



AWS
re:Invent

AIM207-R3

Get started with AWS DeepRacer

Speaker Name

Job Title

Speaker Name

Job Title

Agenda

AWS DeepRacer

AWS DeepRacer League

Reinforcement learning for the Sunday driver

AWS DeepRacer virtual simulator

Under the hood

AWS DeepRacer hands-on lab

AWS DeepRacer at re:Invent 2019

AWS DeepRacer

Introducing AWS DeepRacer Evo



How can we put reinforcement learning in the hands of all developers? Literally.

Get hands-on experience with reinforcement learning



AWS DeepRacer Evo



3D racing simulator



2020 AWS
DeepRacer League



Community Races

AWS DeepRacer League

AWS DeepRacer League 2019: Summit Circuit

	solo@DNP	7.44		Juv Chan	9.090
	astronav	7.620		A Cloud Guru	9.35
	john@invex	7.726		Pedro@pragsis	9.367
	Myplanet	7.851		Rafa	9.579
	Kim Yejun	7.998		grc8@c1	9.590
	Ray G	8.152		Bryan	9.978
	Matt @ GJI	8.290		Cloud Brigade	10.43
	Ray Chang	8.630		Ryan@ACloudGuru	11.108
	Peter@IVE Cloud	8.648		Pon Datalab	13.030
	Kevin Byun	8.715		arthur	13.87
	Jouni @Cybercom	8.732		Mats@ Virgin Mobile	18.078
	Roger@NCTU_CGI	8.734		Rick Fish	51.500
	MattC	8.917		RE:INVENT '19	TBD

21 races, 17 countries, thousands of developers of all skill levels, and a world record of 7.44 seconds

www.deepracerleague.com

AWS DeepRacer League 2019: Virtual Circuit

5/31	Karl-NAB	9.739		v7	kimwooglae	5932.70	
6/30	Fumiaki	10.31		v8	jochem	5931.39	
7/31	2edgy	9.203		v9	abaykov	5930.49	
8/31	Breadcentric	8.03		v10	hiroisojp	5929.38	
9/31	JasonLian	8.72		v11	leo-dnpds	5929.13	
10/31	Eric-NCTU-CGI	7.17		v12	mogamin	5927.61	
V1	Etaggel	5938.23		v13	kire	5926.78	
v2	pgs-tomasz-panek	5937.82		v14	hyeonwoo	5925.89	
v3	Nero-DNPDS	5937.29		v15	tonyj	5925.77	
v4	aiis-dnp	5934.19		v16	richardfan	5925.17	
v5	jimwu	5933.78		v17	robin-castro	5920.27	
v6	Nalbam-me	5933.20		v18	Kagrazaka-DNP	5917.02	

6 virtual race winners and 18 top point-getters

<http://join.deepracing.io/>

AWS DeepRacer League will return in 2020!



2 ways to race

Online Virtual
Circuit

In-person
Summit Circuit

3 race formats

Time trial

Object
Avoidance

Head-to-head

Prizes!

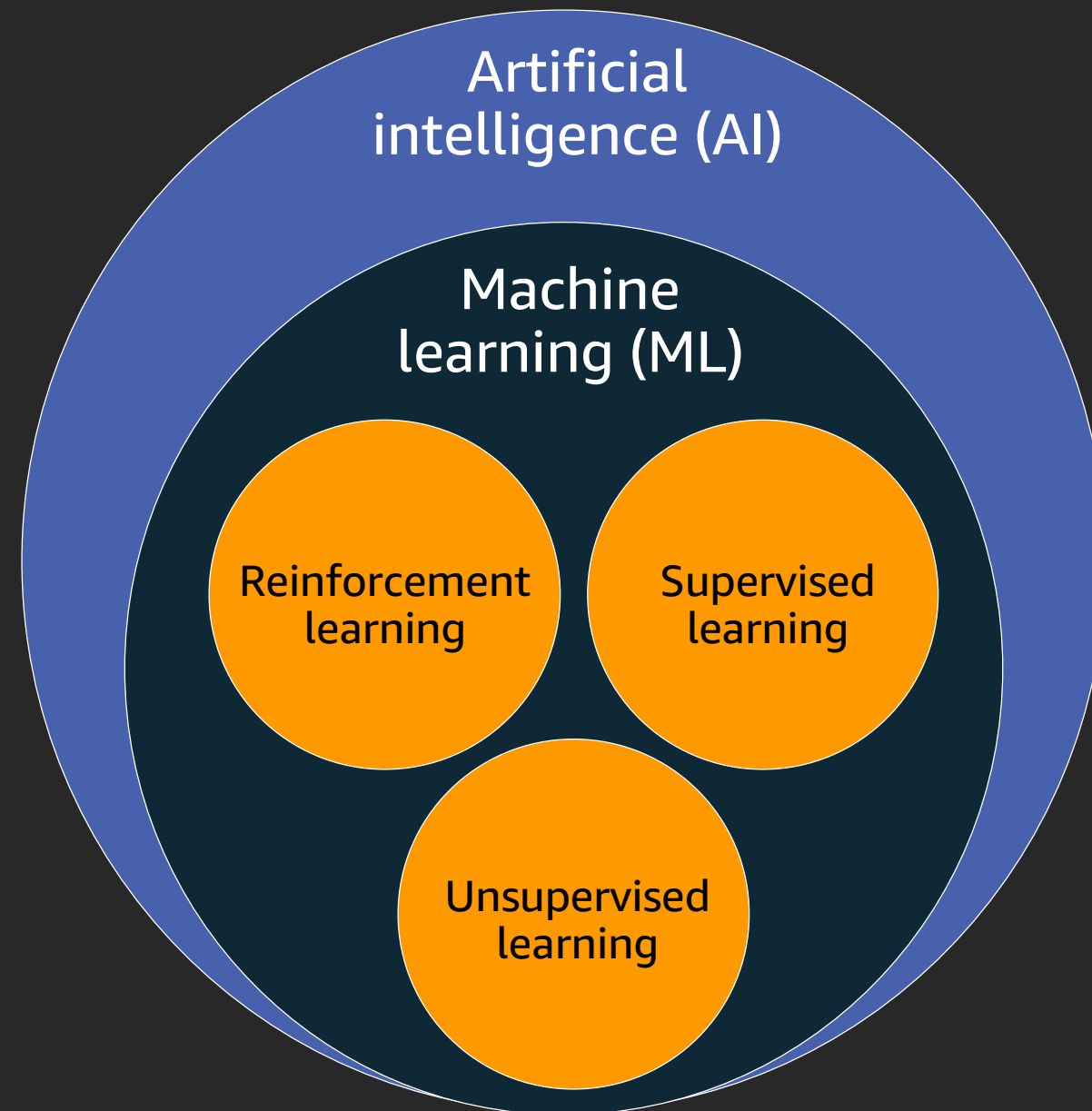
Paid trip to
re:Invent!

Win DeepRacer
cars

www.deepracerleague.com

RL for the Sunday driver

Reinforcement learning in the broader AI context

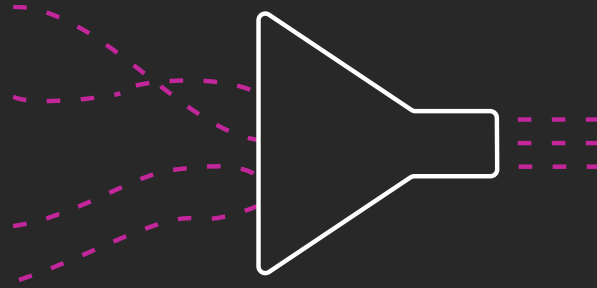


ML overview



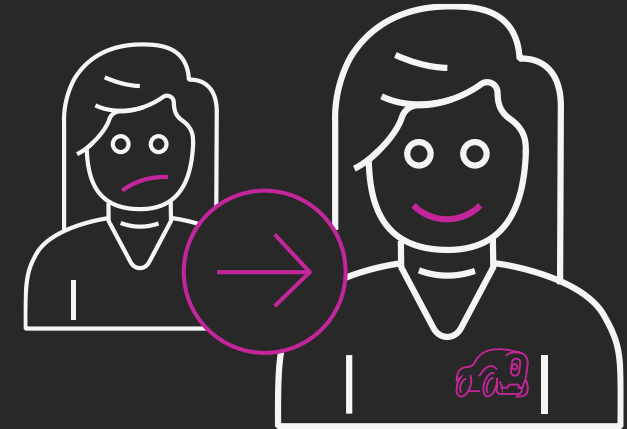
Supervised

Example-driven training; every datum has a corresponding label



Unsupervised

No labels for training data



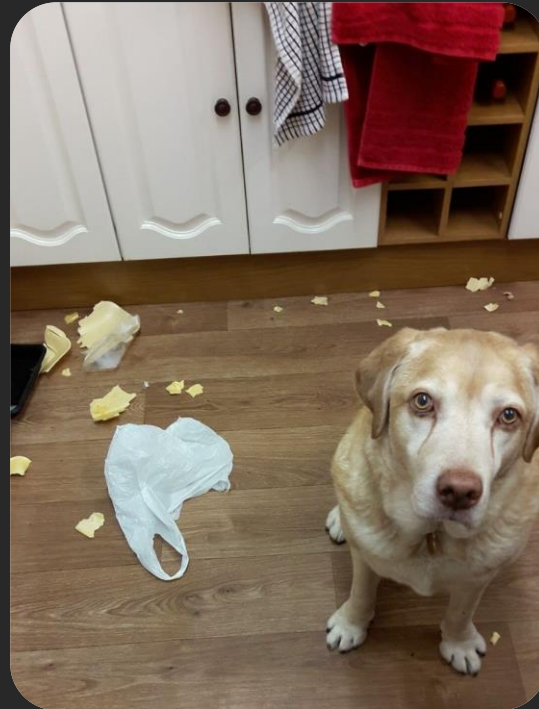
Reinforcement

Learns through consequences of actions in a specific environment

RL in the real world



Reward positive
behavior

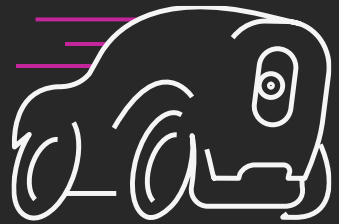


Don't reward
negative behavior

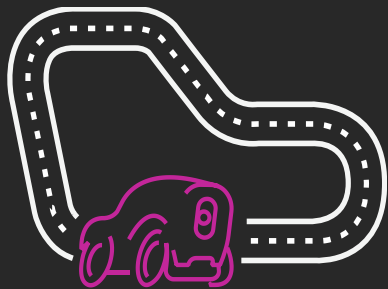


The result!

