

Inference for SRL

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Chapter 1

Probabilistic Inference Using Weighted Model Counting

1.1

1.1.1 ENC 1

For our conversion from the cancer bayesian network to ENC1 please look at 2.1 in our appendix.

1.1.2 ENC 2

As for ENC1 please look at 2.2 in our appendix.

1.2

The CNF of the monty hall problem is given in image 1

```

=====
CNF:
select_door(1)
^ win_keep v -prize(1)
^ -win_keep v prize(1)
^ open_door(2) v prize(2) v -prize(3)
^ -open_door(2) v -prize(2)
^ -open_door(2) v prize(3)
^ open_door(3) v prize(3) v -prize(2)
^ -open_door(3) v -prize(3)
^ -open_door(3) v prize(2)
^ win_switch v -prize(2) v open_door(2)
^ win_switch v -prize(3) v open_door(3)
^ -win_switch v prize(2) v prize(3)
^ -win_switch v prize(2) v -open_door(3)
^ -win_switch v -open_door(2) v prize(3)
^ -win_switch v -open_door(2) v -open_door(3)
Queries:
query(prize(1))
query(prize(2))
query(prize(3))
query(select_door(1))
query(win_keep)
query(win_switch)
=====

```

Figure 1.1: Grounded problog cnf

TODO WEIGHTS

1.3

1.3.1

We will use minic2d and Cachet as WMC counters.

minic2d

minic2d needs to use the $-W$ option to do weighted model counting.

- ENC1:

```

Constructing CNF... DONE
CNF stats:
  Vars=30 / Clauses=74
  CNF Time    0.000s
Constructing vtree (from primal graph)... DONE
Vtree stats:
  Vtree widths: con<=5, c_con=40 v_con=5
  Vtree Time    0.003s
Counting... DONE
  Learned clauses      0
Cache stats:
  hit rate      16.7%
  lookups       12
  ent count     10
  ent memory    0.5 KB
  ht memory     152.6 MB
  clists        1.0 ave, 1 max
  keys          4.2b ave, 6.0b max, 3.0b min
Count stats:
  Count Time     0.000s
  Count/Probability 1.00000
Total Time: 0.128s

```

Figure 1.2: Grounded problog cnf

- ENC2:

```

Constructing CNF... DONE
CNF stats:
  Vars=20 / Clauses=30
  CNF Time    0.000s
Constructing vtree (from primal graph)... DONE
Vtree stats:
  Vtree widths: con<=6, c_con=16 v_con=6
  Vtree Time    0.002s
Counting... DONE
  Learned clauses    0
Cache stats:
  hit rate    23.1%
  lookups    26
  ent count    20
  ent memory    1.0 KB
  ht memory    152.6 MB
  clists    1.0 ave, 1 max
  keys    1.8b ave, 3.0b max, 1.0b min
Count stats:
  Count Time    0.000s
  Count/Probability    1.00000
Total Time: 0.164s

```

Figure 1.3: Grounded problog cnf

- Prolog first:

Cachet

- ENC1:

```

Number of total components    11
Number of split components    2
Number of non-split components    5
Number of SAT residual formula    12
Number of trivial components    0
Number of changed components    0
Number of adjusted components    0
First component split level    1

Number of Decisions    11
Max Decision Level    5
Number of Variables    30
Original Num Clauses    74
Original Num Literals    172
Added Conflict Clauses    0
Added Conflict Literals    0
Deleted Unrelevant clauses    0
Deleted Unrelevant literals    0
Number of Implications    124
Total Run Time    0.018895

Satisfying probability    8.72319e-08
Number of solutions    93.6645

```

Figure 1.4: Grounded problog cnf

- ENC2:

Number of total components	11
Number of split components	2
Number of non-split components	5
Number of SAT residual formula	12
Number of trivial components	0
Number of changed components	0
Number of adjusted components	0
First component split level	1
Number of Decisions	11
Max Decision Level	5
Number of Variables	20
Original Num Clauses	30
Original Num Literals	84
Added Conflict Clauses	0
Added Conflict Literals	0
Deleted Unrelevant clauses	0
Deleted Unrelevant literals	0
Number of Implications	72
Total Run Time	0.017282
Satisfying probability	1
Number of solutions	1.04858e+06

Figure 1.5: Grounded problog cnf

- Prolog first:

For ENC1 we see that with Cachet we get a satisfying probability of almost 0. This is due to the fact that with ENC1 all our negative literals have a weight of 1, while Cachet expects that a literal + its negation = 1.

