An Exploration of Reinforcement Learning in Complex Environments

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Introduction

- What is Rocket League?
- Rocket League as an optimization problem
- Reinforcement Learning and Rocket League

Credit: https://steamcommunity.com/sharedfiles/filedetails/?id=900701590

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Why Reinforcement Learning?

- Reinforcement Learning aims to:
  - Solve problems beyond human capabilities
  - Test new actions or approaches

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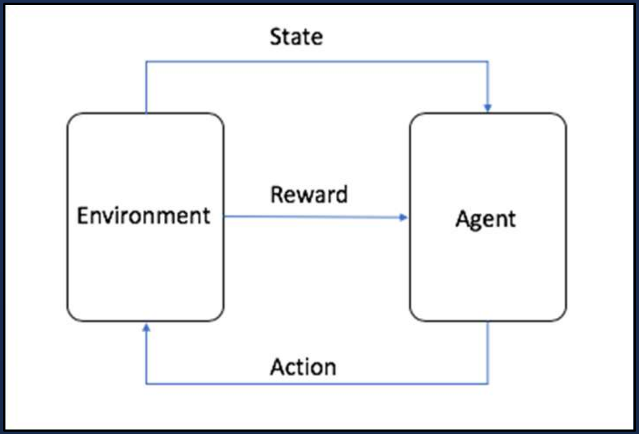
Reinforcement Learning

- Reinforcement Learning training has two components:
  - Agent
  - Environment
- Each timestep, the agent selects an action
- Environment rewards the agent's action
- Environment updates to the new state



Credit: Amazon AWS Machine Learning Blog

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Q-Learning

- Agent learns a q-value
  - Quality of doing *action* in *state*
- Agent selects an action from:
  - *(action, state)* pair with best q-value
  - Random *action* ε-percent of the time
- Agent performs *action*, reward is given

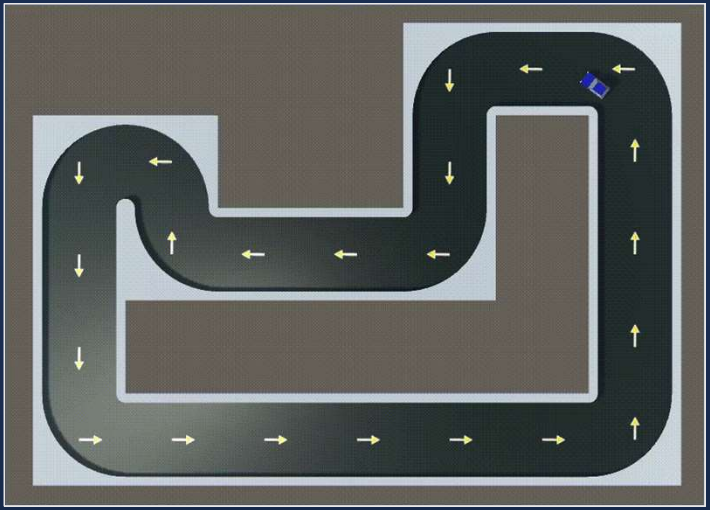
Fig. 1: An agent training to navigate a racetrack as fast as possible.

Q-values are updated from the given reward. Over time the optimal path to the goal is generated.

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Methodology

Credit: https://www.usgamer.net/articles/rocket-league-xbox-one-review

- Determine the objective goal:
  1. Maintain the fastest velocity possible
     - Training episode ends after 5 minutes
  2. Hit the ball efficiently
     - Episode ends once ball is hit
     - Episode ends after 5 minutes

