Artificial Intelligence (CSC261)

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Recap...!

- Our approach to artificial intelligence centers around rational agents, as outlined in Unit 1.
- Along with this we studied about:
  - Definition of AI
  - AI Perspectives
  - History of AI
  - Foundations and Applications of AI
- This chapter aims to provide a more concrete understanding of the notion of rationality, by demonstrating its applicability to various types of agents functioning in any possible environment.

Introduction of agents

- The environment serves as the context within which an agent performs its actions.
- Anything that is capable of perceiving its surroundings through sensors and taking actions in response using actuators can be considered an agent.

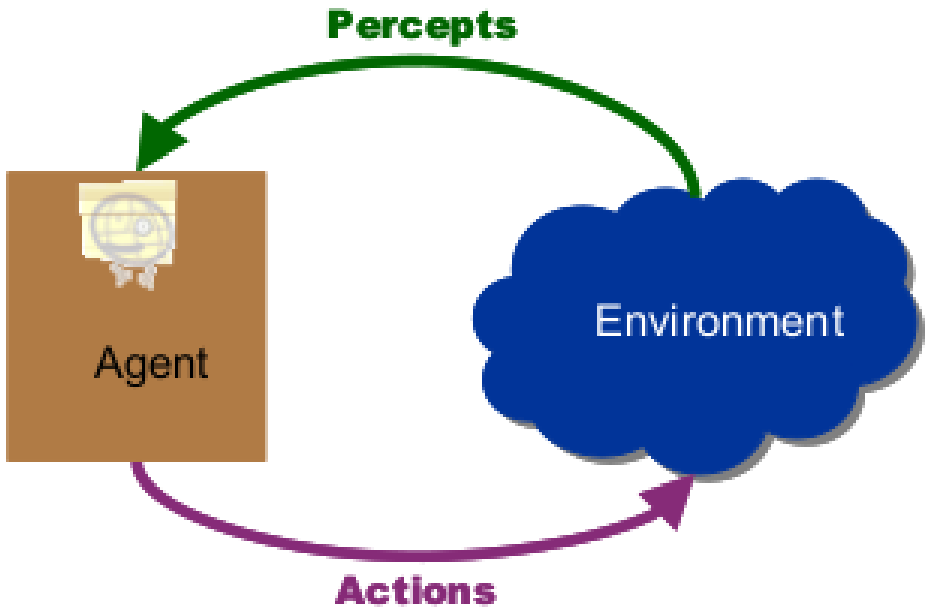
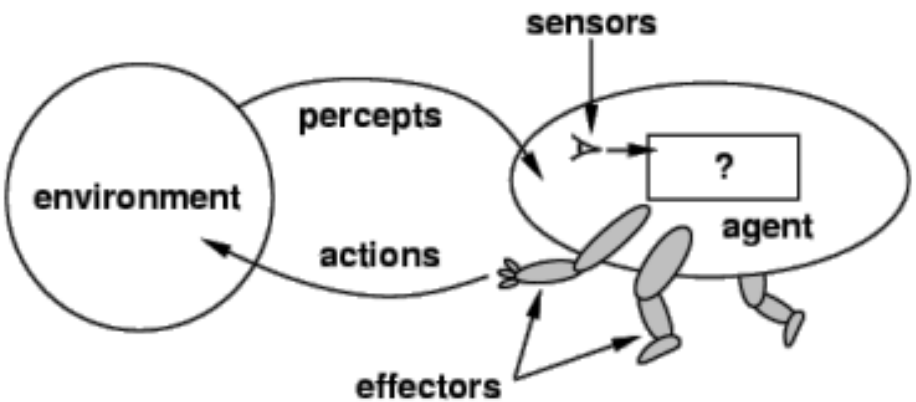


Figure 1: A high level view of agent and environment

Introduction of agents

- What do you mean, sensors/percepts and effectors/actions for human?
  - Sensors: Eyes (vision), ears (hearing), skin (touch), tongue (gestation), and so on.
  - Percepts:
    - At the lowest level: electrical signals from these sensors
    - After pre-processing: objects in the visual field (location, textures, colors, ...), auditory streams (pitch, loudness, direction), and so on.
  - Effectors: limbs, digits, eyes, tongue, and so on.
  - Actions: lift a finger, turn left, walk, run, carry an object, and so on.



