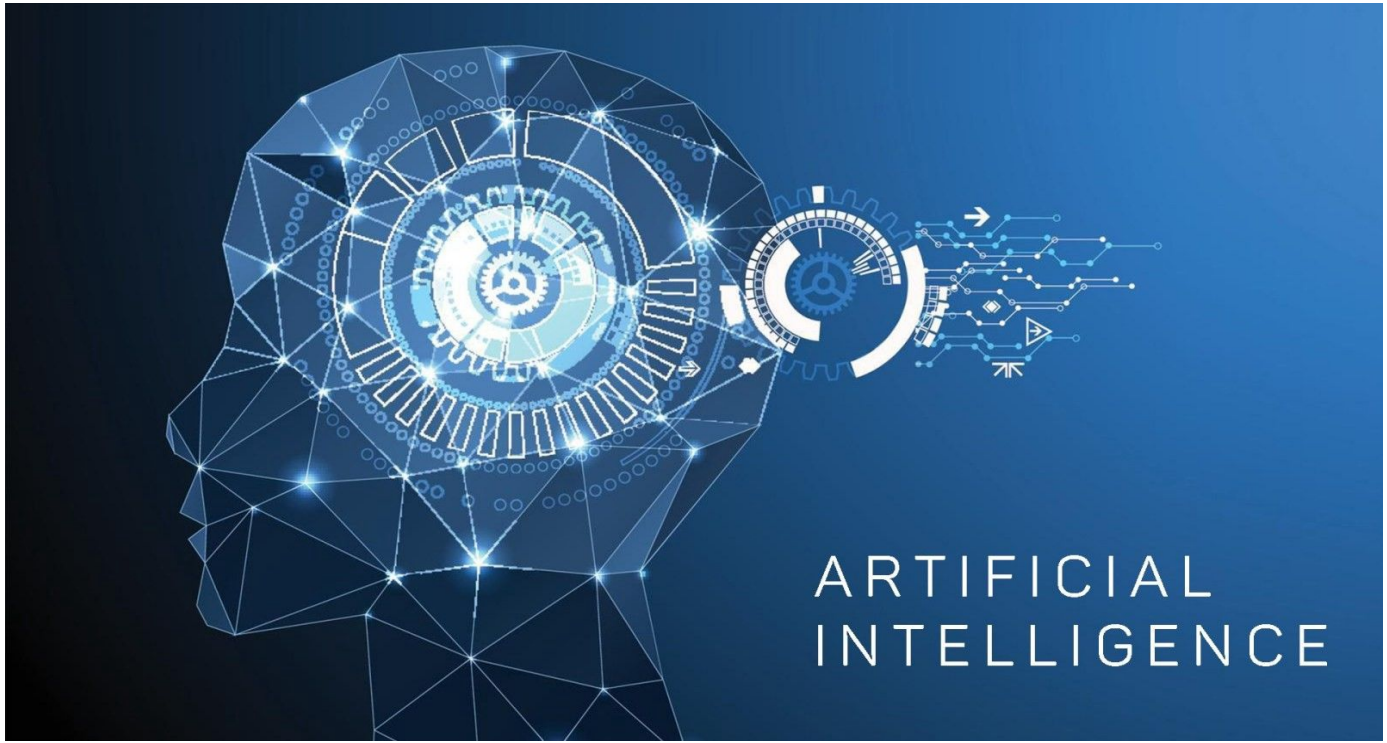


SEMESTER VI (SVU TY)
COURSE CODE: 116U01C603
CREDITS = 3, LEC/WEEK = 3

Faculty - Dr. Ayesha Hakim

MODULE 1 & 2 - SYLLABUS

Module No.	Unit No.	Details	Hrs.	CO
1	**Introduction to Artificial Intelligence**		3	CO1
	1.1	History of Artificial Intelligence, The AI problem*, The AI technique*, Foundations of AI		
	1.2	Categorization of Intelligent System, Components of AI Program,		
	1.3	Sub-areas of AI, Applications of AI, Current trends in AI.		
2	**Intelligent Agents**		5	CO1
	2..1	Agents and Environments, The concept of rationality, The Task environment and their properties, PEAS, The structure of Agents, Types of Agents, Learning Agent, function of agent program		

Students should prepare all Self Learning topics on their own. Self-learning topics will enable students to gain extended knowledge of the topic. Assessment of these topics may be included in IA and Laboratory Experiments.

$- Teachers can choose from any state of art AI application and research work; these are suggestive contents. Based on the latest developments, these topics(minimum 2) could be chosen.

Examination Scheme

ISE - 30 MARKS

IA - 20 MARKS (IA component will be shared in due course of time)

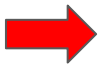
ESE - 50 MARKS

TOTAL - 100 MARKS

Recommended Books:

Sr. No.	Name/s of Author/s	Title of Book	Name of Publisher with country	Edition and Year of Publication
1.	Stuart J. Russell and Peter Norvig	Artificial Intelligence : A Modern Approach	Pearson Education.	Second Edition
2.	*Elaine Rich and Kevin Knight	Artificial Intelligence	The McGraw-Hill	Third Edition
3.	George F Luger	Artificial Intelligence	Pearson Education	Fourth Edition

Expert Systems



Ivan Bratko "**PROLOG** Programming for Artificial Intelligence", Pearson Education, Third Edition.

Course Prerequisites (if any):

Data structures, analysis of algorithms

Course Objectives:

1. The objective of the course is to present an overview of artificial intelligence principles and approaches.
2. To enable students to develop a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, Knowledge representation, inference, logic, and learning.
3. The knowledge of artificial intelligence plays a considerable role in some applications students develop for courses in the program.

