# CS344M
# Autonomous Multiagent Systems
# Spring 2008


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# Good Afternoon, Colleagues

Are there any questions?

# Logistics

- Executable teams due next Tuesday

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- Final reports due on Thursday

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- Final tournament: Wednesday, May 7th, 10am, TAY 3.128

# Machine Learning

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**Training examples:** the data

**Learning method:** training examples $\mapsto$ hypothesis

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# Agent Learning

**Policy:** how to **act** (generate training examples)

neural network training, decision tree training, clustering, genetic algorithms, genetic programming, reinforcement learning...

# 3 vs. 2 Keepaway (joint with Rich Sutton)

- Play in a **small area** (20m $\times$ 20m)
- **Keepers** try to keep the ball
- **Takers** try to get the ball
- **Episode:**
  - Players and ball reset randomly
  - Ball starts near a keeper
  - Ends when taker gets the ball or ball goes out
- Performance measure: **average possession duration**
- Use **CMUnited-99 skills**:
  - HoldBall, PassBall($k$), GoToBall, GetOpen

# Available Skills (from CMUnited-99)

**HoldBall():** Remain stationary while keeping possession of the ball.

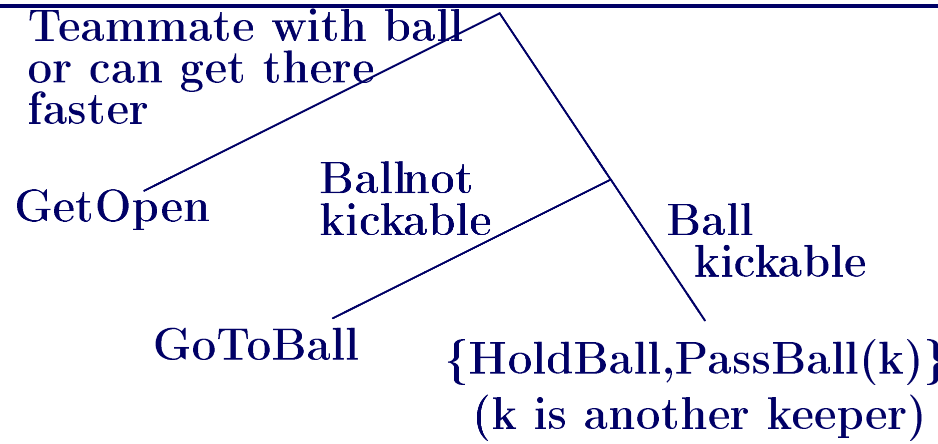
**PassBall($k$):** Kick the ball directly to keeper $k$.

**GoToBall():** Intercept a moving ball or move directly towards a stationary ball.

**GetOpen():** Move to a position that is free from opponents and open for a pass from the ball's current position (using SPAR (Veloso et al., 1999))

**BlockPass($k$):** Get in between the ball and keeper $k$

# The Keepers' Policy Space



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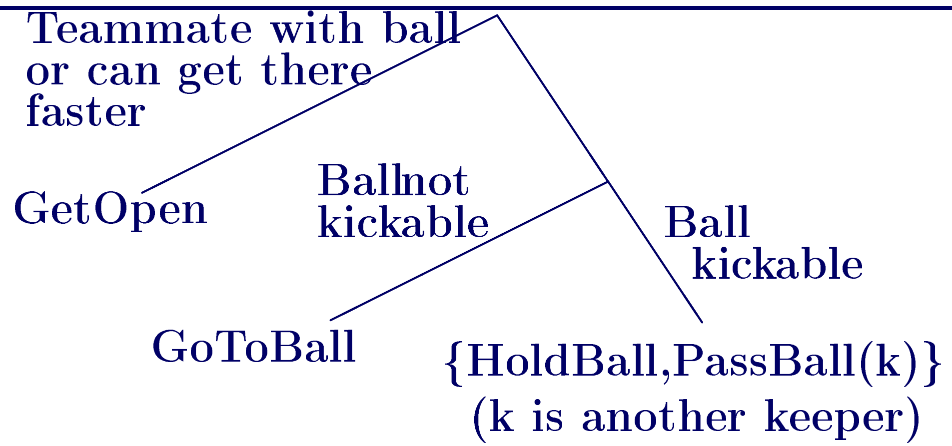