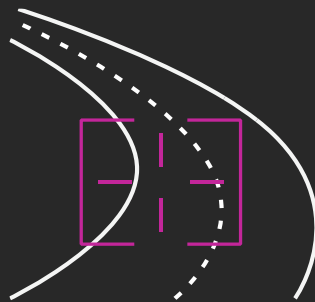
Reinforcement learning terms



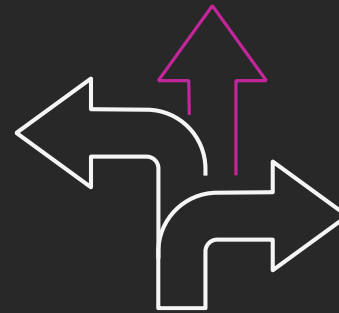
Agent



Environment



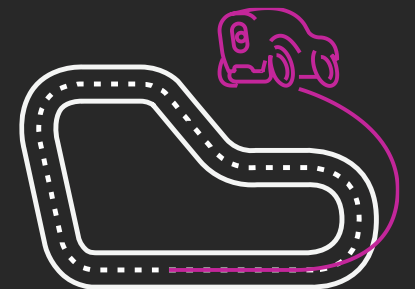
State



Action



Reward



Episode

The reward function

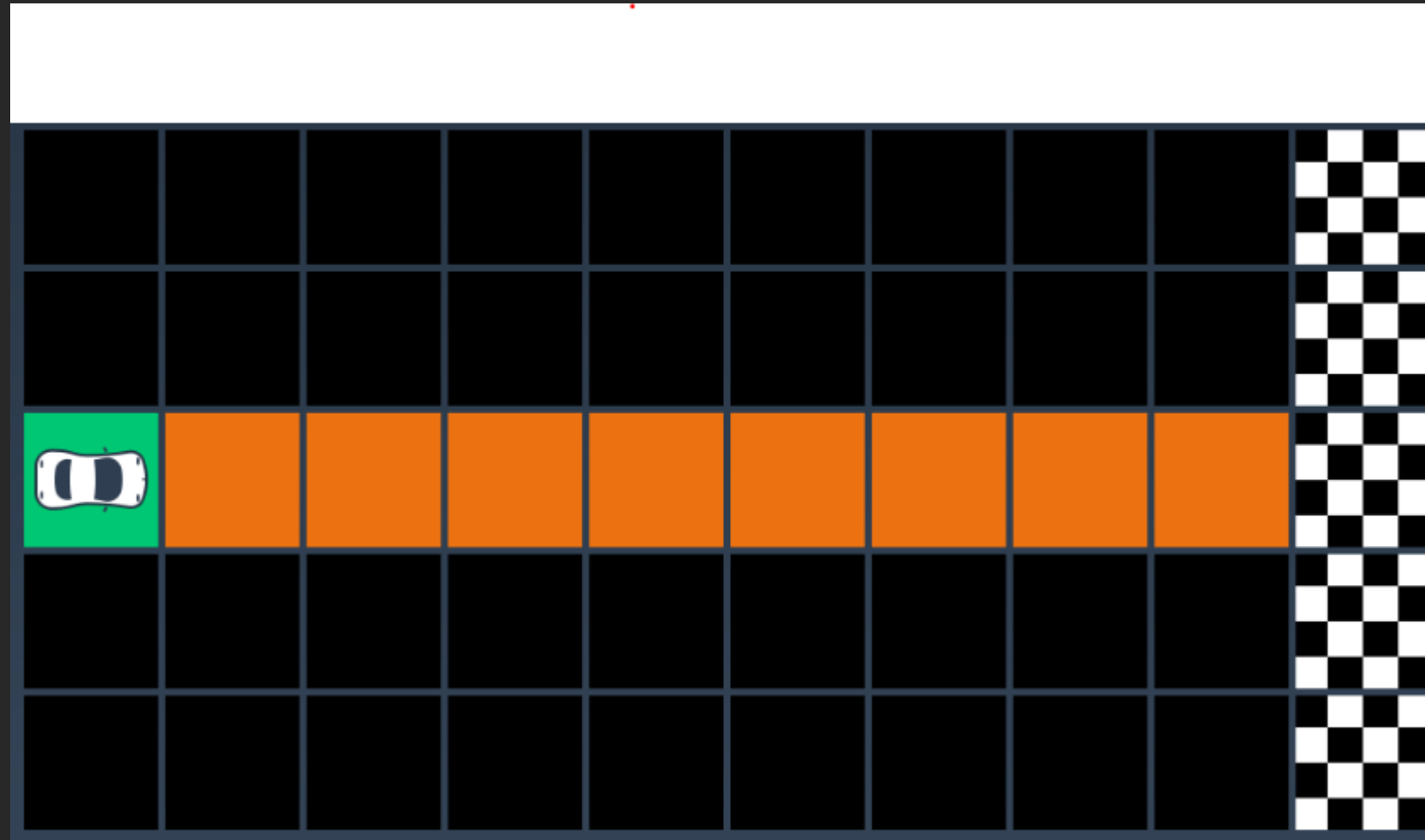


The reward function incentivizes particular behaviors and is at the core of reinforcement learning

