Reinforcement Learning

Linear Function Approximation Example

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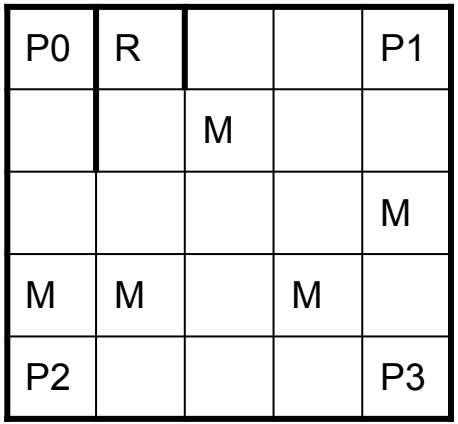
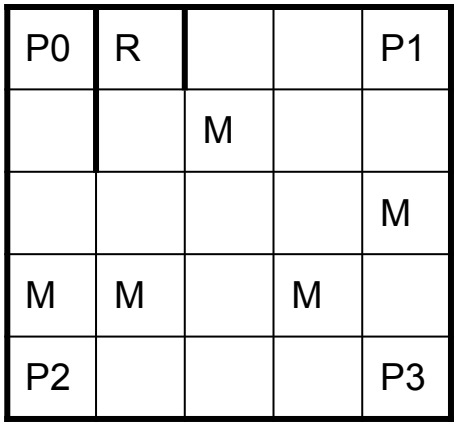
Grid Game



Prize

- Prize could be in one of the corners or no prize
- r(P) = +10
- When the prize is taken it disappears until a new prize is respawned with certain probability.



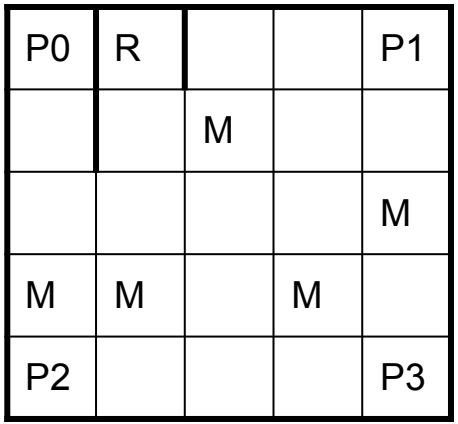
Damage

- At each timestep a monster can appear in any of the M cells.
- If a monster appears in the agent's cell then the agent gets damaged.
- If the agent has already been damaged then it receives r(D, M) = -10
- The agent can get repaired by visiting the R cell

P0	R			P1
		M		
				M
M	M		M	
P2				P3

State

- Fully observable environment
- Represent the state as(X, Y, P, D)
  - X: X position of the agent
  - Y: Y position of the agent
  - P: position of the prize (P=4 - no prize)
  - D: 1 if the agent is damaged, otherwise 0



Linear Function Approximation

- State-action value function:

$$Q_w(s, a) = w_0 + w_1F_1(s, a) + \ldots + w_nF_n(s, a)$$

Linear Function Approximation

- State-action value function:

$$Q_w(s, a) = w_0 + w_1F_1(s, a) + \ldots + w_nF_n(s, a)$$

- What features can we choose?

Possible Features

Feature	Value
$F_1(s, a)$	1 - if action *a* would most likely take the agent from state *s* into a location where a monster could appear; 0 - otherwise
$F_2(s, a)$	1 - if action *a* would most likely take the agent into a wall; 0 - otherwise
$F_3(s, a)$	1 - if action *a* would most likely take the agent toward a prize; 0 - otherwise
$F_4(s, a)$	1 - if the agent is damaged and action *a* would most likely take it to the repair station; 0 - otherwise
$F_5(s, a)$	1 - if the agent is damaged and action *a* would most likely take it to a monster; 0 - otherwise

