Learning efficient logical robot strategies involving composable objects

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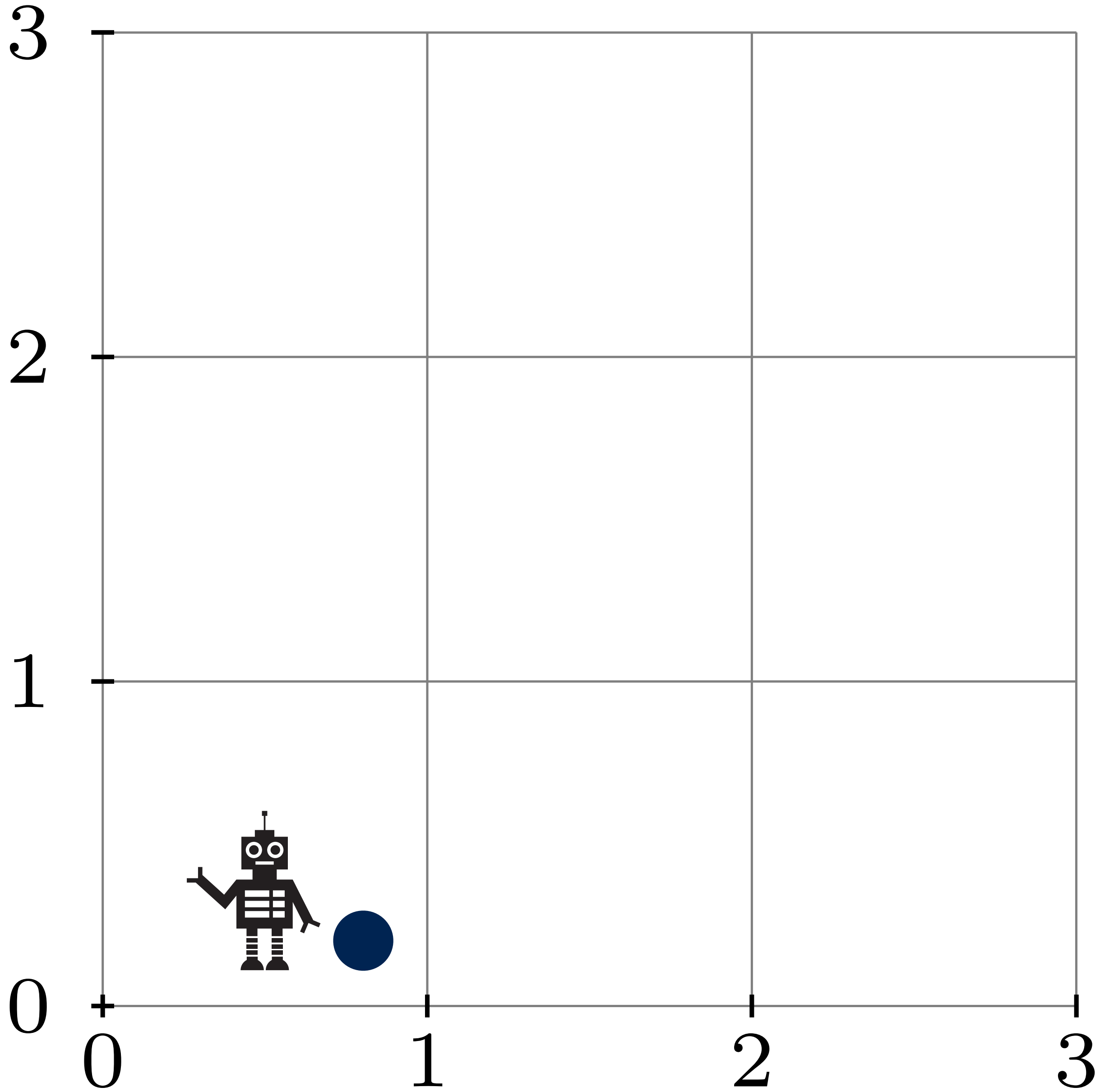
