Feature Term Subsumption using Constraint Programming and Basic Variable Symmetry

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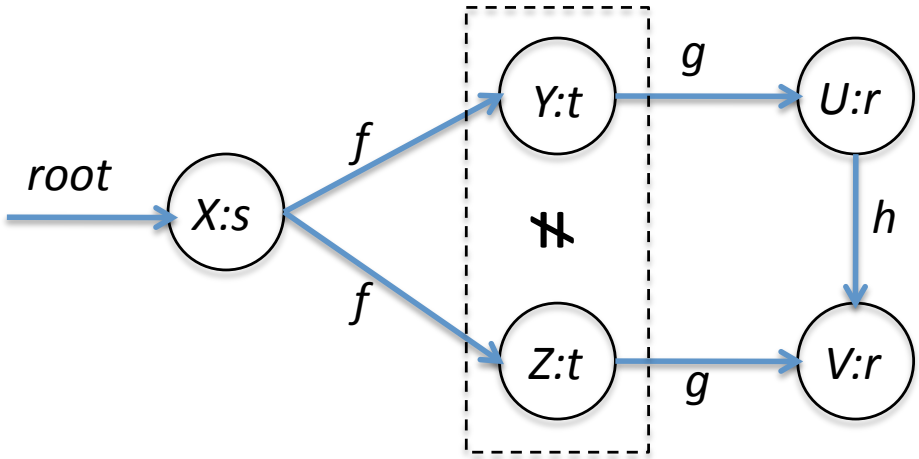
Overview

- Feature Terms
- Subsumption
- Constraint Model
- Variable Symmetry
- Experimental Results
- Conclusions

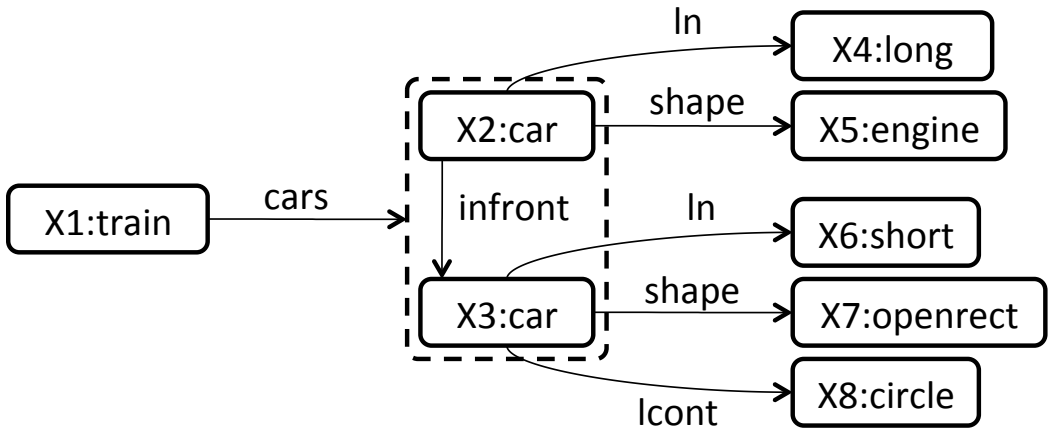
Feature Terms

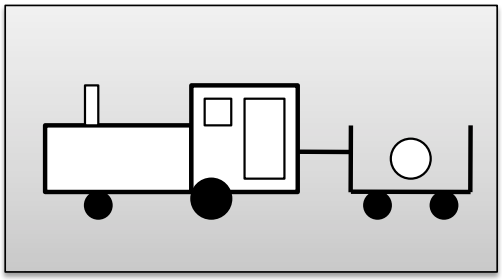
used in Machine Learning

feature terms = labeled directed graphs +
each node, a variable with sort +
a distinguished node (*root*) +
children with same label must be ≠



Example


X1:train
cars
X2:car
infront
X3:car
ln
X4:long
shape
X5:engine
ln
X6:short
shape
X7:openrect
X8:circle
lcont

