# Knowledge Compilation with Continuous Random Variables Applied to Probabilistic Logic Programming

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## The Goal

1. Determine probability of SMT formula being true
2. Apply result to Probabilistic Logic Programming

## Consider the SMT Formula

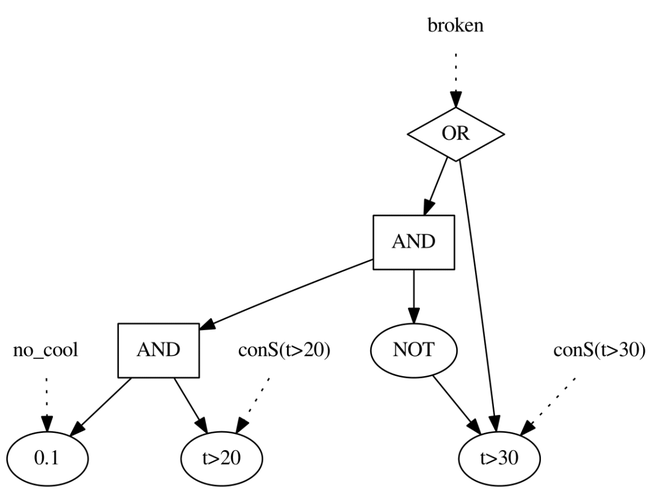
$$\texttt{broken} \leftrightarrow (\texttt{no\_cool} \wedge (\texttt{t} > 20)) \vee (\texttt{t} > 30)$$

## What Is Its Probability Given That:

$$p(\texttt{no\_broken}) = 0.01$$

$$t \sim \mathcal{N}(20, 5)$$

## Graphical Representation of Compiled Formula:




## How to Calculate the Probability from the Graphical Representation

1. Symbolically evaluate the arithmetic circuit:

$$0.01[\texttt{t}{>}20][\texttt{t}{\leq}30] + [\texttt{t}{>}30]$$

2. Multiply with probability densities:

$$(0.01[\texttt{t}{>}20][\texttt{t}{\leq}30] + [\texttt{t}{>}30])\,\mathcal{N}(20, 5)$$

3. Carry out integration over free continuous variables

$$0.01 \int_{20<\texttt{t}\leq 30} \mathcal{N}(20, 5)d\texttt{t} + \int_{\texttt{t}>30} \mathcal{N}(20, 5)d\texttt{t}$$

## Keywords

Knowledge Compilation - Algebraic Model Counting - Weighted Model Integration - Hybrid Probabilistic Logics

Symbolic Inference Engine used:
Gehr T., et. al PSI: Exact Symbolic Inference for Probabilistic Programs.

## Hybrid Logic Program

$$0.2 :: \texttt{h}.$$

$$0.01 :: \texttt{no\_cool}.$$

$$\texttt{normal}(20, 5) :: \texttt{t} \leftarrow \neg\texttt{h}.$$

$$\texttt{normal}(27, 5) :: \texttt{t} \leftarrow \texttt{h}.$$

$$\texttt{broken} \leftarrow \texttt{valS}(\texttt{t}, T), \texttt{conS}(T > 30).$$

$$\texttt{broken} \leftarrow \texttt{no\_cool}, \texttt{valS}(\texttt{t}, T), \texttt{conS}(T > 20).$$

## Grounded Hybrid Logic Program

$0.2{::}\texttt{h}.\quad 0.01{::}\texttt{no\_cool}.$

$(\texttt{t}|\neg\texttt{h} > 20, \texttt{normal}_{\texttt{t}|\neg\texttt{h}}(20, 5)){::}\texttt{conS}(\texttt{t} > 20) \leftarrow \neg\texttt{h}.$

