SCHOOL OF DATA AND COMPUTER SCIENCE, SUN YAT-SEN UNIVERSITY

T03 Planning and Uncertainty

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Contents

1 Q1

1.1 (a)

Initial State: $Contains(p1, 5, s0),\ Contains(p2, 0, s0)$.

1.2 (b)

- empty(p):

  To do empty(p) in situation s, we need to have:

  $\exists w.\ Contains(p, w, s) \bigwedge w \neq 0$

  effects:

  $Contains(p, 0, do(empty(p)))$

- transfer(p, p'):

  To do transfer(p, p') in situation s, we need to have:

  $\exists w1, w2.\ Contains(p, w1, s) \bigwedge w1 \neq 0 \bigwedge Contains(p', w2, s) \bigwedge w2 \neq volume(p')$

  effects:

  $Contains(p, w1 - (volume(p') - w2), do(transfer(p, p')) \bigwedge$

  $((Contains(p', volume(p'), do(transfer(p, p') \bigwedge w1 - (volume(p') - w2) >= 0)) \bigvee$

  $(Contains(p', w1 + w2, do(transfer(p, p') \bigwedge w1 - (volume(p') - w2) < 0)))$

1.3 (c)

Final Goal Situation: $\exists s.Contains(p2, 1, s)$

1.4 (d)

Find σ :

$do(transfer(p1, p2), do(empty(p2), do(transfer(p1, p2), do(empty(p2), do(transfer(p1, p2), S0)))))$

2 Q2

2.1 (a)

2.1.1 Actions

1. move(x, y, z)

   - Pre: $on(x, y), clear(x), clear(z)$
   - Adds: $on(x, z), clear(y)$
   - Dels: $on(x, y), clear(z)$

2. moveFromTable(x, y)

   - Pre: $onTable(x), clear(x), clear(y)$
   - Adds: $on(x, y)$
   - Dels: $onTable(x), clear(y)$

3. moveToTable(x, y)

   - Pre: $on(x, y), clear(x)$
   - Adds: $onTable(x), clear(y)$
   - Dels: $on(x, y)$

2.1.2 Initial KB

$KB = on(a, b), on(b, c), onTable(c), clear(a)$

2.1.3 Goal

$Goal = on(a, b), onTable(b), onTable(c), clear(a), clear(c)$

2.2 (b)

Reachablity analysis:

S0: {onTable(c), on(b,c), on(a,b), clear(a)}

A0: {moveToTable(a,b)}

S1: {onTable(c), on(b,c), on(a,b), clear(a), clear(b), onTable(a)}

A1: {moveFromTable(a,b), moveToTable(b,c)}

S2: {onTable(c), on(b,c), on(a,b), clear(a), clear(b), onTable(a), clear(c), onTable(b)}

A2: {moveFromTable(b,c), moveFromTable(a,c), moveFromTable(c,b), moveFromTable(c,a), moveFromTable(a,b), moveFromTable(b,a))}

===

G: {onTable(b), onTable(c), on(a,b), clear(a), clear(c)}

CountActions(G, S2):

GP = {onTable(c), on(a,b), clear(a)}

GN = {onTable(b), clear(c)}

A = {moveToTable(b,c)}

NewG = {onTable(c), on(a,b), clear(a), on(b,c), clear(b)}

return CountActions(NewG, S1) + size(A)

CountActions(NewG, S1):

GP = {onTable(c), on(a,b), clear(a), on(b,c)}

GN = {clear(b)}

A = {moveToTable(a,b)}

NewG = {onTable(c), on(a,b), clear(a), on(b,c)}

return CountActions(NewG, S0) + size(A)

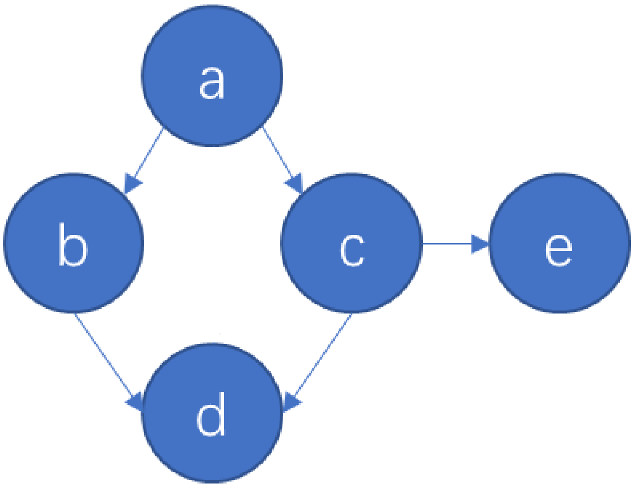
CountActions(NewG, S0):

return 0

minlen(P') = 2.

