

AWS DeepRacer Workshop

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Machine Learning Solutions Architect
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大淵 麻莉

- 機械学習ソリューションアーキテクト
 - AWS 機械学習サービスを担当
 - 前職では機械学習を使ったプロダクト開発
 - 一眼レフ用の画像処理アルゴリズム開発
- 好きなサービス
 - Amazon SageMaker
 - Amazon Rekognition Custom Labels



本ワークショップの内容

- AWS DeepRacer の概要の説明（本動画）
 - 強化学習の概要
 - AWS DeepRacer のシミュレータの説明
 - AWS DeepRacer の構成
- ハンズオン（もくもく）

AWS DeepRacer の概要



AWS DeepRacer

強化学習をすべての開発者の
手に届けるためのサービス

6

Introducing AWS DeepRacer Evo





AWS DeepRacer Evo
1/18スケールの
自律走行カー



3D シミュレータ

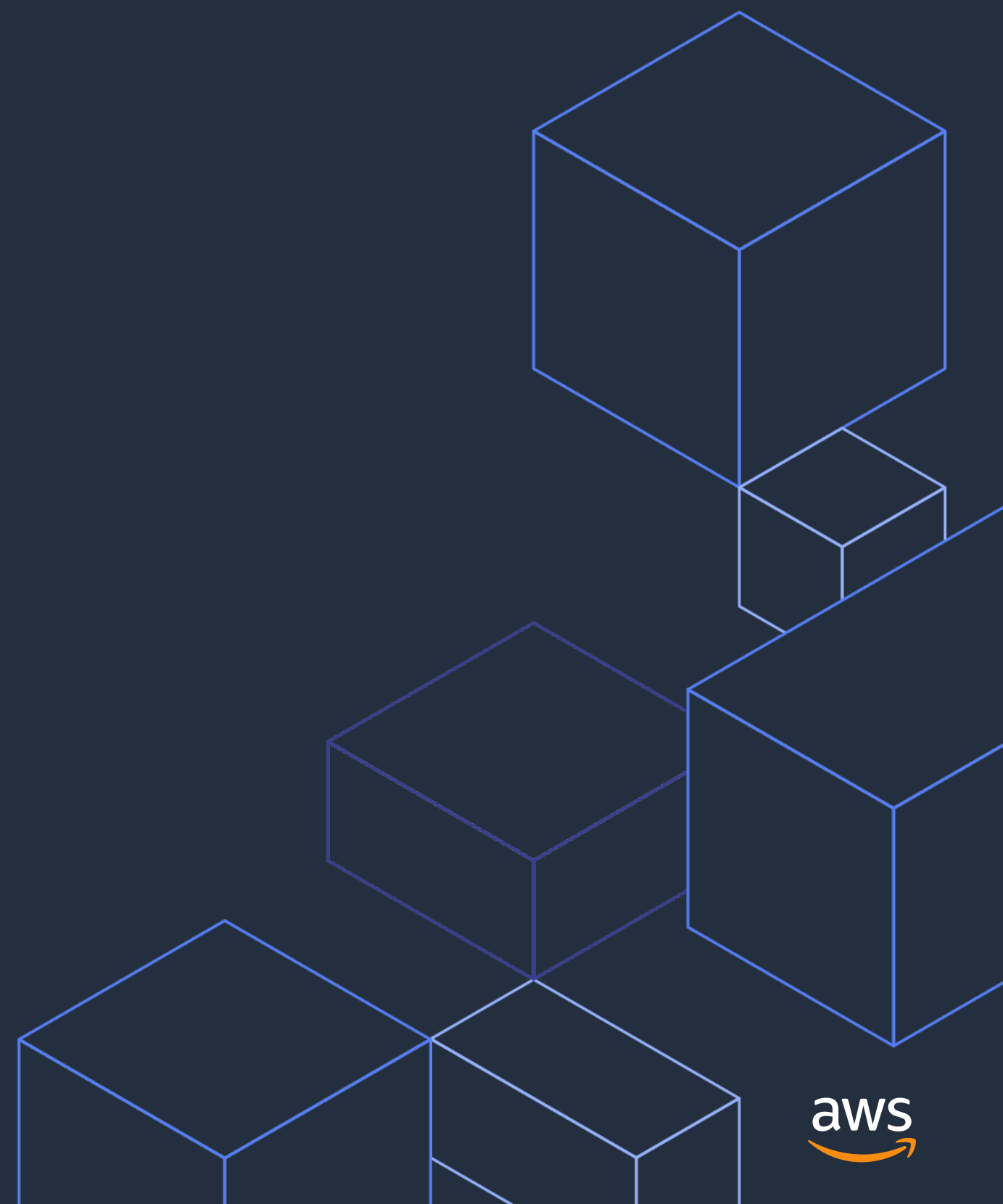


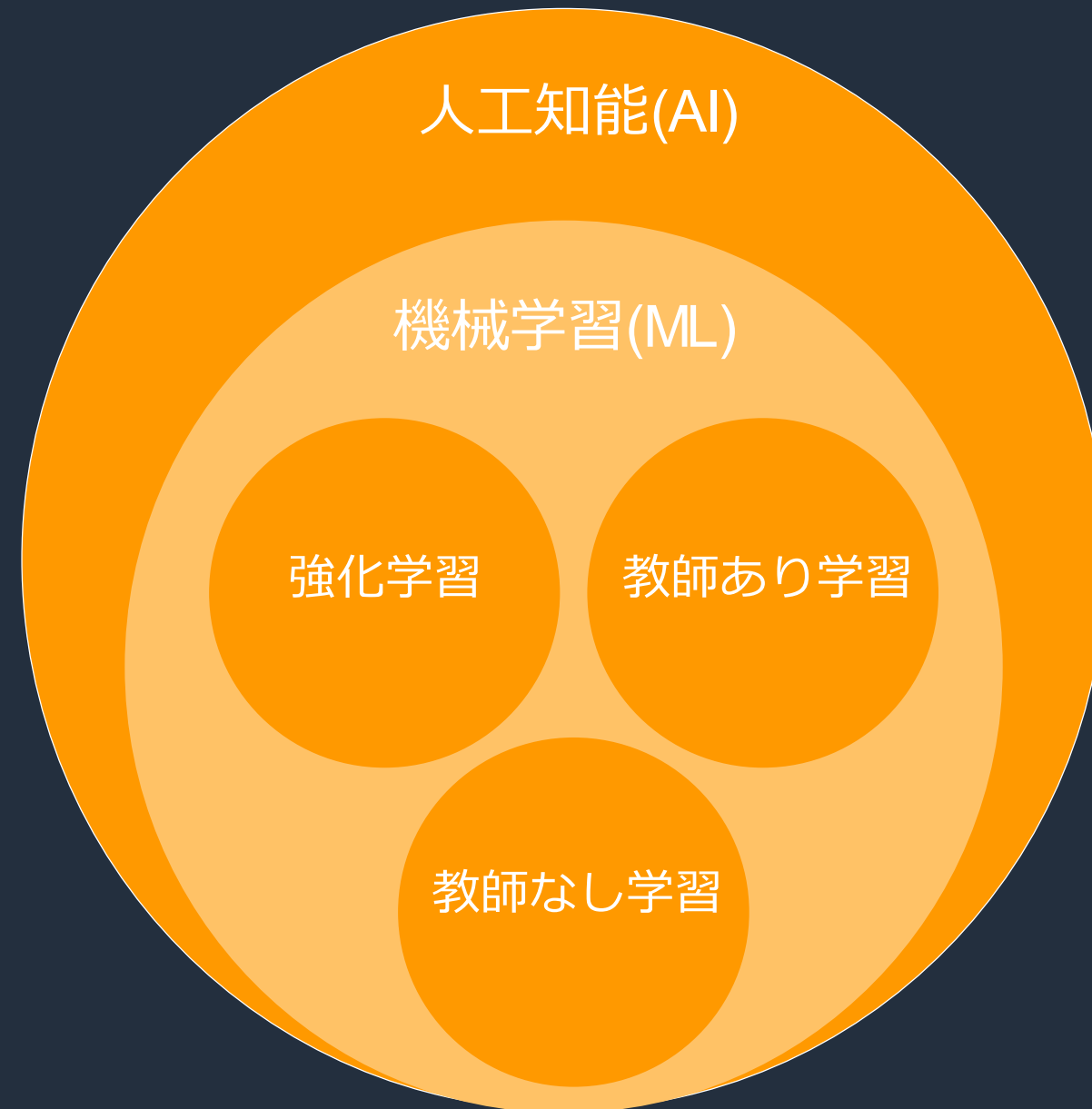
2020 AWS
DeepRacer リーグ
Presented
by Accenture



