



AWS  
re:Invent

**AIM 225**

# How to build a car that does an 8.64-second lap with AWS DeepRacer

***Mr. Wong Chun Yin, Cyrus***

Amazon Machine Learning Hero

IVE (Lee Wai Lee)

Department of Information  
Technology

**Mr. Chong Kwai Hung, Peter**

Student at IVE (Lee Wai Lee)

Department of Information  
Technology

AWS DeepRacer League Hong  
Kong Champion



We are just a group of non-degree students and 100% newbie!

# Common reward function mistakes

## Missing variables

An outcome without a reward



✖ Your reward function failed validation. Please correct it before you start training.



```
1 def reward_function(params):
2
3     # Calculate 3 markers that are at varying distances away from the center line
4     marker_1 = 0.3 * track_width
5
6     # Give higher reward if the car is closer to center line and vice versa
7     if distance_from_center <= marker_1:
8         reward = 1.0
9
10    return float(reward)
```

✔ Your reward function passed validation.



```
1 def reward_function(params):
2
3     # Read input parameters
4     track_width = params['track_width']
5     distance_from_center = params['distance_from_center']
6
7     # Calculate 3 markers that are at varying distances away from the center line
8     marker_1 = 0.3 * track_width
9
10    # Give higher reward if the car is closer to center line and vice versa
11    if distance_from_center <= marker_1:
12        reward = 1.0
13    else:
14        reward = 1e-3 # likely crashed/ close to off track
15
16    return float(reward)
```

