



INNOVATE

AI/ML EDITION

Get rolling with machine learning on AWS DeepRacer

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Developer Specialist Solutions Architect
AWS Developer Acceleration (DevAx)
Amazon Web Services

Agenda

Machine Learning on AWS

Introducing the AWS DeepRacer

Introduction to reinforcement learning

AWS DeepRacer Console

AWS DeepRacer League – What's new for 2021


Machine Learning on AWS

The AWS ML Stack


Broadest and most complete set of machine learning capabilities

AI SERVICES

NEW




Amazon HealthLake




Amazon Transcribe Medical

HEALTH AI



Amazon Comprehend Medical


NEW



AWS Panorama + Appliance


INDUSTRIAL AI

NEW




Amazon Monitron

NEW



Amazon Lookout for Equipment


NEW



Amazon Lookout for Vision

ANOMALY DETECTION


NEW




Amazon Lookout for Metrics

CODE AND DEVOPS

NEW




Amazon DevOps Guru




Amazon CodeGuru

VISION




Amazon Rekognition

SPEECH




Amazon Polly




Amazon Transcribe +Medical


TEXT



Amazon Comprehend +Medical




Amazon Translate




Amazon Textract

SEARCH




Amazon Kendra

CHATBOTS




Amazon Lex

PERSONALIZATION




Amazon Personalize

FORECASTING




Amazon Forecast

FRAUD



Amazon Fraud Detector

CONTACT CENTERS




Contact Lens

Voice ID

For Amazon Connect

ML SERVICES



Amazon SageMaker

Label data

NEW

Aggregate & prepare data

NEW

Store & share features

Auto ML

Spark/R

NEW

Detect bias

Visualize in notebooks

Pick algorithm

Train models

Tune parameters

NEW

Debug & profile

Deploy in production

Manage & monitor

NEW

CI/CD

Human review

NEW: SageMaker JumpStart

NEW: Model management for edge devices

FRAMEWORKS & INFRASTRUCTURE



TensorFlow



mxnet



PyTorch



GLUON



Keras



scikit-learn



Horovod



DeepGraphLibrary

Deep Learning AMIs & Containers

GPUs & CPUs

Elastic Inference

Trainium

Inferentia


FPGA

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SAGEMAKER STUDIO IDE


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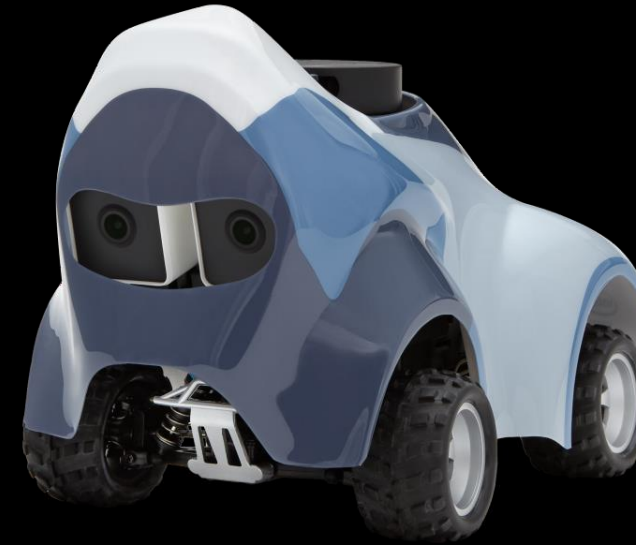


Building your team's skills

HANDS-ON LEARNING



AWS DeepLens
Deep learning



AWS DeepRacer
Reinforcement learning



AWS DeepComposer
Generative AI

Introducing AWS DeepRacer

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

Literally



Under the hood

- 1:18 4WD scale car
- Intel Atom processor
- Intel distribution of OpenVINO toolkit
- Stereo Camera (4MP)
- 360-degree 12-meter scanning radius LIDAR sensor
- System memory: 4 GB RAM
- 802.11ac Wi-Fi
- Ubuntu 16.04.3 LTS
- ROS kinetic



OpenVINO™

Get hands-on experience with reinforcement learning



AWS DeepRacer
Evo

Get hands-on experience with reinforcement learning



AWS DeepRacer
Evo



3D-racing
simulator

Get hands-on experience with reinforcement learning



AWS DeepRacer
Evo



3D-racing
simulator



AWS DeepRacer
League

Get hands-on experience with reinforcement learning



AWS DeepRacer
Evo



3D-racing
simulator



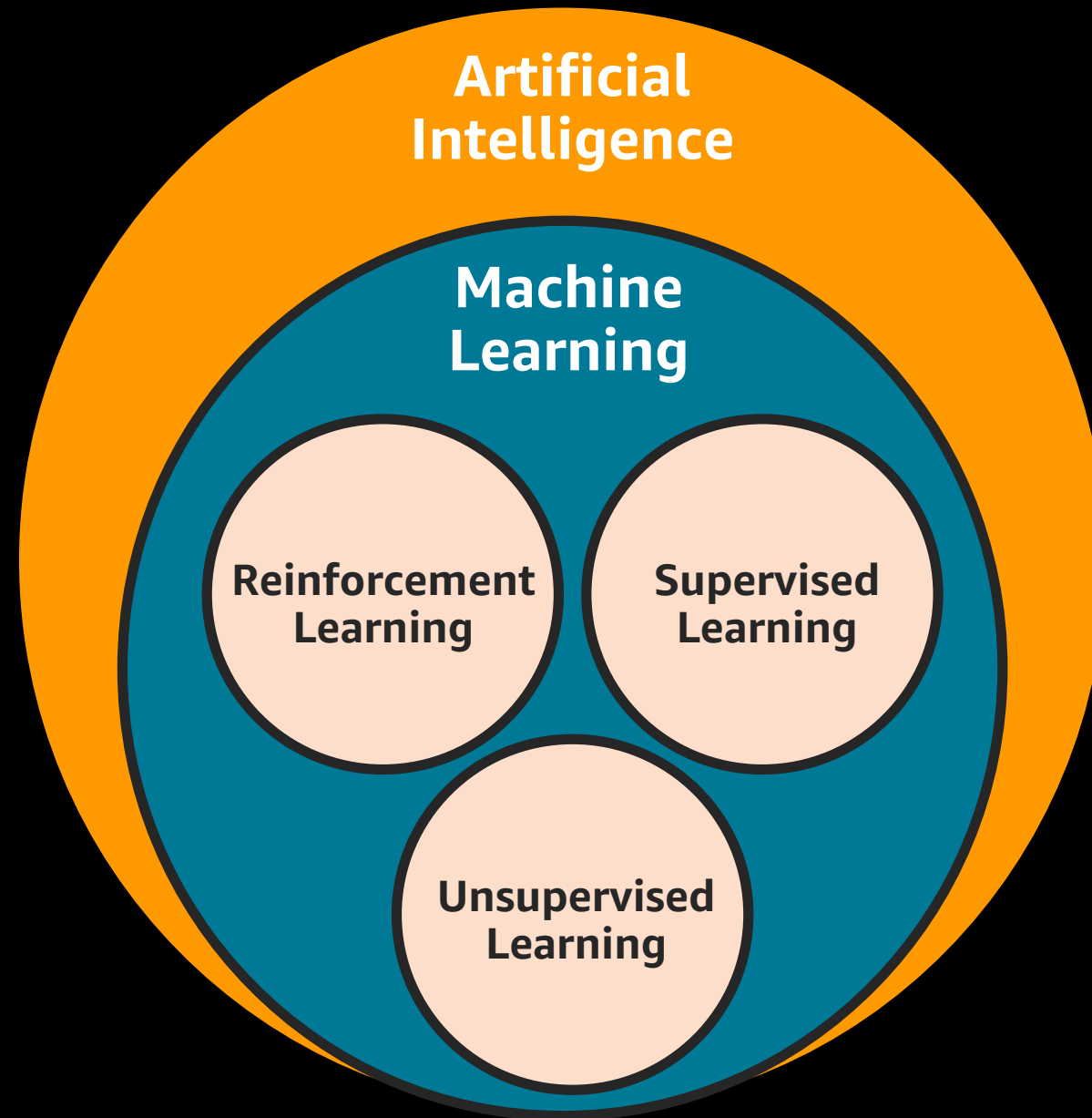
AWS DeepRacer
League



Community
races

Reinforcement learning Introduction

Reinforcement learning in the broader AI context



Reinforcement learning in the real world



**Reward
positive
behavior**



**Don't reward
negative
behavior**



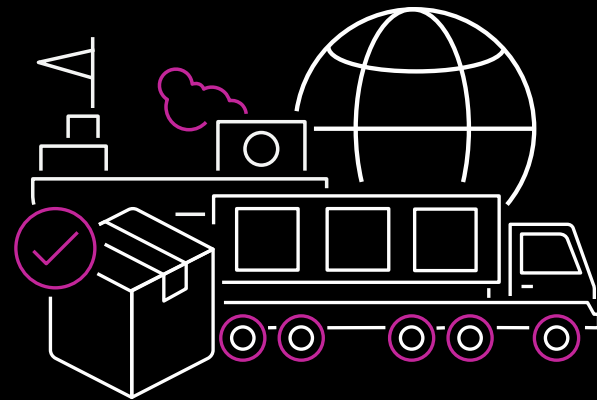
The result!

