Module 1

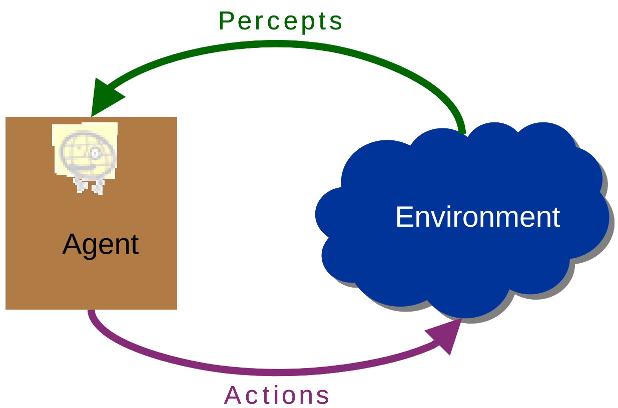
Introduction

Lesson
2

Introduction to Agent

1.3.1 Introduction to Agents

An agent acts in an environment.



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. 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.

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.

1.3.1.1 Agent Performance

An agent function implements a mapping from perception history to action. The behaviour and performance of intelligent agents have to be evaluated in terms of the agent function.

The **ideal mapping** specifies which actions an agent ought to take at any point in time.

The **performance measure** is a subjective measure to characterize how successful an agent is. The success can be measured in various ways. It can be measured in terms of speed or efficiency of the agent. It can be measured by the accuracy or the quality of the solutions achieved by the agent. It can also be measured by power usage, money, etc.

1.3.1.2 Examples of Agents

1. Humans can be looked upon as agents. They have eyes, ears, skin, taste buds, etc. for sensors; and hands, fingers, legs, mouth for effectors.

2. Robots are agents. Robots may have camera, sonar, infrared, bumper, etc. for sensors. They can have grippers, wheels, lights, speakers, etc. for actuators.

   Some examples of robots are Xavier from CMU, COG from MIT, etc.

Xavier Robot (CMU)

   Then we have the AIBO entertainment robot from SONY.

Aibo from SONY

3. We also have software agents or softbots that have some functions as sensors and some functions as actuators. Askjeeves.com is an example of a softbot.
4. Expert systems like the Cardiologist is an agent.
5. Autonomous spacecrafts.
6. Intelligent buildings.

1.3.1.3 Agent Faculties

The fundamental faculties of intelligence are

- Acting
- Sensing
- Understanding, reasoning, learning

Blind action is not a characterization of intelligence. In order to act intelligently, one must sense. Understanding is essential to interpret the sensory percepts and decide on an action. Many robotic agents stress sensing and acting, and do not have understanding.

1.3.1.4 Intelligent Agents

An **Intelligent Agent** must sense, must act, must be autonomous (to some extent),. It also must be rational.

AI is about building rational agents. An agent is something that perceives and acts.
A rational agent always does the right thing.

1. What are the functionalities (goals)?
2. What are the components?
3. How do we build them?

1.3.1.5 Rationality

Perfect Rationality assumes that the rational agent knows all and will take the action that maximizes her utility. Human beings do not satisfy this definition of rationality.
Rational Action is the action that maximizes the expected value of the performance measure given the percept sequence to date.

However, a rational agent is not omniscient. It does not know the actual outcome of its actions, and it may not know certain aspects of its environment. Therefore rationality must take into account the limitations of the agent. The agent has too select the best action to the best of its knowledge depending on its percept sequence, its background knowledge and its feasible actions. An agent also has to deal with the expected outcome of the actions where the action effects are not deterministic.

1.3.1.6 Bounded Rationality

"Because of the limitations of the human mind, humans must use approximate methods to handle many tasks." Herbert Simon, 1972

Evolution did not give rise to optimal agents, but to agents which are in some senses locally optimal at best. In 1957, Simon proposed the notion of Bounded Rationality:
that property of an agent that behaves in a manner that is nearly optimal with respect to its goals as its resources will allow.

Under these promises an intelligent agent will be expected to act optimally to the best of its abilities and its resource constraints.

1.3.2 Agent Environment

Environments in which agents operate can be defined in different ways. It is helpful to view the following definitions as referring to the way the environment appears from the point of view of the agent itself.

1.3.2.1 Observability

In terms of observability, an environment can be characterized as fully observable or partially observable.