コミュニティレース

強化學習





強化学習

- 仮想的なエージェント（車）がシミュレーション環境で行動を繰り返し、経験（入力画像・行動・次状態・報酬）を蓄積
- 経験を利用して学習し、学習したモデルでさらに経験を獲得

教師あり学習

(BEHAVIORAL CLONING)

- カメラ付きの実機カーを熟練のドライバーが運転
- カメラ画像とドライバーの運転を記録し、モデルを学習

学習の結果はどちらも同じ

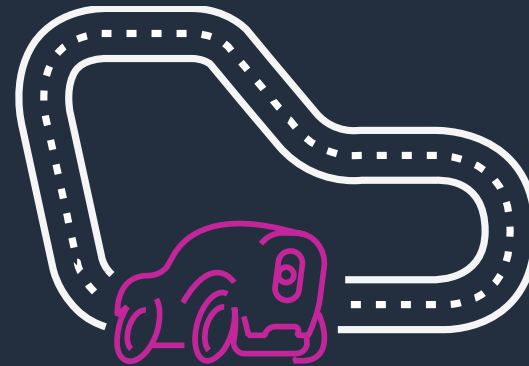
状態（画像）を入力すると運転行動を決定する

AWS DeepRacer における強化学習の要素

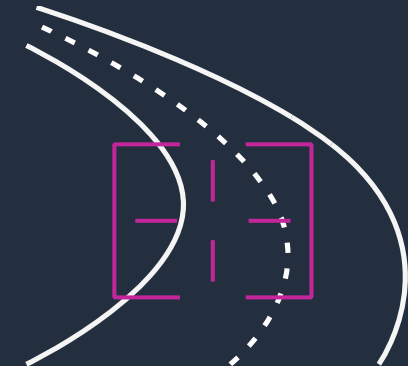
エージェント



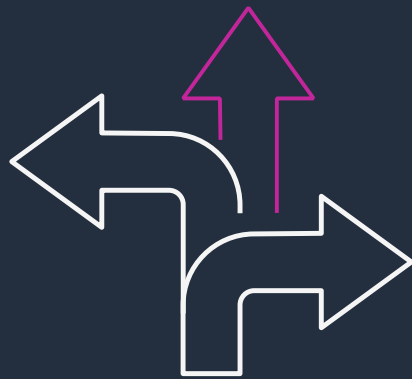
環境



状態



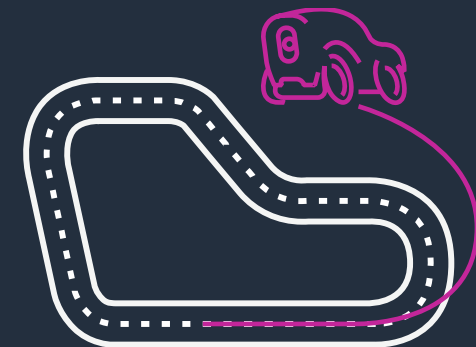
行動



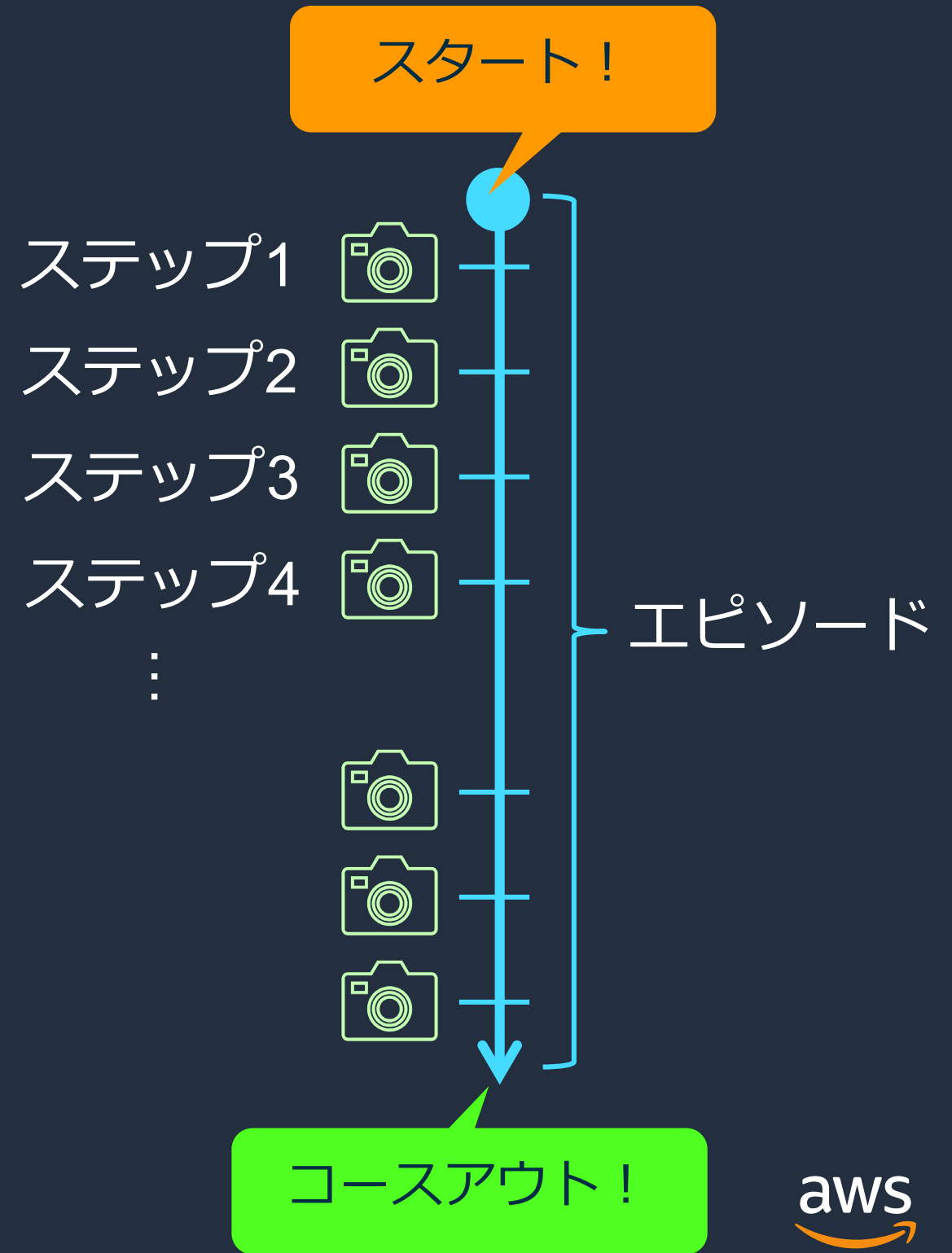
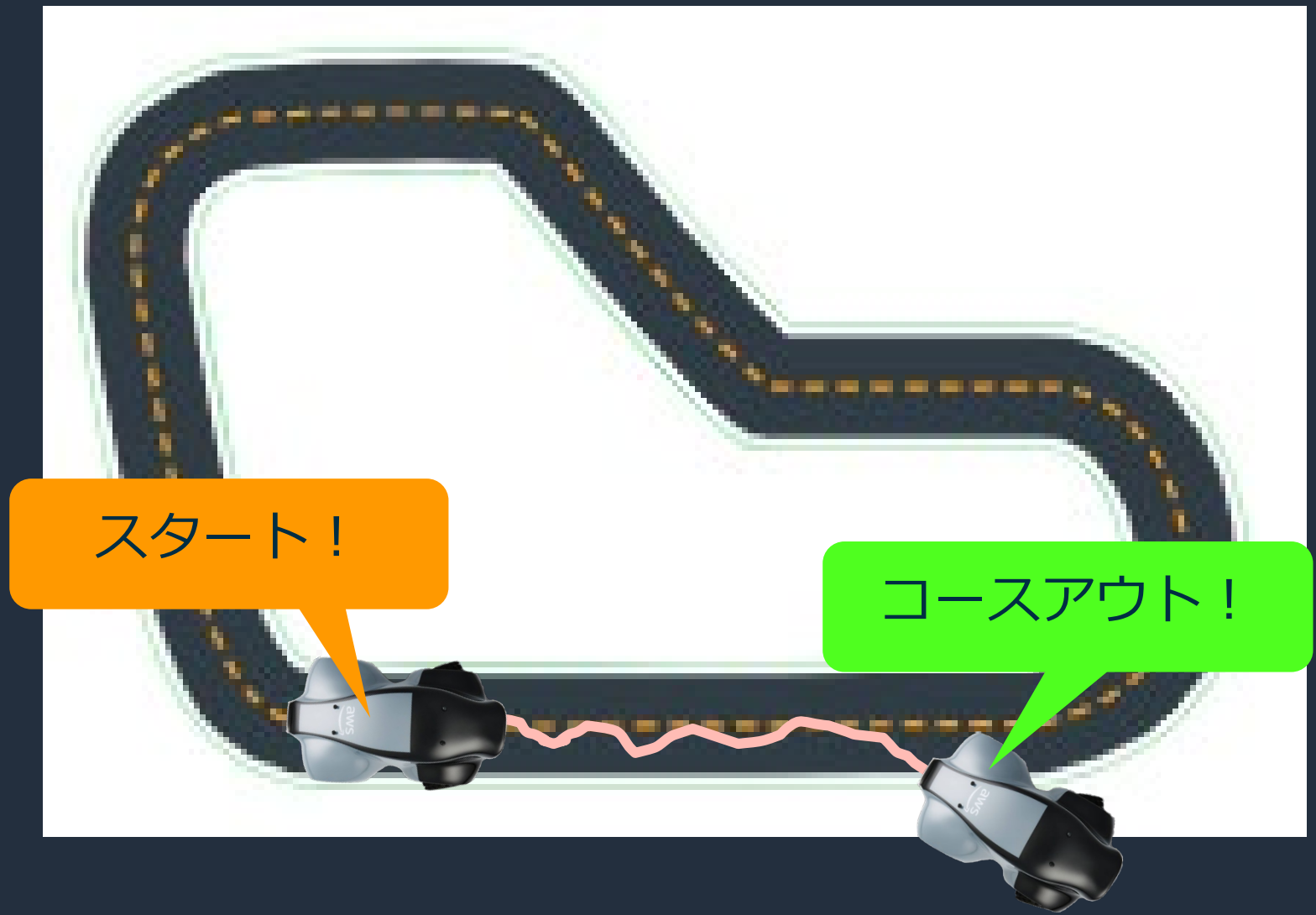
報酬



