General Game Playing
Future of GGP

Michael Genesereth
Logic Group
Stanford University

Metagaming

Metagaming is match-independent game processing, i.e. game processing that is done independent of any particular opponent or any particular state.

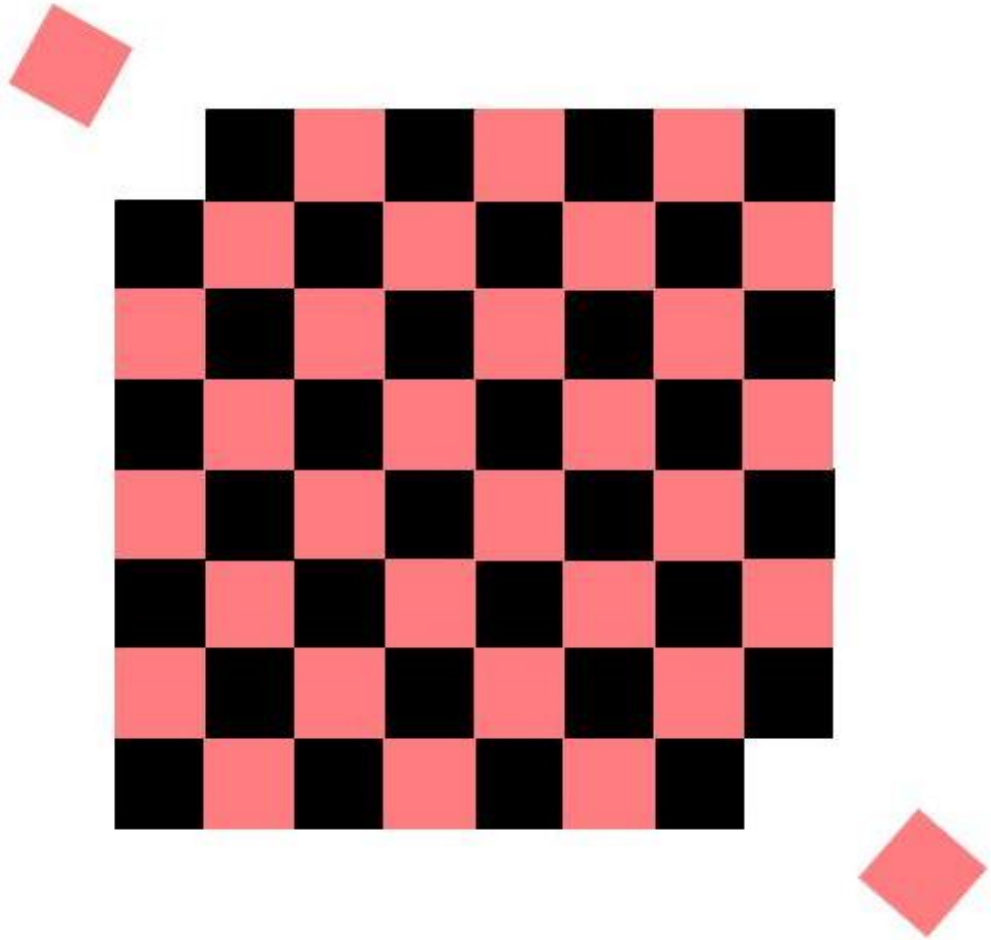
Techniques:

- ✓ Headstart, big switch, etc.