Possible Features

Feature	Value
$F_6(s, a)$	1 - if the agent is damaged in state *s*; 0 - otherwise
$F_7(s, a)$	1 - if the agent is not damaged in state *s*; 0 - otherwise
$F_8(s, a)$	1 - if the agent is damaged and there is a prize in the direction of action *a*; 0 - otherwise
$F_9(s, a)$	1 - if the agent is not damaged and there is a prize in the direction of action *a*; 0 - otherwise

Possible Features

Feature	Value
$F_{10}(s, a)$	distance from left wall if prize at location P0
$F_{11}(s, a)$	distance from right wall if prize at location P0
$F_{12-29}(s, a)$	Similar to F_{10} and F_{11} for different wall and prize combinations

Training with SARSA

- Let $\delta = r + \gamma Q(s',a') - Q(s,a)$ then update the weights with $w_i \leftarrow w_i + \eta \delta F_i(s,a)$

$$Q(s, a) = 2.0 - 1.0 * F_1(s, a) - 0.4 * F_2(s, a) - 1.3 * F_3(s, a)$$
$$- 0.5 * F_4(s, a) - 1.2 * F_5(s, a) - 1.6 * F_6(s, a)$$
$$+ 3.5 * F_7(s, a) + 0.6 * F_8(s, a) + 0.6 * F_9(s, a)$$
$$- 0.0 * F_{10}(s, a) + 1.0 * F_{11}(s, a) + ...$$

Assignment 2: Programming Task

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Setup

- Repository: https://github.com/ipab-rad/rl-cw2
- The README file provides lots of information
- On a DICE machine:

```
> git clone https://github.com/ipab-rad/rl-cw2
```

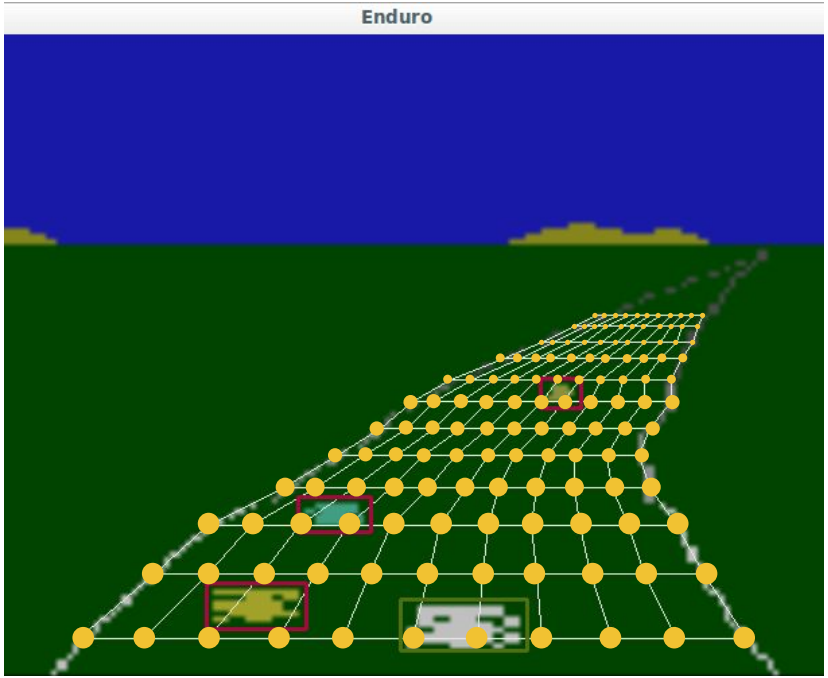
Sensing

- The same agent interface for playing Enduro

- The sensing capabilities of the agent are enhanced
  - Road
  - Cars
  - Speed
  - Grid