エピソード



12 ステップとエピソード

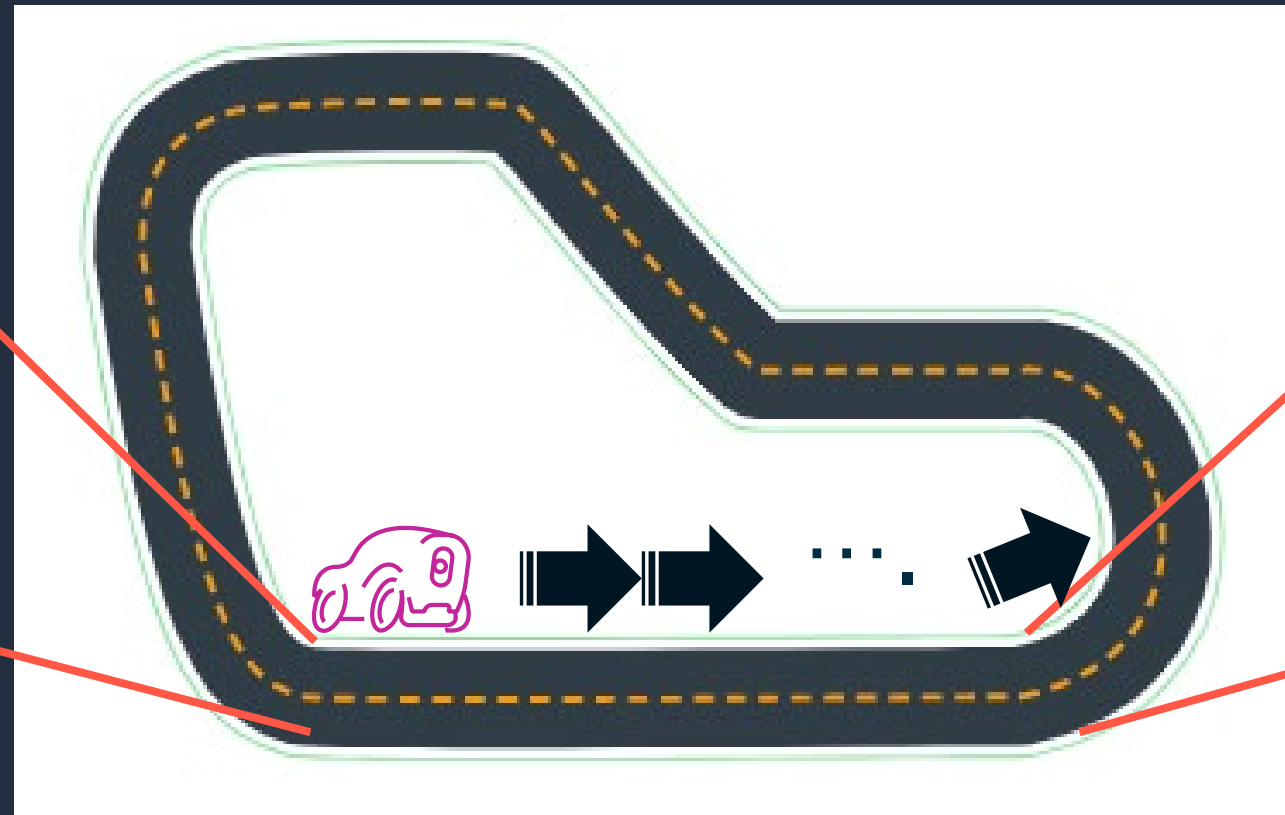


DeepRacer を走らせるために

- カメラ画像（状態）から行動を決定するモデルを学習により作成
- 環境（コース）に対して、エージェントが様々な 行動（運転：ステアリング・スロットル）を試し、ゴールに到達できるように学習



直進

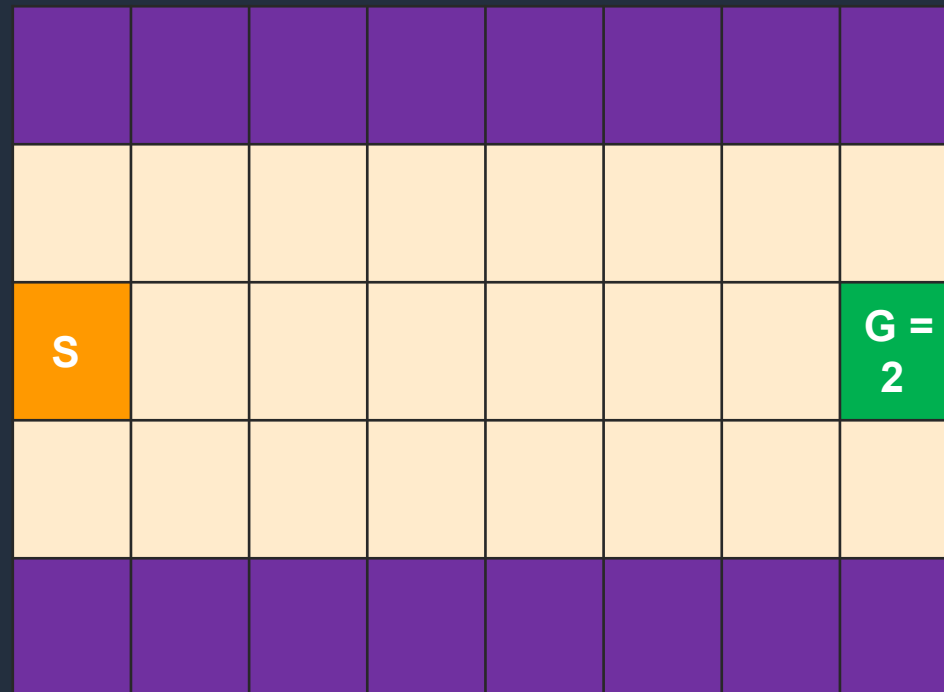


左

行動を決定するための報酬関数



エージェント



ゴール

センターラインを走るようにインセンティブを与える



0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
S	2	2	2	2	2	2	G = 2
0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1



