Artificial & Computational Intelligence

DSE CLZG557

M1 : Introduction to Intelligent Agents

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Course Plan

M1	Introduction to AI
M2	Problem Solving Agent using Search
M3	Game Playing, Constraint Satisfaction Problem
M4	Knowledge Representation using Logics
M5	Probabilistic Representation and Reasoning
M6	Reasoning over time, Reinforcement Learning

Module 1 : Introduction to AI

A. Overview of AI & Applications

B. Intelligent Agents

C. Task Environment

Rational Agents

Rational Agent

Design Principles & Techniques

	Thought / Reasoning	Acting
Human Performance	THINKING HUMANLY "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning, ... " (Bellman, 1978)	ACTING HUMANLY "The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990)
Rational Performance	THINKING RATIONALLY "The study of computations that make it possible to perceive, reason, and act" (Winston, 1992)	ACTING RATIONALLY "Computational intelligence is the study of the design of intelligent agents" (Poole et al., 1998)

Acting Rationally

The Rational Agent Approach

- An agent is an entity that perceives and acts

  This course is about designing rational agents

- Abstractly, an agent is a function from percept histories to actions:

  [f: P* → A]

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Computational limitations make perfect rationality unachievable
- Design best program for given machine resources

Acting Rationally

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The Rational Agent Approach

- Rational behaviour: doing the *right thing*
- The *right thing:* that which is expected to maximize goal achievement, given the available information
- Rational behaviour is not just about correct inference / thinking, skills needed to pass turing test etc.

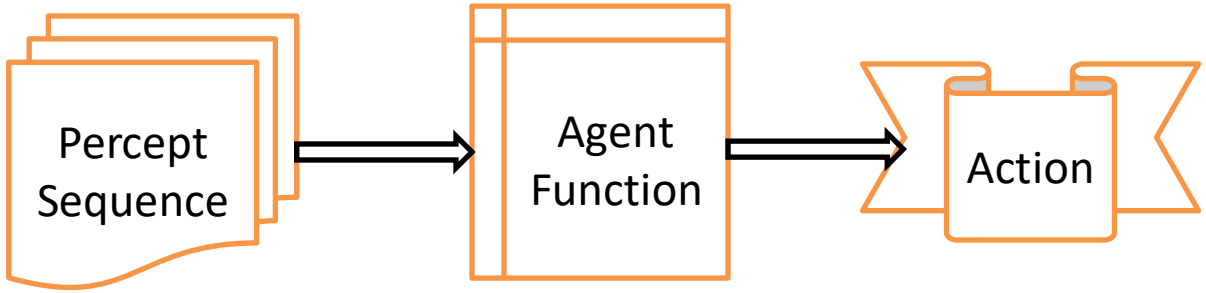
(adv) : More General - Correct inference is just a thing

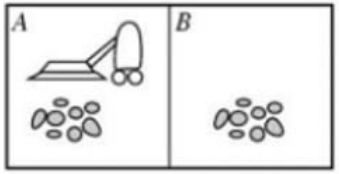
(adv) : More amenable for scientific developments, as the rational behaviour is better defined than human thinking and behaviour

Intelligent Agent

Rational Agent is one that acts to achieve the best outcome or the best expected outcome even under uncertainty

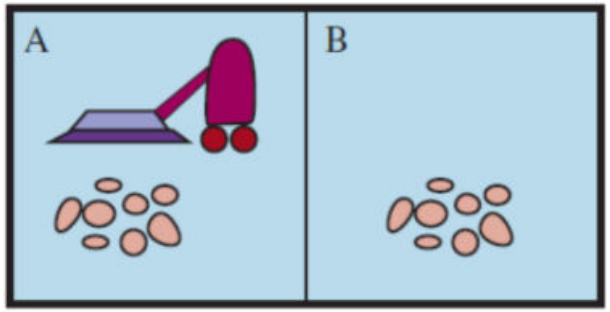
Maps / Tabulated / Programmed





Percept sequence	Action
[A,Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean],[A, Clean]	Right
[A, Clean],[A, Dirty]	Suck
...	...

Intelligent Agent



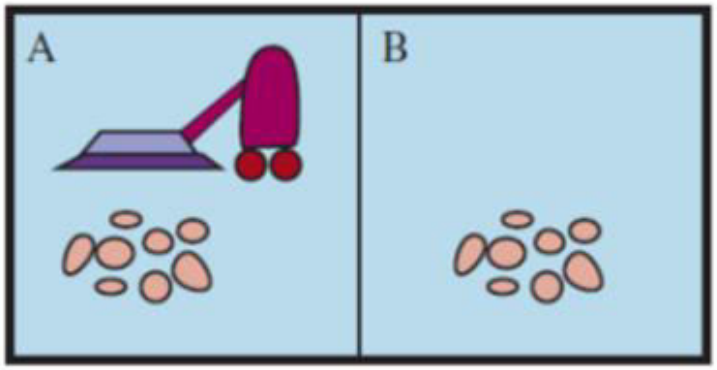
- Percepts: location and contents, e.g., [A , Dirty]
- Actions: *Left*, *Right*, *Suck*, *NoOp*

Performance measure: An objective criterion for success of an agent's behaviour

E.g., performance measure of a vacuum-cleaner agent
» amount of dirt cleaned up
» amount of time taken
» amount of electricity consumed
» amount of noise generated, etc.