In a fully observable environment all of the environment relevant to the action being considered is observable. In such environments, the agent does not need to keep track of the changes in the environment. A chess playing system is an example of a system that operates in a fully observable environment.

In a partially observable environment, the relevant features of the environment are only partially observable. A bridge playing program is an example of a system operating in a partially observable environment.

1.3.2.2 Determinism

In deterministic environments, the next state of the environment is completely described by the current state and the agent's action. Image analysis systems are examples of this kind of situation. The processed image is determined completely by the current image and the processing operations.

If an element of interference or uncertainty occurs then the environment is stochastic. Note that a deterministic yet partially observable environment will *appear* to be stochastic to the agent. Examples of this are the automatic vehicles that navigate a terrain, say, the Mars rovers robot. The new environment in which the vehicle is in is stochastic in nature.

If the environment state is wholly determined by the preceding state and the actions of *multiple* agents, then the environment is said to be strategic. Example: Chess. There are two agents, the players and the next state of the board is strategically determined by the players' actions.

1.3.2.3 Episodicity

An **episodic** environment means that subsequent episodes do not depend on what actions occurred in previous episodes.

In a **sequential** environment, the agent engages in a series of connected episodes.

1.3.2.4 Dynamism

Static Environment: does not change from one state to the next while the agent is considering its course of action. The only changes to the environment are those caused by the agent itself.

- A **static** environment does not change while the agent is thinking.
- The passage of time as an agent deliberates is irrelevant.
- The agent doesn't need to observe the world during deliberation.

A Dynamic Environment changes over time independent of the actions of the agent -- and thus if an agent does not respond in a timely manner, this counts as a choice to do nothing

1.3.2.5 Continuity

If the number of distinct percepts and actions is limited, the environment is **discrete**, otherwise it is **continuous**.

1.3.2.6 Presence of Other agents

Single agent/ Multi-agent

A multi-agent environment has other agents. If the environment contains other intelligent agents, the agent needs to be concerned about strategic, game-theoretic aspects of the environment (for either cooperative *or* competitive agents)

Most engineering environments do not have multi-agent properties, whereas most social and economic systems get their complexity from the interactions of (more or less) rational agents.

1.3.3 Agent architectures

We will next discuss various agent architectures.

1.3.3.1 Table based agent

In table based agent the action is looked up from a table based on information about the agent's percepts. A table is simple way to specify a mapping from percepts to actions. The mapping is implicitly defined by a program. The mapping may be implemented by a rule based system, by a neural network or by a procedure.

There are several disadvantages to a table based system. The tables may become very large. Learning a table may take a very long time, especially if the table is large. Such systems usually have little autonomy, as all actions are pre-determined.

1.3.3.2. Percept based agent or reflex agent

In percept based agents,

1. information comes from **sensors - percepts**
2. changes the agents current **state of the world**
3. triggers **actions** through the **effectors**

Such agents are called reactive agents or stimulus-response agents. Reactive agents have no notion of history. The current state is as the sensors see it right now. The action is based on the current percepts only.

The following are some of the characteristics of percept-based agents.

- Efficient
- No internal representation for reasoning, inference.
- No strategic planning, learning.
- Percept-based agents are not good for multiple, opposing, goals.

1.3.3.3 Subsumption Architecture

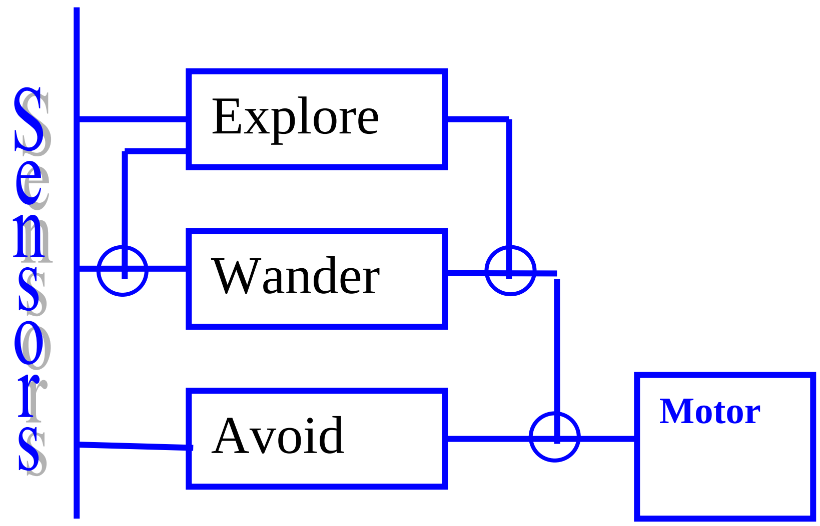
We will now briefly describe the subsumption architecture (Rodney Brooks, 1986). This architecture is based on reactive systems. Brooks notes that in lower animals there is no deliberation and the actions are based on sensory inputs. But even lower animals are capable of many complex tasks. His argument is to follow the evolutionary path and build simple agents for complex worlds.

