Can predicate invention in meta-interpretive learning compensate for incomplete background knowledge?

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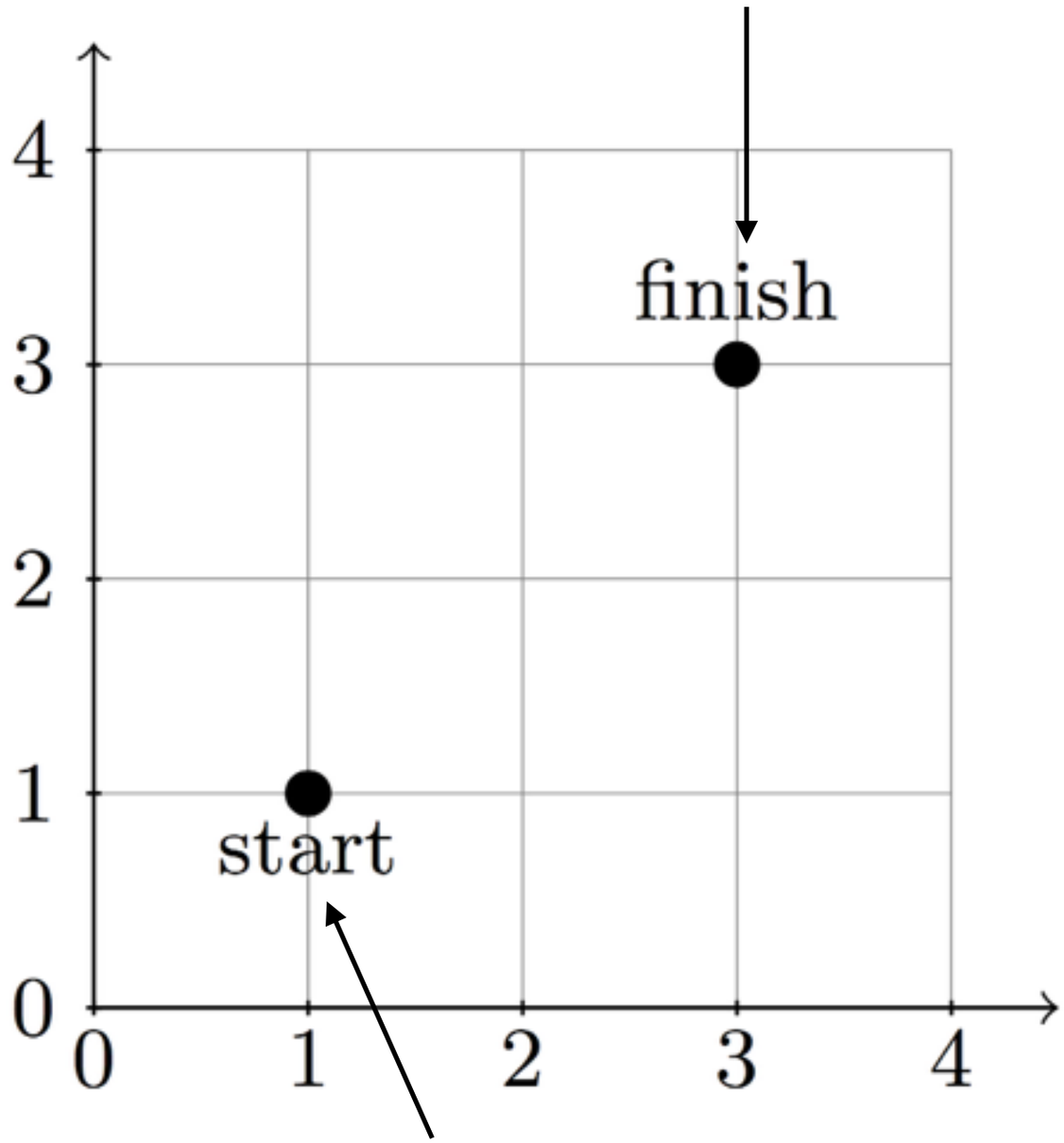
Outline

- robot planning
  - experiments
  - predicate invention
  - related work
  - conclusions and future work