The reward function in a grid race

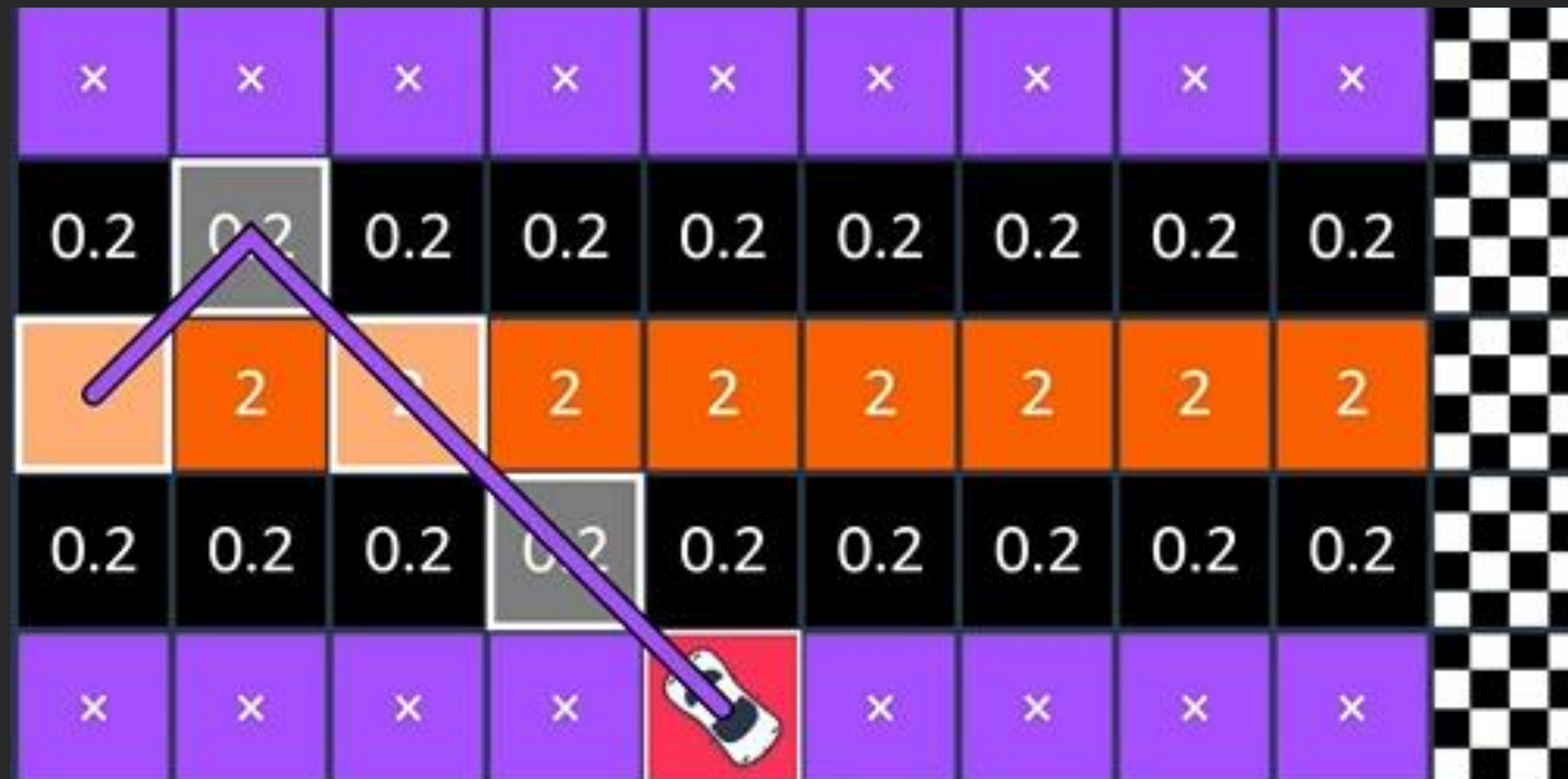


Agent



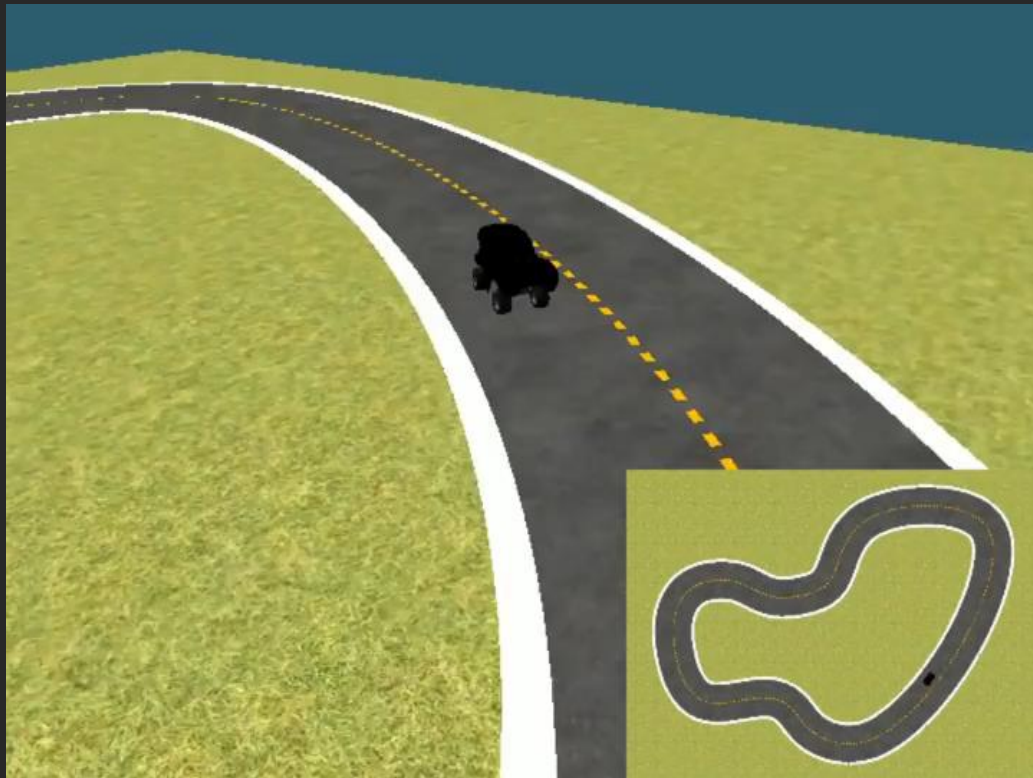
Goal

Iteration and convergence

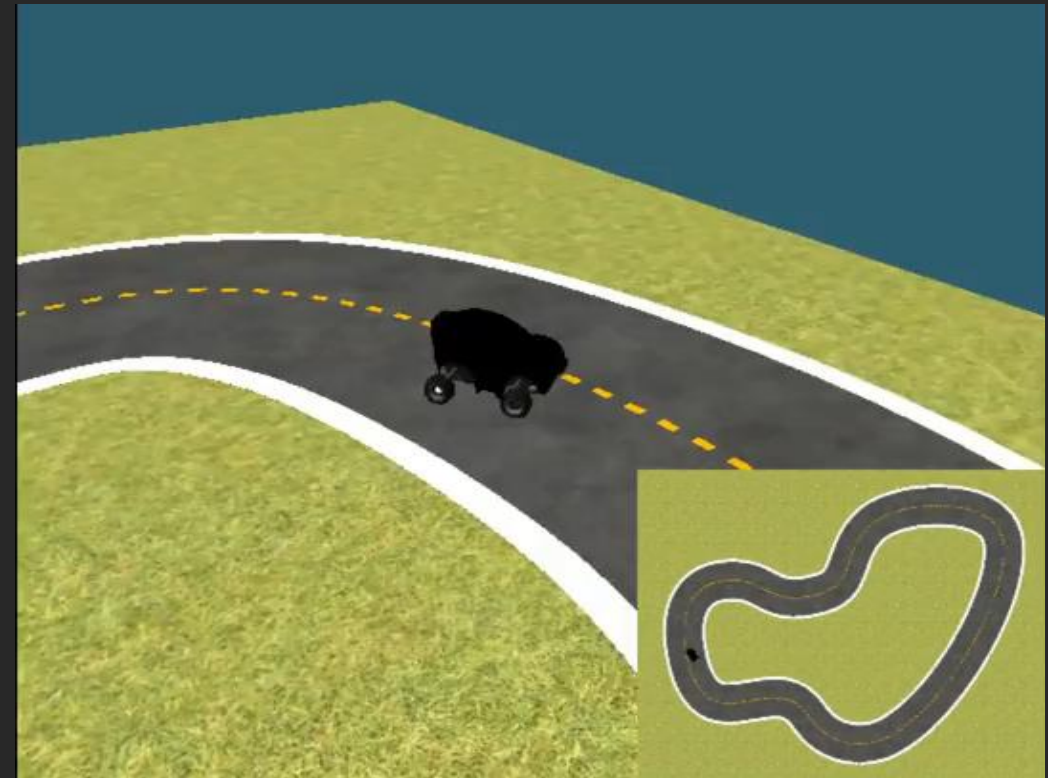


Exploration versus exploitation

Exploration

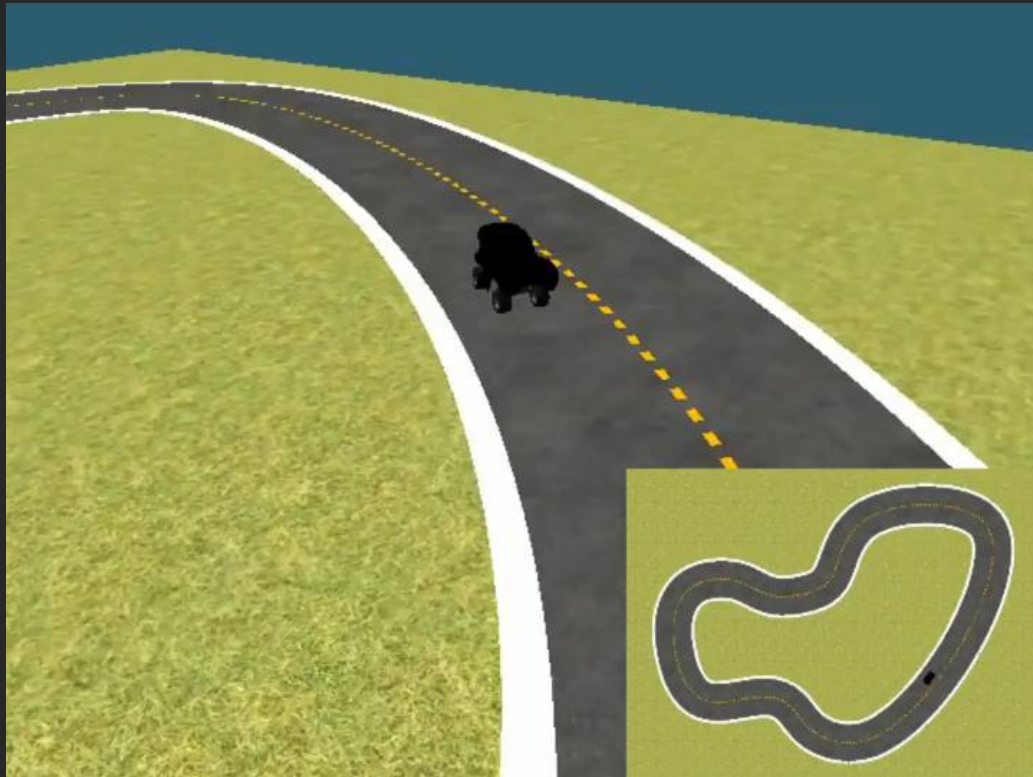


Exploitation

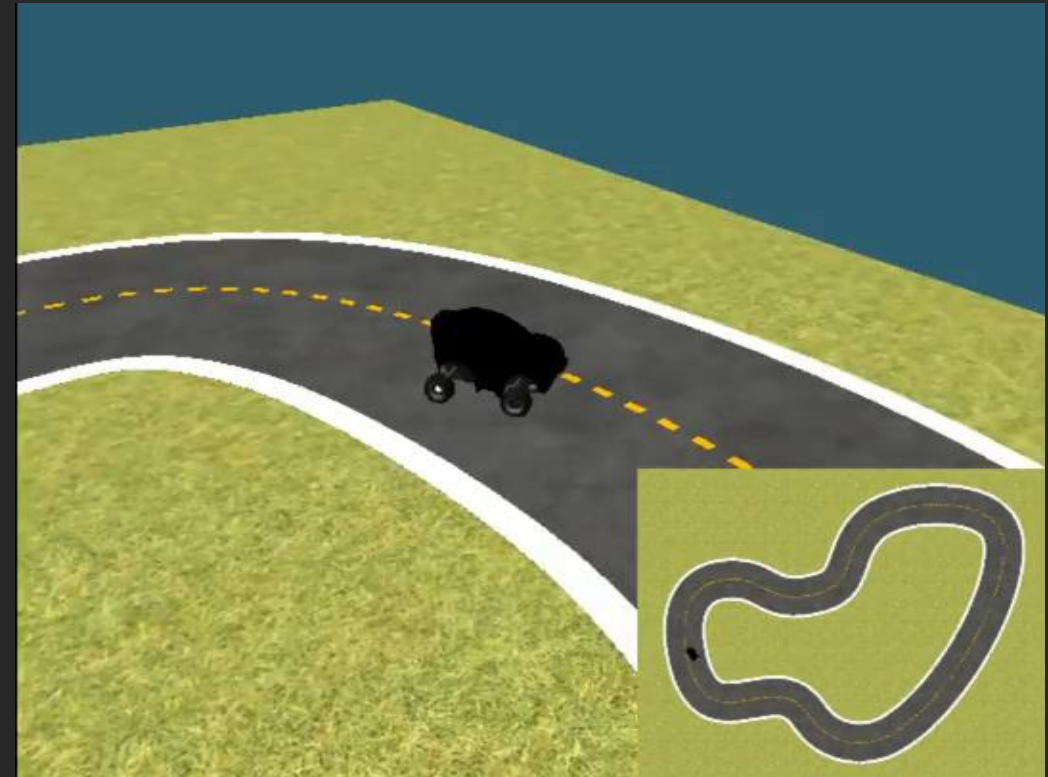