Intelligent Agent

Percept sequence	Action
[A, Clean]	Right
[A, Dirty]	Suck
[B, Clean]	Left
[B, Dirty]	Suck
[A, Clean], [A, Clean]	Right
[A, Clean], [A, Dirty]	Suck
⋮	⋮
[A, Clean], [A, Clean], [A, Clean]	Right
[A, Clean], [A, Clean], [A, Dirty]	Suck
⋮	⋮



Properties of Rational Agent

- Omniscience : Expected Vs Actual Performance
- Learning Capability : Apriori Knowledge
- Autonomous in decision making: An agent is autonomous if its behaviour is determined by its own experience (with ability to learn and adapt)

PEAS Environment

Design on what an application wants the agent to do in the environment

Agent	Performance	Environment	Sensors	Actuators
Medical diagnosis system	Healthy patient, reduced costs	Patient, hospital, staff	Keyboard entry of symptoms, findings, patient's answers	Display of questions, tests, diagnosis, treatments, referrals
Satellite Image analysis system	Correct image categorization	Downlink from orbiting satellite	Color pixel analysis	Display of scene categorization
Interactive English tutor	Student's score on test	Set of students, testing agency	Keyboard entry	Display of exercises, suggestions, corrections

PEAS Environment

Design on what an application wants the agent to do in the environment

Agent	Performance	Environment	Sensors	Actuators
Automated taxi driver	Safe, fast, legal, comfortable trip, maximize profits	Roads, other traffic, pedestrians, customers	Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard	Steering wheel, accelerator, brake, signal, horn

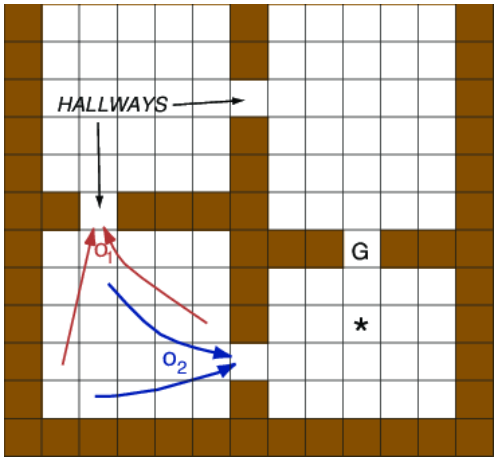
Task Environment

A rational agent is built to solve a specific task. Each such task would then have a different environment which we refer to as Task Environment

Based on the applicability of each technique for agent implementation its task environment design is determined by multiple dimension

Sensor Based:

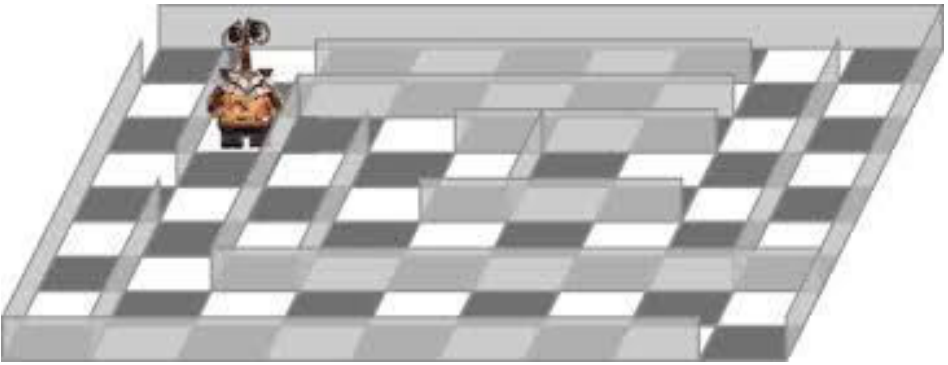
- Observability : Full Vs Partial



Task Environment

Action Based:

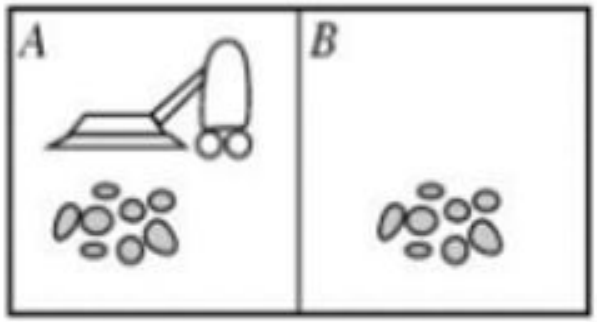
- Dependency : Episodic Vs Sequential



Task Environment

State Based:

- No.of.State : Discrete Vs Continuous



Task Environment

State Based:

