COSC1125/1127 Artificial Intelligence

Week 11: Intelligent Agents

[RN2] (or [RN3]) Chapter 2

Intelligent Agents

An agent

- Perceives its environment through sensors (ie. get percepts)
- Acts on environment through effectors.

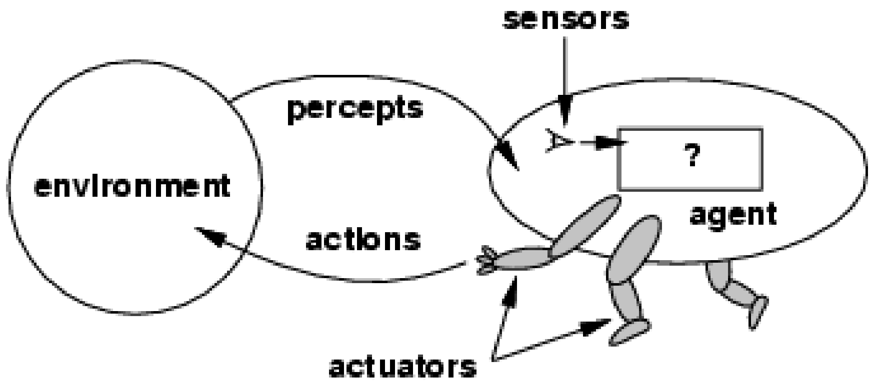
One definition of “agent”:

An agent is anything that can be viewed as perceiving its environment through **sensors** and acting upon that environment through **actuators**

Agent	Sensors	Actuators
Human	Eyes, Ears…	Arms, Fingers, Legs
Robot	Camera, Sonar, Laser	Motors, Manipulators
Softbots	Coded Bit Strings	Code Bit Strings

The big question: How to get from percepts to actions?

Agents and Environments



The agent function maps given percept sequence to actions:

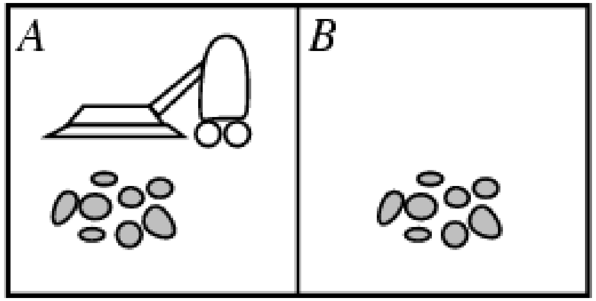
$$[f: \mathcal{P}^{\star} \rightarrow \mathcal{A}]$$

The agent function can be implemented by an agent program, which runs on the physical architecture to produce actions.

agent = **architecture** + **program**

Vacuum-cleaner World

Use the vacuum-cleaner world as an example, the vacuum cleaner can be considered as an agent.



The percepts are: location and contents, e.g., *[A, Dirty]*–(there is dirty in square A)

The actions of the agent: *Left*, *Right*, *Suck*, *NoOp (do nothing)*

A Vacuum–cleaner Agent

Percept sequence	Action
$[A, Clean]$	$Right$
$[A, Dirty]$	$Suck$
$[B, Clean]$	$Left$
$[B, Dirty]$	$Suck$
$[A, Clean]$, $[A, Clean]$	$Right$
$[A, Clean]$, $[A, Dirty]$	$Suck$
$\vdots$	$\vdots$

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*

Rational Agents

Given:

- A performance measure:
  - An objective criterion for success of an agent's behavior
- A perceptual history/ percept sequence
- Agent's knowledge of the environment
- Actions the agent can perform

A rational agent should "do the right thing" based on these given factors.

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

A rational vacuum-cleaner agent should clean up the maximum amount of dirt with minimum amount of time/electricity/noise.

Rational Agents

The definition of **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.

Note: **rationality ≠ omniscience** (perfect knowledge)

It is rational to look both ways before crossing the street.

It is not rational to check for falling space debris.

Omniscience is impossible in reality.

Intelligent Agents

- Agents should be autonomous (or semi autonomous)

- Agents should be 'situate' – sensitive to environment

- Agents should interact – communicate

- Society of agents is structured. Agent oriented systems should cooperate to achieve a goal. Each agent contributes its own know-how

- Intelligence 'emerges' from the behaviour of the society, not just a property of an individual.