Introduction of agents

- An agent perceives its environment through sensors.
- The complete set of inputs at a given time is called a percept.
- The current percept, or a sequence of percepts can influence the actions of an agent.
- The agent can change the environment through actuators or effectors.

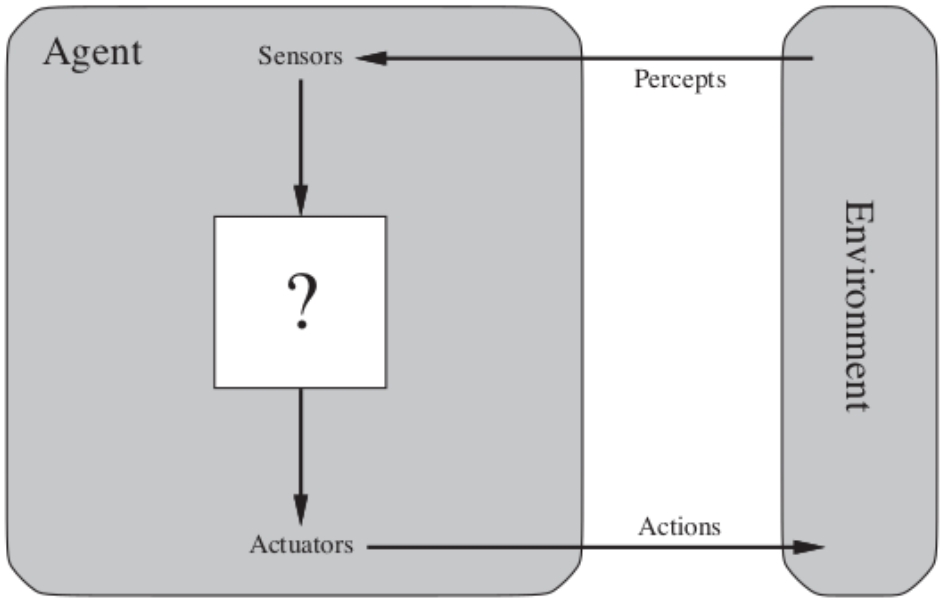


Figure 3: Agents interact with environments through sensors and actuators

Introduction of agents

- An operation involving an effector is called an action.
- Actions can be grouped into action sequences.
- The agent can have goals which it tries to achieve.
- Thus, an agent can be looked upon as a system that implements a mapping from percept sequences to actions.

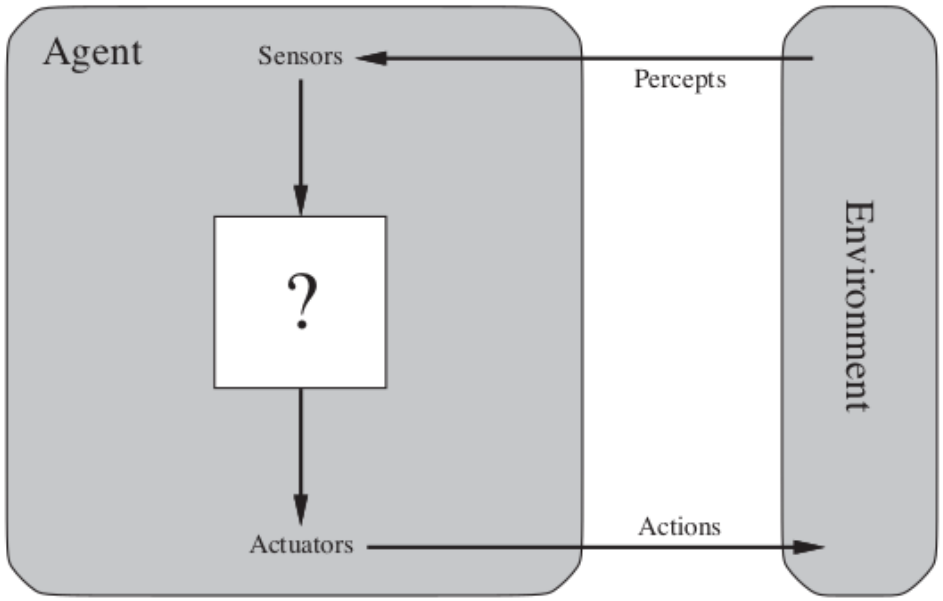


Figure 4: Agents interact with environments through sensors and actuators

Introduction of agents

- A performance measure has to be used in order to evaluate an agent.
- An autonomous agent decides autonomously which action to take in the current situation to maximize progress towards its goals.