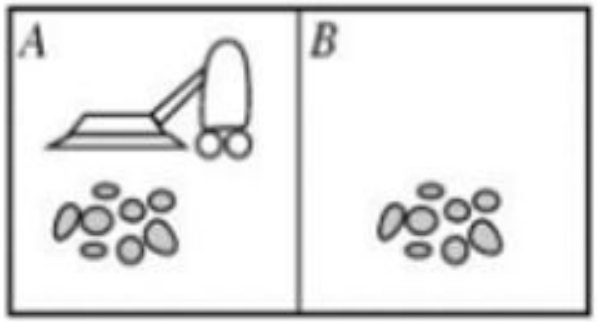
- No.of.State : Discrete Vs Continuous

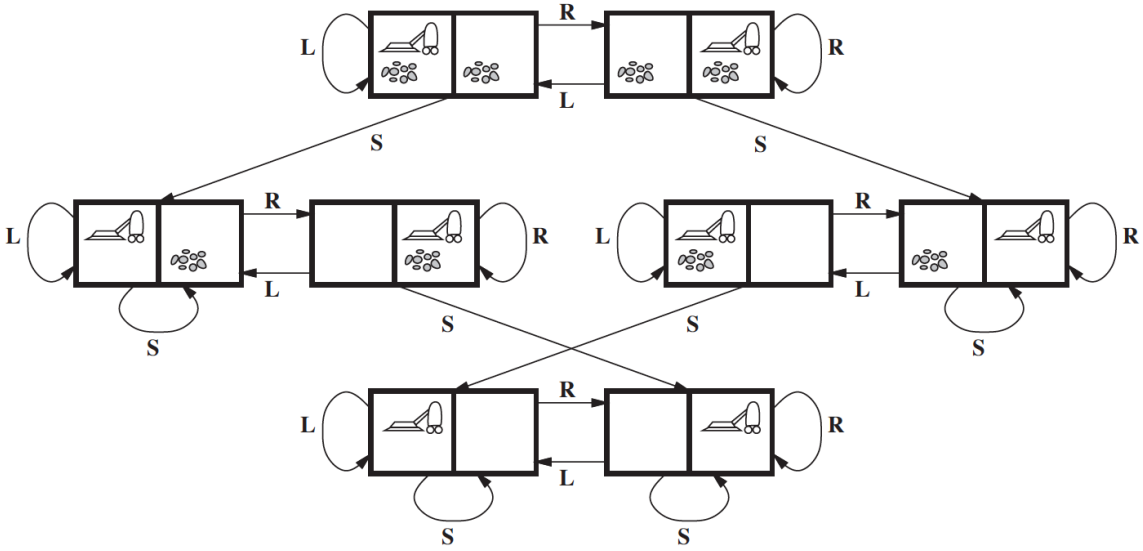
VS.

Task Environment

State Based:

- No.of.State : **Discrete** Vs Continuous



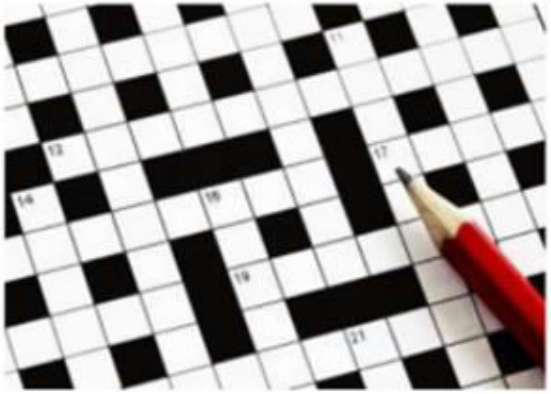


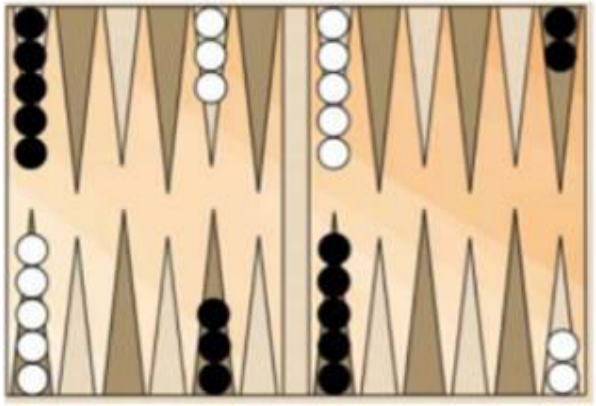
Task Environment

Action & State Based:

- State Determinism : Deterministic Vs Stochastic | Strategic

(If the environment is deterministic except for the actions of other agents, then the environment is strategic)

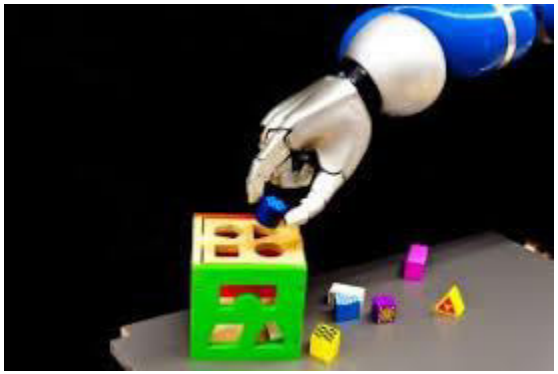




Task Environment

Agent Based:

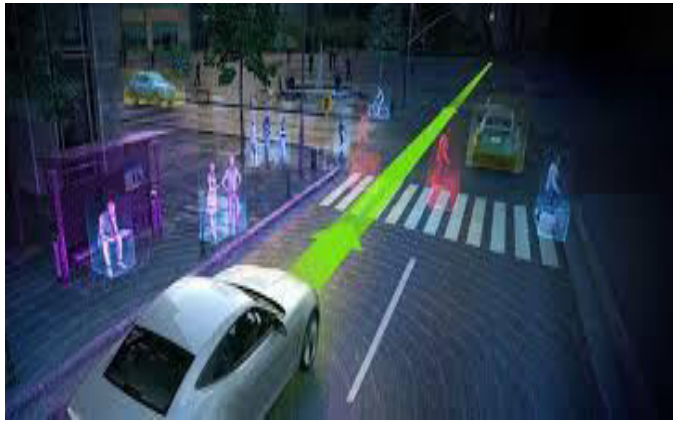
> Cardinality : Single Vs MultiAgent

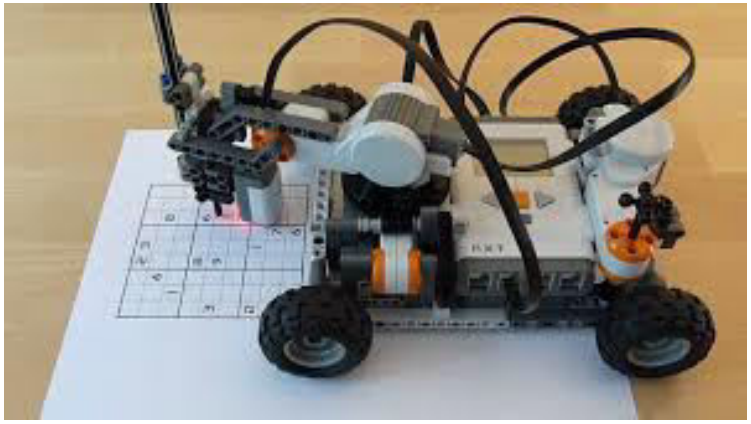


Task Environment

Action & State Based:

- Change in Time : Static Vs Dynamic
- (The environment is semi dynamic if the environment itself does not change with the passage of time but the agent's performance score does)





Task Environment

Sensor Based:

- Observability : Full Vs Partial

Action Based:

- Dependency : Episodic Vs Sequential

State Based:

- No.of.State : Discrete Vs Continuous

Agent Based:

> Cardinality : Single Vs MultiAgent

Action & State Based:

- State Determinism : Deterministic Vs Stochastic | Strategic
- Change in Time : Static Vs Dynamic

Task Environment

Task Environment	Fully vs Partially Observable	Single vs Multi-Agent	Deterministic vs Stochastic	Episodic vs Sequential	Static vs Dynamic	Discrete vs Continuous
Medical diagnosis system	Partially	Single	Stochastic	Sequential	Dynamic	Continuous
Satellite Image Analysis System	Fully	Single	Deterministic	Episodic	Static	Continuous
Interactive English tutor	Partially	Multi	Stochastic	Sequential	Dynamic	Discrete

Task Environment

Task Environment	Fully vs Partially Observable	Single vs Multi-Agent	Deterministic vs Stochastic	Episodic vs Sequential	Static vs Dynamic	Discrete vs Continuous
Taxi Driving	P	M	S	S	D	C
Timed Chess Game	F	M	Strategic	S	SemiDynamic	D

Agent Architectures

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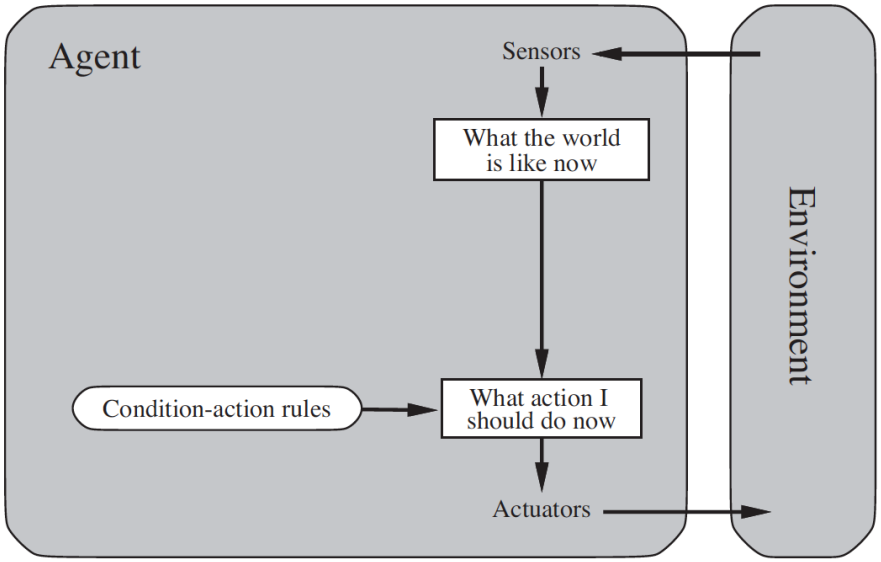
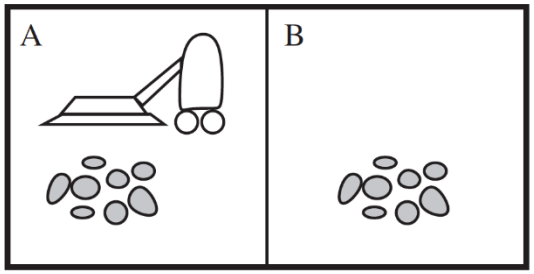
Reflex Agent

```
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
```

```
function REFLEX-VACUUM-AGENT( [location,status]) returns an action
    if status = Dirty then return Suck
    else if location = A then return Right
    else if location = B then return Left
```