Reinforcement learning use cases

AUTONOMOUS CARS



FLEET LOGISTICS



FINANCIAL TRADING

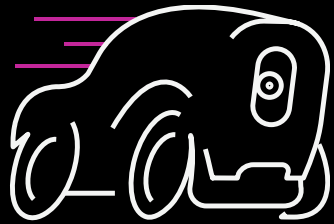


DATA CENTER COOLING

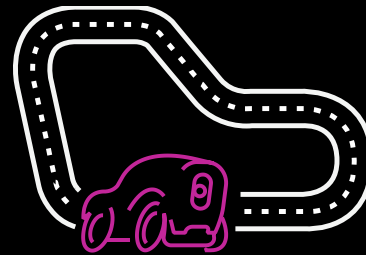


Reinforcement learning terms

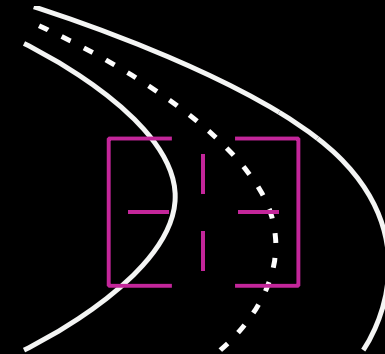
AGENT



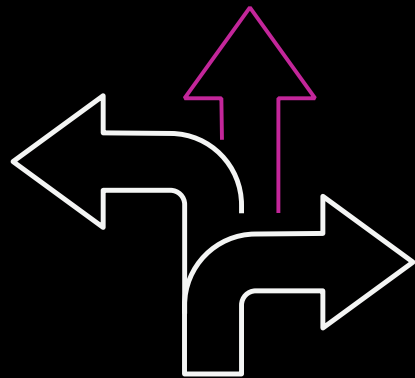
ENVIRONMENT



STATE



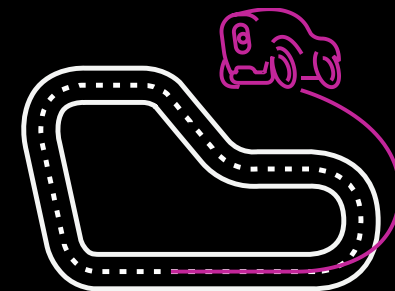
ACTION



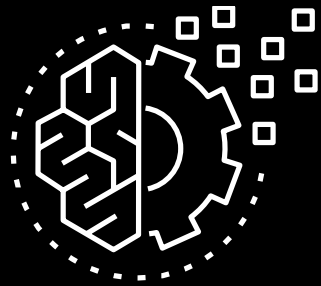
REWARD



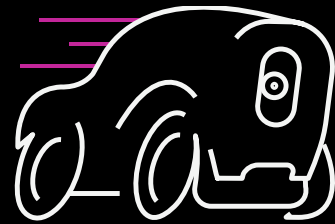
EPISODE



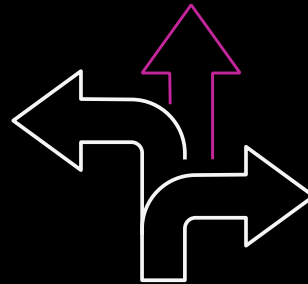
What is reinforcement learning?



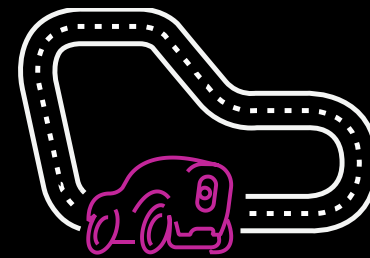
MODEL



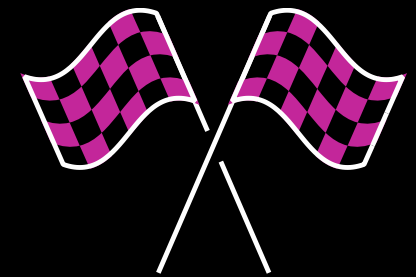
AGENT



ACTION



ENVIRONMENT

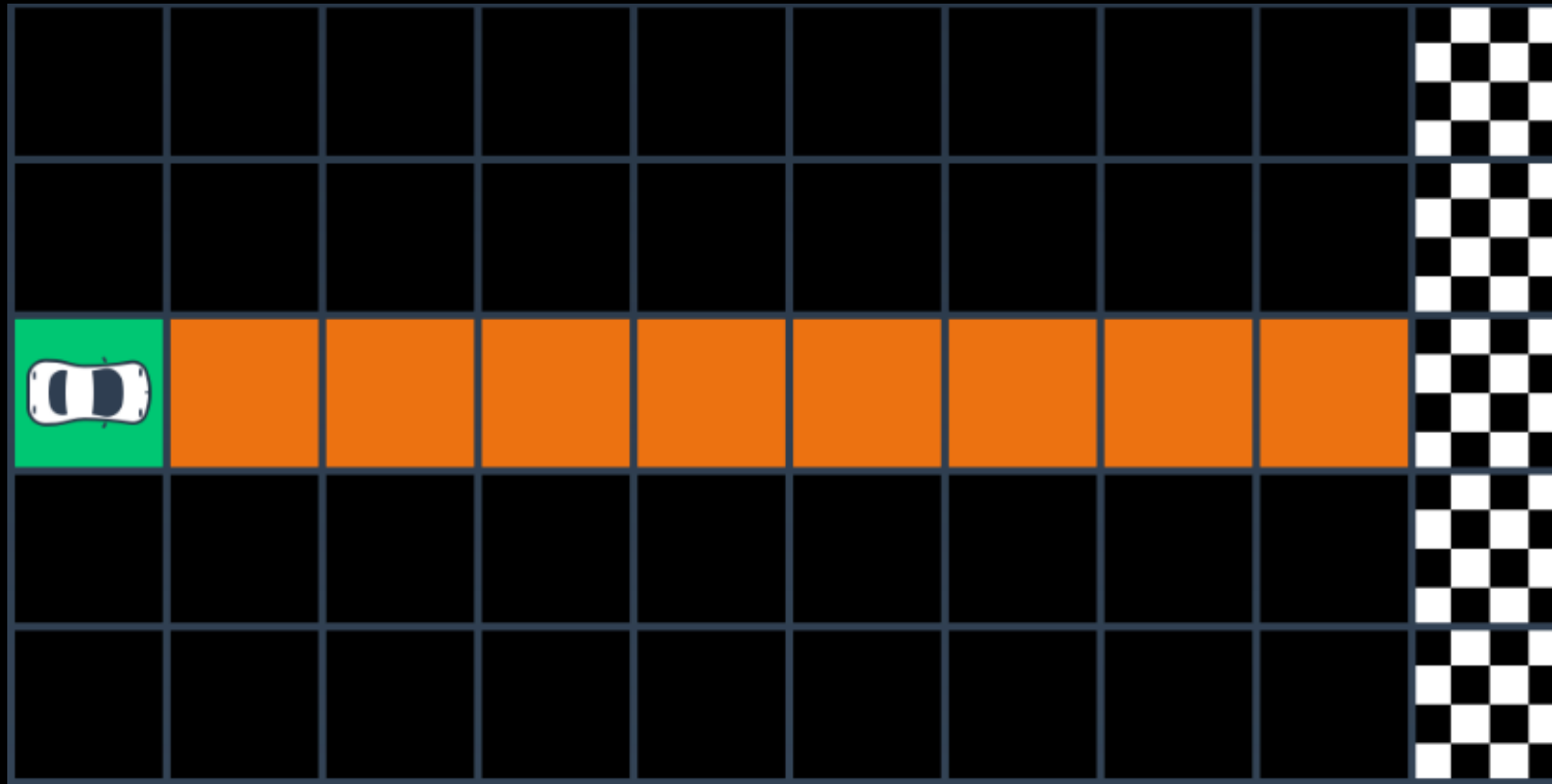


GOAL

The reward function in a grid race





Agent

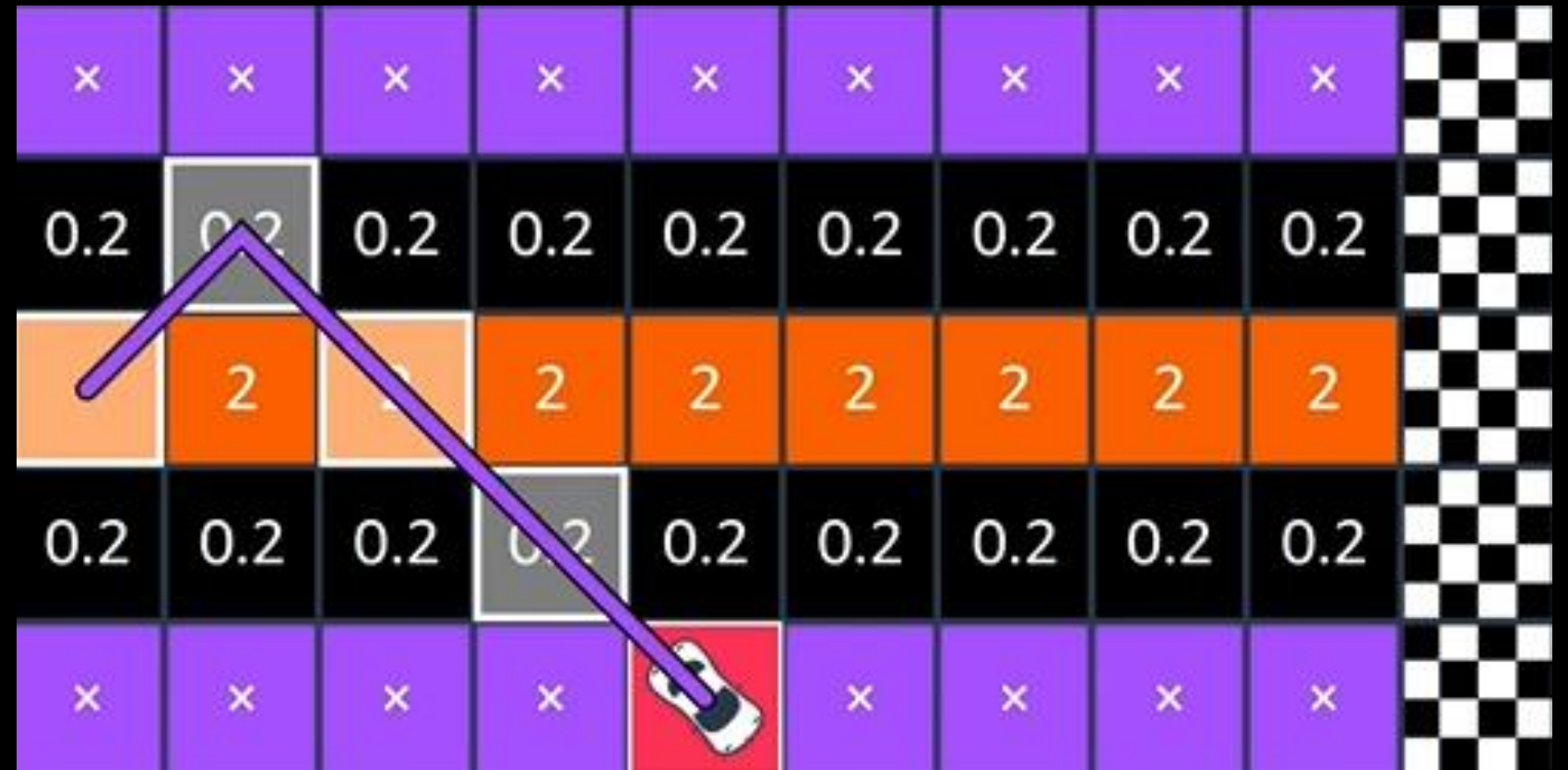
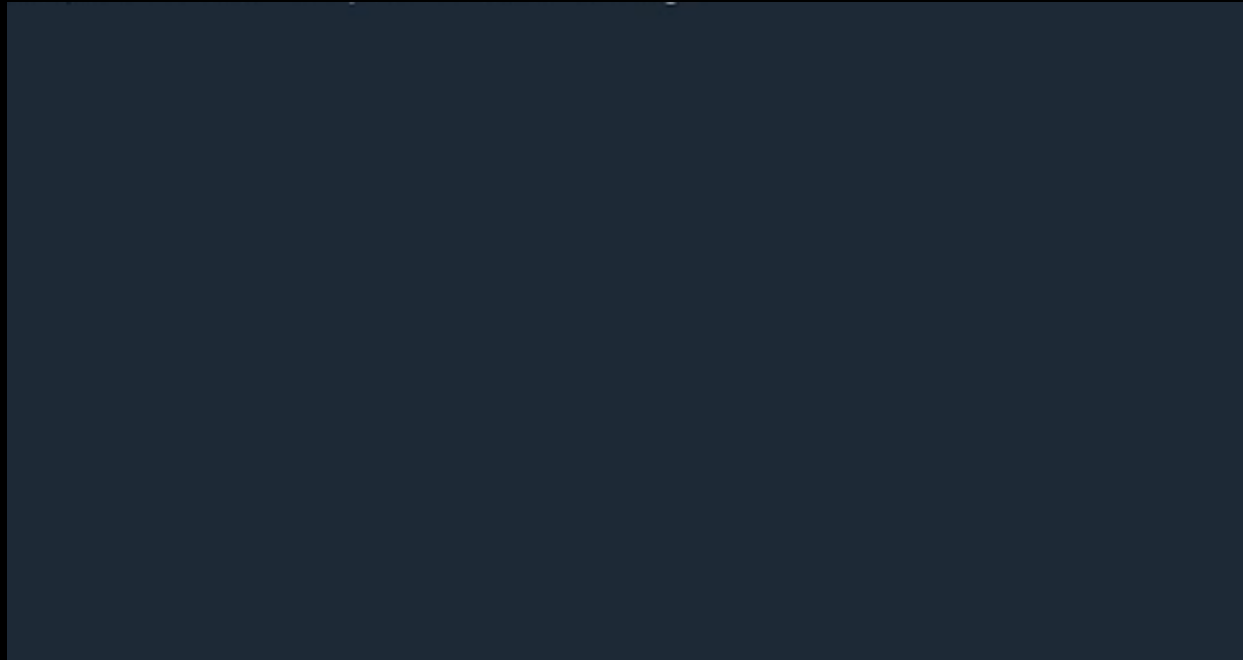