Exploration versus exploitation

Exploration



Exploitation



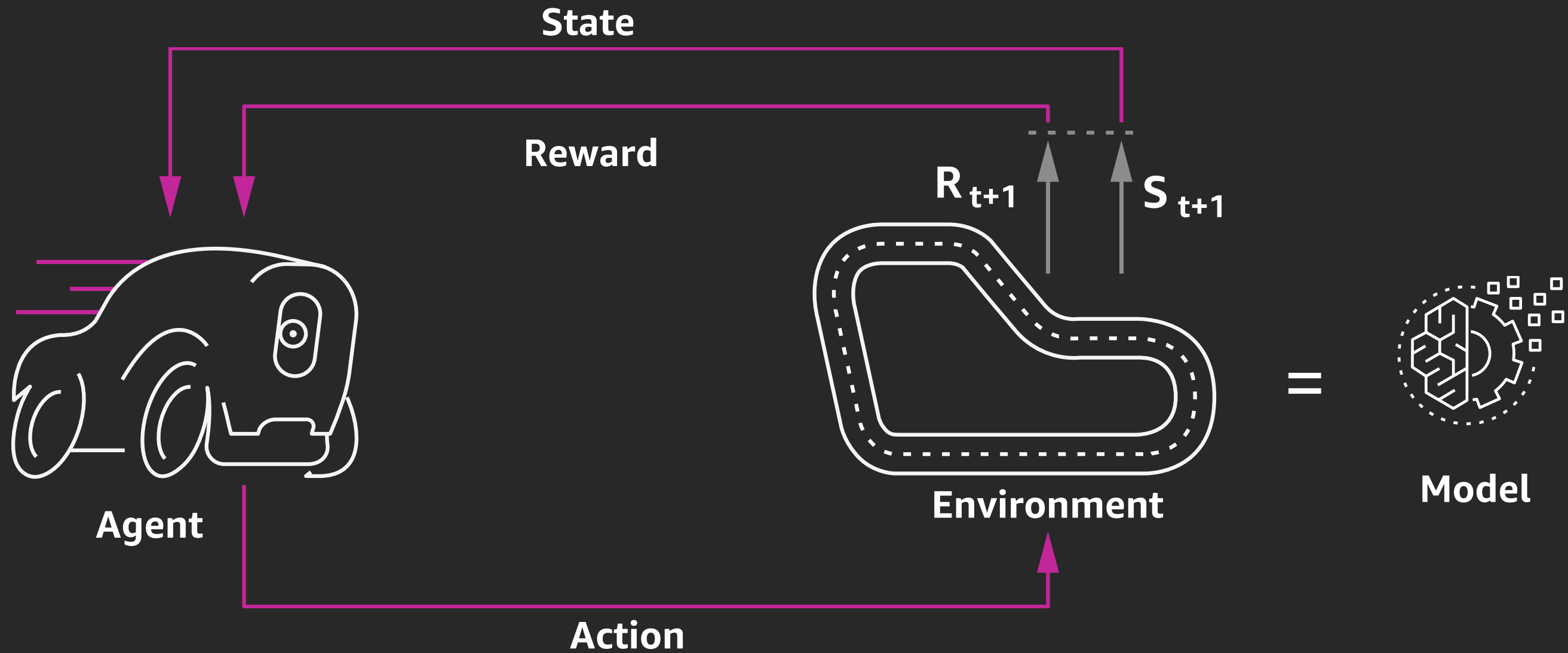
Recap before we continue

Reinforcement
learning

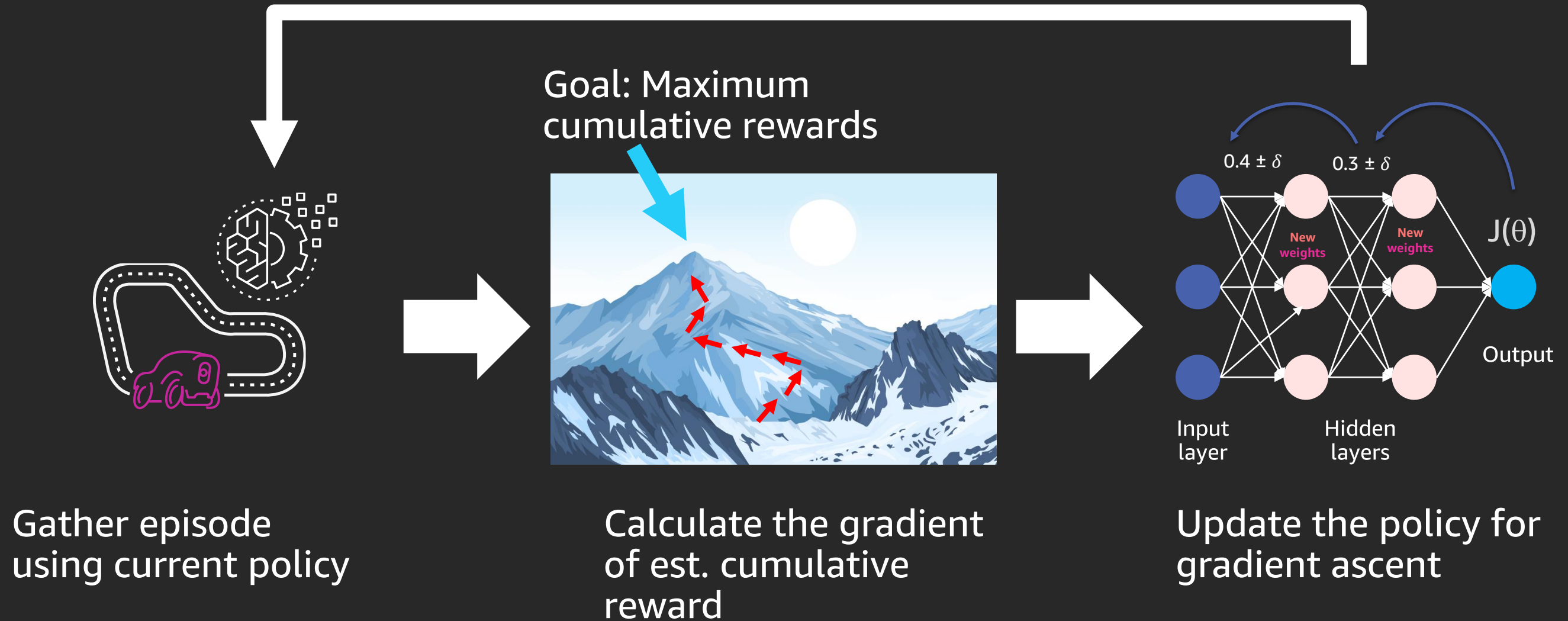


×	×	×	×	×
0.2	0.2	0.2	0.2	0.2
	2	2	2	2
0.2	0.2	0.2	0.2	0.2
×	×	×	×	×

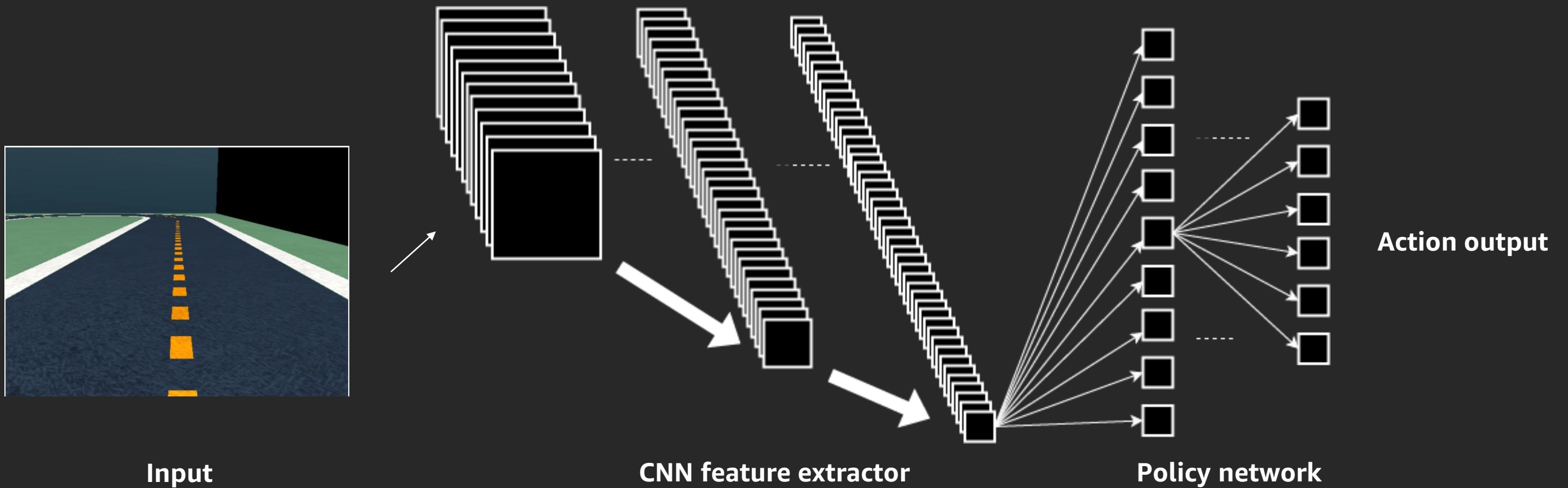
How does learning happen?