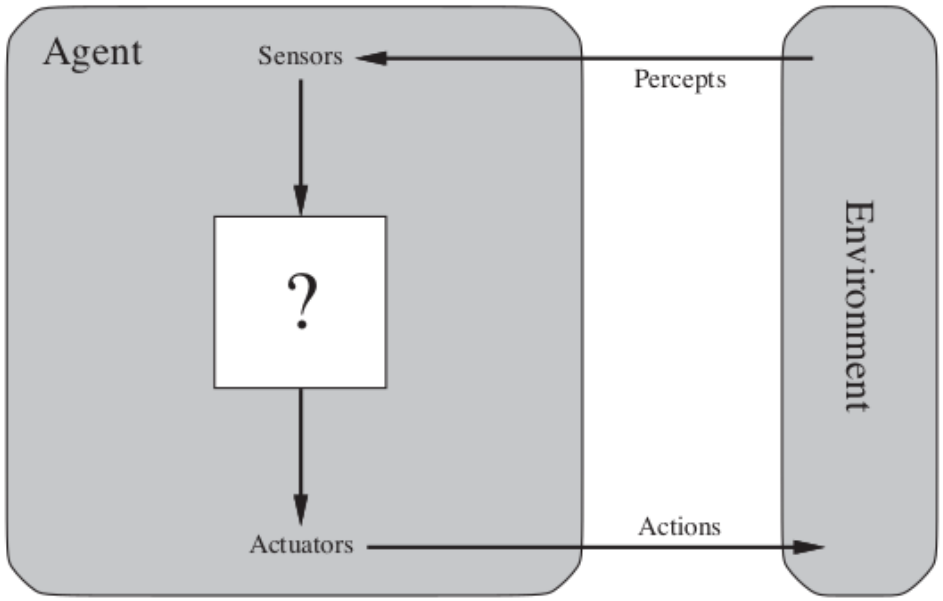


Figure 5: Agents interact with environments through sensors and actuators

Introduction of agents

- For example: Automated driving system
  - Percepts: Video, sonar, speedometer, odometer, engine sensors, keyboard input,microphone, GPS, and so on.
  - Actions: Steer, accelerate, brake, horn, speak/display, and so on.
  - Goals: Maintain safety, reach destination, maximize profits (fuel, tire wear), obey laws, provide passenger comfort, and so on.
  - Environment: Urban streets, freeways, traffic, weather, customer and so on,
- Different aspects of driving may require different types of agent programs.
- Challenge:
  - Compare Software with an agent
  - Compare Human with an agent

Structure and Configuration of Intelligent agent

- We are talking about agents by describing behavior —the action that is performed after any given sequence of percepts.
- The job of AI is to design an agent program that implements the agent function —the mapping from percepts to actions.
- We assume this program will run on some sort of computing device with physical sensors and actuators —we call this the architecture:
  - $agent = architecture + program$
- Generally, the program we choose has to be one that is appropriate for the architecture.
- If the program is going to recommend actions like Walk, the architecture had better have legs.
- The architecture might be just an ordinary PC, or it might be a robotic car with several onboard computers, cameras, and other sensors etc.

Structure and Configuration of Intelligent agent

- **Architecture**: This refers to machinery or devices that consists of actuators and sensors. The intelligent agent executes on this machinery. Examples include a personal computer, a car, or a camera.
- **Agent function**: This is a function in which actions are mapped from a certain percept sequence. Percept sequence refers to a history of what the intelligent agent has perceived.
- **Agent program**: This is an implementation or execution of the agent function. The agent function is produced through the agent program's execution on the physical architecture.

Structure and Configuration of Intelligent agent

- Agent program take the current percept as input from the sensors and return an action to the actuators.
- Percept: The Agents perceptual inputs at any given instant.
- Percept Sequence: The complete history of everything the agent has ever perceived.
- The agent function is mathematical concept that maps percept sequence to actions. $f : P* \rightarrow A$
- The agent function will internally be represented by the agent program.
- The agent program is concrete implementation of agent function it runs on the physical architecture to produce f.

