BBM405 Fundamentals of Artificial Intelligence

Final, Spring 2023, Part 2

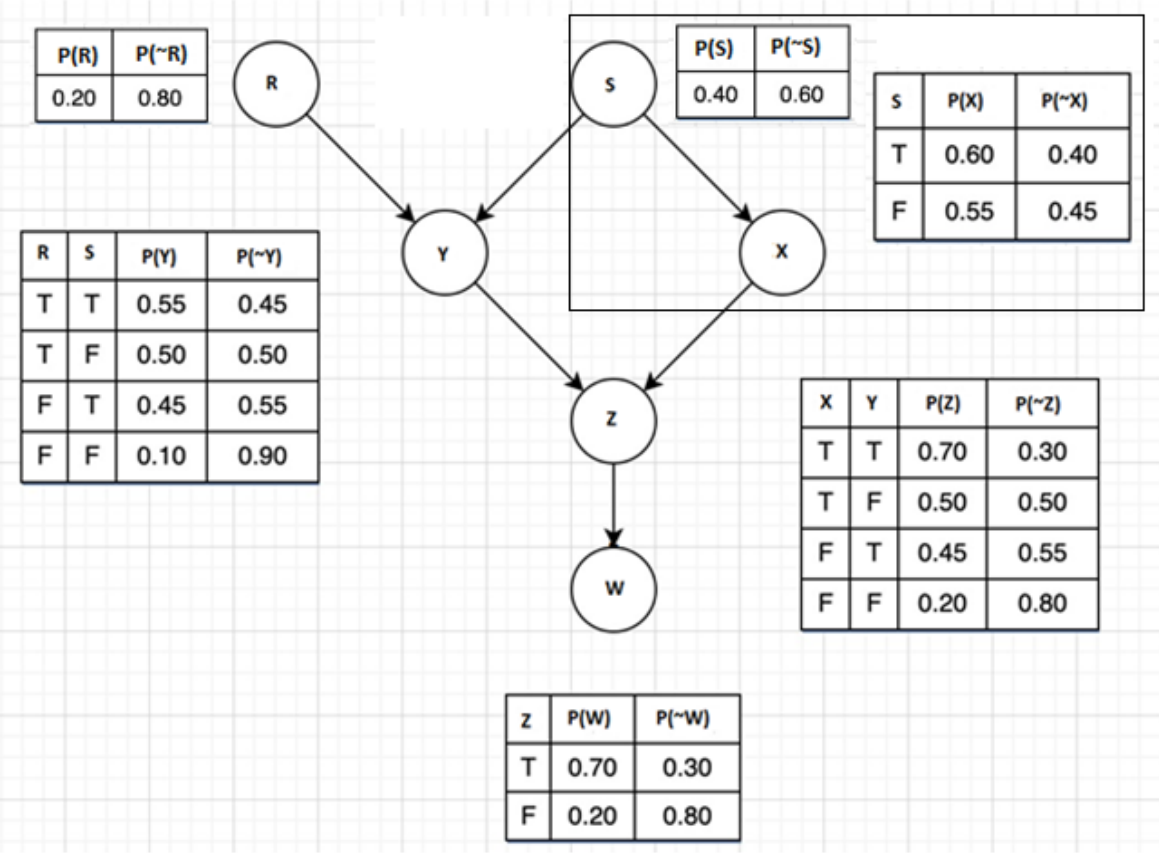
June 12, 2023

Q4) (22 pts) Bayesian Networks

Consider the following Bayesian network where tables represent the conditional probabilities. For example, P (Z=F | X=T, Y=T) is represented by P(~Z | X, Y) and is equal to 0.30.

For all the questions below show in detail how you compute the required probabilities. You do not need to provide the final value, but place the probabilities correctly.

Hint: For (a)-(c) consider only the area selected on the top-right corner.



P(R)	P(~R)
0.20	0.80

P(S)	P(~S)
0.40	0.60

S	P(X)	P(~X)
T	0.60	0.40
F	0.55	0.45

R	S	P(Y)	P(~Y)
T	T	0.55	0.45
T	F	0.50	0.50
F	T	0.45	0.55
F	F	0.10	0.90

X	Y	P(Z)	P(~Z)
T	T	0.70	0.30
T	F	0.50	0.50
F	T	0.45	0.55
F	F	0.20	0.80

Z	P(W)	P(~W)
T	0.70	0.30
F	0.20	0.80

a) (1 pts) P (X = F | S = T) = ?

b) (2 pts) P (X = F , S = T) = ?

c) (3 pts) P (X = F) = ?

d) (6 pts) P (R= T , S= F, X = T, Y = F, Z = T, W = F) = ?

e) (10 pts) P (R= F | S= T, X = T, Y = T, Z = T, W = T) = ?