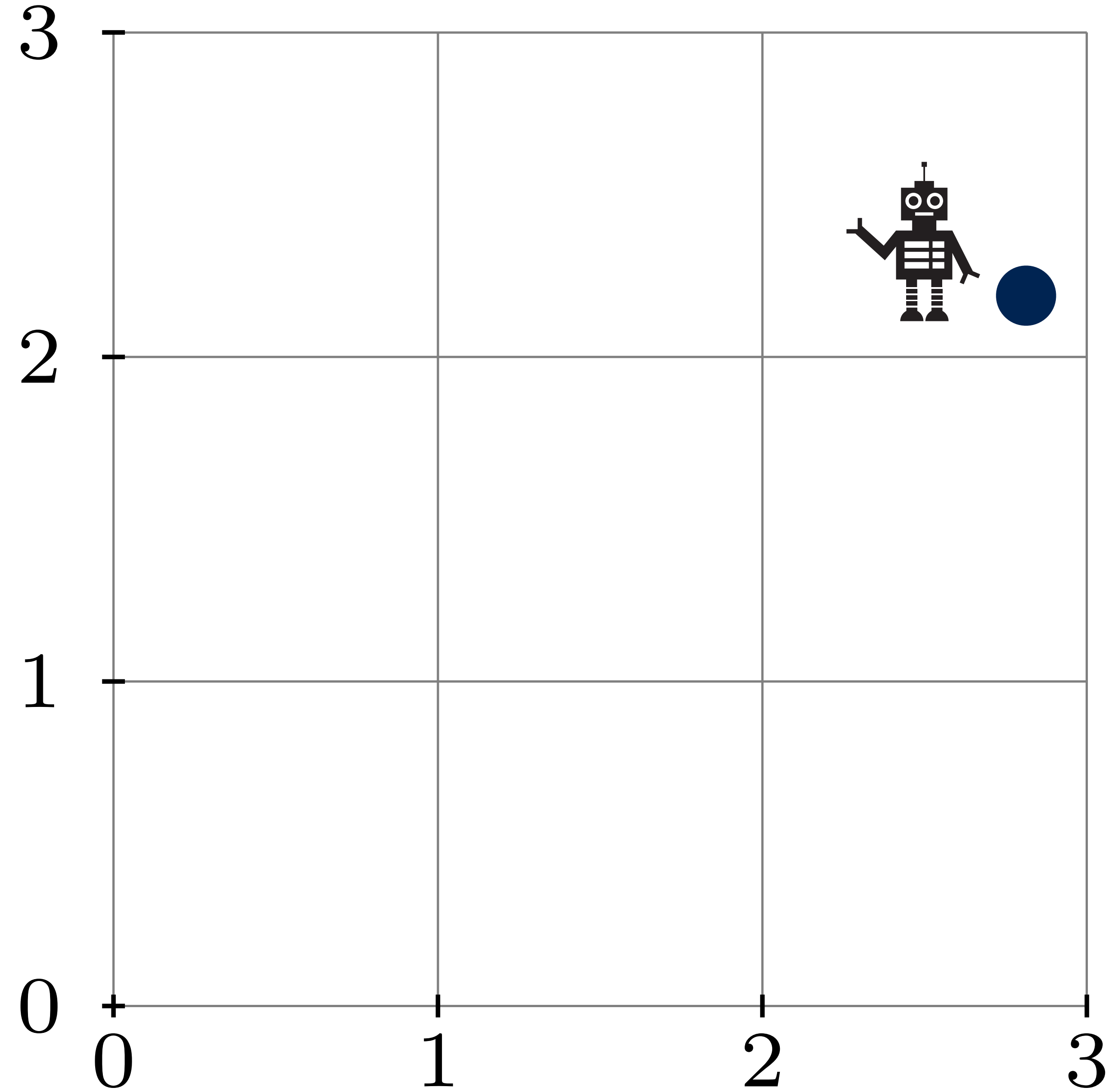
Initial state



[pos(robot,1/1),pos(ball,1/1)]

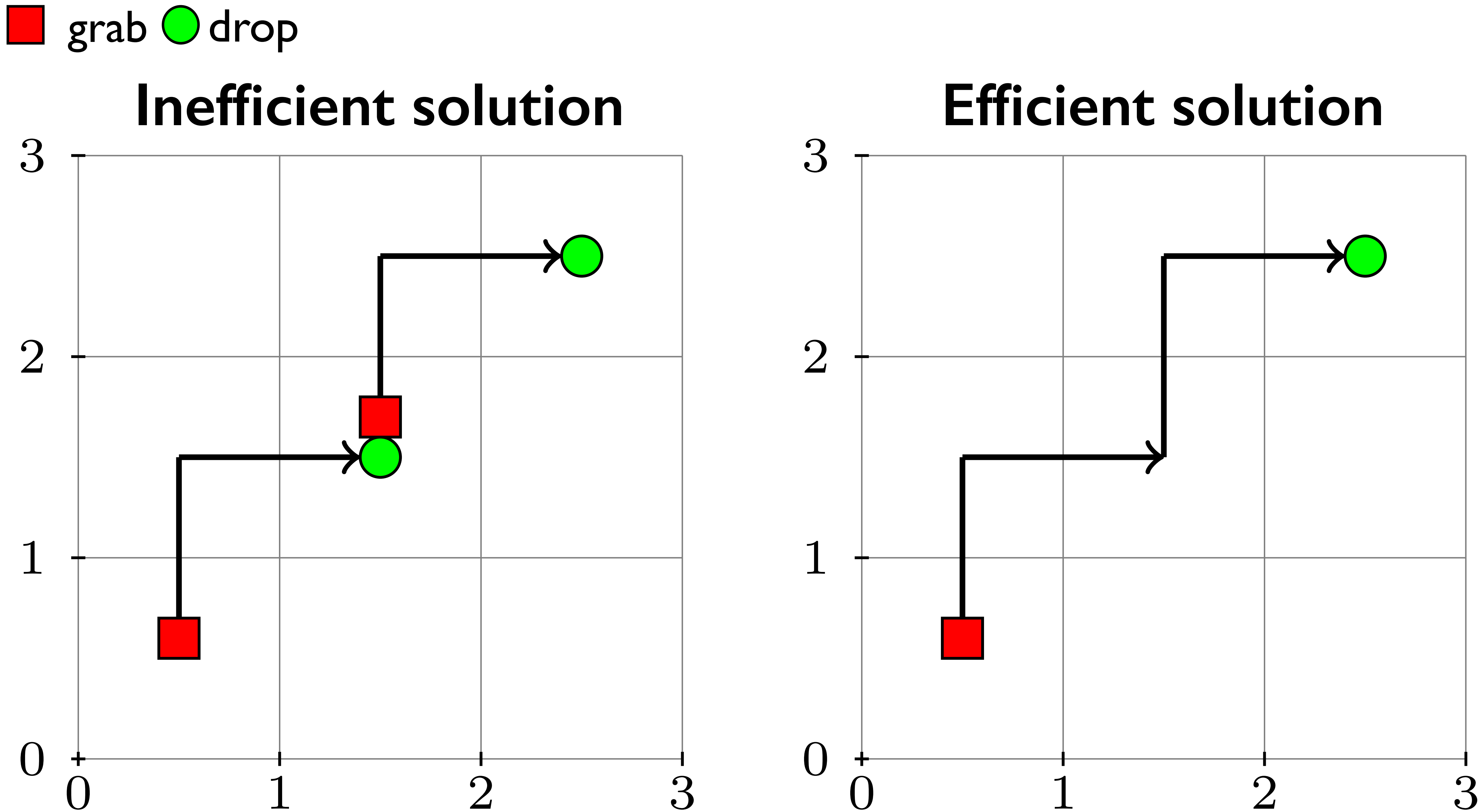
Final state



[pos(robot,3/3),pos(ball,3/3)]

```
move(X,Y):- p3(X,Z),p3(Z,Y).
p3(X,Y):- p2(X,Z), drop(Z,Y).
p2(X,Y):- grab(X,Z), p1(Z,Y).
p1(X,Y):- north(X,Z), east(Z,Y).
