts and techniques of AI and machine learning
6. To explore the various mechanism of Knowledge and Reasoning used for building expert system.

# Syllabus Contents

| Sl. No. | Contents | Contact Hours |
|---|---|---|
| 1 | **Introduction to AI**<br><br>Definition, Problem, State space representation. Intelligent Systems: Categorization of Intelligent System, Components of AI Program, Foundations of AI, Applications of AI, Current trends in AI, Intelligent Agents: Anatomy, structure, Types. | 10 |
| 2 | **Problem solving**<br><br>Solving problem by Searching: Problem Solving Agent, Formulating Problems. Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening (DFID), Informed Search Methods: Greedy best first Search, A* Search, Memory bounded heuristic Search. Local Search Algorithms and Optimization Problems: Hill climbing search Simulated annealing, Local beam search. | 9 |
| 3 | **An Introduction to Data Science**<br><br>Definition, working, benefits and uses of Data Science, Data science vs BI, The data science process, Role of a Data Scientist. | 9 |

# Syllabus Contents

| | | |
|---|---|---|
| 4 | **Statistical Data Analysis & Inference**<br><br>Populations and samples, Statistical modelling, probability distributions, fittings a model, Statistical methods for evaluation, Exploratory Data Analysis, Getting started with R, Manipulating and Processing data in R, working with function in R, Working with descriptive Statistics, Working with graph plot in R. | 9 |
| 5 | **Statistical Applications**<br><br>Basic Statistical operations, Linear Regression Analysis, Logistic and Exponential Regression, Time Series Analysis, Probability Distribution, ANOVA, Correlation and Covariance. | 8 |
| | Total | **45** |

# Course Details

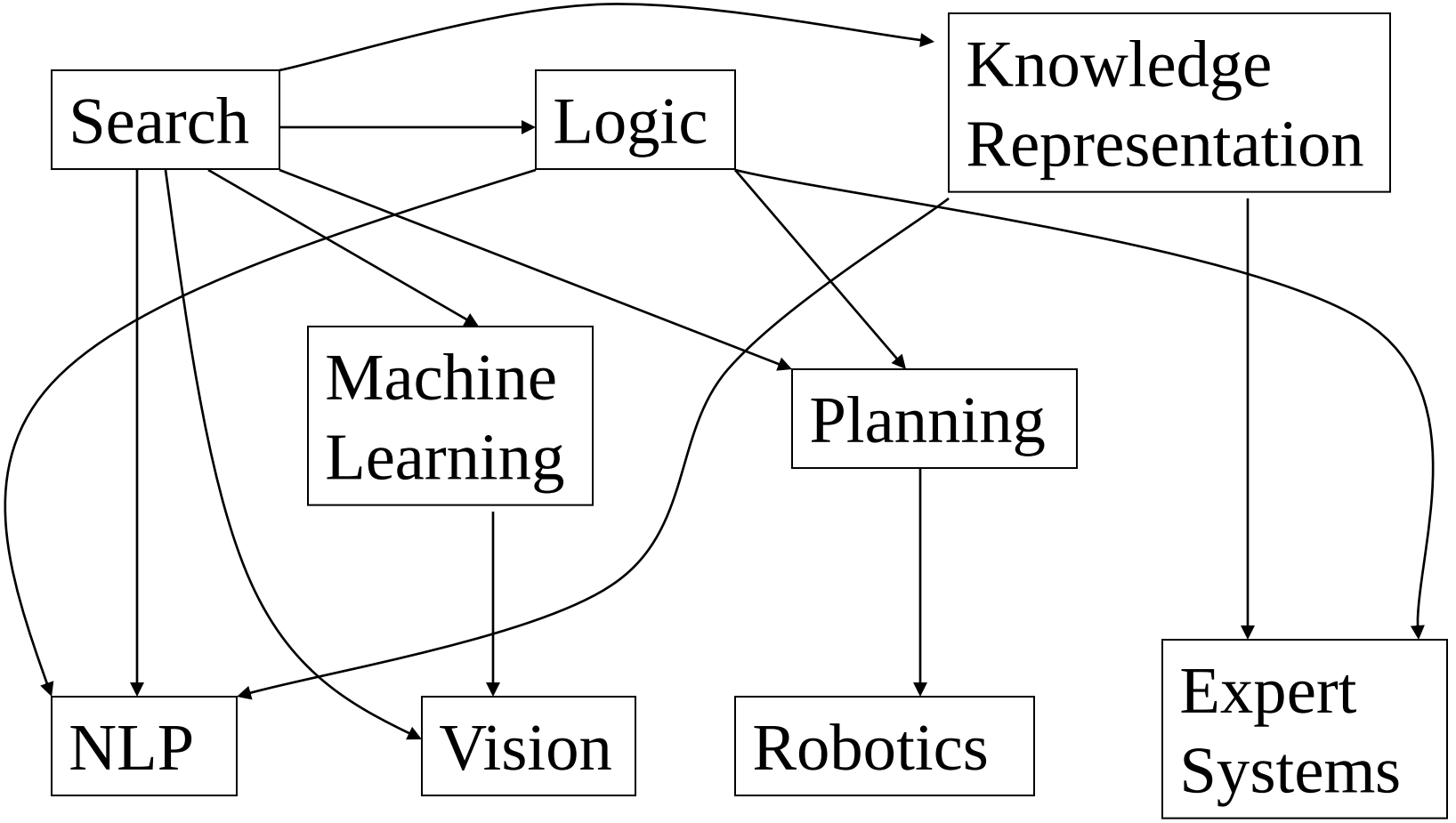
**Text Books:**

1. Tom M. Mitchell. "Machine Learning" McGraw-Hill, 1997.
2. “Statistical programming in R”, Oxford University Press 2017

