

Midterm Exam Solutions.

Artificial Intelligence (Spring 2007)

Question 1

Define in your own words the following terms:

a) State

A **state** is a representation that an agent can find itself in. There are two types of states: world states (the actual concrete situations in the real world) and representational states (the abstract descriptions of the real world that are used by the agent in deliberating about what to do).

b) State space

A **state space** is a graph whose nodes are the set of all states, and whose links are actions that take the agent from one state into another.

c) Search tree

A **search tree** is a tree (a connected graph with no undirected loops) in which the root node is the start state and the set of children for each node consists of the states reachable by taking any action.

d) Search node

A **search node** is a node in the search tree.

e) Goal

A **goal** is a state that the agent is trying to reach.

f) Action

An **action** is something that the agent can choose to do.

g) Successor function

A **successor function** describes the agent's options: given a state, it returns a set of (action, state) pairs, where each state is the state reachable by taking the action.

h) Branching factor

The **branching factor** in a search tree is the number of actions available to the agent.

Question 2

Write whether each statement is true (T) or false (F), and provide a short explanation:

- a) Uniform-cost search is a special case of Breadth-first search.

F

It is the other way around, Breadth-first search is a special case of Uniform-cost search when all step costs are equal.

- b) Breadth-first search, depth-first search and uniform-cost search are special cases of best-first search.

T

Breadth-first search is best-first search with $f(n) = \text{depth}(n)$; depth-first search is best-first search with $f(n) = -\text{depth}(n)$; uniform-cost search is best-first search with $f(n) = g(n)$.

- c) A^* is a special case of uniform-cost search.

F

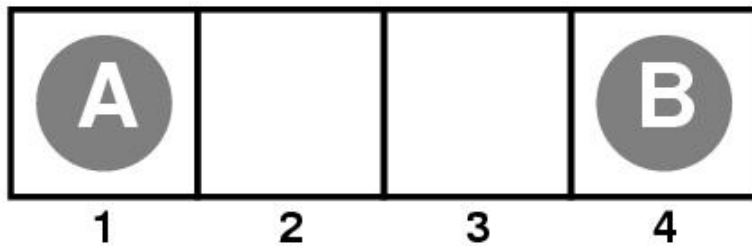
The other way, Uniform-cost search is A^* search with $h(n) = 0$.

Question 3

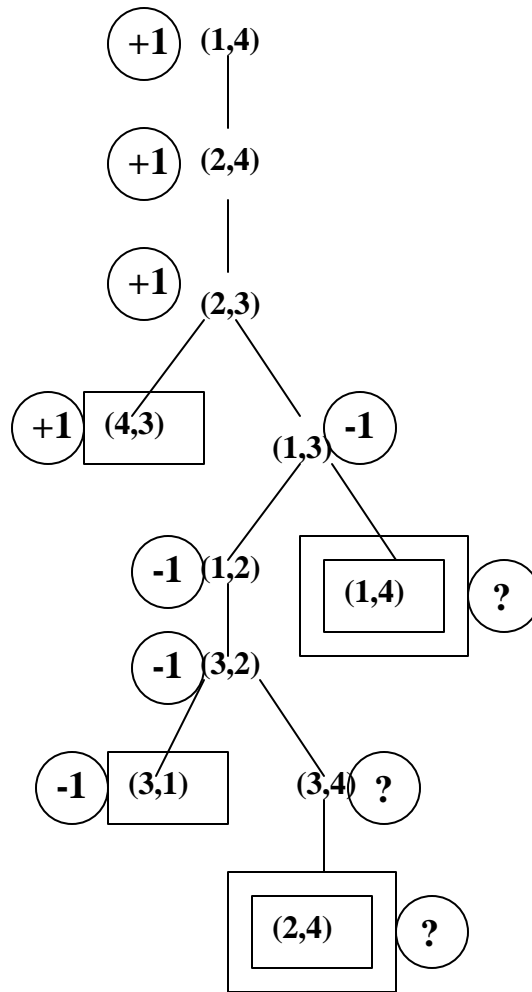
Consider the two-player game described below (Figure 1).

- a) Draw the complete game tree, using the following conventions:
- Write each state as (s_A, s_B) where s_A and s_B denote the token locations.
 - Put each terminal state in a square boxes and write its game value in a circle next to it.
 - Put *loop states* (states that already appear on the path to the root) in double square boxes. Since it is not clear how to assign values to loop states, annotate each with a “?” in a circle.
- b) Now mark each node with its backed-up minimax value (also in a circle). Explain how you handle the “?” values and why.

Figure 1:



This is the starting position of a simple game. Player *A* moves first. The two players take turns moving, and each player must move his token to an open adjacent space *in either direction*. If the opponent occupies an adjacent space, then a player may jump over the opponent to the next open space if any (for example, if *A* is on 3 and *B* is on 2, then *A* may move back to 1). The game ends when one player reaches the opposite end of the board. If player *A* reaches space 4 first, then the value of the game to *A* is +1; if player *B* reaches space 1 first, then the value of the game to *A* is -1.



The game tree for the four-square game. Terminal states are in single boxes, loop states in double boxes. Each state is annotated with its minimax value in a circle.

The “?” values are handled by assuming that an agent with a choice between winning the game and entering a “?” state will always choose the win. That is, $\min(-1, ?)$ is -1 and $\max(+1, ?)$ is $+1$. If all successors are “?”, the backed-up value is “?”.