```

```
move(X,Y):- p3(X,Z),drop(Z,Y).
p3(X,Y):- grab(X,Z), p2(Z,Y).
p2(X,Y):- p1(X,Z), p1(Z,Y).
p1(X,Y):- north(X,Z), east(Z,Y).
```




```
move(X,Y):- p3(X,Z),p3(Z,Y).
p3(X,Y):- p2(X,Z), drop(Z,Y).
p2(X,Y):- grab(X,Z), p1(Z,Y).
p1(X,Y):- north(X,Z), east(Z,Y).
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move(X,Y):- p3(X,Z),drop(Z,Y).
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```
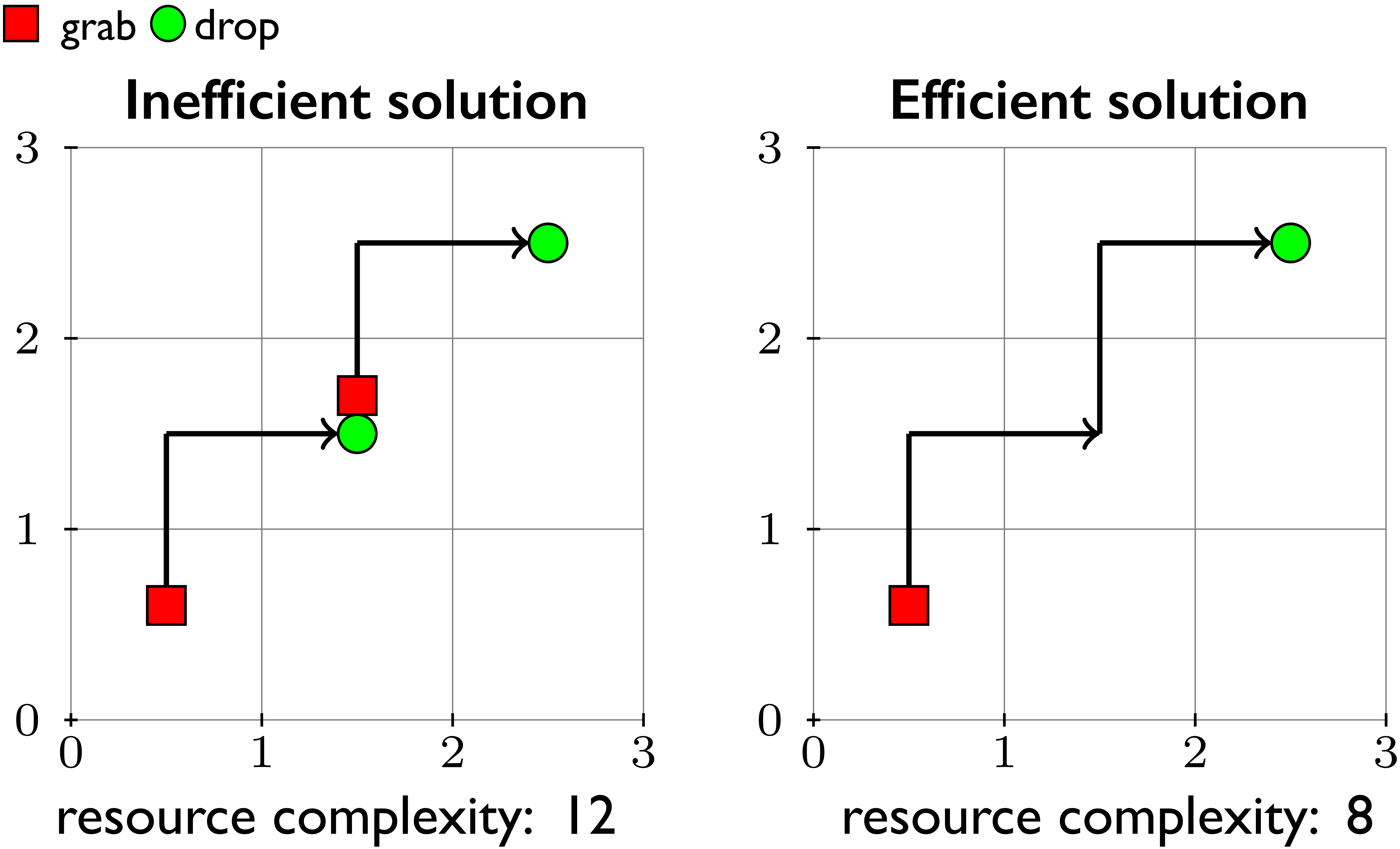



