Playing with Reinforcement Learning in Python

The Q-Learning Algorithm

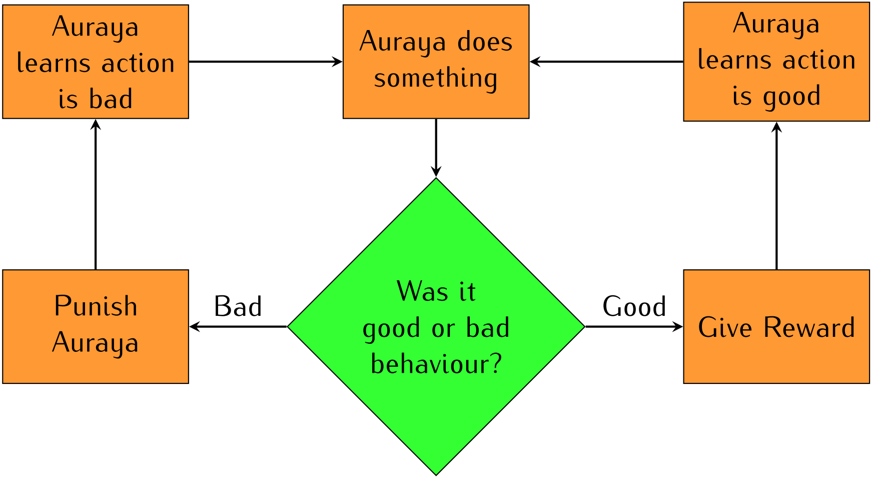
Geraint Palmer

Python Namibia, 2015

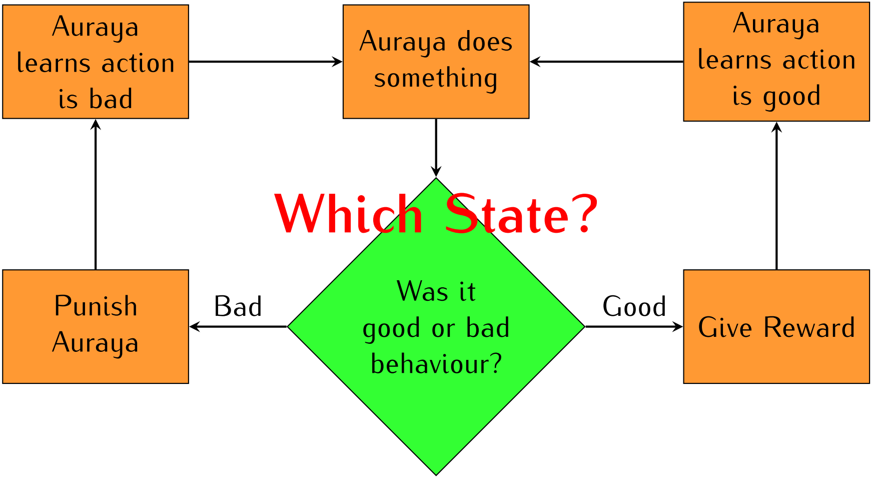
http://python-namibia.org

Auraya

How to train a dog?



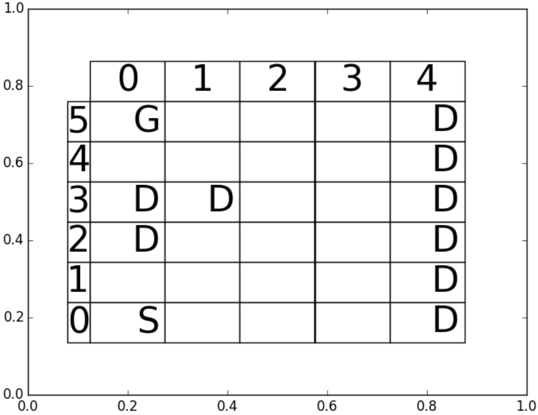
How to train a dog?

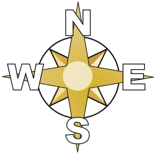


The Q-learning Algorithm

Set all Q and V values to 0
repeat
  Observe the current state s_t
  Select and perform an action a_t
  Observe the reward $r(s_t, a_t)$
  Perform the following updates:
    $Q_{t+1} \leftarrow (1-\alpha)Q_t(s_t, a_t) + \alpha[r(s_t, a_t) + \gamma V_t(s_{t+1})]$
    $V_{t+1}(s) \leftarrow max_a Q_t(s, a)$
until *convergence*

Rory The Robot





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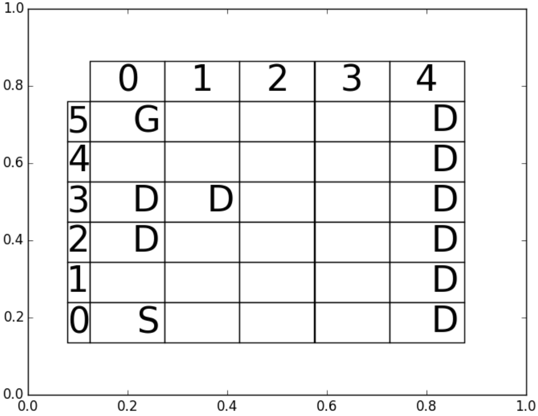