報酬関数

+

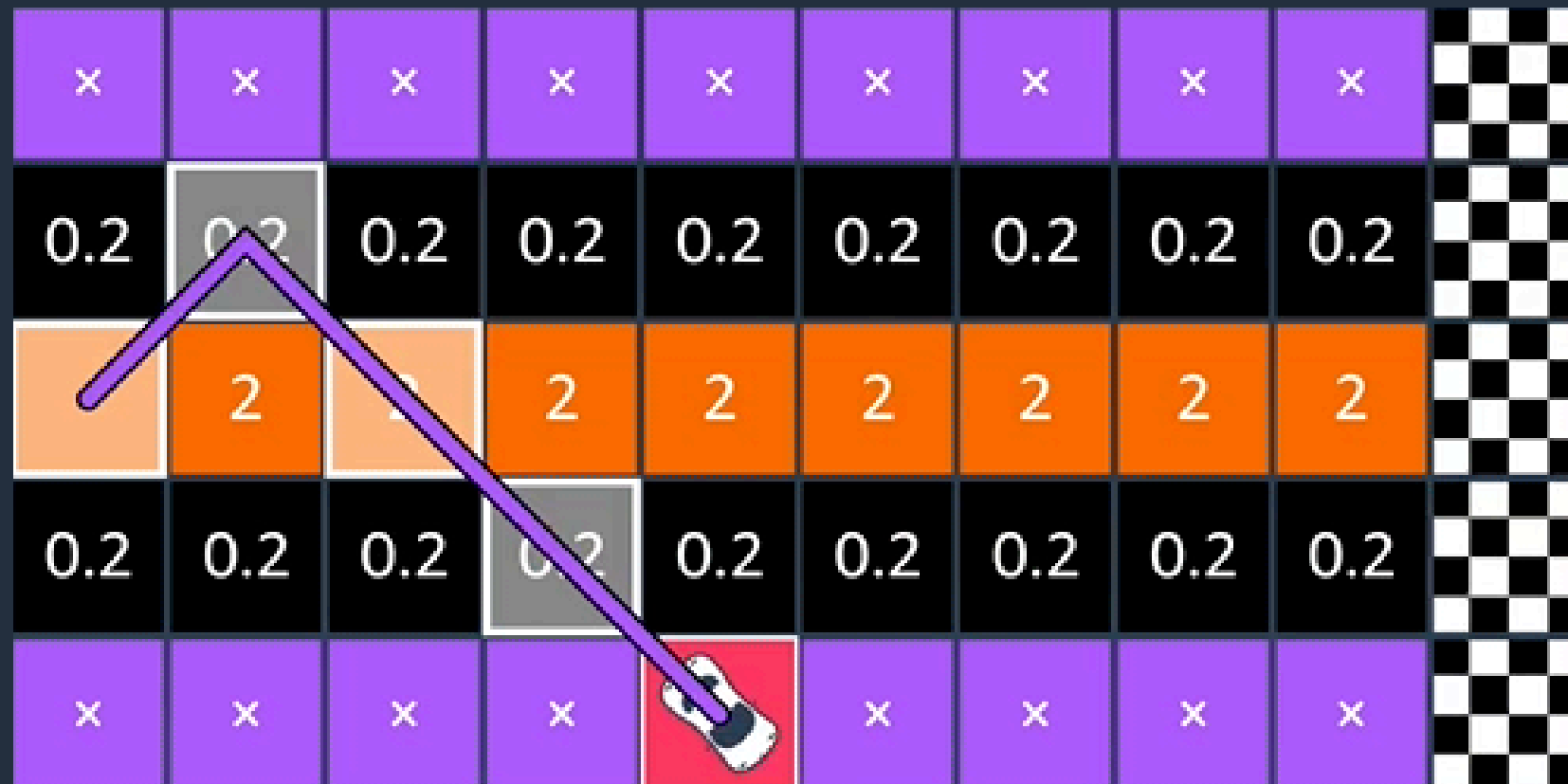
ステップの割引率

8.6	9.5	8.5	7.5	6.3	5.0	3.5	1.9
S	10.4	9.4	8.2	6.9	5.4	3.8	G = 2
8.6	9.5	8.5	7.5	6.3	5.0	3.5	1.9

価値関数:

多数の探索を繰り返した
あとの各状態の最大値

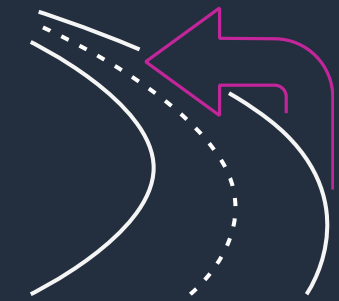
16 Iteration and convergence



状態 (15fps, 画像・シミュレータの中で位置情報も取得可能)



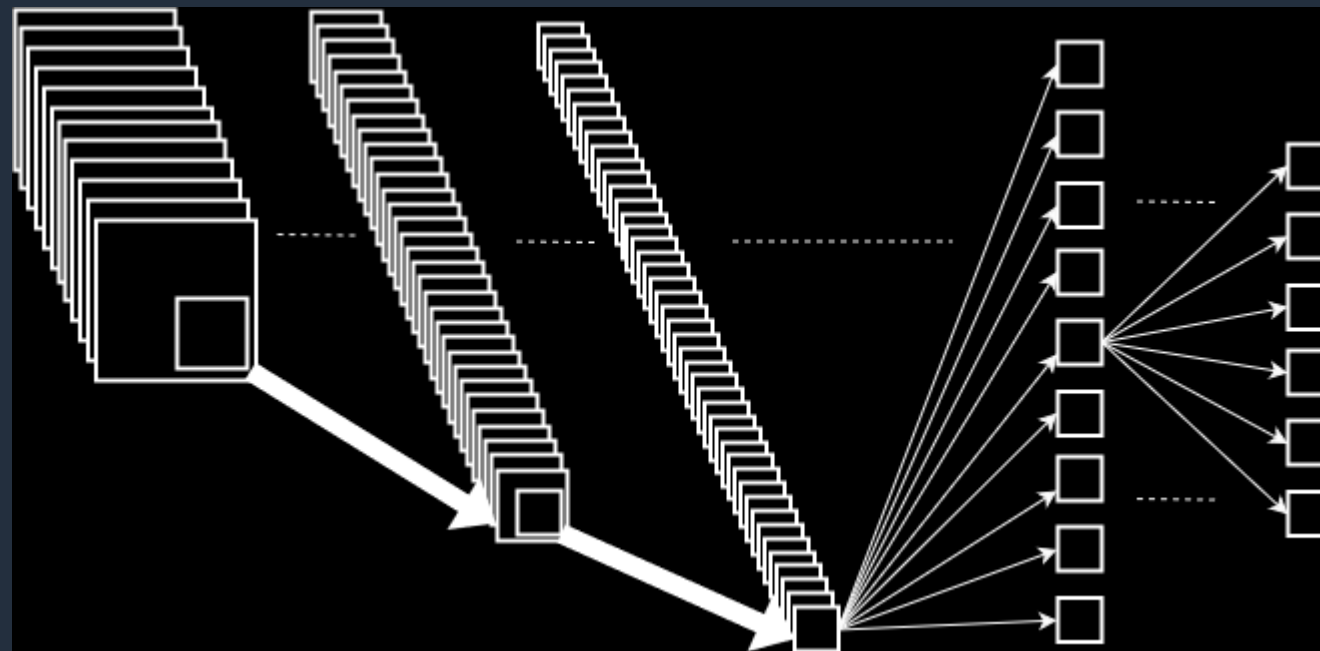
方策関数 (policy fn)



エピソードを集め
PPO*で学習

入力 - 状態 (画像)