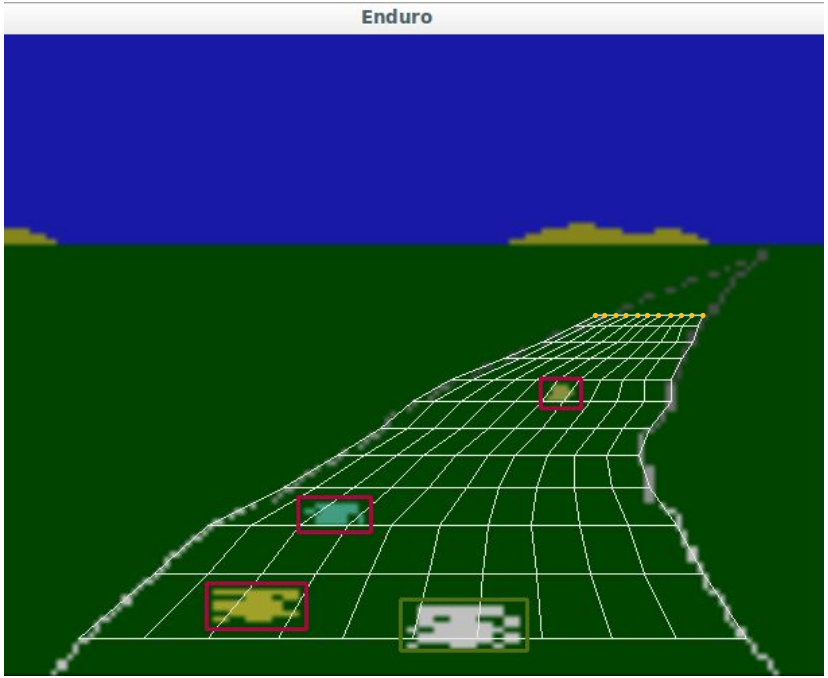
Road Grid

- Plain 2-dimensional array containing [x, y] points in pixel coordinates.
- Note: The image which is displayed is a scaled version of the actual game frame.

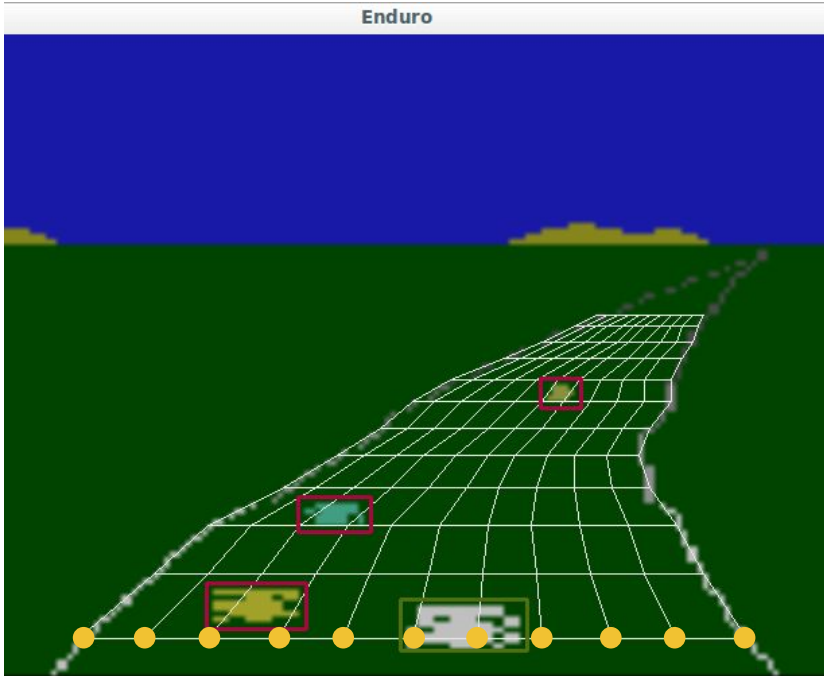


Road Grid

road[0]