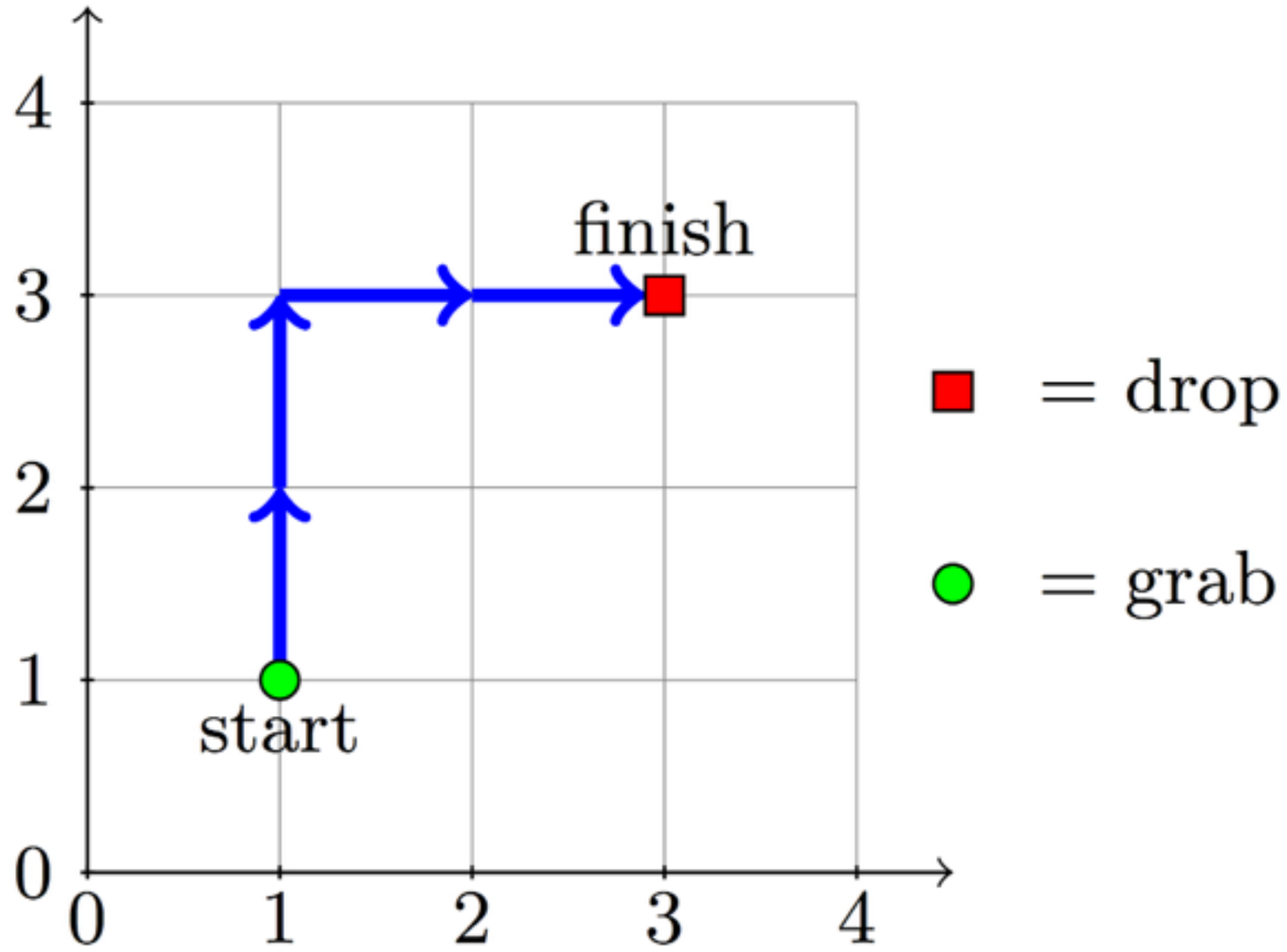
Robot moving a ball - all actions

robot actions:
left/2
right/2
forwards/2
backwards/2
grab/2
drop/2



