Inference for SRL

Armin Halilovic & Thierry Deruyttere (r0660485)

March 30, 2018

Probabilistic Inference Using Weighted Model Counting

1.1 PGM to CNF

1.1.1 ENC 1

Our ENC1 encoding for the Cancer Bayesian network can be found in appendix 4.1.

1.1.2 ENC 2

Our ENC2 encoding for the Cancer Bayesian network can be found in appendix 4.2.

1.2 SRL to CNF

1.2.1 Encoding of Monty Hall as CNF

Our CNF encoding for the given Monty Hall ProbLog program is as follows:
TODO

1.3 Weighted Model Counting

1.3.1 Weighted model counters on above CNFs

We will use MiniC2D and Cachet as WMC counters.

MiniC2D

MiniC2D needs to use the $-W$ option to do weighted model counting.

- ENC1:

Figure 1.1: Grounded problog cnf

- ENC2:

Figure 1.2: 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 1.3: 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 1.4: 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 selected WMCs

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 CNFs 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 vtrees to be able to compile the CNFs into an SDD. TThey, 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

3

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. [**?**] [**?**]

1.3.3 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 ard ".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	val1	val2	a	b	val3	val4

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	val1	val2	a	b	val3	val4

Test 3: sachs 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	val1	val2	a	b	val3	val4

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	val1	val2	a	b	val3	val4

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	val1	val2	a	b	val3	val4

Test 6: alarm network

Table 1.6: My caption

	ENC1			ENC2		
	Prob	**Memory**	**Runtime**	**Prob**	**Memory**	**Runtime**
Minic2d	1.0	959.7KB KB	0.268s	1.0	139KB	0.095s
Cachet	val1	val2	a	b	val3	val4

Test 6: andes network

Table 1.7: My caption

	ENC1			ENC2		
	Prob	**Memory**	**Runtime**	**Prob**	**Memory**	**Runtime**
Minic2d	1.0	2.7GB	122.78s	1.0	139.8MB	6.086s
Cachet	val1	val2	a	b	val3	val4

1.4 Knowledge compilation

Vtree with the most compact circuit

Pattern for a good vtree

Build an Inference Engine

pipeline info

Build an Inference Engine

learning

Appendix

4.1 ENC1

Indicator clauses:

$$(\neg \; \lambda_{PollutionLow} \; \vee \; \neg \; \lambda_{PollutionHigh}) \wedge (\lambda_{PollutionLow} \; \vee \; \lambda_{PollutionHigh}) \wedge (\neg$$
$$\lambda_{SmokerTrue} \; \vee \; \neg \; \lambda_{SmokerFalse}) \wedge (\lambda_{SmokerTrue} \; \vee \; \lambda_{SmokerFalse}) \wedge (\neg$$
$$\lambda_{CancerTrue} \; \vee \; \neg \; \lambda_{CancerFalse}) \wedge (\lambda_{CancerTrue} \; \vee \; \lambda_{CancerFalse}) \wedge (\neg$$
$$\lambda_{XrayPositive} \; \vee \; \neg \; \lambda_{XrayNegative}) \wedge (\lambda_{XrayPositive} \; \vee \; \lambda_{XrayNegative}) \wedge (\neg$$
$$\lambda_{DyspnoeaTrue} \; \vee \; \neg \; \lambda_{DyspnoeaFalse}) \wedge (\lambda_{DyspnoeaTrue} \; \vee \; \lambda_{DyspnoeaFalse})$$

Parameter clauses:

$$(\neg \; \lambda_{PollutionLow} \; \vee \; \theta_{PollutionLow}) \wedge (\lambda_{PollutionLow} \; \vee \; \neg \; \theta_{PollutionLow}) \wedge (\neg$$
$$\lambda_{PollutionHigh} \; \vee \; \theta_{PollutionHigh}) \wedge (\lambda_{PollutionHigh} \; \vee \; \neg \; \theta_{PollutionHigh}) \wedge (\neg$$
$$\lambda_{SmokerTrue} \; \vee \; \theta_{SmokerTrue}) \wedge (\lambda_{SmokerTrue} \; \vee \; \neg \; \theta_{SmokerTrue}) \wedge (\neg$$
$$\lambda_{SmokerFalse} \; \vee \; \theta_{SmokerFalse}) \wedge (\lambda_{SmokerFalse} \; \vee \; \neg \; \theta_{SmokerFalse}) \wedge (\neg$$
$$\lambda_{PollutionLow} \; \vee \; \neg \; \lambda_{SmokerTrue} \; \vee \; \neg \; \lambda_{CancerTrue} \; \vee$$
$$\theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\lambda_{PollutionLow} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\lambda_{SmokerTrue} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\lambda_{CancerTrue} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionLow,SmokerTrue}) \wedge (\neg \; \lambda_{PollutionLow} \; \vee \; \neg \; \lambda_{SmokerTrue} \; \vee \; \neg$$
$$\lambda_{CancerFalse} \; \vee \; \theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\lambda_{PollutionLow} \; \vee \; \neg$$
$$\theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\lambda_{SmokerTrue} \; \vee \; \neg$$
$$\theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\lambda_{CancerFalse} \; \vee \; \neg$$
$$\theta_{CancerFalse|PollutionLow,SmokerTrue}) \wedge (\neg \; \lambda_{PollutionLow} \; \vee \; \neg \; \lambda_{SmokerFalse} \; \vee \; \neg$$
$$\lambda_{CancerTrue} \; \vee \; \theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\lambda_{PollutionLow} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\lambda_{SmokerFalse} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\lambda_{CancerTrue} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionLow,SmokerFalse}) \wedge (\neg \; \lambda_{PollutionLow} \; \vee \; \neg \; \lambda_{SmokerFalse} \; \vee \; \neg$$
$$\lambda_{CancerFalse} \; \vee \; \theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\lambda_{PollutionLow} \; \vee \; \neg$$
$$\theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\lambda_{SmokerFalse} \; \vee \; \neg$$
$$\theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\lambda_{CancerFalse} \; \vee \; \neg$$
$$\theta_{CancerFalse|PollutionLow,SmokerFalse}) \wedge (\neg \; \lambda_{PollutionHigh} \; \vee \; \neg \; \lambda_{SmokerTrue} \; \vee \; \neg$$
$$\lambda_{CancerTrue} \; \vee \; \theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\lambda_{PollutionHigh} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\lambda_{SmokerTrue} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\lambda_{CancerTrue} \; \vee \; \neg$$
$$\theta_{CancerTrue|PollutionHigh,SmokerTrue}) \wedge (\neg \; \lambda_{PollutionHigh} \; \vee \; \neg \; \lambda_{SmokerTrue} \; \vee \; \neg$$
$$\lambda_{CancerFalse} \; \vee \; \theta_{CancerFalse|PollutionHigh,SmokerTrue}) \wedge (\lambda_{PollutionHigh} \; \vee \; \neg$$

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

Weights:

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

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

4.2 ENC2

Indicator clauses

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

$\lambda_{CancerTrue} \lor \neg \lambda_{CancerFalse}) \land (\lambda_{CancerTrue} \lor \lambda_{CancerFalse}) \land (\neg$
$\lambda_{XrayPositive} \lor \neg \lambda_{XrayNegative}) \land (\lambda_{XrayPositive} \lor \lambda_{XrayNegative}) \land (\neg$
$\lambda_{DyspnoeaTrue} \lor \neg \lambda_{DyspnoeaFalse}) \land (\lambda_{DyspnoeaTrue} \lor \lambda_{DyspnoeaFalse})$

Parameter clauses

$(\neg \rho_{PollutionLow} \lor \lambda_{PollutionLow}) \land (\rho_{PollutionLow} \lor \lambda_{PollutionHigh}) \land (\neg$
$\rho_{SmokerTrue} \lor \lambda_{SmokerTrue}) \land (\rho_{SmokerTrue} \lor \lambda_{SmokerFalse}) \land (\neg$
$\lambda_{PollutionLow} \lor \neg \lambda_{SmokerTrue} \lor \neg \rho_{CancerTrue|PollutionLow,SmokerTrue} \lor$
$\lambda_{CancerTrue}) \land (\neg \lambda_{PollutionLow} \lor \neg \lambda_{SmokerTrue} \lor$
$\rho_{CancerTrue|PollutionLow,SmokerTrue} \lor \lambda_{CancerFalse}) \land (\neg \lambda_{PollutionLow} \lor \neg$
$\lambda_{SmokerFalse} \lor \neg \rho_{CancerTrue|PollutionLow,SmokerFalse} \lor \lambda_{CancerTrue}) \land (\neg$
$\lambda_{PollutionLow} \lor \neg \lambda_{SmokerFalse} \lor \rho_{CancerTrue|PollutionLow,SmokerFalse} \lor$
$\lambda_{CancerFalse}) \land (\neg \lambda_{PollutionHigh} \lor \neg \lambda_{SmokerTrue} \lor \neg$
$\rho_{CancerTrue|PollutionHigh,SmokerTrue} \lor \lambda_{CancerTrue}) \land (\neg \lambda_{PollutionHigh} \lor \neg$
$\lambda_{SmokerTrue} \lor \rho_{CancerTrue|PollutionHigh,SmokerTrue} \lor \lambda_{CancerFalse}) \land (\neg$
$\lambda_{PollutionHigh} \lor \neg \lambda_{SmokerFalse} \lor \neg \rho_{CancerTrue|PollutionHigh,SmokerFalse} \lor$
$\lambda_{CancerTrue}) \land (\neg \lambda_{PollutionHigh} \lor \neg \lambda_{SmokerFalse} \lor$
$\rho_{CancerTrue|PollutionHigh,SmokerFalse} \lor \lambda_{CancerFalse}) \land (\neg \lambda_{CancerTrue} \lor \neg$
$\rho_{XrayPositive|CancerTrue} \lor \lambda_{XrayPositive}) \land (\neg \lambda_{CancerTrue} \lor$
$\rho_{XrayPositive|CancerTrue} \lor \lambda_{XrayNegative}) \land (\neg \lambda_{CancerFalse} \lor \neg$
$\rho_{XrayPositive|CancerFalse} \lor \lambda_{XrayPositive}) \land (\neg \lambda_{CancerFalse} \lor$
$\rho_{XrayPositive|CancerFalse} \lor \lambda_{XrayNegative}) \land (\neg \lambda_{CancerTrue} \lor \neg$
$\rho_{DyspnoeaTrue|CancerTrue} \lor \lambda_{DyspnoeaTrue}) \land (\neg \lambda_{CancerTrue} \lor$
$\rho_{DyspnoeaTrue|CancerTrue} \lor \lambda_{DyspnoeaFalse}) \land (\neg \lambda_{CancerFalse} \lor \neg$
$\rho_{DyspnoeaTrue|CancerFalse} \lor \lambda_{DyspnoeaTrue}) \land (\neg \lambda_{CancerFalse} \lor$
$\rho_{DyspnoeaTrue|CancerFalse} \lor \lambda_{DyspnoeaFalse})$