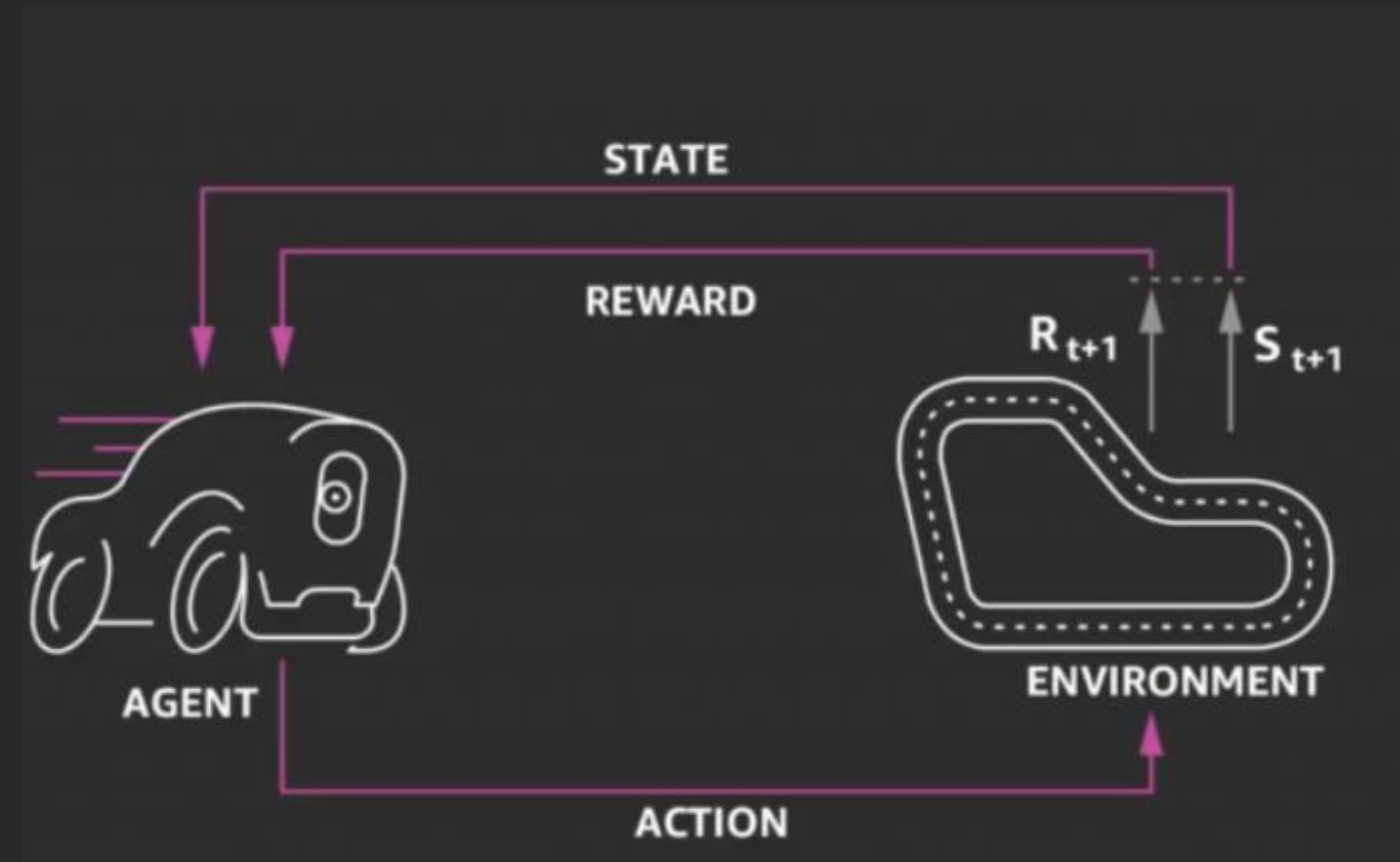




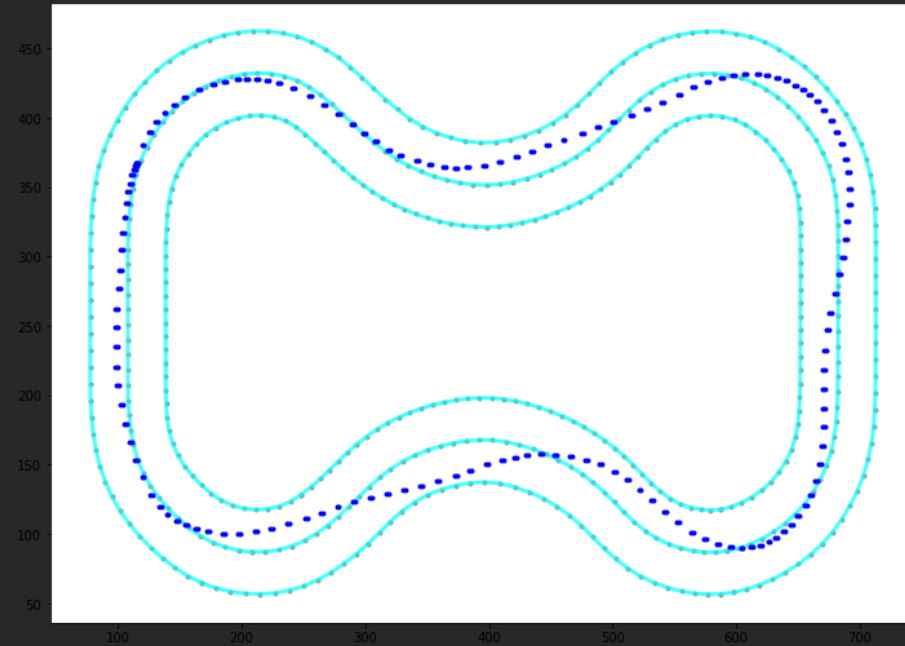
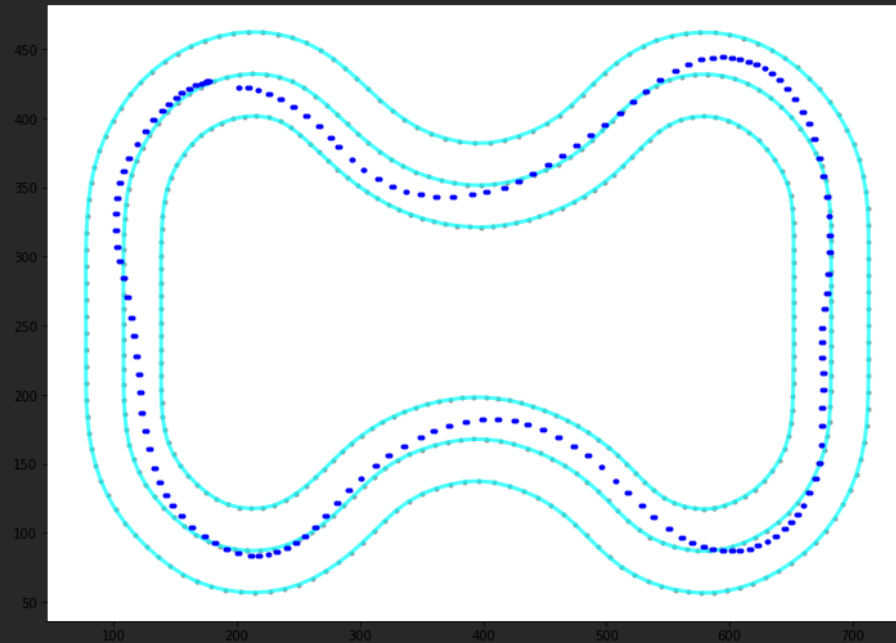
# Useful input parameter: Steps