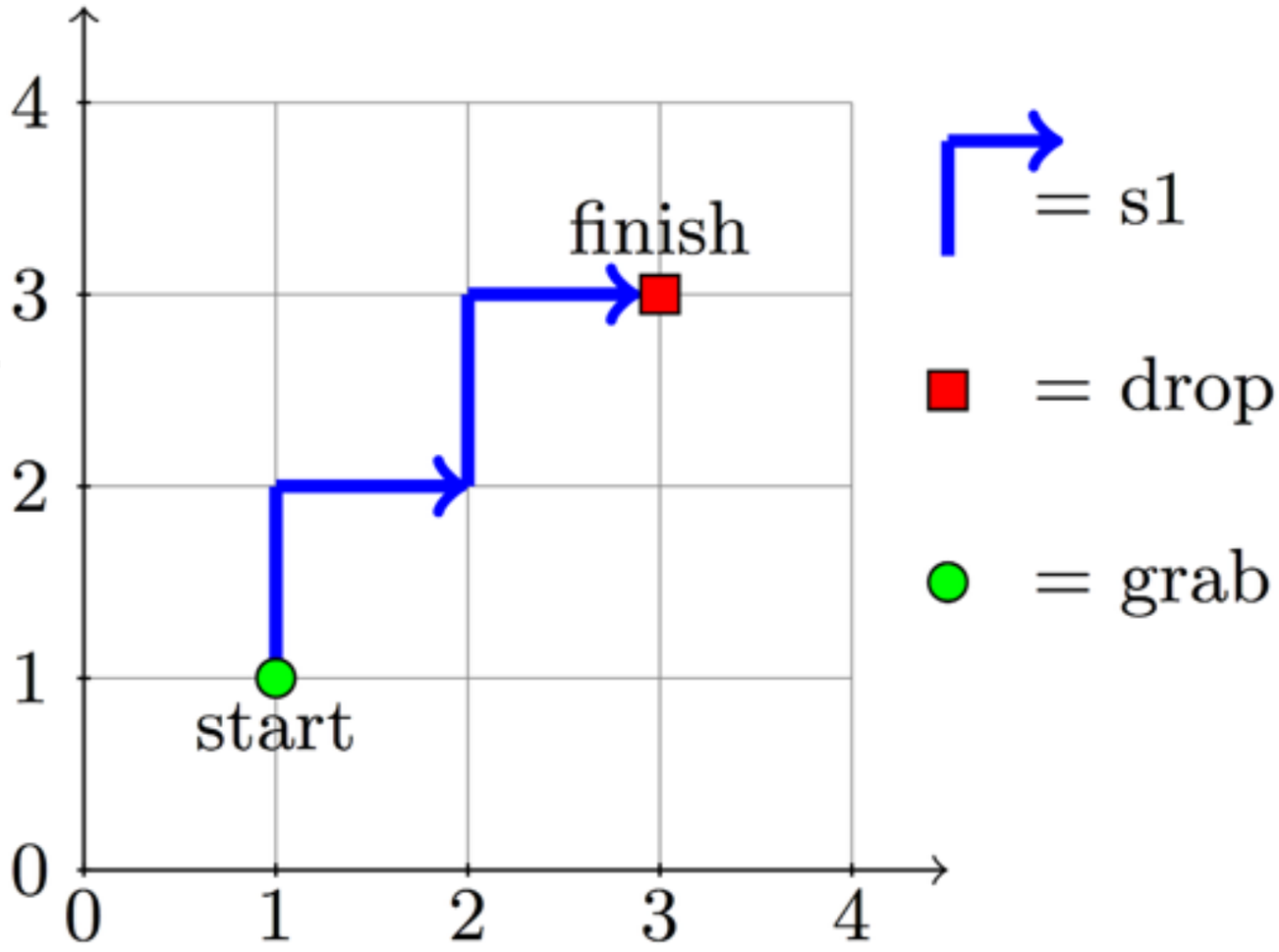
Possible plan

```
move_ball(X,Y) :-
  grab(X,Z1)
  forwards(Z1,Z2),
  forwards(Z2,Z3),
  right(Z3,Z4),
  right(Z4,Z5),
  drop(Z5,Y).
```