Action	drop	grab	north	east
Cost	2	2	1	1

Iterative descent

1. find first consistent solution with minimal textual complexity
2. repeat until convergence:
   A. calculate resource complexity of learned solution
   B. learn new solution with a maximum resource bound that is smaller than the resource complexity of the previous solution

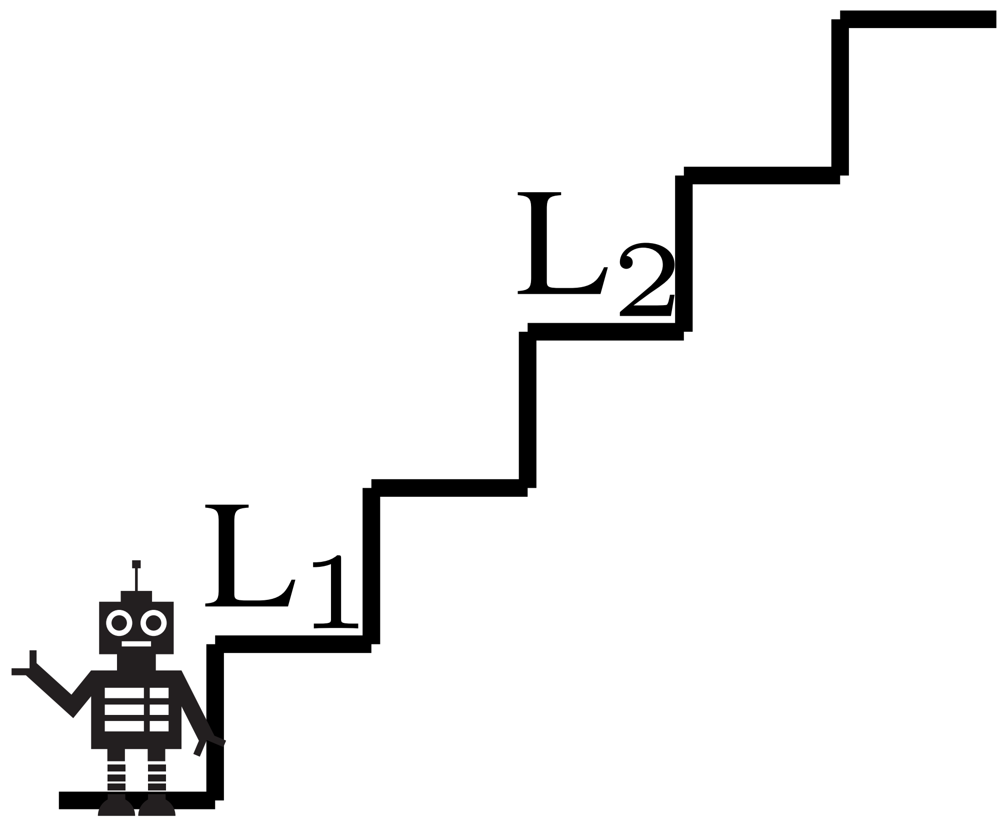
Theorem: guaranteed to converge to minimal resource complexity hypothesis