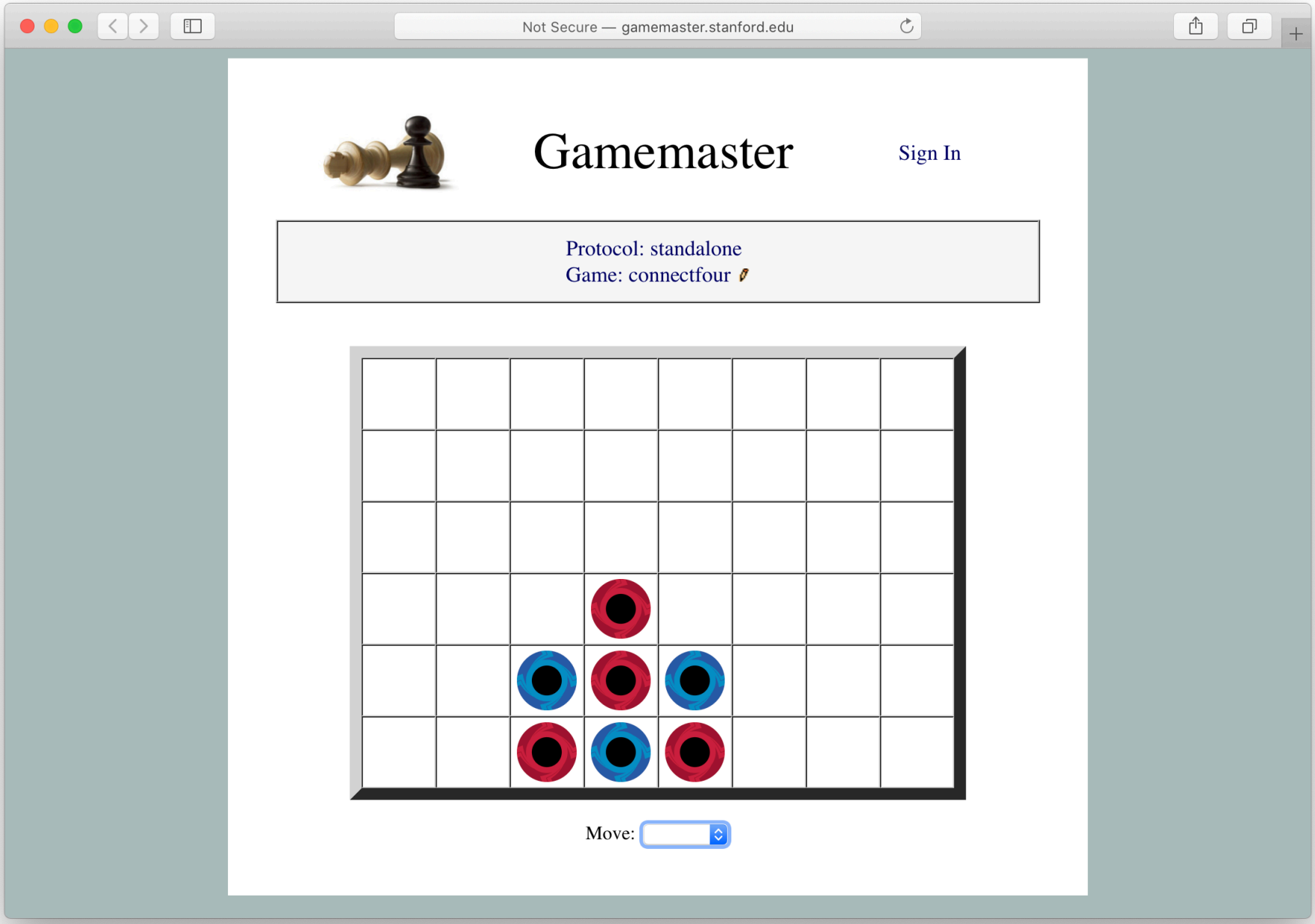
- ✓ Optimization - subgoal and rule ordering, removal
- ✓ Grounding and Symbolizing and Simplifying
- ✓ Game Reformulation