Goal

Rewards that incentivize center-line driving

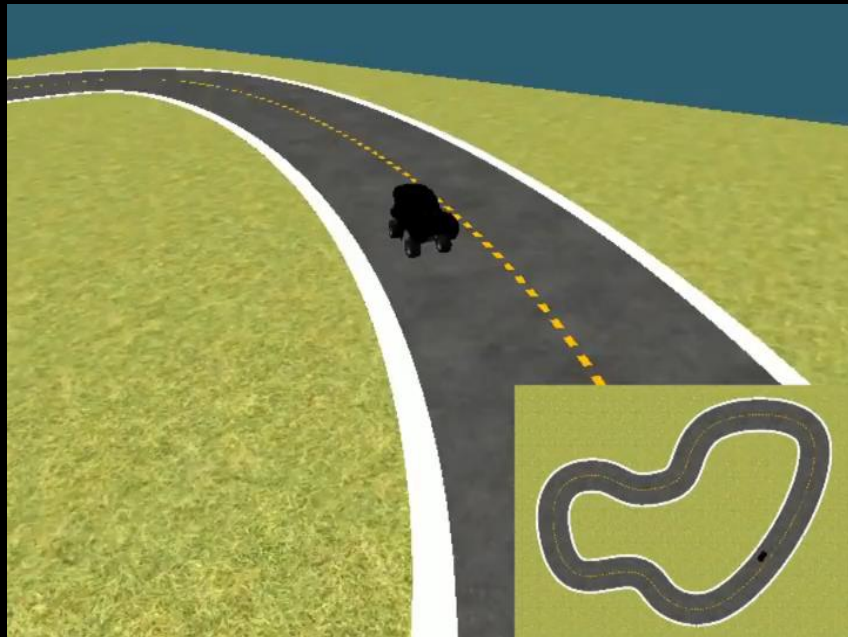
x	x	x	x	x	x	x	x	x	
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
	2	2	2	2	2	2	2	2	
0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
x	x	x	x	x	x	x	x	x	