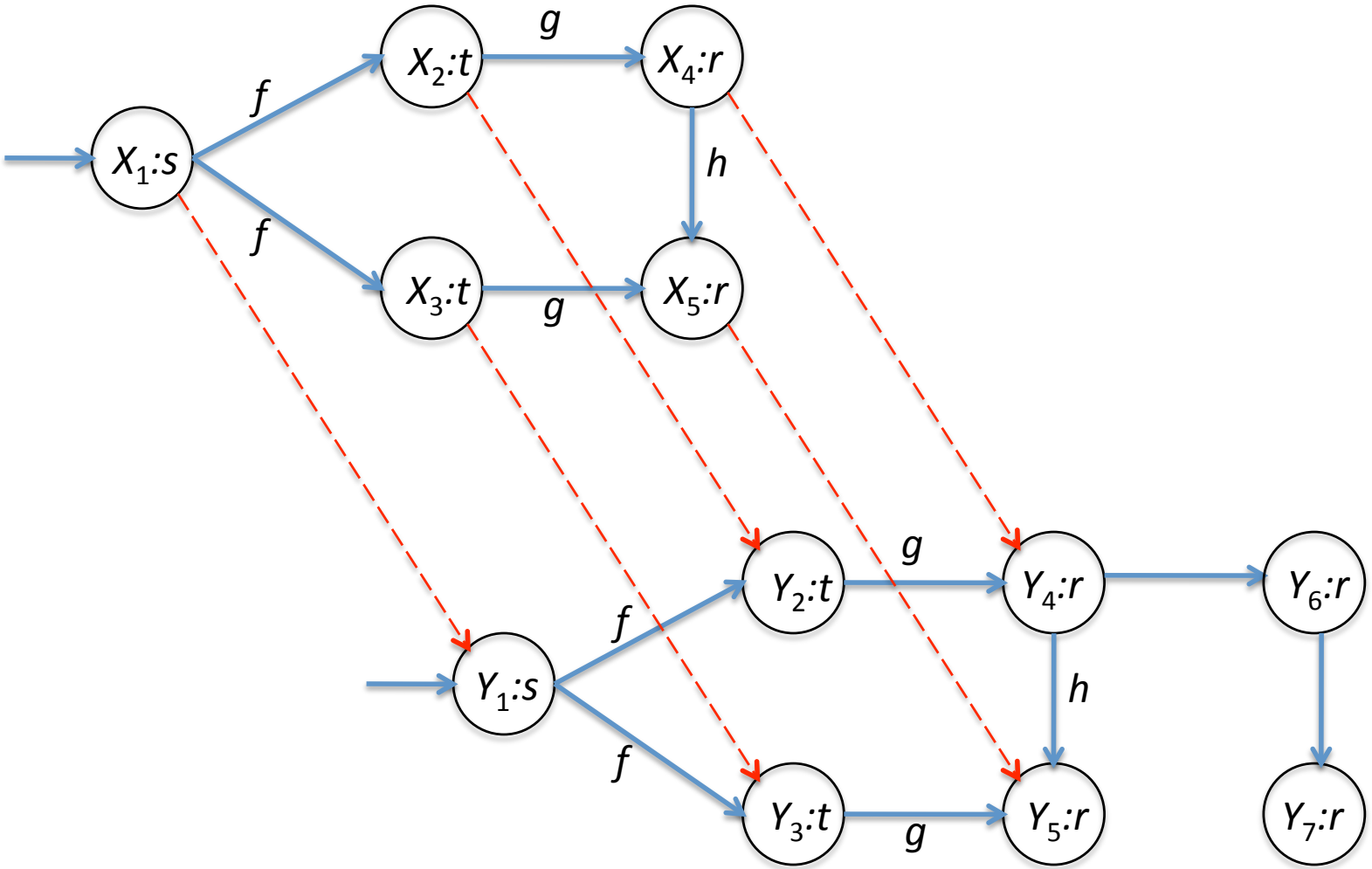


Subsumption

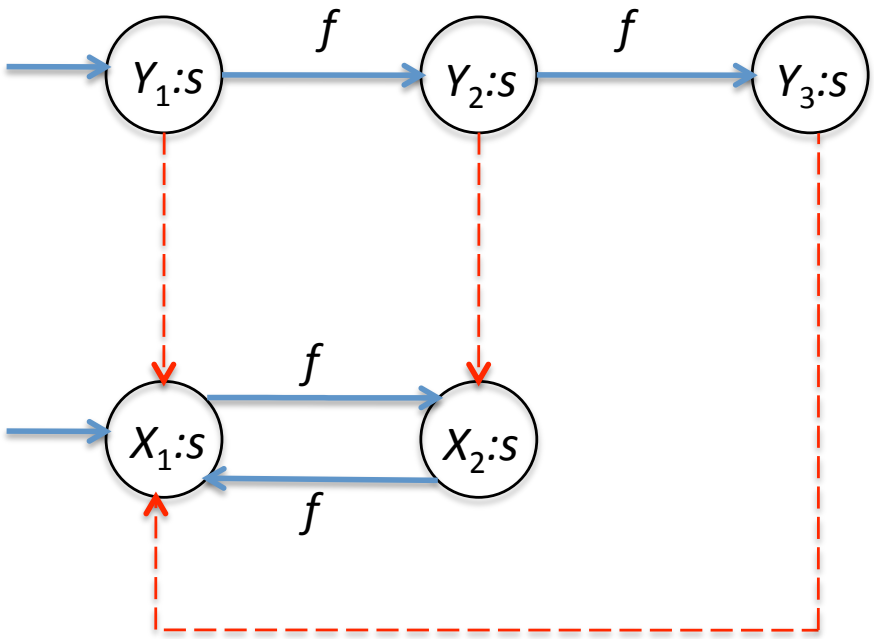
- ψ_1 ψ_2 FT, is ψ_1 more general than or equal to ψ_2?
  ψ_1 subsumes ψ_2?

- Subsumption: mapping *m*: *vars*(ψ_1) -> *vars*(ψ_2)
  - total [all variables of ψ_1 have an image]
  - *root*(ψ_2) = *m*(*root*(ψ_1))
  - sort(*X*) ≤ sort (*m*(*X*)) [more general or equal]
  - for any label *f* st *X.f* = Ψ_1 and *m*(*X.f*) = Ψ_2
    - for all *Y* in Ψ_1 there is a *Z* in Ψ_2 st *m*(*Y*) = *Z*
    - for all *Y, Z* in Ψ_1, if *Y*≠*Z* then *m*(*Y*) ≠ *m*(*Z*)

Example



Warning: Subsumption is not graph isomorphism!!