Symbolic Reasoning
Automatic Programming

Mutilated Checkerboard



Connect Four Suicide

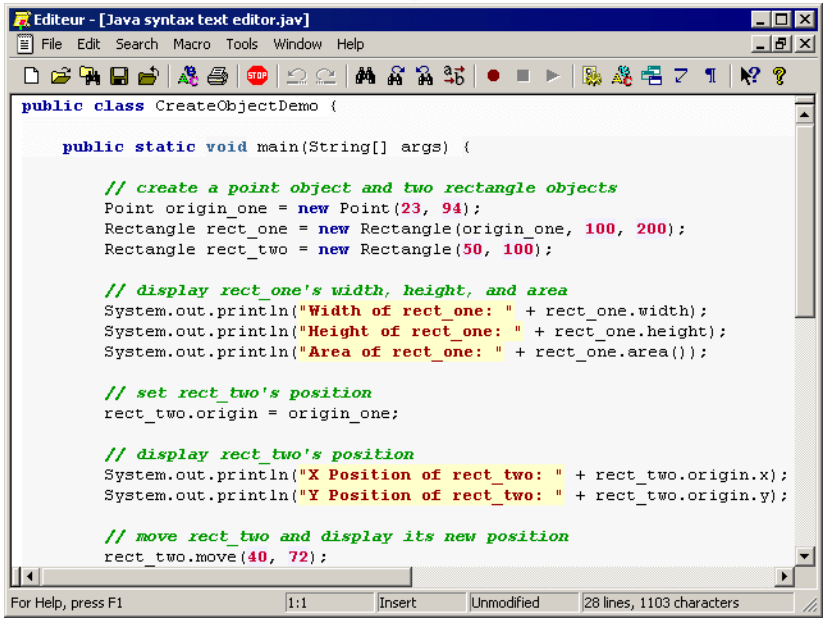


Automatic Programming

```
init(cell(1,1,b))
init(cell(1,2,b))
init(cell(1,3,b))
init(cell(2,1,b))
init(cell(2,2,b))
init(cell(2,3,b))
init(cell(3,1,b))
init(cell(3,2,b))
init(cell(3,3,b))
init(control(x))

legal(P,mark(X,Y)) :-
    true(cell(X,Y,b)) &
    true(control(P))

legal(x,noop) :-
    true(control(o))

legal(o,noop) :-
    true(control(x))
```

```
next(cell(M,N,P)) :-
    does(P,mark(M,N))

next(cell(M,N,Z)) :-
    does(P,mark(M,N)) &
    true(cell(M,N,Z)) & Z#b

next(cell(M,N,b)) :-
    does(P,mark(J,K)) &
    true(cell(M,N,b)) &
    (M#J | N#K)

next(control(x)) :-
    true(control(o))

next(control(o)) :-
    true(control(x))


terminal :- line(P)
terminal :- ~open


goal(x,100) :- line(x)
goal(x,50) :- draw
goal(x,0) :- line(o)

goal(o,100) :- line(o)
goal(o,50) :- draw
goal(o,0) :- line(x)
```

```
row(M,P) :-
    true(cell(M,1,P)) &
    true(cell(M,2,P)) &
    true(cell(M,3,P))


column(N,P) :-
    true(cell(1,N,P)) &
    true(cell(2,N,P)) &
    true(cell(3,N,P))


diagonal(P) :-
    true(cell(1,1,P)) &
    true(cell(2,2,P)) &
    true(cell(3,3,P))


diagonal(P) :-
    true(cell(1,3,P)) &
    true(cell(2,2,P)) &
    true(cell(3,1,P))

line(P) :- row(M,P)
line(P) :- column(N,P)
line(P) :- diagonal(P)

open :- true(cell(M,N,b))

draw :- ~line(x) &
        ~line(o)
```



Algorithmic Expertise

Knuth in a Box; Schaeffer in a Box

Games with Incomplete Information

Complete and Incomplete Information

"Complete" Information Games

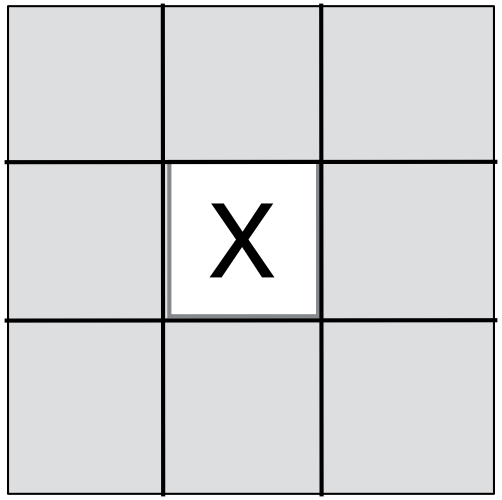
- Initial State
- Legal moves of player in control in all states
- Move of each player on each step
- State resulting from joint moves of players
- Rewards of every player in every state
- Termination

