331 – Intro to Intelligent Systems
Week07
Logic
Wumpus World
R&N Chapter 7.2

T.J. Borrelli

Wumpus World

- Wumpus world is a cave consisting of rooms connected by passageways

- Somewhere in the cave is a terrible beast (wumpus) that eats anyone who enters its room

- The wumpus can be shot by an agent but the agent only has 1 arrow

- Some rooms contain bottomless pits that will trap anyone who enters the room (except the wumpus)

- There is gold hidden somewhere in the environment

Wumpus World

Wumpus World

- Performance measure: Gold +1000; Death -1000; -1 per step; -10 for arrow

- Environment:
  Squares adj. to wumpus smelly
  Squares adj. to pit are breezy
  Glitter if gold on same square
  Shooting kills wumpus if facing it
  Shooting uses up only arrow
  Grabbing picks up gold if in same square
  Releasing drops gold in same square
  Dead if eaten by wumpus or fallen into pit

- Actions: Turn left, right; Forward; Grab; Release; Shoot

- Sensors: Stench; Breeze; Glitter; Bump(hit a wall); Scream (kill wumpus)

4

Wumpus World Properties

- Observable?
  - No (partially observable)
- Deterministic?
  - Yes
- Episodic?
  - No (sequential)
- Static?
  - Yes (wumpus doesn't move)
- Discrete?
  - Yes
- Single agent?
  - Yes (wumpus is a feature of environment)

Wumpus World – where do we start?

- Main challenge here is our initial ignorance of the configuration of the cave

- We have to make inferences based on what we know and the rules of the environment

- We know that the first square [1,1] is safe

- First, percept is [none, none, none, none, none]

[stench, breeze, glitter, bump, scream]

- From this we can conclude that squares [1,2] and [2,1] are free of danger

- We can cautiously proceed to one of these squares.

1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 **OK**	2,2	3,2	4,2
1,1 **A** **OK**	2,1 **OK**	3,1	4,1
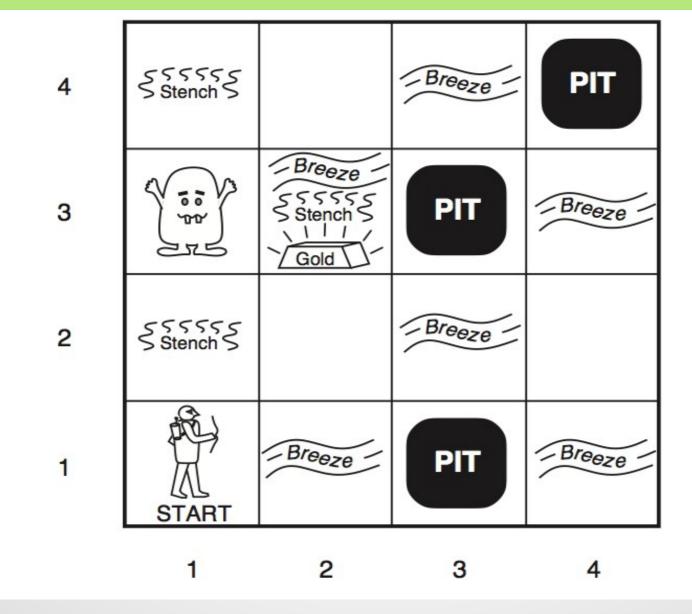
A = Agent
B = Breeze
G = Glitter, Gold
OK = Safe square
P = Pit
S = Stench
V = Visited
W = Wumpus

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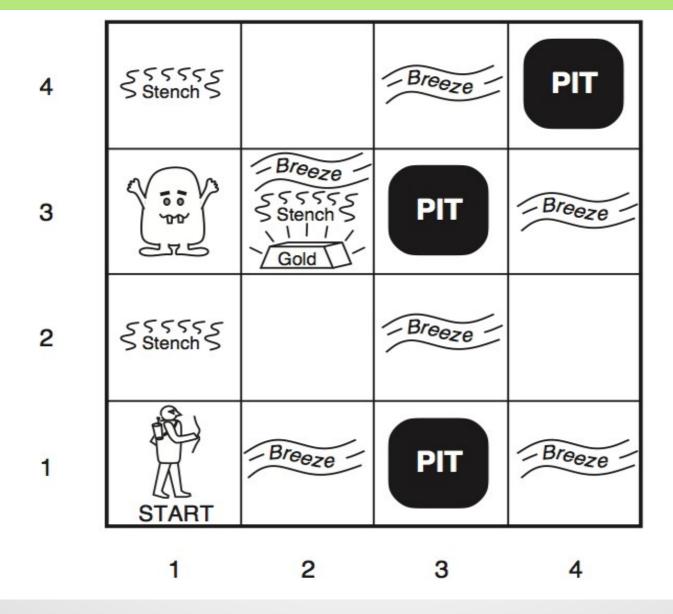
	= Agent
A	= Agent
B	= Breeze
G	= Glitter, Gold
OK	= Safe square
P	= Pit
S	= Stench
V	= Visited
W	= Wumpus

