CS 188 Fall 1993 — Introduction to AI — Stuart Russell — Midterm 2

You have 1 hour, 20 minutes. The exam is open-book, open-notes.
You will not necessarily finish all questions, so do your best ones first.
Write your answers in blue books. Hand them all in.
60 points total. Panic not.

1. (14 pts.) Situation calculus and STRIPS
In this question we will investigate the relationship between STRIPS action schemata and situation calculus descriptions of actions.

(a) (6 pts) Translate the following situation calculus axioms into one or more STRIPS action schemata:

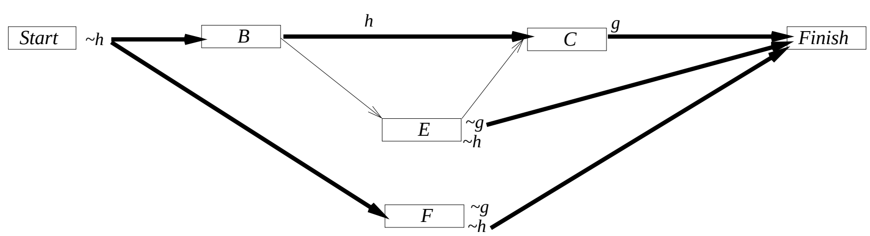
$$\forall sxp Edible(x) \land Holding(p,x,s) \Rightarrow Inside(x,p,Result(Eat(p,x),s))$$
$$\forall sxp Edible(x) \land Holding(p,x,s) \Rightarrow \neg Holding(p,x,Result(Eat(p,x),s))$$
$$\forall sxyp Holding(p,y,s) \land y \neq x \Leftrightarrow Holding(p,y,Result(Eat(p,x),s))$$
$$\forall sxyp Inside(y,p,s) \Rightarrow Inside(y,p,Result(Eat(p,x),s))$$
$$\forall sxyp \neg Inside(y,p,s) \land y \neq x \Rightarrow \neg Inside(y,p,Result(Eat(p,x),s))$$

(b) (2 pts) Are there any frame axioms missing from the above set of axioms?

(c) (6 pts) Translate the following STRIPS action schema into one or more situation calculus axioms (including all necessary frame axioms):

$$\begin{array}{rl} Action: & Barf(p,x) \\ Preconds: & [Inside(x,p)] \\ AddList: & [] \\ DeleteList: & [Inside(x,p)] \end{array}$$

2. (10 pts.) Nonlinear planning
Consider the following partially-ordered plan (a step followed by e.g. ~g means that the steps deleted g):



(a) (2 pts) How many possible linearizations does the plan have?

(b) (2 pts) Which steps possibly threaten $B \xrightarrow{h} C$?

(c) (2 pts) Which steps necessarily threaten $B \xrightarrow{h} C$?

(d) (2 pts) How can the plan be refined (by a standard partial-order planner) to remove a possible threat to $B \xrightarrow{h} C$?

(e) (2 pts) Is g necessarily true at the finish step?

3. (7 pts.) Basic probability
In this question we consider a set of n Boolean random variables $X_1 \ldots X_n$. Suppose that the joint distribution for $X_1 \ldots X_n$ is uniform (all entries identical).

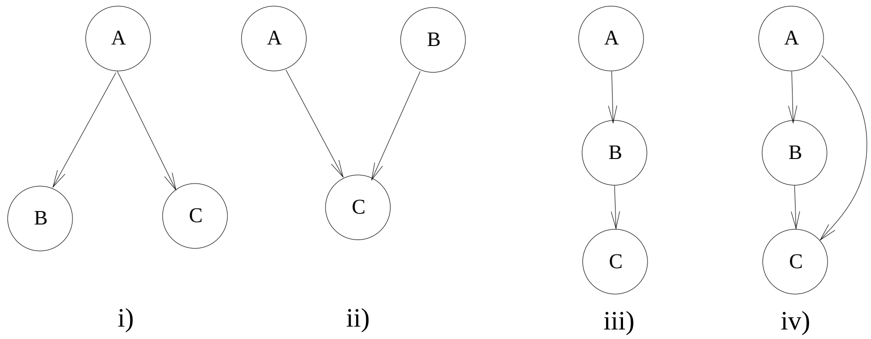
(a) (3 pts) What can you deduce about $\mathbf{P}(X_i)$?

(b) (2 pts) Is it necessarily the case that $\mathbf{P}(X_i|X_j) = \mathbf{P}(X_i)$ for all i, j?

(c) (2 pts) What is the value of each entry in the joint?

4. (13 pts.) Independence in networks

Consider the following four networks, constructed by introducing the nodes in the order A, B, C:



(a) (10 pts) For each of the following statements, say whether it *necessarily* holds in each of the networks (draw a 4×4 table with 1,2,3,4 down the left-hand side and i, ii, iii, iv across the top, and fill in a Y in the boxes where the statement holds):

1 $\mathbf{P}(C|A, B) = \mathbf{P}(C|A)$

2 $\mathbf{P}(C|A, B) = \mathbf{P}(C|B)$

3 $\mathbf{P}(B|A) = \mathbf{P}(B)$

4 $\mathbf{P}(B, C|A) = \mathbf{P}(B|A)\mathbf{P}(C|A)$

(b) (3 pts) *True/false*: It is possible to construct a network topology connecting A, B, C for which it is *necessarily false* that $\mathbf{P}(A|C) = \mathbf{P}(A)$.

5. (16 pts.) Belief network design

Consider the following random variables, pertaining to driving home after a New Year's Eve party in Lake Tahoe:

$BrakeFailure$ — whether your brakes fail

$Drunk$ — whether you are actually over the limit

$AccidentSeverity$ — values $None$, $FenderBender$, $Severe$

$IcyWeather$ — whether the weather is icy

$Arrested$ — whether you get arrested

$Injured$ — whether you are injured

$Jailed$ — whether you go to jail

(a) (8 pts) Pick a reasonable ordering for the variables and use it to construct a network topology. Try to minimize the amount of information required for the conditional probability tables, while respecting the obvious causal influences in the doamin.

(b) (3 pts) Label each node with the number of independent probabilities that must be supplied for the associated conditional probability table.

(c) (4 pts) Give a reasonable conditional probability table associated with the $Jailed$ node.

(d) (1 pt) Is your network singly-connected?