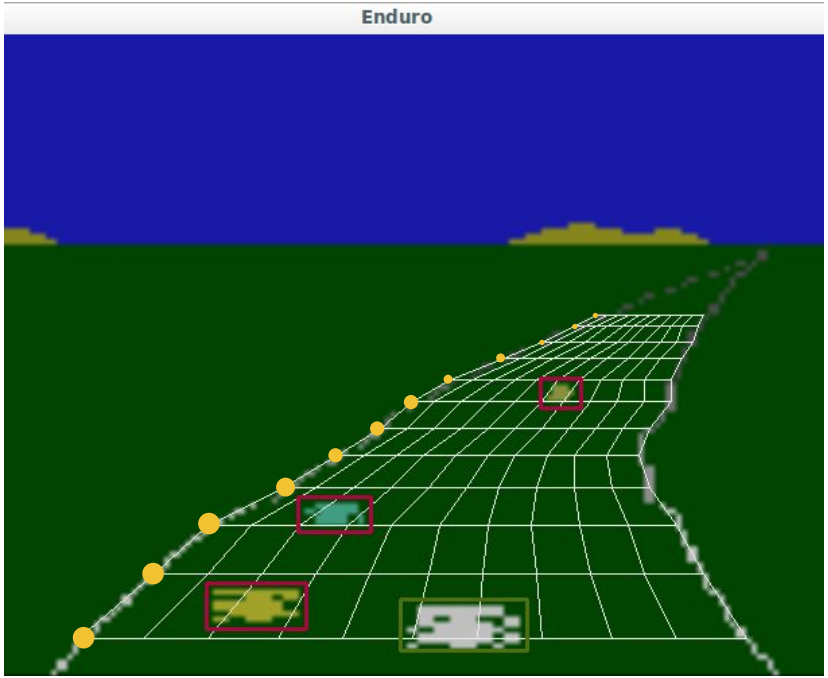


road[11]

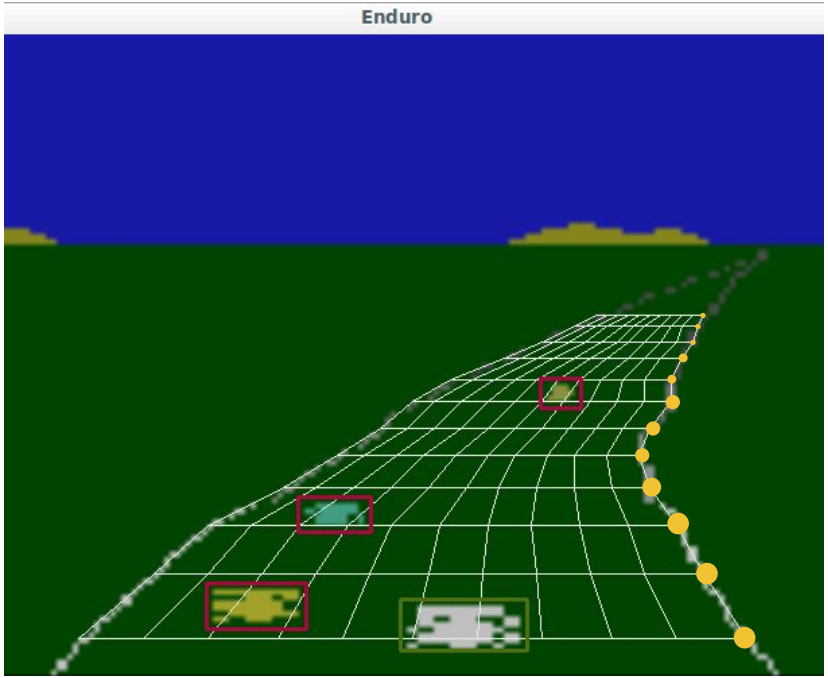


Road Grid

[r[0] for r in road]