# Unit I: Introduction

- Introduction to Artificial Intelligence
- Foundations and History of Artificial Intelligence
- Applications of Artificial Intelligence
- Intelligent Agents
- Structure of Intelligent Agents

# Areas of AI and Some Dependencies



# What is Artificial Intelligence ?

- making computers that think?
- the automation of activities we associate with human thinking, like decision making, learning … ?
- the art of creating machines that perform functions that require intelligence when performed by people ?
- the study of mental faculties through the use of computational models ?

# What is Artificial Intelligence ?

- the study of computations that make it possible to perceive, reason and act ?
- a field of study that seeks to explain and emulate intelligent behaviour in terms of computational processes ?
- a branch of computer science that is concerned with the automation of intelligent behaviour ?
- anything in Computing Science that we don't yet know how to do properly ? (!)

# What is Artificial Intelligence ?

- Artificial Intelligence is composed of two words Artificial and Intelligence, where Artificial defines "man-made," and intelligence defines "thinking power", hence AI means "a man-made thinking power."

So, we can define AI as:

- "It is a branch of computer science by which we can create intelligent machines which can behave like a human, think like humans, and able to make decisions."
- Artificial Intelligence exists when a machine can have human based skills such as learning, reasoning, and solving problems.

# What is Artificial Intelligence ?

| | HUMAN | RATIONAL |
|---|---|---|
| **THOUGHT** | **Systems that think like humans** | **Systems that think rationally** |
| **BEHAVIOUR** | **Systems that act like humans** | **Systems that act rationally** |

# Systems that act like humans: Turing Test

- "The art of creating machines that perform functions that require intelligence when performed by people."
- "The study of how to make computers do things at which, at the moment, people are better."

# Systems that act like humans

- These cognitive tasks include:
  - *Natural language processing*
    - for communication with human
  - *Knowledge representation*
    - to store information effectively & efficiently
  - *Automated reasoning*
    - to retrieve & answer questions using the stored information
  - *Machine learning*
    - to adapt to new circumstances

# The total Turing Test

- Includes two more issues:
  - *Computer vision*
    - to perceive objects (seeing)
  - *Robotics*
    - to move objects (acting)

# What is Artificial Intelligence ?

| | HUMAN | RATIONAL |
|---|---|---|
| THOUGHT | Systems that think like humans | Systems that think rationally |
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# Systems that think like humans: cognitive modeling

- Humans as observed from 'inside'
- How do we know how humans think?
  - Introspection vs. psychological experiments
- Cognitive Science
- "The exciting new effort to make computers think … machines with *minds* in the full and literal sense" (Haugeland)
- "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …" (Bellman)

# What is Artificial Intelligence ?

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# Systems that think ‘rationally’ "laws of thought"

- Humans are not always ‘rational’
- Rational - defined in terms of logic?
- Logic can’t express everything (e.g. uncertainty)
- Logical approach is often not feasible in terms of computation time (needs ‘guidance’)
- “The study of mental facilities through the use of computational models” (Charniak and McDermott)
- “The study of the computations that make it possible to perceive, reason, and act” (Winston)