Plan learned with MIL

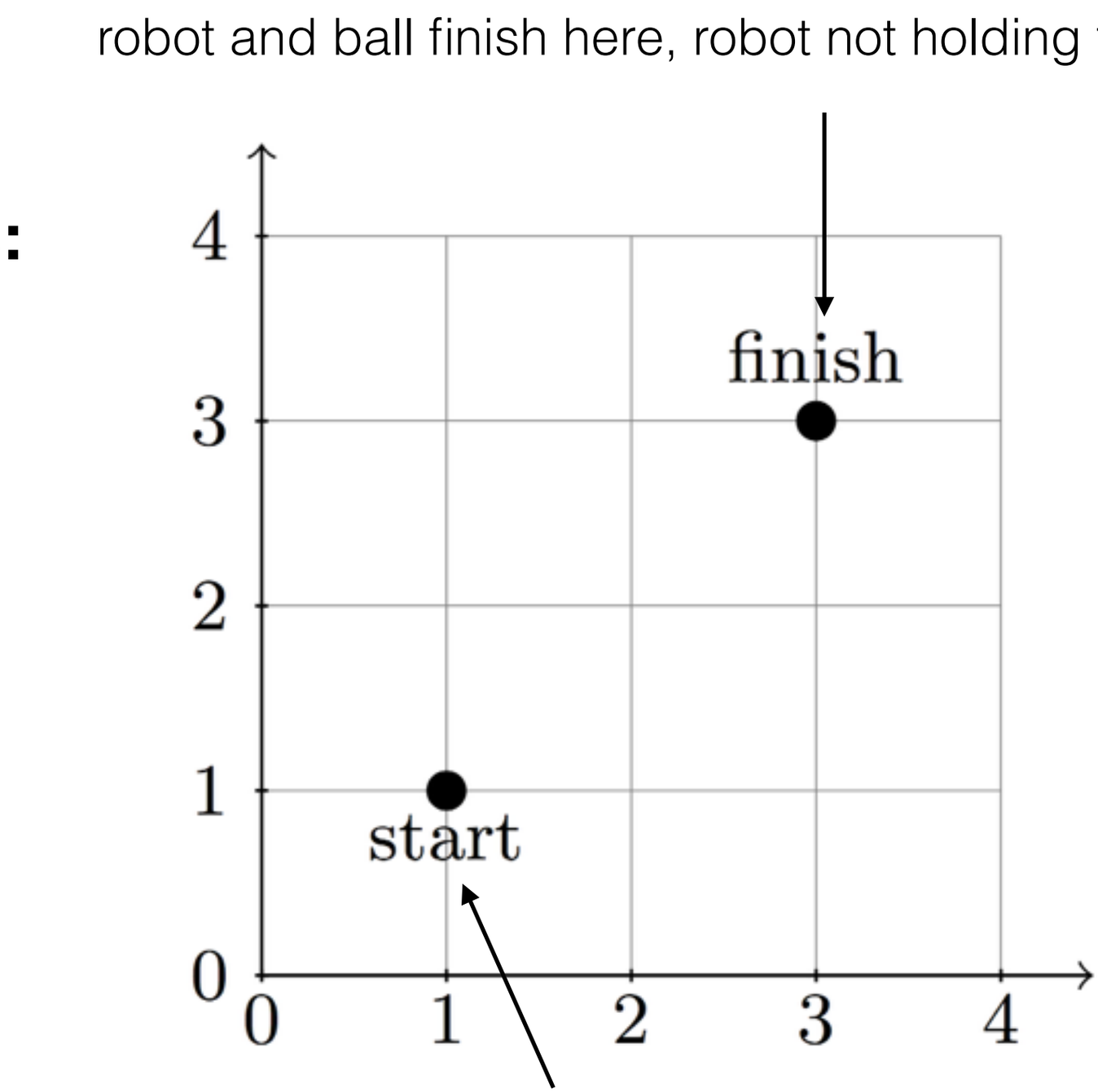
```
s1(X,Y):- forwards(X,Z),right(Z,Y).
s2(X,Y):- s1(X,Z),s1(Z,Y).
s3(X,Y):- grab(X,Z), s2(Z,Y).
move(X,Y):- s3(X,Z),drop(Z,Y).
```