Properties of Intelligent Agents

- They have some level of autonomy that allows them to perform certain tasks on their own.
- They have a learning ability that enables them to learn even as tasks are carried out.
- They can interact with other entities such as agents, humans, and systems.
- New rules can be accommodated by intelligent agents incrementally.
- They exhibit goal-oriented habits (pro-active).
- They are knowledge-based. They use knowledge regarding communications, processes, and entities.

PEAS description of Agents

- To design a rational agent we must specify its task environment.
- Task environment means PEAS description of the environment:
  - Performance
    - Performance measure is the unit to define the success of an agent. Performance varies with agents based on their different precepts.
  - Environment
    - Environment is the surrounding of an agent at every instant. It keeps changing with time if the agent is set in motion.
  - Actuators
    - An actuator is a part of the agent that delivers the output of action to the environment.
  - Sensors
    - Sensors are the receptive parts of an agent that takes in the input for the agent.

PEAS description of Agents

- Example: PEAS description of the environment for fully automated taxi:
  - Performance: Safety, destination, profits, legality, comfort
  - Environment: Streets/freeways, other traffic, pedestrians, weather
  - Actuators: Steering, accelerating, brake, horn, speaker/display
  - Sensors: Video, sonar, speedometer, engine sensors, keyboard, GPS

Rationality

- What is rational at any given time depends on four things:
  - The performance measure that defines the criterion of success.
  - The agent's prior knowledge of the environment.
  - The actions that the agent can perform.
  - The agent's percept sequence to date.
- This leads to a definition of a rational agent:
- For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has

Types of Agents

- Following are the basic kinds of agent programs that embody the principles underlying almost all intelligent systems:
- Simple Reflexive
- Model-Based (State-Based)
- Goal-Based
- Utility Based
- Learning Agent

Simple Reflexive Agent

- The basic form of an agent is a simple reflex agent.
- This agent makes decisions based solely on the current perception, disregarding past perceptual experiences.
- An instance of a simple reflex agent is the vacuum cleaner agent.
- This agent makes decisions based solely on the current position of the vacuum and whether that position has any dirt present.

Simple Reflexive Agent

- Simple Reflex Agent = Current Percept + Conditions Actions Rules

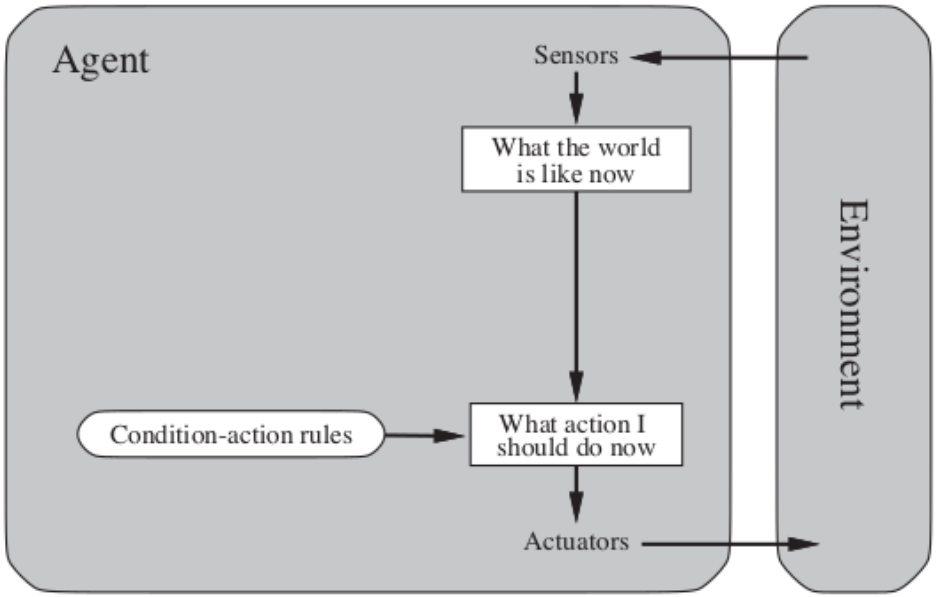


Figure 6: Structure of Simple Reflexive Agents

Model/State Based Agent

- The next level of agent complexity beyond the simple reflex agent is the model-based agent.
- It takes into account the agent's internal state.
- This agent operates by matching the current state of the world to a rule's condition.
- In order to handle tasks in partially observable environments, the model-based agent relies on a model of the world.
- The agent stores the current state internally and maintains a structure that describes the part of the world that is not visible.
- Updating the state requires information about how the world changes independently of the agent, as well as how the agent's actions affect the world.
- By utilizing this information, the agent can navigate through partially observable environments.