# What is Artificial Intelligence ?

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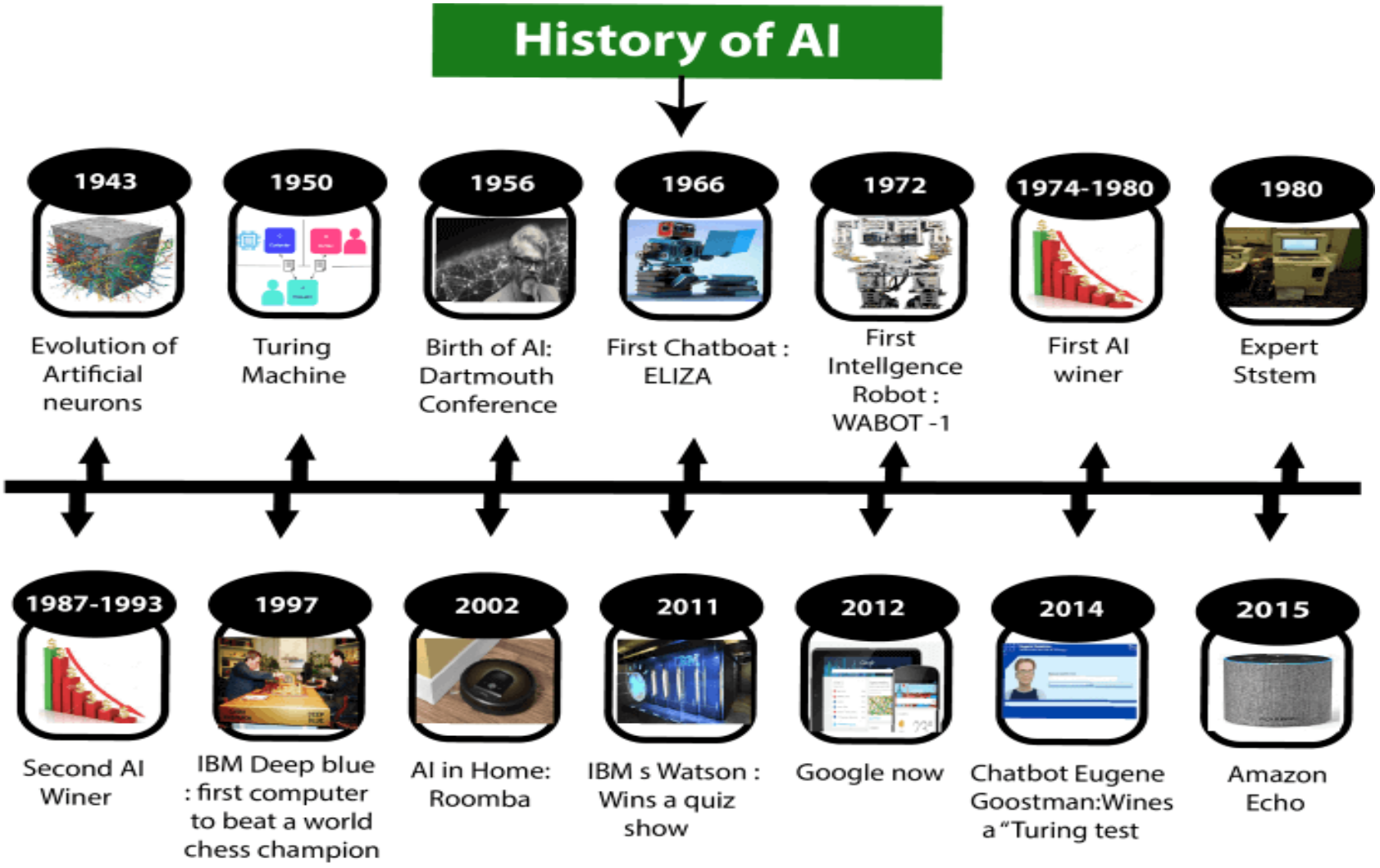
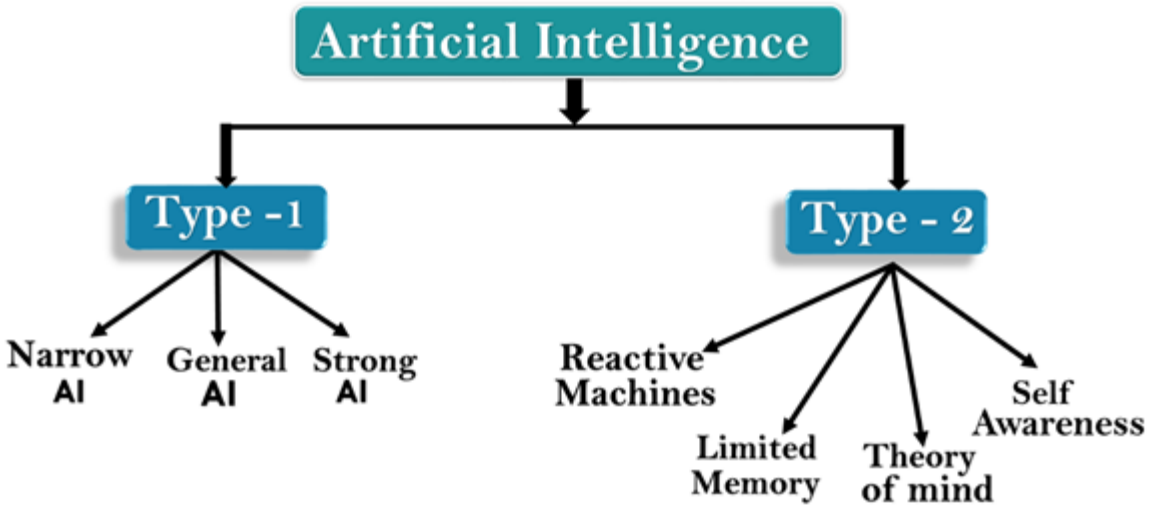
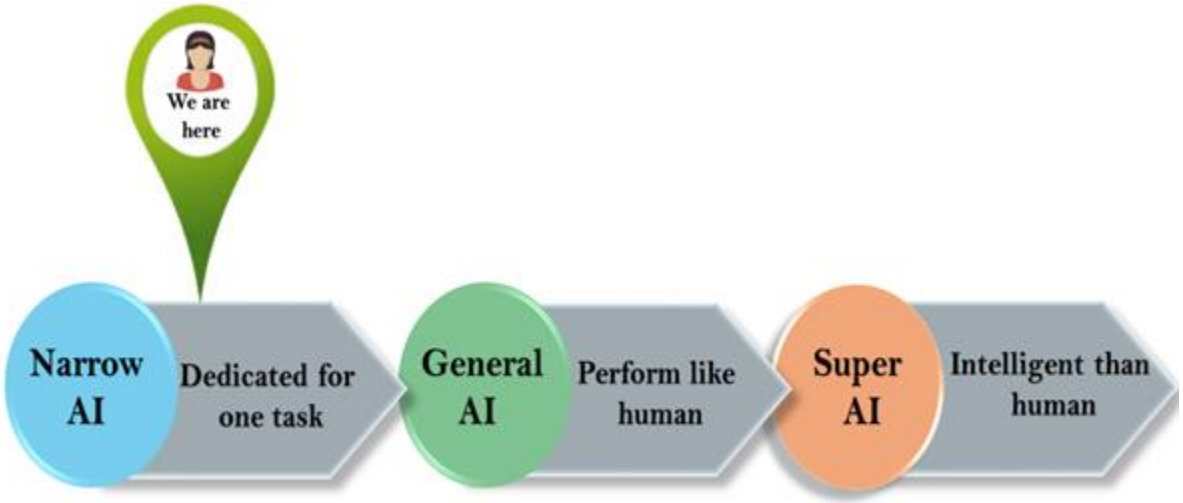
# History of AI