s1,s3,s3 are invented predicates

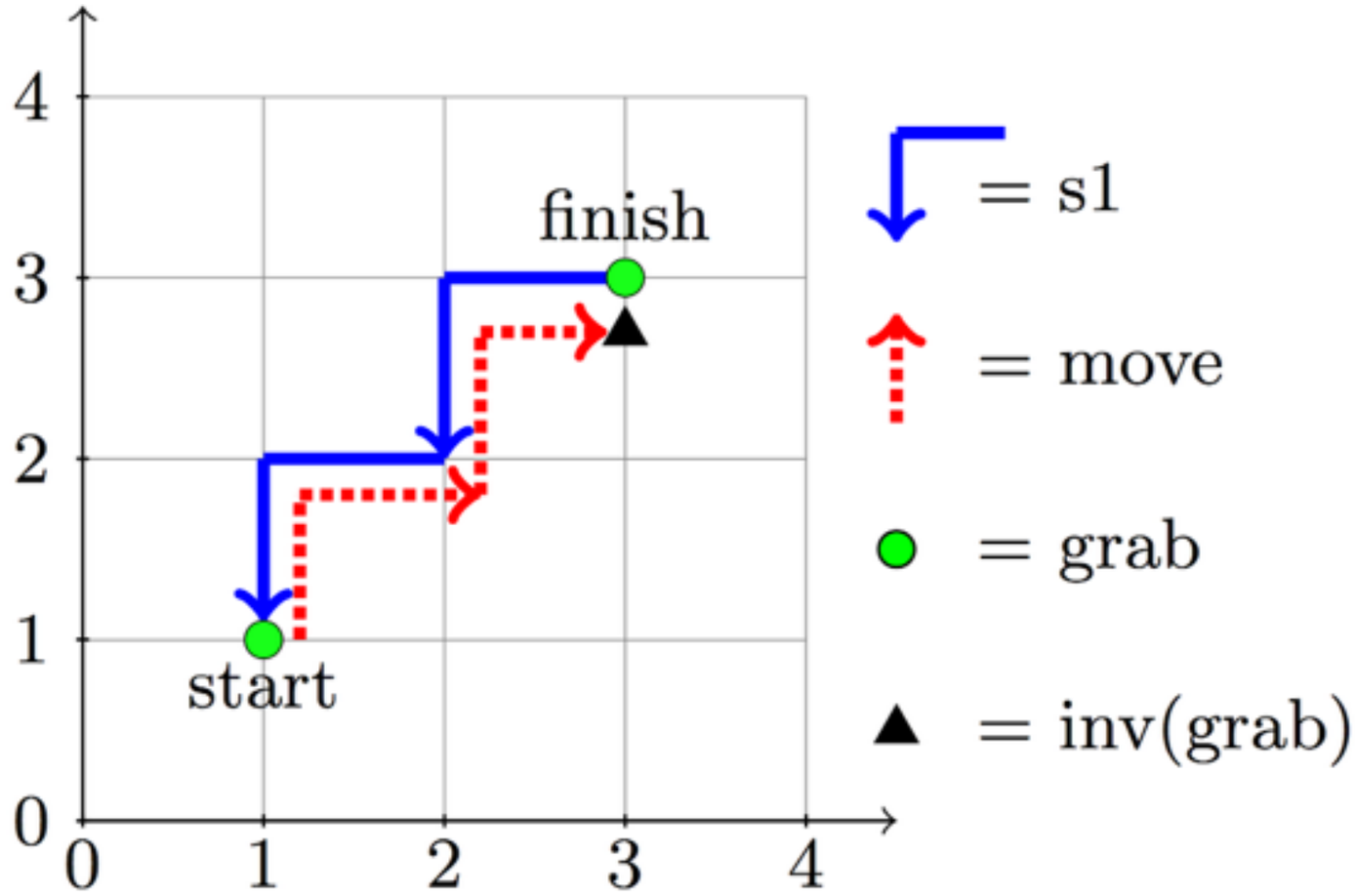
Robot moving a ball - missing actions

robot actions:
left/2
~~right/2~~
~~forwards/2~~
backwards/2
grab/2
~~drop/2~~