Number of steps completed; will be reset when off track

Easy way to improve the finish time



# Comparison and sample code

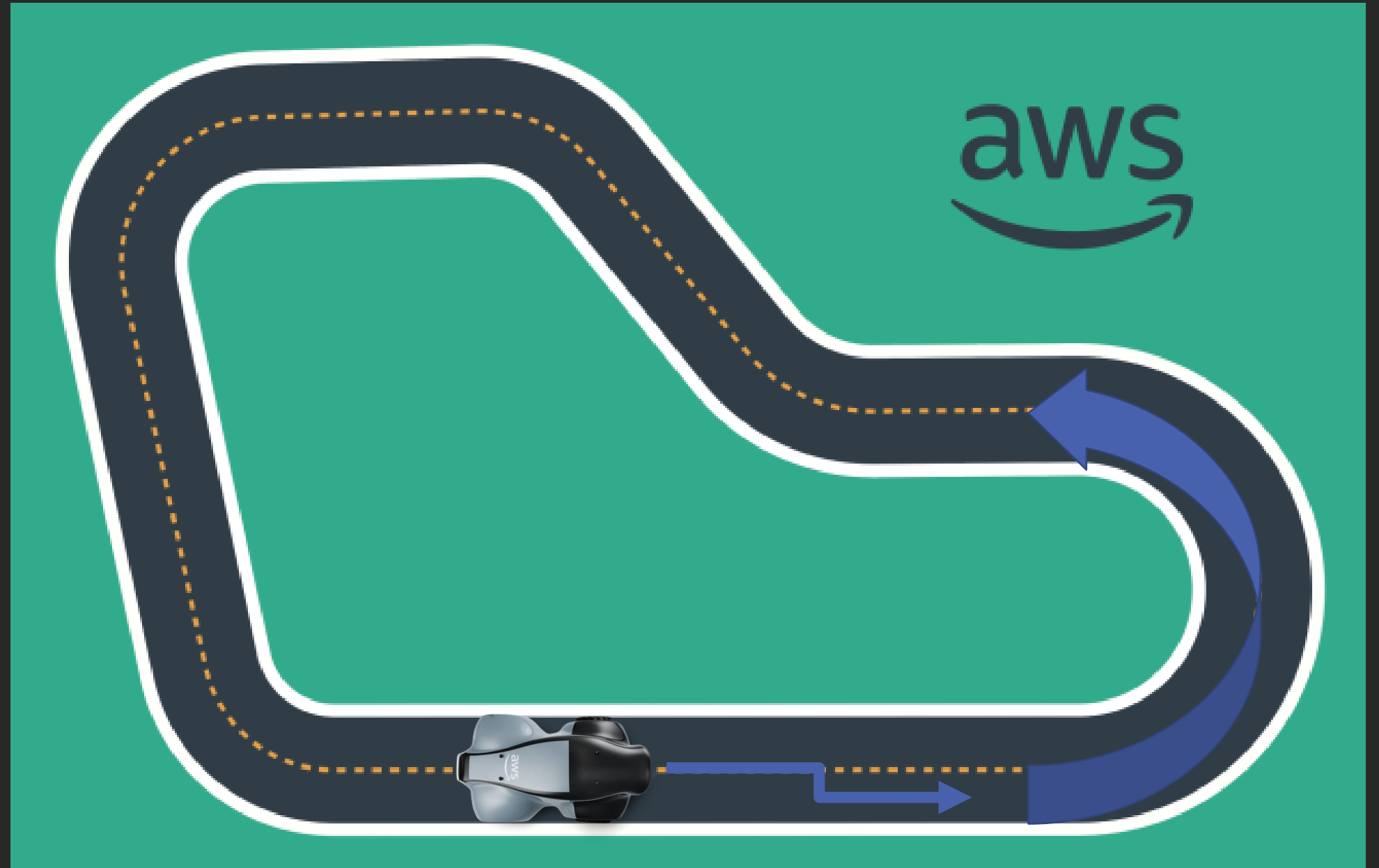


```
16
17 ▾ if steps > 0:
18     reward = ((progress*150)/steps)**2
19 ▾ else:
20     reward= 1
21
```