Incomplete Information Games

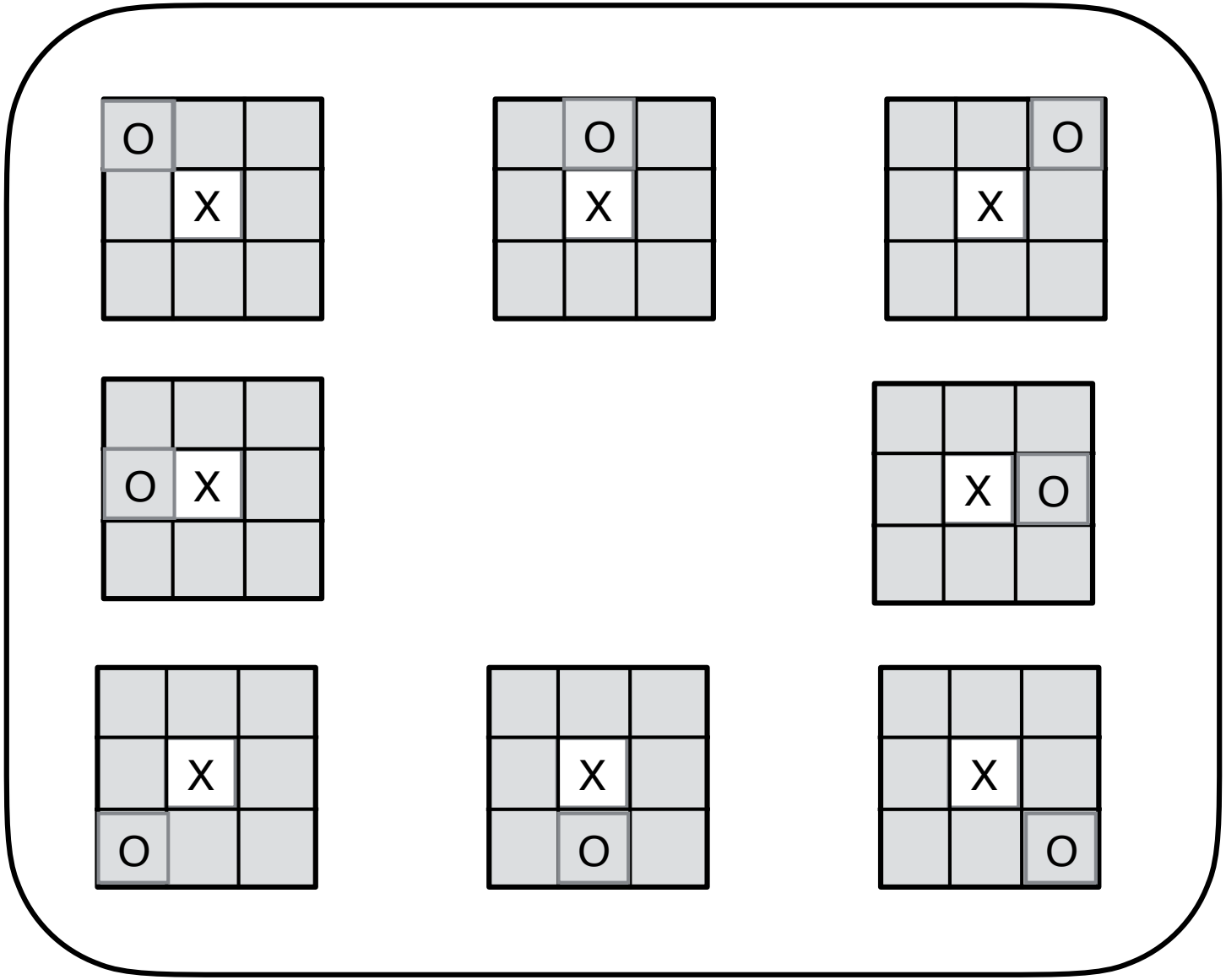
- Incomplete information about initial state
- Rules may not be complete (non-determinism)
- May not even see the moves of others