Most problems will require a variety of agents for their solution.

Emergent Intelligence

The intelligent behaviour emerges from the interactions of much simpler behaviours or simpler agents.

Example

- A mobile robot has 2 behaviours
  - go forwards without going too close to a wall on the left
  - go forwards without going too close to a wall on the right

- Putting these two behaviours together will permit the robot to proceed down the centre of a corridor

Note that this very different from simple programming the robot to go down the centre of a corridor.

Emergent Intelligence

Swarm-bots, an EU project led by Marco Dorigo, aimed to study new approaches to the design and implementation of self-organizing and self-assembling artifacts (http://www.swarm-bots.org/).

Autonomy

Agents can perform actions in order to modify future percepts so as to obtain useful information (information gathering, exploration)

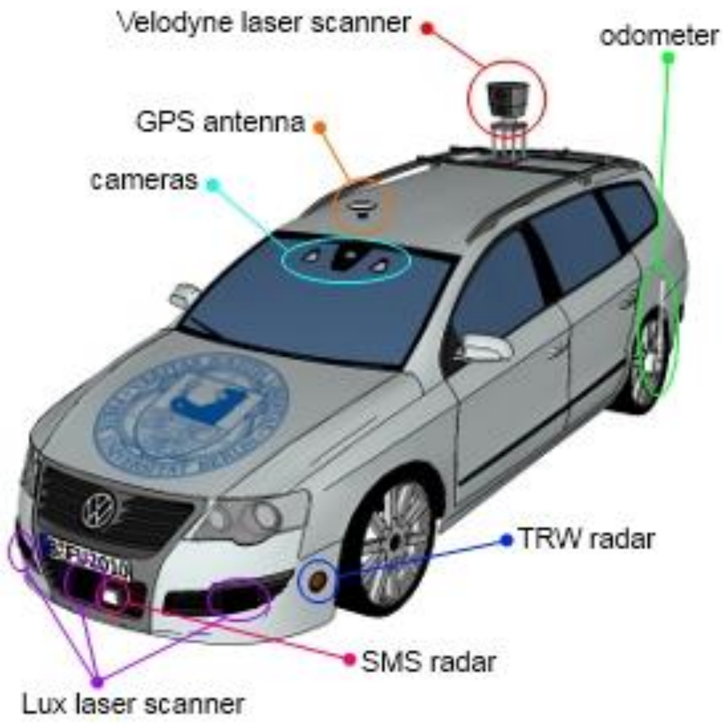
The agent must be able to

- act without human intervention
- take into account the history of percepts
- take into account the knowledge about the domain

A system is autonomous to the extent that its behaviour is determined by its experience (with ability to learn and adapt).

Example: a vacuum cleaner agent should not just keep going if the hose becomes disconnected.

Autonomous Vehicles



Task Environment

The task environment of an agent can be described as PEAS.

PEAS: Performance measure, **E**nvironment, **A**ctuators, **S**ensors

They must be first specified intelligent agent design.

For example, in the task of designing an automated taxi driver

- **P**erformance measure: Safe, fast, legal, comfortable trip, maximize profits
- **E**nvironment: Roads, other traffic, pedestrians, customers
- **A**ctuators: Steering wheel, accelerator, brake, signal, horn
- **S**ensors: Cameras, sonar, speedometer, GPS, odometer, engine sensors, keyboard

These should be specified in the design stage.

PEAS Example

Agent: Medical diagnosis system

Performance measure: Healthy patient, minimize costs, lawsuits

Environment: Patient, hospital, staff

Actuators: Screen display (questions, tests, diagnoses, treatments, referrals)

Sensors: Keyboard (entry of symptoms, findings, patient's answers)

PEAS Example…

Agent: Part-picking robot

Performance measure: Percentage of parts in correct bins

Environment: Conveyor belt with parts, bins

Actuators: Jointed arm and hand

Sensors: Camera, joint angle sensors

PEAS Example...

Agent: Interactive English tutor

Performance measure: Maximize student's score on test

Environment: Set of students

Actuators: Screen display (exercises, suggestions, corrections)

Sensors: Keyboard

Properties of Task Environments

Fully observable vs. partially observable:

An agent's sensors give it access to the complete state of the environment at each point in time.

