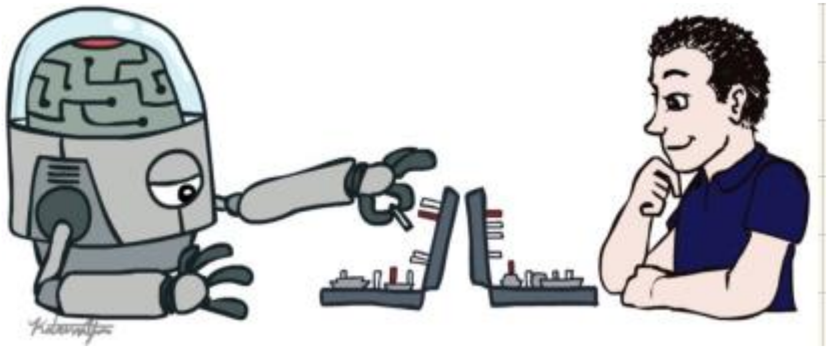
Artificial Intelligence (BCSE306L)

Module 01 - Introduction

- Structure of the Agent



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Lecture Outline

- What makes an Agent Intelligent ?
  - Agent = Architecture + Program
  - The Agent Program
  - Example of Agent – Cleaning Robot
- Types of Agent – architecture, algorithm, properties, usecase
  - Simple Reflex Agents
  - Model based Reflex Agents
  - Goal based Reflex Agents
  - Utility based Agents
  - Learning based Agents

Is Your Coffee machine SMART ?

🕖 **7:00 AM. Monday morning. Your coffee machine starts brewing…**

- It didn’t talk. It didn’t ask.
  =>Yet, it acted *just right.*
- **Is it intelligent?**
- **Is it making decisions?**
- **Or is it just following instructions?**

Is Your Coffee machine SMART ?

👉 Today's Question: What really makes an AI agent *intelligent*?

🕖 **7:00 AM. Monday morning. Your coffee machine starts brewing…**

- It didn't talk. It didn't ask. =>Yet, it acted *just right.*
- **Is it intelligent?**
- **Is it making decisions?**
- **Is it *thinking*?**
- **Or is it just following instructions?**

What really makes an AI agent *intelligent* ?

Class discussion activity

- Does it need to learn ?
- Is it reacting fast enough ?
- What about understanding goals ?

Discuss in group of 3-4 and answer!

- Learning from mistakes ?
- Making decision on its own ?
- Achieving Goals ?
- Understanding Context?

Structure of *intelligent* AI agent!

Class discussion activity

- Simple Reflex Agent => fast reactions.
- Goal-based → purpose-driven
- Utility-based → smart trade-offs
- Learning → adaptation over time

Discuss in group of 3-4 and answer!

- Learning from mistakes ?
- Making decision on its own ?
- Achieving Goals ?
- Understanding Context?

What is an Agent ?

- Excellent! You've just described different dimensions of intelligence.

- Interestingly, in AI, all of these behaviors arise from how we **structure the agent** — its internal architecture and programming.

Agent = Architecture + Program

- **Architecture**: The machinery it runs on.
- **Program**: The software component that implements the agent's behavior.

What is an Agent ?

Agent = Architecture + Program

- **Architecture**: The machinery it runs on.
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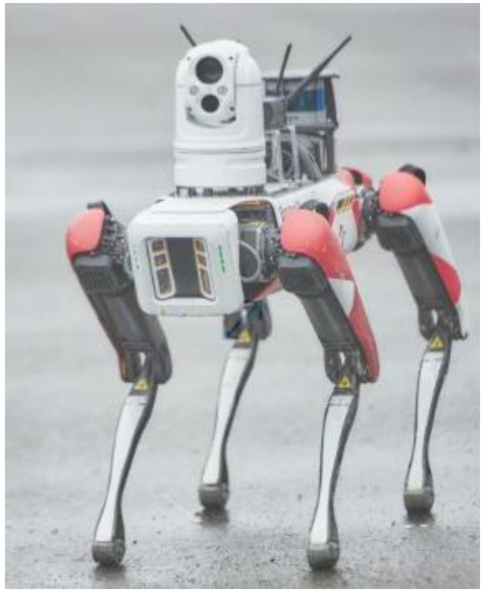


- Is this Agent ?
- **Hardware (Architecture)**

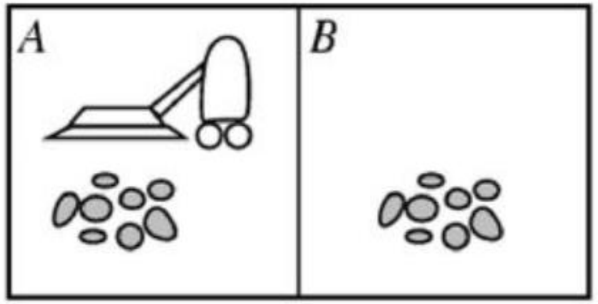
function TABLE-DRIVEN-AGENT(percept) returns an action
persistent: percepts, a sequence, initially empty
table, a table of actions, indexed by percept sequences, initially fully specified

append percept to the end of percepts
action ← LOOKUP(percepts, table)
return action