Course Outcomes

At the end of successful completion of the course the student will be able to

CO1: Design AI solution with appropriate choice of agent architecture

CO2: Analyse and solve problems for goal based agent architecture (searching and planning algorithms).

CO3: Represent and formulate the knowledge to solve the problems using various reasoning techniques

CO4: Analyse applications of AI and understand planning & learning processes in advanced AI applications

Artificial Intelligence:

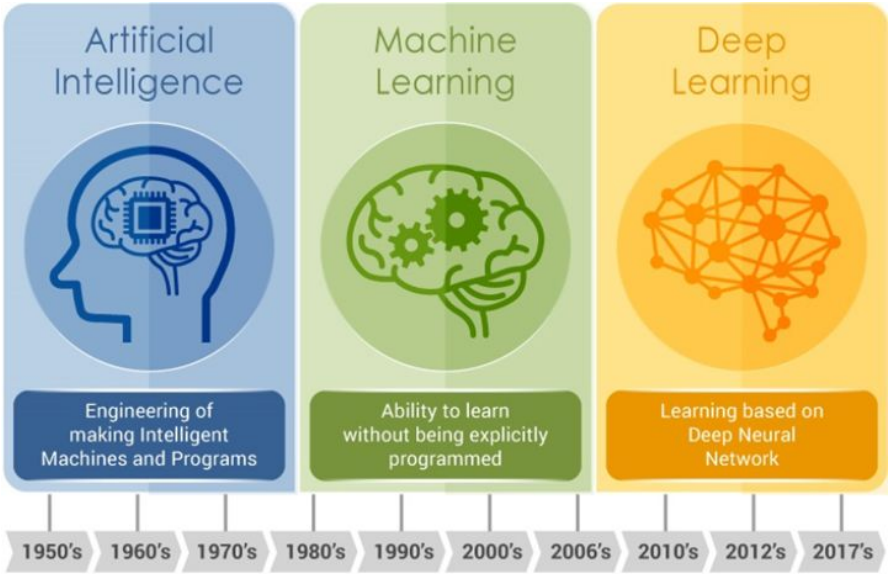
Mimicking the intelligence or behavioural pattern of humans or any other living entity.

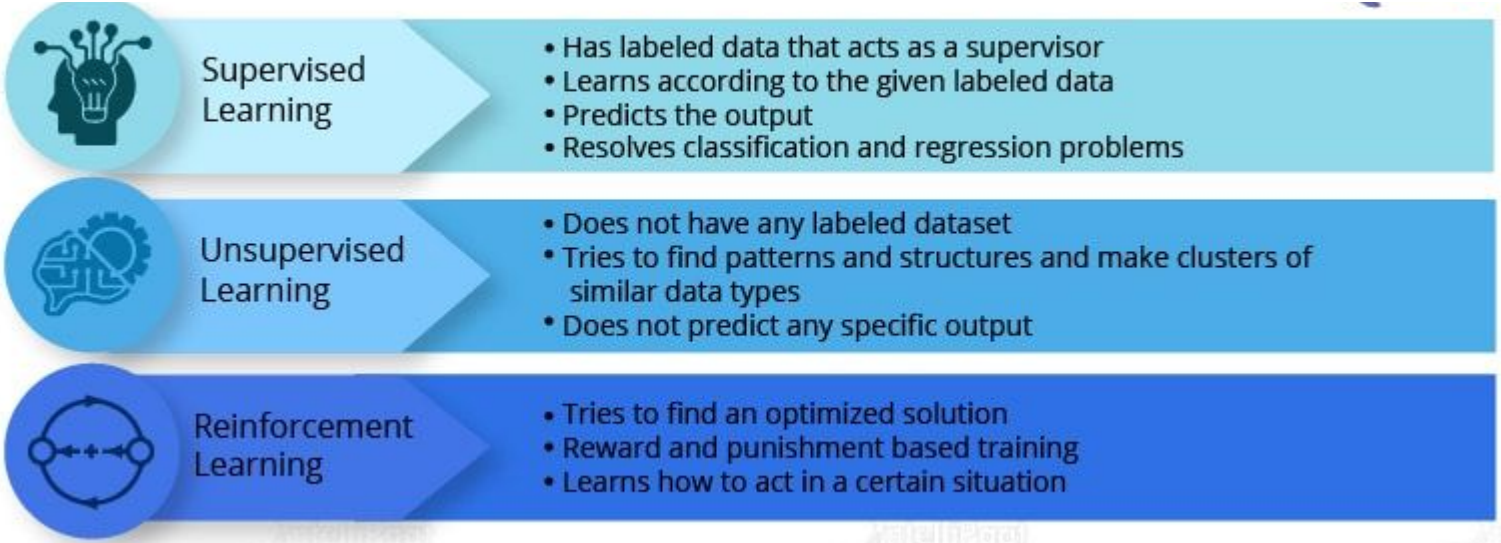
Machine Learning:

A technique by which a computer can "learn" from data, without using a complex set of different rules. This approach is mainly based on training a model from datasets.

Deep Learning:

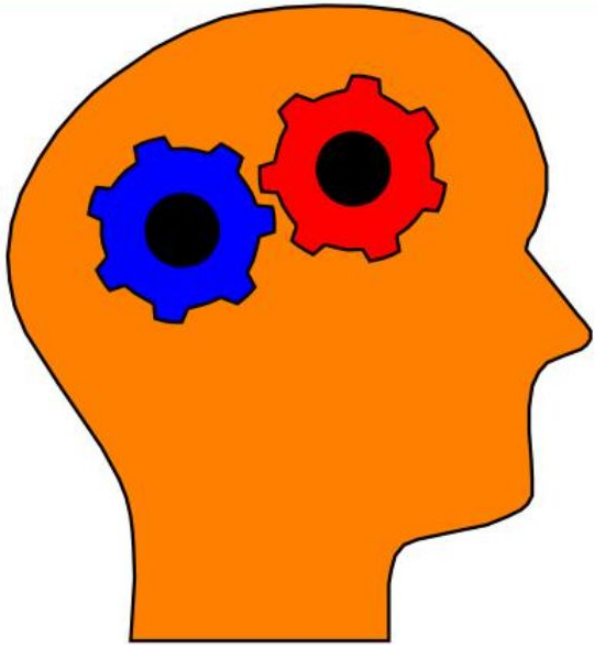
A technique to perform machine learning inspired by our brain's own network of neurons.