# Types of AI


Artificial Intelligence
Type -1
Type - 2
Narrow AI
General AI
Strong AI
Reactive Machines
Limited Memory
Theory of mind
Self Awareness


We are here
Narrow AI
Dedicated for one task
General AI
Perform like human
Super AI
Intelligent than human

# Types of AI- Type 1

**Weak AI or Narrow AI:**

- Narrow AI is a type of AI which is able to perform a dedicated task with intelligence. The most common and currently available AI is Narrow AI in the world of Artificial Intelligence.
- Narrow AI cannot perform beyond its field or limitations, as it is only trained for one specific task.

**General AI:**

- General AI is a type of intelligence which could perform any intellectual task with efficiency like a human.
- The idea behind the general AI to make such a system which could be smarter and think like a human by its own.

**Super AI:**

- Super AI is a level of Intelligence of Systems at which machines could surpass human intelligence, and can perform any task better than human with cognitive properties. It is an outcome of general AI.
- Some key characteristics of strong AI include capability include the ability to think, to reason, solve the puzzle, make judgments, plan, learn, and communicate by its own.

# Types of AI- Type 2

**Reactive Machines:**

- Reactive AI systems do not store memories or past experiences for future actions.
- These machines only focus on current scenarios and react on it as per possible best action.

**Limited Memory:**

- Limited memory machines can store past experiences or some data for a short period of time.
- These machines can use stored data for a limited time period only.

**Theory of Mind:**

- Theory of Mind AI should understand the human emotions, people, beliefs, and be able to interact socially like humans.
- This type of AI machines are still not developed, but researchers are making lots of efforts and improvement for developing such AI machines.

**Self-Awareness:**

- Self-awareness AI is the future of Artificial Intelligence. These machines will be super intelligent, and will have their own consciousness, sentiments, and self-awareness.
- These machines will be smarter than human mind.

# Systems that act rationally:“Rational agent”

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Giving answers to questions is ‘acting’.
- I don't care whether a system:
  - replicates human thought processes
  - makes the same decisions as humans
  - uses purely logical reasoning

# Agents in Artificial Intelligence

- An AI system can be defined as the study of the rational agent and its environment. The agents sense the environment through sensors and act on their environment through actuators. An AI agent can have mental properties such as knowledge, belief, intention, etc.

**What is an Agent?**

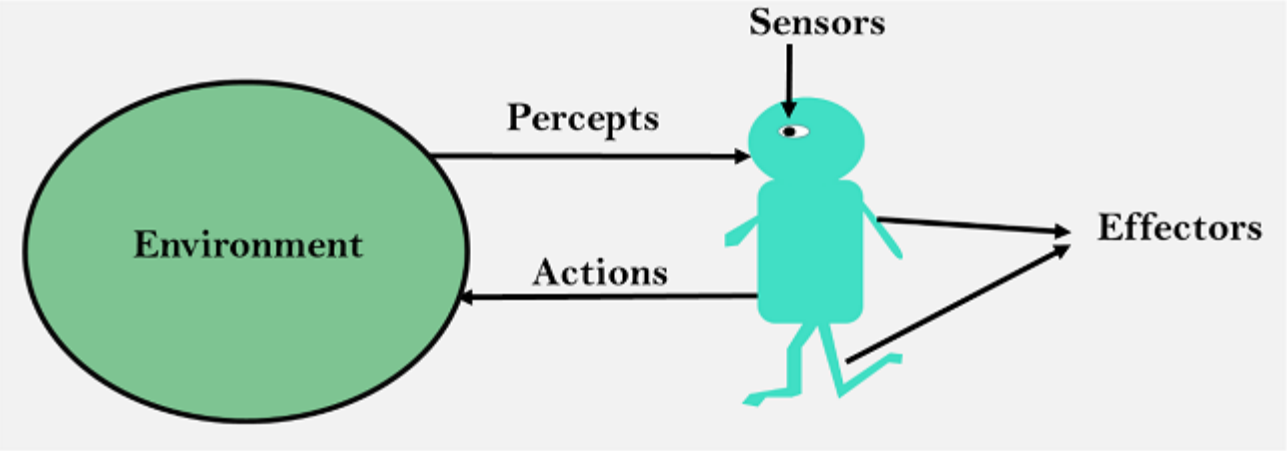
- An agent can be anything that perceive its environment through sensors and act upon that environment through actuators. An Agent runs in the cycle of **perceiving**, **thinking**, and **acting**.