- **Behaviour (Program)**

The Agent Program

- Explain the logic-based structure:
  - **Perception → Action**



- **Percept to Action Mapping**

  [A, clean] => Right
  [A, dirty] => Clean
  [B, clean] => Left
  [B, dirty] => Clean

function REFLEX-VACUUM-AGENT([location, status]) returns an action

  if status = Dirty then return Clean

  else if location = A then return Right

  else if location = B then return Left

Type of Agents

- Simple reflex agent
- Model-based reflex agent
- Goal based Agents
- Utility based Agents
- Learning based Agents

- Let's now look at the various types of agents — from the **simplest reflex machines** to advanced learning agents — and understand what gives them their '**intelligence**.'
- Let us understand each agent with **architecture**, **algorithmic logic**, **properties**, and **real-world use case**.

Simple Reflex Agent

https://github.com/aimacode/aima-pseudocode/tree/master

- **Example**: Fire/Smoke Detector
  - Acts immediately when it sense smoke
    - No memory, just condition, action, rules.

- React to **current percept** using condition-action rules.
- No internal memory.

- 🧩 **Algorithm:** IF condition THEN action

- 📦 **Use Case:** Smoke detector, dishwasher.

Simple Reflex Agent

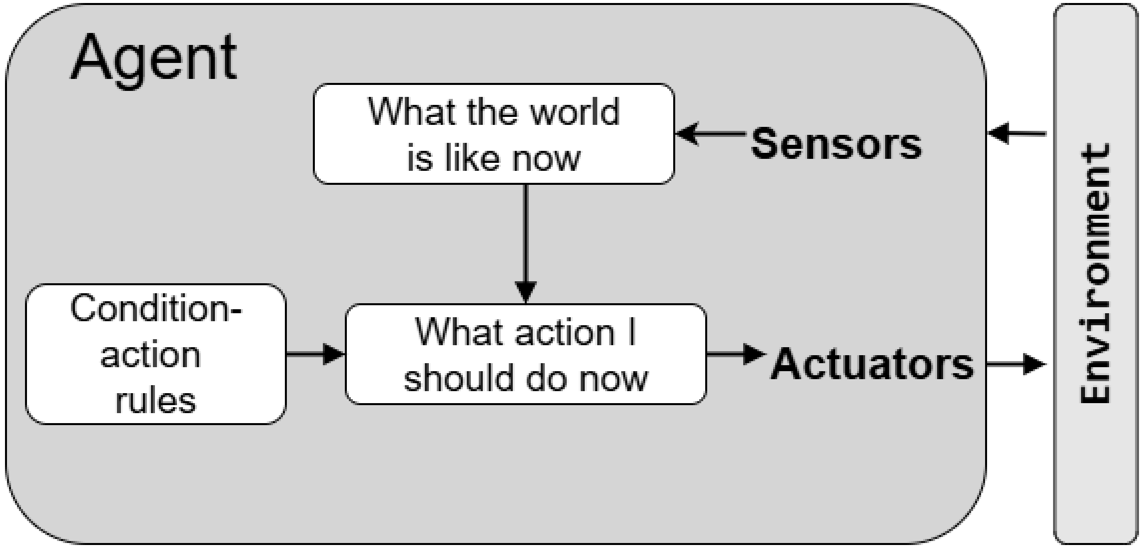


Fig: Architecture Diagram of Simple Reflex Agent

function SIMPLE-REFLEX-AGENT(percept) **returns** an action

persistent rules, a set of condition–action rules

state ← INTERPRET-INPUT(percept)

rule ← RULE-MATCH(state, rules)

action ← rule.ACTION

return action

Fig: Algorithm of Simple Reflex Agent

Model based reflex Agent

- Example: Robot Vacuum Cleaner (e.g. Roomba)
  - Uses a **map of the environment** to **avoid obstacles** and **clean efficiently**.
- Maintain internal state of the world.
- Handles partially observable environments.
- 🧠 **Architecture:** Current Percept + Internal Model → Action
- 📦 **Use Case:** Indoor robot vacuum (e.g., Roomba with obstacle memory)