1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 **OK**	2,2 **P?**	3,2	4,2
1,1 **V** **OK**	2,1 **A** **B** **OK**	3,1 **P?**	4,1

[None, Breeze, None, None, None]

Wumpus World

[Stench, None, None, None, None]

Wumpus World

	= Agent
A	= Agent
B	= Breeze
G	= Glitter, Gold
OK	= Safe square
P	= Pit
S	= Stench
V	= Visited
W	= Wumpus
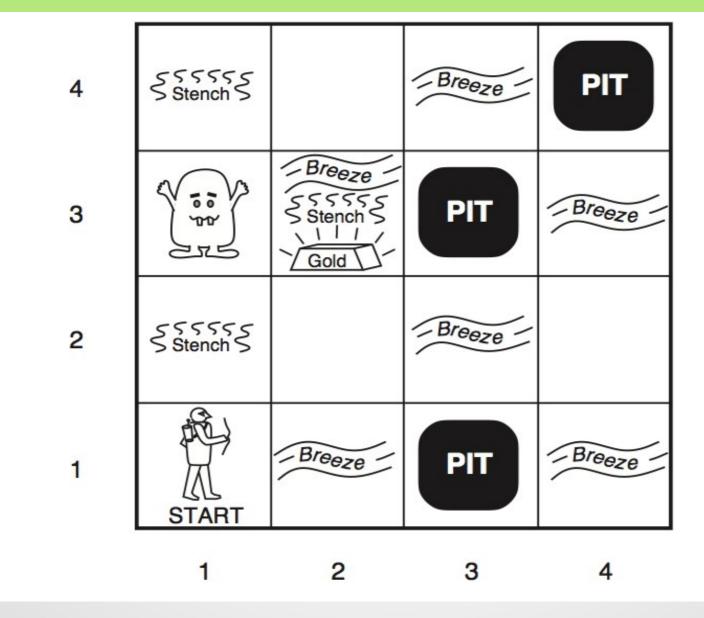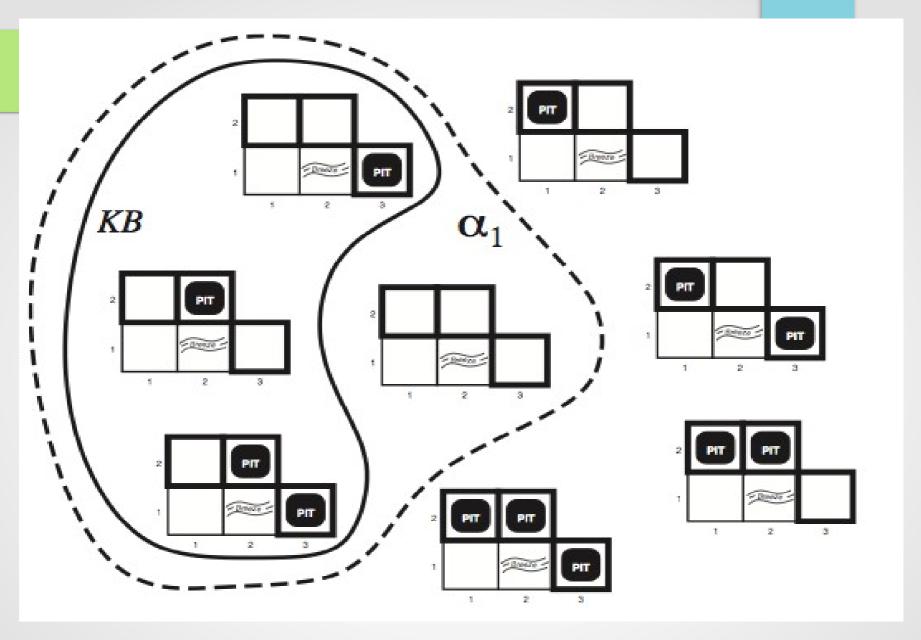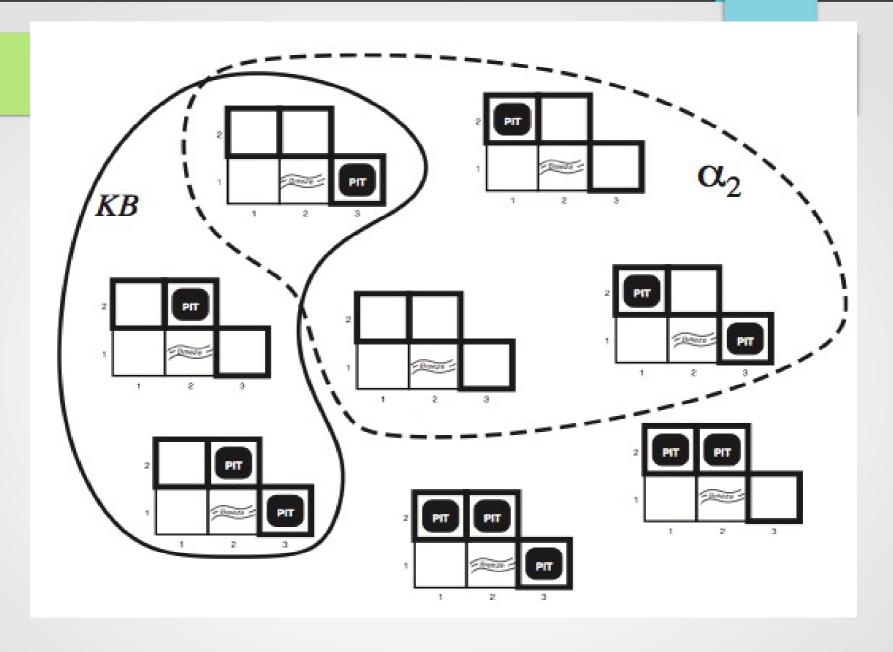
1,4	2,4 P?	3,4	4,4
1,3 W!	2,3 [A] S G B	3,3 P?	4,3
1,2 S V OK	2,2 V OK	3,2	4,2
1,1 V OK	2,1 B V OK	3,1 P!	4,1