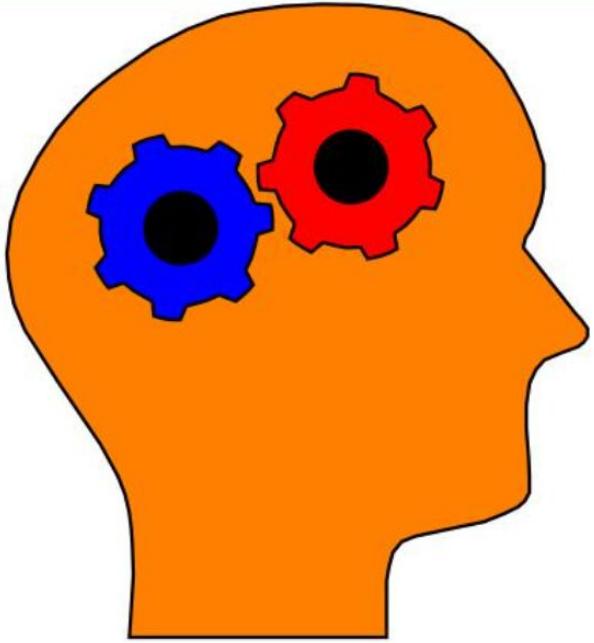
- Supervised learning
  - regression: predict numerical values
  - classification: predict categorical values, i.e., labels
- Unsupervised learning
  - clustering: group data according to "distance"
  - association: find frequent co-occurrences
  - link prediction: discover relationships in data
  - data reduction: project features to fewer features
- Reinforcement learning

What Is (Artificial) Intelligence?



- What is intelligence?
  - The ability to *learn* or *understand* from experience
  - The ability to *acquire* and *retain* knowledge
  - The ability to *respond* quickly and successfully to a new situation
  - The ability to *use reason* to solve problems

What Is *Artificial* Intelligence?

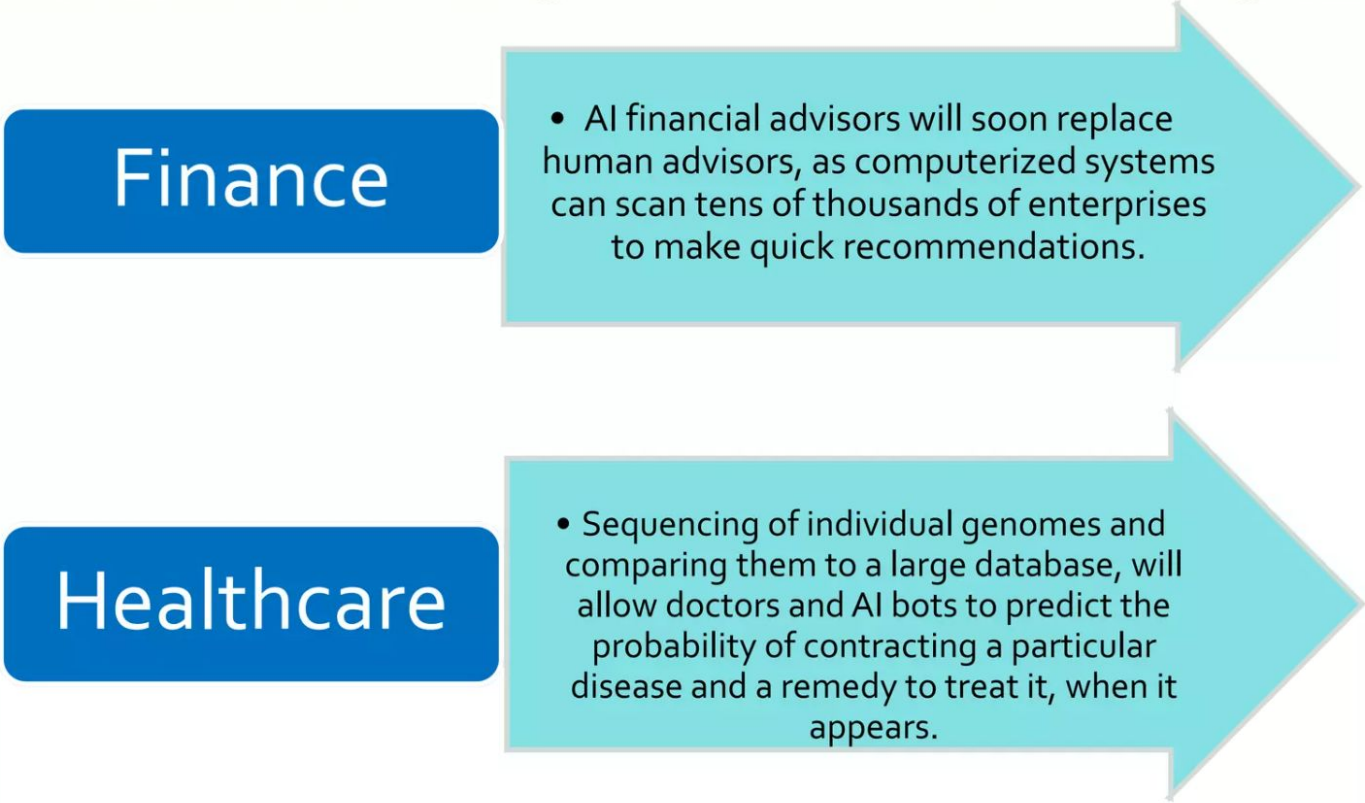


- If intelligence is *learning, understanding, retaining, responding, and using reason* then what is AI?
- Is mimicking such phenomena using a machine an expression of artificial intelligence?