1.3.2. Difference between the used WMC's

minic2d Vs Cachet

Minic2d and Cachet are both weighted model counters but how to do this is quite different. Minic2d is a top down compiler that compiles CNF's into a SDD which results in a faster system but it also uses less space while Cachet is an algorithm that uses formula caching together with clause learning and component analysis. Minic2d needs vtree's to be able to compile the CNF's into an SDD. They, however, both use things from the SAT literature. They both use clause learning and component caching as to be able to reuse components that later appear again in the search. Cachet on the other hand also uses some other things from SAT literature like an explicit on the fly calculation of connected components. This is different in minic2d as it uses a vtree to identify disconnected CNF components.

[1] [2]

1.3.3 Overview of computational requirements

All the tests can be found in the test folder. We used our scripts to create the dimac files. The input files for our enc1 and enc2 converter are “.dsc” files which can be found at

<http://www.bnlearn.com/bnrepository/discrete-small.html#cancer>.

Test 1: Cancer network

Table 1.1: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	1.0	0.2 KB	0.155s	1.0	1.0 KB	0.000s
Cachet	0	?	0.016s	1.0	?	0.016s

Test 2: asia network

Table 1.2: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	1.0	0.9 KB	0.145s	1.0	2.0 KB	0.139s
Cachet	0	?	0.018s	1	?	0.017s

Test 3: sach's network

Table 1.3: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	0.99707	14.3 KB	0.184s	1.0	14.5 KB	0.154s
Cachet	0	?	0.019s	1	?	0.017s

Test 4: earthquake network

Table 1.4: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	1.0	0.6 KB	0.137s	1.0	1.0 KB	0.153s
Cachet	0	?	0.016s	1	?	0.017s

Test 5: survey network

Table 1.5: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	1.0	1.6 KB	0.125s	1.0	2.0 KB	0.125s
Cachet	0	?	0.016s	1	?	0.016s

Test 6: alarm network

Table 1.6: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	0.999	819.4 KB	0.215s	0.999	147.2 KB	0.092s
Cachet	0	?	0.176s	1	?	0.222s

Test 7: andes network

Table 1.7: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	1.0	5.1GB	246.998s	1.0	364.1 MB	12.06s
Cachet	?	?	$> 4h(killed)$	b	val3	?

Test 8: child network

Table 1.8: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	1.0	45.8KB	0.076	1.0	30.8 KB	0.059s
Cachet	0	?	0.03s	1	?	0.03s

Test 9: hailfinder network

Table 1.9: My caption

	ENC1			ENC2		
	Prob	Memory	Runtime	Prob	Memory	Runtime
Minic2d	1.0	129.8 MB	0.999	1.0	13.1 MB	1.854
Cachet	val1	val2	a	b	val3	val4

1.4 Knowledge compilation

Chapter 2

Appendix

2.1 ENC1

Indicator clauses:

$$\begin{aligned} &(\neg \lambda_{PollutionLow} \vee \neg \lambda_{PollutionHigh}) \wedge (\lambda_{PollutionLow} \vee \lambda_{PollutionHigh}) \wedge (\neg \\ &\quad \lambda_{SmokerTrue} \vee \neg \lambda_{SmokerFalse}) \wedge (\lambda_{SmokerTrue} \vee \lambda_{SmokerFalse}) \wedge (\neg \\ &\quad \lambda_{CancerTrue} \vee \neg \lambda_{CancerFalse}) \wedge (\lambda_{CancerTrue} \vee \lambda_{CancerFalse}) \wedge (\neg \\ &\quad \lambda_{XrayPositive} \vee \neg \lambda_{XrayNegative}) \wedge (\lambda_{XrayPositive} \vee \lambda_{XrayNegative}) \wedge (\neg \\ &\quad \lambda_{DyspnoeaTrue} \vee \neg \lambda_{DyspnoeaFalse}) \wedge (\lambda_{DyspnoeaTrue} \vee \lambda_{DyspnoeaFalse}) \end{aligned}$$

