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T03 Planning and Uncertainty

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目录

1 Q1

(a) $\forall s \forall l_1 \forall l_2 (at(o, l_1, s) \bigwedge at(o, l_2, s) \Rightarrow l_1 = l_2)$

(b) s_0: $\neg lightOn(s_0) \bigwedge at(shakey, r_1, s_0) \bigwedge at(b1, r_2, s_0) \bigwedge at(b2, r_3, s_0)$

goal situation: $\exists s, lightOn(\phi(s))$

(c) $walkTo(loc_1, loc_2)$

precondition: $at(shakey, loc_1, s)$

effect: $at(shakey, loc_2, s) \bigwedge \neg at(shakey, loc_1, s)$

$push(box, loc_1, loc_2)$

precondition: $at(shakey, loc_1, s) \bigwedge at(box, loc_1, s)$

effect: $at(box, loc_2, s) \bigwedge \neg at(box, loc_1, s)$

$turnOn$

precondition: $at(b_1, r_1, s) \bigwedge at(b_2, r_2, s) \bigwedge at(shakey, r_1, s)$

effect: $lightOn(s)$

(d) 1.$(\neg lightOn(s_0))$

2.$(at(shakey, r_1, s_0))$

3.$(at(b1, r_2, s_0))$

4.$(at(b2, r_3, s_0))$

5.$(at(shakey, loc_1, s), \neg at(shakey, loc_1, do(walkTo(loc_1, loc_2), s)))$

6.$(at(shakey, loc_1, s), at(shakey, loc_2, do(walkTo(loc_1, loc_2), s)))$

7.$(at(shakey, loc_1, s), at(box, loc_1, s), at(box, loc_2, do(push(box, loc_1, loc_2), s)))$

8.$(at(shakey, loc_1, s), at(box, loc_1, s), \neg at(box, loc_1, do(push(box, loc_1, loc_2), s)))$

9.$(at(b_1, r_1, s), at(b_2, r_2, s), at(shakey, r_1, s), lightOn(do(turnOn), s))$

10.$(\neg lightOn(z), ans(z))$

And by resolution, we can get $ans(z, s_0)$

$z = do(turnOn, do(walkTo(r_2, r_1), do(push(b_1, r_2, r_1), do(walkTo(r_3, r_2),$

$do(push(b_2, r_3, r_2), do(walkTo(r_2, r_3), do(walkTo(r_1, r_2))))))))$

2 Q2

(a)

- actions:
  - move(x, a, b):

    Pre:{on(x, a), clear(x), clear(b), smaller(x, b)}

    Adds:{on(x, b), clear(a)}

    Dels:{on(x, a), clear(b)}
  - moveTwo(x, y, a, b):

    Pre:{on(x, y), on(y, a), clear(x), clear(b), smaller(y, b)}

    Adds:{on(y, b), clear(a)}

    Dels:{on(y, a), clear(b)}
- initial KB: $\{on(d_1, d_2), on(d_2, d_3), on(d_3, p_1), clear(d_1), clear(p_2), clear(p_3)\}$
- goal: $\{on(d_1, d_2), on(d_2, d_3), on(d_3, p_3), clear(d_1), clear(p_1), clear(p_2)\}$

(b) Reachability Analysis:

$S_0 = \{on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2), on(d_3, p_1), clear(p_3)\}$

$A_0 = \{[on(d_1, d_2), clear(d_1), clear(p_2), smaller(d_1, p_2)]move(d_1, d_2, p_2)[on(d_1, p_2), clear(d_2)],$

$[on(d_1, d_2), clear(d_1), clear(p_3), smaller(d_1, p_3)]move(d_1, d_2, p_3)[on(d_1, p_3), clear(d_2)],$

$[on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2), smaller(d_2, p_2)]move(d_1, d_2, d_3, p_2)[on(d_2, p_2), clear(d_3)]$

$[on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_3), smaller(d_2, p_3)]move(d_1, d_2, d_3, p_3)[on(d_2, p_3), clear(d_3)]\}$

$S_1 = \{on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2), on(d_3, p_1), clear(p_3), on(d_1, p_2),$

$on(d_1, p_3), clear(d_2), on(d_2, p_2), on(d_2, p_3), clear(d_3)\}$

$A_1 = \{[on(d_3, p_1), clear(d_3), clear(p_3), smaller(d_3, p_3)]move(d_3, p_1, p_3)[on(d_3, p_3), clear(p_1)] \cdots\}$

$S_2 = \{on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2), on(d_3, p_3), clear(p_1), on(d_3, p_1),$

$clear(p_3), on(d_1, p_2), on(d_1, p_3), clear(d_2), on(d_2, p_2), on(d_2, p_3), clear(d_3) \cdots\}$

因为goal $\notin S_1$, goal $\in S_2$, 所以停止, 接下来计算启发式函数的值。

$CountAction(G, S_2):$

$G_P = \{on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2)\}$

$G_N = \{on(d_3, p_3), clear(p_1)\}$

$A = \{move(d_3, p_1, p_3)\}$

$G_1 = G_P \cup Pre(A) = \{on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2), on(d_3, p_1), clear(d_3), clear(p_3)\}$