# Example Policies

**Random:** HoldBall or PassBall($k$) randomly

**Hold:** Always HoldBall

**Hand-coded:**

**If** no taker within 10m: HoldBall

**Else If** there's a good pass: PassBall($k$)

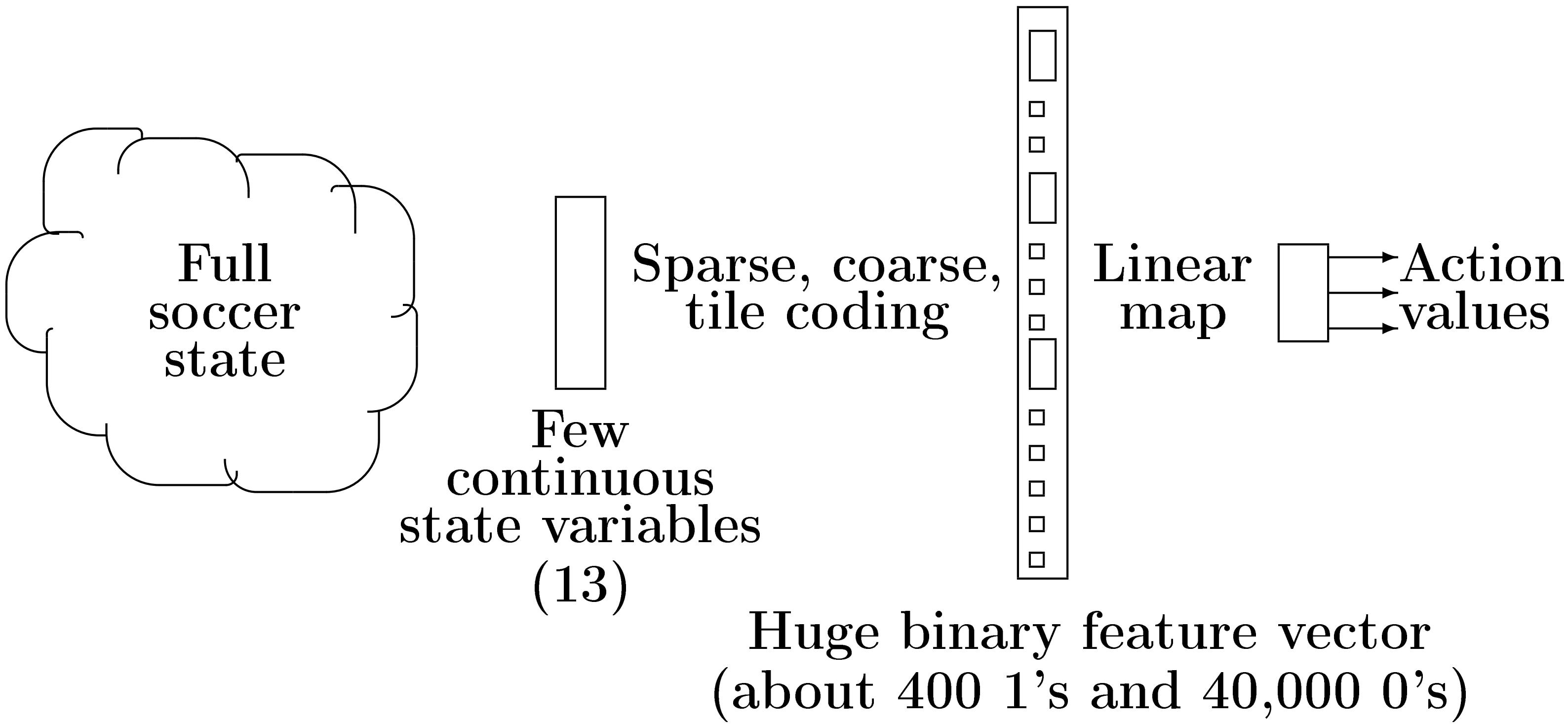
**Else** HoldBall

# Mapping Keepaway to RL

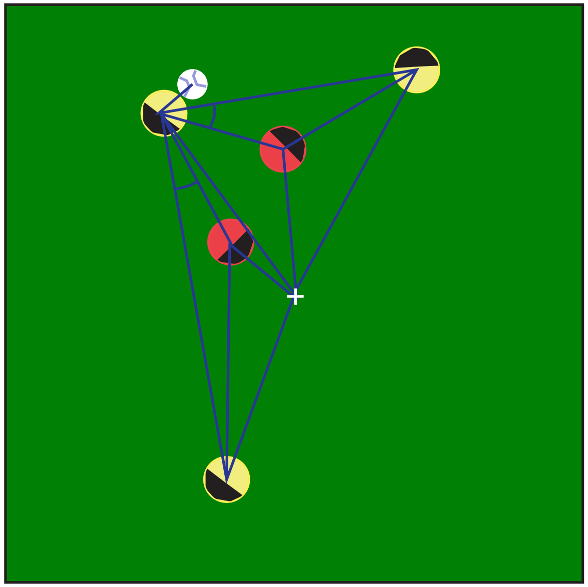
**Discrete-time, episodic, distributed RL**

- Simulator operates in discrete time steps, $t = 0, 1, 2, \ldots$, each representing 100 msec