Deterministic vs. stochastic:

The next state of the environment is completely determined by the current state and the action executed by the agent. (If the environment is deterministic except for the actions of other agents, then the environment is strategic)

Episodic vs. sequential:

The agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving and then performing a single action), and the choice of action in each episode depends only on the episode itself.

Properties of Task Environments…

Static vs. dynamic:

The environment is unchanged while an agent is deliberating. (The environment is semidynamic if the environment itself does not change with the passage of time but the agent's performance score does)

Discrete vs. continuous:

A limited number of distinct, clearly defined percepts and actions.

Single agent vs. multiagent:

An agent operating by itself in an environment.

Properties of Task Environments...

	Solitaire	Backgammon	Internet shopping	Taxi
Observable??	Yes	Yes	No	No
Deterministic??	Yes	No	Partly	No
Episodic??	No	No	No	No
Static??	Yes	Semi	Semi	No
Discrete??	Yes	Yes	Yes	No
Single-agent??	Yes	No	Yes (except auctions)	No

The environment type largely determines the agent design

The real world is (of course) partially observable, stochastic, sequential, dynamic, continuous, multi-agent

Agent Types

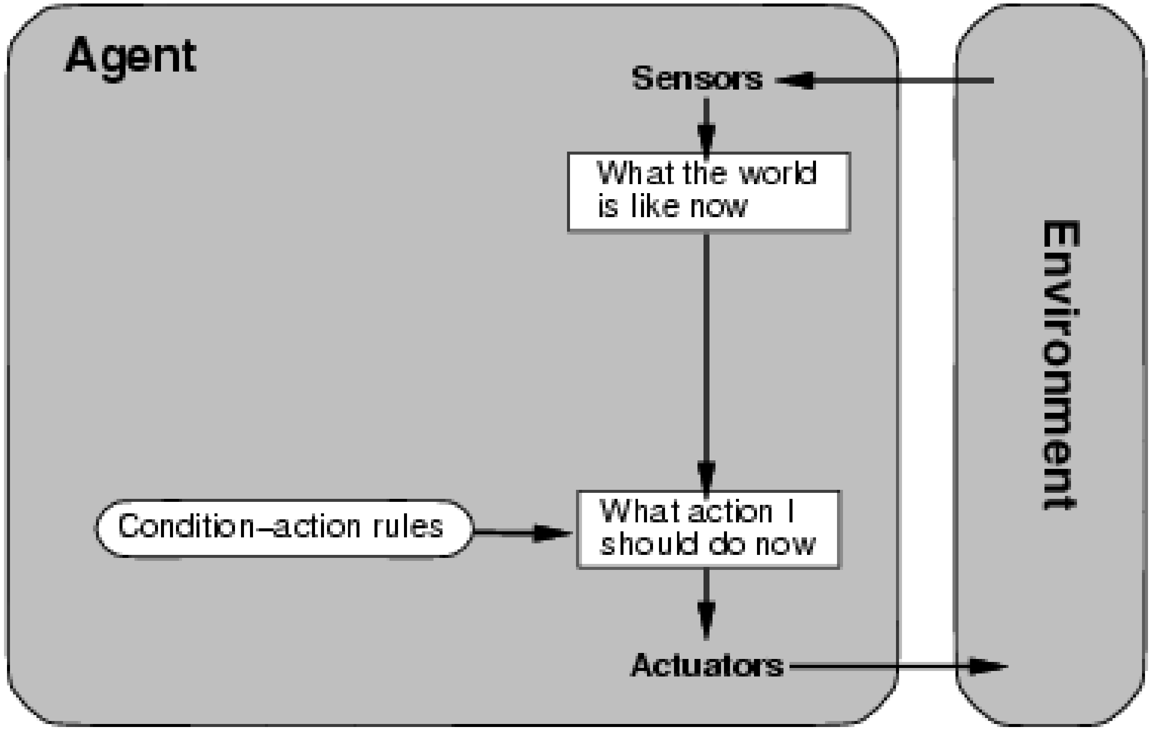
The basic skeleton of agent:

function SKELETON-AGENT**(percept) returns** action
    static: *memory*, the agent's memory of the world

    memory ← UPDATE-MEMORY(*memory, percept*)
    action ← CHOOSE-BEST-ACTION(*memory*)
    memory ← UPDATE-MEMORY(*memory, action*)
    return *action*