3 Q3

3.1 (a)



3.2 (b)

For example, by the chain rule:

$P(d, b, a) = P(d|b, a)P(b|a)P(a)$

By assuming independence:

$P(d, b, a) = P(d|b)P(b|a)P(a)$

3.3 (c)

This problem seems to be a little confusing, I am not sure if the value d, e had been assigned...

Assigned: In other words, to calculate $P(a, b, c|\neg d, e)$:

$$
\begin{aligned}
P(a, b, c|\neg d, e) &= \frac{P(a, b, c, \neg d, e)}{P(\neg d, e)} && (1)\\
&= \frac{P(e|c)P(\neg d|b, c)P(b|a)P(c|a)P(a)}{\sum\limits_{abc} P(e|c)P(\neg d|b, c)P(b|a)P(c|a)P(a)} && (2)\\
&= \frac{P(e|c)P(\neg d|b, c)P(b|a)P(c|a)P(a)}{\sum\limits_{c} P(e|c)\sum\limits_{b} P(\neg d|b, c)\sum\limits_{a} P(b|a)P(c|a)P(a)} && (3)\\
&= \frac{0.8 \times 0.2 \times 0.8 \times 0.2 \times 0.2}{0.04 \times 0.8 + 0.664 \times 0.6} && (4)\\
&= 0.0119 && (5)
\end{aligned}
$$

However, it can also be...

To calculate $P(a,b,c)$, since for given a, b and c are independent:

$$P(a,b,c) = P(b,c|a)P(a) \tag{6}$$
$$= P(c|a)P(b|a)P(a) \tag{7}$$
$$= 0.032 \tag{8}$$

Similarly,

$P(\neg a,b,c) = 0.008$

$P(a,\neg b,c) = 0.008$

$P(a,b,\neg c) = 0.128$

$P(\neg a,\neg b,c) = 0.032$

$P(a,\neg b,\neg c) = 0.032$

$P(\neg a,b,\neg c) = 0.152$

$P(\neg a,\neg b,\neg c) = 0.608$

3.4 (d)

To judge either the given facts help or hinder, I decided to calculate $P(a|\neg d,e)$ and compare it with $P(a)$.

$$P(a|\neg d,e) = \frac{P(a,\neg d,e)}{P(\neg d,e)} \tag{9}$$
$$= \frac{P(b|a)P(c|a)P(a)\sum_d P(d|b,c)\sum_e P(e|c)}{\sum_c P(e|c)\sum_b P(\neg d|b,c)\sum_a P(b|a)P(c|a)P(a)} \tag{10}$$
$$= 0.5379 \tag{11}$$

Consequently, $0.5379 > 0.2$, we are now more inclined to believe that the patient has cancer.

4 Q4

4.1 (a)

VE -> P(e)					
f1(A)		f2(B)			
a	0.9	b	0.2		
~a	0.1	~b	0.8		
f3(ABC)				\	
abc	0.1	a~bc	0.8		
~abc	0.7	ab~c	0.9		
~a~bc	0.4	a~b~c	0.2		
~ab~c	0.3	~a~b~c	0.6		
f4(BD)		f5(CE)		f6(CF)	
bd	0.1	ce	0.7	cf	0.2
b~d	0.9	c~e	0.2	c~f	0.9
~bd	0.8	~ce	0.3	~cf	0.8
~b~d	0.2	~c~e	0.8	~c~f	0.1
Elimination order: {D, A, B, F, C}					