[Stench, Breeze, Glitter, None, None]

(after visiting [1,1] and [2,1] only)
Dotted line shows α$_1$ no pit in [1,2]

Dotted line shows α_2 no pit in [2,2]

KB and entailment

- α_1 = "There is no pit in [1,2]"

- α_2 = "there is no pit in [2,2]"

- In every model in which KB is true α_1 is also true

Thus, KB |= α_1: There is no pit in [1,2]

Logic

- $P_{x,y}$ is true if there is a pit in [x,y]

- $W_{x,y}$ is true if there is a wumpus in [x,y] dead or alive

- $B_{x,y}$ is true if the agent perceives a breeze in [x,y]

- $S_{x,y}$ is true if the agent perceives a stench in [x,y]

Wumpus world Rules

- Rules: No pit in starting position:

- $R_1 : \neg P_{1,1}$

- A square is breezy iff there is a pit in a neighboring square:

- $R_2 : B_{1,1} \Leftrightarrow (P_{1,2} \lor P_{2,1})$

- $R_3 : B_{2,1} \Leftrightarrow (P_{1,1} \lor P_{2,2} \lor P_{3,1})$

- From the first two observations:

- $R_4 : \neg B_{1,1}$

- $R_5 : B_{2,1}$

From these we can infer other rules . . .

- By rule R_2 and bidirectional elimination

- R_6 : $B_{1,1} \rightarrow (P_{1,2} \lor P_{2,1})$ ^ $(P_{1,2} \lor P_{2,1}) \rightarrow B_{1,1}$

- …

Conjunctive Normal Form

- Every sentence in propositional logic is logically equivalent to a conjunction of clauses

- A sentence is in conjunctive normal form (CNF) if it is expressed as a conjunction of clauses

- Steps to convert to CNF

   1) Eliminate <=>

   2) Eliminate → replace with negation ¬α V β

   3) Move negations inward so only literals contain them

   4) Apply distributive law (distribute V over ^)