Knowledge-Based Agents

- Two main components:
  - Knowledge representation
  - Reasoning (or inference)
- Knowledge representation:
  - The collection of known facts about the world is called a *knowledge base* (KB).
  - Each item in the KB is called a *sentence*, expressed in some representation *language* as a computer-tractable form.
  - The KB should be updated over time.
- Reasoning:
  - Reasoning about knowledge in the KB to decide the best action to achieve some given goal.
  - One possibility is *logical reasoning* based on a (deductive) proof-theoretic approach.
- Levels of abstraction for describing KB agents:
  - Highest level: Knowledge level
  - Medium level: Logical level
  - Lowest level: Implementation level

A Generic Knowledge-Based Agent

```
function KB-AGENT(percept) returns an action
  static: KB, a knowledge base
          t, a counter, initially 0, indicating time

  TELL(KB, MAKE-PERCEPT-SENTENCE(percept, t))
  action ← ASK(KB, MAKE-ACTION-QUERY(t))
  TELL(KB, MAKE-ACTION-SENTENCE(action, t))
  t ← t + 1
  return action
```

Types of Knowledge

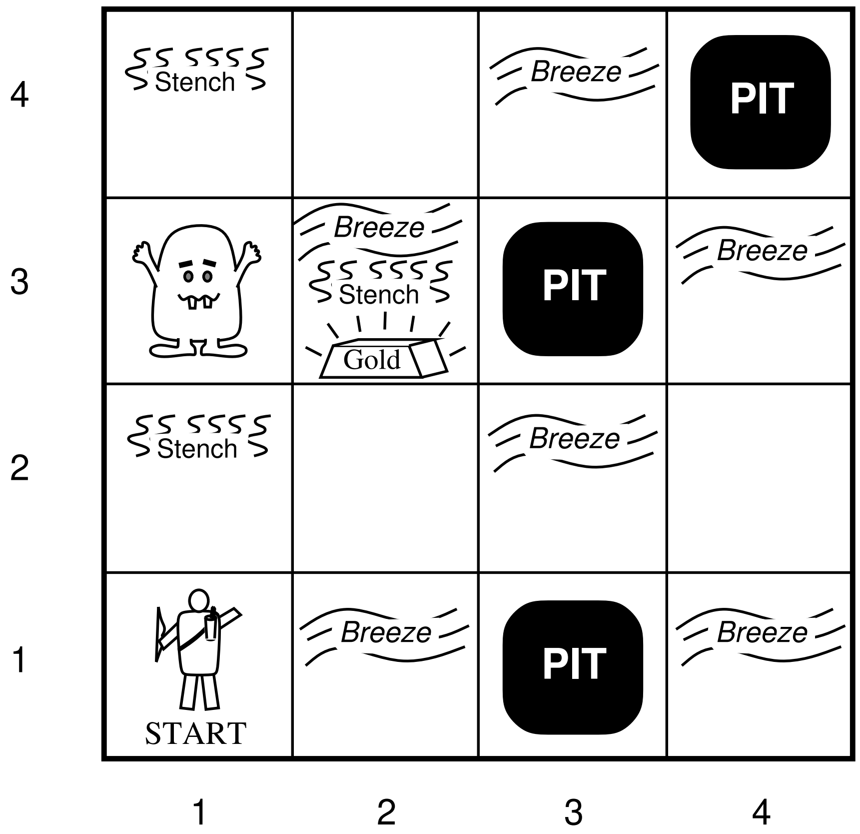
- Objects - facts about objects in the world around us.
- Events - actions and events in the worlds.
- Performance - knowledge about how to do things.
- Meta-knowledge - knowledge about what we know.

An example of Logical Reasoning

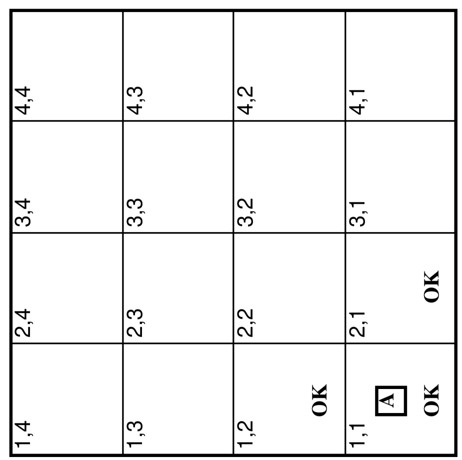
- You are visiting a strange country in which there are just two kinds of people - truthtellers and liars. Truthtellers *always* tell the truth and liars *always* lie. You hail the first two people you meet and say "Are you truthtellers or liars?" The first person mumbles something you can't hear. The second says, "He says he is a truthteller. He is a truthteller and so am I."
- Can you trust the directions that these two may give you?