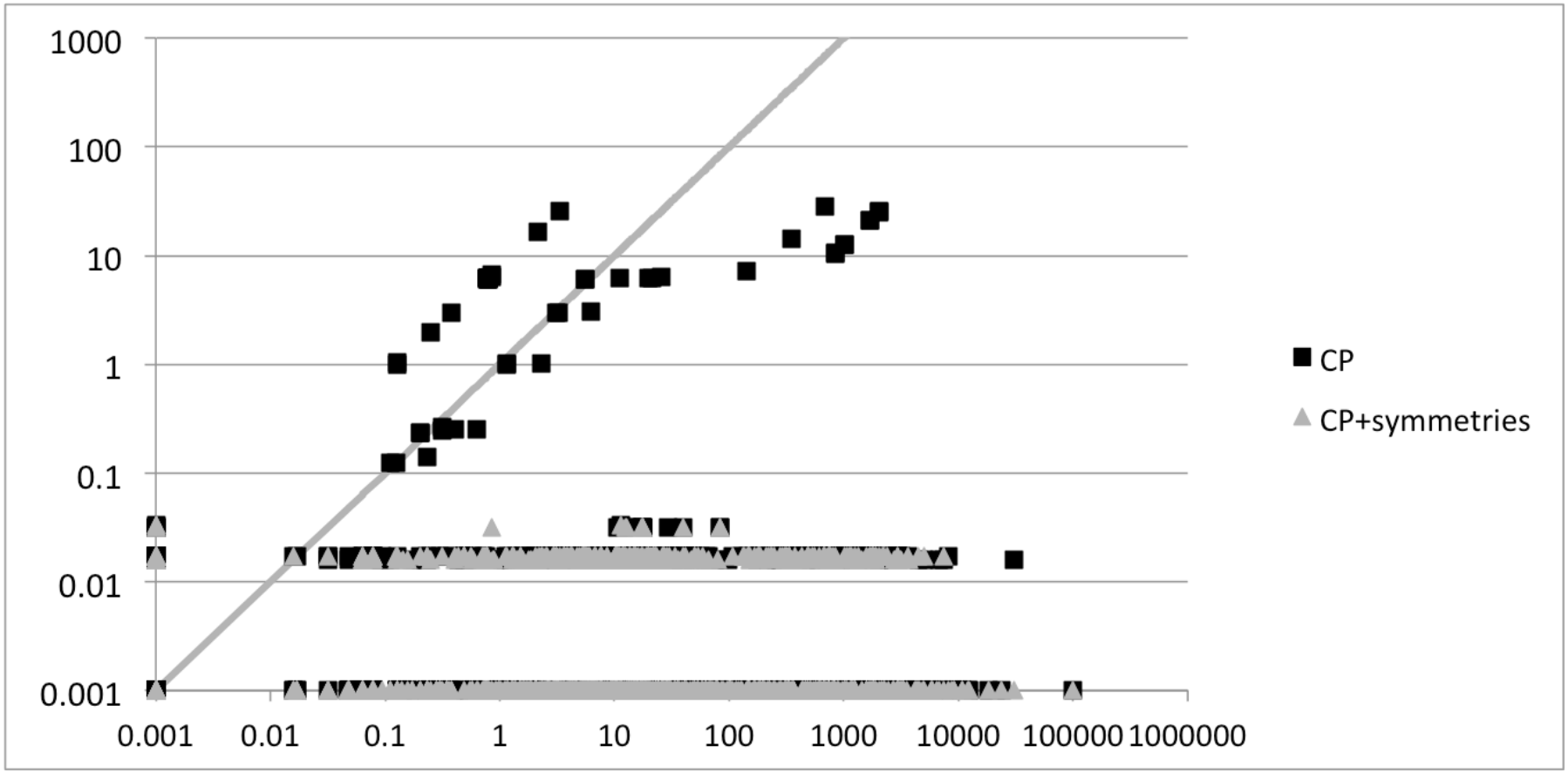
Subsumption Constraint Model

- Given ψ_1 ψ_2, find mapping m
- CP Variables = $vars(\psi_1)$
- Domains
  - $D(\text{root}(\psi_1))=\{\text{root}(\psi_2)\}$
  - any other $D=vars(\psi_2)$
- Constraints
  - unary on sorts (n)
  - binary on labels (n^2m)
  - all-different (nm)

Basic Variable Symmetry

- Interchangeable variables: they do not induce any syntactic change when permutting
- X, Y interchangeable: same parent, sort, children
- If X, Y interchangeable:
  - $m(X) \neq m(Y)$
  - exists m' equal to m except $m'(X)=m(Y)$, $m'(Y)=m(X)$
  - symmetry breaking constraint $m(X) < m(Y)$

Experimental Results



Conclusions

- CP + basic variable symmetry: substantially more efficient than traditional ML methods

- Future work:
  - More sophisticated forms of symmetry
  - Other operations of Feature Terms

Thanks for your attention!