



**NANYANG
TECHNOLOGICAL
UNIVERSITY**
SINGAPORE

CZ3005 Artificial Intelligence

Week 8a – Logical Agent

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Course Overview (2nd Half)

Week	Date	Online (Zoom) https://ntu-sg.zoom.us/j/82750496869 Meeting ID: 827 5049 6869 Passcode: 864874	Topic	Tutorial	Lab
8	06/03/2023	1	Logical Agent (a)	Tutorial 3	
8	08/03/2023	2	Logical Agent (b)		
9	13/03/2023	3	Propositional Logic (a)		
9	15/03/2023	4	Propositional Logic (b)		
10	20/03/2023	5	First-Order Logic (a)		One Lab session in Week 10/11 (Lab Attendance is <u>NOT</u> <u>Compulsory</u>)
10	22/03/2023	6	First-Order Logic (b)		
11	27/03/2023	7	Default Logic (a)	Tutorial 4	
11	29/03/2023	8	Default Logic (b)		
12	03/04/2023	9	Fuzzy Logic (a)		
12	05/04/2023	10	Fuzzy Logic (b)		
13				Tutorial 5	
13					

Why Logic?

- The earliest way people imagined how to build AI system
- Still a relevant tool to guide today's AI with human knowledge
- Good interpretability (which deep learning-based AI lacks)

An Example Logical Agent

https://www.youtube.com/watch?v=Mxl_tzOs6ME



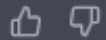
Why Logic?

HA

are you built on computer logic?



Yes, as an AI language model, I am built on computer logic. AI models like me use mathematical algorithms and logic to analyze large amounts of data and learn patterns and relationships in that data. The underlying technology behind my operation is based on computer logic, which enables me to understand and generate human-like responses to questions and queries.



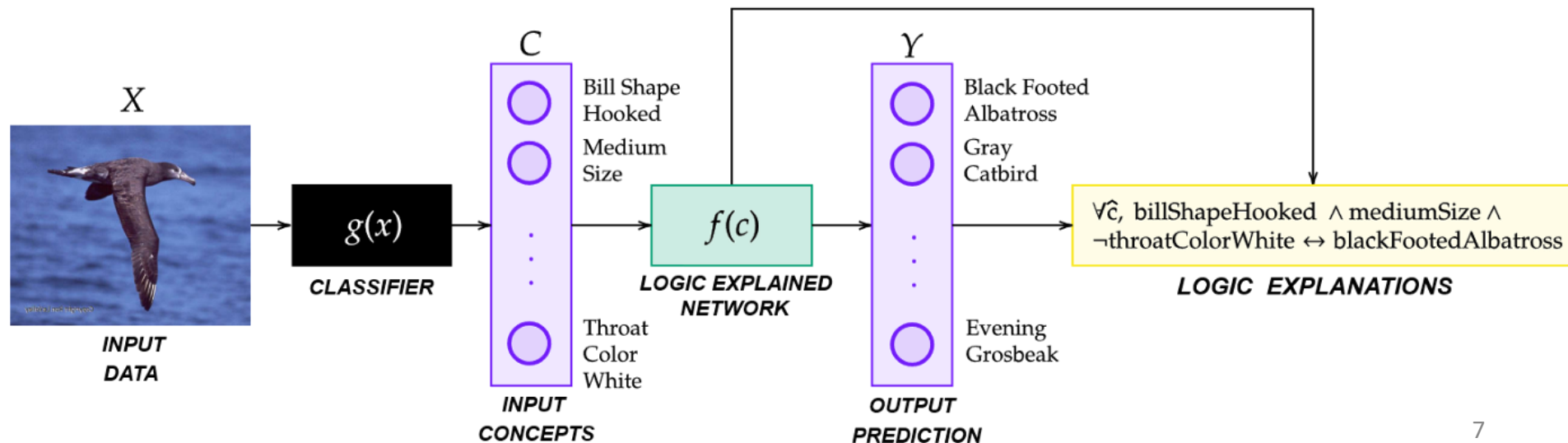
My architecture and design are based on sophisticated algorithms, including deep learning and natural language processing (NLP), which are built on top of the principles of logic and mathematics. These algorithms allow me to analyze and understand natural language, and generate responses that are contextually appropriate and relevant to the query posed to me.

In short, the technology that powers AI language models like me is based on computer logic and mathematical algorithms that enable us to understand and generate human-like responses.