The main features of Brooks' architecture are.

- There is no explicit knowledge representation
- Behaviour is distributed, not centralized
- Response to stimuli is reflexive
- The design is bottom up, and complex behaviours are fashioned from the combination of simpler underlying ones.
- Individual agents are simple

The Subsumption Architecture built in layers. There are different layers of behaviour. The higher layers can override lower layers. Each activity is modeled by a finite state machine.

The subsumption architecture can be illustrated by Brooks' Mobile Robot example.



Subsumption Architecture

The system is built in three layers.

1. Layer 0: Avoid Obstacles
2. Layer1: Wander behaviour
3. Layer 2: Exploration behaviour

Layer 0 (Avoid Obstacles) has the following capabilities:

- Sonar: generate sonar scan
- Collide: send HALT message to forward
- Feel force: signal sent to run-away, turn

Layer1 (Wander behaviour)

- Generates a random heading
- Avoid reads repulsive force, generates new heading, feeds to turn and forward

Layer2 (Exploration behaviour)

- Whenlook notices idle time and looks for an interesting place.
- Pathplan sends new direction to avoid.
- Integrate monitors path and sends them to the path plan.

1.3.3.4 State-based Agent or model-based reflex agent

State based agents differ from percept based agents in that such agents maintain some sort of state based on the percept sequence received so far. The state is updated regularly based on what the agent senses, and the agent's actions. Keeping track of the state requires that the agent has knowledge about how the world evolves, and how the agent's actions affect the world.

Thus a state based agent works as follows:

- information comes from **sensors - percepts**
- based on this, the agent changes the current **state of the world**
- based on **state of the world** and **knowledge (memory)**, it triggers **actions** through the **effectors**

1.3.3.5 Goal-based Agent

The goal based agent has some goal which forms a basis of its actions.
Such agents work as follows:

- information comes from **sensors - percepts**
- changes the agents current **state of the world**
- based on **state of the world** and **knowledge (memory)** and **goals/intentions**, it chooses **actions** and does them through the **effectors**.

Goal formulation based on the current situation is a way of solving many problems and search is a universal problem solving mechanism in AI. The sequence of steps required to solve a problem is not known a priori and must be determined by a systematic exploration of the alternatives.

1.3.3.6 Utility-based Agent

Utility based agents provides a more general agent framework. In case that the agent has multiple goals, this framework can accommodate different preferences for the different goals.
Such systems are characterized by a utility function that maps a state or a sequence of states to a real valued utility. The agent acts so as to maximize expected utility

1.3.3.7 Learning Agent

Learning allows an agent to operate in initially unknown environments. The learning element modifies the performance element. Learning is required for true autonomy

1.4 Conclusion

In conclusion AI is a truly fascinating field. It deals with exciting but hard problems. A goal of AI is to build intelligent agents that act so as to optimize performance.

- An **agent** perceives and acts in an environment, has an architecture, and is implemented by an agent program.
- An **ideal agent** always chooses the action which maximizes its expected performance, given its percept sequence so far.
- An **autonomous agent** uses its own experience rather than built-in knowledge of the environment by the designer.
- An agent program maps from percept to action and updates its internal state.

    - Reflex agents respond immediately to percepts.
    - Goal-based agents act in order to achieve their goal(s).
    - Utility-based agents maximize their own utility function.
- Representing knowledge is important for successful agent design.
- The most challenging environments are partially observable, stochastic, sequential, dynamic, and continuous, and contain multiple intelligent agents.