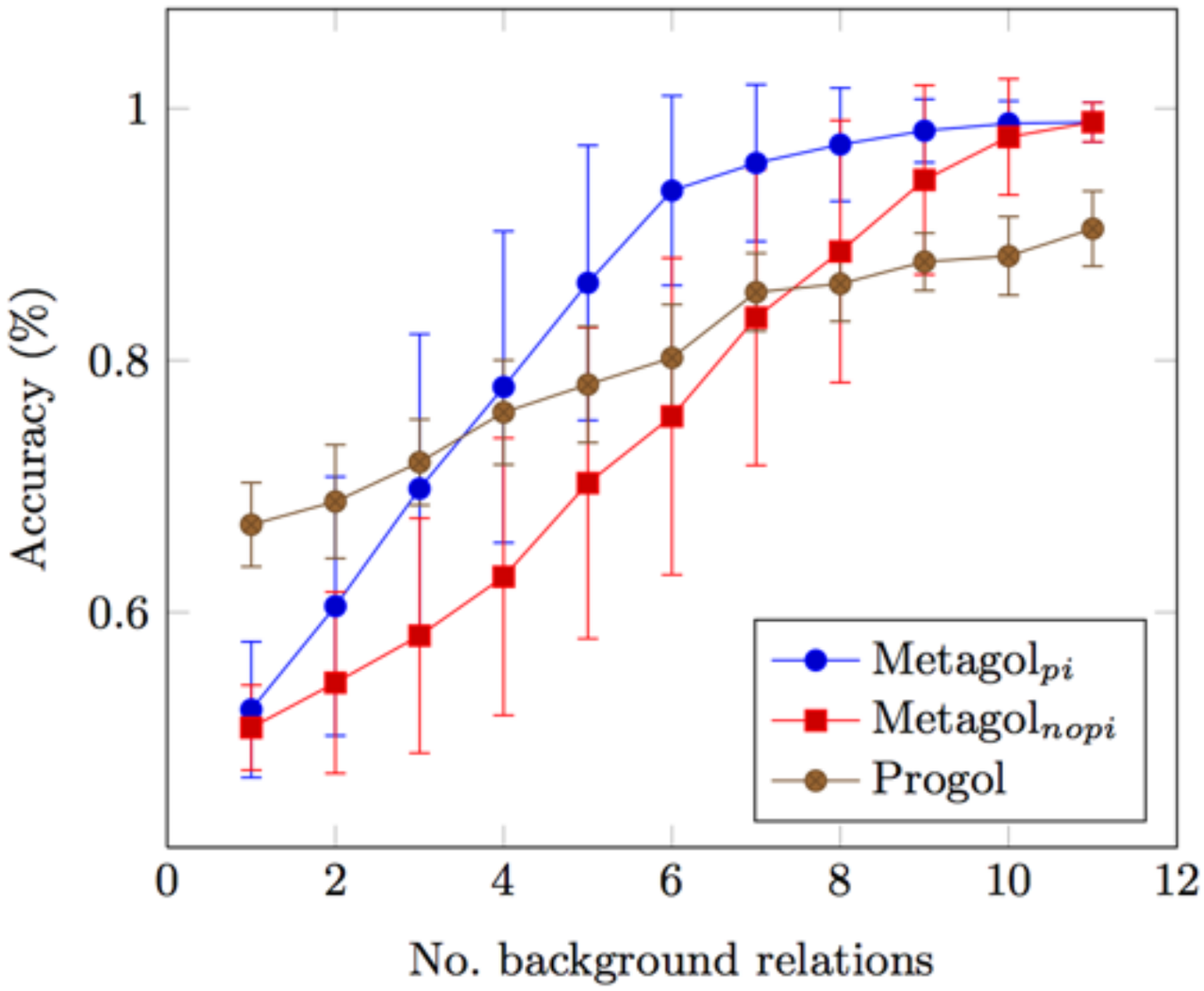
Plan learned with MIL

```
s1(X,Y):- left(X,Z), back(Z,Y).
s2(X,Y):- grab(X,Z), s1(Z,Y).
s3(X,Y):- s2(X,Z), s1(Z,Y).
s4(X,Y):- s3(Y,X).
move(X,Y):- grab(X,Z), s4(Z,Y).
```