- Episode: $s_0, a_0, r_1, s_1, \ldots, s_t, a_t, r_{t+1}, s_{t+1}, \ldots, r_T, s_T$
- $a_t \in$ {HoldBall, PassBall($k$), GoToBall, GetOpen}
- $r_t = 1$
- $V^\pi(s) = E\{T \mid s_0 = s\}$
- Goal: Find $\pi^*$ that maximizes $V$ for all $s$

# Representation



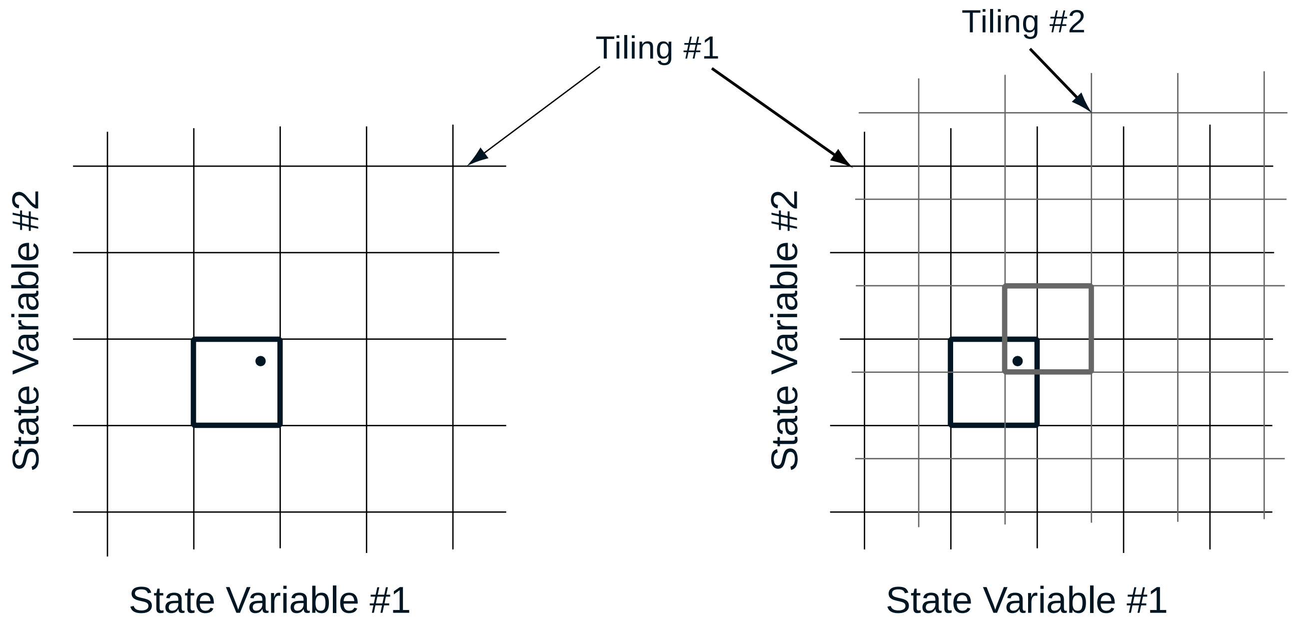
# $s$: 13 Continuous State Variables



- 11 distances among players, ball, and center
- 2 angles to takers along passing lanes