Questions

1. Define intelligence.
2. What are the different approaches in defining artificial intelligence?
3. Suppose you design a machine to pass the Turing test. What are the capabilities such a machine must have?
4. Design ten questions to pose to a man/machine that is taking the Turing test.
5. Do you think that building an artificially intelligent computer automatically shed light on the nature of natural intelligence?
6. List 5 tasks that you will like a computer to be able to do within the next 5 years.
7. List 5 tasks that computers are unlikely to be able to do in the next 10 years.
8. Define an agent.
9. What is a rational agent ?
10. What is bounded rationality ?
11. What is an autonomous agent ?
12. Describe the salient features of an agent.
13. Find out about the Mars rover.
    1. What are the percepts for this agent ?
    2. Characterize the operating environment.
    3. What are the actions the agent can take ?
    4. How can one evaluate the performance of the agent ?
    5. What sort of agent architecture do you think is most suitable for this agent ?
14. Answer the same questions as above for an Internet shopping agent.

Answers

1. Intelligence is a rather hard to define term.

Intelligence is often defined in terms of what we understand as intelligence in humans. Allen Newell defines *intelligence* as the *ability to bring all the knowledge a system has at its disposal to bear in the solution of a problem*.

A more practical definition that has been used in the context of building artificial systems with intelligence is *to perform better on tasks that humans currently do better*.

2.

- Thinking rationally
- Acting rationally
- Thinking like a human
- Acting like a human

3.

- Natural language processing
- Knowledge representation
- Automated reasoning
- Machine Learning
- Computer vision
- Robotics

4-7 : Use your own imagination

8. An agent is anything that can be viewed as perceiving its environment through sensors and executing actions using actuators.
9. A rational agent always selects an action based on the percept sequence it has received so as to maximize its (expected) performance measure given the percepts it has received and the knowledge possessed by it.
10. A rational agent that can use only bounded resources cannot exhibit the optimal behaviour. A bounded rational agent does the best possible job of selecting good actions given its goal, and given its bounded resources.
11. Autonomous agents are software entities that are capable of independent action in dynamic, unpredictable environments. An autonomous agent can learn and adapt to a new environment.
12.
    - An agent perceives its environment using sensors
    - An agent takes actions in the environment using actuators
    - A rational agent acts so as to reach its goal, or to maximize its utility
    - Reactive agents decide their action on the basis of their current state and the percepts. Deliberative agents reason about their goals to decide their action.

13. Mars Rover
    a. Spirit’s sensor include
        i. panoramic and microscopic cameras,
        ii. a radio receiver,
        iii. spectrometers for studying rock samples including an alpha particle x-ray spectrometer, M¨ossbauer spectrometer, and miniature thermal emission spectrometer

    b. The environment (the Martian surface)
        i. partially observable,
        ii. non-deterministic,
        iii. sequential,
        iv. dynamic,
        v. continuous, and
        vi. may be single-agent. If a rover must cooperate with its mother ship or other rovers, or if mischievous Martians tamper with its progress, then the environment gains additional agents

c. The **rover** Spirit has
    i. motor-driven wheels for locomotion
    ii. along with a robotic arm to bring sensors close to interesting rocks and a
    iii. rock abrasion tool (RAT) capable of efficiently drilling 45mm holes in hard volcanic rock.
    iv. Spirit also has a radio transmitter for communication.

d. Performance measure: A **Mars rover** may be tasked with
    i. maximizing the distance or variety of terrain it traverses,
    ii. or with collecting as many samples as possible,
    iii. or with finding life (for which it receives 1 point if it succeeds, and 0 points if it fails).

    Criteria such as maximizing lifetime or minimizing power consumption are (at best) derived from more fundamental goals; e.g., if it crashes or runs out of power in the field, then it can't explore.

e. A model-based reflex agent is suitable for low level navigation.
    For route planning, experimentation etc, some combination of goal-based, and utility-based would be needed.

14. **Internet book shopping agent**
    f. Sensors: Ability to parse Web pages, interface for user requests
    g. Environment: Internet. Partially observable, partly deterministic, sequential, partly static, discrete, single-agent (exception: auctions)
    h. Actuators: Ability to follow links, fill in forms, display info to user
    i. Performance Measure: Obtains requested books, minimizes cost/time
    j. Agent architecture: goal based agent with utilities fro open-ended situations