Midterm Exam

ARTIFICIAL INTELLIGENCE

CSC 380

SPRING 2008

Problems :

1. For an Internet book-shopping agent, develop a PEAS / PAGE description of the task environment. Then characterize the environment according to the properties discussed in class (observable/…, deterministic/…, episodic/…, static/…, continuous/…, and single / multi-agent. Select an agent architecture (design) suitable for this domain substantiate your choice by a brief rationale.

   (25 (=9+8+8) **points**)

   Solution:

Performance measure / Goals:	Obtain requested / interesting books while minimizing expenditure
Environment:	Internet

Actuators / Actions:	Follow links, enter / submit data in fields, display to user
Sensors / Percepts:	Web pages, user requests

The environment is partially observable, stochastic, sequential, dynamic, discrete, multi-agent.

A goal-based agent would be appropriate for specific book requests. For more open-ended tasks (e.g. 'find me something interesting to read'), tradeoffs are involved and the agent must compare utilities for various possible purchases.

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2. For an Autonomous Mars rover agent, develop a PEAS / PAGE description of the task environment. Then characterize the environment according to the properties discussed in class (observable/…, deterministic/…, episodic/…, static/…, continuous/…, and single / multi-agent. Select an agent architecture (design) suitable for this domain substantiate your choice by a brief rationale.

(25 (=9+8+8) points)

Solution:

Performance measure / Goals:	Terrain explored and reported, samples gathered and analyzed
Environment:	Launch vehicle, lander, Mars
Actuators / Actions:	Wheels, legs, sample collection devices, analysis devices, radio transmitter
Sensors / Percepts:	Camera, touch sensors, accelerometers, orientation sensors, wheel/joint encoders, radio receiver.

The environment is partially observable, stochastic, sequential, dynamic, continuous, single-agent.

A model-based reflex agent would suffice for low level navigation and obstacle avoidance tasks; for route planning, exploration planning, experimentation, etc. some combination of goal-based and utility-based agent would be needed.

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3. Give the initial state, goal test, operators, and path cost function for the following problem. There are several possible formulations for the problem, with varying levels of detail. The most important aspects of your formulation should be its preciseness and coherence so that they could be implemented.

   Problem: You have a program that outputs the message “Illegal input record” when fed a certain file of input records. You know that processing of each record is independent of the other records. You want to discover what record is illegal.

(25 points)

Solution:

States: Considering subsets of all input records

Initial State: Considering all input records

Goal Test: Considering a single input record which produces the message “Illegal input record”

Operators (successor function):

- (I) Run the program again on the first half of the records
- (II) Run the program again on the second half of the records

Path Cost: Number of runs.

Note: This is a contingency problem and one needs to see if the run produces the error message to decide what to do next.

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4. Give the initial state, goal test, operators, and path cost function for the following problem. There are several possible formulations for the problem, with varying levels of detail. The most important aspects of your formulation should be its preciseness and coherence so that they could be implemented.

   Problem: You have three jugs, measuring 12 gallons, 8 gallons, and 3 gallons, and a water faucet. You can fill the jugs up or empty them out from one to another or onto the ground. You need to measure exactly 1 gallon.

(25 points)

Solution:

States:	Jugs represented by values x, y, and z denoting the amount of water in them [x,y,z]
Initial State:	Jugs have values [0,0,0]
Goal Test:	[1,y,z] or [x,1,z] or [x,y,1].
Operators (successor function):	Given a state [x,y,z],

(I) generate [12,y,z] by *filling the first jug*

(II) generate [x,8,z] by *filling the second jug*

(III) generate [x,y,3] by *filling the third jug*

(IV) generate [0,y,z] by *emptying the first jug*

(V) generate [x,0,z] by *emptying the second jug*

(VI) generate [x,y,0] by *emptying the third jug*

(VII) generate [min(12,x+y), y-min(12-x,y), z] from [x,y,z]
by *pouring from the second into the first jug until either filling the first or emptying the second one*