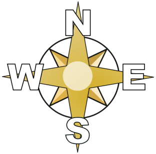

only 85% successful

Code Structure

```
class Board():
```

grid_height

grid_width

number_of_episodes

robot

squares

```
class Squares():
```

coords

identifier

reward

```
class Robot():
```

playing_board

actions

action_selection_parameter

learning_rate

discount_rate

moves

episode

coords

Vs

Qs

movement_dictionary

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Action Selection - Exploration vs Exploitation

ϵ-Soft Policy

```python
def select_action(self, sqr):
    """
    Selects which action to take using the epsilon-soft action selection policy
    """
    rnd_num = random.random()
    if rnd_num < 1 - self.action_selection_parameter:
        return str(max(self.Qs[sqr], key=lambda x: self.Qs[sqr][x]))
    return random.choice(self.actions)
```

Movement

```python
def find_destination(self, sqr, action):
    """
    Chooses the new coordinates after taking an action, according to the faultiness
    """
    rnd_num = random.random()
    sum_p, indx = 0, 0
    while rnd_num > sum_p:
        direction = self.actions[indx]
        sum_p += self.transitions[action][indx]
        indx += 1
    return self.movement_dict[direction](sqr)
```

Learning

```python
def Q_Learning(self, action, reward, sqr, new_sqr):
    """
    Updates Rory's Q and V values
    """
    self.Qs[sqr][action] = (
        1-self.learning_rate)*self.Qs[sqr][action] + self.learning_rate*(
        reward + self.discount_rate*self.Vs[new_sqr]
        )
    self.Vs[sqr] = max(self.Qs[sqr].values())
```

Simulation

```python
def simulate(self):
    """
    Simulates many episodes of the game while the robots learns the best policies
    """
    plt.ion()
    self.show_board()
    wait = raw_input('Press enter to continue.')
    print 'Simulating .......'
    while self.robot.episode < self.number_of_episodes:
        action = self.robot.select_action(self.robot.coords)
        new_coords = self.robot.find_destination(self.robot.coords, action)
        self.robot.moves += 1

        reward = self.squares[new_coords[1]][new_coords[0]].reward + (
            self.squares[new_coords[1]][new_coords[0]].move_cost * self.robot.moves)
        self.robot.Q_Learning(action, reward, self.robot.coords, new_coords)

        self.robot.coords = new_coords

        if (self.squares[new_coords[1]][new_coords[0]].identifier == 'Death' or
            self.squares[new_coords[1]][new_coords[0]].identifier == 'Goal'):
            self.robot.moves = 0
            self.robot.coords = tuple(self.starting_coords)
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    self.update_results()
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Demo

Learning Rate, α

$$\text{Small } \alpha \implies \text{historical rewards more important}$$

$$\text{Large } \alpha \implies \text{the latest reward more important}$$

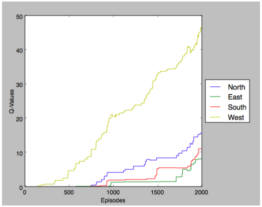


Figure: $\alpha = 0.03$

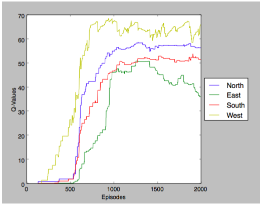


Figure: $\alpha = 0.1$

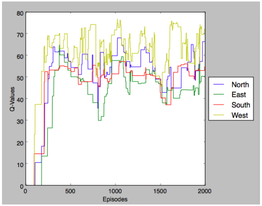


Figure: $\alpha = 0.5$

Discount Rate, γ

$$\text{Small } \gamma \implies \text{look for immediate rewards}$$

$$\text{Large } \gamma \implies \text{strive for long term rewards}$$

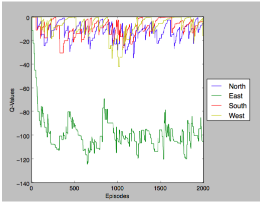


Figure: $\gamma = 0.1$

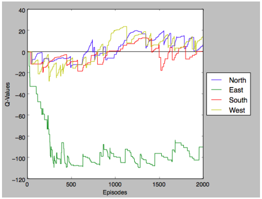


Figure: $\gamma = 0.9$

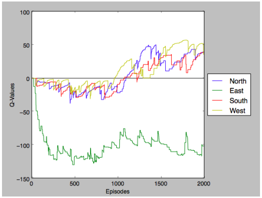
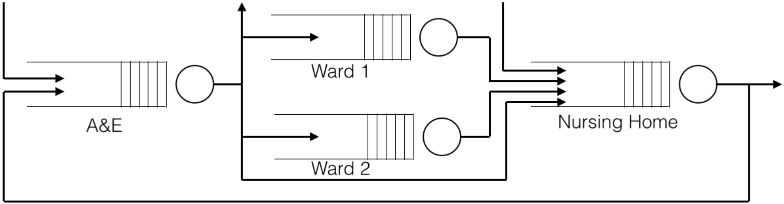


Figure: $\gamma = 0.99$

Using RL in a Healthcare System



Links

A robot learning to walk
A computer learning to play 'snake'
A virtual car learning not to crash
An agent learning the shortest route through a maze

https://github.com/geraintpalmer/Python_Namibia_2015