**An agent can be:**

- **Human-Agent:** A human agent has eyes, ears, and other organs which work for sensors and hand, legs, vocal tract work for actuators.
- **Robotic Agent:** A robotic agent can have cameras, infrared range finder, NLP for sensors and various motors for actuators.
- **Software Agent:** Software agent can have keystrokes, file contents as sensory input and act on those inputs and display output on the screen.

# Agents in Artificial Intelligence

- **Sensor:** Sensor is a device which detects the change in the environment and sends the information to other electronic devices. An agent observes its environment through sensors.
- **Actuators:** Actuators are the component of machines that converts energy into motion. The actuators are only responsible for moving and controlling a system. An actuator can be an electric motor, gears, rails, etc.
- **Effectors:** Effectors are the devices which affect the environment. Effectors can be legs, wheels, arms, fingers, wings, fins, and display screen.



# Intelligent Agents:

- An intelligent agent is an autonomous entity which act upon an environment using sensors and actuators for achieving goals.
- An intelligent agent may learn from the environment to achieve their goals.

- **Following are the main four rules for an AI agent:**

**Rule 1:** An AI agent must have the ability to perceive the environment.

**Rule 2:** The observation must be used to make decisions.

**Rule 3:** Decision should result in an action.

**Rule 4:** The action taken by an AI agent must be a rational action.

# Structure of an AI Agent

- The task of AI is to design an agent program which implements the agent function. The structure of an intelligent agent is a combination of architecture and agent program. It can be viewed as:

  Agent = Architecture + Agent program

**Following are the main three terms involved in the structure of an AI agent:**

- **Architecture:** Architecture is machinery that an AI agent executes on.
- **Agent Function:** Agent function is used to map a percept to an action.
- $f: P^* \rightarrow A$
- **Agent program:** Agent program is an implementation of agent function. An agent program executes on the physical architecture to produce function f.

# The Foundation of AI

- ***Philosophy***
  - At that time, the study of human intelligence began with no formal expression
  - Initiate the idea of mind as a machine and its internal operations

# The Foundation of AI

- Mathematics formalizes the three main area of AI: *computation*, *logic*, and *probability*
  - Computation leads to analysis of the problems that can be computed
    - *complexity theory*
  - Probability contributes the *"degree of belief"* to handle *uncertainty* in AI
  - *Decision theory* combines *probability theory* and *utility theory* (bias)

# The Foundation of AI

- Psychology
  - How do humans think and act?
  - The study of human reasoning and acting
  - Provides reasoning models for AI
  - Strengthen the ideas
    - humans and other animals can be considered as information processing machines

# The Foundation of AI

- Computer Engineering
  - How to build an efficient computer?
  - Provides the artifact that makes AI application possible
  - The power of computer makes computation of large and difficult problems more easily
  - AI has also contributed its own work to computer science, including: time-sharing, the linked list data type, OOP, etc.

# The Foundation of AI

- **Control theory and Cybernetics**
  - How can artifacts operate under their own control?
  - The artifacts adjust their actions
    - To do better for the environment over time
    - Based on an objective function and feedback from the environment
  - Not limited only to linear systems but also other problems
    - as language, vision, and planning, etc.

# The Foundation of AI

- Linguistics
  - For understanding natural languages
    - different approaches has been adopted from the linguistic work
  - Formal languages
  - Syntactic and semantic analysis
  - Knowledge representation

# The main topics in AI

Artificial intelligence can be considered under a number of headings:

- Search (includes Game Playing).
- Representing  Knowledge and Reasoning with it.
- Planning.
- Learning.
- Natural language processing.
- Expert Systems.
- Interacting with the Environment  (e.g. Vision, Speech recognition, Robotics)

# Some Advantages of Artificial Intelligence

- more powerful and more useful computers
- new and improved interfaces
- solving new problems
- better handling of information
- relieves information overload
- conversion of information into knowledge