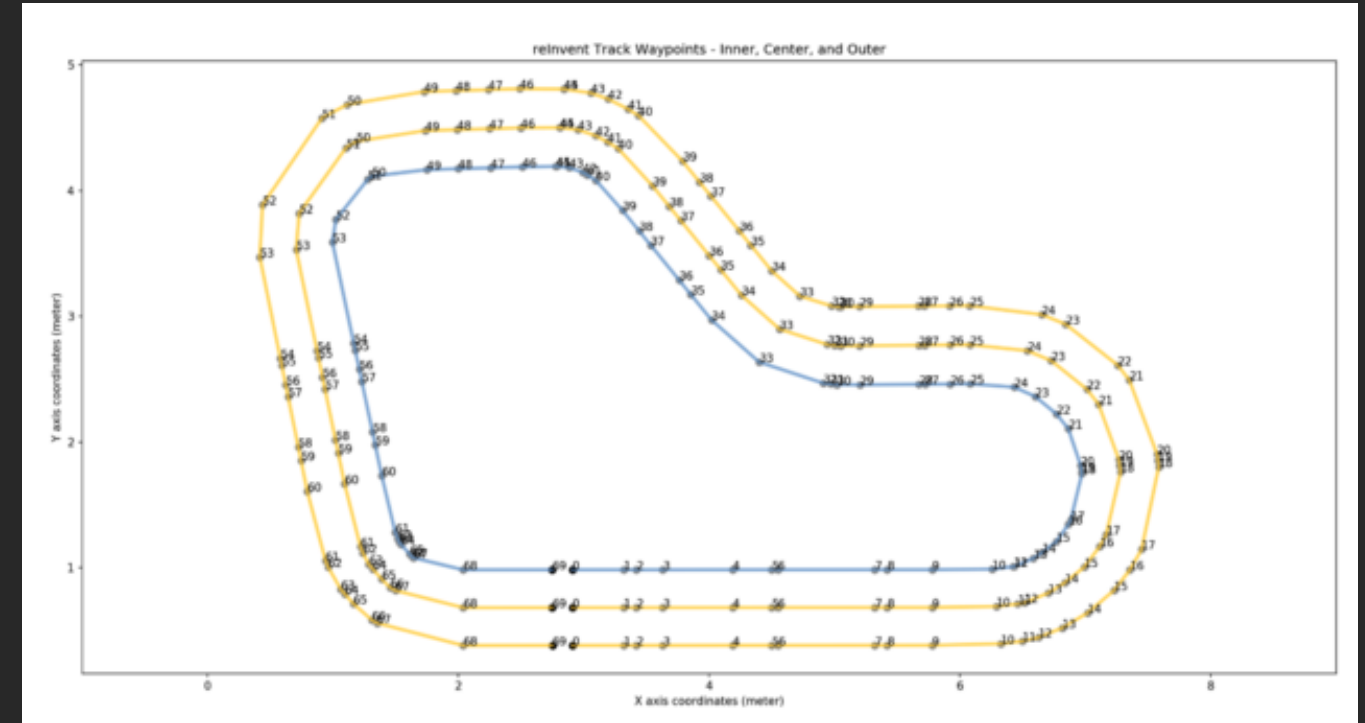
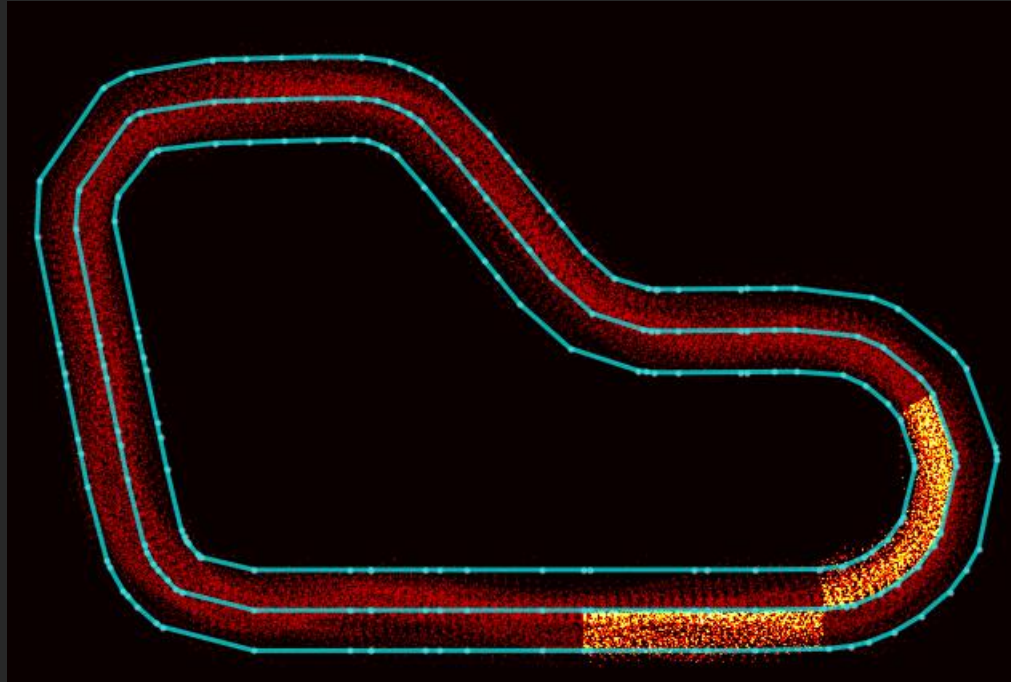
# Useful input parameter: Waypoints