Model based reflex Agent

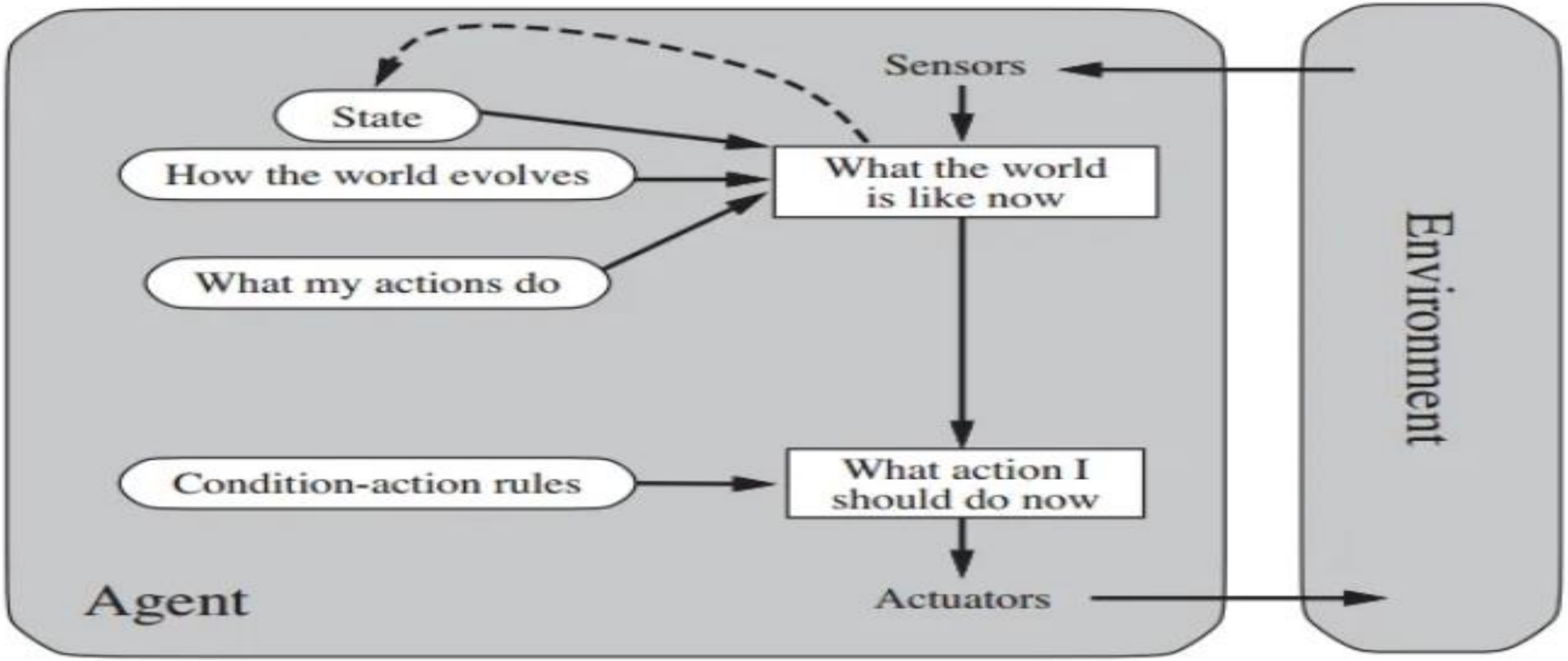


Fig: Architecture Diagram of Model based Reflex Agent

Model based reflex Agent

function MODEL-BASED-REFLEX-AGENT(percept) **returns** an action

persistent ***state***, the agent's current conception of world state, *transition_model*, *a* description of how **next state** depends on **current state** and **action**

sensor_model ← **a description of how the current world state is reflected in the agent's percepts**

rules ← **a set of condition–action rules**

action ← **the most recent action, initially none**

state ← UPDATE-STATE(state, action, percept, transition_model, sensor_model)

rule ← RULE-MATCH(state, rules)

action ← rule.ACTION

return action

Fig: Algorithm of Model based Reflex Agent

Goal-Based Agents

- Example: Autonomous Delivery Drone
  - **Plans its route** dynamically to reach a destination while **avoiding hazards**.
  - Acts based on desired outcomes (goals).
  - Needs search and planning.

- 🧩 **Algorithm:** A* Search / Planning Graph

- 📦 **Use Case:** Pathfinding in Google Maps, automated delivery drones.

- 💡 **Think-Pair-Share:** "Why might a goal-based agent be inefficient in real-time games?"