Weights
$W(\lambda_{PollutionLow}) = 1.00$
$W(\neg \lambda_{PollutionLow}) = 1.00$
$W(\lambda_{PollutionHigh}) = 1.00$
$W(\neg \lambda_{PollutionHigh}) = 1.00$
$W(\lambda_{SmokerTrue}) = 1.00$
$W(\neg \lambda_{SmokerTrue}) = 1.00$
$W(\lambda_{SmokerFalse}) = 1.00$
$W(\neg \lambda_{SmokerFalse}) = 1.00$
$W(\lambda_{CancerTrue}) = 1.00$
$W(\neg \lambda_{CancerTrue}) = 1.00$
$W(\lambda_{CancerFalse}) = 1.00$
$W(\neg \lambda_{CancerFalse}) = 1.00$
$W(\lambda_{XrayPositive}) = 1.00$
$W(\neg \lambda_{XrayPositive}) = 1.00$
$W(\lambda_{XrayNegative}) = 1.00$
$W(\neg \lambda_{XrayNegative}) = 1.00$
$W(\lambda_{DyspnoeaTrue}) = 1.00$
$W(\neg \lambda_{DyspnoeaTrue}) = 1.00$
$W(\lambda_{DyspnoeaFalse}) = 1.00$
$W(\neg \lambda_{DyspnoeaFalse}) = 1.00$
$W(\rho_{PollutionLow}) = 0.90$
$W(\neg \rho_{PollutionLow}) = 0.10$

$W(\rho_{SmokerTrue}) = 0.30$

$W(\neg\ \rho_{SmokerTrue}) = 0.70$

$W(\rho_{CancerTrue|PollutionLow,SmokerTrue}) = 0.03$

$W(\neg\ \rho_{CancerTrue|PollutionLow,SmokerTrue}) = 0.97$

$W(\rho_{CancerTrue|PollutionLow,SmokerFalse}) = 0.00$

$W(\neg\ \rho_{CancerTrue|PollutionLow,SmokerFalse}) = 1.00$

$W(\rho_{CancerTrue|PollutionHigh,SmokerTrue}) = 0.05$

$W(\neg\ \rho_{CancerTrue|PollutionHigh,SmokerTrue}) = 0.95$

$W(\rho_{CancerTrue|PollutionHigh,SmokerFalse}) = 0.02$

$W(\neg\ \rho_{CancerTrue|PollutionHigh,SmokerFalse}) = 0.98$

$W(\rho_{XrayPositive|CancerTrue}) = 0.90$

$W(\neg\ \rho_{XrayPositive|CancerTrue}) = 0.10$

$W(\rho_{XrayPositive|CancerFalse}) = 0.20$

$W(\neg\ \rho_{XrayPositive|CancerFalse}) = 0.80$

$W(\rho_{DyspnoeaTrue|CancerTrue}) = 0.65$

$W(\neg\ \rho_{DyspnoeaTrue|CancerTrue}) = 0.35$

$W(\rho_{DyspnoeaTrue|CancerFalse}) = 0.30$

$W(\neg\ \rho_{DyspnoeaTrue|CancerFalse}) = 0.70$