

# CENG 466

## Artificial Intelligence

### Lecture 7

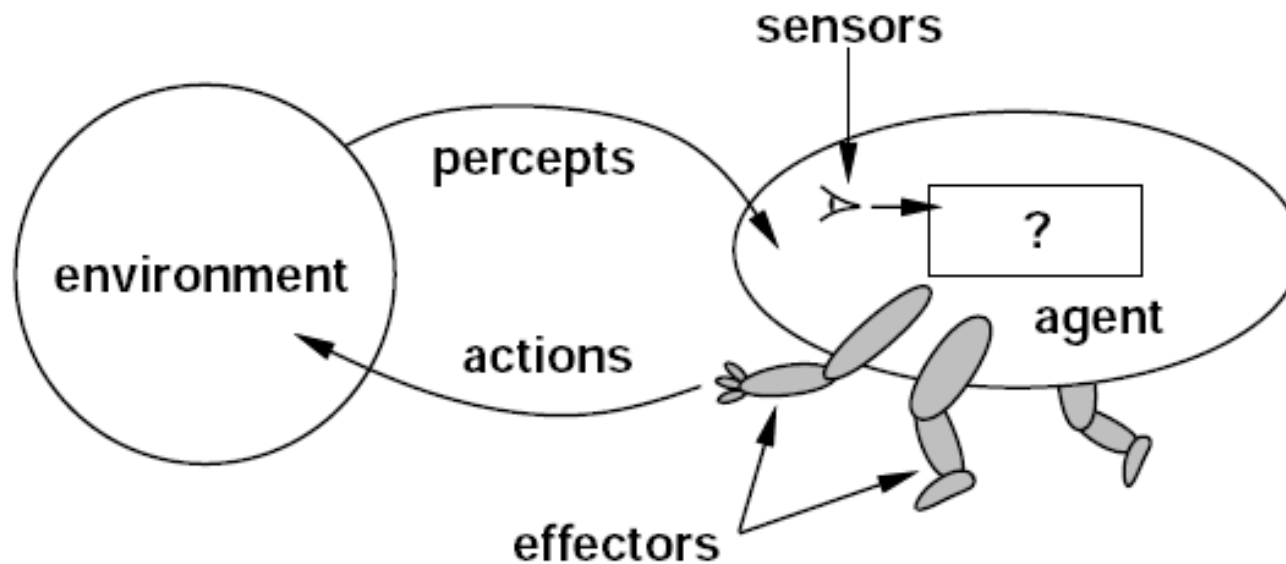
### Knowledge and Reasoning

# Topics

- ▶ Knowledge-based Agents
- ▶ Knowledge Base
- ▶ Knowledge Representation
- ▶ Knowledge-based Agent Description Levels
- ▶ Inference
- ▶ Example

# Intelligent Agents

- ▶ An agent is something that perceives and acts in an environment
- ▶ An ideal agent always takes actions that maximizes its performance
- ▶ An agent adopts a goal and searches the best path to reach that goal



# Intelligent Agents

- ▶ An agent that has goals and searches for solutions to the goals can do better than one that just reacts to its environment.
- ▶ Therefore, an agent should have some knowledge about its goal, its environment, and its actions.
- ▶ In addition, the agent should be capable of general logical reasoning.
- ▶ It uses logical reasoning to:
  - ▶ describe the world as new percepts arrive,
  - ▶ decide the action to achieve its goals.

# Knowledge-based Agents

- ▶ knowledge-based agents are agents which
  - ▶ can be seen as *knowing* about their world,
  - ▶ and *reasoning* about their possible action.

# Knowledge Base (I)

- ▶ The central component of a knowledge-based agent is its **knowledge base**, or KB.
- ▶ Informally, a knowledge base is a set of facts about the world.
- ▶ Each fact in a KB is called a **sentence**.

# Knowledge Base (II)

- ▶ The sentences are expressed in a language called a **knowledge representation language**.
- ▶ There must be a way to add new sentences to the knowledge base, and a way to query what is known.
- ▶ The standard names for these tasks are **TELL** and **ASK**, respectively.

# Knowledge Base (III)

- ▶ The fundamental requirement on **TELL** and **ASK** is that when one **ASKS** a question of the KB, the answer should follow from what has been **TOLD** to the KB previously.
- ▶ Determining what follows from what the KB has been TOLD is the job of the **inference mechanism**, the other main component of a knowledge-based agent.



# How does the Knowledge-based Agent Act?

- ▶ The agent maintains a *KB*, which contains some background knowledge.
- ▶ The agent **TELLS** the knowledge base what it perceives.
- ▶ Then, it **ASKS** the KB what action it should perform.
- ▶ To answer this query, logical reasoning is used to prove which action is better than all others, given:
  - ▶ what the agent knows
  - ▶ what its goals are.
- ▶ The agent then performs the chosen action.