Goal based reflex Agent

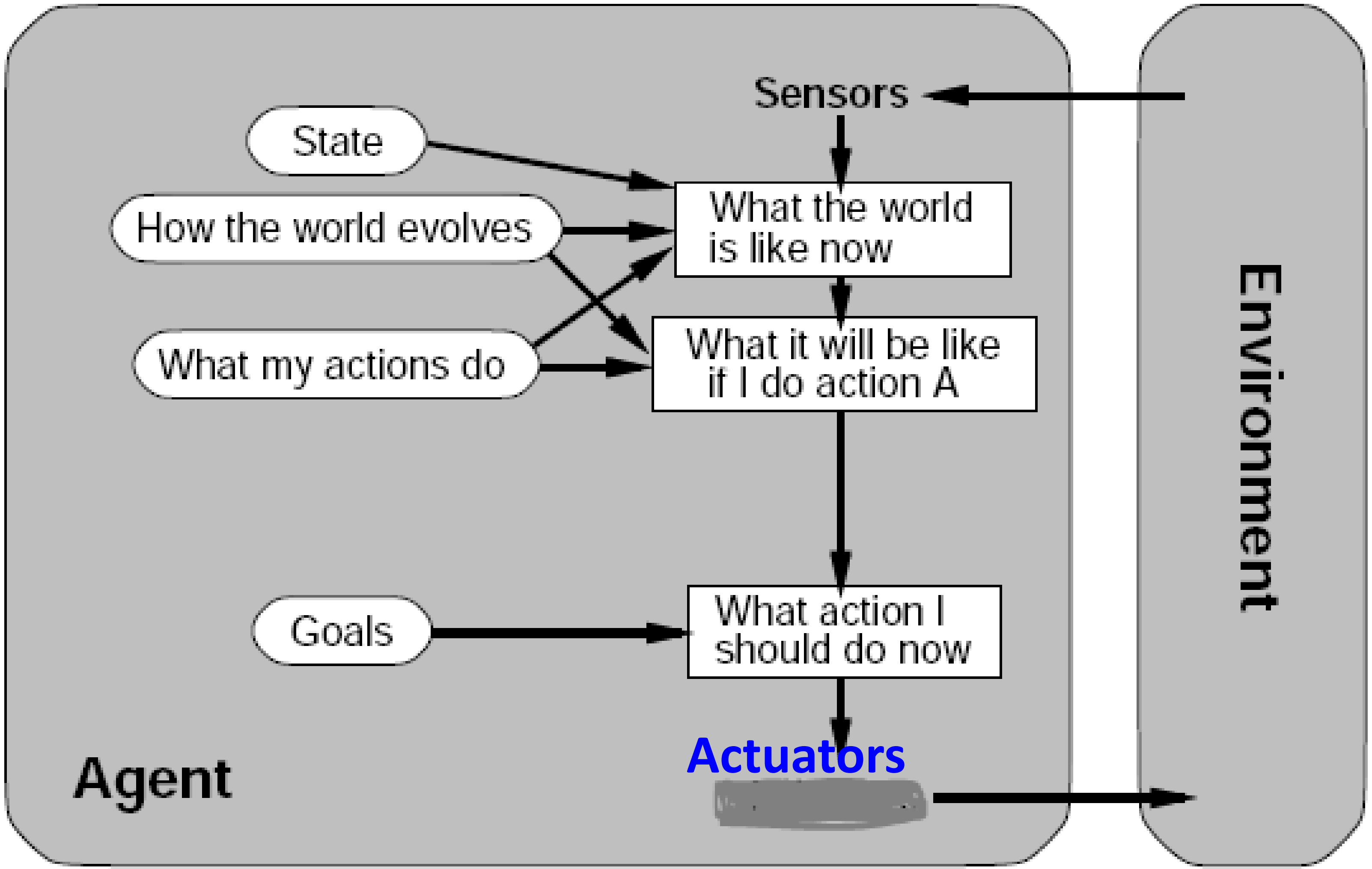


Fig: Architecture Diagram of Goal based Agent

Utility-Based Agents

https://github.com/michaeljwright/robobull-trading-bot

- Example: Stock Trading Bot
  - **Chooses trade** that **maximizes** expected financial return **not just reaching a goal**.
  - Measures *how good each state is.*
  - Maximizes expected utility.

- **Concepts:** Utility Function, Optimization
- **Use Case:** AI in trading bots, recommendation systems.
- **Exercise:** Rate 3 outcomes for a recommender system. Which has higher utility?