🔄 Regenerate response

Why Logic?

- New life for an old technology:
 - Deep Learning and Logic Programming are starting to merge today for building Explainable AI (XAI) systems.
 - Logic Explained Networks:



From Search to Logical Reasoning

- Representation of Knowledge and the Reasoning Processes are central to the entire field of AI
- A knowledge-based system (KBS) is a computer program that reasons and uses a knowledge base to solve complex problems.

Knowledge and Intelligence



The Knowledge-Based Approach

- Agents that ***know***
 - Achieve competence by being told new knowledge or by learning
 - Achieve adaptability by updating their knowledge
 - > *Knowledge representation*
 - State of the world, properties and evolution of the world; goals of the agent, actions and their effect
- Agents that ***reason***
 - Use knowledge to deduce course of actions
 - > *Knowledge inference*

Logic



Knowledge-Based Agents

- **Knowledge base (KB)**
 - Set of sentences i.e., representations of facts (DB)
 - Knowledge representation language
- Adding and querying knowledge
 - **Tell**: add a sentence to the KB
 - **Ask**: retrieve knowledge from the KB
 - Answers must *follow* from what has been **Tell**'ed (told)
- Inference mechanism
 - Determine what follows from the KB

Problem Formulation of KBS

- Knowledge Based System
 - States: Instances of the KB (sets of sentences)
 - Use **Tell** to build the KB
 - e.g. Tell(KB, "Smoke \Rightarrow Fire")
 - Tell(KB, "Fire \Rightarrow Call_999")
 - ...
 - Tell(KB, "Smoke")
 - Operators: Add / Infer a new sentence
 - Goal: Answer a query
 - Use **Ask** to query the KB
 - e.g. Ask(KB, "? Call_999")

A Generic Knowledge-Based Agent

```
function KB-Agent (percept) returns action
    static KB,           // a knowledge base
            t             // a time counter, initially 0

    Tell (KB, Make-Percept-Sentence (percept, t))
    action  $\leftarrow$  Ask (KB, Make-Action-Query (percept, t))
    Tell (KB, Make-Action-Sentence (action, t))
    t  $\leftarrow$  t + 1
    return action
```

- > 3 steps: interpretation, inference, execution
- > KB: background knowledge (observed)
+ acquired information (deduced)

Levels of Knowledge

- **Epistemological level**

- Declarative description of knowledge

- e.g. facts: “there is smoke in the kitchen”, “it is not warm enough”
 - rules: “if there is smoke then there must be a fire”

- **Logical level**

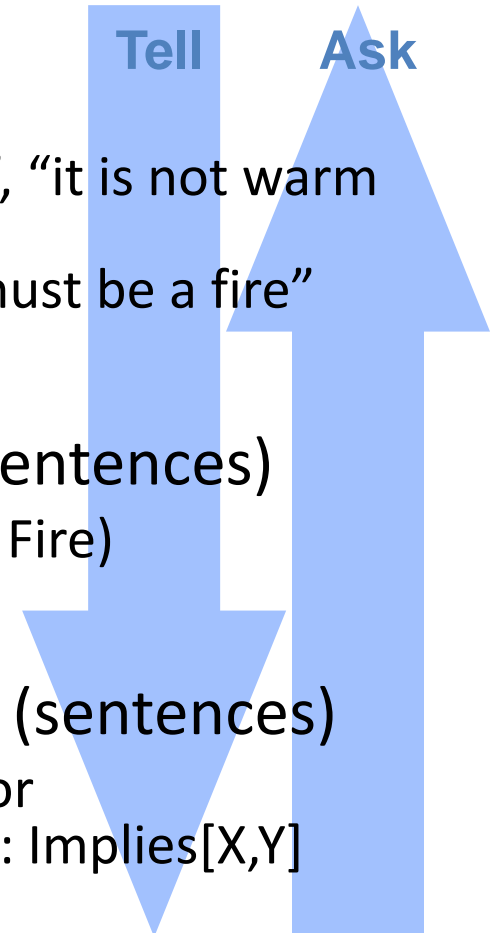
- Logical encoding of knowledge (into sentences)

- e.g. facts: Smoke; rules: Implies(Smoke, Fire)