(VIII) generate [min(12,x+z), y, z-min(12-x,z)] from [x,y,z]
by *pouring from the third into the first jug until either filling the first or emptying the third one*

(IX) generate [x-min(|8-x|,x), min(8,x+y), z] from [x,y,z]
by *pouring from the first into the second jug until either filling the second or emptying the first one*

(X) generate [x-min(|3-x|,x), y, min(3,x+z)] from [x,y,z]
by *pouring from the first into the third jug until either filling the third or emptying the first one*

(XI) generate [x, min(8,y+z), z-min(8-y,z)] from [x,y,z]
by *pouring from the third into the second jug until either filling the second or emptying the third one*

(XII) generate [x, y-min(|3-y|,y), min(3,y+z)] from [x,y,z]
by *pouring from the second into the third jug until either filling the third or emptying the second one*

Path Cost: Number of actions.

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5. Represent the following sentences in First Order Logic using a consistent vocabulary (which you must first define) :

(25 (=13+12) points)

(a) A person born outside of U.S., one of whose parents is a U.S. citizen, is a U.S. citizen by descent.

Solution:
$\forall x\ Person(x) \wedge \neg Born(x,US) \wedge (\ \exists y\ Parent(y,x) \wedge Citizen(y,US,Birth)) \rightarrow Citizen(x,US,Descent)$

(b) There is an insurance agent who sells policies only to people who are not insured by other insurance companies.

Solution:
$\exists x\ Agent(x) \wedge \forall y,z\ \ Policy(y) \wedge Sells(x,y,z) \rightarrow (Person(z) \wedge \neg Insured(z))$

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6. Convert the following First Order Logic sentence into its Conjunctive Normal Form :

$\forall x\ LegalExpert(x) \leftrightarrow \exists s\ (\ LawSchool(s) \wedge GraduateOf(x,s)\ )$

(25 points)

Solution:
$[\neg\ LegalExpert(x) \vee LawSchool(SchoolFinishedBy(x))] \wedge$
$[\neg\ LegalExpert(x) \vee GraduateOf(x,SchoolFinishedBy(x))] \wedge$
$[\neg\ LawSchool(z) \vee \neg GraduateOf(x,z) \vee LegalExpert(x)]$

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7. Following is a story that you need to translate into a FOL knowledge base (its sentences numbered and described by FOL clauses): The ITF handbook of tennis rules states that it is an offense meriting disqualification from a match when a player

engages in repeated unsportsmanship conduct. Taking excessive time between the points or during the changeovers, swearing at opponent, officials or spectators, as well as wearing improper attire all qualify as such. Joe Doe has started his match by engaging a spectator in a rude exchange which included insults and cursing which resulted in receiving a warning from the umpire. During the match, he took over 40 seconds between his consecutive serves during a point while tennis rules allow for up to 20 seconds.

Provide a proof that ***Joe Doe should be disqualified from the match.*** In the proof, for each step indicate :

(a) the inference rule being used,
(b) the unifiers being applied,
(c) the sentences the rule is being applied to, and
(d) the sentence derived by the rule (number it, as well).

(25 points)

Solution:

It is an offense meriting disqualification from a match when a player engages in repeated unsportsmanship conduct.	***1. TenPlayer(x) ∧ UnSportCon(y) ∧ UnSportCon(z) ∧ EngageIn(x,y) ∧ EngageIn(x,z) ➔ Disqual(x)***
Excessive time between points qualifies as unsportsmanship conduct.	***2. UnSportCon(ExcBetPointTime)***
Excessive time during changeovers qualifies as unsportsmanship conduct.	***3. UnSportCon(ExcChgOverTime)***
Swearing at opponent qualifies as unsportsmanship conduct.	***4. UnSportCon(SwearAtOpon)***
Swearing at official qualifies as unsportsmanship conduct.	***5. UnSportCon(SwearAtOffic)***