$return\ 1 + CountAction(G_1, S_1)$

$CountAction(G_1, S_1):$

$G_P = \{on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2)\}$

$G_N = \{on(d_3, p_1), clear(d_3), clear(p_3)\}$

$A = \{move(d_1, d_2, d_3, p_2)\}$

$G_2 = G_P \cup Pre(A) = \{on(d_1, d_2), on(d_2, d_3), clear(d_1), clear(p_2)\}$

$return\ 1 + CountAction(G_2, S_0)$

$CountAction(G_2, S_0) = 0$

综上：$CountAction(G, S_2) = 1 + 1 + 0 = 2$

3 Q3

1. (a) see the Figure 1.

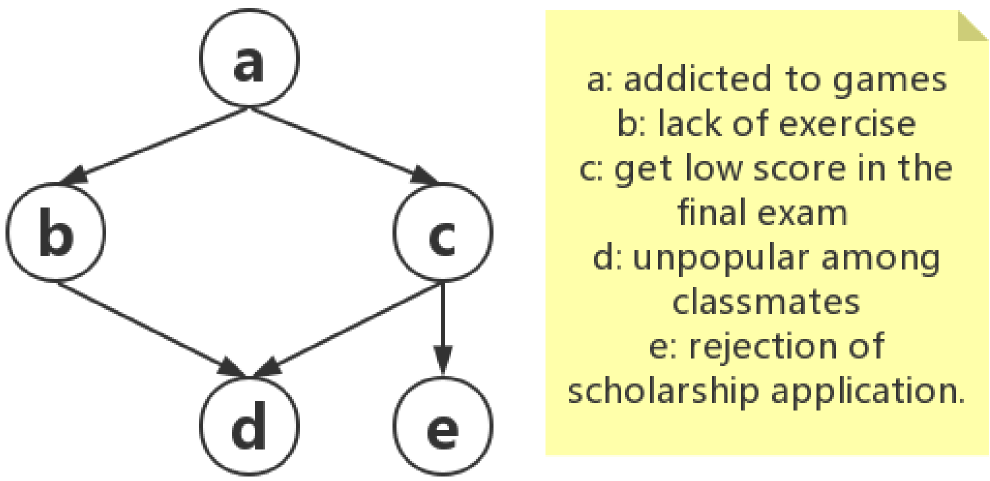

图 1: Q3 1(a)

(b) e is independent of a,b,d, given c.

b is independent of c, given a.

d is independent of a, given b and c.

(c) 设节点a的因子为$f_1(A)$, 节点b因子为$f_2(A, B)$, 节点c因子为 $f_3(A, C)$, 节点d因子为$f_4(B, C, D)$, 节点e因子为$f_5(C, E)$，由题目已知条件得到表1

a	0.2
$\neg a$	0.8

ab	0.7
$a\neg b$	0.3
$\neg ab$	0.2
$\neg a\neg b$	0.8

ac	0.2
$a\neg c$	0.8
$\neg ac$	0.05
$\neg a\neg c$	0.95

bcd	0.8
$bc\neg d$	0.2
$b\neg cd$	0.7
$b\neg c\neg d$	0.3
$\neg bcd$	0.7
$\neg bc\neg d$	0.3
$\neg b\neg cd$	0.05
$\neg b\neg c\neg d$	0.95

ce	0.7
$c\neg e$	0.3
$\neg ce$	0.6
$\neg c\neg e$	0.4

表 1: $f_1(A), f_2(A,B), f_3(A,C), f_4(B,C,D), f_5(C,E)$

要计算$P(A,B,C|\neg d,e)$，因证据变量为$D=\neg d, E=e$，故可以得到$f_4(B,C,D=\neg d)=f_6(B,C)$以及$f_5(C,E=e)=f_7(C)$，见表2。

bc	0.2
$b\neg c$	0.3
$\neg bc$	0.3
$\neg b\neg c$	0.95

c	0.7
$\neg c$	0.6

表 2: $f_6(B,C), f_7(C)$

经过计算并归一化后我们可以得到表3

(d) 计算$P(a)$，先要计算分布$P(A)$，查询变量为A，证据变量为$D=\neg d, E=e$，相关变量为A,B,C,D,E。

首先限制因子，得到$f_6(B,C)=f_4(B,C,D=\neg d, f_7(C)=f_5(C,E=e)$，见表2

设消元顺序为B,C。

B: $f_2(A,B), f_7(B,C)$

C: $f_3(A,C), f_6(C)$

消去B，即$f_8(A,C)=\sum_B f_2(A,B)\times f_7(B,C)=f_2(A,b)f_7(b,C)+f_2(A,\neg b)f_7(\neg b,C)$，见

abc	0.009	$\neg abc$	0.003
$ab\neg c$	0.046	$\neg ab\neg c$	0.063
$a\neg bc$	0.006	$\neg a\neg bc$	0.015
$a\neg b\neg c$	0.063	$\neg a\neg b\neg c$	0.795