Model/State Based Agent

- Model/State Based Agent = Simple Reflexive Agent + Model (Percept history(s))
- An example of a model-based reflex agent is a chess-playing computer program.

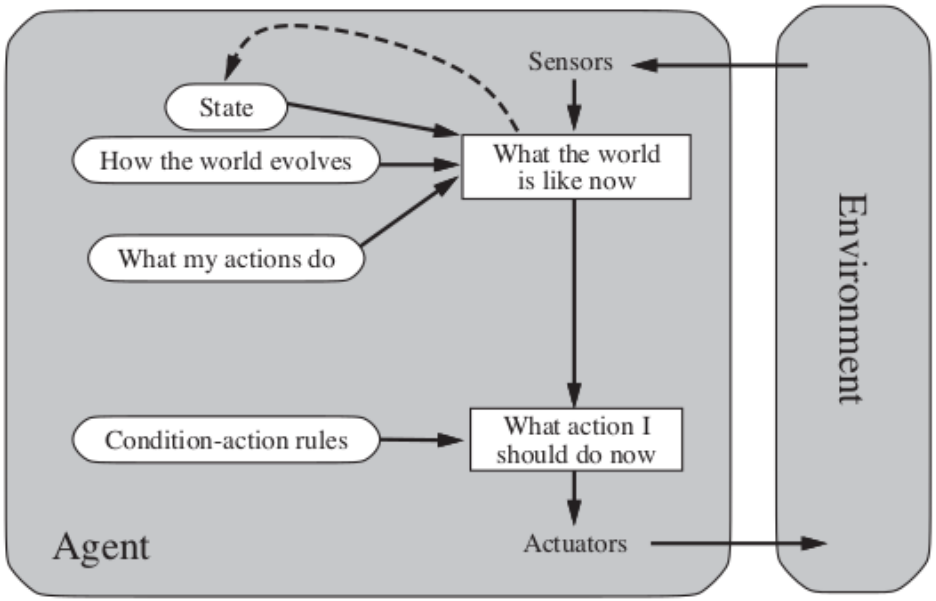


Figure 7: Structure of Model/State Based Reflexive Agents

Goal Based Agent

- The goal-based agent is an extension of the model-based agent, where the agent has information about the goal state in addition to the model of the environment.
- These agents make decisions based on whether the current state is the goal state or not.
- The goal-based agent plans a sequence of actions to reach the goal state while minimizing the cost of each action.
- The agent selects the action that brings it closer to the goal state and continues to do so until it reaches the goal.
- This allows the agent to choose among multiple possibilities and select the one that leads to the goal state.

Goal Based Agent

- Goal-Based Agent = Model-Based Agent + Goal Information
- An example of a goal-based agent is a delivery drone that plans the most efficient route to deliver a package.