- If the first person was a liar, he would have lied about himself and said that he was a truthteller.
- If he was a truthteller, he would have answered the question correctly.
- Whatever the actual nature of the first person, he will always describe himself as a truthteller.
- Thus, the first part of the response of the second person is true, and so the second person is a truthteller.
- The first person is also a truthteller because the second person says he is.

The Wumpus World Environment

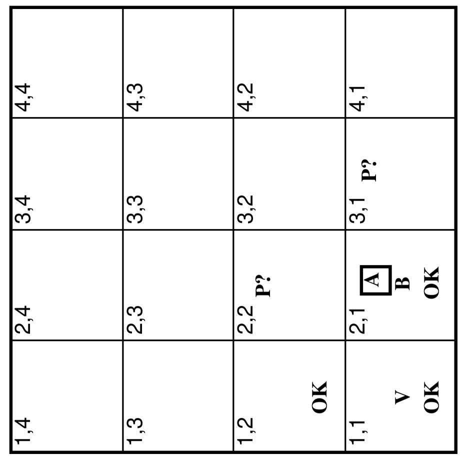


Acting and Reasoning in the Wumpus World



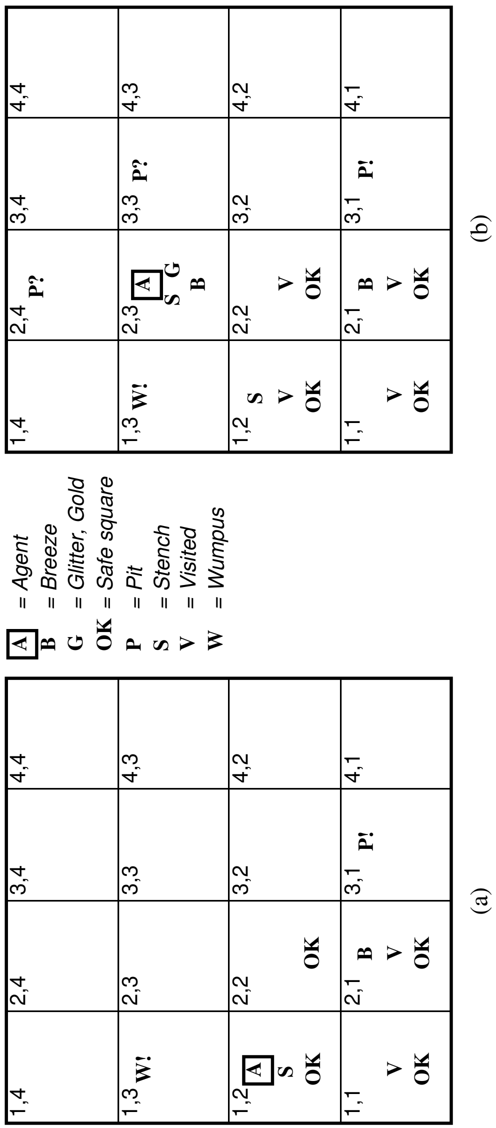
(a)

A = *Agent*
B = *Breeze*
G = *Glitter, Gold*
OK = *Safe square*
P = *Pit*
S = *Stench*
V = *Visited*
W = *Wumpus*



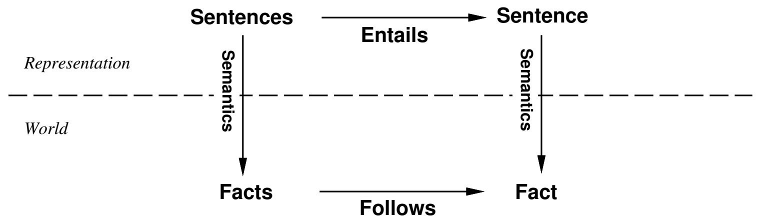
(b)

Acting and Reasoning in the Wumpus World (cont'd)



Knowledge Representation Languages

- Two aspects of knowledge representation languages:
  - Syntax
  - Semantics (i.e. meaning)
- Relationships between representations (sentences) and facts:



- Good knowledge representation languages should be:
  - *expressive* and *concise* like natural languages
  - *unambiguous* and *precise* like formal languages.

Logical Inference

- Inference is the process of deriving new sentences from old ones.
- Logical inference is governed by the *proof theory*, which is a set of inference rules for deducing the entailments of a set of sentences.
- Two common kinds of logic:
  - Propositional logic (also called Boolean logic)
  - First-order predicate logic (or simply first-order logic)