FACOLTÀ DI INGEGNERIA DELL'INFORMAZIONE

Artificial Intelligence 2010–11

Test 1 – 1st July 2011

You have 75 minutes to complete the test: be accurate, but concise!
You can answer in English or Italian
You can use no texts, notes, computers, calculators, mobile phones, etc.
Please write your name and student ID on all sheets
Please answer Questions 4 and 5 (Logic) on a separate sheet to speed up marking

1. State Space Search (5 points)

Explain the difference between *tree search* and *graph search*, and clarify the advantages of the latter over the former. Then explain how the difference between tree search and graph search is implemented in the basic search algorithm. (You are not required to report the whole search algorithm, only to explain the main difference between the tree-search and the graph-search version.)

2. CSP (5 points)

Explain why the Depth First search strategy on a CSP is both complete and optimal. Then clarify why CSP search trees tend to have high branching factors (which makes the use of heuristics very important).

3. Planning (10 points)

Consider the planning problem stated below:

In a room there is a box containing a coin. The agent's goal is to get the coin.

The agent can: walk from one location in the room to another (you can represent different locations in the room as L1, L2, etc.); open a box; pick up an object from an open box.

Initially, the box is closed and the agent is far from the box.

Adopting the STRIPS approach, you are requested to:

- define a suitable set of predicates and constants, briefly describing their intuitive meanings;
- define a suitable set of action schemes;
- represent the initial state and the goal;
- write a plan that achieves the goal (you do not have to explain how STRIPS would build the plan).

4. Logic (theory) (6 points)

Provide a definition of the following concepts:

a) inference rule;
b) consistency;
c) completeness.

5. Logic (exercise) (6 points)

5.1 Transform the following sentences into logical formulae:

a) every person in this room is either British or French;
b) Tina comes from Hamburg;
c) Tina is not in this room.

5.2 Show that sentence c in 5.1 is a logical consequence of the other two (provided that some other formulae are added to the set).

Question 3.

Predicates:

Open(x)	x is open
Closed(x)	x is closed
At(x,y)	x is at location y
In(x,y)	x is in y
Has(x)	the agent has x

Constants:

Agent	the agent
Box	the box
Coin	the coin
L1, L2	locations

Initial state:

{At(Agent,L1), At(Box,L2), Closed(Box), In(Coin,Box)}

Goal:

{Has(Coin)}

Action schemes:

walk(x,y)

constraints	$x \neq y$
preconditions	At(Agent,x)
effects	¬At(Agent,x) ∧ At(Agent,y)

open(x,y)

preconditions	Closed(x) ∧ At(x,y) ∧ At(Agent,y)
effects	¬Closed(x) ∧ Open(x)

pickUp(x,y,z)

preconditions	In(x,y) ∧ Open(y) ∧ At(y,z) ∧ At(Agent,z)
effects	¬In(x,y) ∧ Has(Agent,x)

Plan and execution:

action	*state*
	{At(Agent,L1), At(Box,L2), Closed(Box), In(Coin,Box)}
walk(L1,L2)	{At(Agent,L2), At(Box,L2), Closed(Box), In(Coin,Box)}
open(Box,L2)	{At(Agent,L2), At(Box,L2), Open(Box), In(Coin,Box)}
pickUp(Coin,Box,L2)	{At(Agent,L2), At(Box,L2), Open(Box), Has(Coin)}

Question 5.
A possible solution is as follows:

5.1)

a) $\forall x$ (InRoom(x) $\Rightarrow$ British(x) $\vee$ French(x))
b) From(Tina, Hamburg)
c) $\neg$InRoom(Tina)

5.2)
We may add:

d) $\forall x$ (From(x, Hamburg) $\Rightarrow$ German(x))
e) $\forall x$ (German(x) $\Rightarrow$ $\neg$(British(x) $\vee$ French(x)))
and proceed:

1) From(Tina, Hamburg) $\Rightarrow$ German(Tina)	[d, $\forall$-elimination]
2) German(Tina)	[1, b, Modus Ponens]
3) German(Tina) $\Rightarrow$ $\neg$(British(Tina) $\vee$ French(Tina))	[e, $\forall$-elimination]
4) $\neg$(British(Tina) $\vee$ French(Tina))	[2, 3, Modus Ponens]
5) InRoom(Tina) $\Rightarrow$ British(Tina) $\vee$ French(Tina)	[a, $\forall$-elimination]
6) $\neg$(British(Tina) $\vee$ French(Tina)) $\Rightarrow$ $\neg$InRoom(Tina)	[5, contraposition]
7) $\neg$InRoom(Tina)	[4, 6, Modus Ponens]

Thus, we obtained c) with a proof from a), b), d), and e).
The proof is based on notoriously sound inference rules,
hence c) is a logical consequence of a), b), d), and e).