Simple Reflex Agents



Agent Architectures

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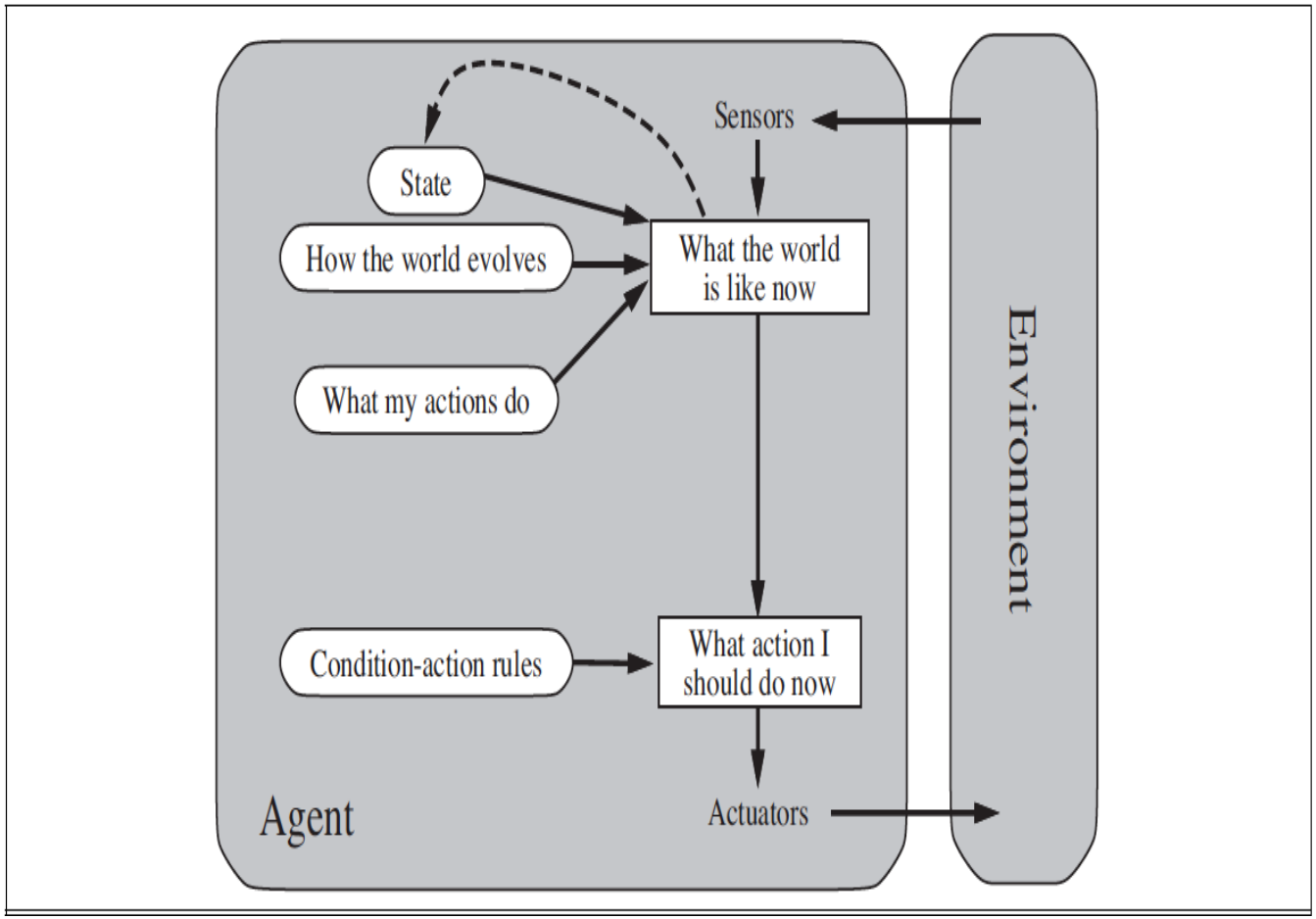
Model based Agent

Simple Reflex Agents

Model Based Agents



Agent Architectures

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Model based Agent

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

persistent: *state*, the agent's current conception of the world state
transition model, a description of how the next state depends on the 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*

Agent Architectures

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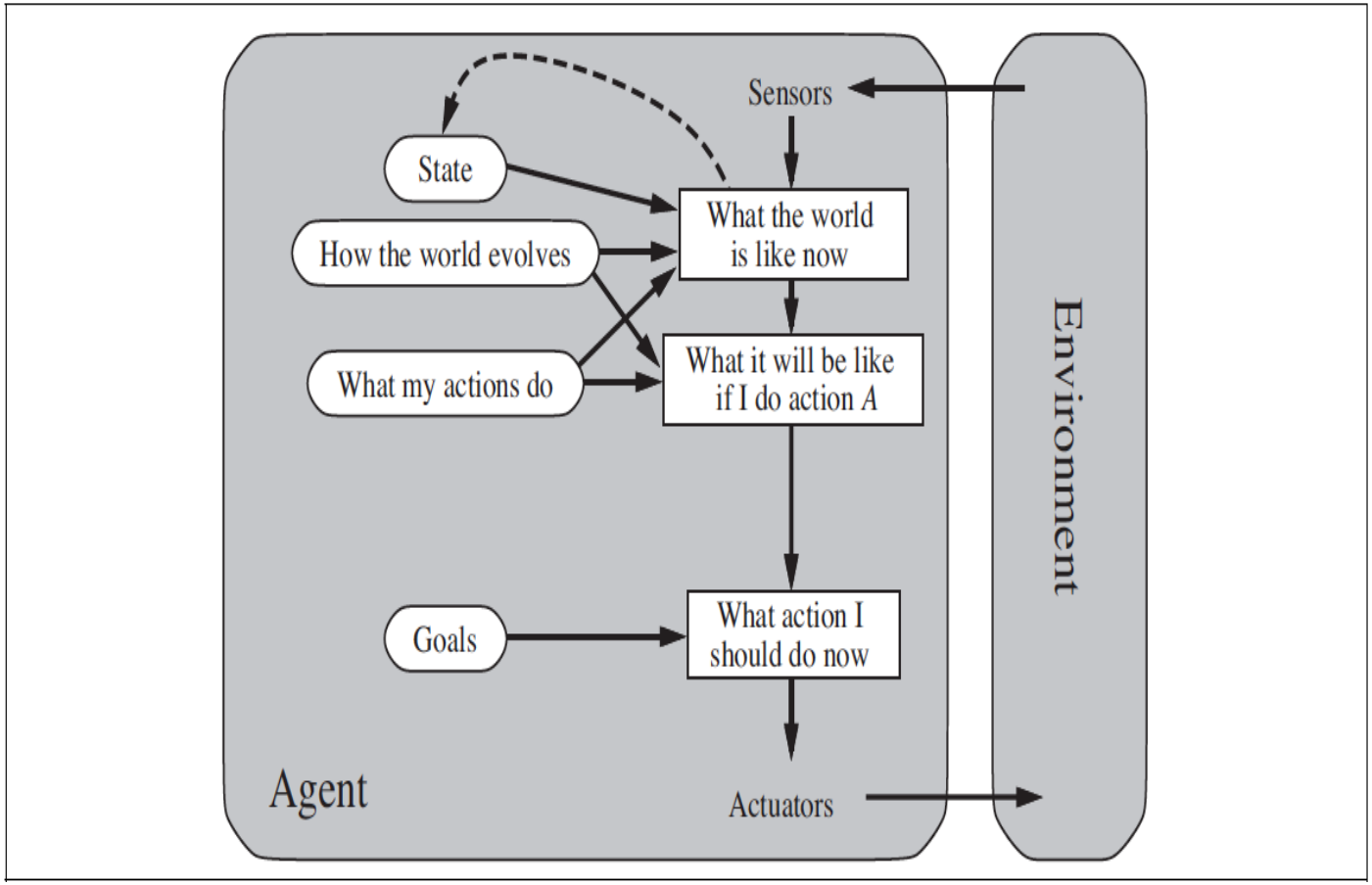
Goal based Agent