RL algorithms: Vanilla policy gradient

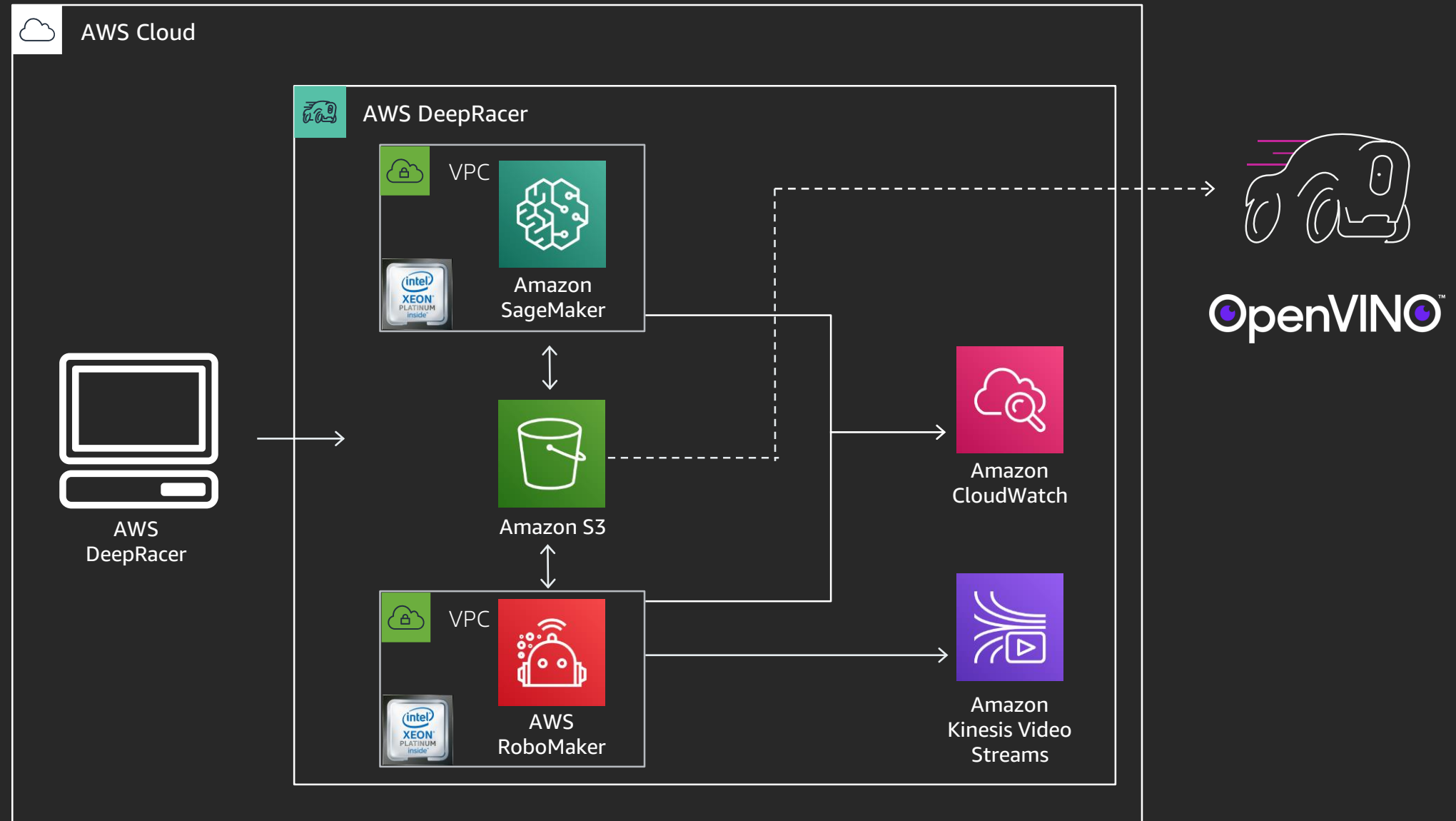


AWS DeepRacer neural network architecture

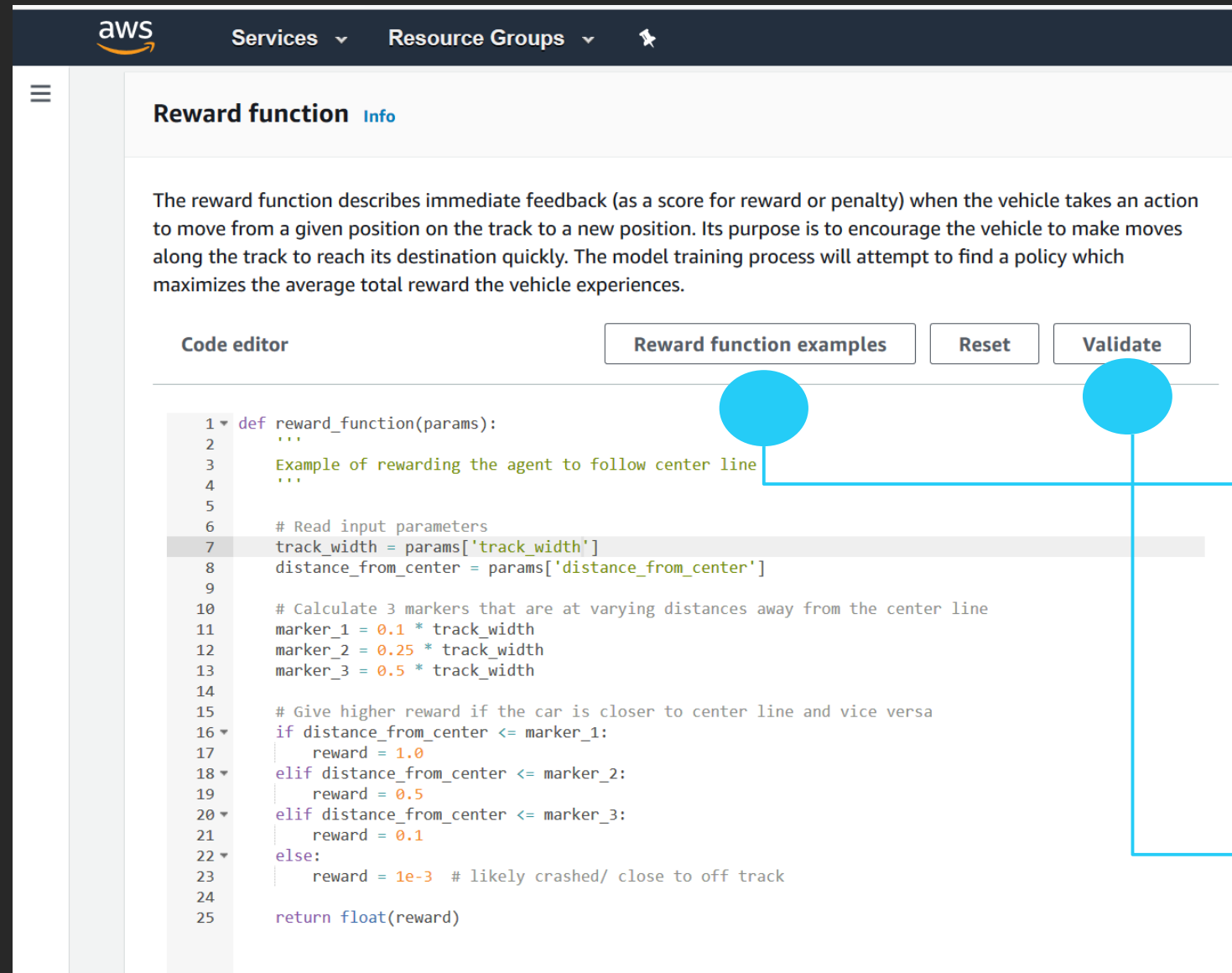


Virtual simulator

AWS DeepRacer simulator architecture



Programming your own reward function



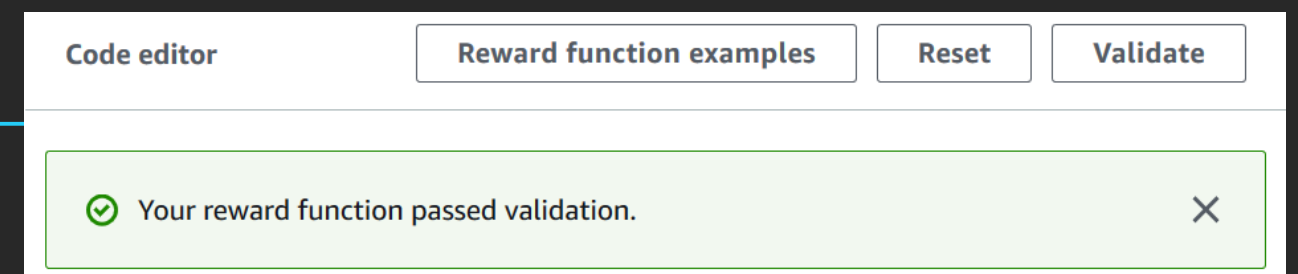
The screenshot shows the AWS Lambda console interface for a function named "Reward function". The "Code editor" tab is active, displaying a Python function. The function calculates a reward based on the distance from the center line of a track. It defines three markers at 0.1, 0.25, and 0.5 of the track width. Rewards are 1.0, 0.5, and 0.1 for distances within these markers, respectively. A reward of 1e-3 is given for distances outside these markers, indicating a crash or off-track event. The function returns the reward as a float.

```
1 def reward_function(params):
2     ...
3     Example of rewarding the agent to follow center line
4     ...
5
6     # Read input parameters
7     track_width = params['track_width']
8     distance_from_center = params['distance_from_center']
9
10    # Calculate 3 markers that are at varying distances away from the center line
11    marker_1 = 0.1 * track_width
12    marker_2 = 0.25 * track_width
13    marker_3 = 0.5 * track_width
14
15    # Give higher reward if the car is closer to center line and vice versa
16    if distance_from_center <= marker_1:
17        reward = 1.0
18    elif distance_from_center <= marker_2:
19        reward = 0.5
20    elif distance_from_center <= marker_3:
21        reward = 0.1
22    else:
23        reward = 1e-3 # likely crashed/ close to off track
24
25    return float(reward)
```