Question 4

In the wumpus world shown in Figure 2b, suppose the agent has progressed to the point shown in Figure 2a, having perceived nothing in [1,1], a breeze in [2,1] and a stench in [1,2], and is now concerned with the contents of [1,3], [2,2] and [3,1]. Each of these can contain a pit and at most one can contain a wumpus. Analogous to the example from class, which is based on only two squares observations (see Figure 3), construct the set of possible worlds from these three square observations (you should find 32 of them). You should use the page provided with the exam to answer this question, where 32 replicas of the states up to Figure 2a, are provided. Mark the worlds in which KB is true and those in which each of the following sentences is true:

- a_2 = "There is no pit in [2,2]"
- a_3 = "There is a wumpus in [1,3]"

Hence show that $KB \models a_2$ and $KB \models a_3$.

Figure 2:

1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 A S OK	2,2	3,2	4,2
1,1 V OK	2,1 B V OK	3,1	4,1

(a)

Progress of the agent after the third move

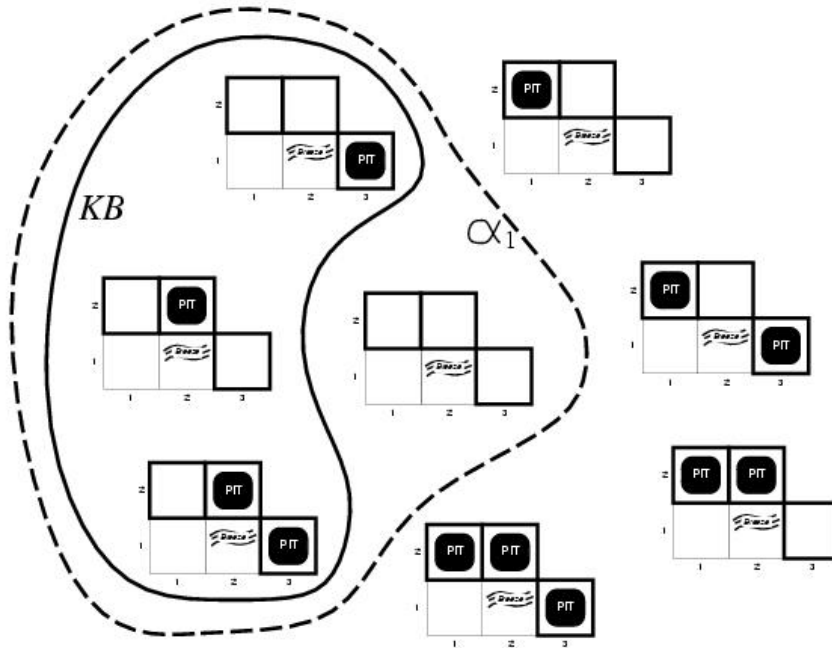
A = Agent
B = Breeze
G = Glitter, Gold
OK = Safe square
P = Pit
S = Stench
V = Visited
W = Wumpus

4	Stench		Breeze	PIT
3	Wumpus	Breeze Stench Gold	PIT	Breeze
2	Stench		Breeze	
1	START	Breeze	PIT	Breeze
	1	2	3	4

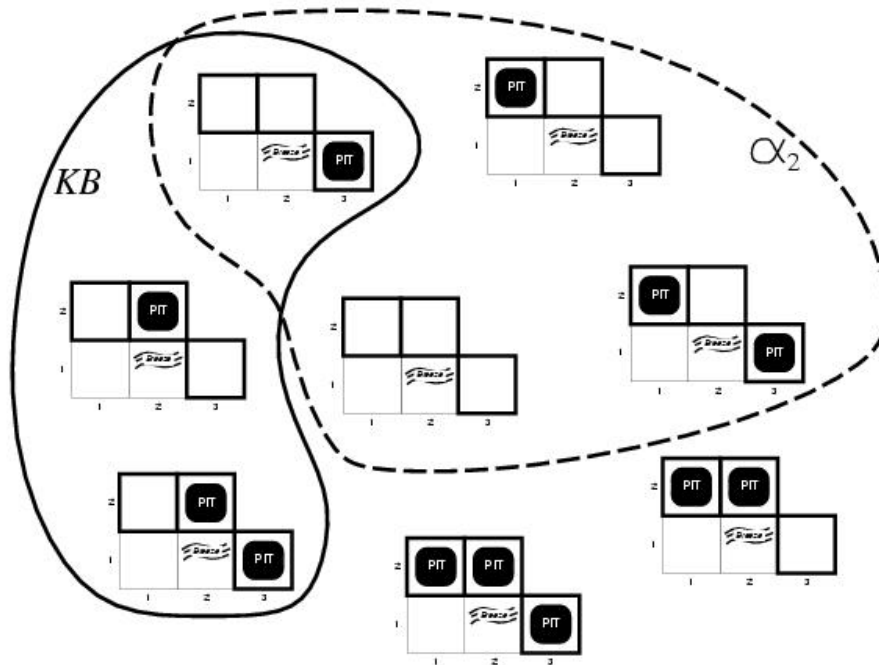
(b)

A wumpus world

Figure 3: Example from the book/class, when the agent have visited only two squares, having perceived nothing in [1,1], a breeze in [2,1]. Possible models for the presence of pits in squares [1,2], [2,2] and [3,1].



a) Models of the knowledge base and α_1 (no pit in [1,2])



b) Models of the knowledge base and α_2 (no pit in [2,2]).

h

Question 4: Solution