An ordered list of track-dependent max milestones along the track center

Let you set different criteria at different positions



# Reward distribution and sample code



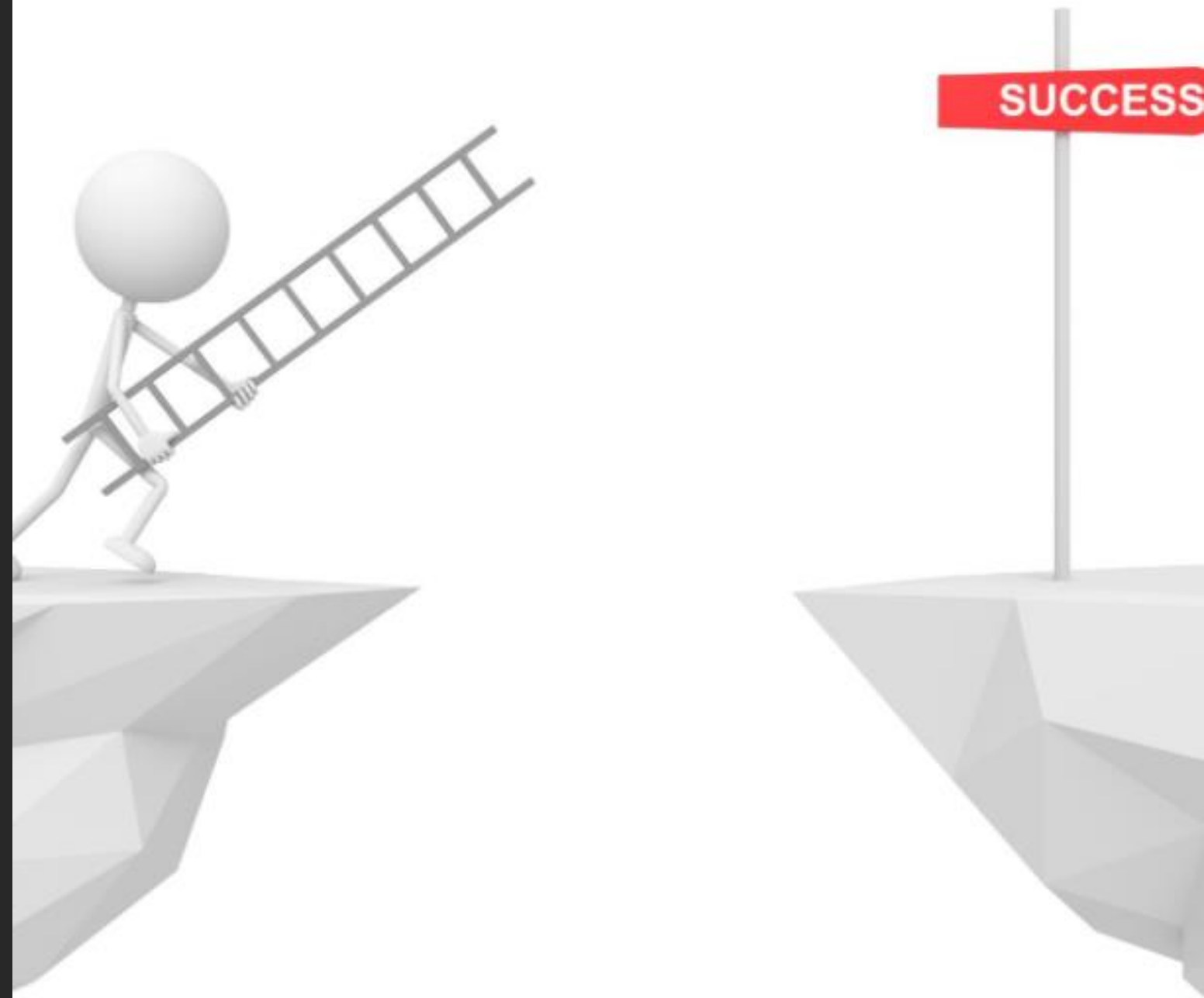
```
21
22     R = [5,6,7,8,9]
23     L = [10,11,12,13,14,15,16,17,18,19,20]
24
25     if (closest_waypoints[0] in (L)) and (is_left_of_center == True):
26         reward = 1
27     elif (closest_waypoints[0] in (R)) and (is_left_of_center == False):
28         reward = 1
29     else:
30         reward = 0.3
31
32
```



# Simulation-to-real domain transfer

Train model in virtual world  
using simulated images

Race model in the real world  
using real world images



# Calibrate first

Calibrate the steering regularly

Calibration > Calibrate steering angle

Step 1  
Set your vehicle on the ground

Step 2  
Calibrate center

Step 3  
Calibrate maximum left steering

Step 4  
Calibrate maximum right steering

## Calibrate steering angle

### Center steering

Increase or decrease the **Center** value to center your vehicle. It is centered when any of the wheels points forward. Use a ruler or straight edge to ensure it is aligned with the rear wheel.

