An Abduction Framework for Handling Incompleteness in First-Order Learning

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Overview

- INTHELEX
  - INcremental THEory Learner from EXamples
    - Features
    - Architecture
    - Multistrategy operators

- Experiments

- Connected Work
Features

- Multi-purpose
  - First-order logic hierarchical theories
- Object Identity assumption
- Fully incremental
  - Closed loop
- Multi-conceptual
  - Dependency graph
- Full memory storage
  - Historical memory of all positive/negative examples
- Multi-strategy
  - Induction
    - generalization, specialization
  - Abduction
  - Abstraction
  - Deduction
Induction

- Generalization
  - (Least) General Generalization
    - under Object Identity
  - Addition of new clause
  - Exception

- Specialization
  - Addition of positive literal(s)
    - Any clause in the derivation
  - Addition of negative literal
    - Top-level clause
  - Exception
Deduction

- Based on a saturation operator
  - Recognizes higher level concepts, deduced via subsumption and/or resolution, in the example descriptions

```
father(X, Y) :-
  parent(X,Y),
  male(X).
```

```
grand_father(mike, anne) :-
  parent(mike,john),
  male(mike),
  parent(john,anne),
  male(john).
```

```
grand_father(mike, anne) :-
  parent(mike,john),
  male(mike),
  father(mike,john),
  parent(john,anne),
  male(john),
  father(john,anne).
```
Abstraction

• Shift of representation language
  – Abstraction Theory
    • Set of operators
      – Replacing a number of components by a compound object
      – Decreasing the grain-size of a set of values
      – Ignoring whole objects or just part of their features
      – Neglecting the number of occurrences of some kind of object

Abstraction Theory

father(X, Y) :-
  parent(X,Y),
  male(X).

grand_father(mike, anne) :-
  parent(mike,john),
  male(mike),
  parent(john,anne).

Abstraction operator

grand_father(mike, anne) :-
  father(mike,john),
  parent(john,anne).
Abduction

- Abductive logic theory
  - Intertwined abductive and consistency derivations
    - Abducibles
      - Predicates on which abductions can be made
    - Integrity Constraints
      - Indirect information about abducibles
- Given a goal and a set of initial assumptions
  Find a set of consistency hypotheses

father(x,y) :-
  parent(x,y),
  male(x).

father(mike,mary) :-
  parent(mike,mary).

:- male(x),female(x).

male(mike).
Experiments

• Multiplexer
  – 64 possible configurations
    • 25% examples corrupted by 50% of description
  – Better behaviour and theories
  – Same time and accuracy

• Congressional Voting Records
  – Better behaviour, theories and accuracy
  – 33% worse runtime
Experiments

- Family Relationships
  - 36+, 200– examples, 742 literals description
    - Progressive Corruption (100% .. 40%)
    - Better behaviour, theories, runtime and accuracy

- Scientific Paper Classification
  - 4 classes, 112 literals description on average
    - 8% corruption of each example
  - Better behaviour, theories and accuracy
  - Worse runtime
Connected Work

- Automatic induction of integrity constraints
  - Providing correct abstraction theories can be difficult even for human experts
    - See above experiments for performance

- Induction of type constraints
  - Groups of unary predicates that represent different values of the same property
    - At most one literal in each group can be true for any given term
      - Speeds up the abductive proof