Swearing at spectator qualifies as unsportsmanship conduct.	***6. UnSportCon(SwearAtSpect)***
Wearing improper attire qualifies as unsportsmanship conduct.	***7. UnSportCon(WearImpAtt)***
Joe Doe is a tennis player.	***8. TenPlayer(JoeDoe)***
Joe Doe has engaged a spectator by insulting and swearing.	***9. EngageIn(JoeDoe,InsultSpect) ∧ EngageIn(JoeDoe,SwearAtSpect)***
Joe Doe has engaged in taking excessive time between points.	***10. EngageIn(JoeDoe,ExcBetPointTime)***
To be proved: Joe Doe should be disqualified from the match.	***11. Disqual(JoeDoe)***

(AE) 9: ***EngageIn(JoeDoe,SwearAtSpect)*** (12)

(GMP) 1, 8, 2, 6, 10, and 12 with: x/JoeDoe, y/ExcBetPointTime, z/SwearAtSpect

Disqual(JoeDoe) (11)

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8. Following is a story that you need to translate into a FOL knowledge base (its sentences numbered and described by FOL clauses): Jack owns a dog. Every dog owner is an animal lover. No animal lover ever kills an animal. It is know that either Jack or Curiosity killed the cat whose name is Tuna.

   Provide a proof that Curiosity killed Tuna. In the proof, for each step indicate:
   (a) the inference rule being used,
   (b) the unifiers being applied,

(c) the sentences the rule is being applied to, and
(d) the sentence derived by the rule (number it, as well)

(25 points)

Solution:

We will prove ***Kills(Curiosity, Tuna)*** by proving that the knowledge base and the negation of ***Kills(Curiosity, Tuna)*** yield a contradiction.

The knowledge base:

Jack owns a dog.	1. $\exists x\ Dog(x) \wedge Owns(Jack, x)$
Every dog owner is an animal lover.	2. $\forall x\ (\exists y\ Dog(y) \wedge Owns(x, y)) \rightarrow AnimalLover(x)$
No animal lover kills an animal.	3. $\forall x\ AnimalLover(x) \rightarrow (\forall y\ Animal(y) \rightarrow \neg Kills(x, y))$
Either Jack or Curiosity killed the cat whose name is Tuna.	4. $Kills(Jack, Tuna)\ \ Kills(Curiosity, Tuna)$
	5. $Cat(Tuna)$
	6. $\forall x\ \ Cat(x) \rightarrow Animal(x)$
To be proved: Curiosity killed Tuna.	7. $Kills(Curiosity, Tuna)$.

The knowledge base converted to CNF:

Jack owns a dog.	***1. Dog(D) ∧ Owns(Jack, D)***
	1.a. Dog(D)
	1.b. Owns(Jack, D)
Every dog owner is an animal lover.	***2. ¬ Dog(y) ∨ ¬Owns(x,y) ∨ AnimalLover(x)***
No animal lover kills an animal.	***3. ¬AnimalLover(x) ∨ ¬Animal(y) ∨ ¬Kills(x, y)***
Either Jack or Curiosity killed the cat whose name is Tuna.	***4. Kills(Jack, Tuna) ∨ Kills(Curiosity, Tuna)***
	5. Cat(Tuna)
	6. ¬Cat(x) ∨ Animal(x)
To be proved: Curiosity killed Tuna.	***Kills(Curiosity, Tuna).***

Negated ***Kills(Curiosity, Tuna)*** in CNF :

Curiosity did NOT kill Tuna.	***7. ¬ Kills(Curiosity, Tuna)***

(RR) 1.a. and 2. with ***y/D*** ***¬Owns(x,D) ∨ AnimalLover(x)*** (8)
(RR) 1.b. and 2. with ***x/Jack*** ***AnimalLover(Jack)*** (9)
(RR) 5. and 6. with ***x/Tuna*** ***Animal(Tuna)*** (10)
(RR) 3. and 10. with ***y/Tuna*** ***¬AnimalLover(x) ∨ ¬Kills(x, Tuna)*** (11)

(RR)	9. and 11. with ***x/Jack***	***¬Kills(Jack, Tuna)***	(12)
(RR)	12. and 4.	***Kill(Curiosity, Tuna)***	(13)
(RR)	7. and 13.	***CONTRADICTION***	