Battleship

Blind Tic Tac Toe



State Set for Blind Tic Tac Toe



GDL-II

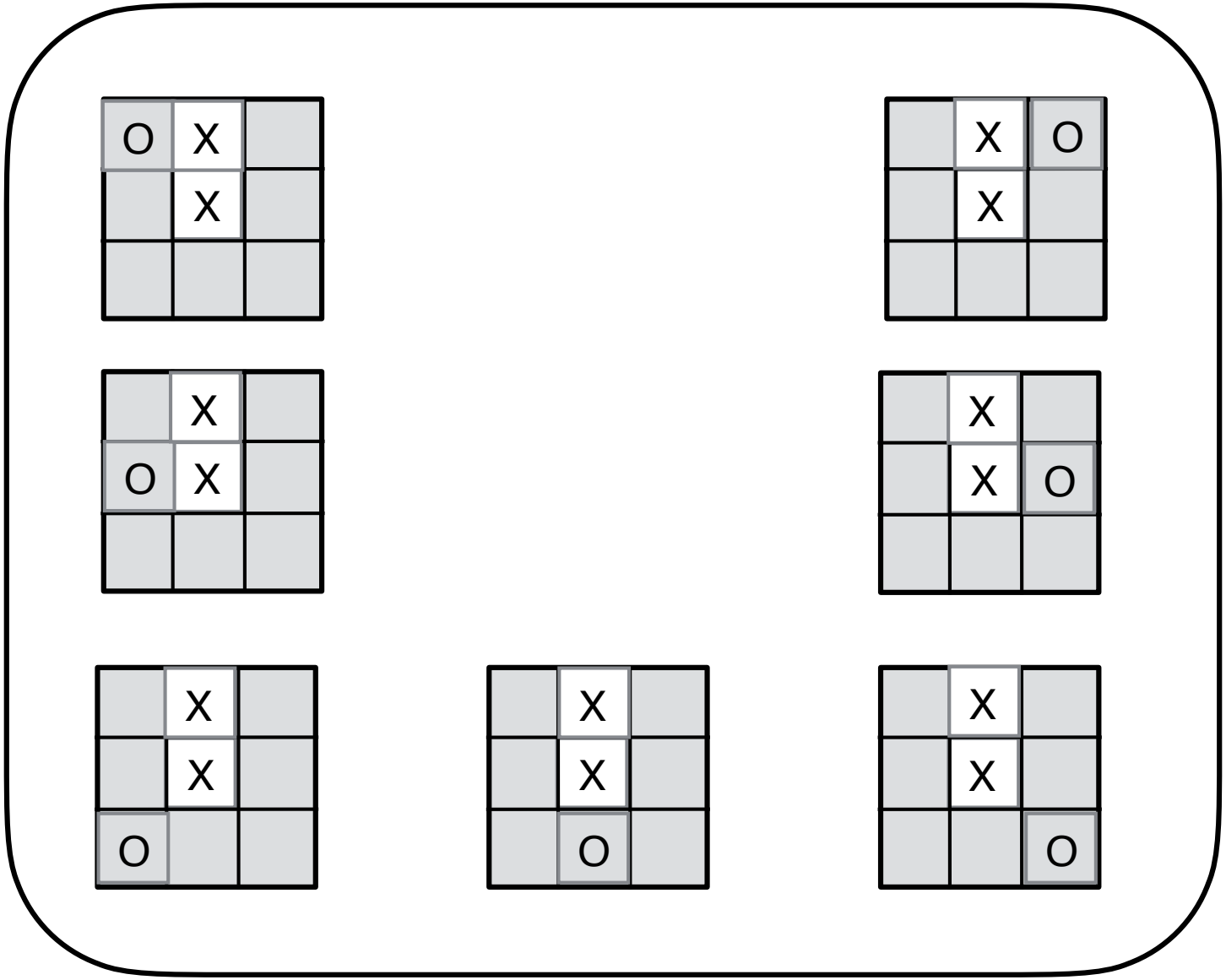