- Simple Reflex Agents
- Model Based Agents
- Goal Based Agents



Agent Architectures

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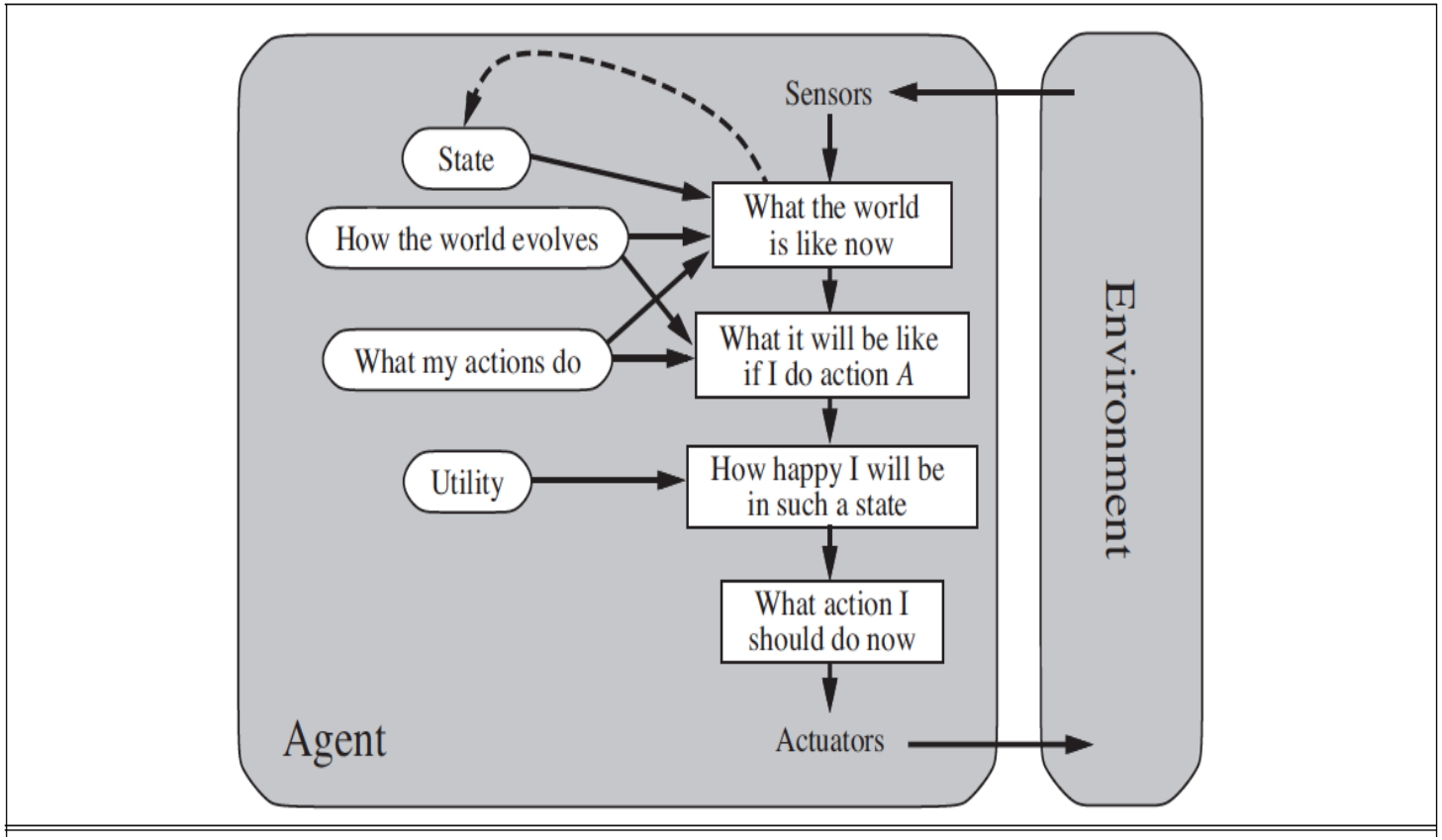
Utility based Agent

- Simple Reflex Agents
- Model Based Agents
- Goal Based Agents
- Utility Based Agents