Artificial Intelligence

- The capacity of a computer to perform operations analogous to learning and decision making in humans, as by an expert system, a program for CAD or CAM, or a program for the perception and recognition of shapes in computer vision systems

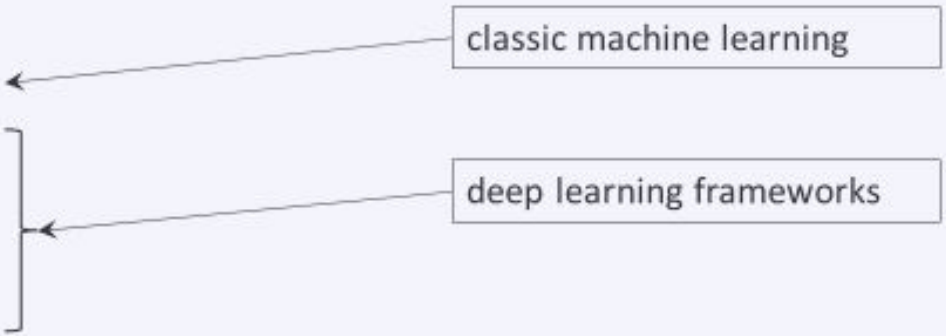
Industries which will benefit because of Machine Learning and Artificial Intelligence



Frameworks

- Programming languages
  - Python
  - R
  - C++
  - ...
- Many libraries
  - scikit-learn
  - PyTorch
  - TensorFlow
  - Keras
  - ...

Fast-evolving ecosystem!



scikit-learn

- Nice end-to-end framework
  - data exploration (+ pandas + holoviews)
  - data preprocessing (+ pandas)
    - cleaning/missing values
    - normalization
  - training
  - testing
  - application
- "Classic" machine learning only
- https://scikit-learn.org/stable/

Keras

- High-level framework for deep learning
- TensorFlow backend
- Layer types
  - dense
  - convolutional
  - pooling
  - embedding
  - recurrent
  - activation
  - …
- https://keras.io/

What is the definition of AI?

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

Bellman, 1978

"[The automation of] activities that we associate with human thinking, activities such as decision making, problem solving, learning"

What is the definition of AI?

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

Charniak & McDermott, 1985

"The study of mental faculties through the use of computational models"

What is the definition of AI?

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

Dean et al., 1995

"The design and study of computer programs that behave intelligently. These programs are constructed to perform as would a human or an animal whose behavior we consider intelligent"

What is the definition of AI?

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

Haugeland, 1985

"The exciting new effort to make computers think *machines with minds*, in the full and literal sense"

What is the definition of AI?

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

Kurzweil, 1990

"The art of creating machines that perform functions that require intelligence when performed by people"

What is the definition of AI?

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

Luger & Stubblefield, 1993

"The branch of computer science that is concerned with the automation of intelligent behavior"

What is the definition of AI?

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

Nilsson, 1998

"Many human mental activities such as writing computer programs, doing mathematics, engaging in common sense reasoning, understanding language, and even driving an automobile, are said to demand intelligence. We might say that [these systems] exhibit artificial intelligence"

What is the definition of AI?

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

Rich & Knight, 1991

"The study of how to make computers do things at which, at the moment, people are better"

What is the definition of AI?

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

Schalkoff, 1990

"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes"

What is the definition of AI?

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

Winston, 1992

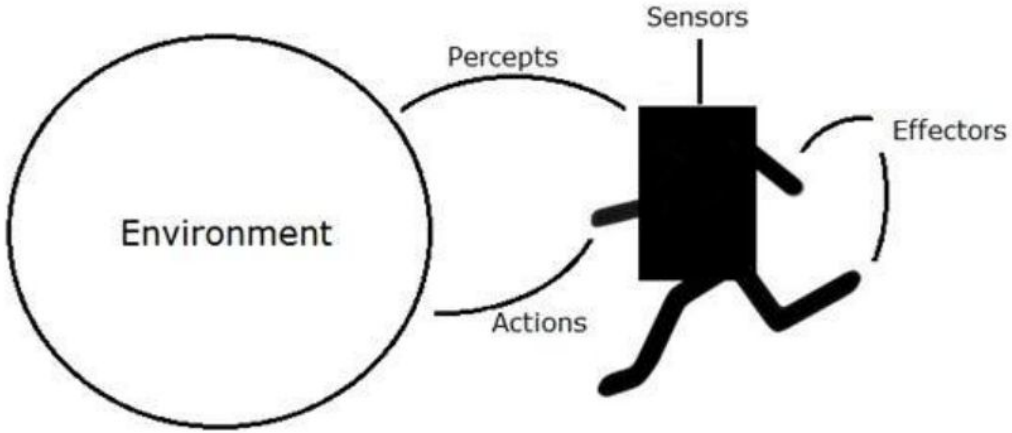
"The study of the computations that make it possible to perceive, reason, and act"

An AI system is composed of an agent and its environment. The agents act in their environment. The environment may contain other agents.

What are Agent and Environment?

An **agent** is anything that can perceive its **environment** through **sensors** and acts upon that environment through **effectors.**

- A **human agent** has sensory organs such as eyes, ears, nose, tongue and skin parallel to the sensors, and other organs such as hands, legs, mouth, for effectors.
- A **robotic agent** replaces cameras and infrared range finders for the sensors, and various motors and actuators for effectors.
- A **software** agent has encoded bit strings as its programs and actions.