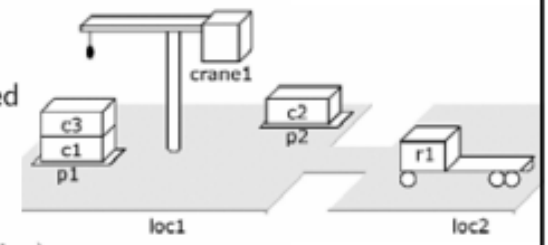
Q5) (22 pts) Planning

Consider the operators below in the DWR domain for planning.

move(r, l, m)
;; robot r moves from location l to location m
precond: adjacent(l, m), at(r, l), $\neg$ occupied(m)
effects: at(r, m), occupied(m), $\neg$ occupied(l), $\neg$ at(r, l)

load(k, l, c, r)
;; crane k at location l loads container c onto robot r
precond: belong(k, l), holding(k, c), at(r, l), unloaded(r)
effects: empty(k), $\neg$ holding(k, c), loaded(r, c), $\neg$ unloaded(r)

unload(k, l, c, r)
;; crane k at location l takes container c from robot r
precond: belong(k, l), at(r, l), loaded(r, c), empty(k)
effects: $\neg$ empty(k), holding(k, c), unloaded(r), $\neg$ loaded



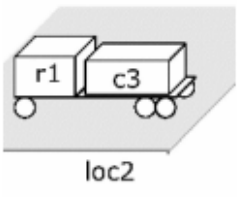
put(k, l, c, d, p)
;; crane k at location l puts c onto d in pile p
precond: belong(k, l), attached(p, l), holding(k, c), top(d, p)
effects: $\neg$ holding(k, c), empty(k), in(c, p), top(c, p), on(c, d), $\neg$ top(d, p)

take(k, l, c, d, p)
;; crane k at location l takes c off of d in pile p
precond: belong(k, l), attached(p, l), empty(k), top(c, p), on(c, d)
effects: holding(k, c), $\neg$ empty(k), $\neg$ in(c, p), $\neg$ top(c, p), $\neg$ on(c, d), top(d, p)

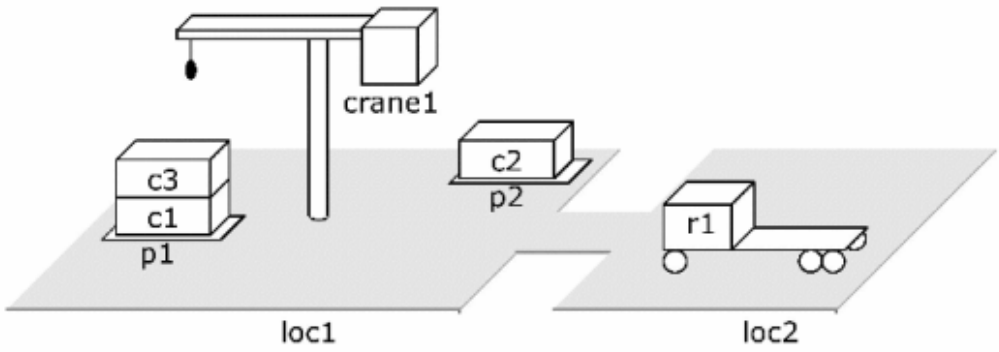
Given, the initial state and the goal state below, answer the following questions.

GOAL STATE:

$g_1 = \{\text{loaded(r1,c3),at(r1,loc2)}\}$



INITIAL STATE:



$s_1 = \{$attached(p1,loc1), in(c1,p1), in(c3,p1), top(c3,p1), on(c3,c1), on(c1,pallet), attached(p2,loc1), in(c2,p2), top(c2,p2), on(c2,pallet), belong(crane1,loc1), empty(crane1), adjacent(loc1,loc2), adjacent(loc2,loc1), at(r1,loc2), occupied(loc2), unloaded(r1)$\}$.

a) (4 pts) Show that `move` action is applicable to initial state. Explain clearly with correct substitutions.

b) (14 pts) Show how the following plan in state-space search works, by providing the correct substitutions. For each action applied you must show that the preconditions are satisfied, and you should provide the effects so that at the end of the plan the goal is satisfied.

Plan :
take(crane1,loc1,c3,c1,p1),
move(r1,loc2,loc1),
load(crane1,loc1,c3,r1),
move(r1,loc1,loc2)

c) (4 pts) Can you provide another non-redundant plan?