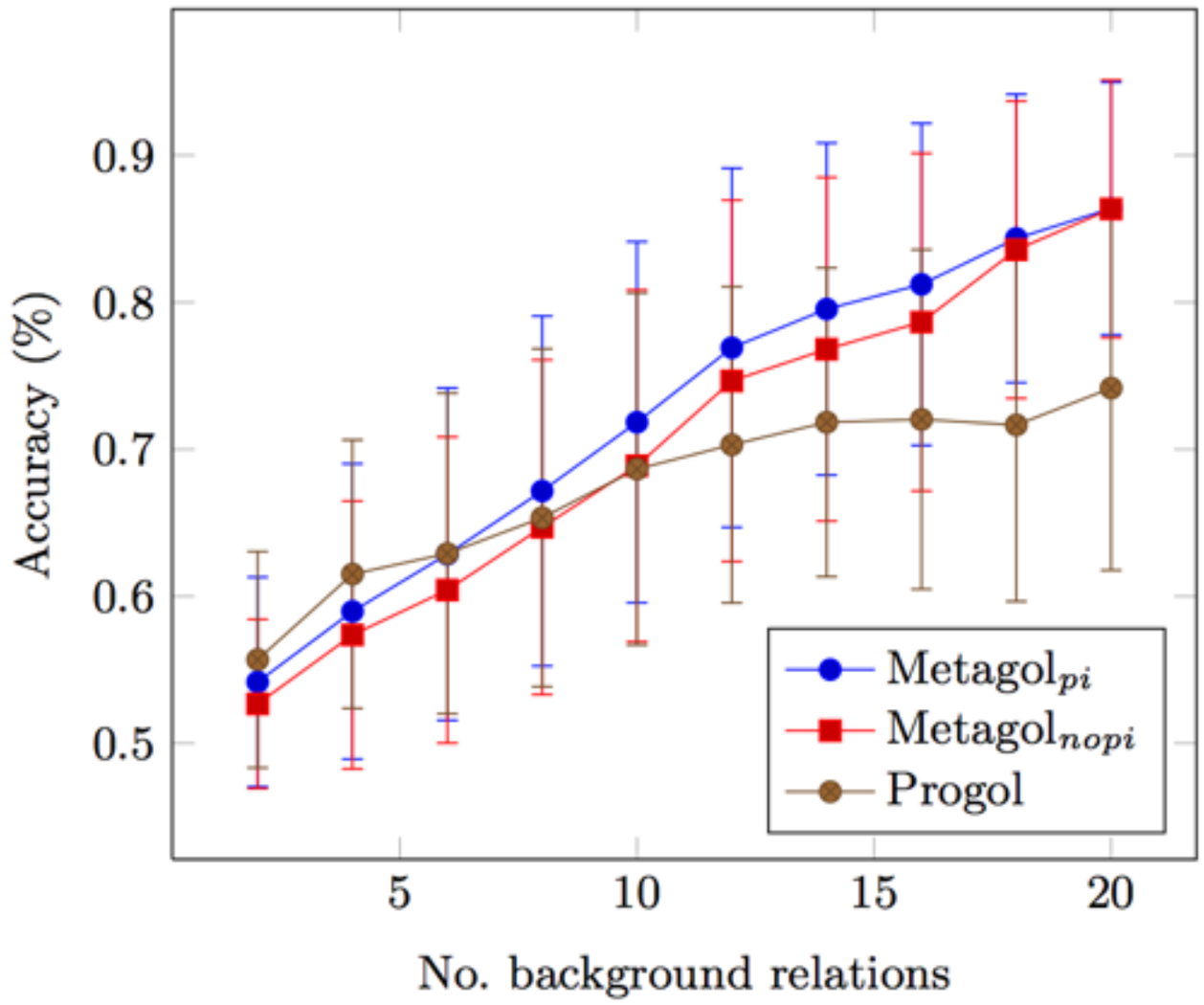


s1,s3,s3,s4 are invented predicates

Experiments



(a) Hinton's kinship dataset



(b) Our kinship dataset

(a) 12 dyadic predicates and 104 examples uniformly distributed
(b) 21 dyadic predicates and 154 examples normally distributed

Learning great-great-grandparent relation

How can we learn the great-great-grandparent relation if we only have mother and father relation?

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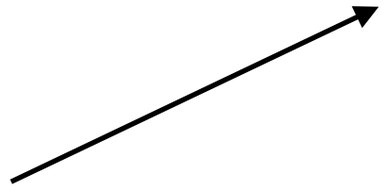
s2 = invented *parent* relation

s2(X,Y):- father(X,Y).
s2(X,Y):- mother(X,Y).
s3(X,Y):- s2(X,Z), s2(Z,Y).
gggparent(X,Y):- s3(X,Z), s2(Z,Y).



s3 = invented *grandparent* relation

Related work

Missing data (feature based ML)

- Ghahramani & Jordan (1995)
- Marlin (2006)

Incomplete background knowledge

- Srinivasan, et al.,(1995)
- Muggleton(2011)

Effect of missing predicates

- Liu and Zhong (1999)

Compensating for incomplete background knowledge

- Dzeroski (1993)

Dimensionality reduction

- Furnkranz (1997)

Conclusions and future work

Conclusions

- MIL can compensate for missing background predicates through predicate invention.
- Purposely remove background predicates to improve efficiency, analogous to dimensionality reduction.

Future work

- Automate removal of redundant background predicates
- Naming invented predicates