Iteration and convergence

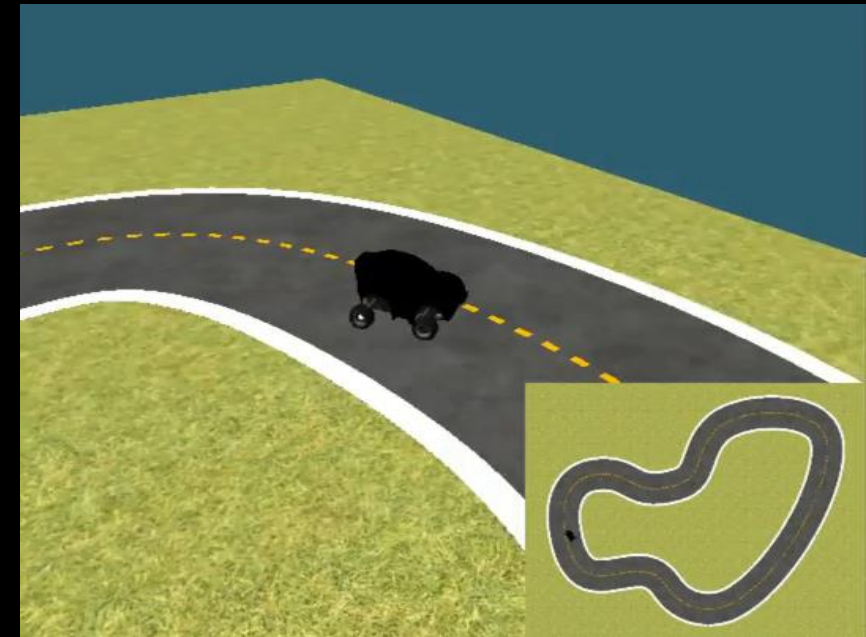


Exploration vs. exploitation

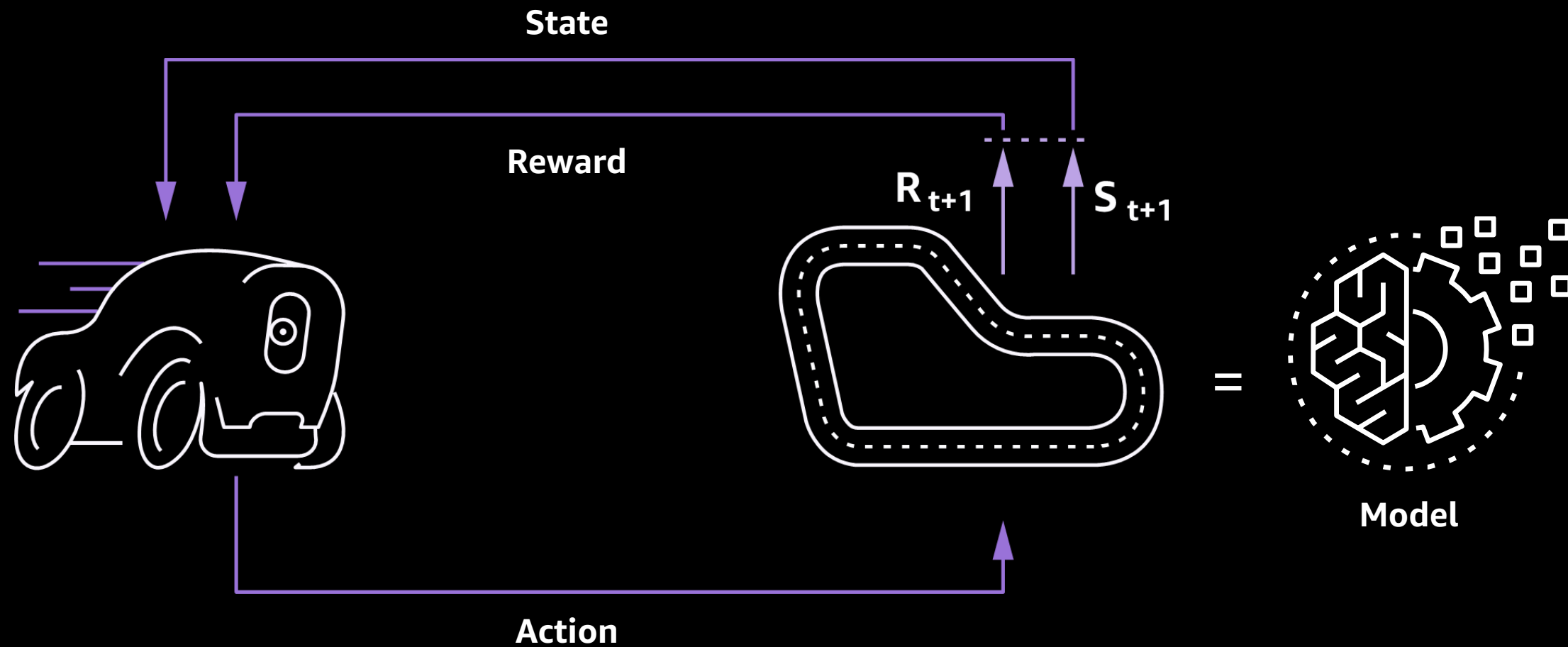
EXPLORATION



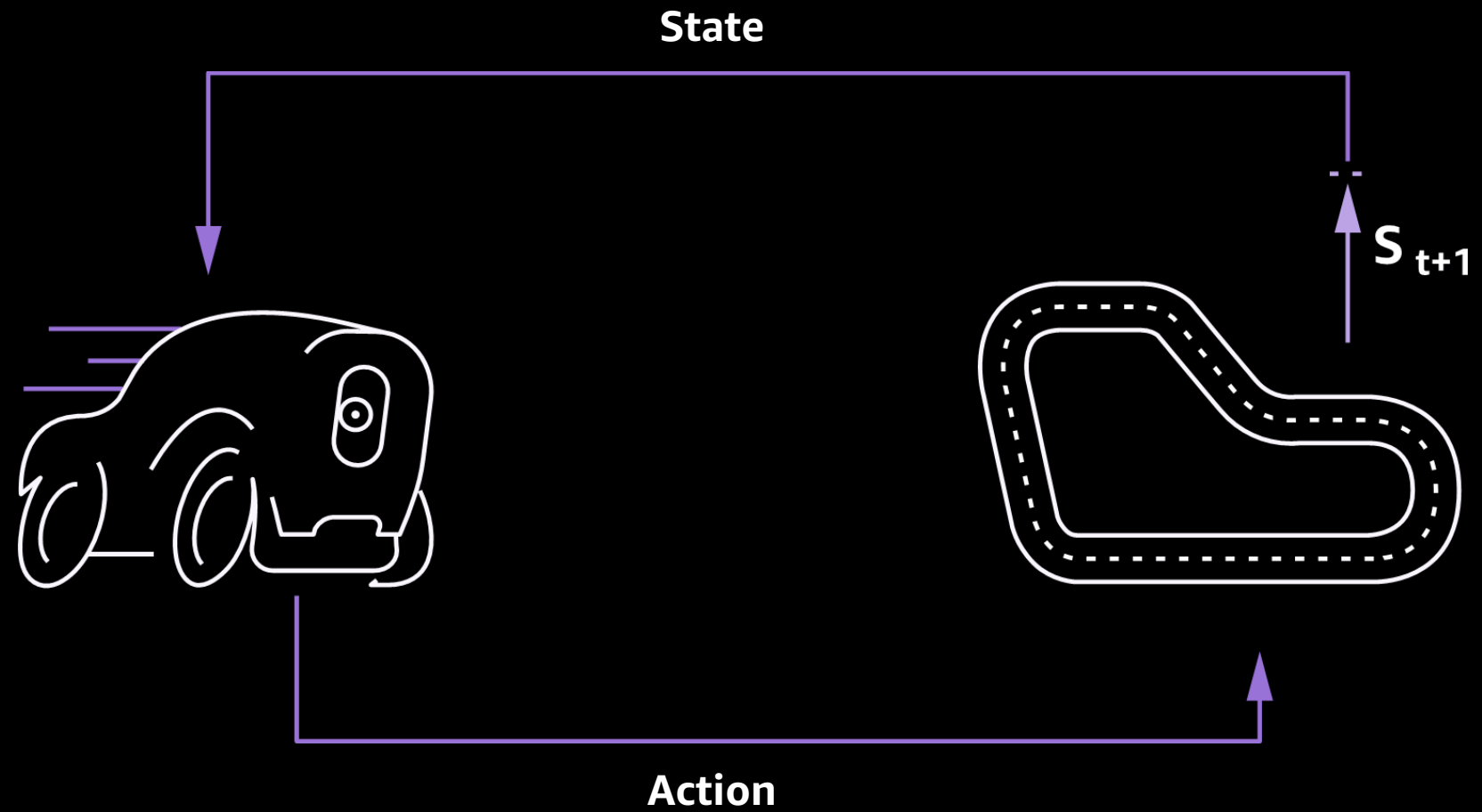
EXPLOITATION



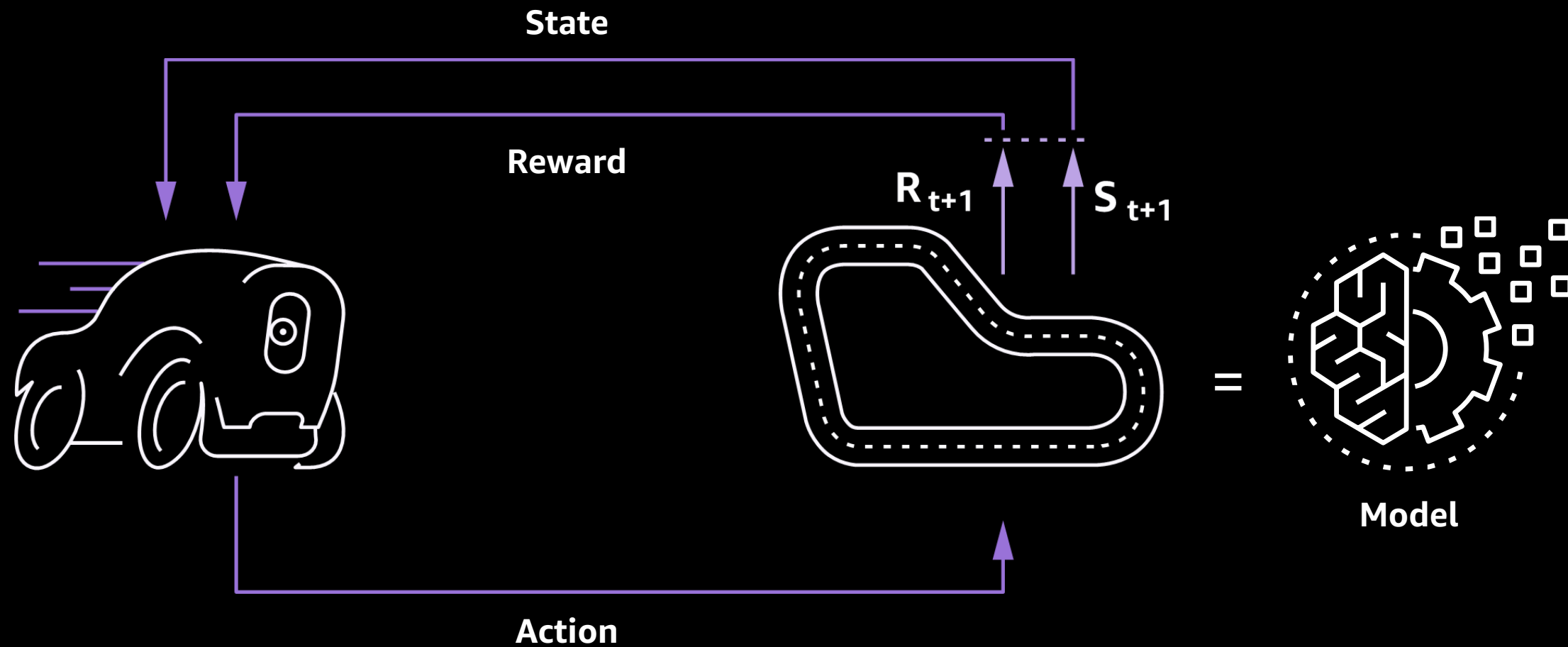
How does learning happen?



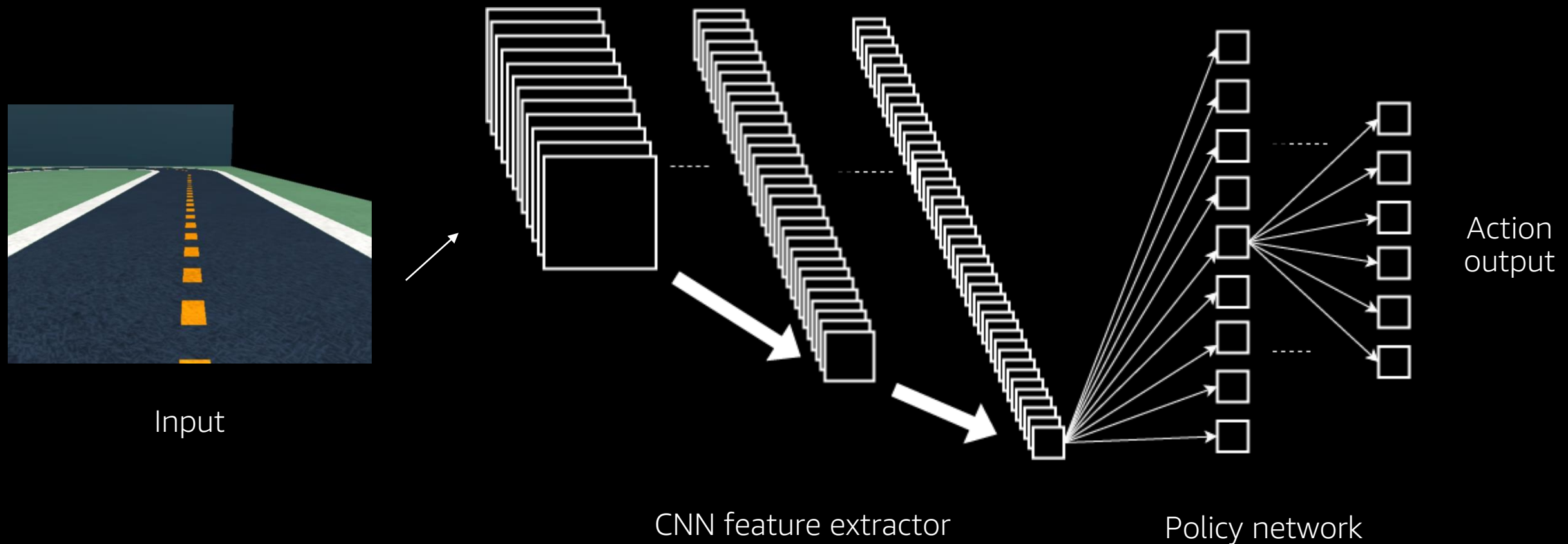
How does learning happen?



How does learning happen?