Utility based reflex Agent

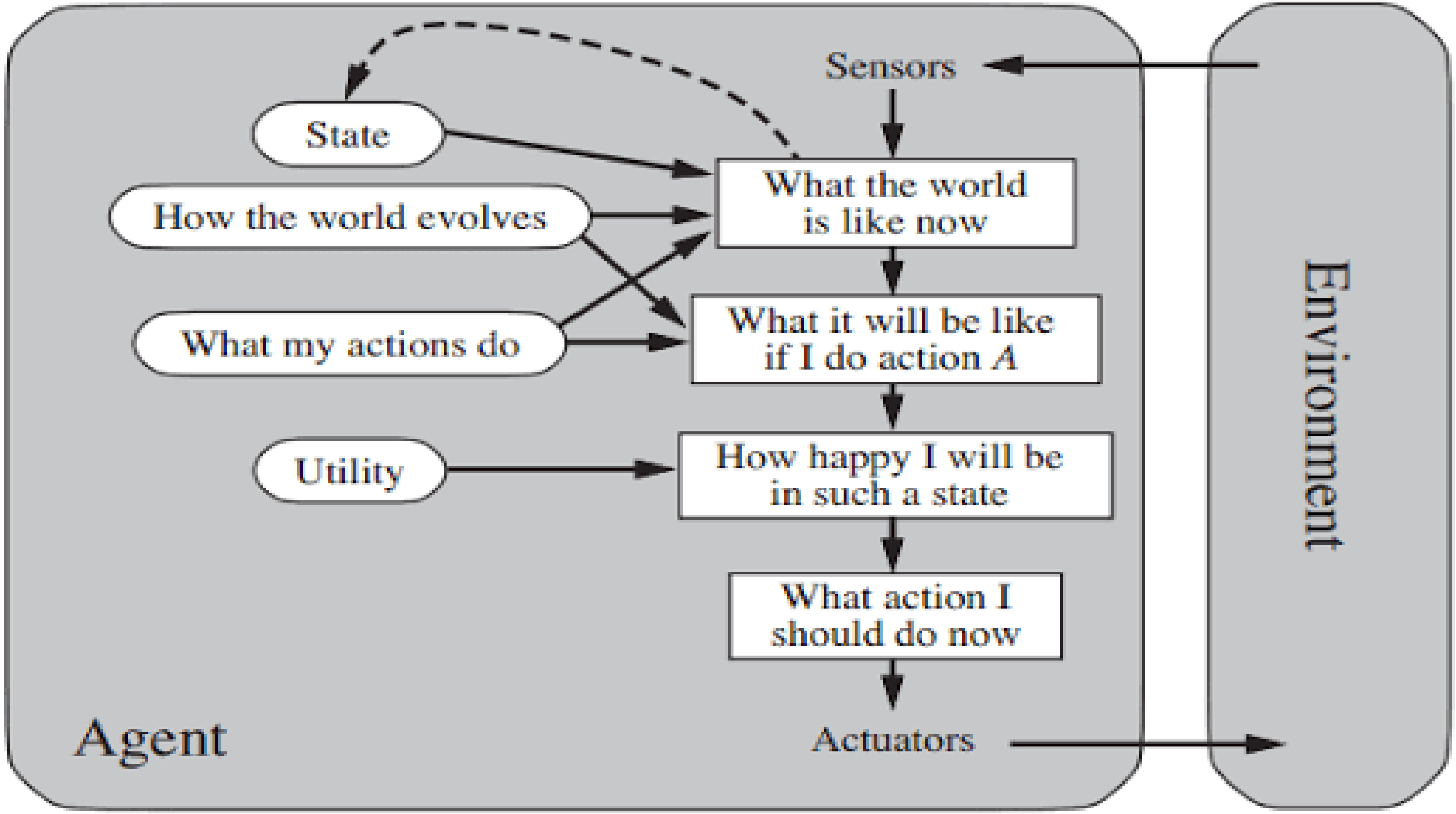


Fig: Architecture Diagram of Utility based Reflex Agent

Learning-Based Agents

ChatGPT

- Example: ChatGPT
  - **Continuously improve** its **responses** by learning from **user interactions and feedback**.
  - Improves performance over time.
- **Components:** Learning element, Performance metric, critic, problem generator
- **Use Case:** ChatGPT, AlphaZero (chess/Go), adaptive traffic signals.
- **Mini Case Study:** Draw diagrams to show evolution from rule-based to learning agent.