# The Disadvantages

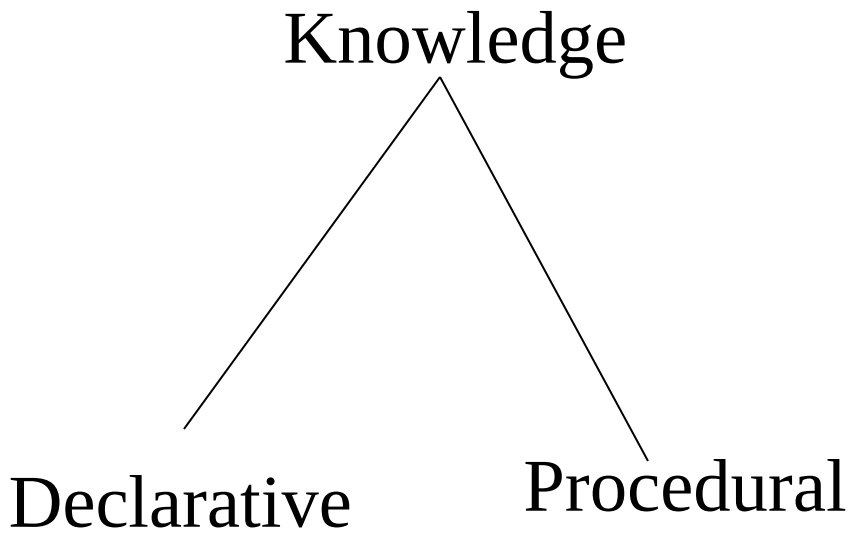
- increased costs
- difficulty with software development - slow and expensive
- few experienced programmers
- few practical products have reached the market as yet.

# Search

- *Search* is the fundamental technique of AI.
  - Possible answers, decisions or courses of action are structured into an abstract space, which we then search.
- Search is either "blind" or “uninformed":
  - blind
    - we move through the space without worrying about what is coming next, but recognising the answer if we see it
  - informed
    - we guess what is ahead, and use that information to decide where to look next.
- We may want to search for the first answer that satisfies our goal, or we may want to keep searching until we find the best answer.

# Knowledge Representation & Reasoning

- The second most important concept in AI
- If we are going to act rationally in our environment, then we must have some way of describing that environment and drawing inferences from that representation.
  - how do we describe what we know about the world ?
  - how do we describe it *concisely* ?
  - how do we describe it so that we can get hold of the right piece of knowledge when we need it ?
  - how do we generate new pieces of knowledge ?
  - how do we deal with *uncertain* knowledge ?




- Declarative knowledge deals with factoid questions (what is the capital of India? Etc.)
- Procedural knowledge deals with “How”
- Procedural knowledge can be embedded in declarative knowledge

# Planning

Given a set of goals, construct a sequence of actions that achieves those goals:

- often very large search space
- but most parts of the world are independent of most other parts
- often start with goals and connect them to actions
- no necessary connection between order of planning and order of execution
- what happens if the world changes as we execute the plan and/or our actions don't produce the expected results?

# Learning

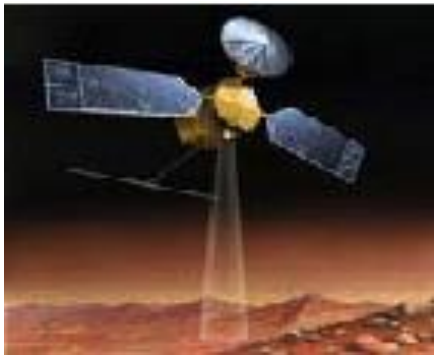
- If a system is going to act truly appropriately, then it must be able to change its actions in the light of experience:
  - how do we generate new facts from old ?
  - how do we generate new concepts ?
  - how do we learn to distinguish different situations in new environments ?

# Interacting with the Environment

- In order to enable intelligent behaviour, we will have to interact with our environment.
- Properly intelligent systems may be expected to:
  - accept sensory input
    - vision, sound, …
  - interact with humans
    - understand language, recognise speech, generate text, speech and graphics, …
  - modify the environment
    - robotics

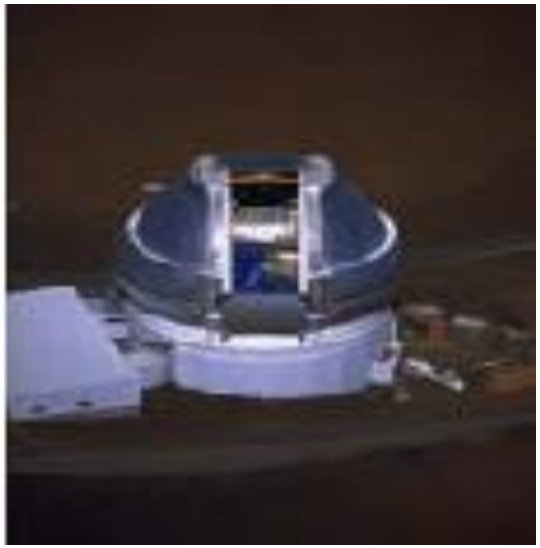
# AI Applications

- Autonomous Planning & Scheduling:
  - Autonomous rovers.