Code editor: Python 3 syntax

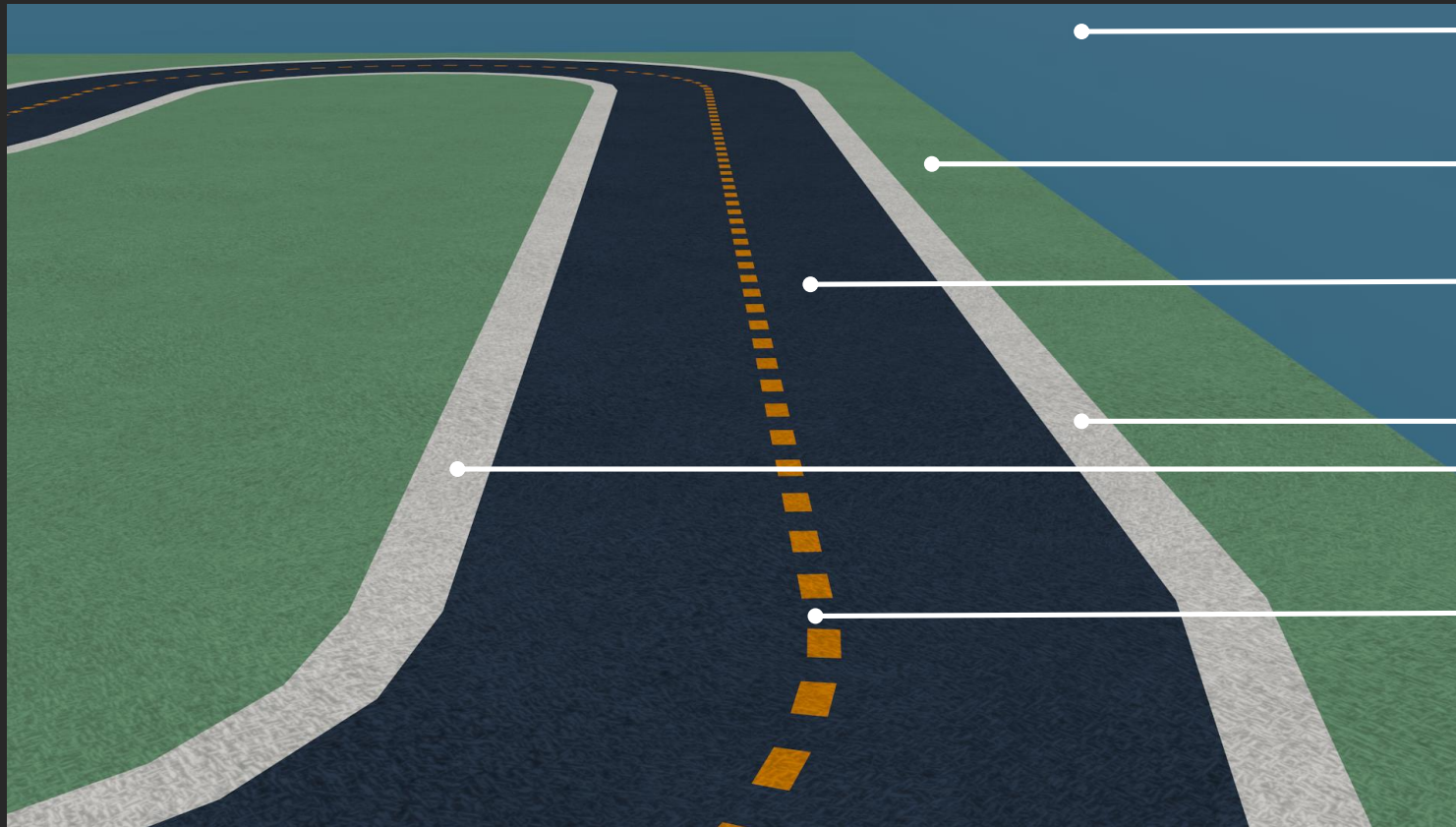
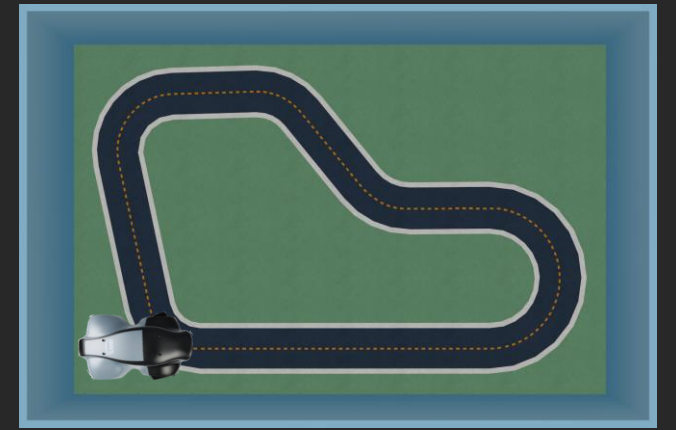
Three example reward functions

Code validation via AWS Lambda



The screenshot shows the AWS Lambda console interface for the same function. The "Validate" button has been clicked, and a green notification box at the bottom of the console displays a checkmark icon and the message: "Your reward function passed validation." The notification box has a close button (X) in the top right corner.