Parameter clauses:

$$\begin{aligned} &(\neg \lambda_{PollutionLow} \vee \theta_{PollutionLow}) \wedge (\lambda_{PollutionLow} \vee \neg \theta_{PollutionLow}) \wedge (\neg \\ &\quad \lambda_{PollutionHigh} \vee \theta_{PollutionHigh}) \wedge (\lambda_{PollutionHigh} \vee \neg \theta_{PollutionHigh}) \wedge (\neg \\ &\quad \lambda_{SmokerTrue} \vee \theta_{SmokerTrue}) \wedge (\lambda_{SmokerTrue} \vee \neg \theta_{SmokerTrue}) \wedge (\neg \\ &\quad \lambda_{SmokerFalse} \vee \theta_{SmokerFalse}) \wedge (\lambda_{SmokerFalse} \vee \neg \theta_{SmokerFalse}) \wedge (\neg \\ &\quad \lambda_{PollutionLow} \vee \neg \lambda_{SmokerTrue} \vee \neg \lambda_{CancerTrue} \vee \\ &\quad \theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\lambda_{PollutionLow} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\lambda_{SmokerTrue} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\lambda_{CancerTrue} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\neg \lambda_{PollutionLow} \vee \neg \lambda_{SmokerTrue} \vee \neg \\ &\quad \lambda_{CancerFalse} \vee \theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\lambda_{PollutionLow} \vee \neg \\ &\quad \theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\lambda_{SmokerTrue} \vee \neg \\ &\quad \theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\lambda_{CancerFalse} \vee \neg \\ &\quad \theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\neg \lambda_{PollutionLow} \vee \neg \lambda_{SmokerFalse} \vee \neg \\ &\quad \lambda_{CancerTrue} \vee \theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\lambda_{PollutionLow} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\lambda_{SmokerFalse} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\lambda_{CancerTrue} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\neg \lambda_{PollutionLow} \vee \neg \lambda_{SmokerFalse} \vee \neg \\ &\quad \lambda_{CancerFalse} \vee \theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\lambda_{PollutionLow} \vee \neg \\ &\quad \theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\lambda_{SmokerFalse} \vee \neg \\ &\quad \theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\lambda_{CancerFalse} \vee \neg \\ &\quad \theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\neg \lambda_{PollutionHigh} \vee \neg \lambda_{SmokerTrue} \vee \neg \\ &\quad \lambda_{CancerTrue} \vee \theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\lambda_{PollutionHigh} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\lambda_{SmokerTrue} \vee \neg \\ &\quad \theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\lambda_{CancerTrue} \vee \neg \end{aligned}$$