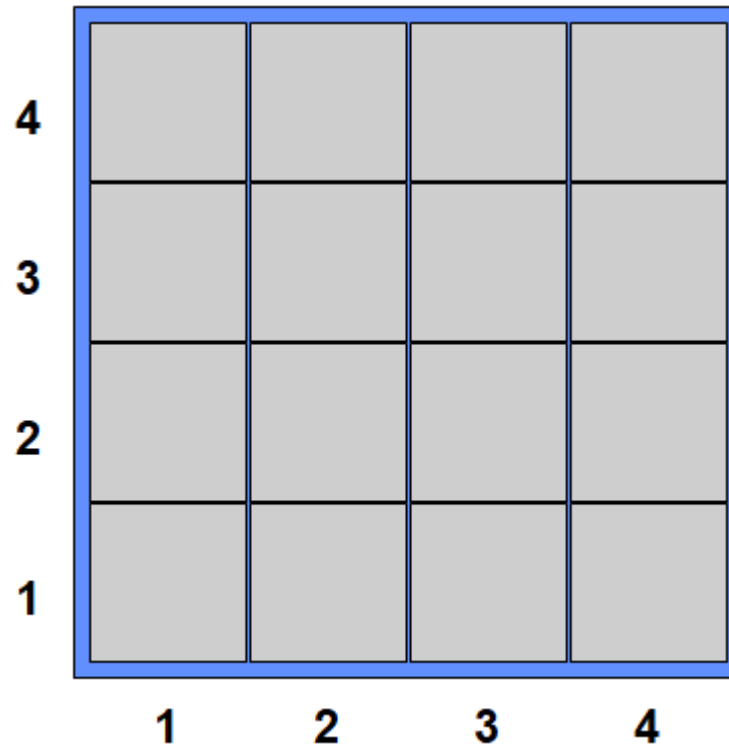
- **Implementation level**

- Physical representation of knowledge (sentences)

- e.g. - the string “Implies(Smoke, Fire)”, or
 - a “1” entry in a 2-dimensional array: Implies[X,Y]

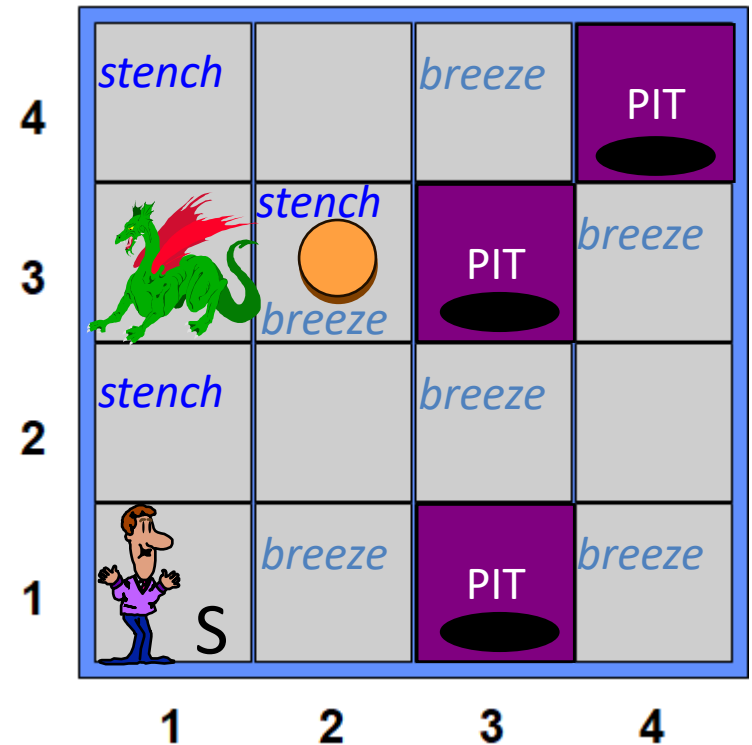


Example: the Wumpus World



Example: the Wumpus World

- Problem description (PAGE)
 - Environment
 - Grid of squares, walls;
 - Agent, gold, pits, wumpus.
 - Goal
 - Find the gold, return to S at [1,1].
 - Percepts
 - A list of 5 symbols, e.g. [Stench, Breeze, Glitter, Bump, Scream];
 - Agent's location *not* perceived.
 - Actions
 - Go-Forward, Turn-Left, Turn-Right, Grab, Shoot (1 arrow only), Climb.