Turing Test

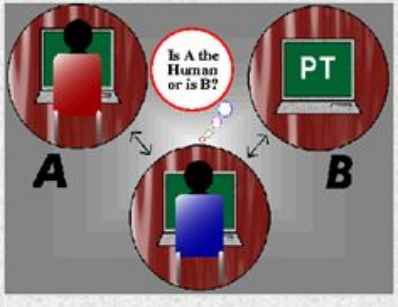
The success of an intelligent behavior of a system can be measured with Turing Test.

Two persons and a machine to be evaluated participate in the test. Out of the two persons, one plays the role of the tester. Each of them sits in different rooms. The tester is unaware of who is machine and who is a human. He interrogates the questions by typing and sending them to both intelligences, to which he receives typed responses.

This test aims at fooling the tester. If the tester fails to determine machine's response from the human response, then the machine is said to be intelligent.

Approach 1: Acting Humanly

- Turing test: ultimate test for acting humanly
  - Computer and human both interrogated by judge
  - Computer passes test if judge can't tell the difference



How effective is this test?

- Agent must:
  - Have command of language
  - Have wide range of knowledge
  - Demonstrate human traits (humor, emotion)
  - Be able to reason
  - Be able to learn

Approach 2: Thinking Humanly

- Requires knowledge of brain function
- What level of abstraction?
- How can we validate this
- This is the focus of Cognitive Science

Approach 3: Thinking Rationally

- Aristotle attempted this
- What are correct arguments or thought processes?
- Provided foundation of much of AI
- Not all intelligent behavior controlled by logic
- What is our goal? What is the purpose of thinking?

Approach 4: Acting Rationally

- Act to achieve goals, given set of beliefs
- Rational behavior is doing the "right thing"
  - Thing which expects to maximize goal achievement
- This is approach adopted by Russell & Norvig

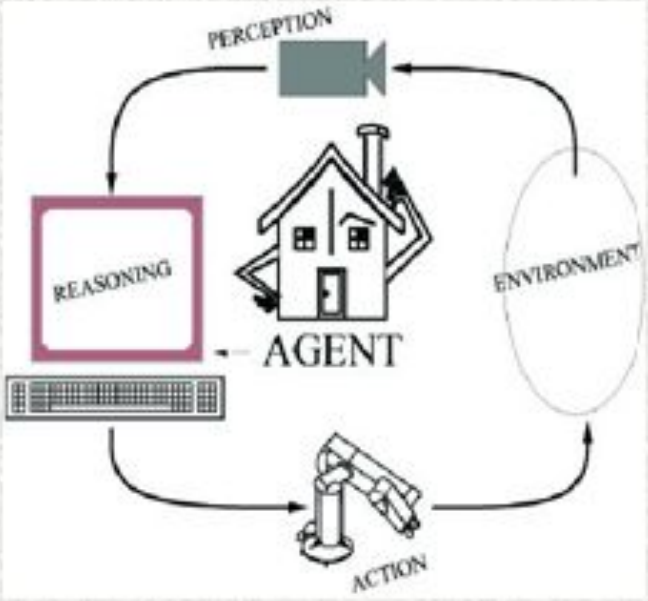
Foundations of AI

- Philosophy
  - 450 BC, Socrates asked for algorithm to distinguish pious from non-pious individuals
  - Aristotle developed laws for reasoning
- Mathematics
  - 1847, Boole introduced formal language for making logical inference
- Economics
  - 1776, Smith views economies as consisting of agents maximizing their own well being (payoff)
- Neuroscience
  - 1861, Study how brains process information
- Psychology
  - 1879, Cognitive psychology initiated
- Linguistics
  - 1957, Skinner studied behaviorist approach to language learning

History of AI

- CS-based AI started with "Dartmouth Conference" in 1956
- Attendees
  - John McCarthy
    - LISP, application of logic to reasoning
  - Marvin Minsky
    - Popularized neural networks
    - Slots and frames
    - The Society of the Mind
  - Claude Shannon
    - Computer checkers
    - Information theory
    - Open-loop 5-ball juggling
  - Allen Newell and Herb Simon
    - General Problem Solver

Components of an AI System



An agent perceives its environment through sensors and acts on the environment through actuators.

Human: sensors are eyes, ears, actuators (effectors) are hands, legs, mouth.

Robot: sensors are cameras, sonar, lasers, ladar, bump, effectors are grippers, manipulators, motors

The agent's behavior is described by its function that maps percept to action.

Rationality

- A rational agent does the right thing (what is this?)
- A fixed performance measure evaluates the sequence of observed action effects on the environment

Rationality

Rationality is nothing but status of being reasonable, sensible, and having good sense of judgment.

Rationality is concerned with expected actions and results depending upon what the agent has perceived. Performing actions with the aim of obtaining useful information is an important part of rationality.

What is Ideal Rational Agent?

An ideal rational agent is the one, which is capable of doing expected actions to maximize its performance measure, on the basis of −

- Its percept sequence
- Its built-in knowledge base

Rationality of an agent depends on the following four factors −

- The **performance measures**, which determine the degree of success.
- Agent's **Percept Sequence** till now.
- The agent's **prior knowledge about the environment**.
- The **actions** that the agent can carry out.

A rational agent always performs right action, where the right action means the action that causes the agent to be most successful in the given percept sequence. The problem the agent solves is characterized by Performance Measure, Environment, Actuators, and Sensors $PEAS$.