Track components



Track wall

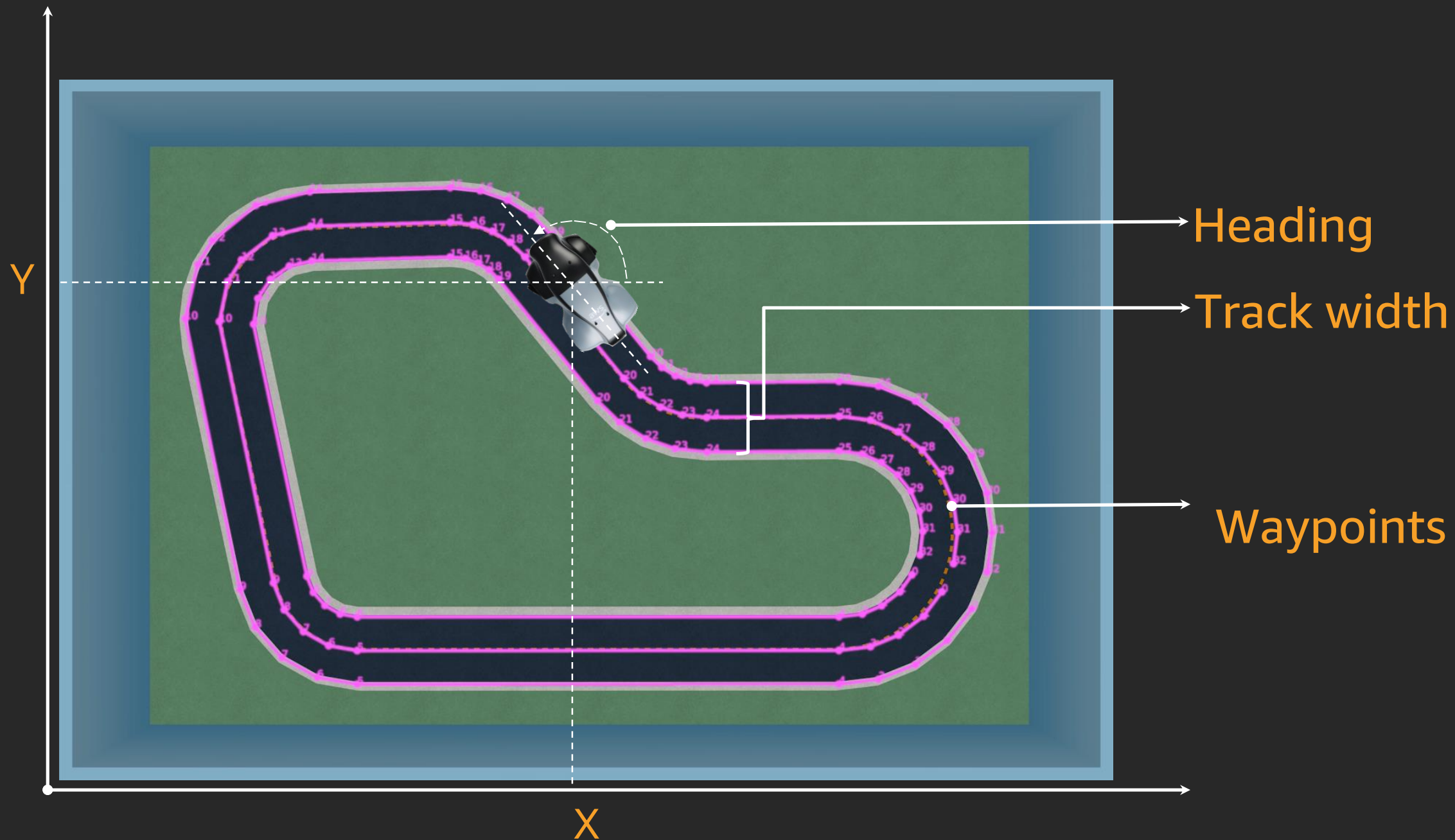
Field aka off-track

Track surface aka on-track

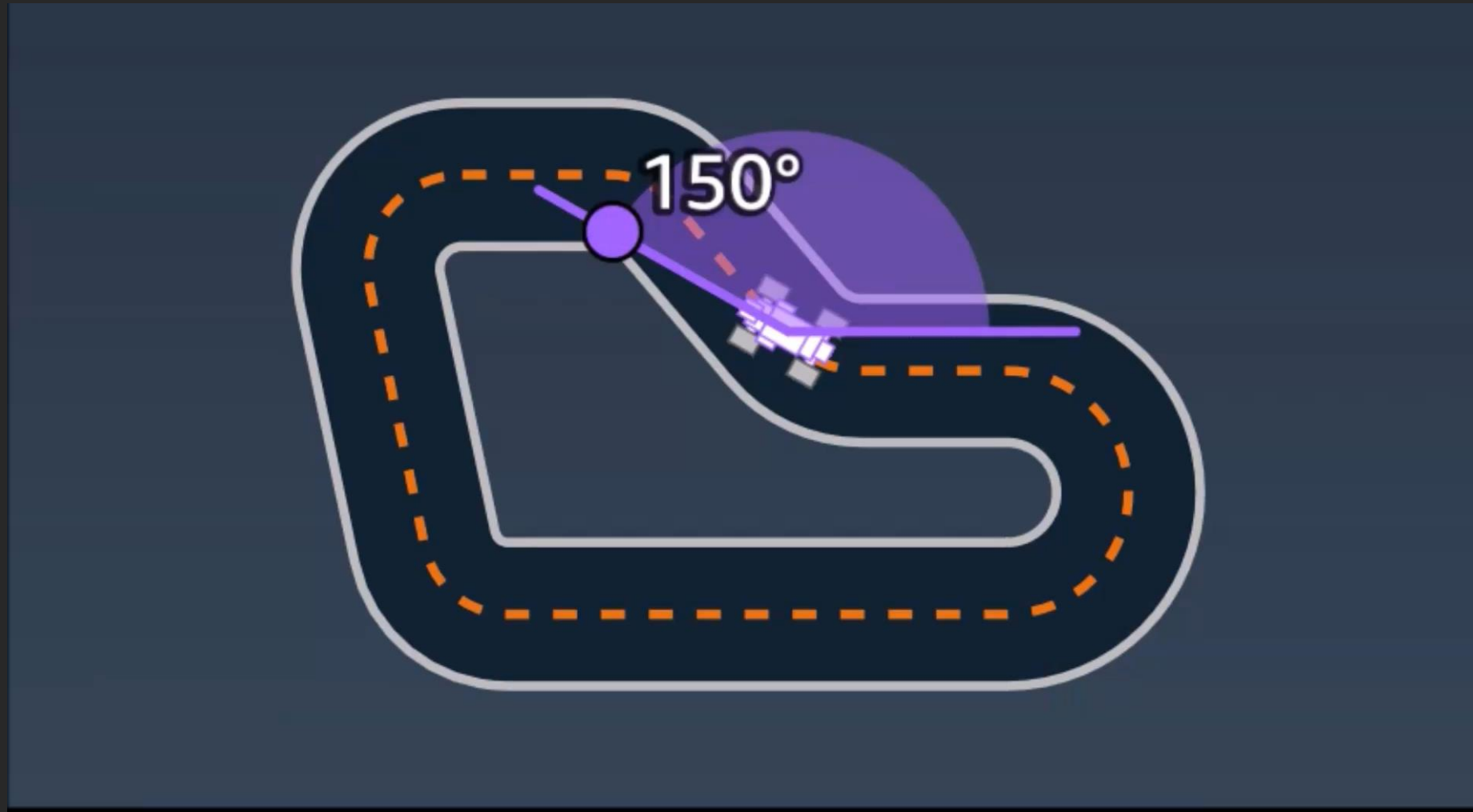
Track boundaries

Track center

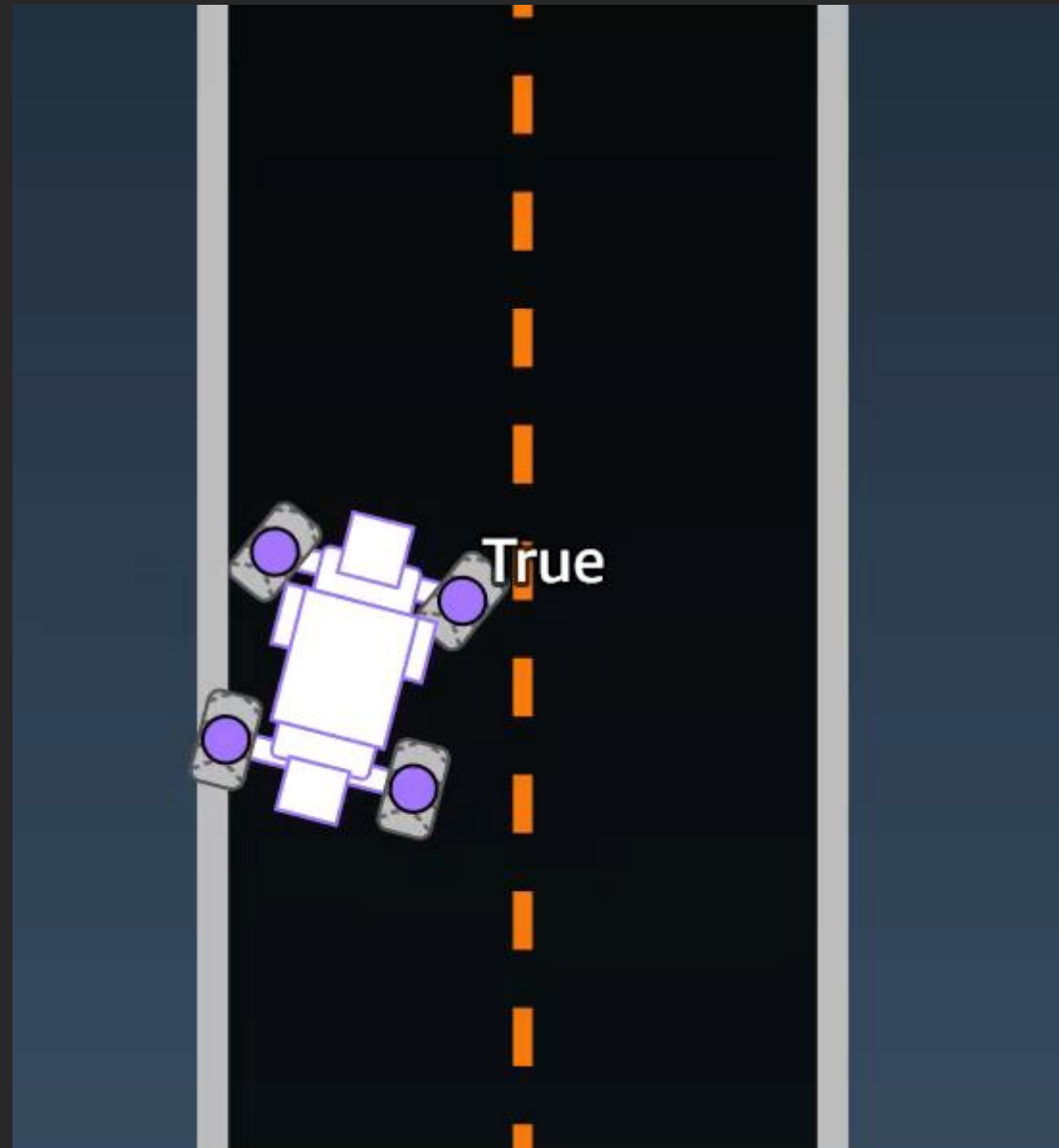
Coordinate system and track waypoints



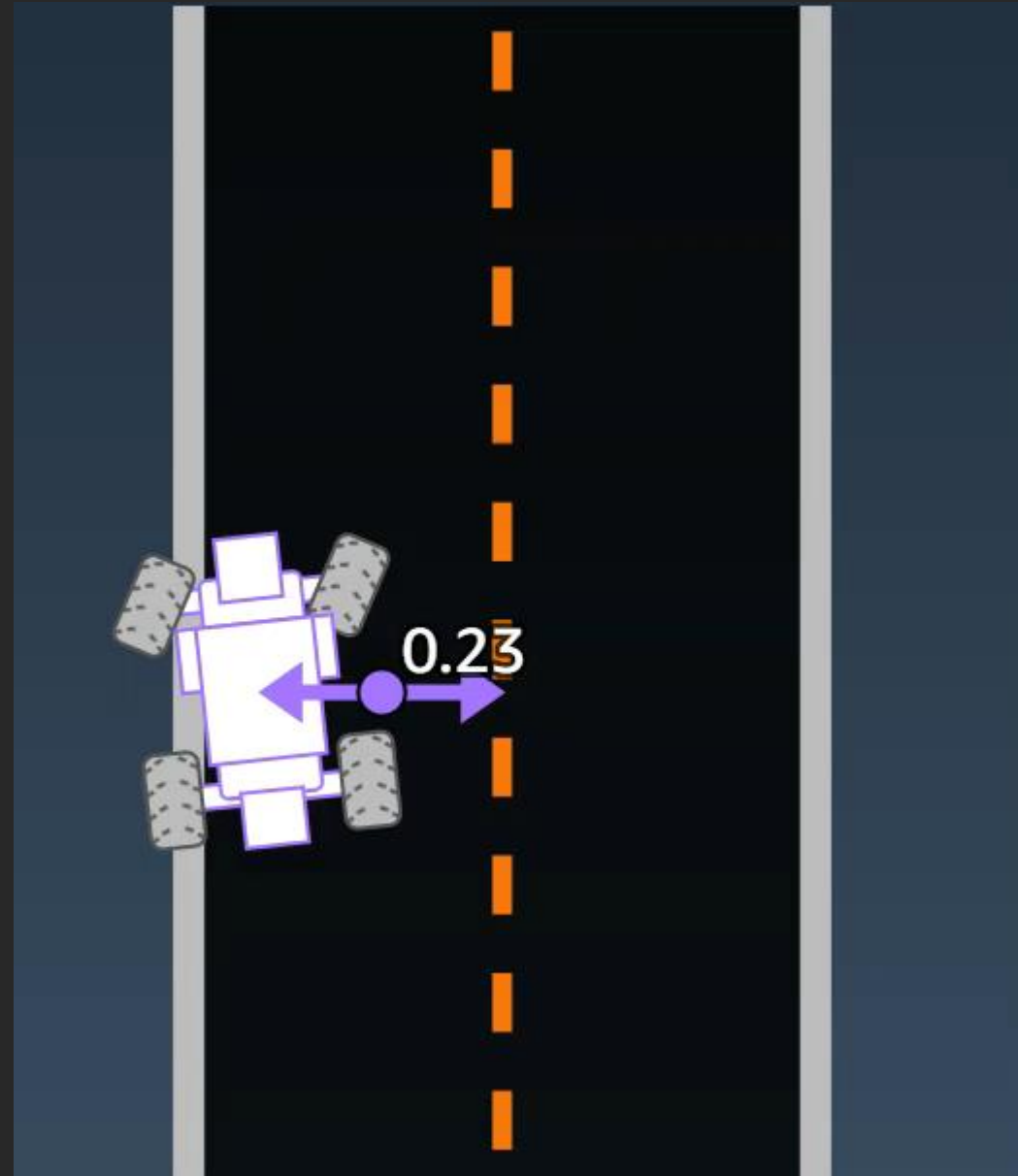
Example parameter: heading



Example parameter: `all_wheels_on_track`



Example parameter: `distance_from_center`



Customize your agent's sensors in the Garage

AWS DeepRacer > Reinforcement learning > Garage

Garage

Create model

Build new vehicle

The garage shows the DeepRacer vehicles that you can train models for. You can add vehicles by using the "build new vehicle button"

Evo

Mod vehicle

Sensor

Lidar

Stereo cameras

Neural network topology

DCN Shallow

Action space

Speed: 4 m/s

Steering
Angle: 30°



Mod your own vehicle

Mod specifications

The garage shows the DeepRacer vehicles that you can train models for. You can add vehicles by using the "build new vehicle button"

Sensor modification

Swap sensors to improve your DeepRacer's racing performance

☐ Front-facing camera

Single camera that captures the images with sizes of 160 x 120 in front of the agent at 15 fps. The camera has 120 wide angle lens. The images are converted into grey scale before being fed to the neural network

► Benefits of the front-facing camera

☒ Stereo cameras (right/left) sensor

Composed of two front-facing cameras, stereo cameras can generate depth information of the objects in front of the agent and thus be used to detect and avoid obstacles on the track. The cameras capture images with the same resolution and frequency. Images from both cameras are converted into grey scale, stacked and then fed into the neural network.