“Percepts”

```
ok
ng
```

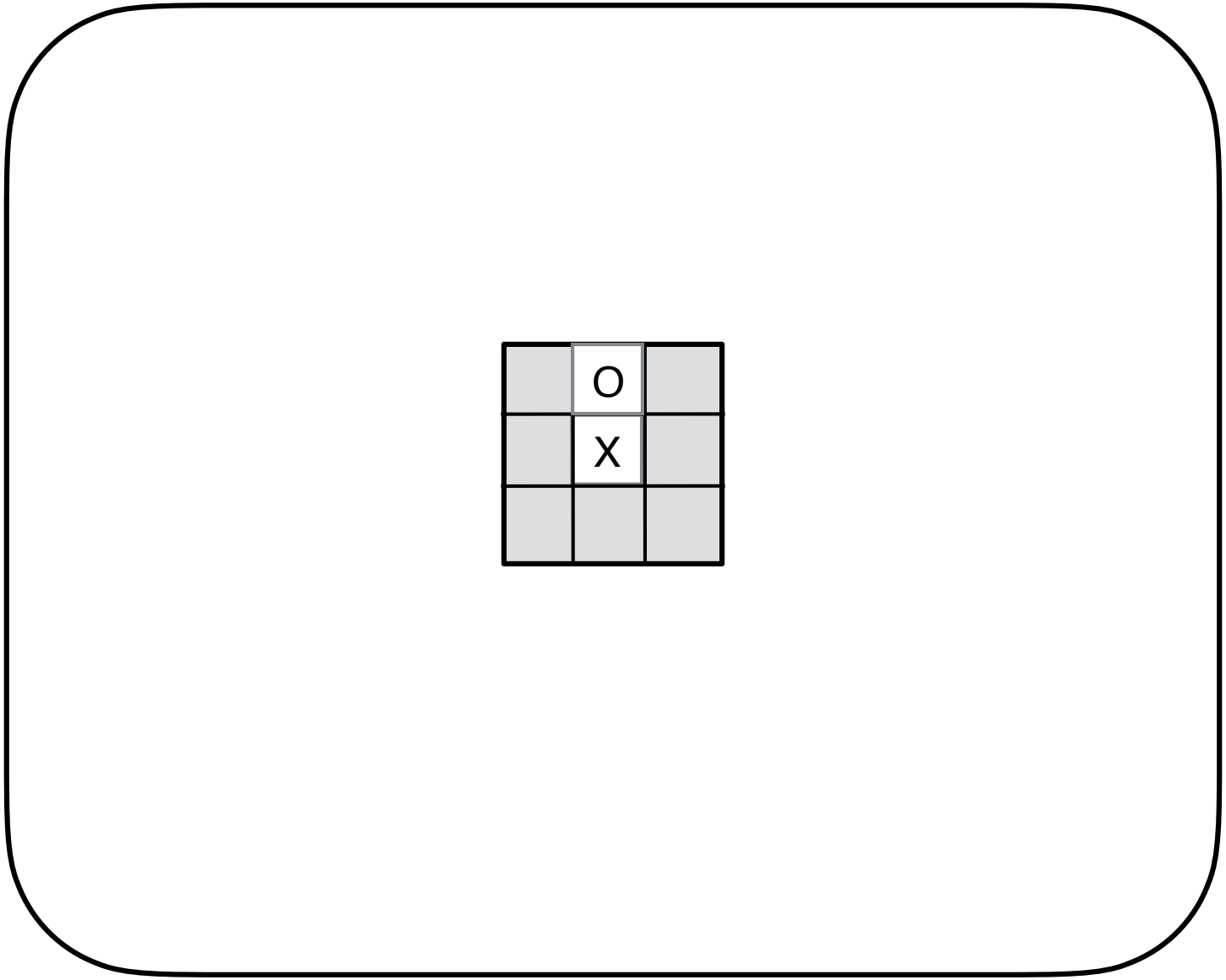
Percepts provided by game manager:

```
play(ok)
```