$$\begin{aligned}
& \theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\neg \lambda_{PollutionHigh} \vee \neg \lambda_{SmokerTrue} \vee \neg \\
& \quad \lambda_{CancerFalse} \vee \theta_{CancerFalse|PollutionHigh,SmokerTrue}) \wedge (\lambda_{PollutionHigh} \vee \neg \\
& \quad \theta_{CancerFalse|PollutionHigh,SmokerTrue}) \wedge (\lambda_{SmokerTrue} \vee \neg \\
& \quad \theta_{CancerFalse|PollutionHigh,SmokerTrue}) \wedge (\lambda_{CancerFalse} \vee \neg \\
& \theta_{CancerFalse|PollutionHigh,SmokerTrue}) \wedge (\neg \lambda_{PollutionHigh} \vee \neg \lambda_{SmokerFalse} \vee \\
& \neg \lambda_{CancerTrue} \vee \theta_{CancerTrue|PollutionHigh,SmokerFalse}) \wedge (\lambda_{PollutionHigh} \vee \neg \\
& \quad \theta_{CancerTrue|PollutionHigh,SmokerFalse}) \wedge (\lambda_{SmokerFalse} \vee \neg \\
& \quad \theta_{CancerTrue|PollutionHigh,SmokerFalse}) \wedge (\lambda_{CancerTrue} \vee \neg \\
& \theta_{CancerTrue|PollutionHigh,SmokerFalse}) \wedge (\neg \lambda_{PollutionHigh} \vee \neg \lambda_{SmokerFalse} \vee \\
& \neg \lambda_{CancerFalse} \vee \theta_{CancerFalse|PollutionHigh,SmokerFalse}) \wedge (\lambda_{PollutionHigh} \vee \neg \\
& \quad \theta_{CancerFalse|PollutionHigh,SmokerFalse}) \wedge (\lambda_{SmokerFalse} \vee \neg \\
& \quad \theta_{CancerFalse|PollutionHigh,SmokerFalse}) \wedge (\lambda_{CancerFalse} \vee \neg \\
& \theta_{CancerFalse|PollutionHigh,SmokerFalse}) \wedge (\neg \lambda_{CancerTrue} \vee \neg \lambda_{XrayPositive} \vee \\
& \theta_{XrayPositive|CancerTrue}) \wedge (\lambda_{CancerTrue} \vee \neg \theta_{XrayPositive|CancerTrue}) \wedge \\
& (\lambda_{XrayPositive} \vee \neg \theta_{XrayPositive|CancerTrue}) \wedge (\neg \lambda_{CancerTrue} \vee \neg \\
& \quad \lambda_{XrayNegative} \vee \theta_{XrayNegative|CancerTrue}) \wedge (\lambda_{CancerTrue} \vee \neg \\
& \theta_{XrayNegative|CancerTrue}) \wedge (\lambda_{XrayNegative} \vee \neg \theta_{XrayNegative|CancerTrue}) \wedge (\neg \\
& \lambda_{CancerFalse} \vee \neg \lambda_{XrayPositive} \vee \theta_{XrayPositive|CancerFalse}) \wedge (\lambda_{CancerFalse} \vee \neg \\
& \theta_{XrayPositive|CancerFalse}) \wedge (\lambda_{XrayPositive} \vee \neg \theta_{XrayPositive|CancerFalse}) \wedge (\neg \\
& \lambda_{CancerFalse} \vee \neg \lambda_{XrayNegative} \vee \theta_{XrayNegative|CancerFalse}) \wedge (\lambda_{CancerFalse} \vee \\
& \neg \theta_{XrayNegative|CancerFalse}) \wedge (\lambda_{XrayNegative} \vee \neg \theta_{XrayNegative|CancerFalse}) \wedge \\
& (\neg \lambda_{CancerTrue} \vee \neg \lambda_{DyspnoeaTrue} \vee \theta_{DyspnoeaTrue|CancerTrue}) \wedge (\lambda_{CancerTrue} \\
& \vee \neg \theta_{DyspnoeaTrue|CancerTrue}) \wedge (\lambda_{DyspnoeaTrue} \vee \neg \theta_{DyspnoeaTrue|CancerTrue}) \\
& \wedge (\neg \lambda_{CancerTrue} \vee \neg \lambda_{DyspnoeaFalse} \vee \theta_{DyspnoeaFalse|CancerTrue}) \wedge \\
& (\lambda_{CancerTrue} \vee \neg \theta_{DyspnoeaFalse|CancerTrue}) \wedge (\lambda_{DyspnoeaFalse} \vee \neg \\
& \theta_{DyspnoeaFalse|CancerTrue}) \wedge (\neg \lambda_{CancerFalse} \vee \neg \lambda_{DyspnoeaTrue} \vee \\
& \theta_{DyspnoeaTrue|CancerFalse}) \wedge (\lambda_{CancerFalse} \vee \neg \theta_{DyspnoeaTrue|CancerFalse}) \wedge \\
& (\lambda_{DyspnoeaTrue} \vee \neg \theta_{DyspnoeaTrue|CancerFalse}) \wedge (\neg \lambda_{CancerFalse} \vee \neg \\
& \lambda_{DyspnoeaFalse} \vee \theta_{DyspnoeaFalse|CancerFalse}) \wedge (\lambda_{CancerFalse} \vee \neg \\
& \theta_{DyspnoeaFalse|CancerFalse}) \wedge (\lambda_{DyspnoeaFalse} \vee \neg \theta_{DyspnoeaFalse|CancerFalse})
\end{aligned}$$