PEAS

- Use PEAS to describe task environment
  - Performance measure
  - Environment
  - Actuators
  - Sensors
- Example: Taxi driver
  - Performance measure: safe, fast, comfortable (maximize profits)
  - Environment: roads, other traffic, pedestrians, customers
  - Actuators: steering, accelerator, brake, signal, horn
  - Sensors: cameras, sonar, speedometer, GPS, odometer, accelerometer, engine sensors

Environment Properties

- Fully observable vs. partially observable
- Deterministic vs. stochastic / strategic
- Episodic vs. sequential
- Static vs. dynamic
- Discrete vs. continuous
- Single agent vs. multiagent

Properties of Environment

The environment has multifold properties −

- **Discrete / Continuous** − If there are a limited number of distinct, clearly defined, states of the environment, the environment is discrete *Forexample*, *chess*; otherwise it is continuous *Forexample*, *driving*.
- **Observable / Partially Observable** − If it is possible to determine the complete state of the environment at each time point from the percepts it is observable; otherwise it is only partially observable.
- **Static / Dynamic** − If the environment does not change while an agent is acting, then it is static; otherwise it is dynamic.
- **Single agent / Multiple agents** − The environment may contain other agents which may be of the same or different kind as that of the agent.
- **Accessible / Inaccessible** − If the agent's sensory apparatus can have access to the complete state of the environment, then the environment is accessible to that agent.
- **Deterministic / Non-deterministic** − If the next state of the environment is completely determined by the current state and the actions of the agent, then the environment is deterministic; otherwise it is non-deterministic.
- **Episodic / Non-episodic** − In an episodic environment, each episode consists of the agent perceiving and then acting. The quality of its action depends just on the episode itself. Subsequent episodes do not depend on the actions in the previous episodes. Episodic environments are much simpler because the agent does not need to think ahead.

Agent Terminology

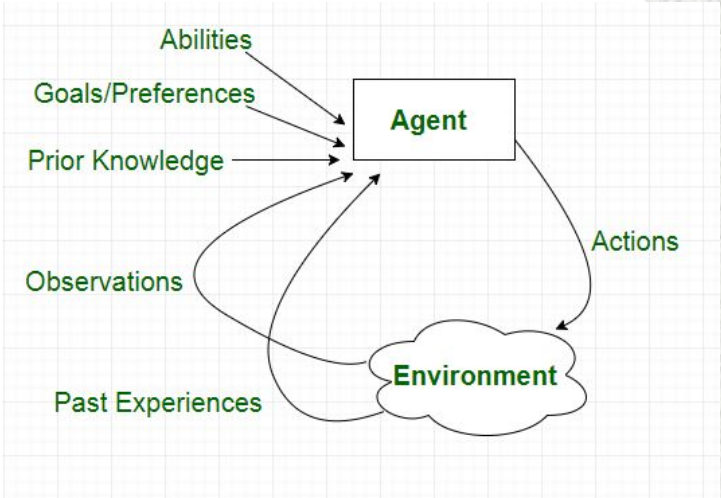
- **Performance Measure of Agent** − It is the criteria, which determines how successful an agent is.
- **Behavior of Agent** − It is the action that agent performs after any given sequence of percepts.
- **Percept** − It is agent's perceptual inputs at a given instance.
- **Percept Sequence** − It is the history of all that an agent has perceived till date.
- **Agent Function** − It is a map from the precept sequence to an action.

The Structure of Intelligent Agents

Agent's structure can be viewed as −

- *Agent = Architecture + Agent Program*
- Architecture = the machinery that an agent executes on.
- Agent Program = an implementation of an agent function.

Agents can be grouped into **five classes** based on their degree of perceived intelligence and capability



Agent Types

- Types of agents (increasing in generality and ability to handle complex environments)
  - Simple reflex agents
  - Reflex agents with state
  - Goal-based agents
  - Utility-based agents
  - Learning agent

Simple reflex agents ignore the rest of the percept history and act only on the basis of the **current percept**. Percept history is the history of all that an agent has perceived to date.

The agent function is based on the **condition-action rule**. A condition-action rule is a rule that maps a state i.e, condition to an action. **If the condition is true, then the action is taken, else not.** This agent function only succeeds when the environment is fully observable.

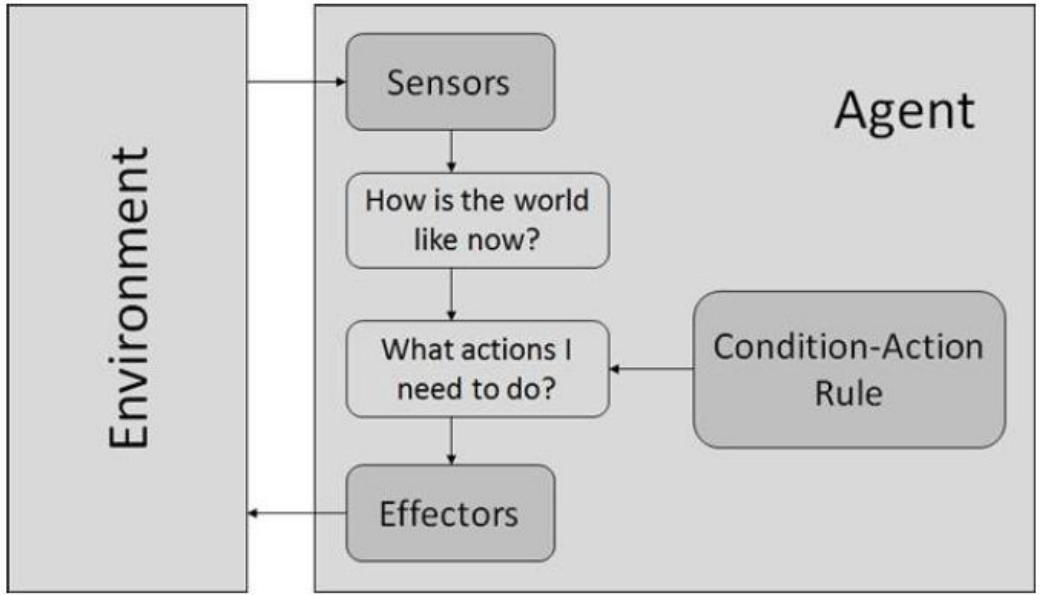
Con-

- Very limited intelligence.