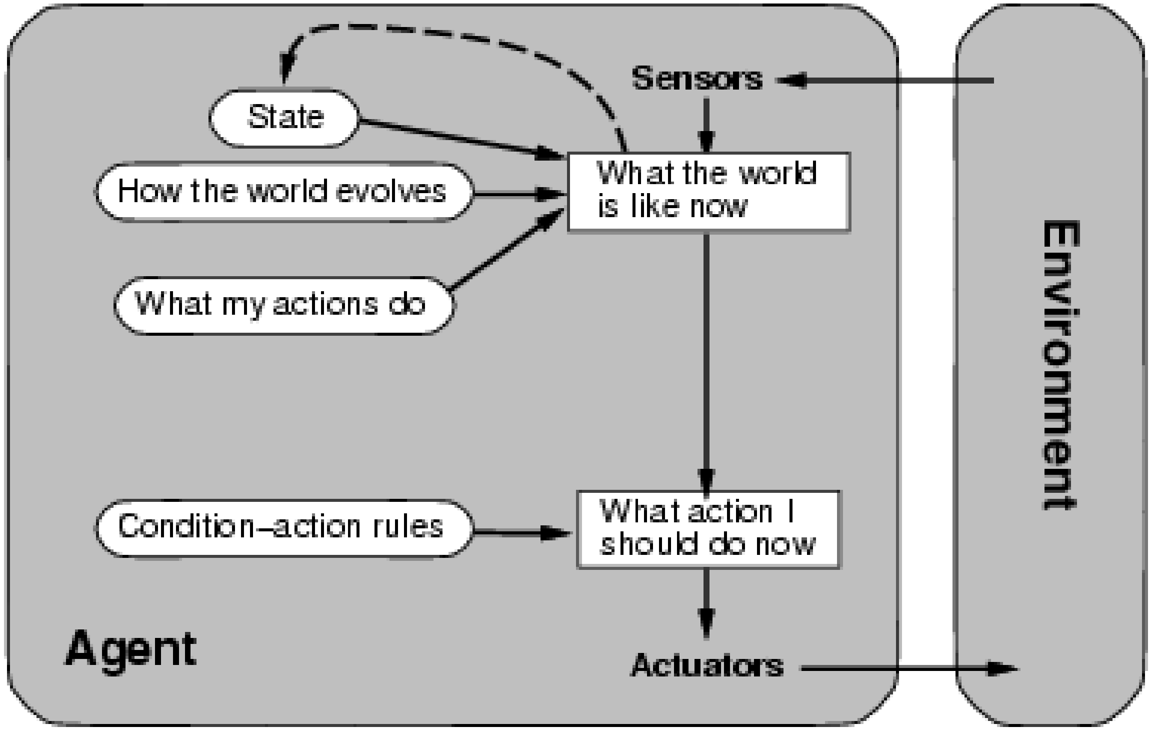
Four basic types in order of increasing generality:
- Simple reflex agents
- Model-based reflex agents
- Goal-based agents
- Utility-based agents