AWS DeepRacer neural network architecture

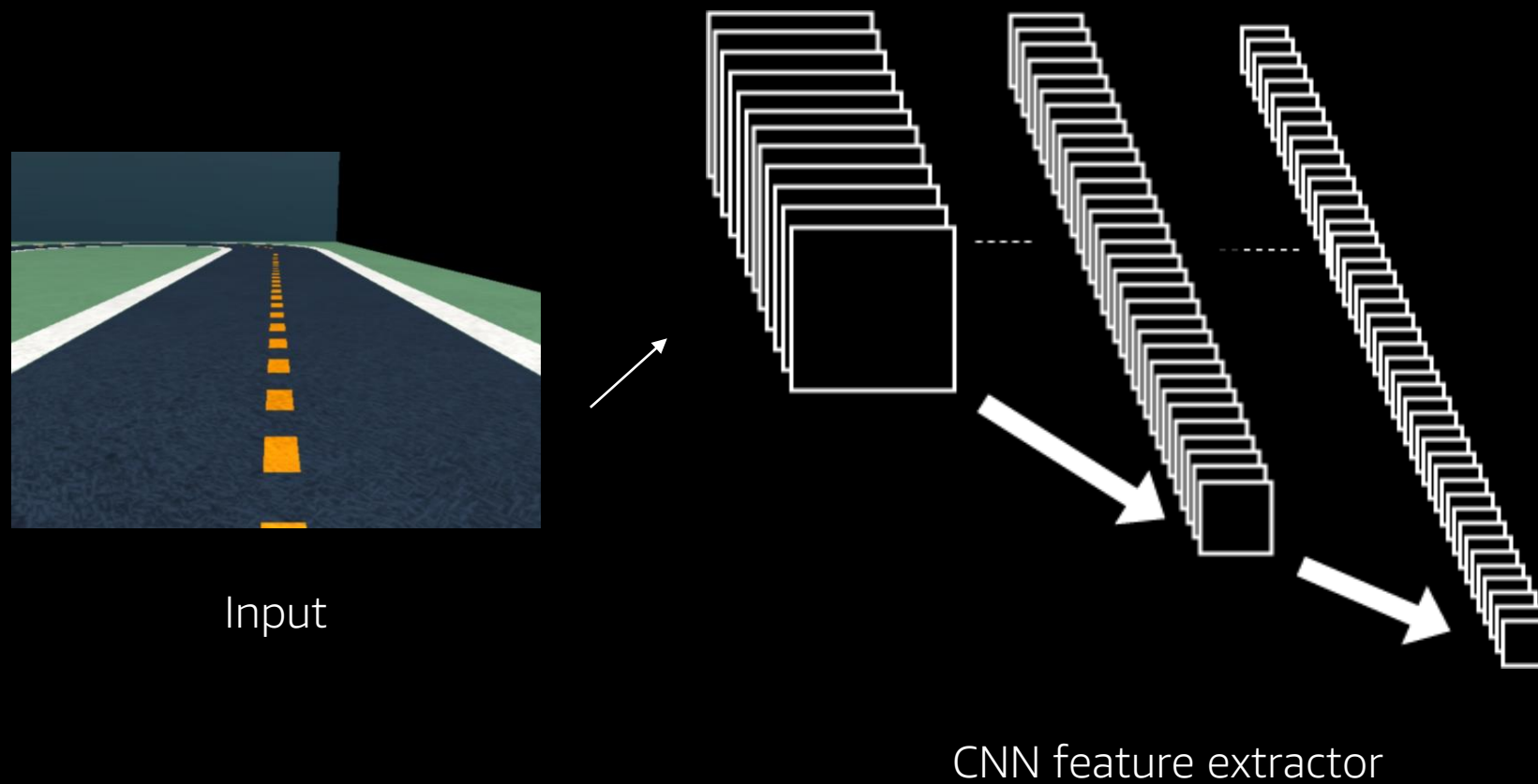


AWS DeepRacer neural network architecture

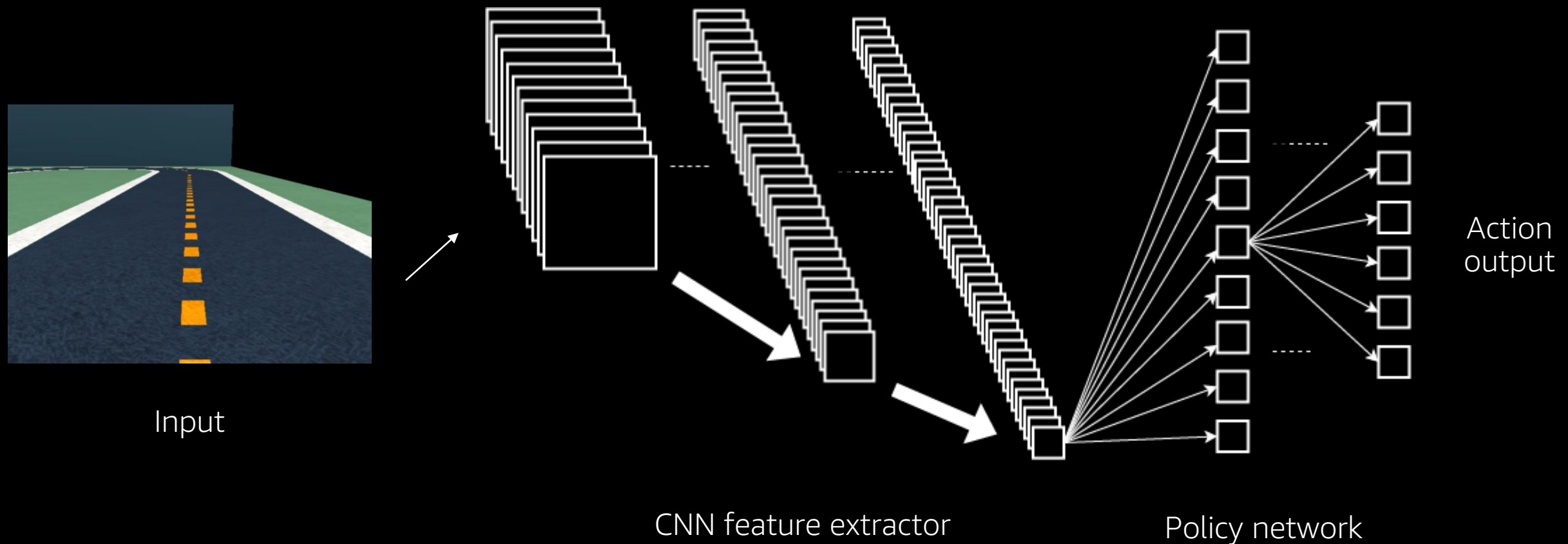


Input

AWS DeepRacer neural network architecture

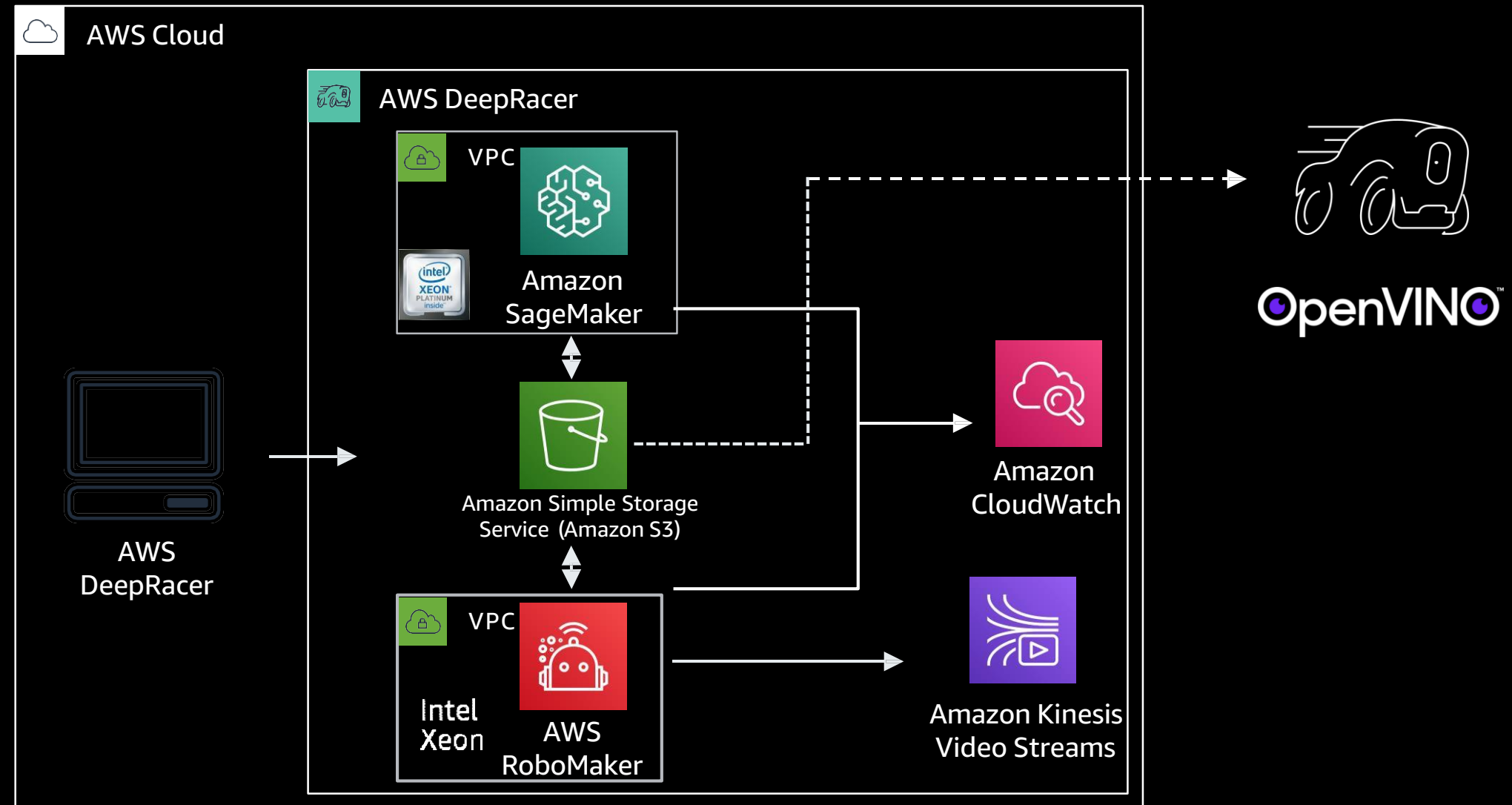


AWS DeepRacer neural network architecture



The AWS DeepRacer console

AWS DeepRacer simulator architecture



Programming your own reward function

Reward function [Info](#)

The reward function describes immediate feedback (as a score for reward or penalty) when the vehicle takes an action to move from a given position on the track to a new position. Its purpose is to encourage the vehicle to make moves along the track to reach its destination quickly. The model training process will attempt to find a policy which maximizes the average total reward the vehicle experiences.