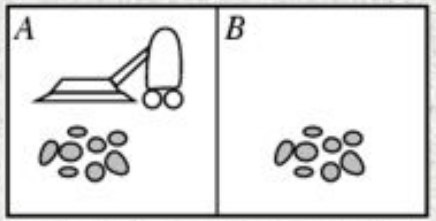
Simple Reflex Agents

- They choose actions only based on the current percept.
- They are rational only if a correct decision is made only on the basis of current precept.
- Their environment is completely observable.

Condition-Action Rule – It is a rule that maps a state *condition* to an action.



Example: Vacuum Agent



- Performance?
  - 1 point for each square cleaned in time T?
  - #clean squares per time step - #moves per time step?
- Environment: vacuum, dirt, multiple areas defined by square regions
- Actions: left, right, suck, idle
- Sensors: location and contents
  - [A, dirty]

- Rational is not omniscient
  - Environment may be partially observable
- Rational is not clairvoyant
  - Environment may be stochastic
- Thus Rational is not always successful

Model Based Reflex Agents

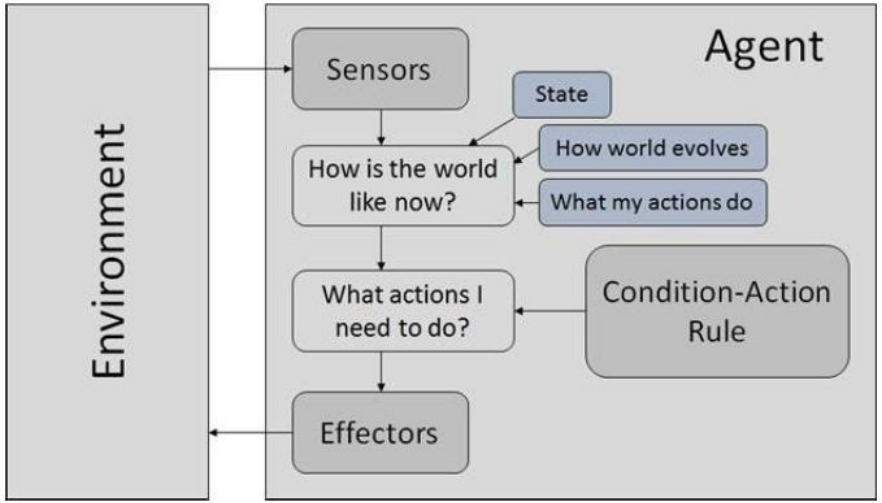
They use a model of the world to choose their actions. They maintain an internal state.

Model – The knowledge about how the things happen in the world.

Internal State – It is a representation of unobserved aspects of current state depending on percept history.

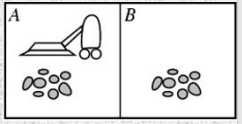
Updating the state requires the information about –

- How the world evolves.
- How the agent's actions affect the world.



- Store previously-observed information
- Can reason about unobserved aspects of current state

Reflex Vacuum Agent



- If status=Dirty then Suck

  else if have not visited other square in >3 time units, go there

MODEL BASED REFLEX AGENTS

It works by finding a rule whose condition matches the current situation. A model-based agent can handle **partially observable environments** by the use of a model about the world. **The agent has to keep track of the internal state which is adjusted by each percept and that depends on the percept history.**

The current state is stored inside the agent which maintains some kind of structure describing the part of the world which cannot be seen.

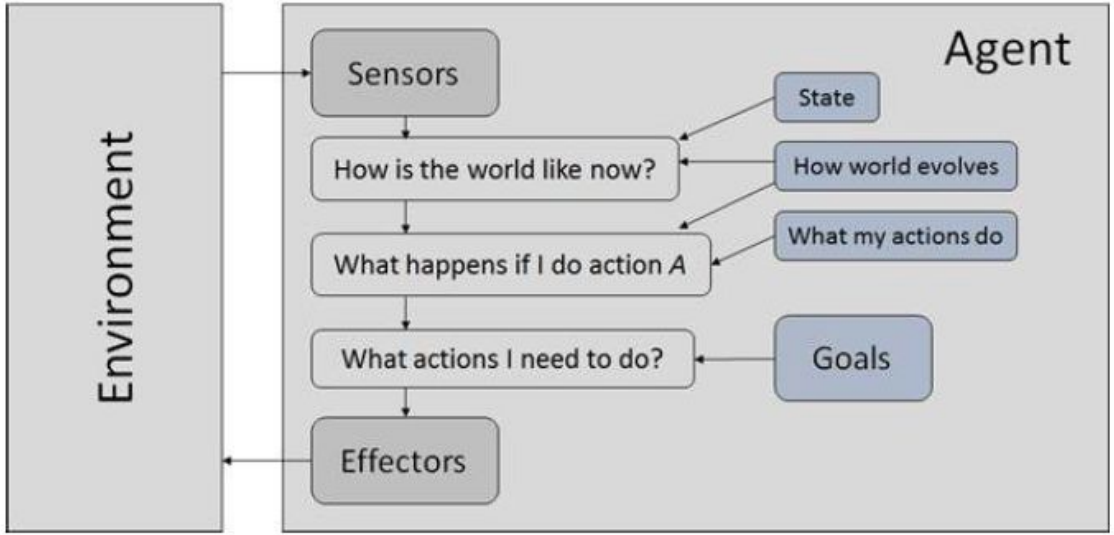
Updating the state requires information about :

- how the world evolves independently from the agent, and
- how the agent's actions affect the world.