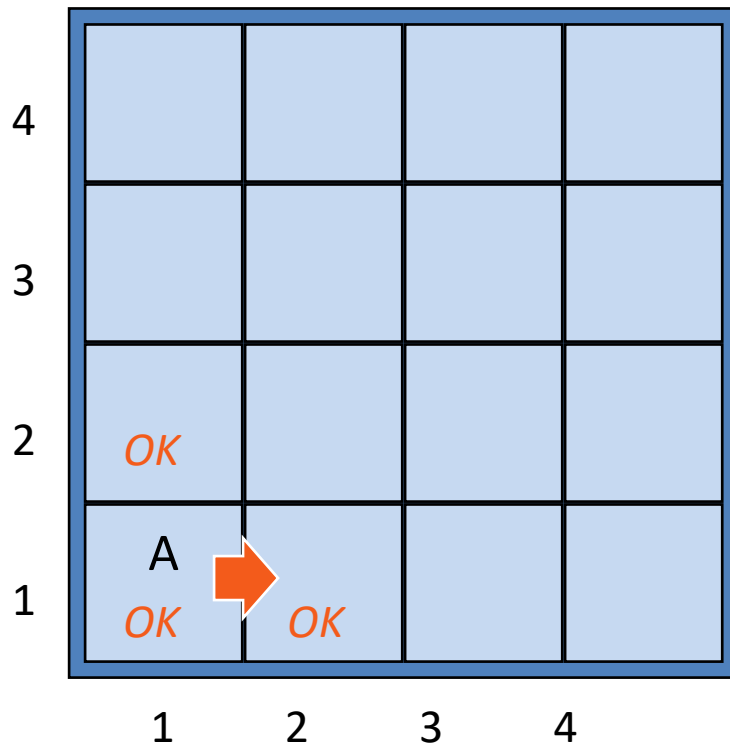
The Wumpus World

- Problem description (cont'd)
 - Initial state
 - Agent at [1,1]; gold, pits and wumpus in random squares.
 - Path-cost
 - Climbing out with the gold: +1000 (without: 0)
 - Each action: -1
 - Getting killed (pit or wumpus): -10000
 - Knowledge
 - “In all squares adjacent to the one where the wumpus is, the agent will perceive a stench.”
 - “In all squares adjacent to a pit, the agent will perceive a breeze.”
 - In the square where the gold is, the agent will perceive a glitter.”
 - When walking into a wall, the agent will perceive a bump.”
 - When the wumpus is killed, the agent will perceive a scream.”

Acting and Reasoning in the Wumpus World

(0) Initial state

[nil, nil, nil, nil, nil]



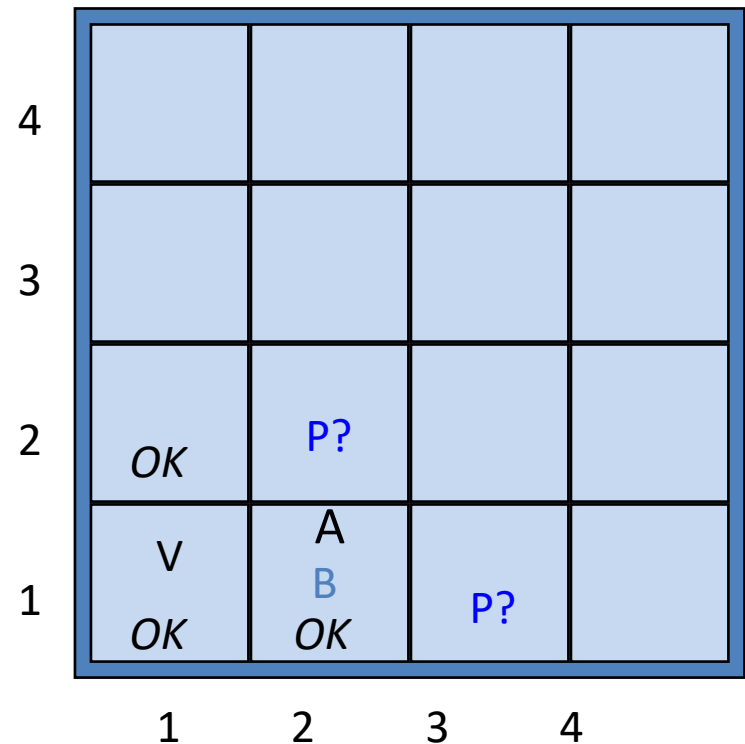
A = Agent G = Glitter, Gold

B = Breeze

OK = Safe square

(1) after {F}

[nil, Breeze, nil, nil, nil]