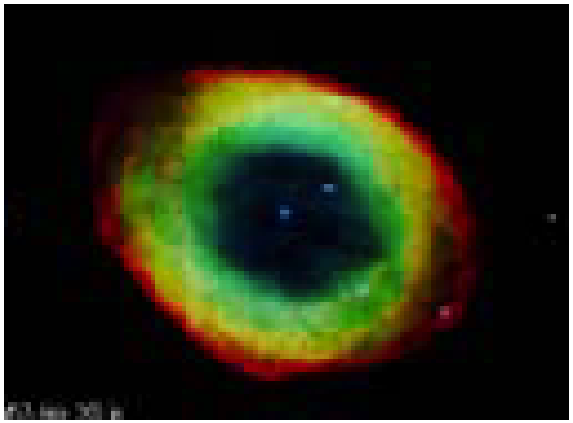
# AI Applications

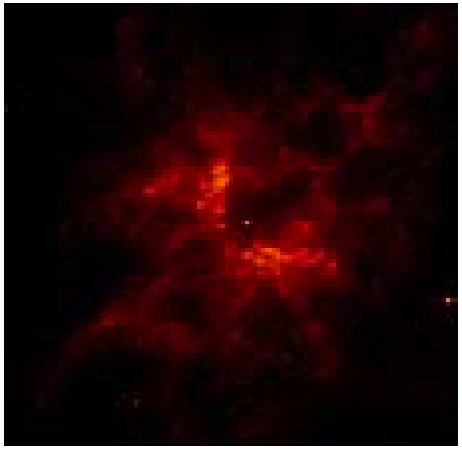
- Autonomous Planning & Scheduling:
  - Telescope scheduling



# AI Applications

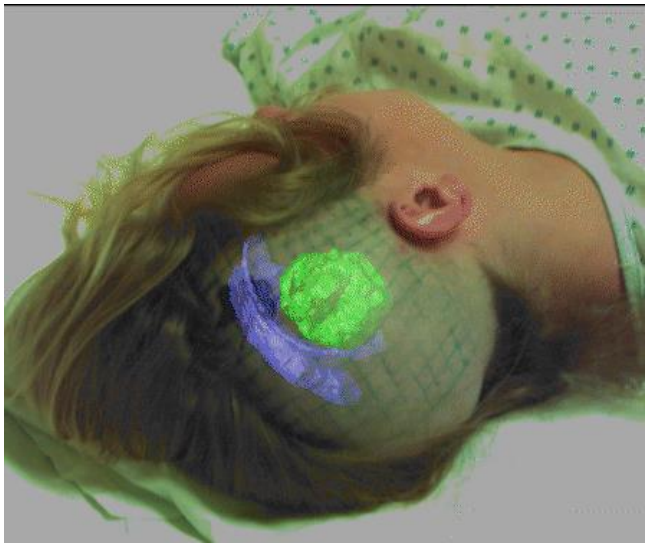
- Autonomous Planning & Scheduling:
  - Analysis of data:

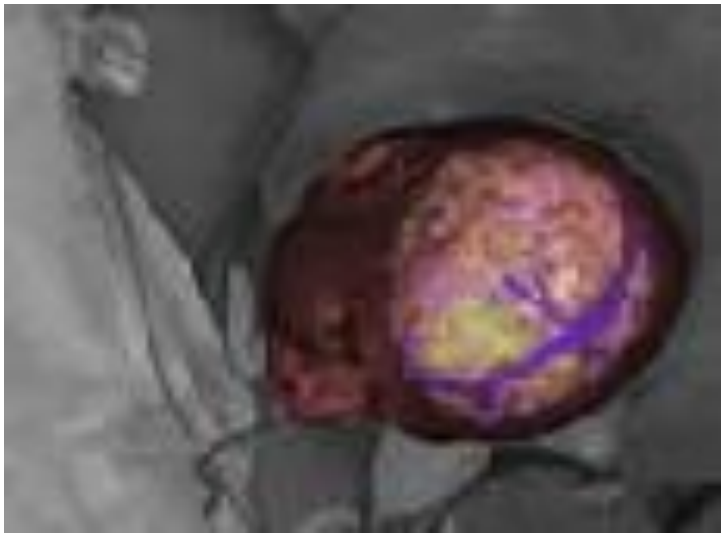




# AI Applications

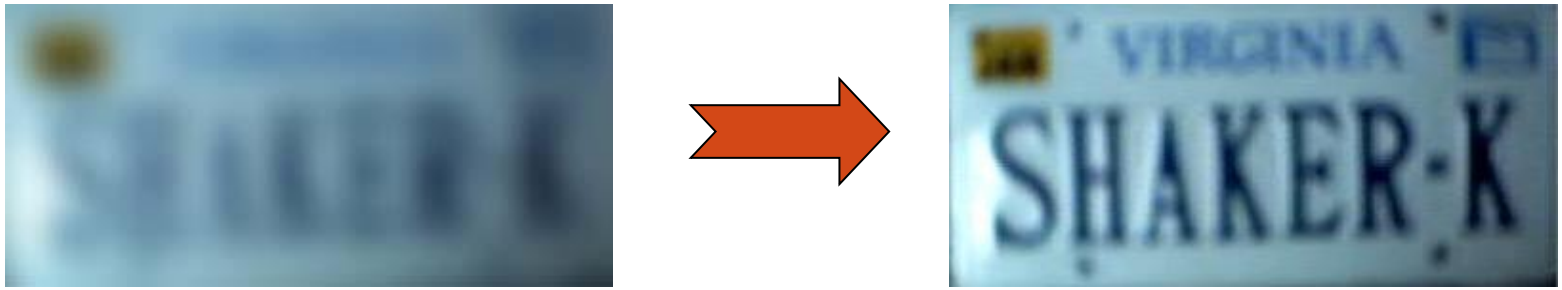
- **Medicine**:
  - Image guided surgery