MetagolO

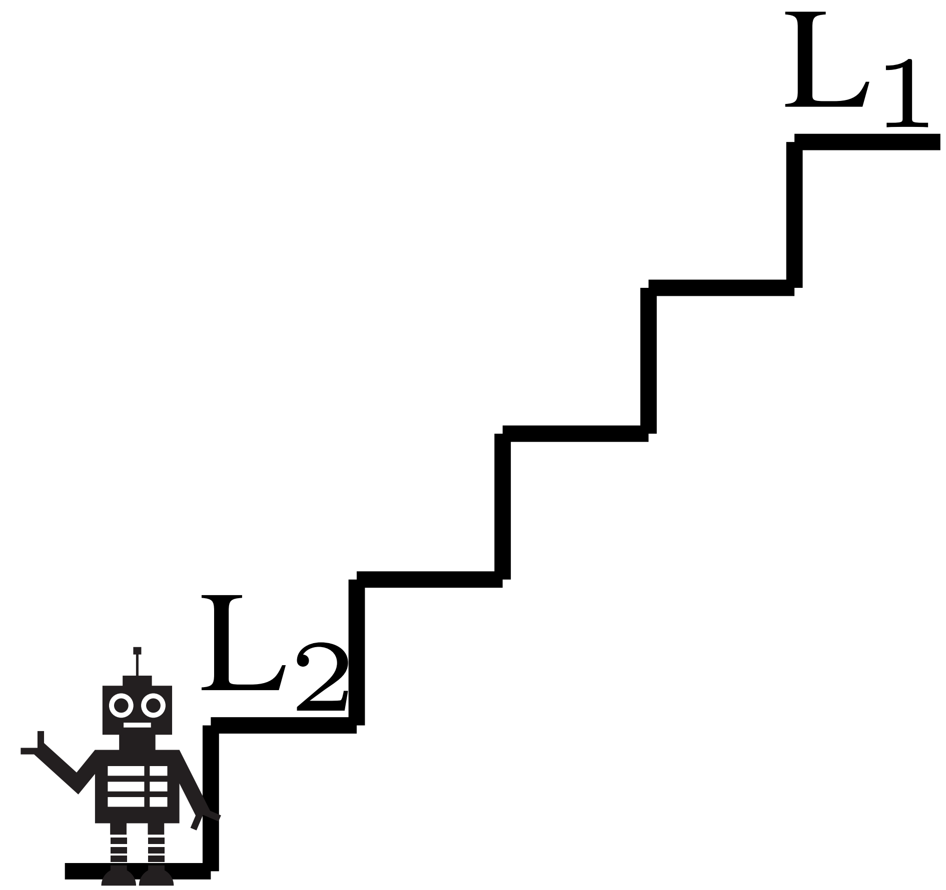
Implementation of meta-interpretive learning*, a form of inductive logic programming based on a Prolog meta-interpreter, which supports predicate invention and the learning of recursive theories

* S.H. Muggleton, D. Lin, and A. Tamaddoni-Nezhad. Meta-interpretive learning of higher-order dyadic datalog: Predicate invention revisited. Machine Learning, 100(1):49-73, 2015.