Weights:

$$\begin{aligned}
W(\lambda_{PollutionLow}) &= 1.00 \\
W(\neg \lambda_{PollutionLow}) &= 1.00 \\
W(\lambda_{PollutionHigh}) &= 1.00 \\
W(\neg \lambda_{PollutionHigh}) &= 1.00 \\
W(\lambda_{SmokerTrue}) &= 1.00 \\
W(\neg \lambda_{SmokerTrue}) &= 1.00 \\
W(\lambda_{SmokerFalse}) &= 1.00 \\
W(\neg \lambda_{SmokerFalse}) &= 1.00 \\
W(\lambda_{CancerTrue}) &= 1.00 \\
W(\neg \lambda_{CancerTrue}) &= 1.00 \\
W(\lambda_{CancerFalse}) &= 1.00 \\
W(\neg \lambda_{CancerFalse}) &= 1.00 \\
W(\lambda_{XrayPositive}) &= 1.00 \\
W(\neg \lambda_{XrayPositive}) &= 1.00 \\
W(\lambda_{XrayNegative}) &= 1.00 \\
W(\neg \lambda_{XrayNegative}) &= 1.00 \\
W(\lambda_{DyspnoeaTrue}) &= 1.00 \\
W(\neg \lambda_{DyspnoeaTrue}) &= 1.00
\end{aligned}$$

$W(\lambda_{DyspnoeaFalse}) = 1.00$
 $W(\neg\lambda_{DyspnoeaFalse}) = 1.00$
 $W(\theta_{PollutionLow}) = 0.90$
 $W(\neg\theta_{PollutionLow}) = 1.00$
 $W(\theta_{PollutionHigh}) = 0.10$
 $W(\neg\theta_{PollutionHigh}) = 1.00$
 $W(\theta_{SmokerTrue}) = 0.30$
 $W(\neg\theta_{SmokerTrue}) = 1.00$
 $W(\theta_{SmokerFalse}) = 0.70$
 $W(\neg\theta_{SmokerFalse}) = 1.00$
 $W(\theta_{CancerTrue|PollutionLow,SmokerTrue}) = 0.03$
 $W(\neg\theta_{CancerTrue|PollutionLow,SmokerTrue}) = 1.00$
 $W(\theta_{CancerFalse|PollutionLow,SmokerTrue}) = 0.97$
 $W(\neg\theta_{CancerFalse|PollutionLow,SmokerTrue}) = 1.00$
 $W(\theta_{CancerTrue|PollutionLow,SmokerFalse}) = 0.00$
 $W(\neg\theta_{CancerTrue|PollutionLow,SmokerFalse}) = 1.00$
 $W(\theta_{CancerFalse|PollutionLow,SmokerFalse}) = 1.00$
 $W(\neg\theta_{CancerFalse|PollutionLow,SmokerFalse}) = 1.00$
 $W(\theta_{CancerTrue|PollutionHigh,SmokerTrue}) = 0.05$
 $W(\neg\theta_{CancerTrue|PollutionHigh,SmokerTrue}) = 1.00$
 $W(\theta_{CancerFalse|PollutionHigh,SmokerTrue}) = 0.95$
 $W(\neg\theta_{CancerFalse|PollutionHigh,SmokerTrue}) = 1.00$
 $W(\theta_{CancerTrue|PollutionHigh,SmokerFalse}) = 0.02$
 $W(\neg\theta_{CancerTrue|PollutionHigh,SmokerFalse}) = 1.00$
 $W(\theta_{CancerFalse|PollutionHigh,SmokerFalse}) = 0.98$
 $W(\neg\theta_{CancerFalse|PollutionHigh,SmokerFalse}) = 1.00$
 $W(\theta_{XrayPositive|CancerTrue}) = 0.90$
 $W(\neg\theta_{XrayPositive|CancerTrue}) = 1.00$
 $W(\theta_{XrayNegative|CancerTrue}) = 0.10$
 $W(\neg\theta_{XrayNegative|CancerTrue}) = 1.00$
 $W(\theta_{XrayPositive|CancerFalse}) = 0.20$
 $W(\neg\theta_{XrayPositive|CancerFalse}) = 1.00$
 $W(\theta_{XrayNegative|CancerFalse}) = 0.80$
 $W(\neg\theta_{XrayNegative|CancerFalse}) = 1.00$
 $W(\theta_{DyspnoeaTrue|CancerTrue}) = 0.65$
 $W(\neg\theta_{DyspnoeaTrue|CancerTrue}) = 1.00$
 $W(\theta_{DyspnoeaFalse|CancerTrue}) = 0.35$
 $W(\neg\theta_{DyspnoeaFalse|CancerTrue}) = 1.00$
 $W(\theta_{DyspnoeaTrue|CancerFalse}) = 0.30$
 $W(\neg\theta_{DyspnoeaTrue|CancerFalse}) = 1.00$
 $W(\theta_{DyspnoeaFalse|CancerFalse}) = 0.70$
 $W(\neg\theta_{DyspnoeaFalse|CancerFalse}) = 1.00$