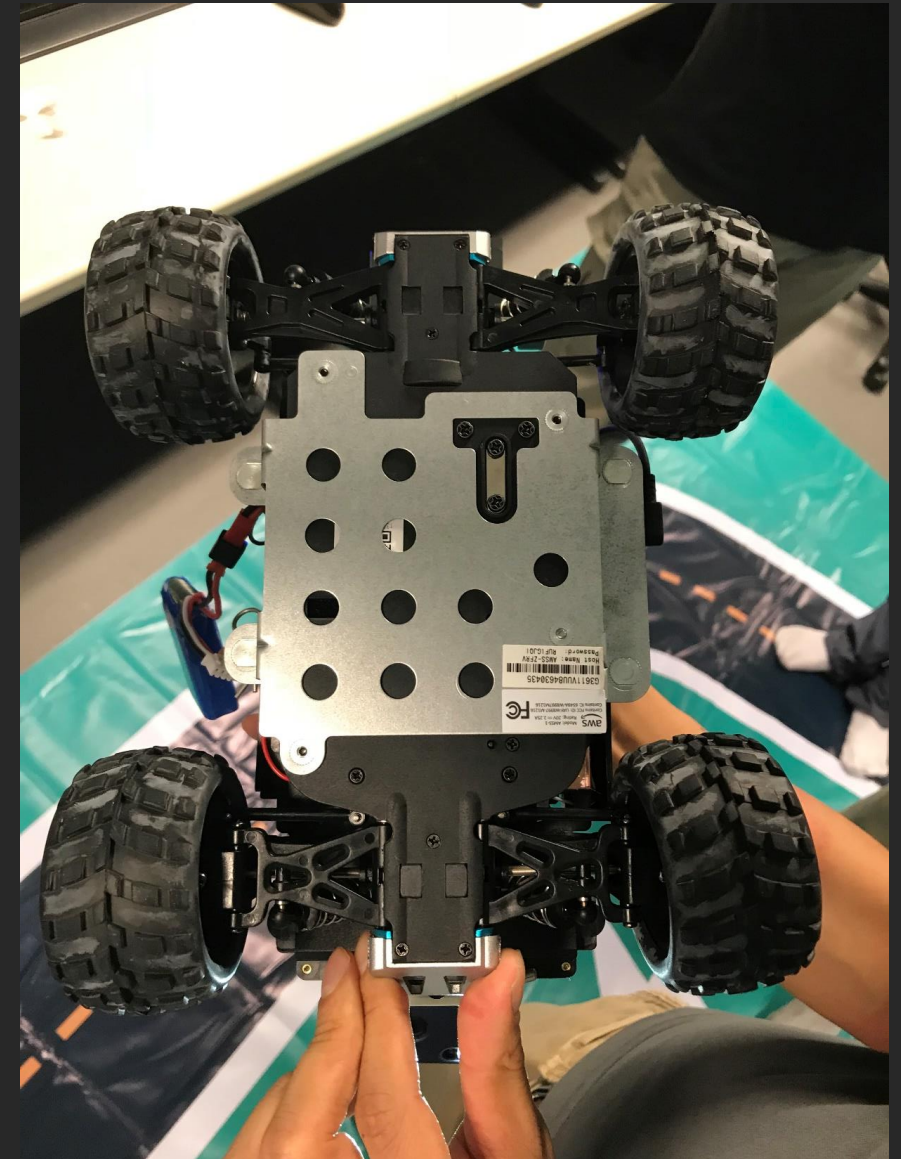
Center value

-30 -20 -10 0 10 20 30

-2

ⓘ The front wheels may not be perfectly aligned to each other -- it is important for one front wheel to be facing forward. DeepRacer uses Ackermann steering.

Cancel Previous Next



# Surround the track with barrier

Items outside the track may confuse the model and lead to incorrect actions, so we should surround the track with a barrier

Don't use something that is reflective since this may also confuse the model





# Reflection of the track

- The reflection of the track will affect the performance of AWS DeepRacer. Aim for matte finish to reduce glare.
- You can watch streaming from the AWS DeepRacer webpage to understand what DeepRacer really sees.



# Midnight AWS DeepRacer

*Inspired by the idea of “no server and no server down!”, we get “no light, no reflection!”*



You can turn off the lights in the room and install USB-powered headlights at the front of the car if you cannot resolve the reflection issue. You will find the view from the AWS DeepRacer is very similar to the view of the AWS RoboMaker simulator.