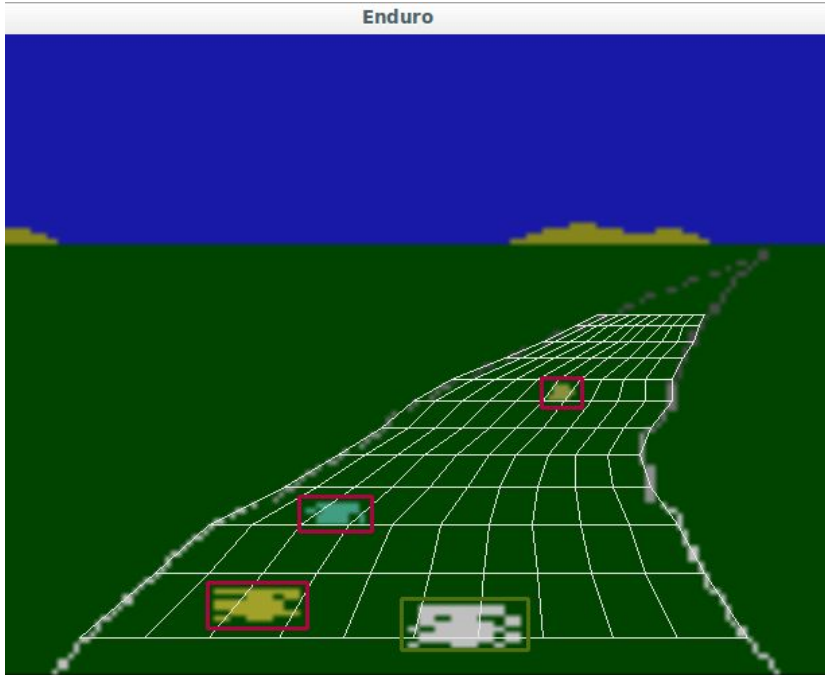
[r[10] for r in road]



Cars

- Dictionary containing the size and location of each car in the game frame
- (x, y) top left pixel coordinate
- (w, h) size in pixels

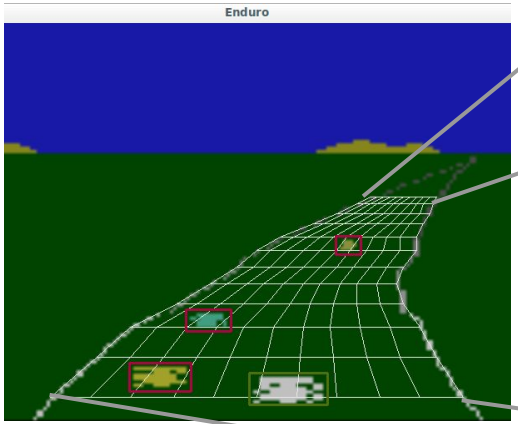
```
{  ‘self’: (x, y, w, h),
 ‘others’: [(x1, y1, w1, h1),
            (x2, y2, w2, h2),
            (x3, y3, w3, h3)]}
```

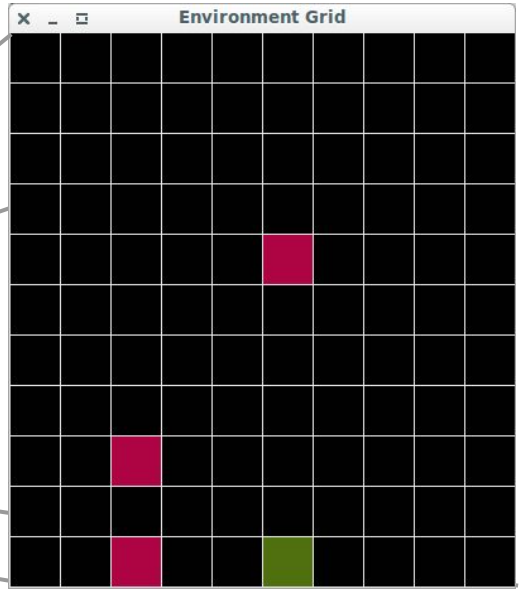


Speed

- Speed relative to the opponents in the range [-50, 50]
- The speed is set to -50 when the agent collides
- If the agent is moving as fast as possible its speed is 50

Grid





Col 0 Col 9

Row 10 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
0 0 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0
Row 0 0 0 1 0 0 2 0 0 0 0

Questions?