State Set if We See ok



State Set if We See ng



Inductive General Game Playing

In traditional GGP, players are given rules:

```
legal(move(X,Y)) :-
  location(robot,X) & left(X,Y)
```

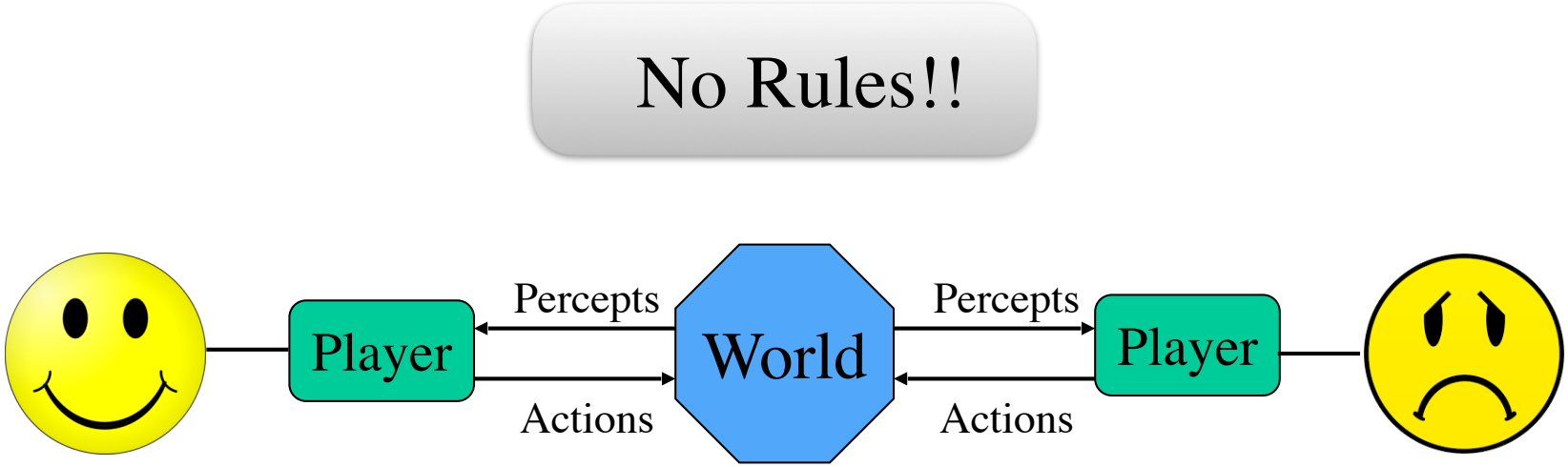
In IGGP, players are given histories:

	white	black
1	noop	mark(1,1)
2	mark(3,3)	noop
3	noop	mark(1,2)
4	mark(2,2)	noop
5	noop	mark(2,1)
6	mark(1,3)	noop
7	noop	mark(2,3)
8	mark(3,1)	noop
9	**100**	**0**

Statistical Learning

Really General Game Playing

Percept-Action and Utility Model for Players



Discussion

- A "bit" more difficult
- Inferring hidden state
- Deep Learning and Reinforcement Learning

Competition Strategies

Most Important Suggestion

Make sure it works.

Second Most Important Suggestion

Make sure it works.

Third Most Important Suggestion

Make sure it works.

Fourth Most Important Suggestion

Make sure it works.


GENERAL
GAME
PLAYING


Celebrating AAAI's 25th
Anniversary