2.2 ENC2

Indicator clauses

$$(\neg \lambda_{PollutionLow} \vee \neg \lambda_{PollutionHigh}) \wedge (\lambda_{PollutionLow} \vee \lambda_{PollutionHigh}) \wedge (\neg$$

$$\begin{aligned} & \lambda_{SmokerTrue} \vee \neg \lambda_{SmokerFalse} \wedge (\lambda_{SmokerTrue} \vee \lambda_{SmokerFalse}) \wedge (\neg \\ & \lambda_{CancerTrue} \vee \neg \lambda_{CancerFalse}) \wedge (\lambda_{CancerTrue} \vee \lambda_{CancerFalse}) \wedge (\neg \\ & \lambda_{XrayPositive} \vee \neg \lambda_{XrayNegative}) \wedge (\lambda_{XrayPositive} \vee \lambda_{XrayNegative}) \wedge (\neg \\ & \lambda_{DyspnoeaTrue} \vee \neg \lambda_{DyspnoeaFalse}) \wedge (\lambda_{DyspnoeaTrue} \vee \lambda_{DyspnoeaFalse}) \end{aligned}$$

Parameter clauses

$$\begin{aligned} & (\neg \rho_{PollutionLow} \vee \lambda_{PollutionLow}) \wedge (\rho_{PollutionLow} \vee \lambda_{PollutionHigh}) \wedge (\neg \\ & \rho_{SmokerTrue} \vee \lambda_{SmokerTrue}) \wedge (\rho_{SmokerTrue} \vee \lambda_{SmokerFalse}) \wedge (\neg \\ & \lambda_{PollutionLow} \vee \neg \lambda_{SmokerTrue} \vee \neg \rho_{CancerTrue|PollutionLow,SmokerTrue} \vee \\ & \lambda_{CancerTrue}) \wedge (\neg \lambda_{PollutionLow} \vee \neg \lambda_{SmokerTrue} \vee \\ & \rho_{CancerTrue|PollutionLow,SmokerTrue} \vee \lambda_{CancerFalse}) \wedge (\neg \lambda_{PollutionLow} \vee \neg \\ & \lambda_{SmokerFalse} \vee \neg \rho_{CancerTrue|PollutionLow,SmokerFalse} \vee \lambda_{CancerTrue}) \wedge (\neg \\ & \lambda_{PollutionLow} \vee \neg \lambda_{SmokerFalse} \vee \rho_{CancerTrue|PollutionLow,SmokerFalse} \vee \\ & \lambda_{CancerFalse}) \wedge (\neg \lambda_{PollutionHigh} \vee \neg \lambda_{SmokerTrue} \vee \neg \\ & \rho_{CancerTrue|PollutionHigh,SmokerTrue} \vee \lambda_{CancerTrue}) \wedge (\neg \lambda_{PollutionHigh} \vee \neg \\ & \lambda_{SmokerTrue} \vee \rho_{CancerTrue|PollutionHigh,SmokerTrue} \vee \lambda_{CancerFalse}) \wedge (\neg \\ & \lambda_{PollutionHigh} \vee \neg \lambda_{SmokerFalse} \vee \neg \rho_{CancerTrue|PollutionHigh,SmokerFalse} \vee \\ & \lambda_{CancerTrue}) \wedge (\neg \lambda_{PollutionHigh} \vee \neg \lambda_{SmokerFalse} \vee \\ & \rho_{CancerTrue|PollutionHigh,SmokerFalse} \vee \lambda_{CancerFalse}) \wedge (\neg \lambda_{CancerTrue} \vee \neg \\ & \rho_{XrayPositive|CancerTrue} \vee \lambda_{XrayPositive}) \wedge (\neg \lambda_{CancerTrue} \vee \\ & \rho_{XrayPositive|CancerTrue} \vee \lambda_{XrayNegative}) \wedge (\neg \lambda_{CancerFalse} \vee \neg \\ & \rho_{XrayPositive|CancerFalse} \vee \lambda_{XrayPositive}) \wedge (\neg \lambda_{CancerFalse} \vee \\ & \rho_{XrayPositive|CancerFalse} \vee \lambda_{XrayNegative}) \wedge (\neg \lambda_{CancerTrue} \vee \neg \\ & \rho_{DyspnoeaTrue|CancerTrue} \vee \lambda_{DyspnoeaTrue}) \wedge (\neg \lambda_{CancerTrue} \vee \\ & \rho_{DyspnoeaTrue|CancerTrue} \vee \lambda_{DyspnoeaFalse}) \wedge (\neg \lambda_{CancerFalse} \vee \neg \\ & \rho_{DyspnoeaTrue|CancerFalse} \vee \lambda_{DyspnoeaTrue}) \wedge (\neg \lambda_{CancerFalse} \vee \\ & \rho_{DyspnoeaTrue|CancerFalse} \vee \lambda_{DyspnoeaFalse}) \end{aligned}$$