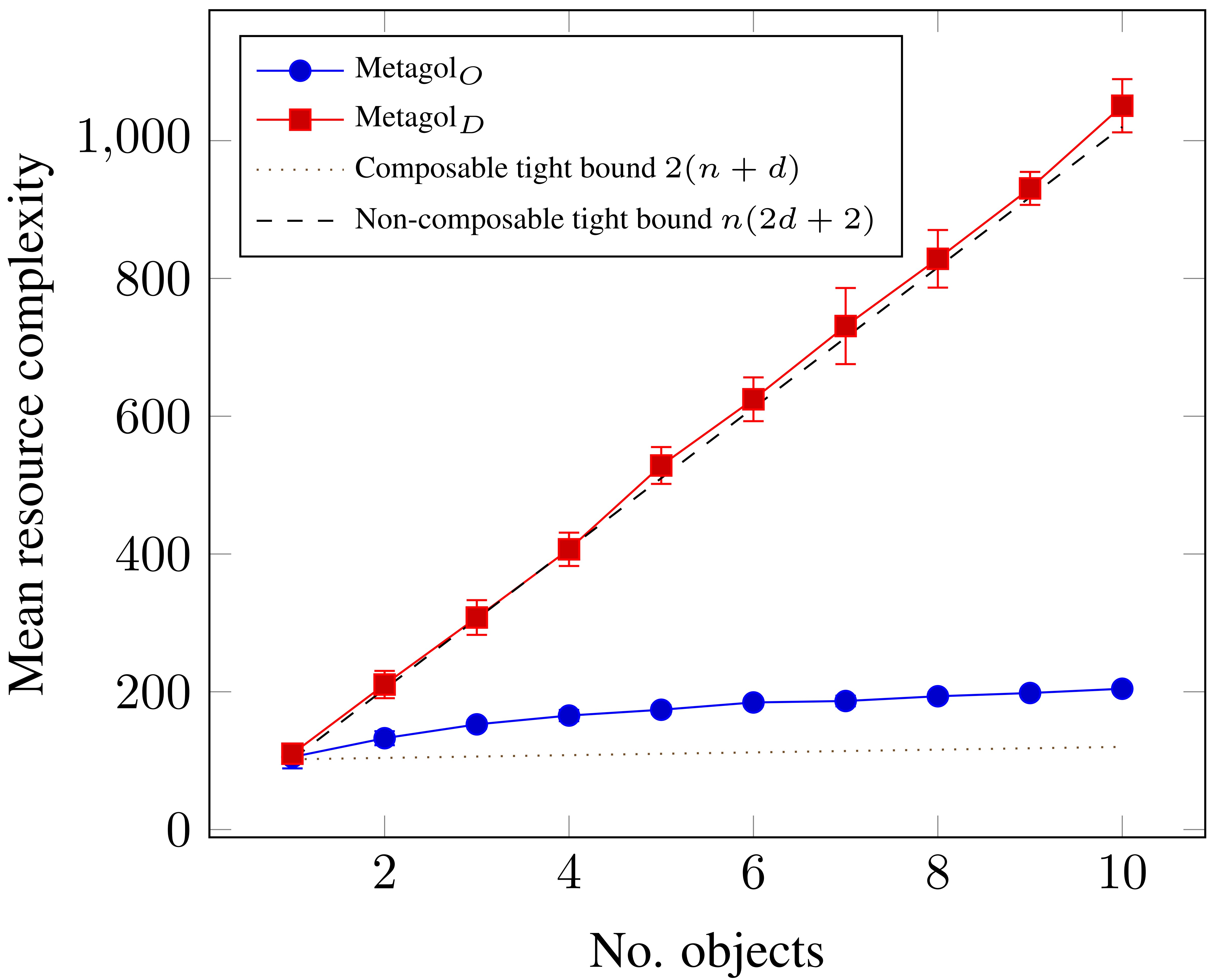
Initial state



Final state



Actions: go_to_bottom/2, go_to_top/2, find_next_sender/2, find_next_recipient/2, take_letter/2, give_letter/2, bag_letter/2

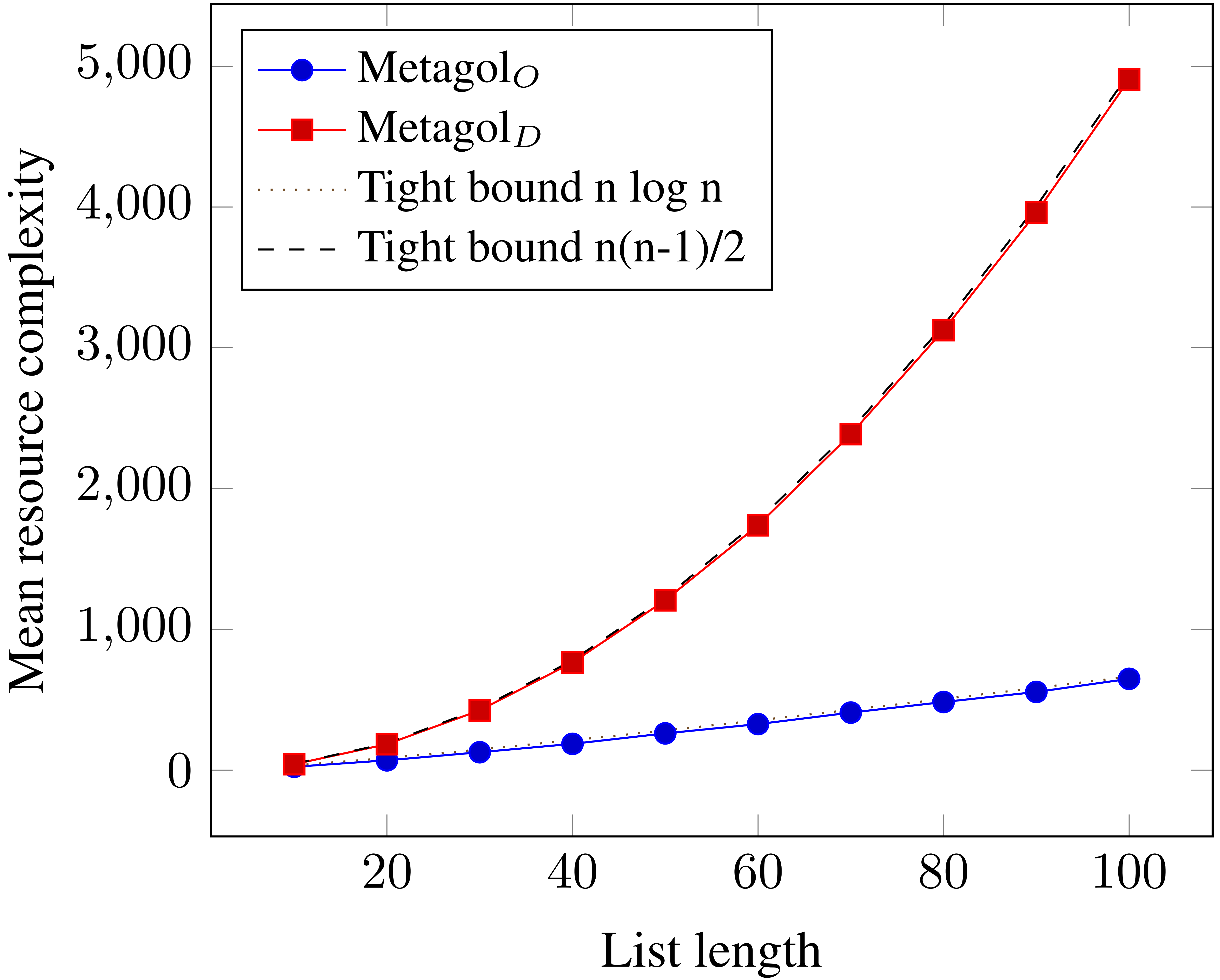


Metagol$_O$
Metagol$_D$
Composable tight bound $2(n + d)$
Non-composable tight bound $n(2d + 2)$
Mean resource complexity
0
200
400
600
800
1,000
2
4
6
8
10
No. objects

Initial state	**Final state**
[2,5,6,1,9,7,3,4,8]	[1,2,3,4,5,6,7,8,9]

Actions:

comp_adjacent/2
decrement_end/2
go_to_start/2
pick_up_left/2
split/2
combine/2


Metagol$_O$
Metagol$_D$
Tight bound n log n
Tight bound n(n-1)/2
5,000
4,000
3,000
2,000
1,000
0
20
40
60
80
100
Mean resource complexity
List length

Conclusions

- Suggests that we can build delivery and sorting robots which learn resource efficient strategies from examples

Future work

- Optimise the iterative descent search procedure
- Generalise to a broader class of logic programs

Thank you