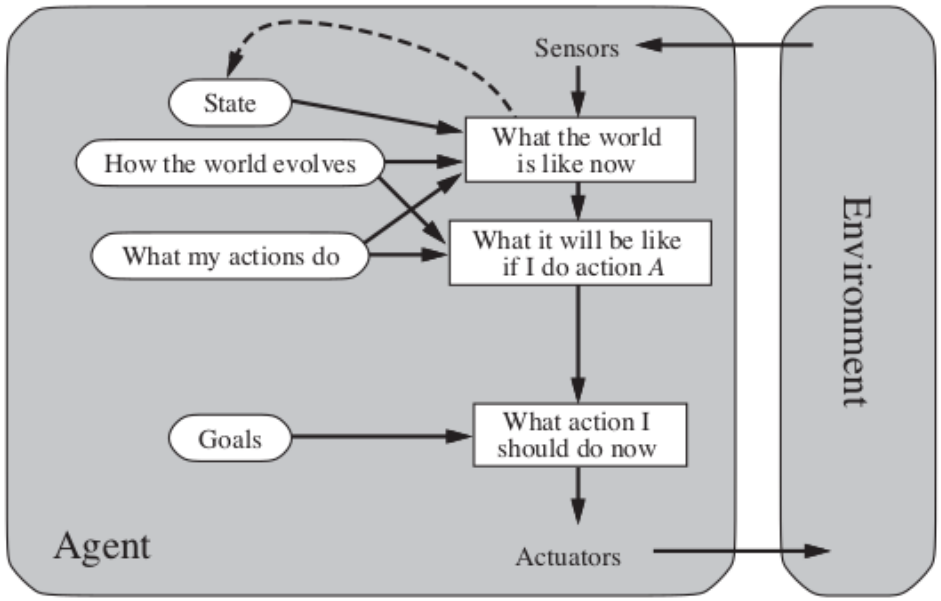


Figure 8: Structure of Goal Based Agents

Utility Based Agent

- One issue with goal-based agents is that they cannot distinguish whether state "A" or state "B" is better.
- To solve this problem, the agent needs to evaluate each state and determine its utility.
- The evaluation is performed using a calculation known as a utility function or evaluation function.
- A utility-based agent chooses actions based on a preference or utility value for each state.
- Achieving the desired goal may not always be enough, as we may prefer a quicker, safer, or cheaper way to reach the destination.
- The utility agent selects the action that maximizes the expected utility due to the uncertainty in the real world.

Utility Based Agent

- A utility function maps each state onto a real number that represents the degree of happiness or satisfaction associated with that state.
- For example, being 70% closer to the goal may have a higher utility value than simply knowing that the current state is not the goal.
- This approach allows the agent to make informed decisions that take into account the relative desirability of each possible state.

Utility Based Agent

- Utility-Based Agent = Goal-Based Agent + Utility Function
- An example of a utility-based agent is a stock trading program that makes decisions based on the potential returns and risks associated with each investment.

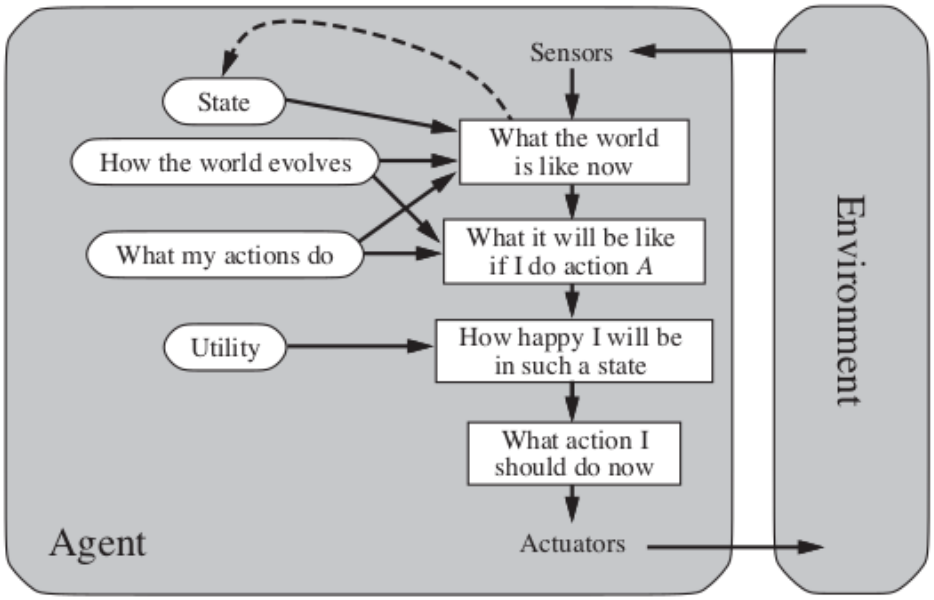


Figure 9: Structure of Utility-Based Agents

Learning Agent

- A learning agent in AI is the type of agent that uses machine learning techniques (such as Reinforcement Learning) in order to learn from its past experiences.
- This is the only agent which can perform in every type of environment.
- It starts to act with basic knowledge and then is able to act and adapt automatically through learning.

Learning Agent

- A learning agent has mainly four conceptual components, which are discussed as:
  - Learning element: It is responsible for making improvements by learning from the environment. It works on feedback from critics.
  - Critic: This component evaluates current action and criticizes if the overall performance of the agent decreases.
  - Performance element: It is responsible for selecting external action
  - Problem Generator: This component is responsible for suggesting actions that will lead to new and informative experiences.