出力 - 行動



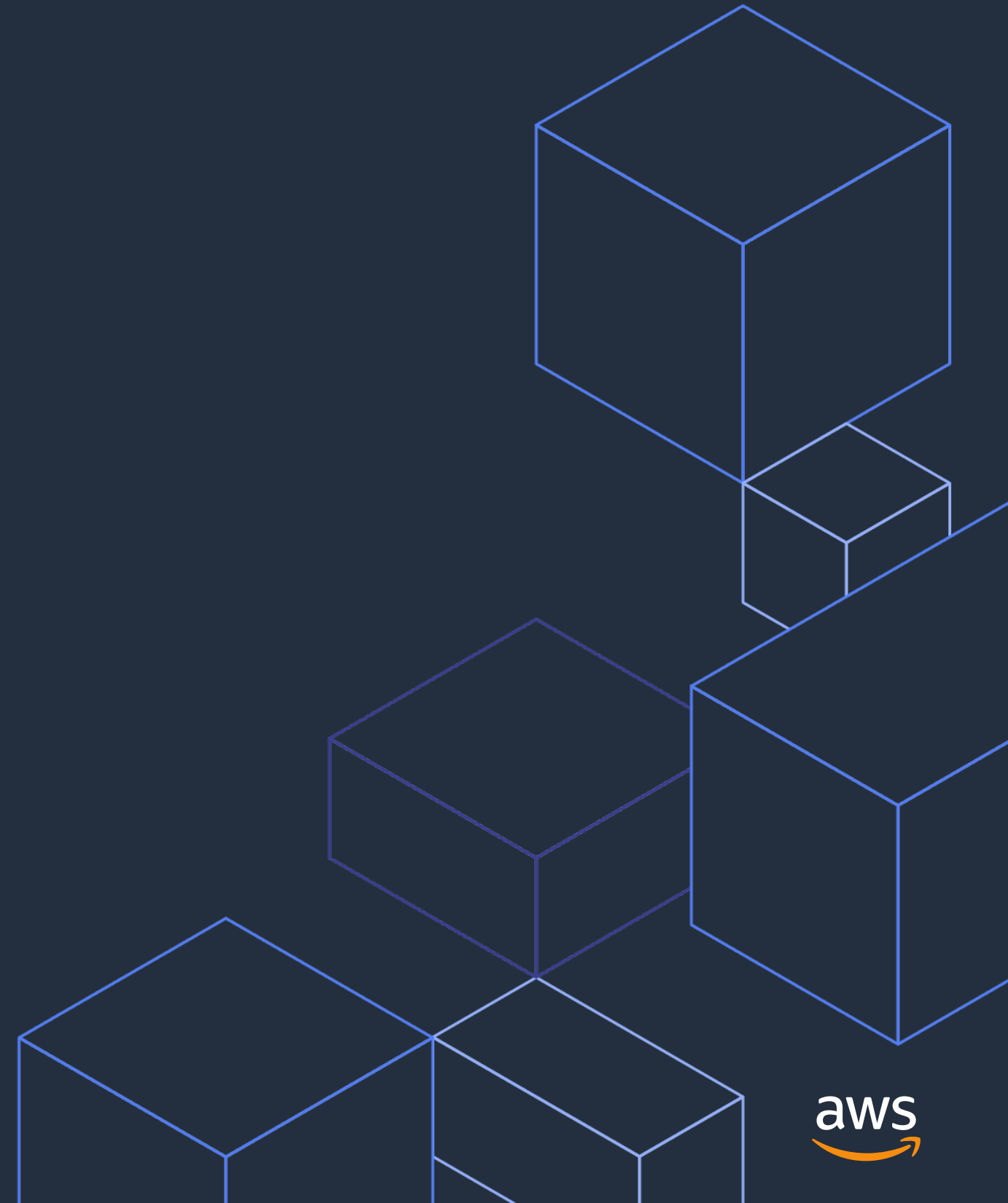
CNN - 特徴抽出器

全結合層

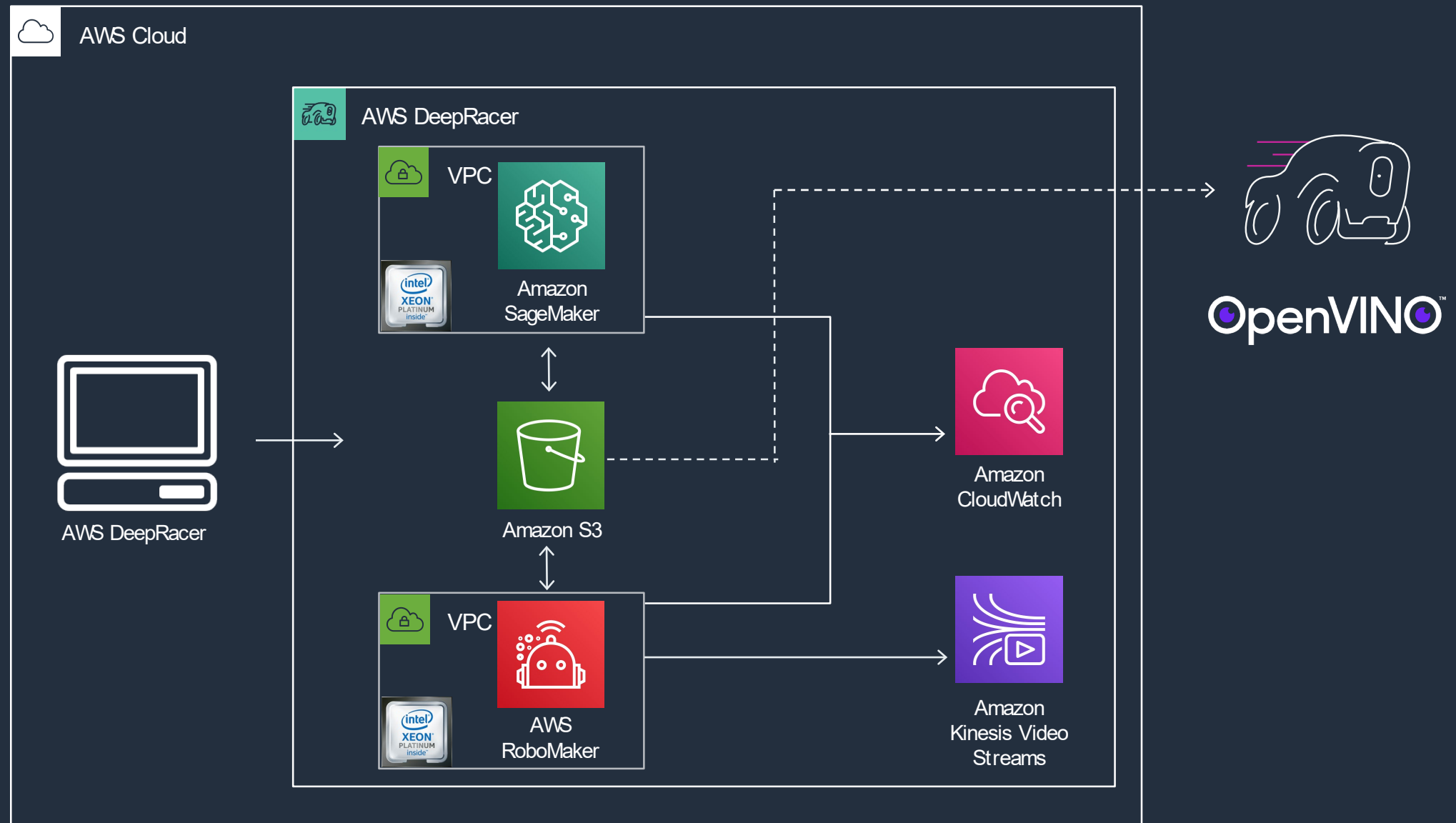
AWS Summit Tokyo 2019 DeepRacer League



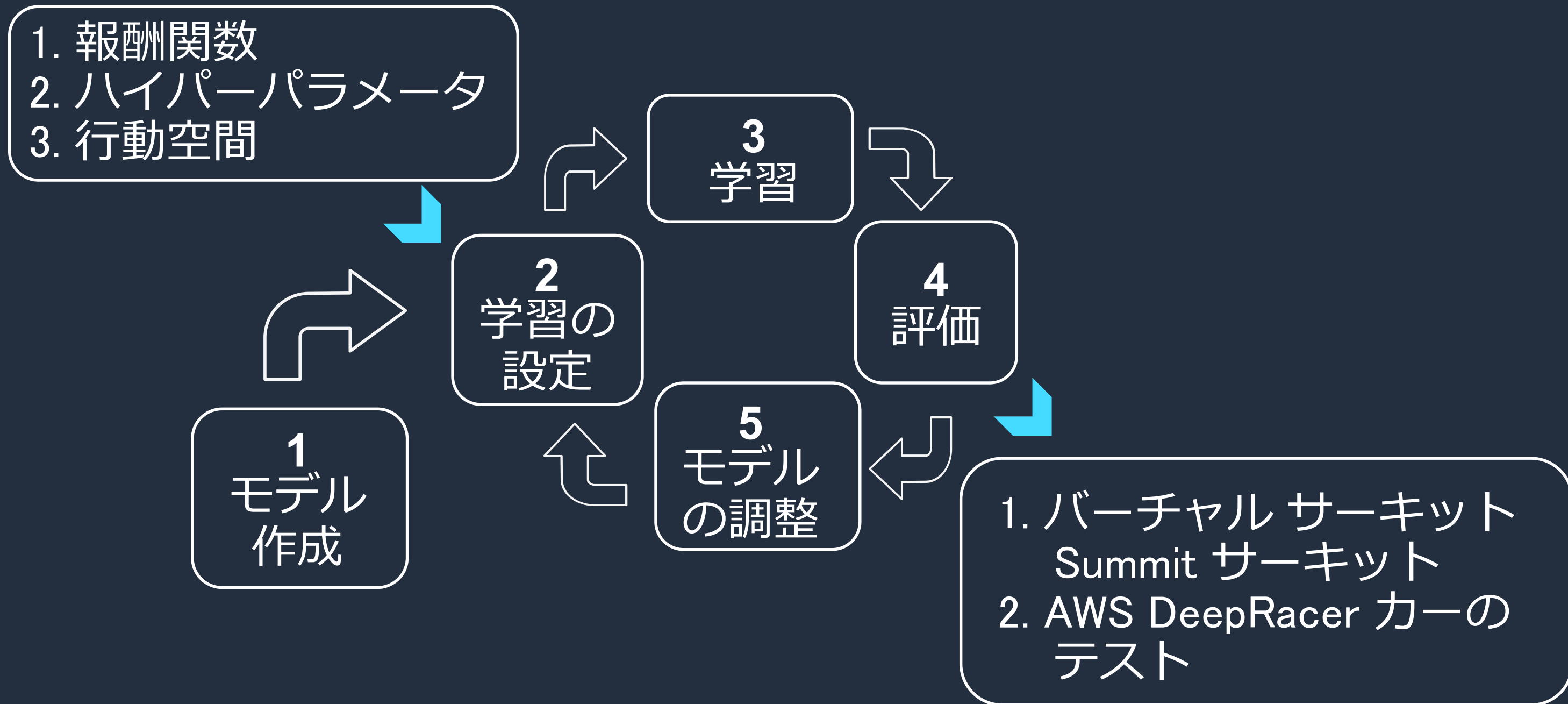
シミュレータ



AWS DeepRacer simulator architecture



AWS DeepRacer コンソールの流れ



- スピードとステアリングの組合せで定義
- 細かい調整を行うために粒度を設定可能