Agent Architectures

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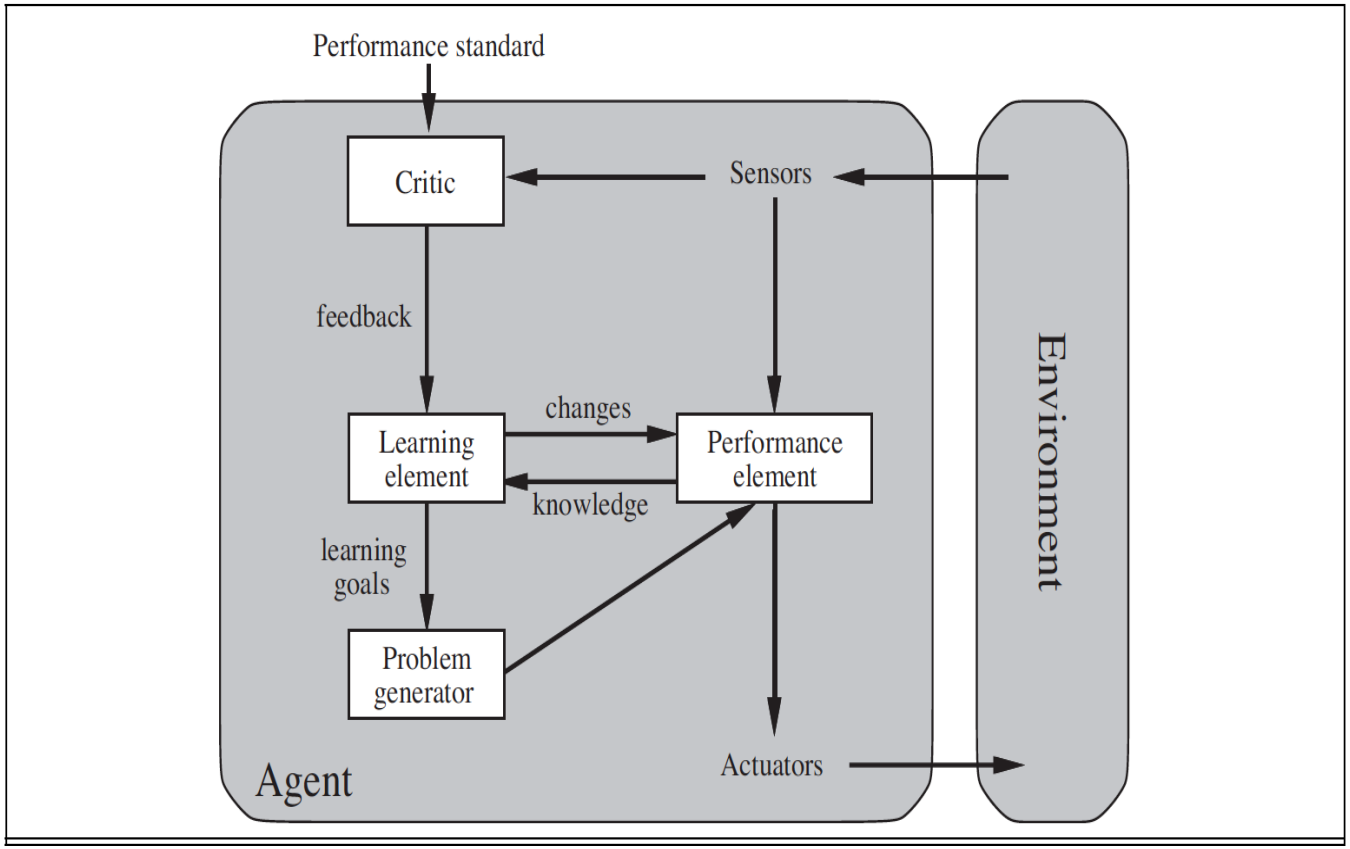
Learning Agent

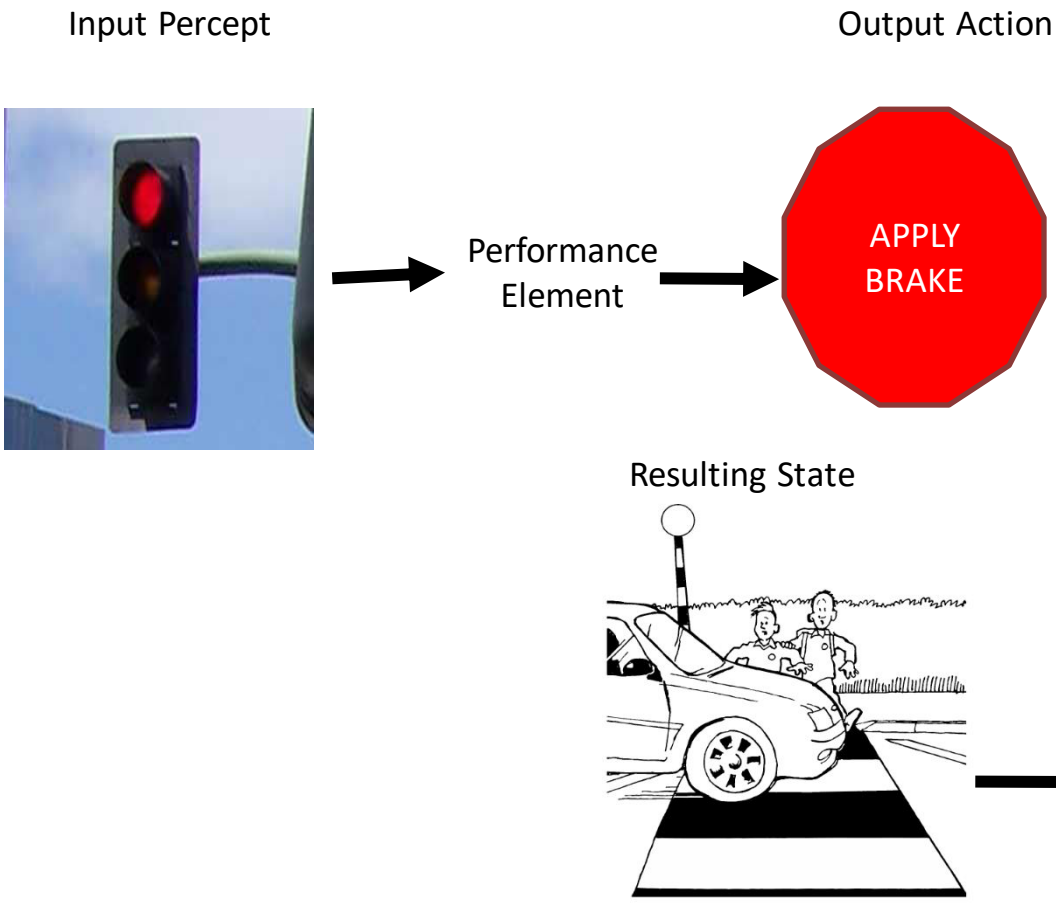
- Simple Reflex Agents
- Model Based Agents
- Goal Based Agents
- Utility Based Agents
- Learning Agents