Goal Based Agents

They choose their actions in order to achieve goals. Goal-based approach is more flexible than reflex agent since the knowledge supporting a decision is explicitly modeled, thereby allowing for modifications.

Goal – It is the description of desirable situations.



- Goal reflects desires of agents
- May project actions to see if consistent with goals
- Takes time, world may change during reasoning

These kinds of agents take decisions based on how far they are currently from their goal (description of desirable situations).

Their **every action is intended to reduce its distance from the goal**. This allows the agent a way to **choose among multiple possibilities, selecting the one which reaches a goal state.**

- Flexible

•Evaluation function to measure utility f(state) -> value

•Useful for evaluating competing goals

When there are multiple possible alternatives, then to decide which one is best, utility-based agents are used.

They choose actions based on a **preference (utility)** for each state.

Sometimes achieving the desired goal is not enough. We may look for a quicker, safer, cheaper trip to reach a destination.

Agent happiness should be taken into consideration. Utility describes how **"happy"** the agent is.

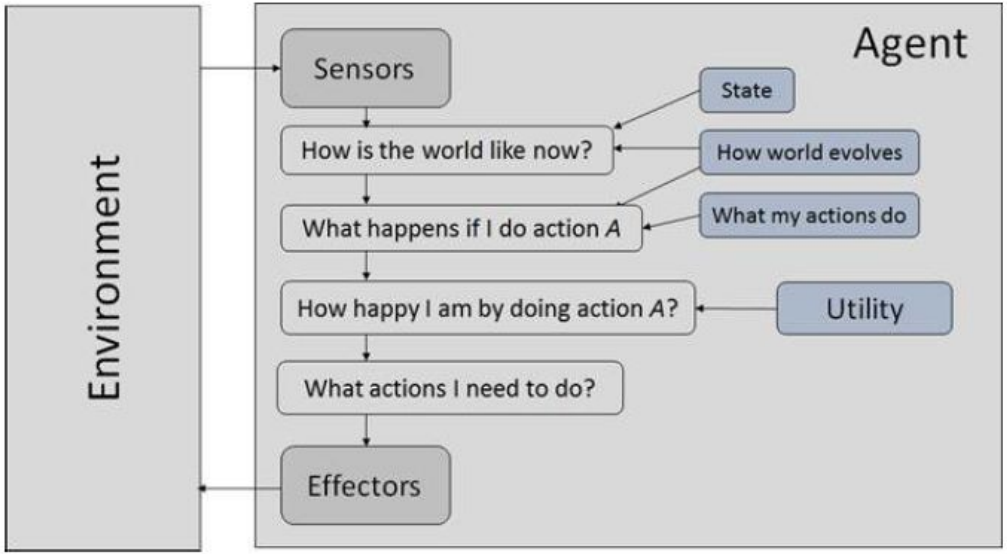
Because of the uncertainty in the world, a utility agent **chooses the action that maximizes the expected utility.**

Utility Based Agents

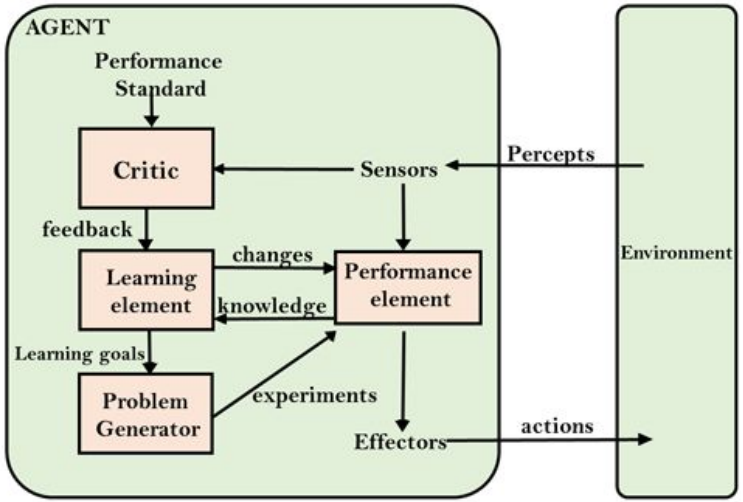
They choose actions based on a preference *utility* for each state. Goals are inadequate when –

- There are conflicting goals, out of which only few can be achieved.

- Goals have some uncertainty of being achieved and you need to weigh likelihood of success against the importance of a goal.



Learning Agent :



A learning agent in AI is the type of agent that can learn from its past experiences or it has learning capabilities. It starts to act with basic knowledge and then is able to act and adapt automatically through learning.

A learning agent has mainly four conceptual components, which are:

1. **Learning element:** It is responsible for making improvements by learning from the environment
2. **Critic:** The learning element takes feedback from critics which describes how well the agent is doing with respect to a fixed performance standard.
3. **Performance element:** It is responsible for selecting external action
4. **Problem Generator:** This component is responsible for suggesting actions that will lead to new and informative experiences.

Typical AI Problems

While studying the typical range of **tasks that we might expect an "intelligent entity" to perform**, we need to consider both "common-place" tasks as well as expert tasks.

Examples of **common-place tasks** include:
– Recognizing people, objects
– Communicating (through natural language)
– Navigating around obstacles on the streets

These tasks are **done matter of factly and routinely by people** and some other animals.

Expert tasks include:
• Medical diagnosis
• Mathematical problem solving
• Playing games like chess

These tasks **cannot be done by all people**, and can only be performed by skilled specialists.