# Function Approximation: Tile Coding

- Form of sparse, coarse coding based on CMACS (Albus, 1981)




- Tiled state variables individually (13)

# Policy Learning

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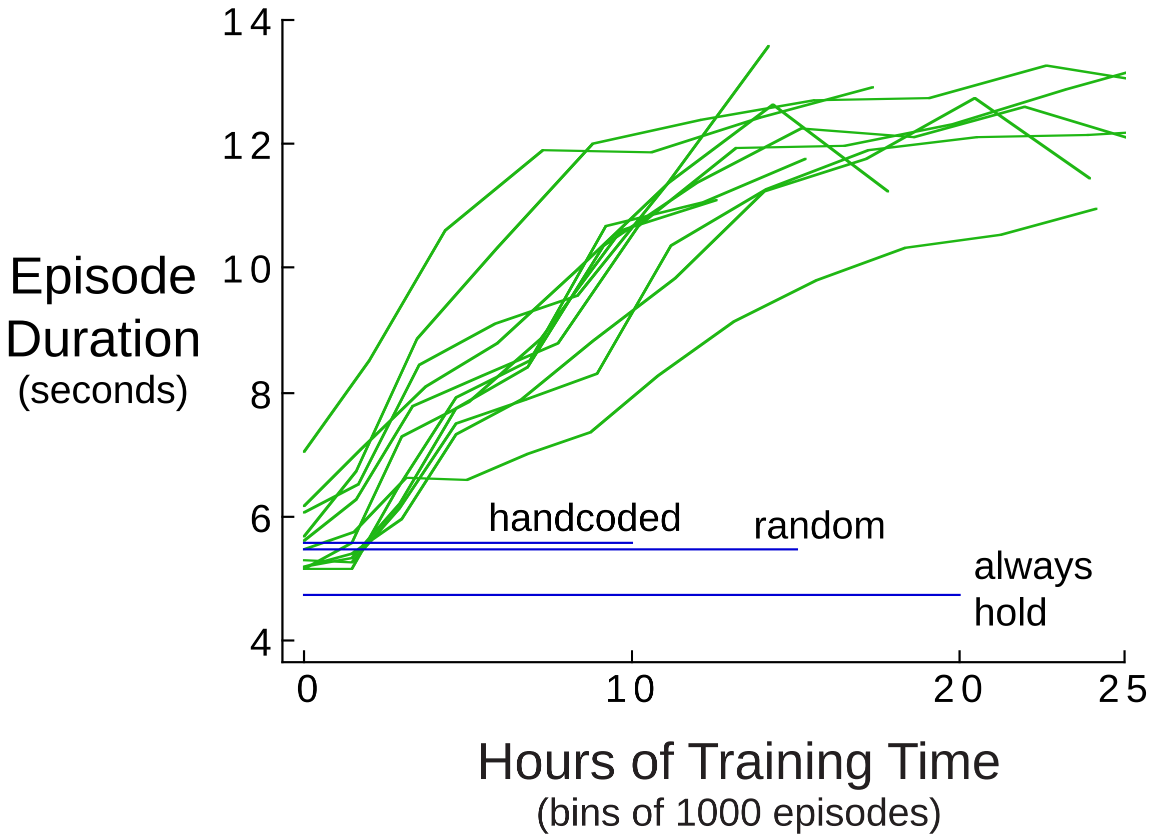
- Linear Sarsa($\lambda$) — each agent learns independently
  - On-policy method: advantages over e.g. Q-learning
  - Not known to converge, but works (e.g. (Sutton, 1996))

