Navigable atom-rule interactions in PSL models enhanced by rule verbalizations, with an application to etymological inference

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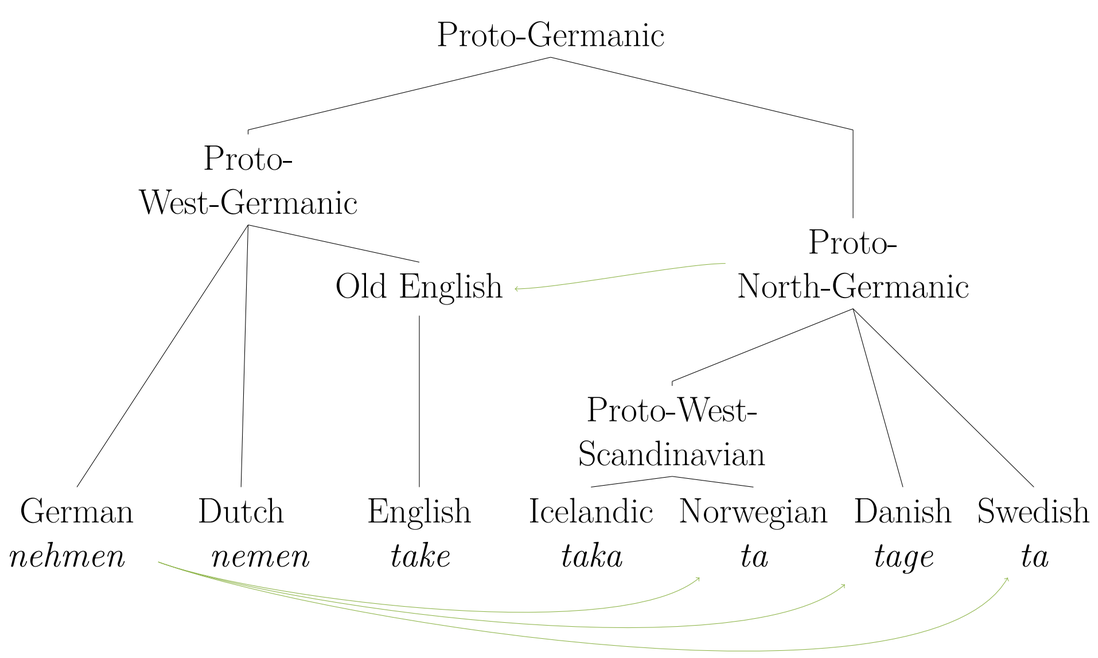
Etymological inference

What's the origin of a given word?



Probabilistic soft logic (PSL) [1]

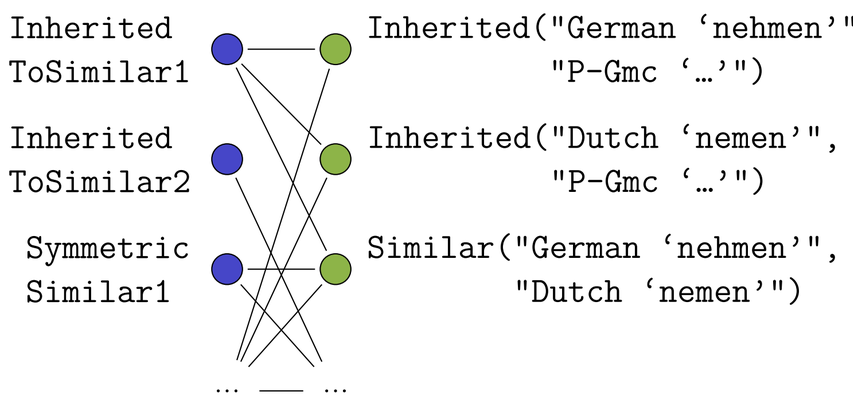
- Templating language for a graphical model for statistical relational learning → First-order logic + statistics
- **Atom** examples: `Inherited(X,Y)`, `Similar(X,Y)`, ...
- Atoms have values $\in [0;1]$ that are either fixed or should be inferred
- **Rule** examples: `Similar(X,Y) = Similar(Y,X) .`, `Inherited(X,Z) & Inherited(Y,Z) & (X != Y) -> Similar(X,Y)`
- **Ground** rules/atoms are ones where all variables are replaced by constants
- Rules are **satisfied** if their (in)equalities are fulfilled / if the score of a consequent in an implication is higher than that of the antecedent
- **Distance to satisfaction** quantifies how unsatisfied a rule is: max{antecedent score - consequent score, 0}

```
  Inherited("Icelandic ‘taka’","P-W-Sca ‘…’")     0.9 ⎫
& Inherited("Norwegian ‘ta’","P-W-Sca ‘…’")       0.9 ⎬0.8
& ("Icelandic ‘taka’" != "Norwegian ‘ta’")       1.0 ⎭ ≤
-> Similar("Icelandic ‘taka’","Norwegian ‘ta’")        0.7
                                                      ✗
```

→ distance to satisfaction: $0.8 - 0.7 = 0.1$

- Inference goal: minimize all distances to satisfaction

Rule-atom graph



Upward/downward pressure

Each rule-atom link exerts up- and/or downward **pressure** on the value of the atom:

```
     ↓                  ↓                          ↑
Inherited(X,Z) & Inherited(Y,Z) & (X!=Y) -> Similar(X,Y)
```

- Can explain why an atom value is higher/lower than expected
- GUI: "Why is the value not higher/lower?"

Rule activity

A rule is **active** with respect to an atom if

- it is dissatisfied
- it *would* be dissatisfied if the atom's value were changed slightly

Active rules directly contribute to the MAP estimate and thus the atoms' exact values!

- GUI: black (active) vs. grey (inactive) rules

Atom/rule verbalization

- Expressing the mechanics of each ground rule in terms of domain-specific natural language (useful for domain experts who don't know PSL)
- Based on templates
- Introductory sentence (idea behind the rule) & details specific to...
  - the rule grounding and atom value
  - the upward/downward pressure on the atom
  - the position of the atom within the rule
- GUI: toggle between internal (PSL) view and verbalized view

Try it out!

github.com/jdellert/psl-infrastructure
github.com/verenablaschke/psl-ragviewer

References

[1] Stephen H. Bach, Matthias Broecheler, Bert Huang, and Lise Getoor. Hinge-loss Markov random fields and probabilistic soft logic. *Journal of Machine Learning Research*, 18(109):1–67, 2017.

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