Code editor **Reward function examples** **Reset** **Validate**

```
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

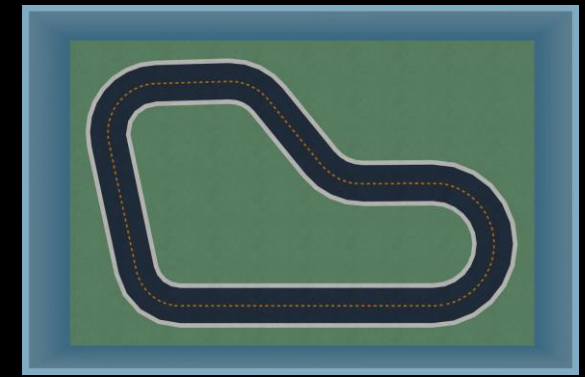
Three example reward functions

Code validation via AWS Lambda

Code editor **Reward function examples** **Reset** **Validate**

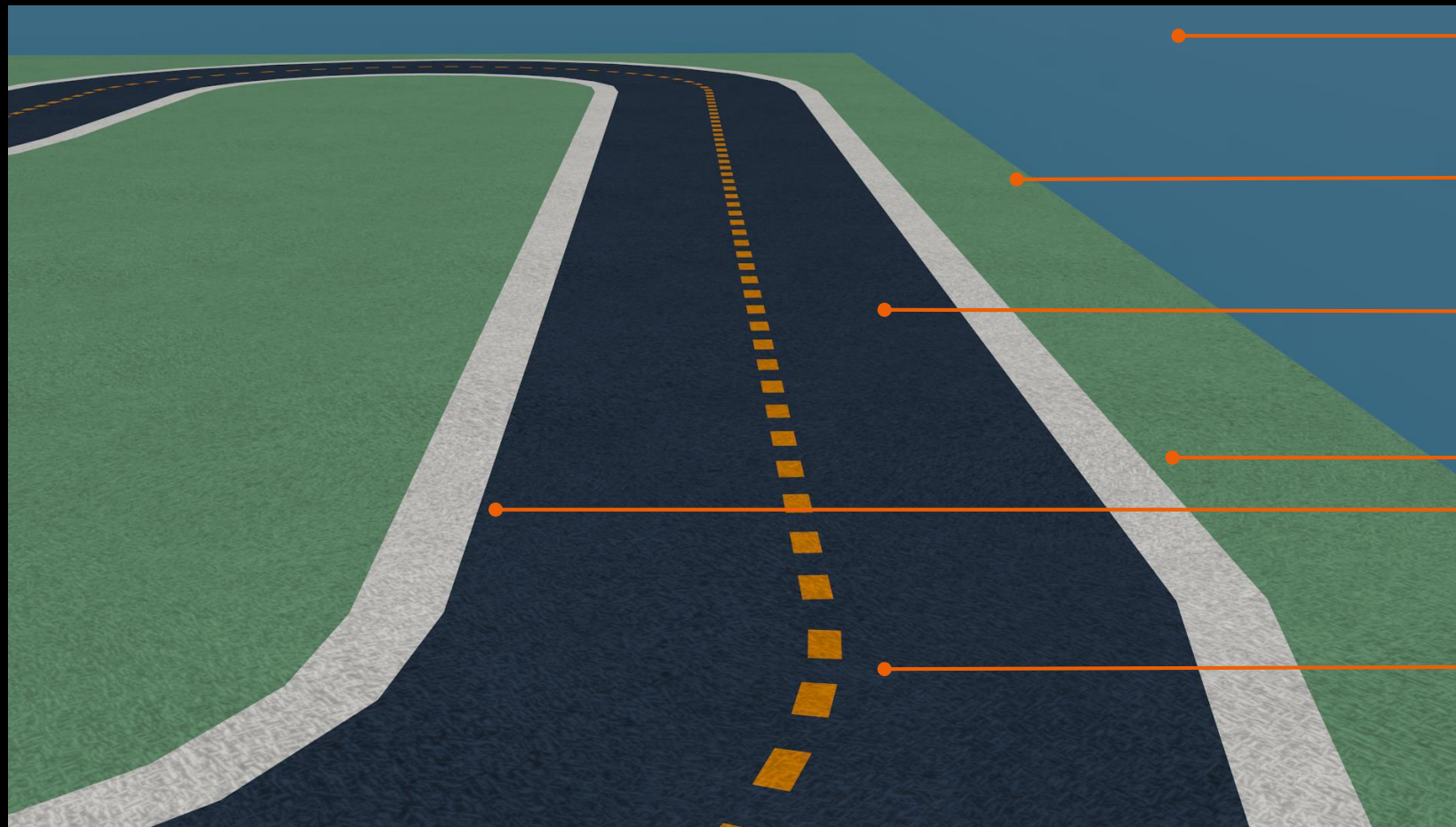
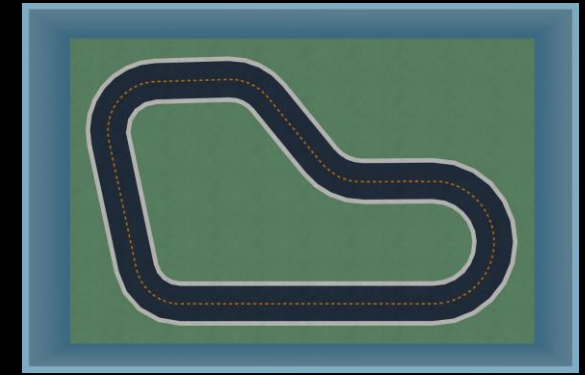
✔ Your reward function passed validation. ✕

Track components



Track wall

Track components



Track wall

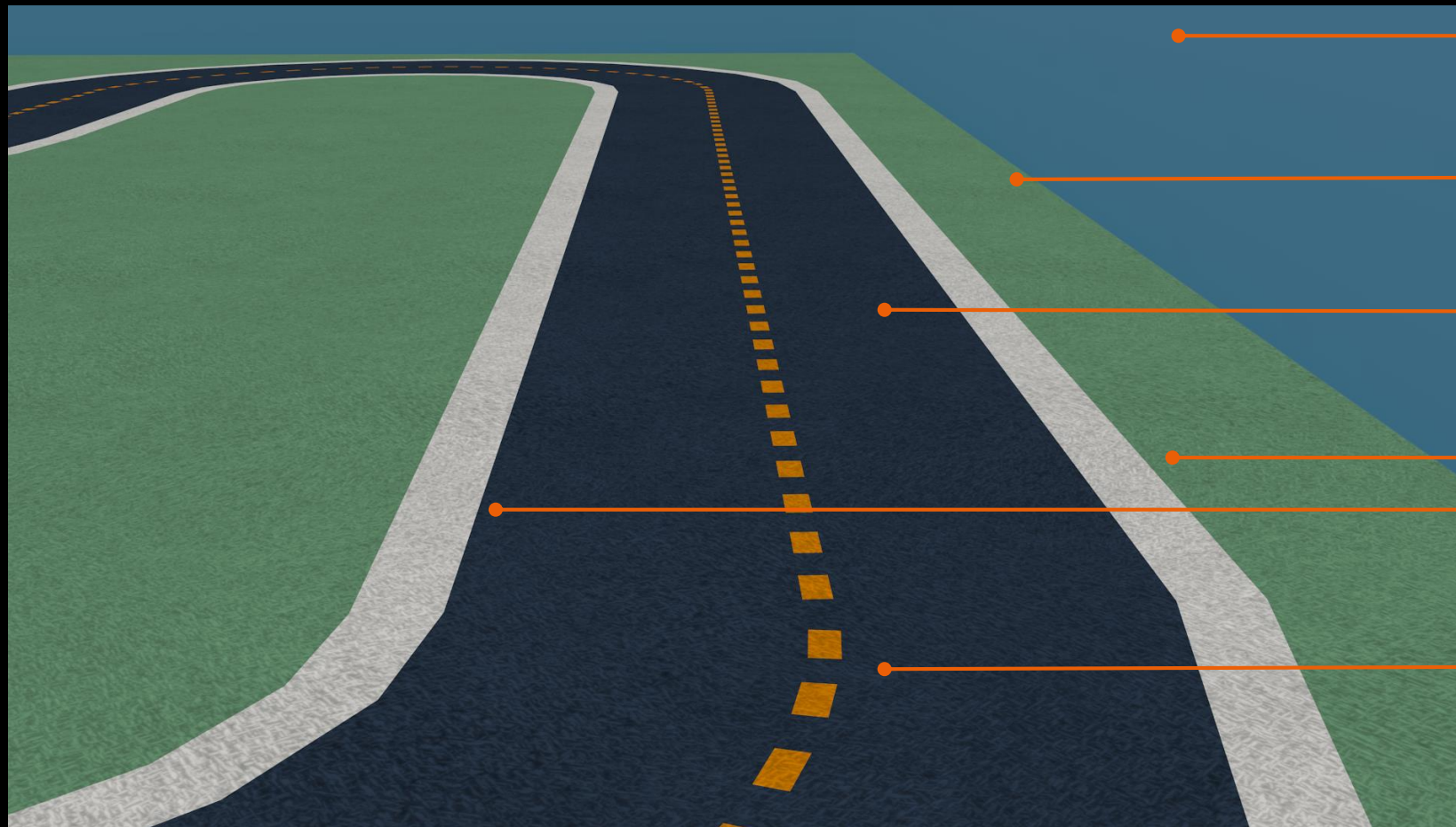
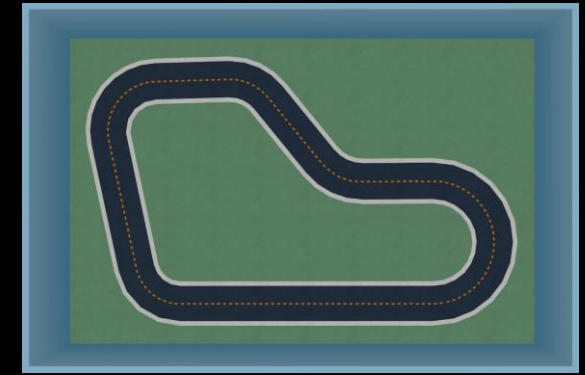
Field aka off-track

Track surface aka on-track

Track boundaries

Track center

Track components



Track wall

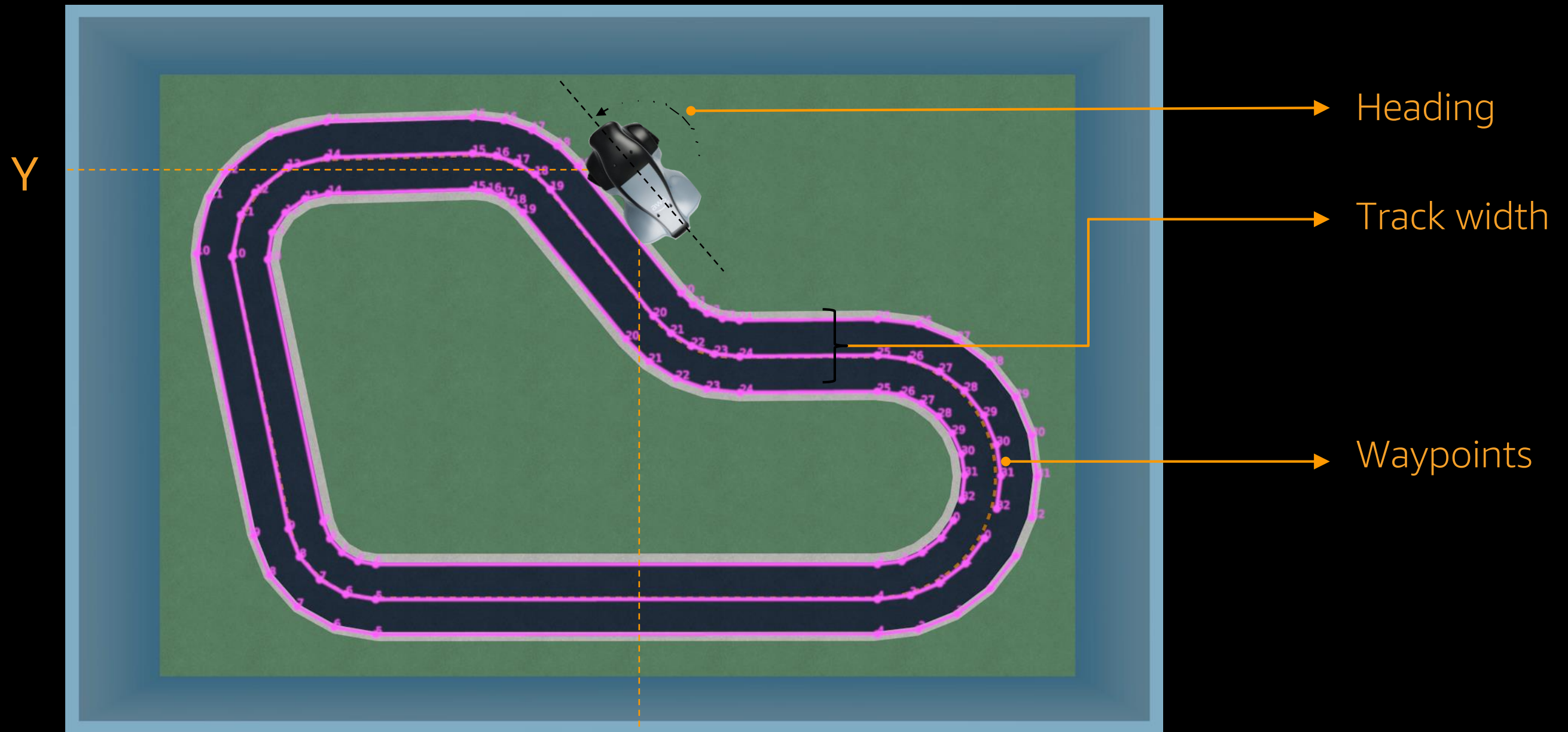
Field aka off-track

Track surface aka on-track

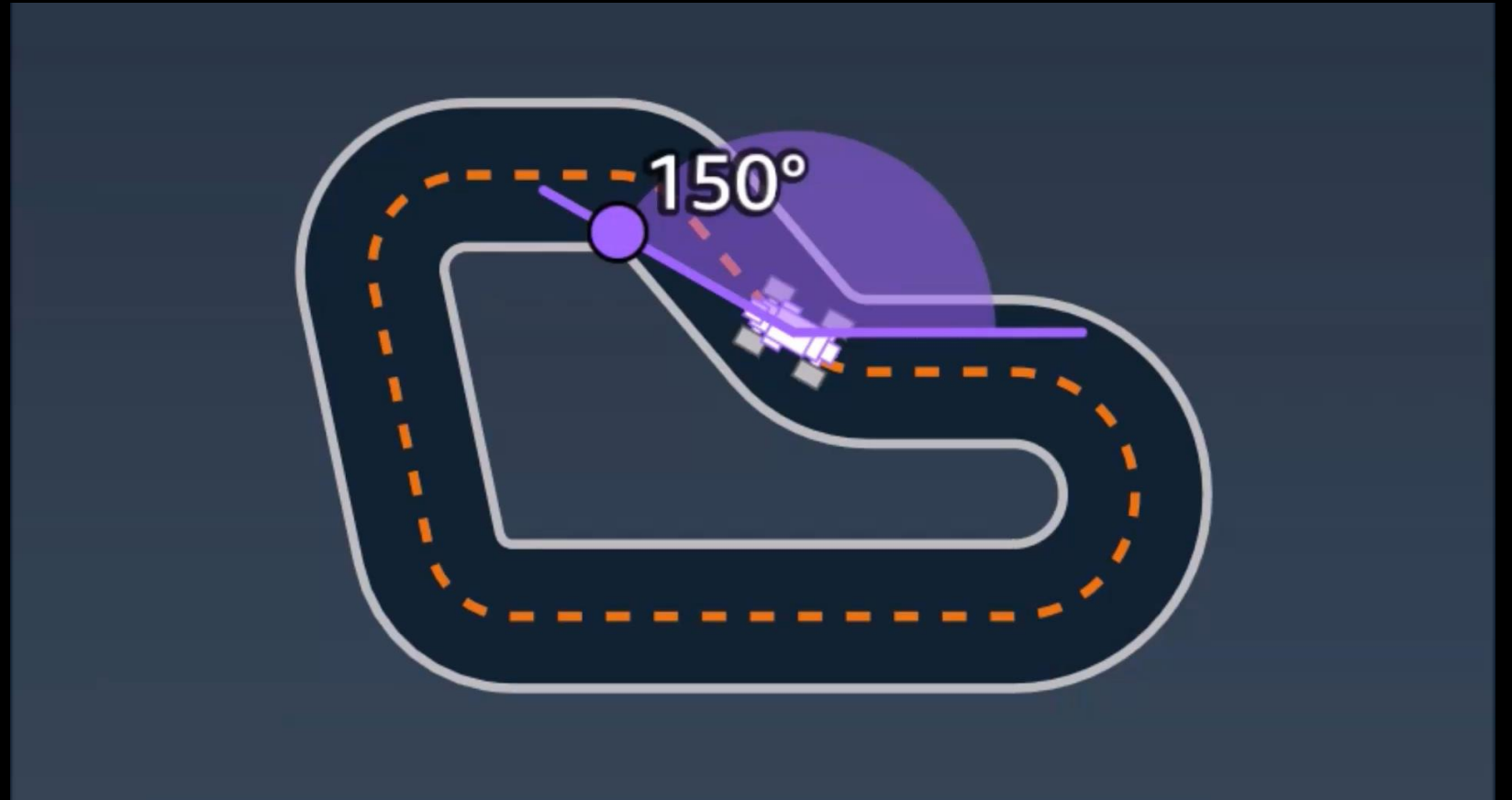
Track boundaries

Track center