Learning based reflex Agent

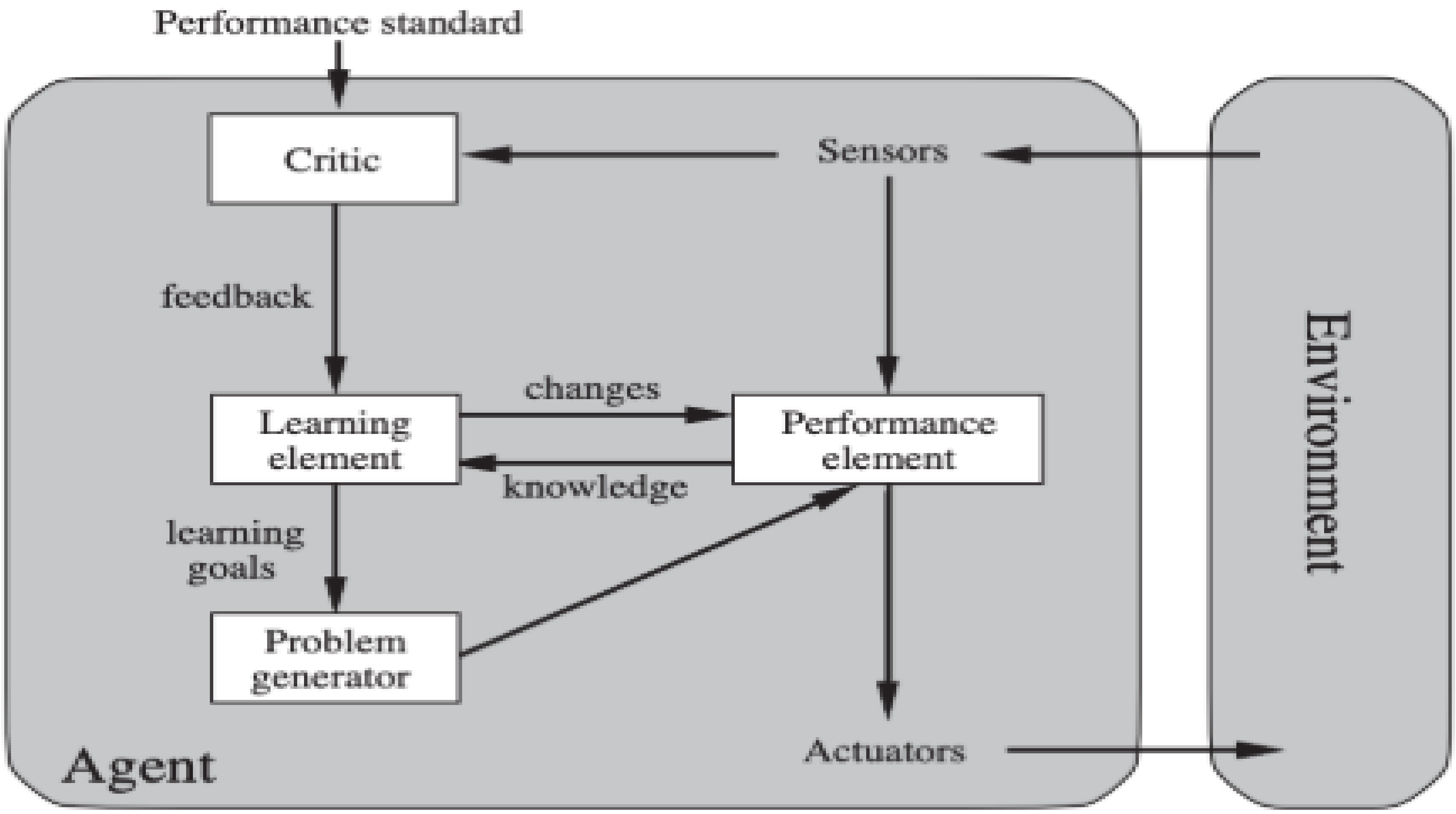


Fig: Architecture Diagram of Learning based Reflex Agent

Comparison Table of different Agents

Agent Type	Memory	Goal-Oriented	Learning	Use Case Example
Simple Reflex	❌	❌	❌	🌡️ Thermostat
Model-Based	✅	❌	❌	🤖 Robot Vacuum
Goal-Based	✅	✅	❌	🗺️ Navigation Assistant
Utility-Based	✅	✅	⚙️ Optional	📈 Stock Trading Bot
Learning Agent	✅	✅	✅	🚗 Autonomous Driving

Sample Questions – Q1

- Q1 Consider an artificial agent learning to play chess, where the agent learns the game's rules and optimal moves through multiple plays and feedback from critics. Which type of agent would be most suitable for a chess-playing agent? Justify your answer. Also, briefly describe the agent architecture with a suitable diagram.[**5 Marks]**

Sample Questions – Q1

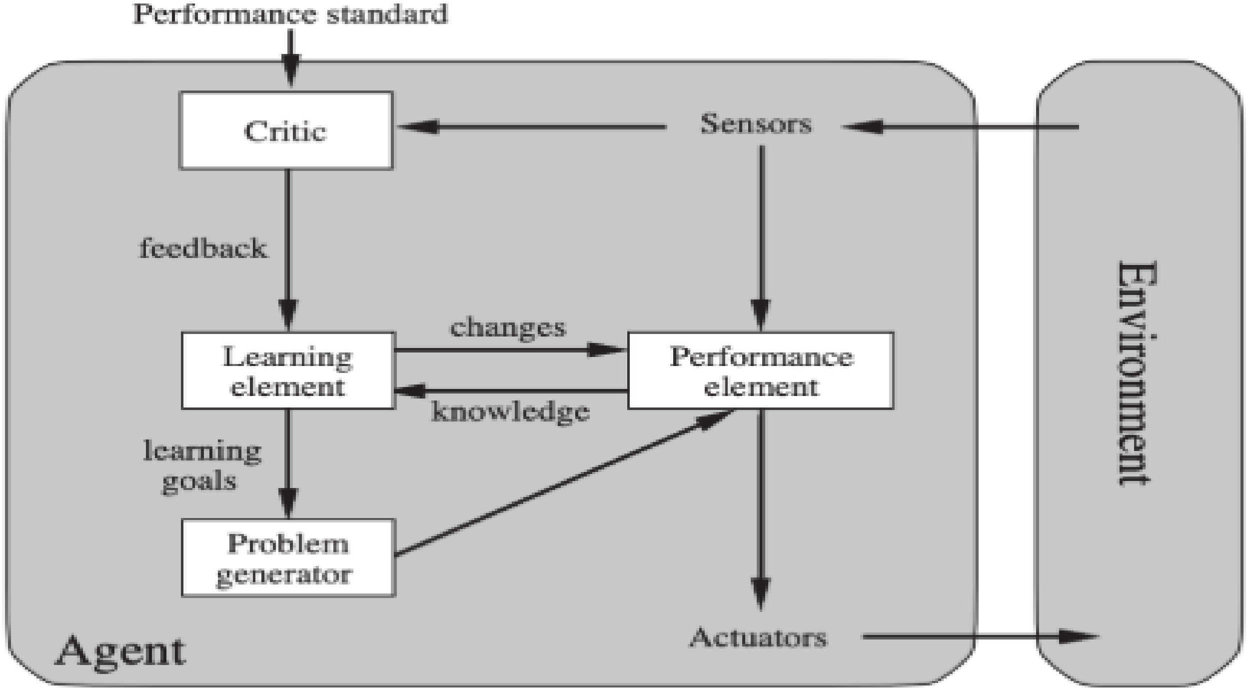
- Consider an artificial agent learning to play chess, where the agent learns the game's rulesand optimal moves through multiple plays and feedback from critics. Which type of agent would be most suitable for a chess-playing agent? Justify your answer. Also, briefly describe the agent architecture with a suitable diagram. **[5 Marks]**

