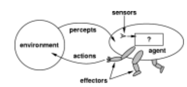
Chapter 2:
Intelligent Agents

Intelligent Agents

- Agent is something that acts.
- An Intelligent Agent perceives it environment via sensors and acts rationally upon that environment with its effectors (actuators).
- An agent gets percepts one at a time, and maps this percept sequence to actions.
- Properties of the agent
  - Autonomous
  - Interacts with other agents plus the environment
  - Reactive to the environment
  - Pro-active (goal- directed)



Intelligent Agents

For Humans

- **Sensors**: Eyes, ears , skin, tongue , nose, neuromuscular system
- **Percepts**:
  - At the lowest level – electrical signals from these sensors
  - After preprocessing – objects in the visual field (location, textures, colors, …), auditory streams (pitch, loudness, direction), …
- **Effectors**: limbs, eyes, tongue, etc…..
- **Actions**: lift a finger, turn left, walk, run, carry an object, …

Intelligent Agents

For Automated taxi driving system

- **Percepts**: Video, sonar (for sound navigation), speedometer, odometer (distance), engine sensors, keyboard input, microphone, GPS (Global Positioning System), …
- **Actions**: Steer, accelerate, brake, horn, speak/display, …
- **Goals**: Maintain safety, reach destination, maximize profits (fuel, tire wear), obey laws, provide passenger comfort, …
- **Environment**: Urban streets, freeways, traffic, pedestrians, weather, customers, …

Intelligent Agents

The vacuum-cleaner world: Example of Agent

- **Environment:** square A and B
- **Percepts:** [location and content] *E.g. [A, Dirty]*
- **Actions:** left, right, suck, and no-op
- **Percept sequence to Action**

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

Agent Function

- **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.

  $f : P^* \dashrightarrow A$
- 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.*

Rationality

- **Rational behavior**: doing the right thing.
- **The right thing**: that which is expected to maximize goal achievement, given the available information.
- **Rational Agent** is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.
- A rational agent chooses whichever action maximizes the expected value of the performance measure given the percept sequence to date and prior environment knowledge.

Rationality

- *It is better to design Performance measure according to what is wanted in the environment instead of how the agents should behave.*
- It is not easy task to choose the performance measure of an agent.
- For example
  - if the performance measure for automated vacuum cleaner is "The amount of dirt cleaned within a certain time"
  - Then a rational agent can maximize this performance by cleaning up the dirt , then dumping it all on the floor, then cleaning it up again , and so on.
  - Therefore "How clean the floor is" is better choice for performance measure of vacuum cleaner.

Structure of Agents

- An intelligent agent is a combination of Agent Program and Architecture.
- Intelligent Agent = Agent Program + Architecture
- Agent Program is a function that implements the agent mapping from percepts to actions.
- Architecture is a computing device used to run the agent program.

Characteristics of agents

Internal characteristics are

- Learning/reasoning:
  - An agent has the ability to learn from previous experience and to successively adapt its own behavior to the environment.
- Reactivity:
  - An agent must be capable of reacting appropriately to influences or information from its environment.
- Autonomy:
  - There may need intervention from the user only for important decisions else operate automatically (independently).
- Goal-oriented:
  - An agent has well-defined goals, gradually influence its environment so as to achieve its own goals.

Characteristics of agents

External characteristics are

- Communication:
  - An agent often requires an interaction with its environment to fulfill its tasks, such as human, other agents, and arbitrary information sources.
- Cooperation:
  - Cooperation of several agents permits faster and better solutions for complex tasks that exceed the capabilities of a single agent.
- Mobility:
  - An agent may navigate within electronic communication networks.
- Character:
  - like human, an agent may demonstrate an external behavior with many human characters as possible.

PAGE Descriptors of Agent

- In designing intelligent systems there are four main factors to consider:
  - **P** Percepts – the inputs to our system
  - **A** Actions – the outputs of our system
  - **G** Goals – what the agent is expected to achieve
  - **E** Environment – what the agent is interacting with
- *PAGE Descriptors are not the only way of describing intelligent systems.*

PEAS Descriptors of Agent

- To design a rational agent we must specify its task environment.
- Task environment is defined and described by the PEAS description of the environment.
  - **P** Performance – how we measure the system's achievements
  - **E** Environment – what the agent is interacting with
  - **A** Actuators – what produces the outputs of the system
  - **S** Sensors – what provides the inputs to the system

Agents and PAGE Descriptors

Agent Type	Percepts	Actions	Goals	Environment
Medical diagnostic system	Symptoms, test results, patient's answers	Questions, test requests, treatments, referrals	Healthy patients, minimise costs	Patient, hospital, staff
Satellite image analysis system	Pixels of varying intensity and colour	Display a categorisation of the scene	Correct image categorisation	Images from orbiting satellite
Part-picking robot	Pixels of varying intensity and colour	Pick up parts and sort them into bins	Place parts into correct bins	Conveyor belt with parts, bins
Refinery controller	Temperature, pressure and chemical readings	Open and close valves, adjust temperature	Maximise purity, yield, safety	Refinery, staff
Interactive English tutor	Typed words	Display exercises, suggestions, corrections	Maximise student's exam results	Set of students, exam papers