First time to finish a lap



# Track size

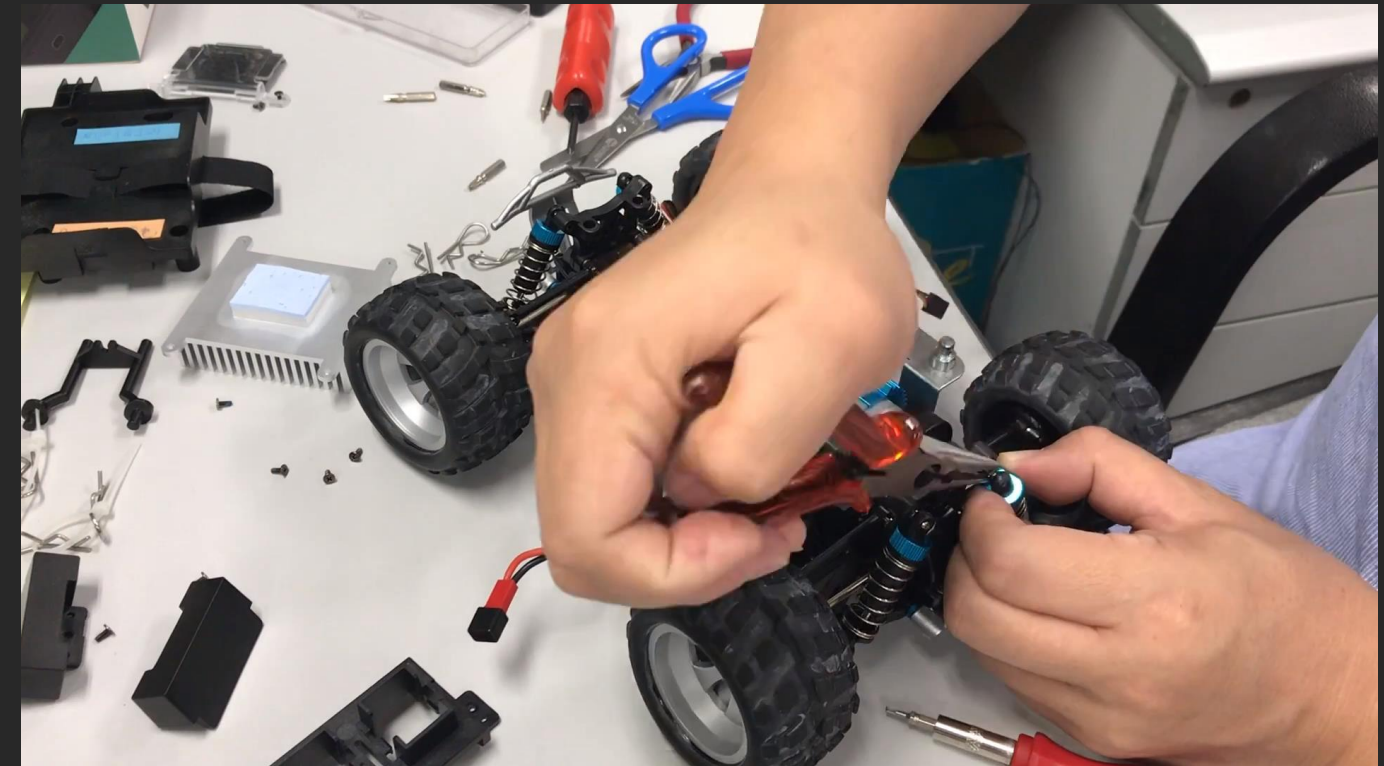
Follow AWS track specifications when you build the track, which can help prevent glare

Pay attention the size of track if you look at any online providers



# AWS DeepRacer is not a bumper car

Another reason to put a barrier around the track is to prevent crashes. Take care of the car.