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

▼

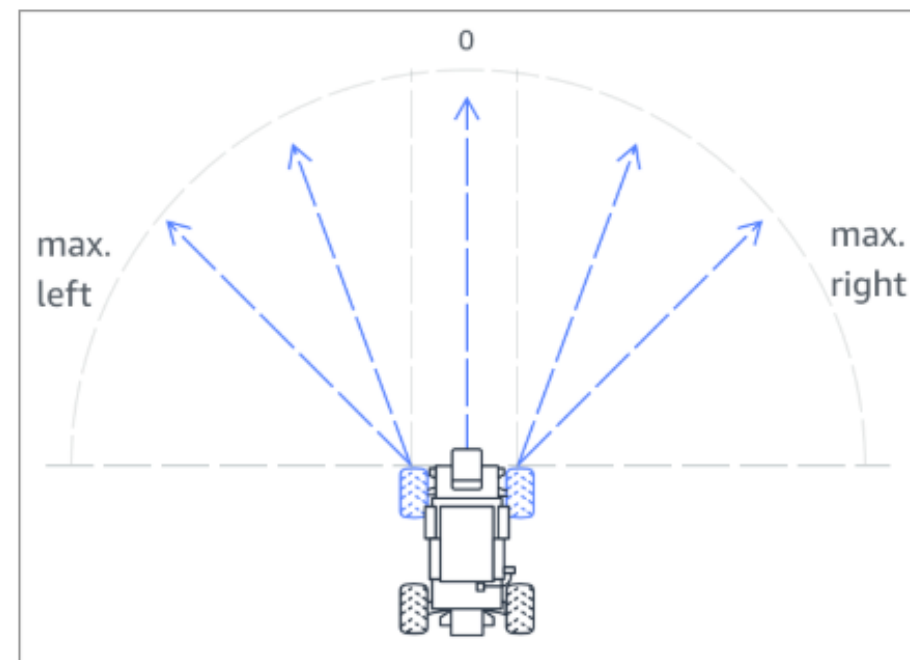
Maximum speed

m/s

Max values are between 0.8 and 5.

Speed granularity

▼



Action list

Action number	Steering	Speed
0	-30 degrees	0.5 m/s
1	-30 degrees	1 m/s

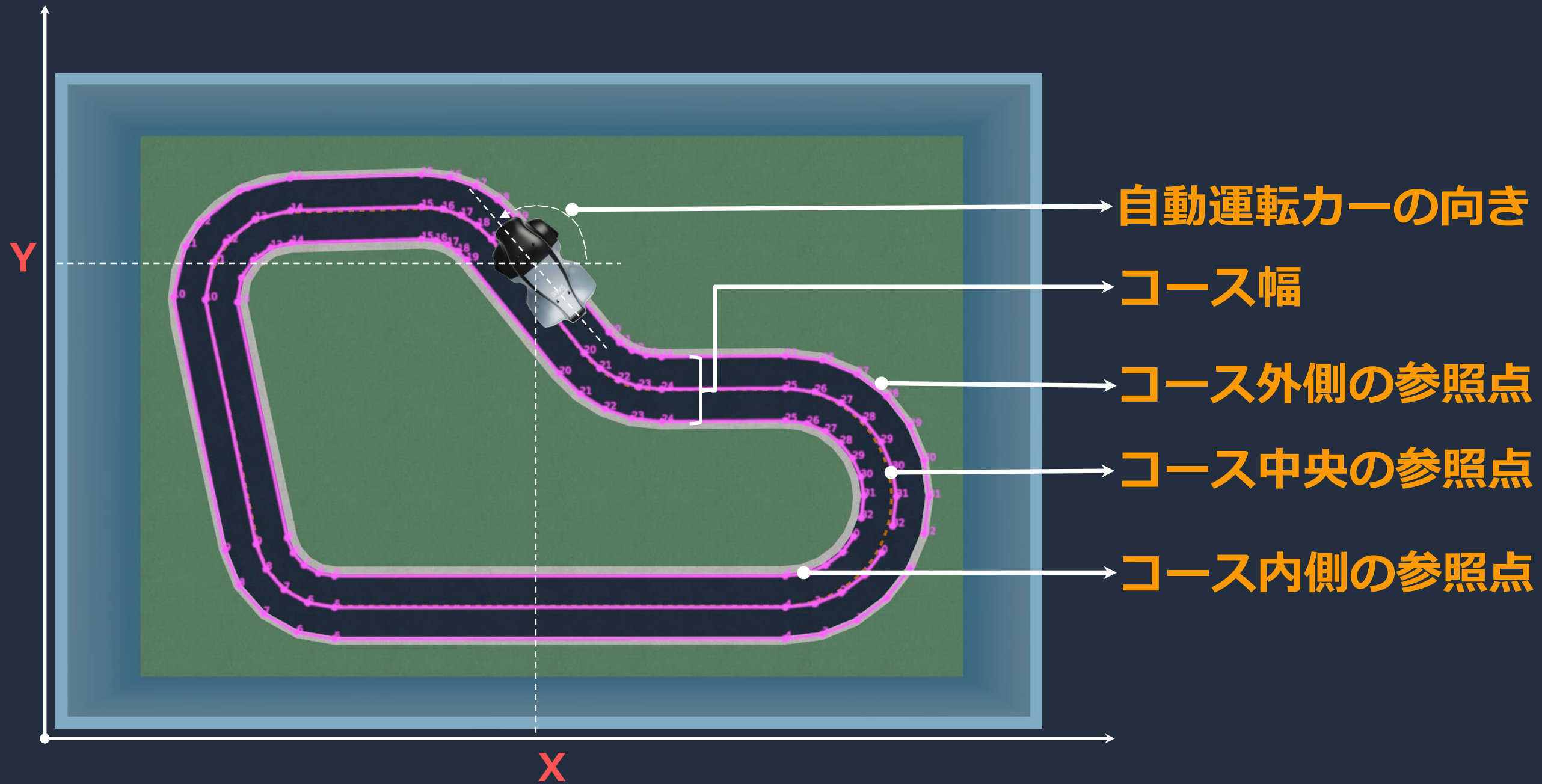
Reward function [Info](#)