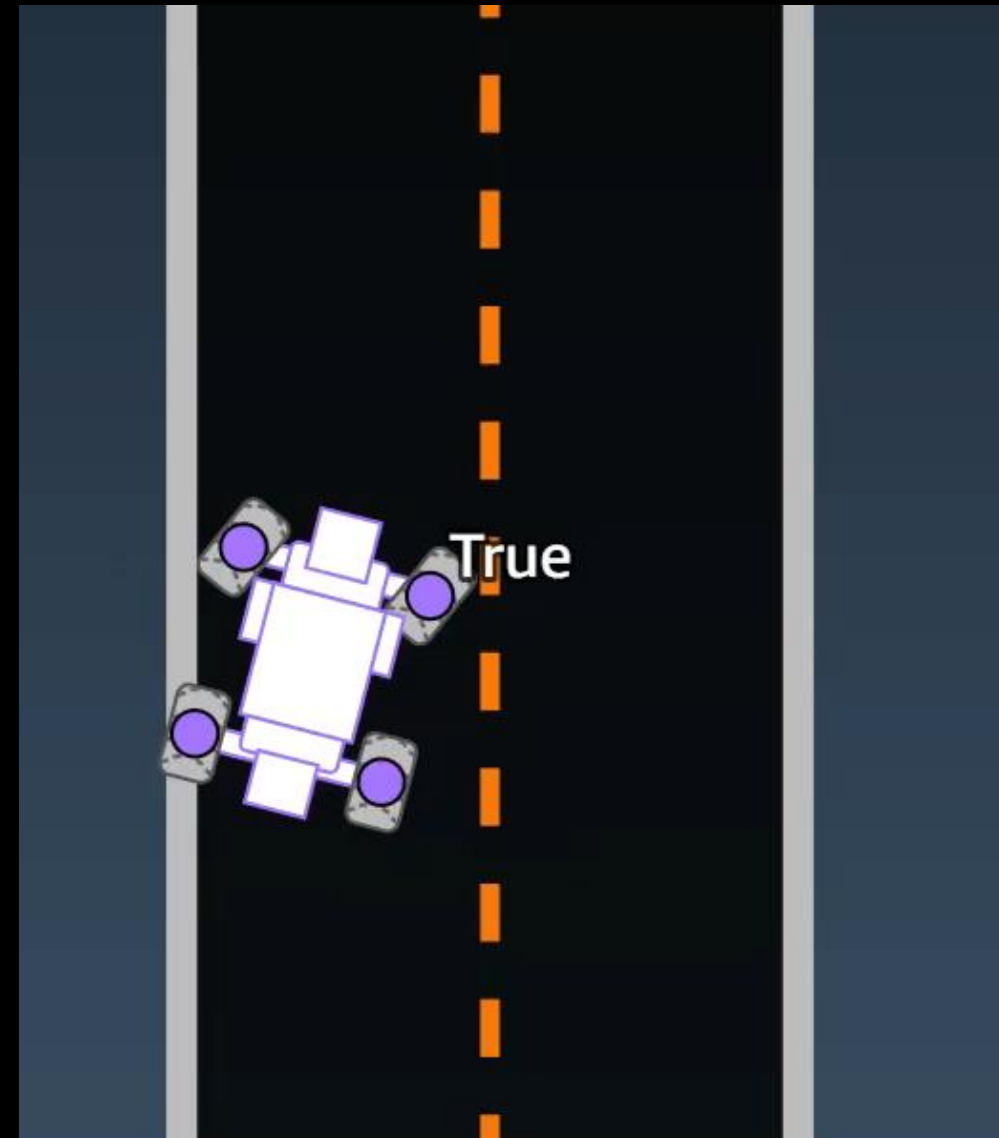
Coordinate system and track waypoints



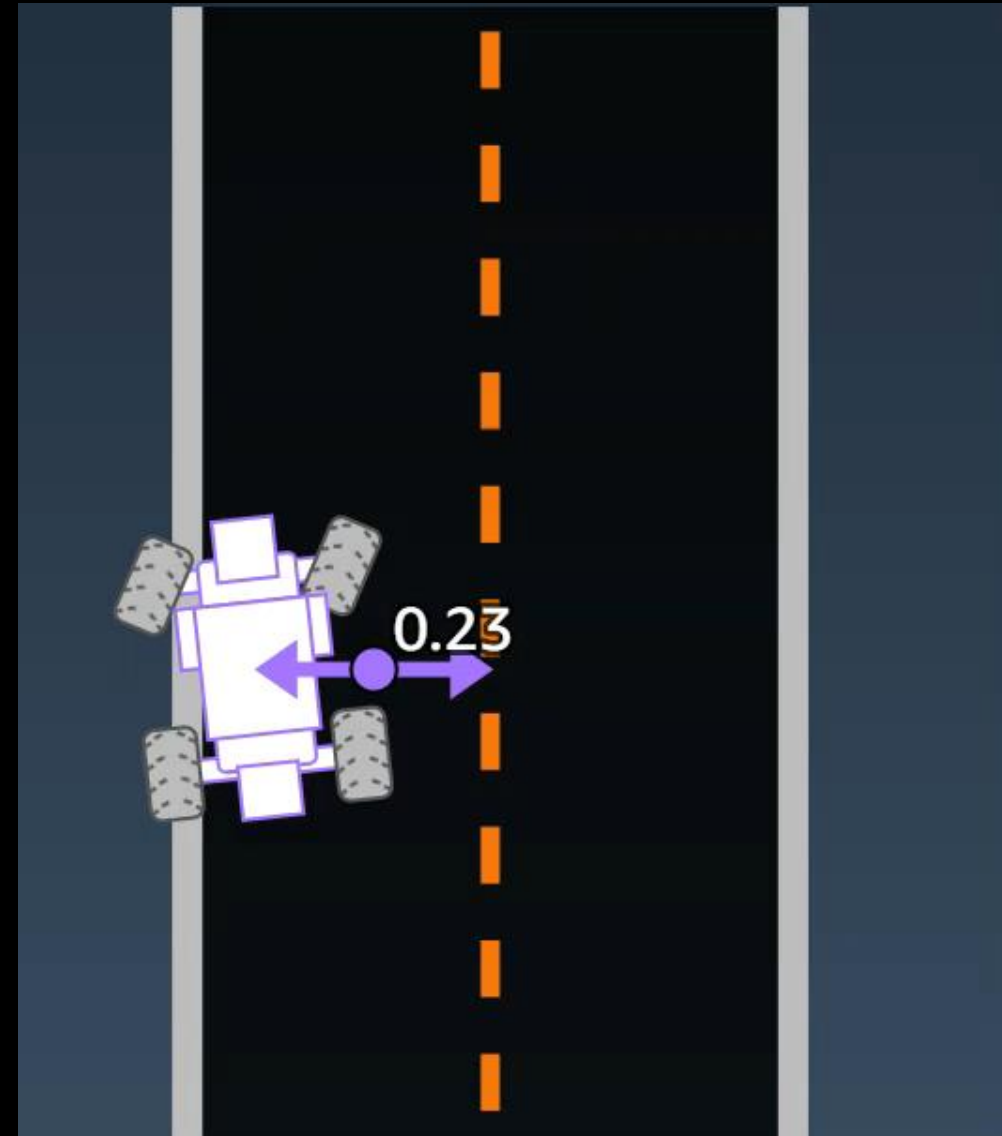
Example parameter –
heading



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"

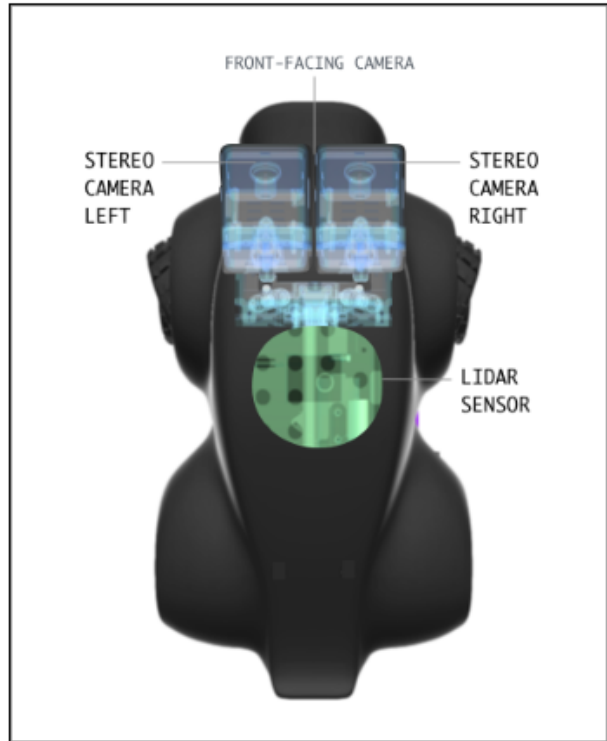
Sensor modification

Swap sensors to improve your DeepRacer's racing performance

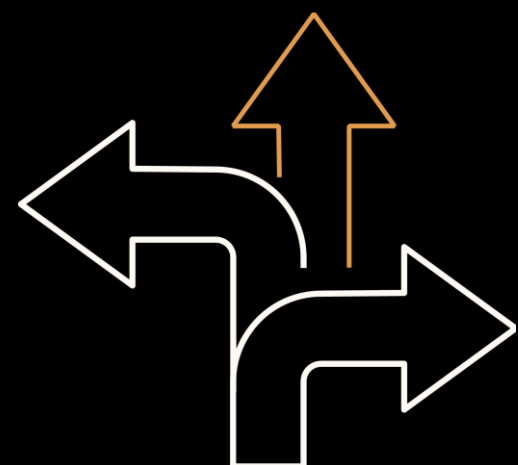
- ☐ Front-facing camera
 - Single camera that captures the images with sizes of 160 x 120 in front of the agent at 15 fps. The camera has 120 wide angle lens. The images are converted into grey scale before being fed to the neural network
 - Benefits of the front-facing camera
- ☒ Stereo cameras (right/left) 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

▼

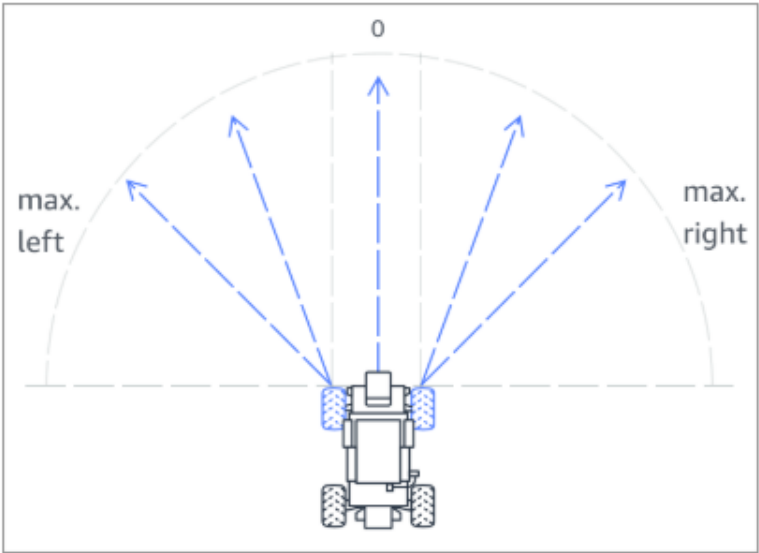
Maximum speed

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

Demo

AWS DeepRacer console



<https://amzn.to/2Myrqzv>

Additional resources

- AWS 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>
- AWS Developer Acceleration twitch channel - <https://www.twitch.tv/devaxconnect>

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Dive deeper with these resources, get inspired and learn how you can use machine learning to accelerate business outcomes.

- The machine learning journey e-book
- Machine learning enterprise guide
- 7 leading machine learning use cases e-book
- A strategic playbook for data, analytics, and machine learning
- Accelerating ML innovation through security e-book
- ... and more!



<https://tinyurl.com/aiml-aws>

Visit resource hub »

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aws.training/machinelearning

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Thank you!