Pairwise Markov Logic

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Terminology

w_1 Smokes(x) **unit formula**

w_2 Smokes(x) $\rightarrow$ Asthma(x) **pairwise formula**

w_3 Friend(x,y) $\rightarrow$ (Smokes(x) $\leftrightarrow$ Smokes(y))

w_4 Property(x) $\wedge$ Property(y) $\rightarrow$ Link(x,y)

w_5 Class(x,c) $\wedge$ Link(x,y) $\rightarrow$ Class(y,c)
triplewise formula

Terminology

w_1 Smokes(x)

w_2 Smokes(x) $\rightarrow$ Asthma(x)

w_3 Friend(x,y) $\rightarrow$ (Smokes(x) $\leftrightarrow$ Smokes(y))

triplewise MLN

max formula length = 3

Terminology

w_1 Smokes(x)

w_2 Smokes(x) $\rightarrow$ Asthma(x)

pairwise MLN

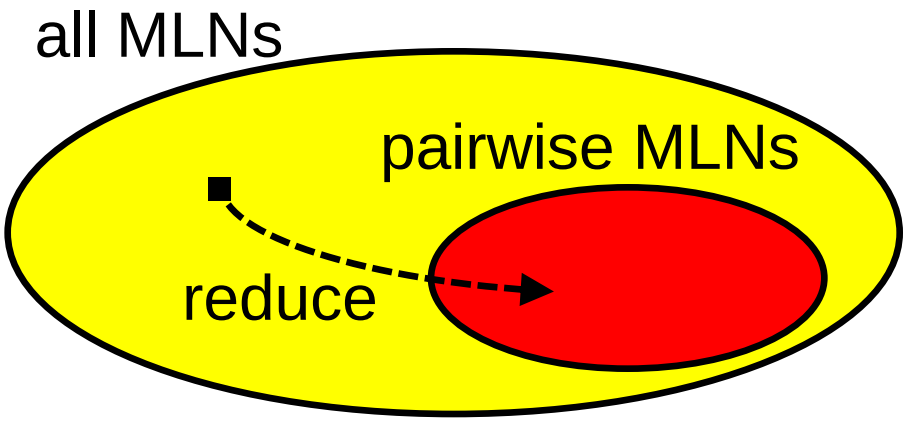
max formula length = 2

Pairwise Markov Logic

Pairwise MLNs:

☺ Convenient for inference

☹ Too restrictive when learning



Solution: **'reduce'** non-pairwise MLN to pairwise

Cf. graphical models literature

Advantage of Pairwise MLNs for Inference

We consider MPE inference ('MAP')

Ground-level inference:

Many state-of-the-art algorithms assume a pairwise model

Lifted inference:

Some recent algorithms use graph-theoretic notions that assume a pairwise model

Pairwise $\Rightarrow$ broader range of algorithms

The need for non-pairwise MLNs

w_1 Friend(x,y) → (Smokes(x) ↔ Smokes(y))

w_2 Property(x) ^ Property(y) → Link(x,y)

w_3 Class(x,c) ^ Link(x,y) → Class(y,c)

Relational patterns often require triplewise MLNs !

Reduce a triplewise MLN to a pairwise MLN

We can do it at the **ground** or the **first-order** level

Two-step rewriting process:

- Convert to normal form
- Reduce triplewise to pairwise

Trick: introduce auxiliary predicates

see paper

Example

w	Friend(x,y) → (Smokes(x) ↔ Smokes(y))

reduce

2w	Friend(x,y) ∧ A(x,y)
2w	Smokes(x) ∧ A(x,y)
2w	Smokes(y) ∧ A(x,y)
-w	Friend(x,y) ∧ Smokes(x)
-w	Friend(x,y) ∧ Smokes(y)
-4w	A(x,y)

Experiments

Compare:

- Inference on **triplewise** MLN
- Reduce & inference on **pairwise** MLN

240 experiments:

☺ 60% pairwise better

😐 38% same

☹ 2% triplewise better

Before doing inference:
do reduction to pairwise MLN