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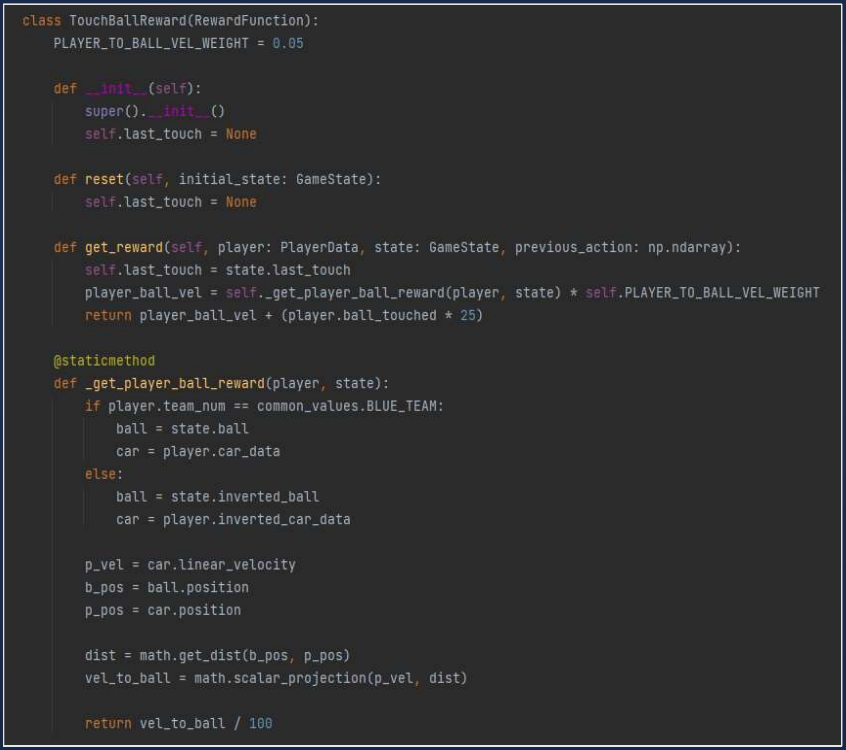
Methodology

- Define rewards:
  1. For moving as quickly as possible:
     - Reward the bot its instantaneous speed
  2. For hitting the ball:
     - Reward the bot its velocity to ball
     - Large reward for touching the ball



```python
class TouchBallReward(RewardFunction):
    PLAYER_TO_BALL_VEL_WEIGHT = 0.05

    def __init__(self):
        super().__init__()
        self.last_touch = None

    def reset(self, initial_state: GameState):
        self.last_touch = None

    def get_reward(self, player: PlayerData, state: GameState, previous_action: np.ndarray):
        self.last_touch = state.last_touch
        player_ball_vel = self._get_player_ball_reward(player, state) * self.PLAYER_TO_BALL_VEL_WEIGHT
        return player_ball_vel + (player.ball_touched * 25)

    @staticmethod
    def _get_player_ball_reward(player, state):
        if player.team_num == common_values.BLUE_TEAM:
            ball = state.ball
            car = player.car_data
        else:
            ball = state.inverted_ball
            car = player.inverted_car_data

        p_vel = car.linear_velocity
        b_pos = ball.position
        p_pos = car.position

        dist = math.get_dist(b_pos, p_pos)
        vel_to_ball = math.scalar_projection(p_vel, dist)

        return vel_to_ball / 100
```

Fig. 2: TouchBallReward code which defines how the agent is rewarded.

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Fig. 3: Rocket League agent during early training. (0 – 100,000 timesteps)

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Results: Max Speed

50:00
BALL CAM
PRESS SPACEBAR TO TOGGLE

Fig. 4.1: Rocket League agent training for maximum speed, 5 million timesteps.