- Ans: Learning based Agent is most suitable as the agent **learn game's rules** and **optimal moves** through multiple plays and feedback from critics. [2 Marks]

Sample Questions – Q1

Q1 Ans: a) Learning based Agent is most suitable as the agent **learn game's rules** and **optimal moves** through multiple plays and feedback from critics. [2 Marks]

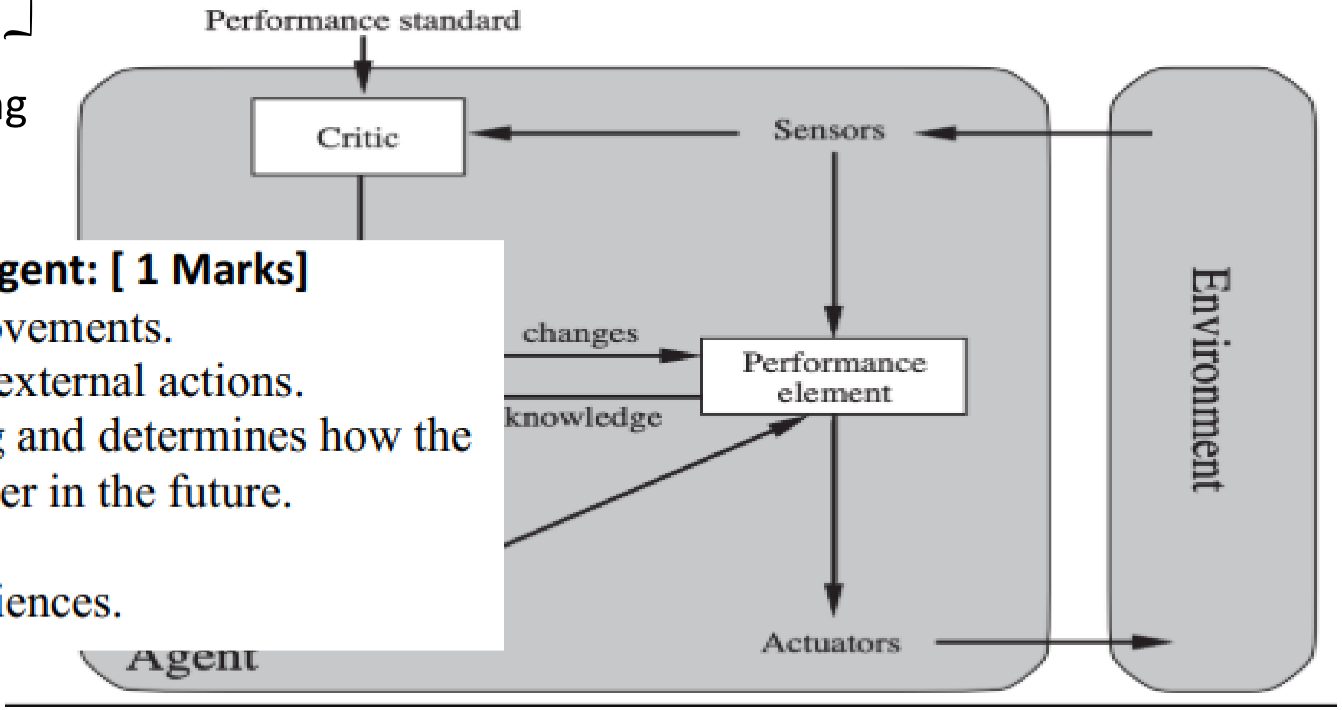
b) Architecture Diagram of Learning based Reflex Agent **[2 Marks]**



Sample Questions – Q1

Q1 Ans: a) Learning based Agent is most suitable as the agent **learn game's rules** and **optimal moves** through multiple plays and feedback from critics. [2 Marks]

b) Architecture Diagram of Learning based Reflex Agent **[2 Marks]**



Following are the major components of Leanring based Agent: [1 Marks]

i. **Learning element** is responsible for making improvements.
ii. **Performance element** is responsible for selecting external actions.
iii. **Critic** provides feedback on how the agent is doing and determines how the performance element should be modified to do better in the future.
iv. **Problem generator** is responsible for suggesting actions that will lead to new and informative experiences.

Sample Questions – Q2

- Q2 A taxi company wants to optimize its drivers' routes to reduce fuel consumption, minimize travel time, and enhance customer satisfaction. List the **challenges** and **plans** in developing an AI system for a realtime route optimization system that assists drivers in selecting the most efficient routes while considering dynamic factors like traffic, road conditions, toll plazas and weather conditions? Discuss with diagram the **most suitable type of agent** that can be used for this type of system.