Weights

$$\begin{aligned} W(\lambda_{PollutionLow}) &= 1.00 \\ W(\neg \lambda_{PollutionLow}) &= 1.00 \\ W(\lambda_{PollutionHigh}) &= 1.00 \\ W(\neg \lambda_{PollutionHigh}) &= 1.00 \\ W(\lambda_{SmokerTrue}) &= 1.00 \\ W(\neg \lambda_{SmokerTrue}) &= 1.00 \\ W(\lambda_{SmokerFalse}) &= 1.00 \\ W(\neg \lambda_{SmokerFalse}) &= 1.00 \\ W(\lambda_{CancerTrue}) &= 1.00 \\ W(\neg \lambda_{CancerTrue}) &= 1.00 \\ W(\lambda_{CancerFalse}) &= 1.00 \\ W(\neg \lambda_{CancerFalse}) &= 1.00 \\ W(\lambda_{XrayPositive}) &= 1.00 \\ W(\neg \lambda_{XrayPositive}) &= 1.00 \\ W(\lambda_{XrayNegative}) &= 1.00 \\ W(\neg \lambda_{XrayNegative}) &= 1.00 \\ W(\lambda_{DyspnoeaTrue}) &= 1.00 \\ W(\neg \lambda_{DyspnoeaTrue}) &= 1.00 \\ W(\lambda_{DyspnoeaFalse}) &= 1.00 \\ W(\neg \lambda_{DyspnoeaFalse}) &= 1.00 \\ W(\rho_{PollutionLow}) &= 0.90 \end{aligned}$$

$$\begin{aligned}
W(\neg \rho_{PollutionLow}) &= 0.10 \\
W(\rho_{SmokerTrue}) &= 0.30 \\
W(\neg \rho_{SmokerTrue}) &= 0.70 \\
W(\rho_{CancerTrue}|PollutionLow,SmokerTrue) &= 0.03 \\
W(\neg \rho_{CancerTrue}|PollutionLow,SmokerTrue) &= 0.97 \\
W(\rho_{CancerTrue}|PollutionLow,SmokerFalse) &= 0.00 \\
W(\neg \rho_{CancerTrue}|PollutionLow,SmokerFalse) &= 1.00 \\
W(\rho_{CancerTrue}|PollutionHigh,SmokerTrue) &= 0.05 \\
W(\neg \rho_{CancerTrue}|PollutionHigh,SmokerTrue) &= 0.95 \\
W(\rho_{CancerTrue}|PollutionHigh,SmokerFalse) &= 0.02 \\
W(\neg \rho_{CancerTrue}|PollutionHigh,SmokerFalse) &= 0.98 \\
W(\rho_{XrayPositive}|CancerTrue) &= 0.90 \\
W(\neg \rho_{XrayPositive}|CancerTrue) &= 0.10 \\
W(\rho_{XrayPositive}|CancerFalse) &= 0.20 \\
W(\neg \rho_{XrayPositive}|CancerFalse) &= 0.80 \\
W(\rho_{DyspnoeaTrue}|CancerTrue) &= 0.65 \\
W(\neg \rho_{DyspnoeaTrue}|CancerTrue) &= 0.35 \\
W(\rho_{DyspnoeaTrue}|CancerFalse) &= 0.30 \\
W(\neg \rho_{DyspnoeaTrue}|CancerFalse) &= 0.70
\end{aligned}$$

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