P = Pit

S = Stench

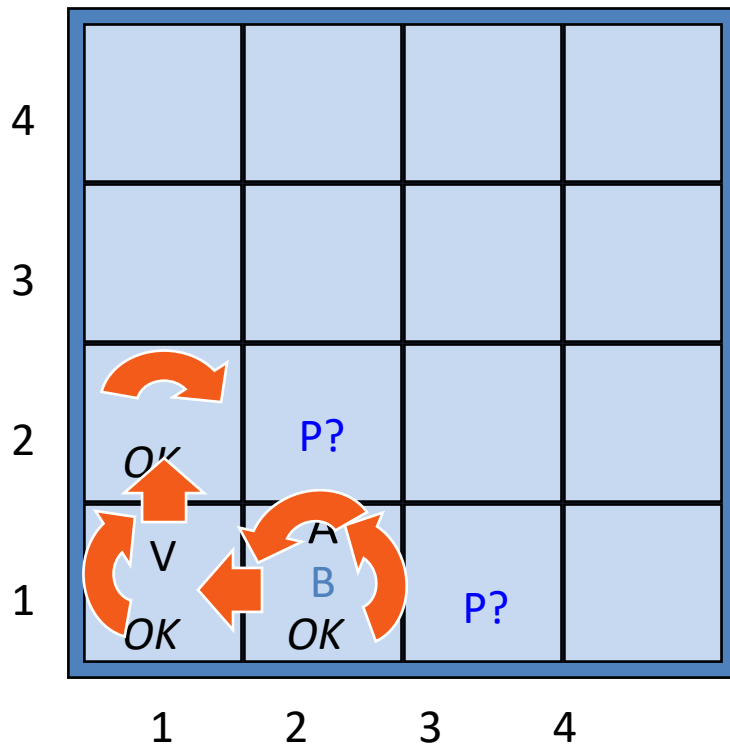
V = Visited

W = Wumpus

Acting and Reasoning in the Wumpus World

(1) after {F}

[nil, Breeze, nil, nil, nil]



A = Agent G = Glitter, Gold

B = Breeze

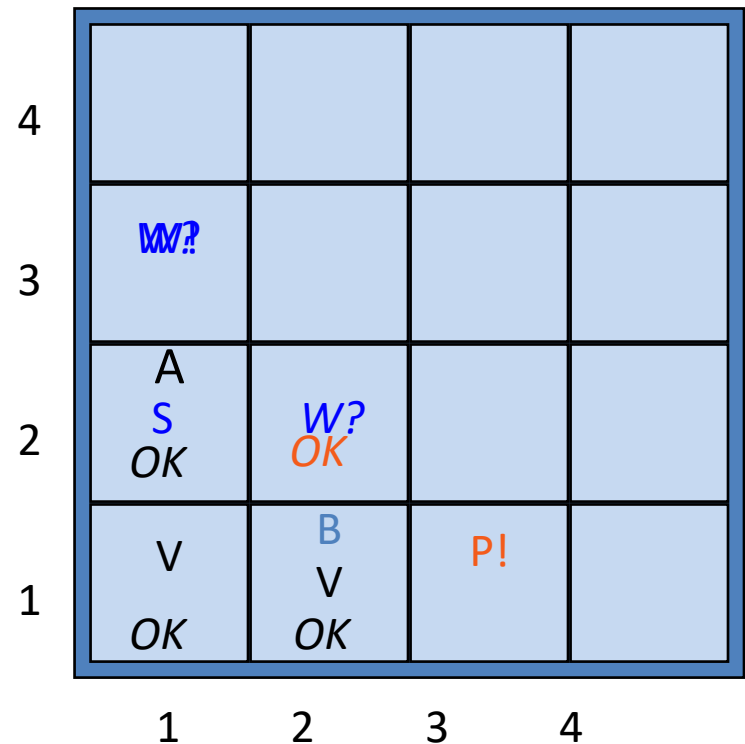
OK = Safe square

P = Pit

S = Stench

(6) after {F, L, L, F, R, F}

[Stench, nil, nil, nil, nil]