Figure 2: (a)-1

<table>
<tr><th colspan="3">Eliminating D</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f7(B) = sum_D{f4(B, D)}</td><td rowspan="4">f4</td></tr>
<tr><td colspan="2">f7(B)</td></tr>
<tr><td>b</td><td>1</td></tr>
<tr><td>~b</td><td>1</td></tr>
<tr><th colspan="3">Eliminating A</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f8(B, C) = sum_A{f1(A)f3(A, B, C)}</td><td rowspan="6">f1, f3</td></tr>
<tr><td colspan="2">f8(B, C)</td></tr>
<tr><td>bc</td><td>0.16</td></tr>
<tr><td>b~c</td><td>0.84</td></tr>
<tr><td>~bc</td><td>0.76</td></tr>
<tr><td>~b~c</td><td>0.24</td></tr>
<tr><th colspan="3">Eliminating B</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f9(C) = sum_B{f2(B)f7(B)f8(B, C)}</td><td rowspan="4">f2, f7, f8</td></tr>
<tr><td colspan="2">f9(C)</td></tr>
<tr><td>c</td><td>0.64</td></tr>
<tr><td>~c</td><td>0.36</td></tr>
<tr><th colspan="3">Eliminating F</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f10(C) = sum_F{f6(CF)}</td><td rowspan="4">f6</td></tr>
<tr><td colspan="2">f10(C)</td></tr>
<tr><td>c</td><td>1</td></tr>
<tr><td>~c</td><td>1</td></tr>
<tr><th colspan="3">Eliminating C</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f11(E) = sum_C{f5(CE)f9(C)f10(C)}</td><td rowspan="4">f5, f9, f10</td></tr>
<tr><td colspan="2">f11(E)</td></tr>
<tr><td>e</td><td>0.52</td></tr>
<tr><td>~e</td><td>0.48</td></tr>
<tr><th colspan="3">Calculate P(e)</th></tr>
<tr><td>alpha = 1</td><td colspan="2">P(e) = alpha * f11(E) = 0.52</td></tr>
<tr><td colspan="3">Accomplished.</td></tr>
</table>

Figure 3: (a)-2

4.2 (b)

VE -> P(e|~f)					
f1(A)		f2(B)		f6(CF)	
a	0.9	b	0.2	cf	0.2
~a	0.1	~b	0.8	c~f	0.9
f3(ABC)				~cf	0.8
abc	0.1	a~bc	0.8	~c~f	0.1
~abc	0.7	ab~c	0.9	Restriction on f, f = ~f	
~a~bc	0.4	a~b~c	0.2		
~ab~c	0.3	~a~b~c	0.6		
f4(BD)		f5(CE)		f7(C)	
bd	0.1	ce	0.7	c	0.9
b~d	0.9	c~e	0.2	~c	0.1
~bd	0.8	~ce	0.3		
~b~d	0.2	~c~e	0.8		
Elimination order: {D, A, B, C}					

Figure 4: (b)-1

<table>
<tr><th colspan="3">Eliminating D</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f8(B) = sum_D{f4(B, D)}</td><td rowspan="4">f4</td></tr>
<tr><td colspan="2">f8(B)</td></tr>
<tr><td>b</td><td>1</td></tr>
<tr><td>~b</td><td>1</td></tr>
<tr><th colspan="3">Eliminating A</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f9(B, C) = sum_A{f1(A)f3(A, B, C)}</td><td rowspan="6">f1, f3</td></tr>
<tr><td colspan="2">f9(B, C)</td></tr>
<tr><td>bc</td><td>0.16</td></tr>
<tr><td>b~c</td><td>0.84</td></tr>
<tr><td>~bc</td><td>0.76</td></tr>
<tr><td>~b~c</td><td>0.24</td></tr>
<tr><th colspan="3">Eliminating B</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f10(C) = sum_B{f2(B)f8(B)f9(B, C)}</td><td rowspan="4">f2, f8, f9</td></tr>
<tr><td colspan="2">f10(C)</td></tr>
<tr><td>c</td><td>0.64</td></tr>
<tr><td>~c</td><td>0.36</td></tr>
<tr><th colspan="3">Eliminating C</th></tr>
<tr><th colspan="2">ADD Factor</th><th>DELETE Factor</th></tr>
<tr><td colspan="2">f11(E) = sum_C{f5(CE)f7(C)f10(C)}</td><td rowspan="4">f5, f7, f10</td></tr>
<tr><td colspan="2">f11(E)</td></tr>
<tr><td>e</td><td>0.4104</td></tr>
<tr><td>~e</td><td>0.2016</td></tr>
<tr><th colspan="3">Calculate P(e|~f)</th></tr>
<tr><td colspan="2">alpha = 1/0.612</td><td>P(e|~f) = alpha * f11(E) = 0.6706</td></tr>
<tr><td colspan="3">Accomplished.</td></tr>
</table>

Figure 5: (b)-2

In conclusion, computation from Eliminating D to Eliminating B can be reused. Those different parts from (a) are:

- Restriction in Figure 4
- Elimination on C in Figure 5