# How to build a powerful reward function with AWS Lambda

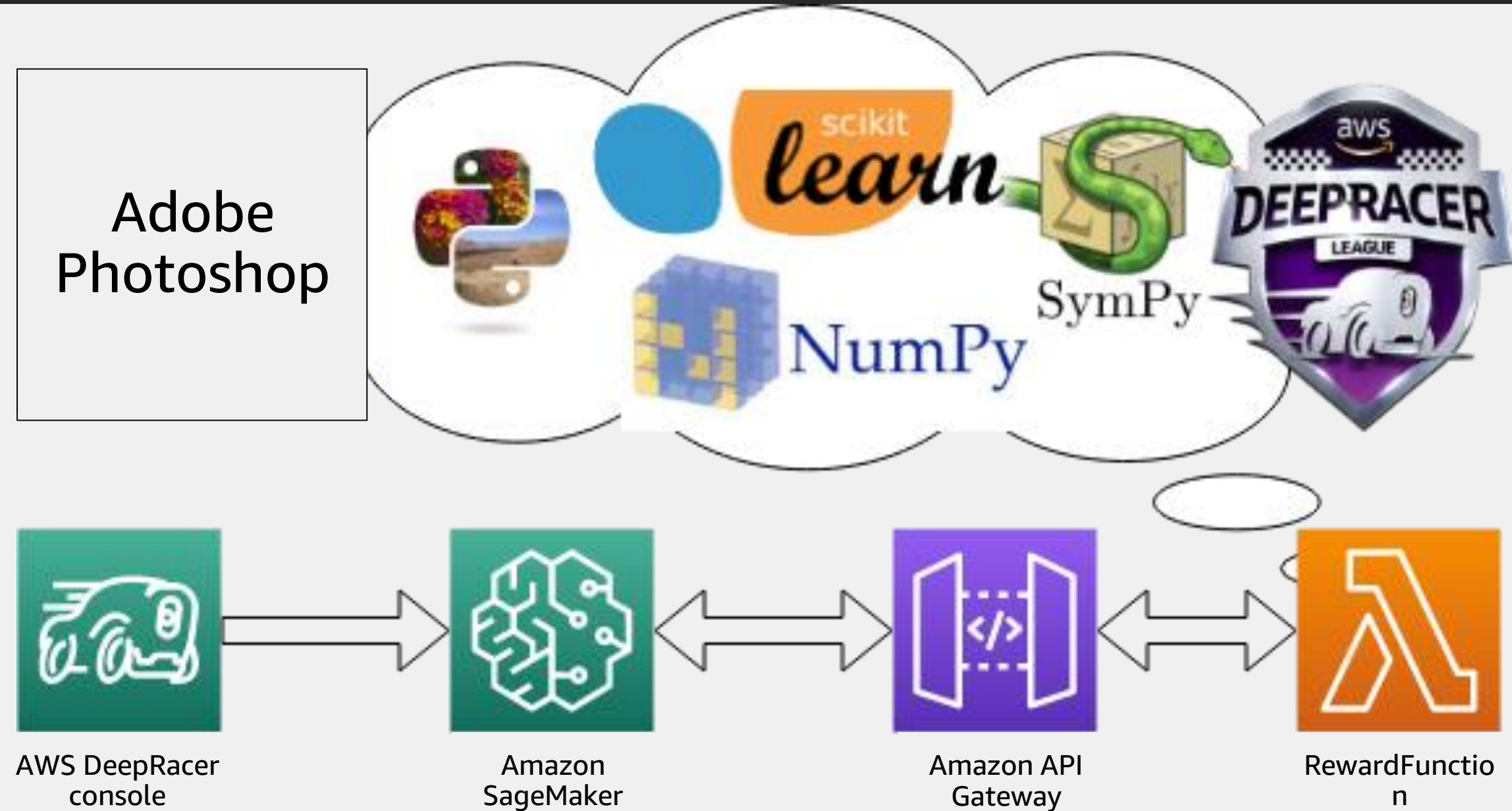
# Problem

If you want to build a complex reward function, you may find you need to recode a lot of functions that already exist in other libraries, e.g., geometry

*It is undifferentiated heavy lifting!*



# Solution



# Reward functions makes call to API Gateway only

```
import urllib.request

import urllib.parse

import json

def reward_function(params):

    url = 'https://XXXXX.execute-api.us-east-1.amazonaws.com/Prod/reward/'

    query_string = urllib.parse.urlencode({"json":json.dumps(params)})

    url = url + "?" + query_string

    with urllib.request.urlopen( url ) as response:

        response_text = response.read().decode('utf-8')

        result = json.loads(response_text)

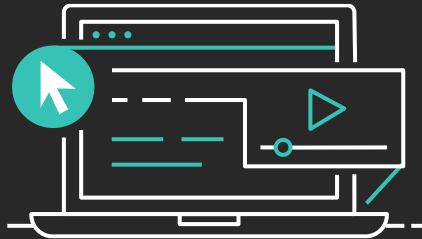
    return float(result["reward"])
```

# Learn ML with AWS Training and Certification

The same training that our own developers use, now available on demand



Role-based ML learning paths for developers, data scientists, data platform engineers, and business decision makers



70+ free digital ML courses from AWS experts let you learn from real-world challenges tackled at AWS



Validate expertise with the  
**AWS Certified Machine Learning - Specialty** exam

Visit <https://aws.training/machinelearning>

# Thank you!

**Mr. Cyrus Wong, Amazon Machine Learning Hero**

LinkedIn: [linkedin.com/in/cyruswong/](https://www.linkedin.com/in/cyruswong/)

Twitter: [twitter.com/wongcyrus](https://twitter.com/wongcyrus)



Please complete the session  
survey in the mobile app.