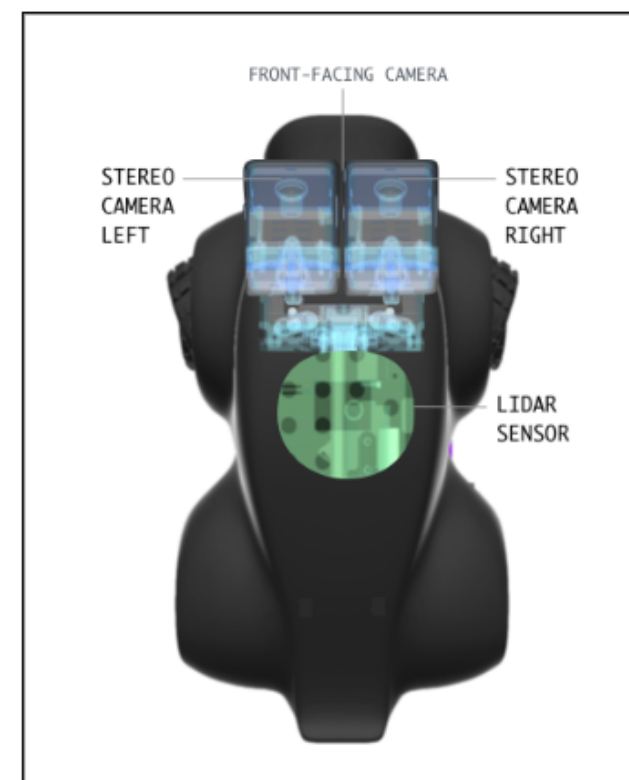
► Benefits of the stereo camera

Add-on sensors

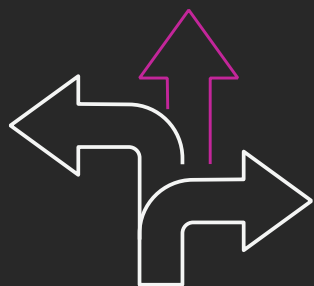
☒ LIDAR sensor

LIDAR is a surveying method that measures a distance to a target by illuminating the target with laser light and measuring the reflected light with a sensor.

► How LIDAR works with autonomous driving



Action space



Action space [Info](#)

Action space defines the specific actions an agent can take in both the simulator and physical world. While a real vehicle can choose from a continuum of actions, AWS DeepRacer simplifies the agent's decision-making process by reducing that space to a set of discrete actions.

Configure this discrete action space by setting the range and granularity for speed and steering angle. The system automatically generates an action space according to that specification. Note that your model will take longer to train under a larger action space.

Maximum steering angle

degrees

Max values are between 1 and 30.

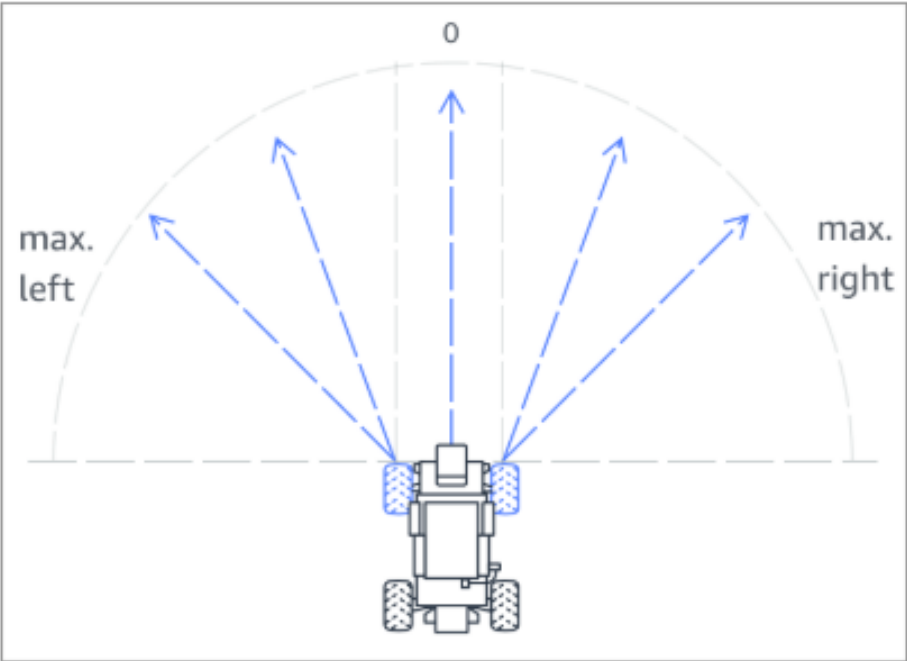
Steering angle granularity

Maximum speed

m/s

Select values between 0.1 and 4.

Speed granularity



Action list

Action number	Steering	Speed
0	-30 degrees	4 m/s
1	-15 degrees	4 m/s
2	0 degrees	4 m/s
3	15 degrees	4 m/s
4	30 degrees	4 m/s

Under the hood

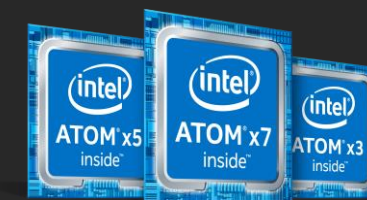
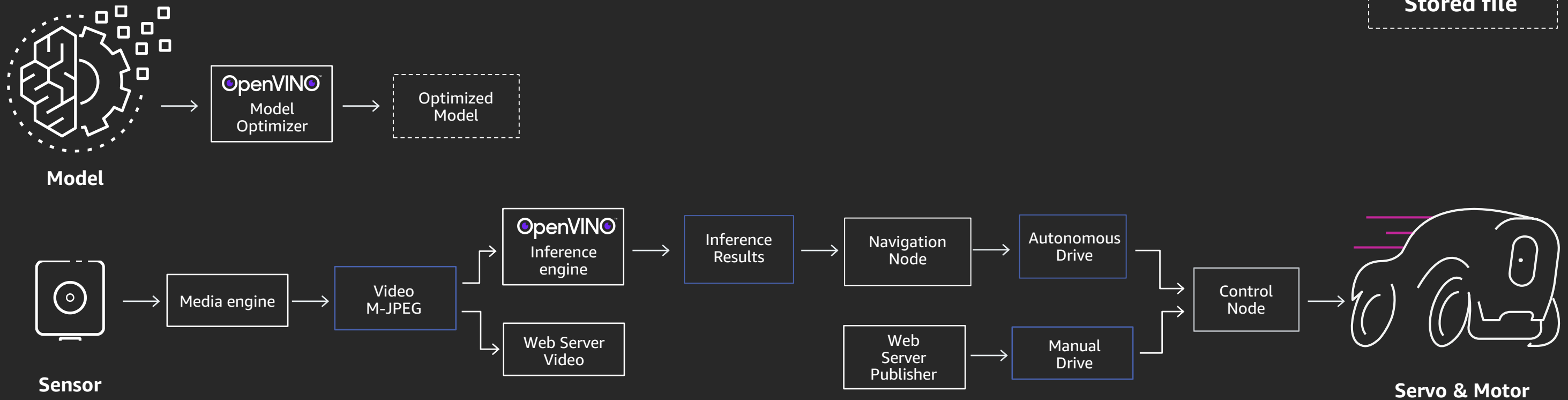
Under the hood

- 1:18 4WD scale car
- Intel Atom processor
- Intel distribution of OpenVINO toolkit
- Stereo Camera (4MP)
- 360 Degree 12 Meters Scanning Radius LIDAR Sensor
- System memory: 4 GB RAM
- 802.11ac Wi-Fi
- Ubuntu 16.04.3 LTS
- ROS Kinetic



OpenVINO™

AWS DeepRacer software architecture

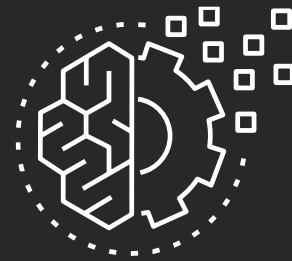


OpenVINO™

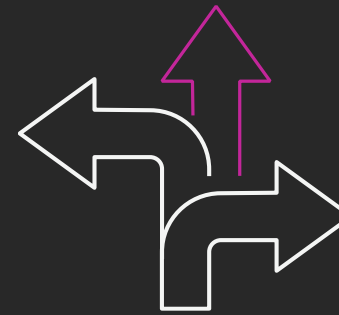
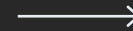
Optimizing and inferencing with OpenVINO™



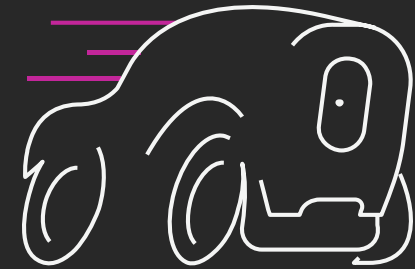
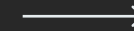
Input
data



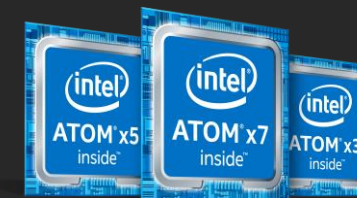
OpenVINO™
optimized
model



OpenVINO™
inference
results



Racing



Free Download ► software.intel.com/openvino-toolkit
Open Source version ► 01.org/openvinotoolkit

AWS DeepRacer hands-on lab

Additional resources

- **DeepRacer Slack Community:** <http://join.deepracing.io/>
- **GitHub:** <https://github.com/aws-samples/aws-deepracer-workshops/>
- **Free video course:** <https://www.aws.training/Details/eLearning?id=32143>
- **Tips:** <https://aws.amazon.com/deepracer/racing-tips/>
- **Forum:** <https://forums.aws.amazon.com/forum.jspa?forumID=318>
- **Intel® Distribution of OpenVINO™ toolkit:**
<https://software.intel.com/en-us/openvino-toolkit>

Lab: AWS DeepRacer service

Objective: Build your first AWS DeepRacer Time-Trial model

1. Find the lab content here:

<https://github.com/aws-samples/aws-deepracer-workshops/>

2. Navigate to:

[Workshops/2019-reInvent/Lab_200_AIM207](#)

AWS DeepRacer at re:Invent 2019

Go race!

MGM Grand Garden



League Knockout
Rounds

Race your model!

Experience
DeepRacer Evo

Quad at Aria



DeepRacer Expert
Boot camp

Venetian



Final, Thursday at
8am, Hall A or
livestream

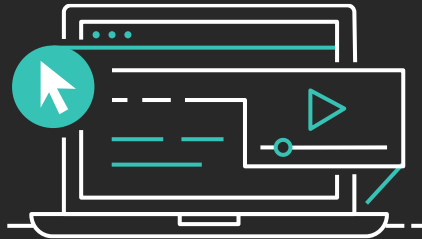


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Thank you!



Please complete the session
survey in the mobile app.