# Main Result



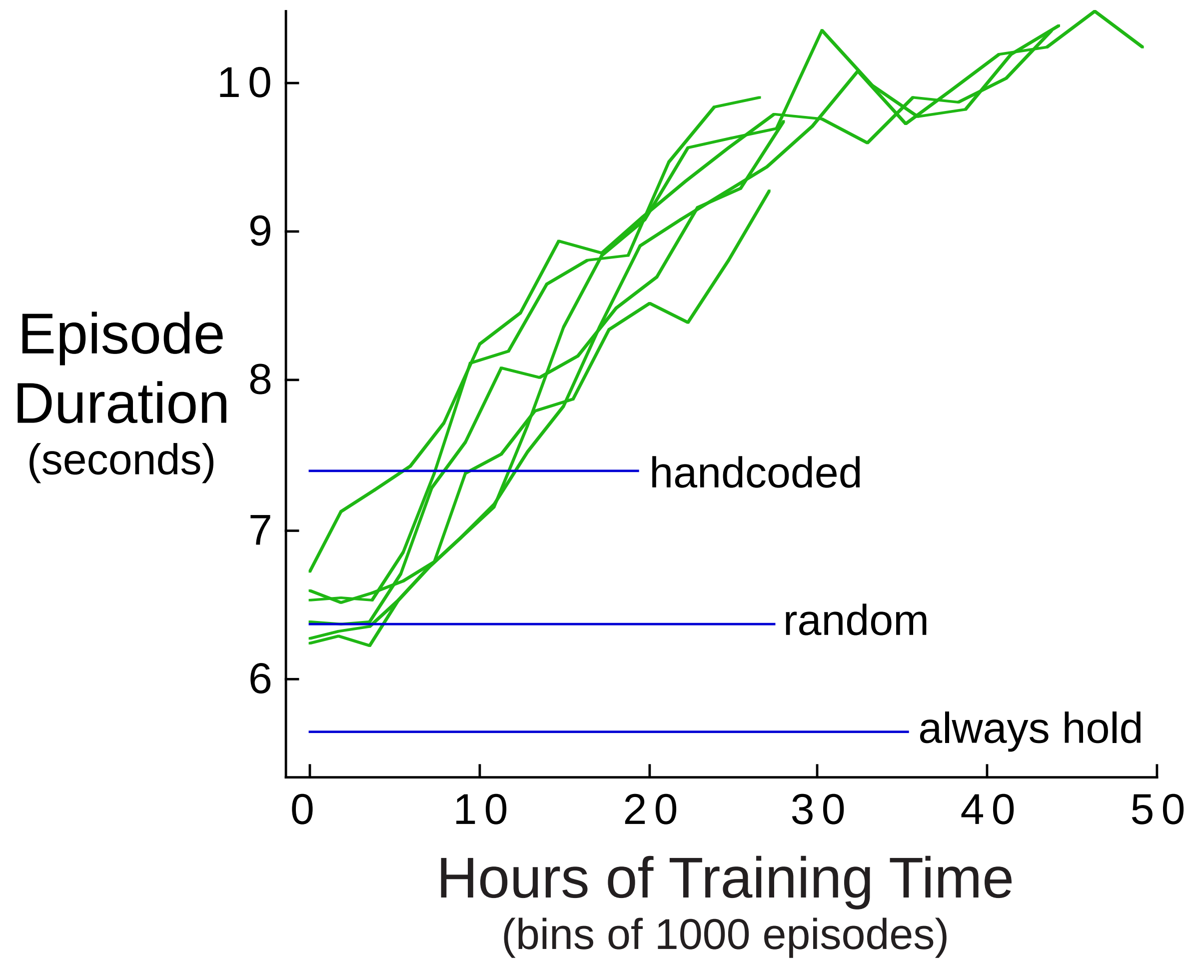

1 hour = 720 5-second episodes

# Varied Field Size

| Keepers | | Testing Field Size 15x15 | 20x20 | 25x25 |
|---|---|---|---|---|
| Trained on field of size | 15x15 | **11.0** | 9.8 | 7.2 |
| | 20x20 | 10.7 | **15.0** | 12.2 |
| | 25x25 | 6.3 | 10.4 | **15.0** |
| Benchmarks | Hand | 4.3 | 5.6 | 8.0 |
| | Hold | 3.9 | 4.8 | 5.2 |
| | Random | 4.2 | 5.5 | 6.4 |

- Single runs
- learning specific to fields
  - mechanism generalizes better than policies

# 4 vs. 3 Keeper Learning




- Preliminary: taker learning successful as well

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  - Communication updates when others have the ball
- Any coevolution?

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- Keep a population of individuals
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**The fitness function matters**

- Playing against top-notch competition $\rightarrow$ no info
- Playing against a single foe $\rightarrow$ too brittle

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  - Millions of generations
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  - Millions of generations
  - Worse than perfect play
  - Why compare against old methods?

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- Simultaneous learning by teammates could be thought of in this way as well.