Agent Architectures - Components

Learning Agent

Agents that improve their performance by learning from their own experiences



Agent Architectures - Components

Learning Agent

Input Percept

Possible Actions

Brake
Change Gear to Lower
Change Gear to Higher
Accelerate
Steer left
Steer right

Random

Selected Action

Change Gear to Lower

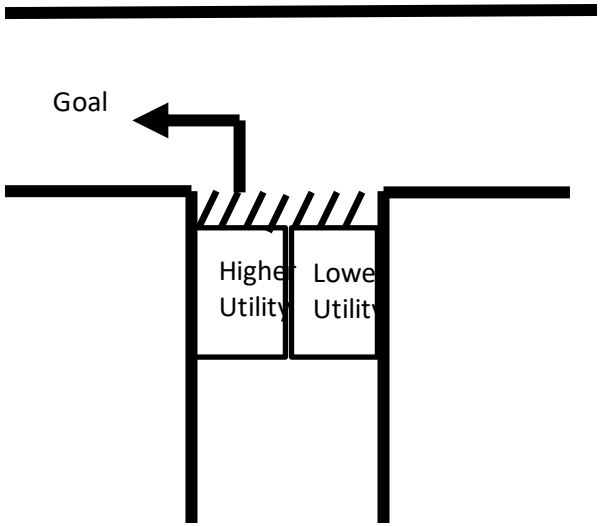
Agent Architectures - Components

Learning Agent

Performance Element – Takes decision on action based on percept

$$f(red\ signal,\quad distance) = 15k\ N\ brake$$
$$distance = f'(percept\ sequence)$$
$$f(percepts, distance, raining)$$

- $f(state_0, actionA) = 0.83,$
- $f(state_0, actionB) = 0.45$



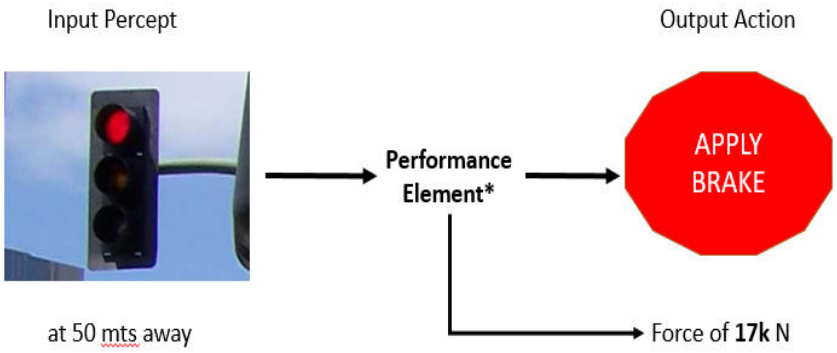
Agent Architectures - Components

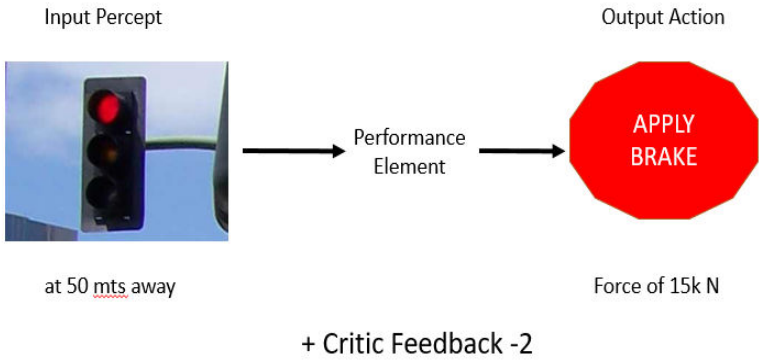
Learning Agent

Critic – Provides feedback on the actions taken

Learning :

Supervised Vs Unsupervised Vs Reinforcement





Agent Architectures - Components

Learning Agent

Performance Element – Takes decision on action based on percept

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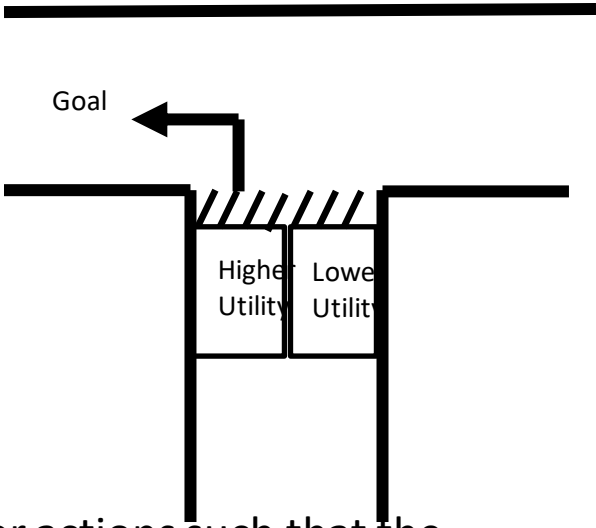

- $f(state_0, actionA) = 0.83,$
- $f(state_0, actionB) = 0.45$

Learning Element – Make the performance element select better actions such that the utility function is optimized

Critic – Provides feedback on the actions taken

Problem Generator – Make the Performance Element select sub-optimal actions such that you would learn from unseen actions

Required Reading: AIMA - Chapter # 1.2, 1.4, 2

Thank You for all your Attention

Note : Some of the slides are adopted from AIMA TB materials