Simple Reflex Agents

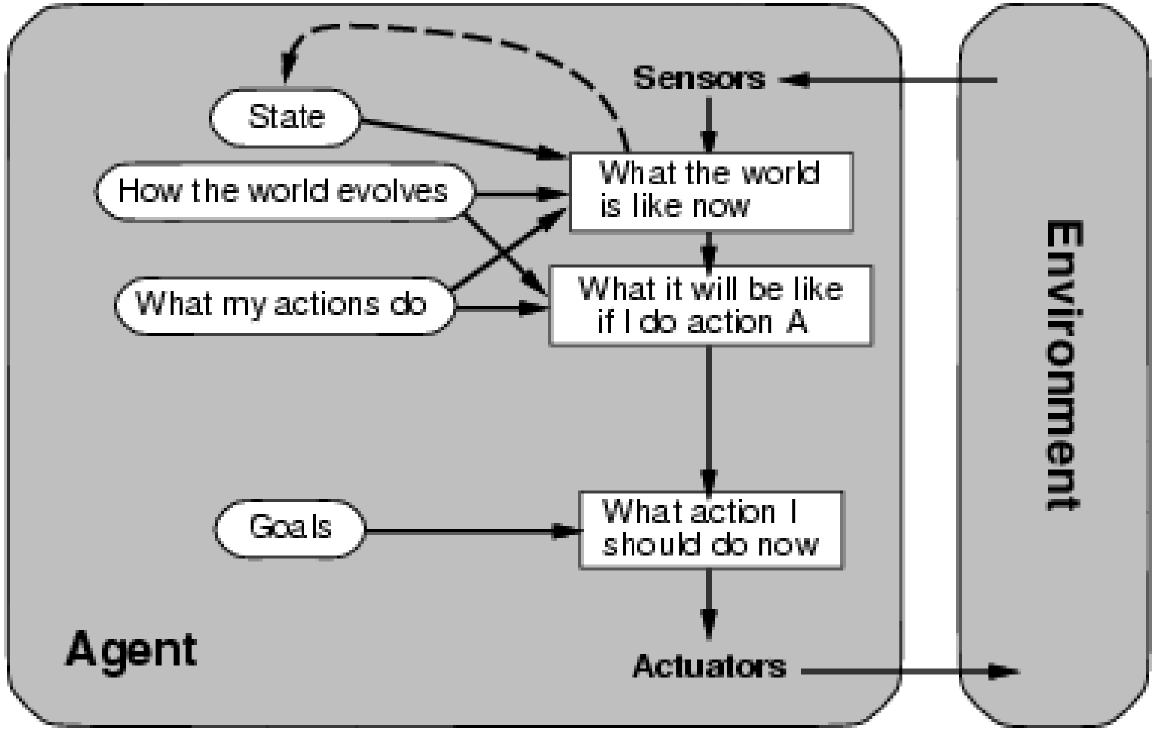


Note: Agent has no memory

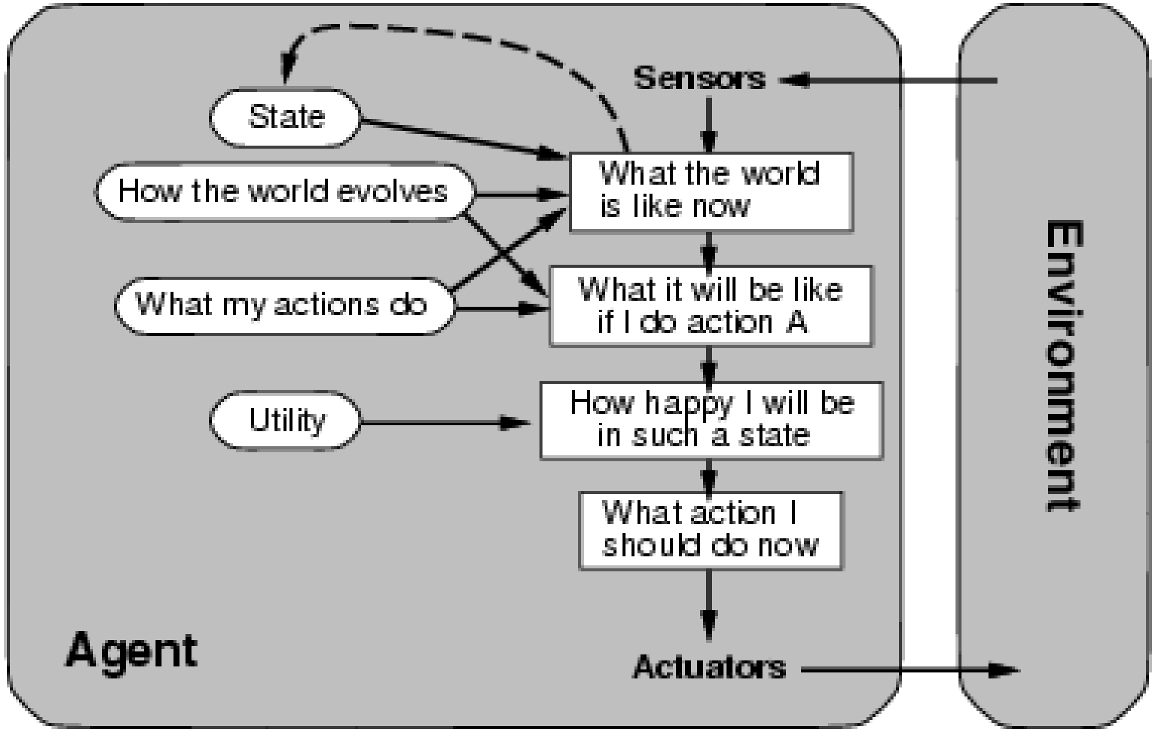
Model-based reflex agents



Goal-based agents

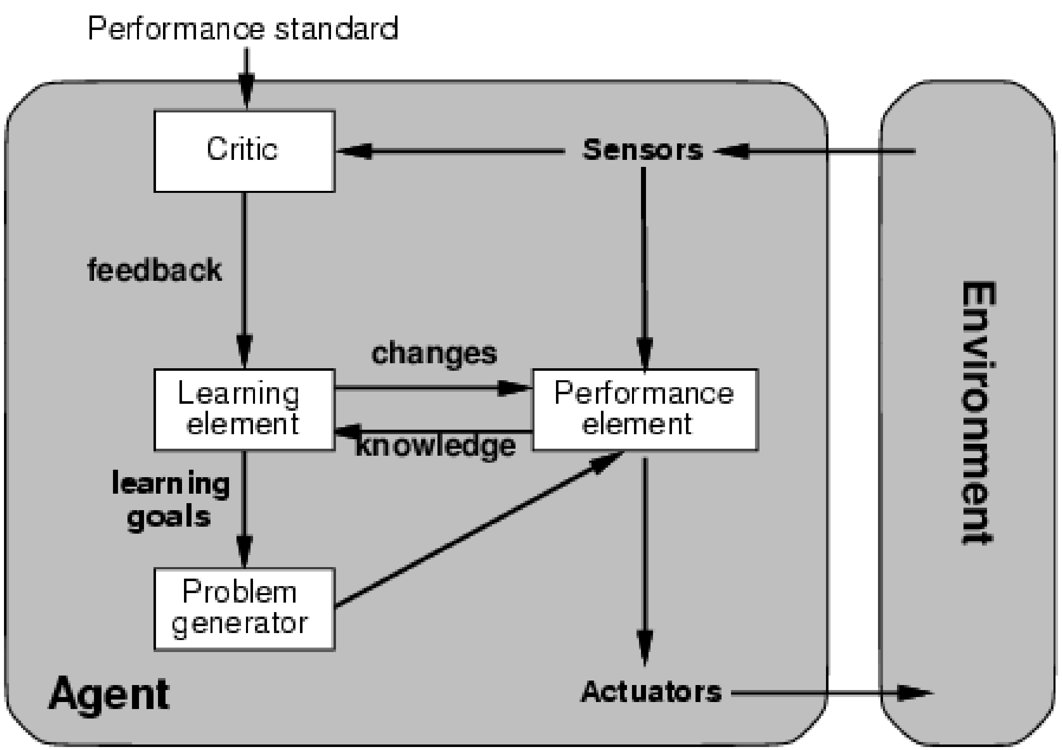


Utility-based agents



Learning agents

These four types of agents can be converted into learning agents.



(We will see this diagram again in the section of machine learning.)

Robot Soccer Agent

- Performance Measure:

  win game, score goals, prevent opposition from scoring
- Environment: real or simulated soccer field
- Actuators: kick, dash, turn
- Sensor: ball position, goal position, other players

How can the soccer player be implemented as an agent?

- Simple reflex agent ?
- Model-based reflex agent ?
- Goal based agent ?
- Utility based agent ?

Note: building a real soccer player is currently beyond the state of the art, however many of the necessary technologies already exist.

Summary

- Agent, sensors, actuators
- Agent functions
- Rational agent
- Performance measure
- Rationality vs. omniscience
- Emergent Intelligence
- Autonomy
- Task environment
- PEAS (Performance measure, Environment, Actuators, Sensors)
- Properties of task environment (fully observable vs. partially observable, deterministic vs. stochastic, episodic vs. sequential, static vs. dynamic, discrete vs. continuous, single agent vs. multiagent)
- Agent Types: simple reflex agents, model-based reflex agents, goal-based agents, utility based agents.

Acknowledgement: the slides were developed based on notes from Russell & Norvig's text, and several RMIT computer science staff members over the years.