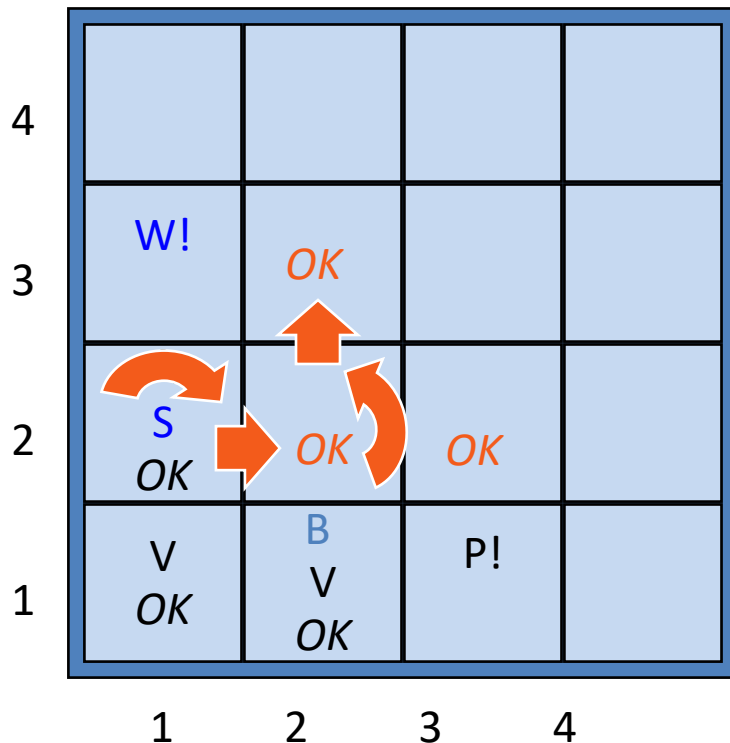
V = Visited

W = Wumpus

Acting and Reasoning in the Wumpus World

(6) after {F, L, L, F, R, F}

[Stench, nil, nil, nil, nil]



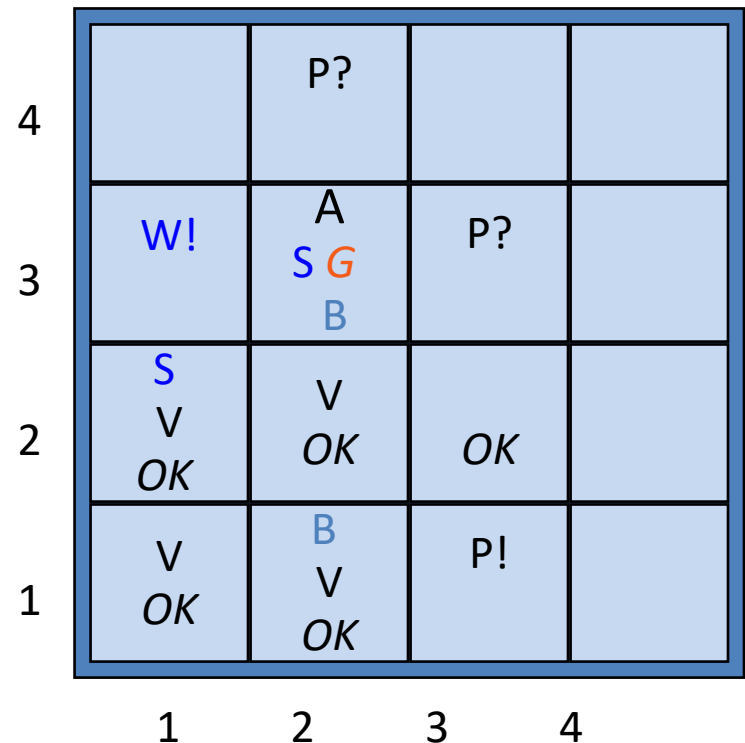
A = Agent G = Glitter, Gold

B = Breeze

OK = Safe square

(10) after {F, L, L, F, R, F, R, F, L, F}

[Stench, Breeze, Glitter, nil, nil]



P = Pit

S = Stench

V = Visited

W = Wumpus

Summary

- **Intelligent agents need ...**
 - Knowledge about the world to make good decisions.
- **Knowledge can be ...**
 - Defined using a knowledge representation language.
 - Stored in a knowledge base in the form of sentences.
 - Inferred, using an inference mechanism and rules.

Thank you!