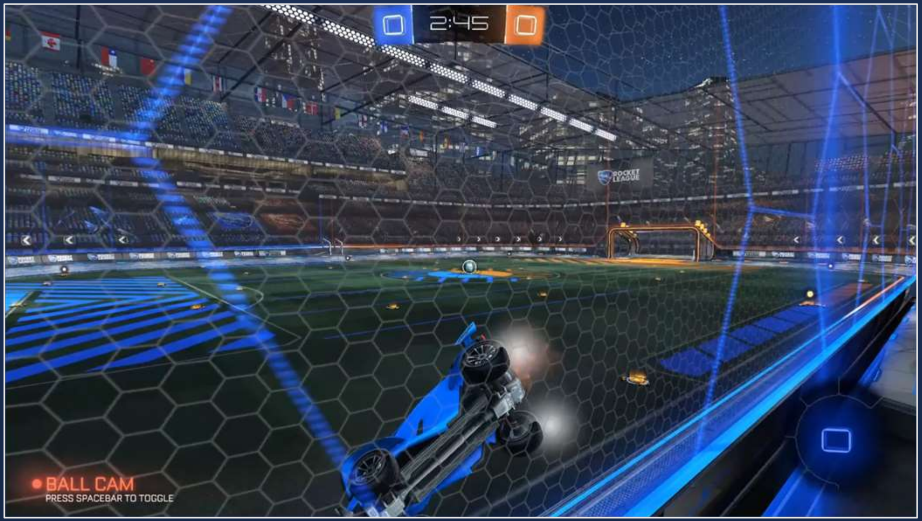

Fig. 4.2: Rocket League agent training for maximum speed, 15.5 million timesteps.

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Results: Hitting the Ball

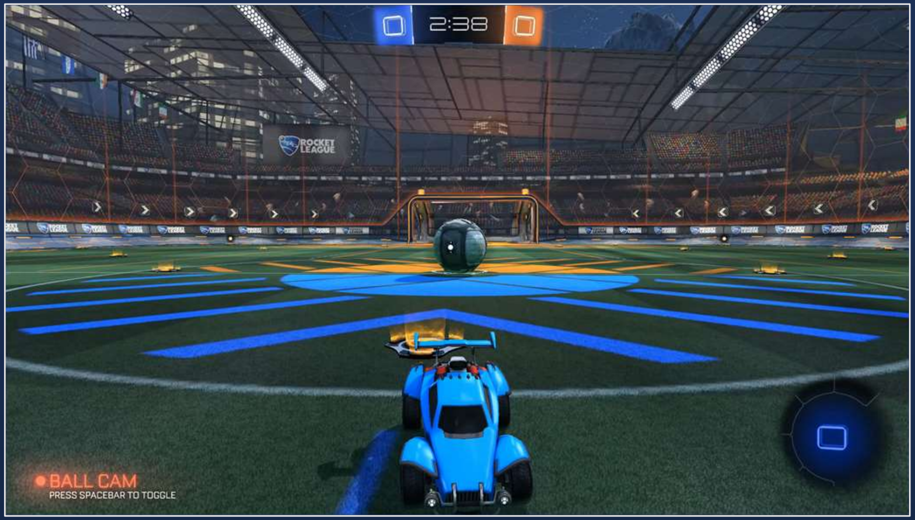

Fig. 5.1: Rocket League agent training to hit the ball, 500,000 timesteps.

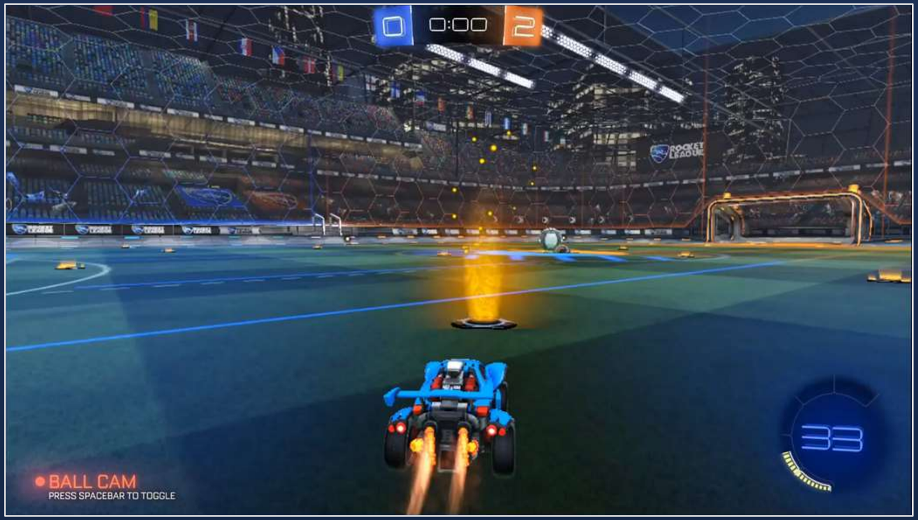

Fig. 5.2: Rocket League agent training to hit the ball, 3 million timesteps.

