The Effect of Predicate Order on Curriculum Learning in ILP

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Motivation

- Progoļ - admissable single-clause search [Srinivasan, 1995] avoids degradation for single-clause search space
- Meta-Interpretive Learning - admissable search avoids degradation in multi-clause search?
Implementation of Meta-Interpreter

prove([], Prog, Prog).
prove([Atom|As], Prog1, Prog2) :-
  metarule(Name, MetaSub, (Atom :- Body), Order),
  Order, abduce(metasub(Name, MetaSub), Prog1, Prog3),
  prove(Body, Prog3, Prog4),
  prove(As, Prog4, Prog2).
# Universal Metarules [Cropper+Muggleton, 2015]

<table>
<thead>
<tr>
<th>Name</th>
<th>Metarule</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverse</td>
<td>$P(x, y) \leftarrow Q(y, x)$</td>
<td>$P \succ Q$</td>
</tr>
<tr>
<td>Chain</td>
<td>$P(x, y) \leftarrow Q(x, z), R(z, y)$</td>
<td>$P \succ Q, P \succ R$</td>
</tr>
<tr>
<td>TailRec</td>
<td>$P(x, y) \leftarrow Q(x, z), P(z, y)$</td>
<td>$P \succ Q, x \succ z \succ y$</td>
</tr>
</tbody>
</table>
Metagol Web Interface

Metagol is an inductive logic programming (ILP) system based on the meta-interpretive learning framework.
Download on Github: [https://github.com/metagol/metagol](https://github.com/metagol/metagol)

### Predicates to use in background knowledge

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of arguments</th>
</tr>
</thead>
<tbody>
<tr>
<td>add new</td>
<td></td>
</tr>
</tbody>
</table>

### Arguments to use in background knowledge

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>add new</td>
</tr>
</tbody>
</table>

### Edit background knowledge

<table>
<thead>
<tr>
<th>Predicate</th>
<th>Argument 1</th>
<th>Argument 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>add new</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Experimental domain**

**Materials.** Hindi family relationships - 43 family relations, 5000 individuals from US Bureau Census data.

<table>
<thead>
<tr>
<th>Family relationship</th>
<th>Hindi</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father’s brother</td>
<td>Taaoo</td>
<td>Uncle</td>
</tr>
<tr>
<td>Mother’s brother</td>
<td>MaaMaa</td>
<td>Uncle</td>
</tr>
<tr>
<td>Brother’s sister’s son</td>
<td>Beta</td>
<td>Nephew</td>
</tr>
<tr>
<td>Sister’s sister’s son</td>
<td>Bhaanjaa</td>
<td>Nephew</td>
</tr>
<tr>
<td>Daughter of mother’s brother</td>
<td>Deedee</td>
<td>Cousin</td>
</tr>
</tbody>
</table>
Experimental hypotheses

**Hypothesis 1.** Number of predicate definitions does not decrease Metagol performance.

**Experiment 1.** 50 trials, 43 predicates in each trial. Training on 1% positives and negatives. Testing on 10% positives and negatives.

**Hypothesis 2.** Learning with randomized order lowers predictive accuracy.

**Experiment 2.** Increasing number of random swaps. 50 trials, 43 predicates. Training on 20% positives and negatives. Testing on remaining 80% positives and negatives.
Experiment 1 - Well-Ordered

Accuracy

Learning time
Experiment 2 - Permuted

Predictive accuracy

accuracy vs. number of swaps

accuracy (with standard error)

number of swaps

0.925
0.92
0.915
0.91
0.91
0.905
0.9
0.9
0.895
0.89

0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50
Conclusions and further work

Quinlan and Cameron-Jones - FOIL mid-term report

Good ordering - admissable multi-clause search does not degrade

Random still does degrade search

Further work - dependent discovers reasonable ordering?
Bibliography

• Logical minimisation of meta-rules within meta-interpretive learning. ILP 2015.

• A. Cropper and S.H. Muggleton. Learning higher-order logic programs through abstraction and invention. IJCAI 2016.