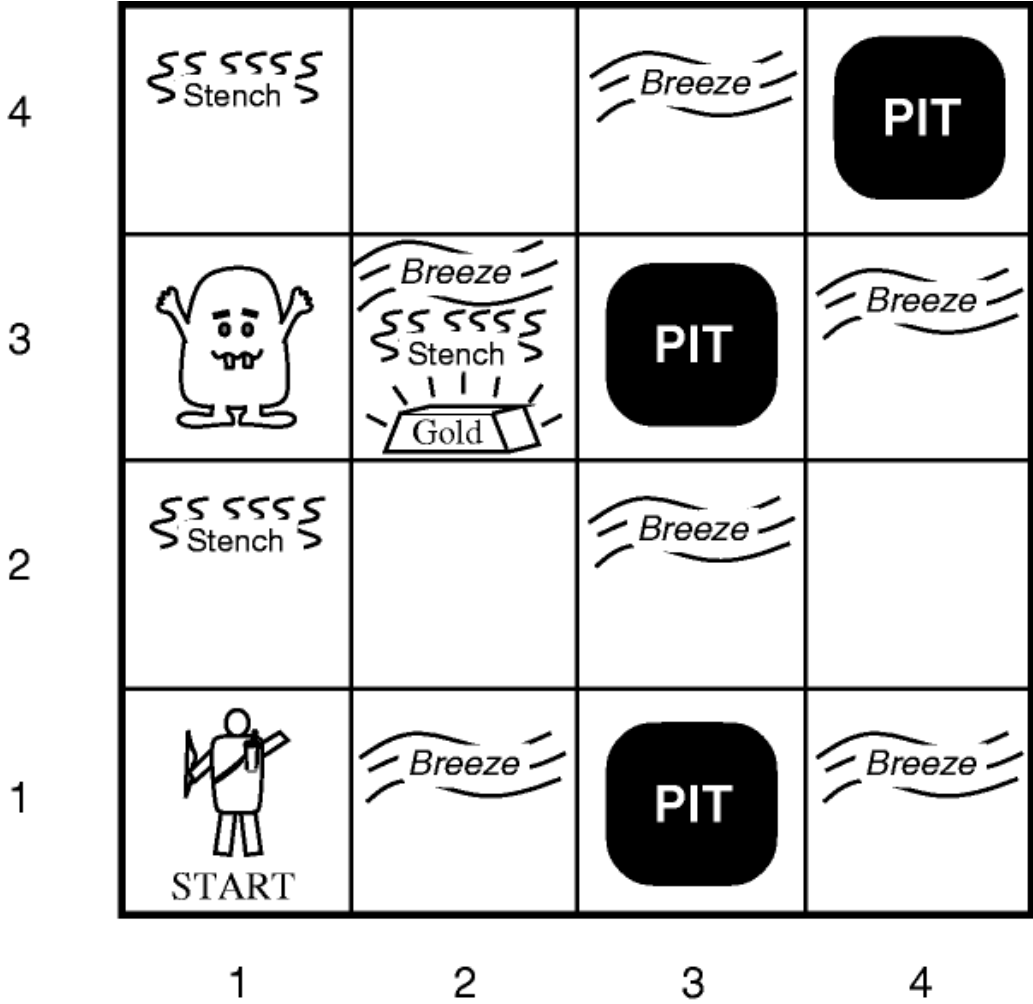
# Example: Knowledge Base

- ▶ **Wumpus** was an early computer game, based on an agent who explores a cave consisting of rooms connected by passageways.

# Example: The Wumpus

- ▶ Somewhere in a cave is a beast (the wumpus) that eats anyone who enters its room.
- ▶ Some rooms have bottomless pits that will trap anyone who enters into these rooms (except for the wumpus, who is too big to fall in).
- ▶ There are heaps of gold at some of the rooms.

# Wumpus Environment



# Wumpus' Knowledge Base (I)

- ▶ In the room with the wumpus and in the directly (not diagonally) adjacent rooms the agent will perceive a stench.
- ▶ In the rooms directly adjacent to a pit, the agent will perceive a breeze.
- ▶ In the room where the gold is, the agent will perceive a glitter.
- ▶ When an agent walks into a wall, it will perceive a bump.
- ▶ When the wumpus is killed, it gives out a scary scream that can be perceived anywhere in the cave.

# Wumpus' Knowledge Base (II)

- ▶ The percepts will be given to the agent in the form of a list of five symbols;
- ▶ for example:  
[stench=Yes, breeze=Yes, glitter=Yes, bump=No, scream=No]
- ▶ The agent *cannot* perceive its own location.

# Wumpus' Knowledge Base (III)

## ▶ Actions :

- ▶ **go forward**, **turn right by 90°**, **turn left by 90°**, **Grab** (to pick up an object), **Climb** (to leave the cave; it is used only when the agent is in the start room), **Shoot** (to fire an arrow in a straight line in the direction the agent is facing).
- ▶ The arrow continues until it either hits and kills the wumpus or hits the wall.
- ▶ The agent only has one arrow, so only the first *Shoot* action has any effect.
- ▶ The agent dies if it enters a room containing a pit or a live wumpus.
- ▶ It is safe (but smelly) to enter a room with a dead wumpus.