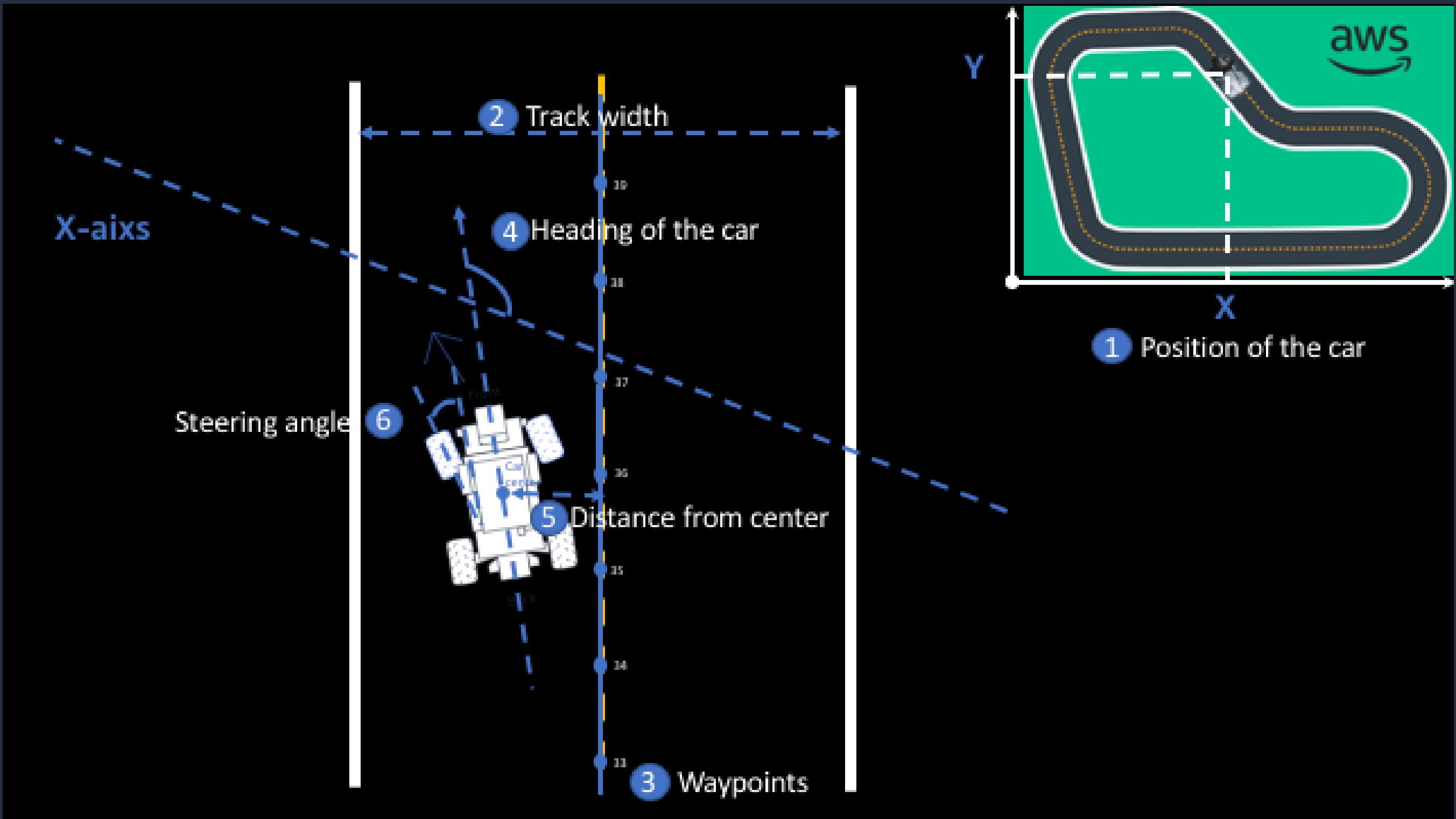
The reward function describes immediate feedback (as a score for reward or penalty) when the vehicle takes an action to move from a given position on the track to a new position. Its purpose is to encourage the vehicle to make moves along the track to reach its destination quickly. The model training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

[Code editor](#)[Reward function examples](#)[Reset](#)[Validate](#)

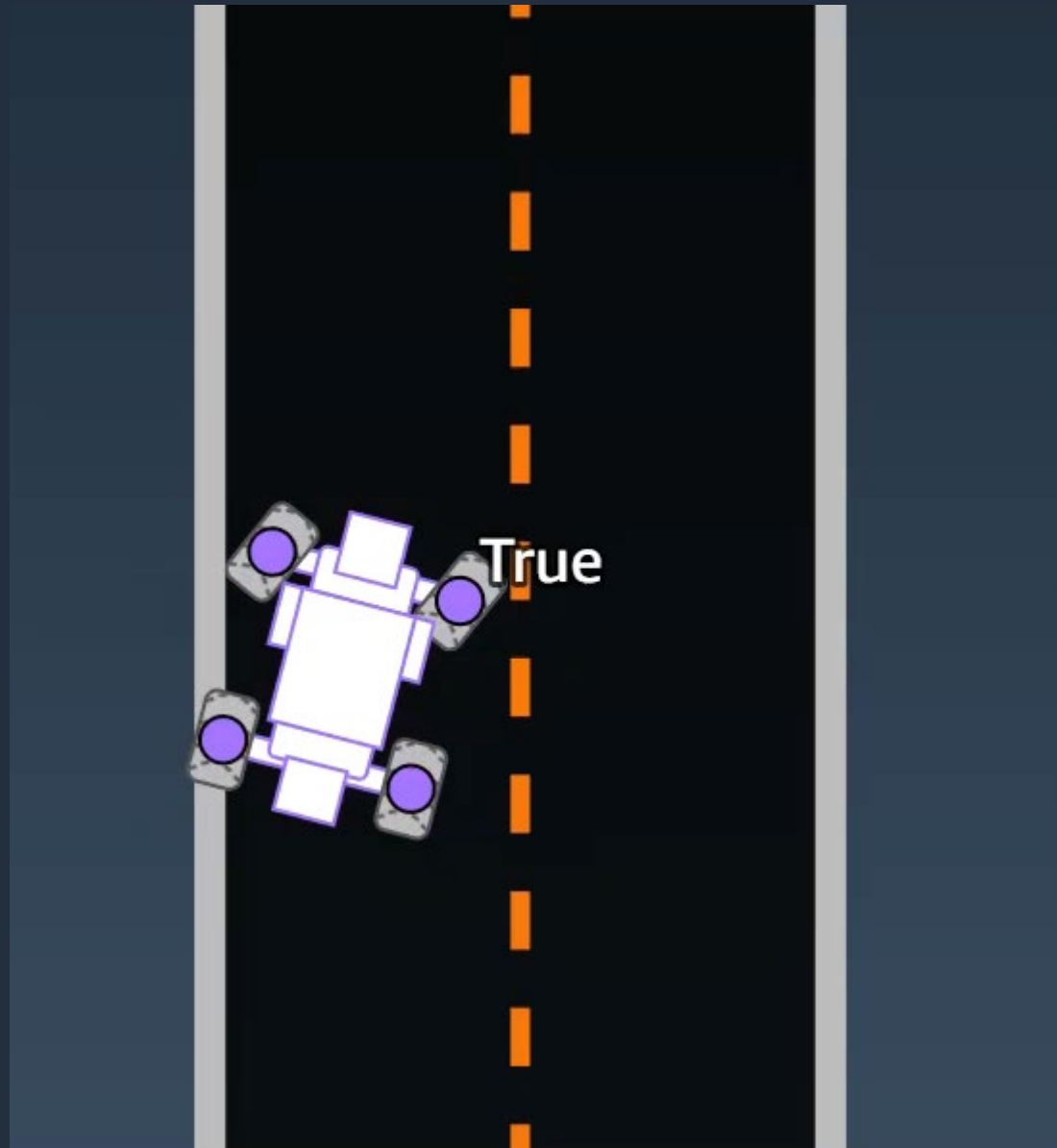
```
1 def reward_function(params):
2     '''
3     Example of rewarding the agent to follow center line
4     '''
5
6     # Read input parameters
7     track_width = params['track_width']
8     distance_from_center = params['distance_from_center']
9
10    # Calculate 3 markers that are at varying distances 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)
```