Learning Agent

- Learning Agent = Utility-Based Agent + Learning Mechanism/Function
- An example of a learning agent is a spam filter that learns to identify and filter out spam emails based on examples of previously identified spam emails.

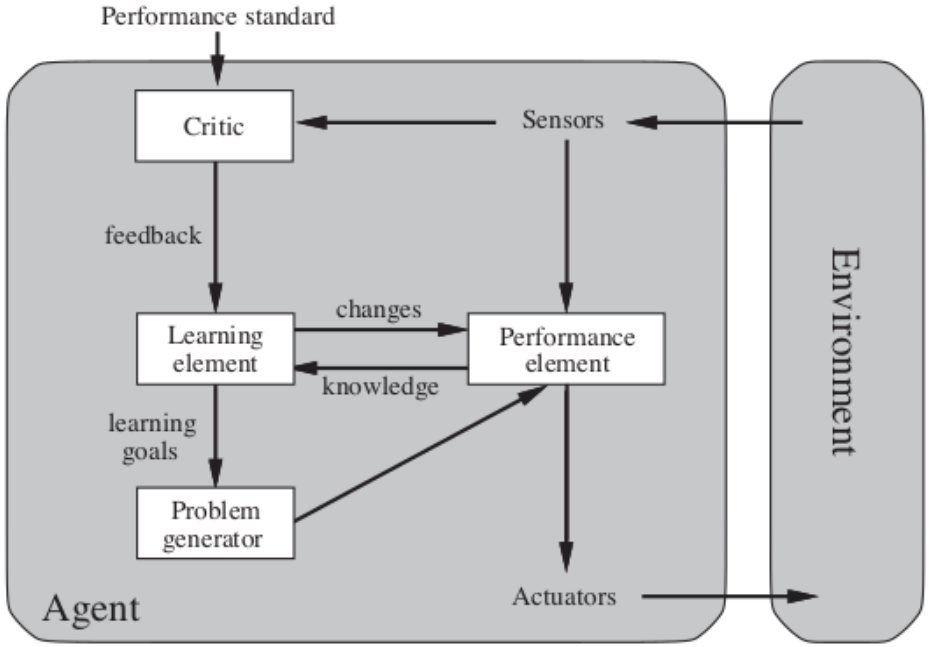


Figure 10: Structure of Utility-Based Agents

Types of Environments

- There are several different types of environments that can be encountered in the context of intelligent agents. Some of the main types of environments are:
  - Deterministic
  - Stochastic
  - Static
  - Dynamic
  - Observable
  - Semi-observable
  - Single-Agent
  - Multi-Agent

Types of Environments

- Deterministic
  - These are environments where the outcome of each action is certain and predictable.
  - An example of a deterministic environment is a game of chess.
- Stochastic
  - These are environments where the outcome of each action is uncertain and subject to change.
  - An example of a stochastic environment is a game of poker.

Types of Environments

- Static
  - These are environments where the state of the environment does not change while the agent is deliberating.
  - An example of a static environment is a maze.
- Dynamic
  - These are environments where the state of the environment changes while the agent is deliberating.
  - An example: self-driving car navigating a busy city street.

Types of Environments

- Observable
  - These are environments where the agent can observe the entire state of the environment.
  - An example of an observable environment is a game of tic-tac-toe.
- Semi-observable
  - These are environments where the agent cannot observe the entire state of the environment, but must infer some aspects of the state based on the available information.
  - An example of a semi-observable environment is a card game like poker.

Types of Environments

- Single-Agent
  - These are environments where there is only one agent operating.
  - An example of a single-agent environment is a computer program that plays chess against a human opponent.
- Multi-Agent
  - These are environments where there are multiple agents operating simultaneously.
  - An example of a multi-agent environment is a stock market where multiple agents (human or computer-based) are buying and selling stocks based on their own goals and strategies.

Learners Should Be Able To Answer The Following:

1. What do you mean by rational agents? Are rational agents intelligent? Explain.
2. How an agent can be configured using the PEAS framework? Illustrate with an example.
3. What are intelligent agents? Differentiate Model-Based Agents differ from utility Based Agent. Mention suitable examples of each.
4. Discuss the types of environments where an agent can work on.
5. What is an intelligent agent? Design PEAS framework for Soccer playing agents and Internet shopping assistants.
6. What are rational agents? How episodic task environment differs from a sequential task environment? Support your answer with suitable examples.