Agent: 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

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)

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

Agent: Interactive English tutor

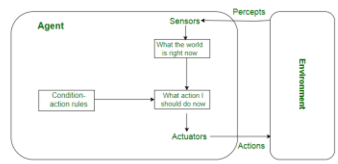
- Performance measure: Maximize student's score on test
- Environment: Set of students
- Actuators: Screen display (exercises, suggestions, corrections)
- Sensors: Keyboard

Types of Agents

Simple Reflex Agents

- Simple reflex agents ignore the rest of the percept history and act only on the basis of the **current percept**.
- The agent function is based on the **condition-action rule**.
- Problems with Simple reflex agents are :
  - Very limited intelligence.
  - No knowledge of non-perceptual parts of state.
  - Usually too big to generate and store.
  - If there occurs any change in the environment, then the collection of rules need to be updated.

Simple Reflex Agents

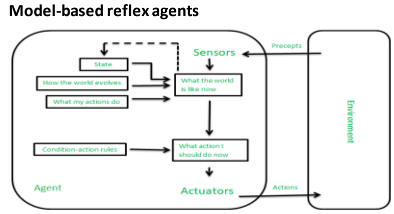


Types of Agents

Model-based reflex agents

- A model-based agent can handle **partially observable environments** by use of model about the world.
- The agent has to keep track of **internal state** which is adjusted by each percept and that depends on the percept history.
- Updating the state requires information about :
  - how the world evolves in-dependently from the agent, and
  - how the agent actions affects the world.

Model-based reflex agents

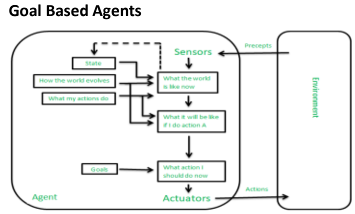


Types of Agents

Goal Based Agents

- These kind of agents take decision 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.

Goal Based Agents

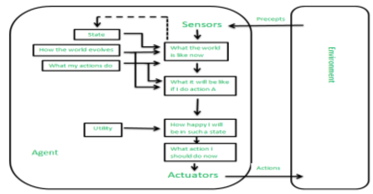


Types of Agents

Utility-based agents

- 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.
- 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.
- A utility function maps a state onto a real number which describes the associated degree of happiness.

Utility-based agents



The Agent Environments

Complete vs. Incomplete –

- Complete AI environments are those on which, at any given time, we have enough information to complete a branch of the problem.
  - Chess is a classic example of a complete AI environment.
  - Poker, on the other hand, is an incomplete environments.

The Agent Environments

Fully Observable vs. Partially Observable

- A fully observable AI environment has access to all required information to complete target task.
  - Image recognition operates in fully observable domains.
- Partially observable environments such as the ones encountered in self-driving vehicle scenarios deal with partial information in order to solve AI problems.

The Agent Environments

Deterministic vs. Non-deterministic (stochastic) –

- Deterministic AI environments are those on which the outcome can be determined based on a specific state. In other words, deterministic environments ignore uncertainty.
  - eg: vacuum world problem.
- But most real world AI environments are not deterministic. Instead, they can be classified as stochastic.
  - Self-driving vehicles are a classic example of stochastic AI processes.

The Agent Environments

Episodic vs. Non-episodic –

- In an episodic environment the agent’s experience can be divided into “episodes” consisting of the agent perceiving and then producing actions that depend only on that episode.
- *Episodic environment:* mail sorting system
  Non-episodic environment: chess game

The Agent Environments

Discrete vs. Continuous –

- A discrete environment has a limited/finite number of distinct, clearly defined percepts and actions.
  - Chess is also classified as a discrete AI problem.
- Continuous AI environments rely on unknown and rapidly changing data sources.
  - Vision systems in drones or self-driving cars operate on continuous AI environments.

The Agent Environments

Competitive vs. Collaborative

- Competitive AI environments face AI agents against each other in order to optimize a specific outcome.
  - Games such as GO or Chess are examples of competitive AI environments.
- Collaborative AI environments rely on the cooperation between multiple AI agents.
  - Self-driving vehicles or cooperating to avoid collisions or smart home sensors interactions are examples of collaborative AI environments.

The Agent Environments

Static vs. Dynamic –

- Static AI environments rely on data-knowledge sources that don't change frequently over time.
  - Speech analysis is a problem that operates on static AI environments.
- Dynamic AI environments such as the vision AI systems in drones deal with data sources that change quite frequently.

Single agent vs, multiple agent –

- When there is only one agent in a defined environment, the environment is called the single agent environment.
  - The agent acts and interacts only with its environment.
- If there is more than one agent in the environment, it is called multiple agent environment.
  - The agents interact with each other and their environment.

Components of an AI Agent

- A means to infer properties of the world from its percepts.
- Information about the way the world evolves.
- Information about what will happen as a result of its possible actions.
- Utility information indicating the desirability of possible world states and the actions that lead to them.
- Goals that describe the classes of states whose achievement maximizes the agent's utility.
- A mapping from the above forms of knowledge to its actions.
- An active learning system that will improve the agent's ability to perform well.

Thank you !
Any questions ?