表 3: $P(A,B,C|\neg d,e)$

表4

消去C，即$f_9(A)=\sum_C f_3(A,C)\times f_6(C)\times f_8(A,C)=f_3(A,c)f_6(c)f_8(A,c)+f_3(A,\neg c)f_6(\neg c)f_8(A,\neg c)$，见表4

故$f_{10}(A)=f_1(A)\times f_9(A)$

最后对$f_{11}(A)$归一化，得到$f_{12}(A)=\alpha f_{11}(A),\alpha=1/\sum_A f_{11}(A)$，见表4

因此$P(a|\neg d,e)=0.124<0.2=P(a)$

因此此时我们更加不倾向于相信学生沉迷于游戏。

ac	0.23
$a\neg c$	0.495
$\neg ac$	0.28
$\neg a\neg c$	0.82

a	0.2698
$\neg a$	0.4772

a	0.124
$\neg a$	0.876

表 4: $f_8(A,C),f_9(A),f_{11}(A)$

2. 设节点A的因子为$f_1(A)$, 节点B因子为$f_2(B)$, 节点C因子为 $f_3(A,B,C)$, 节点D因子为$f_4(B,D)$, 节点E因子为$f_5(C,E)$, 节点F因子为$f_6(C,F)$,见表(5)

a	0.8
$\neg a$	0.2

b	0.2
$\neg b$	0.8

abc	0.2
$ab\neg c$	0.8
$a\neg bc$	0.7
$a\neg b\neg c$	0.3
$\neg abc$	0.8
$\neg ab\neg c$	0.2
$\neg a\neg bc$	0.4
$\neg a\neg b\neg c$	0.6

bd	0.1
$b\neg d$	0.9
$\neg bd$	0.8
$\neg b\neg d$	0.2

ce	0.8
$c\neg e$	0.2
$\neg ce$	0.1
$\neg c\neg e$	0.9

cf	0.2
$c\neg f$	0.8
$\neg cf$	0.8
$\neg c\neg f$	0.2

表 5: $f_1(A),f_2(B),f_3(A,B,C),f_4(B,D),f_5(C,E),f_6(C,F)$

(a) 计算P(e), 先要计算分布P(E),查询变量为E, 证据变量无, 那么我们只需考虑查询变量E和E的祖先即可,相关变量为E, C, A, B。

设消元顺序为A,B,C。

$A:f_1(A),f_3(A,B,C)$

$B:f_2(B)$

$C:f_5(C,E)$

消去A，即$f_7(B,C)=\sum_A f_1(A)\times f_3(A,B,C)=f_1(a)f_3(a,B,C)+f_1(\neg a)f_3(\neg a,B,C)$，见表(6)。

$B: f_2(B), f_7(B,C)$

$C: f_5(C,E)$

消去B，即$f_8(C)=\sum_B f_2(B)\times f_7(B,C)=f_2(b)f_7(b,C)+f_2(\neg b)f_7(\neg b,C)$,见表(6)。

$C: f_5(C,E), f_8(C)$

消去C，即$f_9(E)=\sum_C f_5(C,E)\times f_8(C)=f_5(c,E)f_8(c)+f_5(\neg c,E)f_8(\neg c)$,见表(6)。

因此$P(e)=P(E=e)=f_9(e)=0.5032$

bc	0.32
$b\neg c$	0.68
$\neg bc$	0.64
$\neg b\neg c$	0.36

c	0.576
$\neg c$	0.424

e	0.5032
$\neg e$	0.4968

表 6: $f_7(B,C), f_8(C), f_9(E)$

(b) 计算$P(e|\neg f)$，要计算分布$P(E|\neg f)=\alpha P(E,\neg F)$，相关的变量有E和E的祖先A,B,C还有F(因为证据变量F是相关变量C的后代)。

设消元顺序为A,B,C。

首先限制因子，$f_{10}(C)=f_6(C,F=\neg f)$,见表(7)

$A: f_1(A), f_3(A,B,C)$

$B: f_2(B)$

$C: f_5(C,E), f_{10}(C)$

消去A，即$f_7(B,C)=\sum_A f_1(A)\times f_3(A,B,C)$，(a)中已经计算出来了，可以直接使用，见(a)中表(6)。

$B: f_2(B), f_7(B,C)$

$C: f_5(C,E), f_{10}(C)$

消去B，即$f_8(C)=\sum_B f_2(B)\times f_7(B,C)$，(a)中已经计算出来了，可以直接使用，见(a)中表(6)。

$C: f_5(C,E), f_{10}(C), f_8(C)$

消去C，即$f_{11}(E)=\sum_C f_5(C,E)\times f_{10}(C)\times f_8(C)$

最后对$f_{11}(E)$归一化，$f_{12}(E)=\alpha f_{11}(E)$，$\alpha=1/\sum_E f_{11}(E)$,见表(7)。

因此$P(e|\neg f)=P(E=e|\neg f)=f_{12}(e)=0.6912$

c	0.8
$\neg c$	0.2

e	0.6912
$\neg e$	0.3088

表 7: $f_{10}(C), f_{12}(E)$