Learners Should Be Able To Answer The Following:

1. Define the Model-Based and Cased Based systems. Discuss which system is suitable for electronic circuit testing and Legal Reasoning.
2. For each of the given agents, Medical diagnosis system, Satellite imagine analysis system, Part-picking robot, and Refinery controller determine what type of agent architecture is most appropriate (i.e., table lookup, simple reflex, goal-based or utility-based).

References


S. J. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 3rd ed. Pearson, 2010.

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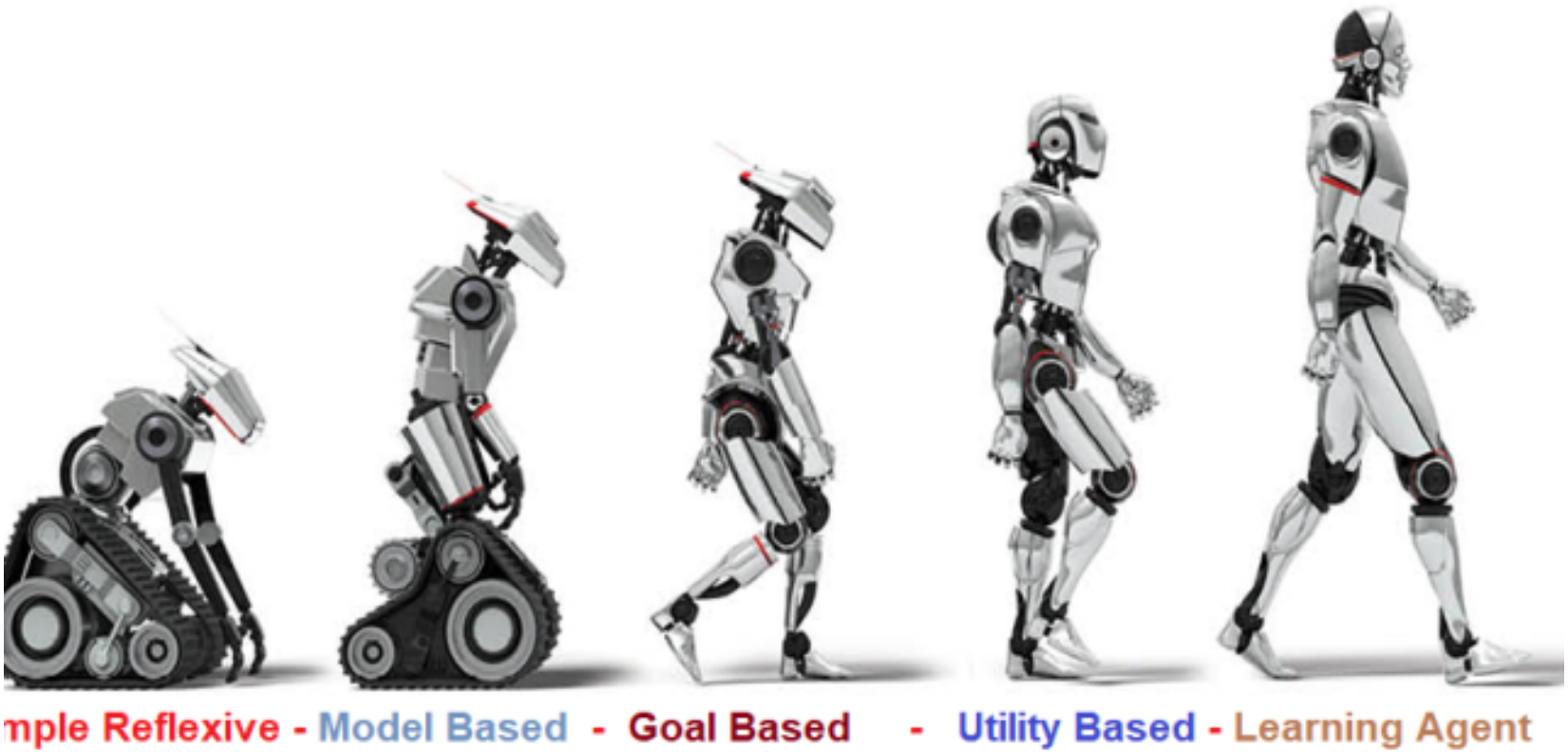
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