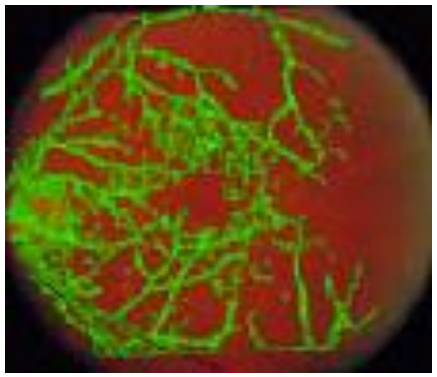


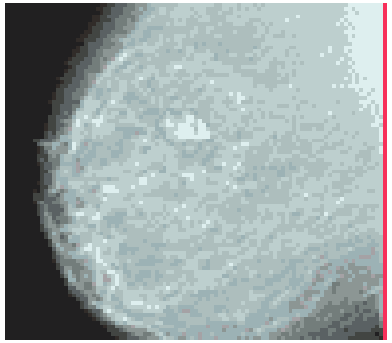


# AI Applications

- **Medicine**:
  - Image analysis and enhancement





# AI Applications

- **Transportation**:
  - **Autonomous vehicle control:**

# AI Applications

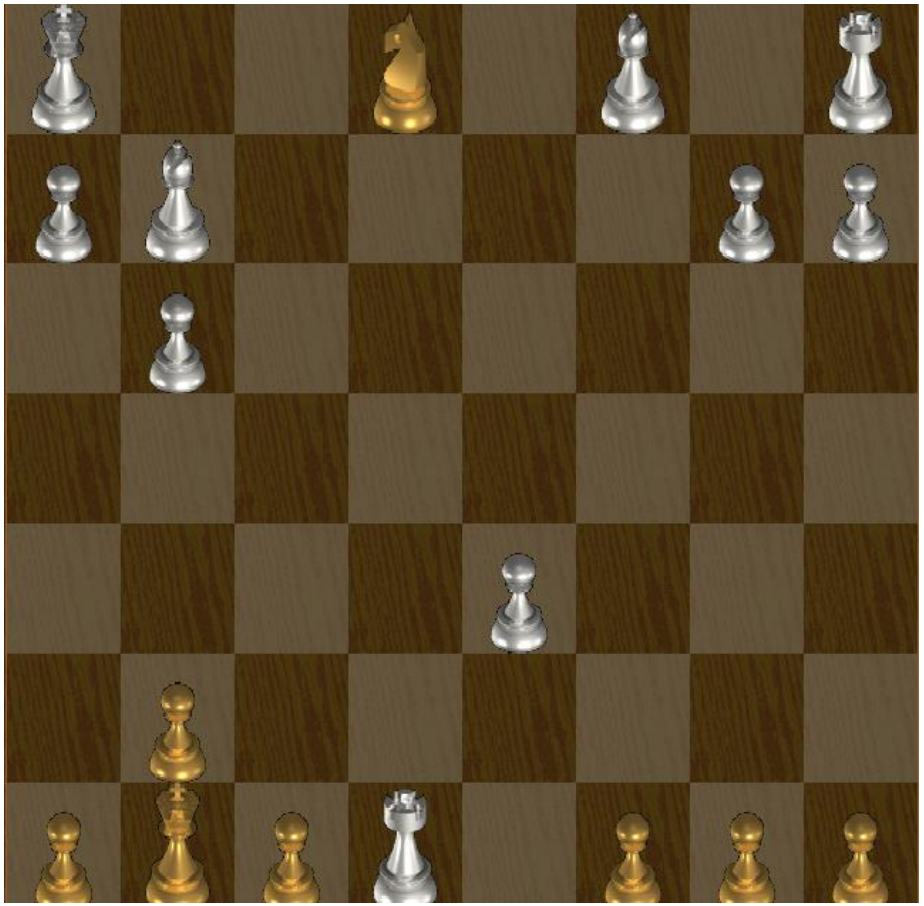
- **Transportation**:
  - **Pedestrian detection:**

# AI Applications

**Games**:

# AI Applications

- **Games**:



# AI Applications

- **Robotic toys**:

# AI Applications

**Other application areas**:

- **Bioinformatics:**
  - Gene expression data analysis
  - Prediction of protein structure
- **Text classification, document sorting**:
  - Web pages, e-mails
  - Articles in the news
- **Video, image classification**
- **Music composition, picture drawing**
- **Natural Language Processing** 
-