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Results

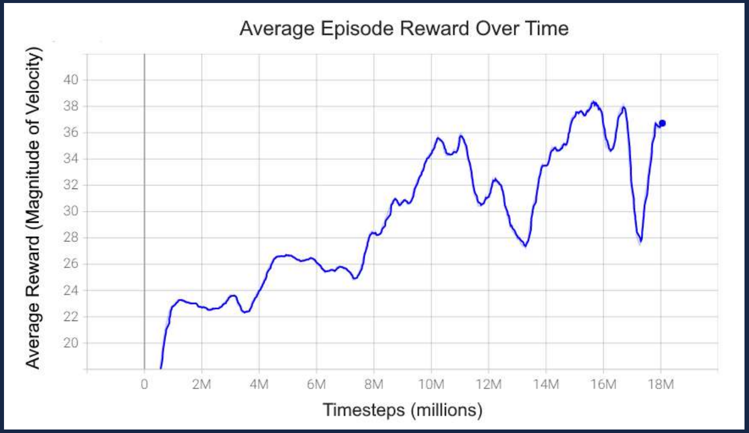

Fig. 6: Average episode reward over time for objective 1. (Maintain the fastest velocity possible)

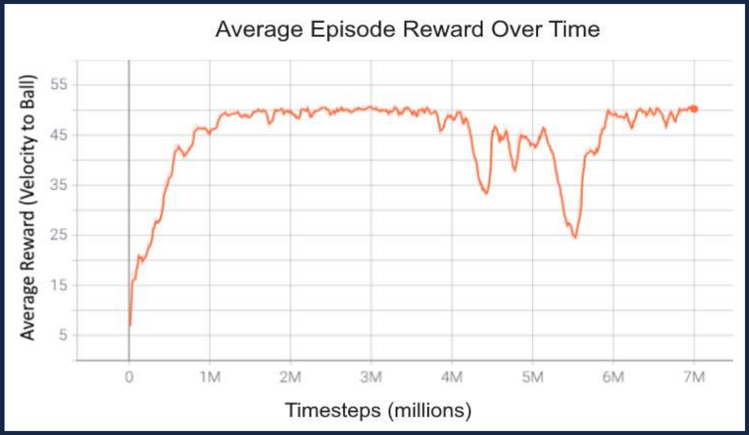

Fig. 7.1: Average episode reward over time for objective 2. (Hitting the ball)

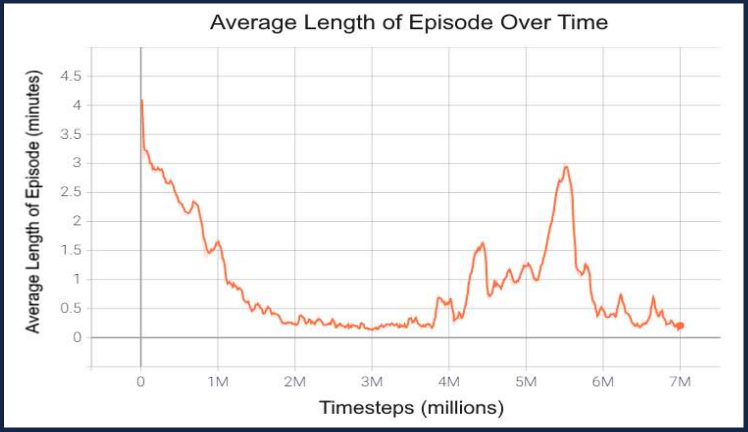

Fig. 7.2: Average length of episode over time for objective 2. (Hitting the ball)

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Conclusion

The Rocket League bot learned to execute simple tasks efficiently.

Our research about agents learning in complex environments shows promise for more difficult tasks.

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For More Information:

- https://gym.openai.com/
- https://rlbot.org/
- https://github.com/lucas-emery/rocket-league-gym