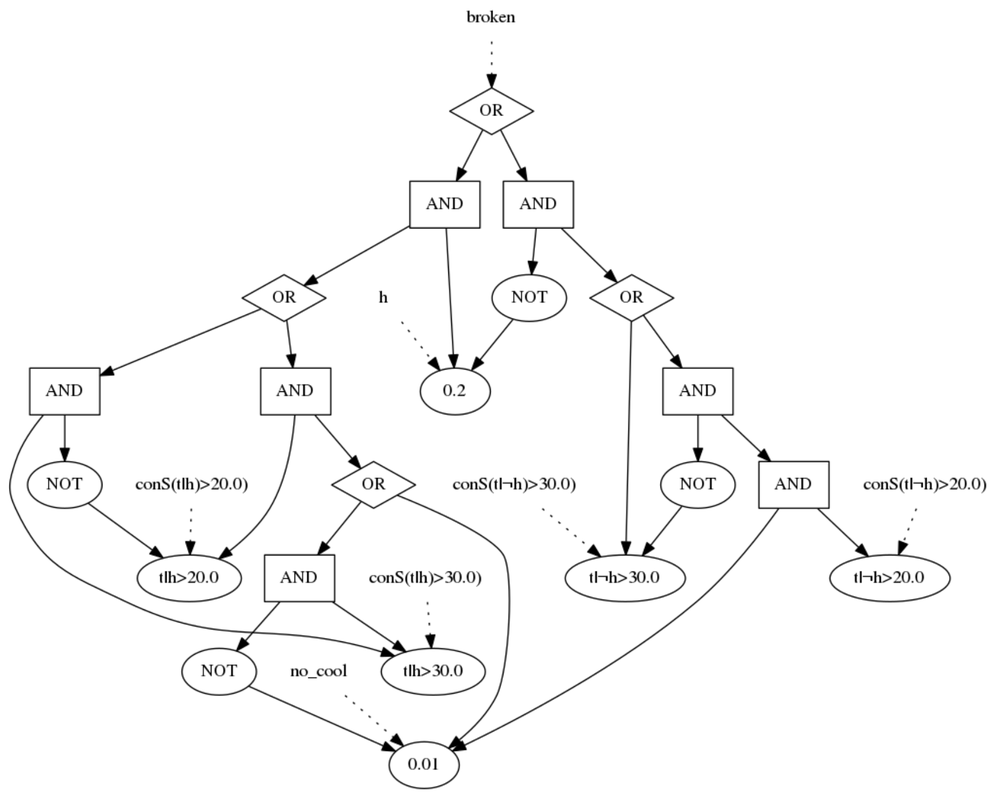
$(\texttt{t}|\texttt{w} > 20, \texttt{normal}_{\texttt{t}|\texttt{w}}(27, 5)){::}\texttt{conS}(\texttt{t} > 20) \leftarrow \texttt{h}.$

$(\texttt{t}|\neg\texttt{h} > 30, \texttt{normal}_{\texttt{t}|\neg\texttt{h}}(20, 5)){::}\texttt{conS}(\texttt{t} > 30) \leftarrow \neg\texttt{h}.$

$(\texttt{t}|\texttt{w} > 30, \texttt{normal}_{\texttt{t}|\texttt{w}}(27, 5)){::}\texttt{conS}(\texttt{t} > 30) \leftarrow \texttt{h}.$

$\texttt{broken} \leftarrow \texttt{conS}(\texttt{t} > 30).\ \texttt{broken} \leftarrow \texttt{no\_cool}, \texttt{conS}(\texttt{t} > 20).$

## Graphical Representation of Compiled Program




## Experimental Results (in milliseconds)

| Benchmark | KC | Evaluation | PSI | Domain |
|---|---|---|---|---|
| BurglarAlarm | 31.4 | 0.8 | 190.1 | Discrete |
| CoinBias | 41.9 | 7.9 | 12.9 | Hybrid |
| Grass | 31.2 | 1.2 | 228.0 | D |
| NoisyOR | 35.8 | 11.2 | 12.7 | D |
| TwoCoins | 27.0 | 2.1 | 57.8 | D |
| ClickGraph | 4300 | – | 10500 | H |
| ClinicalTrial | 54.6 | 25.7 | 3400 | H |
| AddFun/max | 25.2 | 4.4 | 53.1 | H |
| AddFun/sum | 27.1 | 2.1 | 84.9 | H |
| MurderMystery | 27.6 | 0.3 | 65.4 | D |