Sample Questions – Q2

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- Q2 Ans: **3 M** – Challenges; **3 M** – Plan; **4M** – Agent type and Architecture diagram

Sample Questions – Q2

- Q2 Ans:

  i) Challenges [3 Marks]

  - Traffic conditions can change rapidly, affecting travel times.
  - Weather conditions may impact driving routes and times.
  - Customers may have specific preferences or constraints, such as avoiding toll roads or choosing scenic routes.

- ii) Plans [3 Marks]

Sample Questions – Q2

- Q2 Ans:**ii)** Plans [3 Marks]
  - Collect historical trip data, including **routes**, **travel times**, and **customer feedback**.
  - Integrate real-time data sources such as **GPS**, **traffic sensors**, **weather updates**, and. **road closures**
  - Segment the data based on time of **day**, **location**, and **trip type** to identify patterns.
  - Implement graph-based algorithms such as **Dijkstra's** or **A*** for initial route calculations.
  - Display optimized routes and real-time updates for drivers.
  - Include features for voice navigation, alternative route suggestions, and customer-specific instructions.

Most suitable Agent

Sample Questions – Q2

- Q2 Ans:
- **ii)** Plans [3 Marks]
  - Collect historical trip data, including routes, travel times, and customer feedback.
  - Integrate real-time data sources such as GPS, traffic sensors, weather updates, and road closures.
  - Segment the data based on time of day, location, and trip type to identify patterns.
  - Implement graph-based algorithms such as Dijkstra's or A* for initial route calculations.
  - Display optimized routes and real-time updates for drivers.
  - Include features for voice navigation, alternative route suggestions, and customer-specific instructions.

Most suitable Agent

Here it is given dynamic factors like traffic, road conditions, toll plazas and weather conditions, so most suitable model is **Model based agent**.

Whereas for **learning-based agent** it can learn from past experiences, for continuous improvement, which is not that in this case as the given scenario is dynamic in nature.

Sample Questions – Q2

- Q2

Agent Type	Description	Strengths for Route Optimization	Limitations	Suitability
Simple Reflex Agent	Acts only on current percepts without memory or learning.	Very fast decisions based on current traffic/perceptual inputs.	Cannot adapt or improve routes over time. No memory or learning.	❌ Poor fit
Model-Based Agent	Maintains internal state (model of the world) based on past percepts.	Can simulate traffic and delivery conditions to plan better routes. Good for dynamic environments.	Needs an accurate and updated model. Limited adaptability without learning.	✅ Suitable
Goal-Based Agent	Makes decisions by evaluating future states to achieve specific goals.	Can prioritize between minimizing fuel vs. time vs. customer satisfaction.	Computationally expensive. Does not learn from past performance.	✅ Suitable
Utility-Based Agent	Considers multiple factors (like fuel, time, satisfaction) to maximize a utility function.	Handles trade-offs well. Can prioritize different goals based on business needs.	Needs a well-defined utility function and good domain knowledge.	✅ Highly Suitable
Learning Agent	Improves performance over time by learning from past experiences and environment.	Learns traffic patterns, customer feedback, driver behavior to improve routes	Needs training time and good data. May perform poorly initially.	🌟 **Best Choice**

Sample Questions – Q2

- Q2 *A*

Agent Type	Why It's Still Used	Example Use Case
Model-Based Agent	- Requires less data to start working. - More predictable and explainable. - Ideal when the environment is well understood and doesn't change frequently.	Route planning for **static road networks** (e.g., fixed delivery zones in rural areas).
Goal-Based Agent	- Focuses directly on **achieving specific objectives.** - Easier to implement for well-defined tasks. - Doesn't need prior data.	Emergency routing (e.g., "get to hospital ASAP") where **goal is clear**, learning is unnecessary.
Utility-Based Agent	- Handles **multiple conflicting objectives** elegantly. - Best for situations with trade-offs (e.g., fuel vs. speed).	Logistics systems where fuel cost, customer wait time, and delivery time **must be balanced.**
Learning Agent	- Needs **large data** and **training time.** - Harder to explain and control behavior. - Risk of **suboptimal early performance.**	Urban delivery fleet optimization over time — once enough data is collected.

Sample Questions – Q2

- Q2 Ans:

Learning agents shine in dynamic, data-rich environments with changing conditions and feedback loops.

Other agent types are more efficient and reliable when:

- Goals are fixed and known,
- The environment is predictable,
- Or learning is costly, risky, or unnecessary.

Sample Questions – Q2

- Q2 Ans:

In many **real-world systems**, these agents are **combined**.

A typical **intelligent delivery system** might:

- Use a **model-based agent** to simulate traffic
- Apply **goal-based logic** to ensure delivery time constraints
- Use a **utility function** to weigh cost vs. time
- And incorporate **learning** to refine decisions over time.

This hybrid approach leverages **the strengths of each type**.

Thank you

Questions ?