# Wumpus in Action (I)

- ▶ The agent's goal is to find the gold and bring it back to the start as quickly as possible, without getting killed.
- ▶ An agent can do better by memorizing the sequence of actions that it takes.
- ▶ Assume a 4 x 4 grid surrounded by walls.
- ▶ The agent always starts in the room labeled (1,1), facing toward the right.



# Wumpus in Action (II)

- ▶ An example scenario for the agent is as follows:
- ▶ From the fact that there was no stench or breeze in [1,1], the agent can infer that [1,2] and [2,1] are free of dangers.
- ▶ The agent marks with an *OK* to indicate this.
- ▶ From the fact that the agent is still alive, it can infer that [1,1 ] is also *OK*.
- ▶ Agent will only move into a room that it knows is *OK*.
- ▶ The agent decides to move forward to [2,1],
- ▶ The agent perceives a breeze in [2,1], so there must be a pit in a neighboring room, either [2,2] or [3,1].

# Knowledge-based Agent Levels (I)

- ▶ A knowledge-based agent can be described at three levels:
- ▶ **The knowledge level:** we can describe the agent by saying what it knows.
  - ▶ For example, an automated taxi might be said to know that a bridge links street A and street B.
  - ▶ If TELL and ASK work correctly, then most of the time we can work at the knowledge level and not worry about lower levels.
- ▶ **The logical level:** the knowledge is encoded into sentences.
  - ▶ For example, the taxi might be described as having the logical sentence *Links(street A, street B)* in its knowledge base.

# Knowledge-based Agent Levels (II)

- ▶ **The implementation level:** It is the level at which there are physical representations of the sentences at the logical level.
- ▶ For example, a sentence such as *Links(Street A, Street B)* could be represented in the KB by a "1" entry in a three-dimensional table indexed by road links and location pairs.
- ▶ The choice of implementation is very important to the efficient performance of the agent, but it is irrelevant to the logical level and the knowledge level.

# Designing Knowledge Bases (I)

- ▶ *It is possible to understand the operation of a KB agent in terms of what it knows.*
- ▶ *It is possible to construct a KB agent by TELLing it what it needs to know. The agent's initial program, before it starts to receive percepts, is built by adding the sentences one by one.*
- ▶ These sentences are the designer's knowledge of the environment.
- ▶ This is called the **declarative approach** to system building.

# Designing Knowledge Bases (II)

- ▶ Also, we can design learning mechanisms that output general knowledge about the environment given a series of percepts.
- ▶ By connecting a learning mechanism to a knowledge-based agent, we can make the agent fully **autonomous**.

# Knowledge Representation

- ▶ The goal of **knowledge representation** is to express knowledge in computer-usable form.
- ▶ This format is used to help agents perform well.
- ▶ A knowledge representation language is defined by two aspects:
  - ▶ Syntax
  - ▶ Semantics

# Knowledge Representation Syntax

- ▶ The **syntax** of a language describes the possible configurations that make sentences.
- ▶ A syntax is a set of rules that define the patterns of the sentences in a language.

# Knowledge Representation

## Semantics

- ▶ The **semantics** determines the facts in the world to which the sentences refer.
- ▶ Without semantics, a sentence is just an arrangement of marks on a page.
- ▶ With semantics, each sentence makes a claim about the world.
- ▶ Semantics is the meaning or the concept that we want to store in a KB.



# Inference (I)

- ▶ The terms "**reasoning**" and "**inference**" are generally used to cover any process by which conclusions are reached.
- ▶ **Logical inference or deduction** is a process that implements the entailment relation between sentences.
- ▶  $P \models Q$  means P entails Q

# Inference (II)

- ▶ If a sentence A entails B it means:
  - ▶ If A is true then B is true
  - ▶ E.g.
  - ▶ A: The temperature is 100 degrees
  - ▶ B: Water is boiling

# Inference (III)

- ▶ Given a knowledge base  $KB$  a new sentence  $a$ , can be generated,
- OR*
- ▶ Given a knowledge base  $KB$  and another sentence  $a$ , the inference system can report whether or not  $a$  is entailed by  $KB$ .
- ▶ An inference procedure that generates only entailed sentences is called **sound** or **truth-preserving**.

# Knowledge Representation Methods

- ▶ Propositional Logic
- ▶ Predicate Logic

# Summary

- ▶ Knowledge-based agents use what they know about the environment, restrictions, and their possible actions make correct decisions.
- ▶ What an agent knows is stored in its knowledge base
- ▶ Knowledge can be added by an expert, or learned by the agent.
- ▶ The agent uses its knowledge to make decisions using reasoning

Questions?