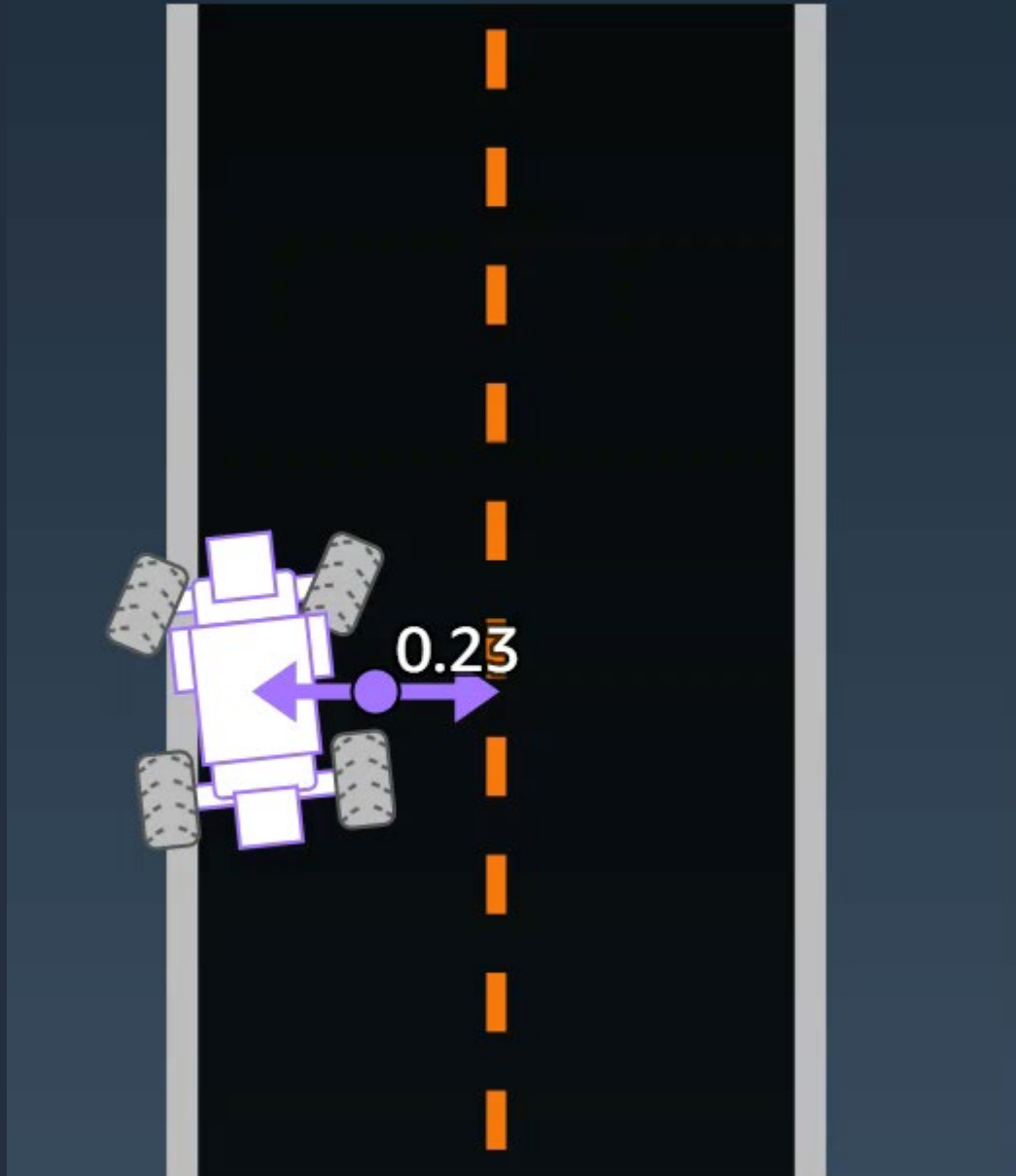

26 座標系と参照点 (waypoints)







取得できる情報 : `all_wheels_on_track`

取得できる情報 : `distance_from_center`

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.

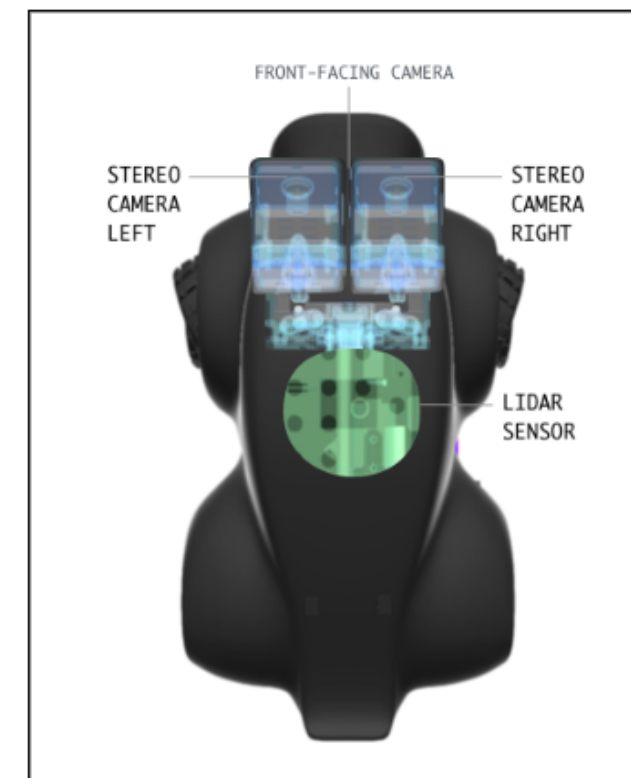
► Benefits of the stereo camera

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

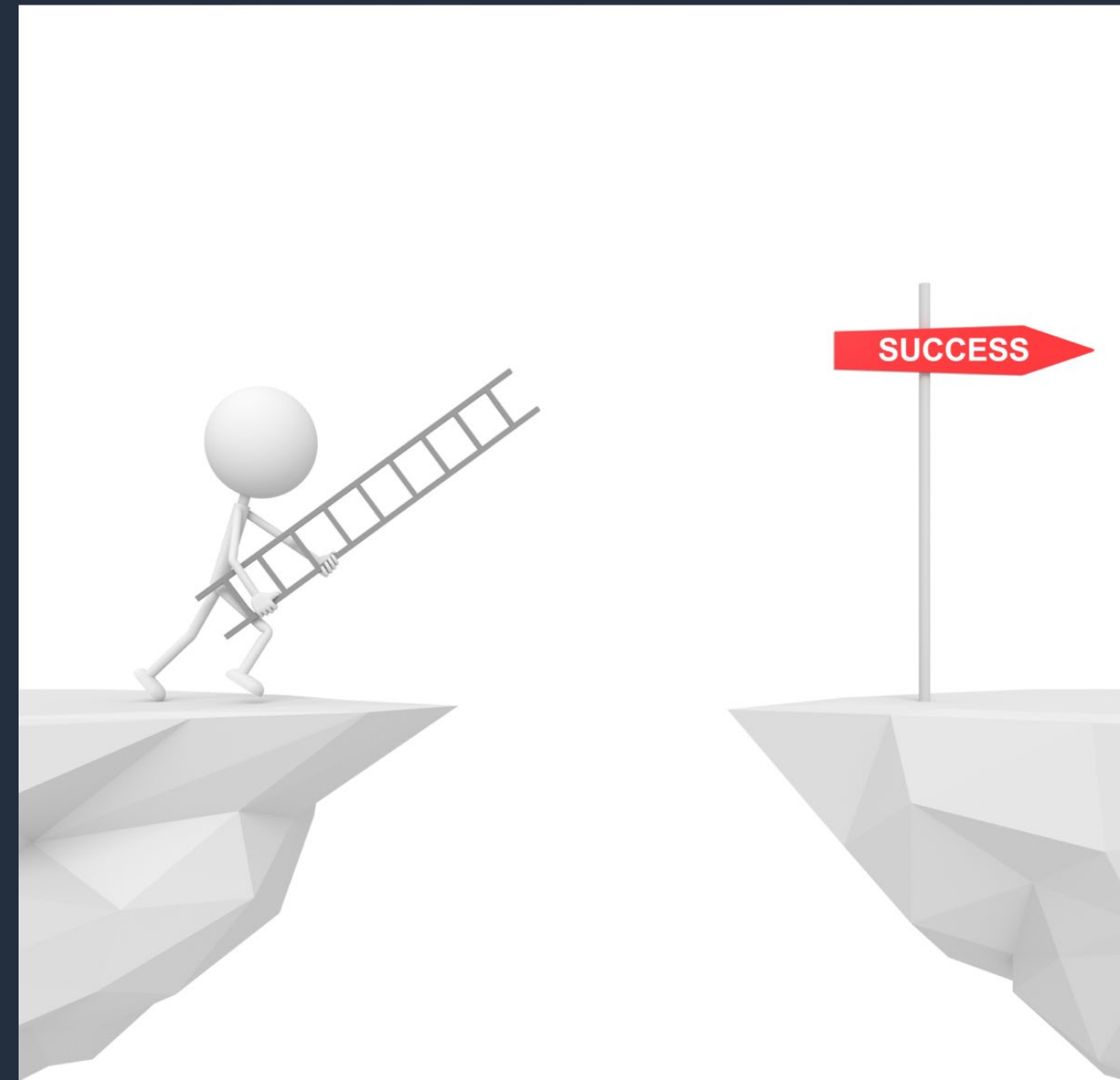


シミュレーションから実環境への難しさ

- シミュレーション画像を利用して学習しているが、実機では実世界の画像を利用
- 実環境の完全なシミュレーションも難しい

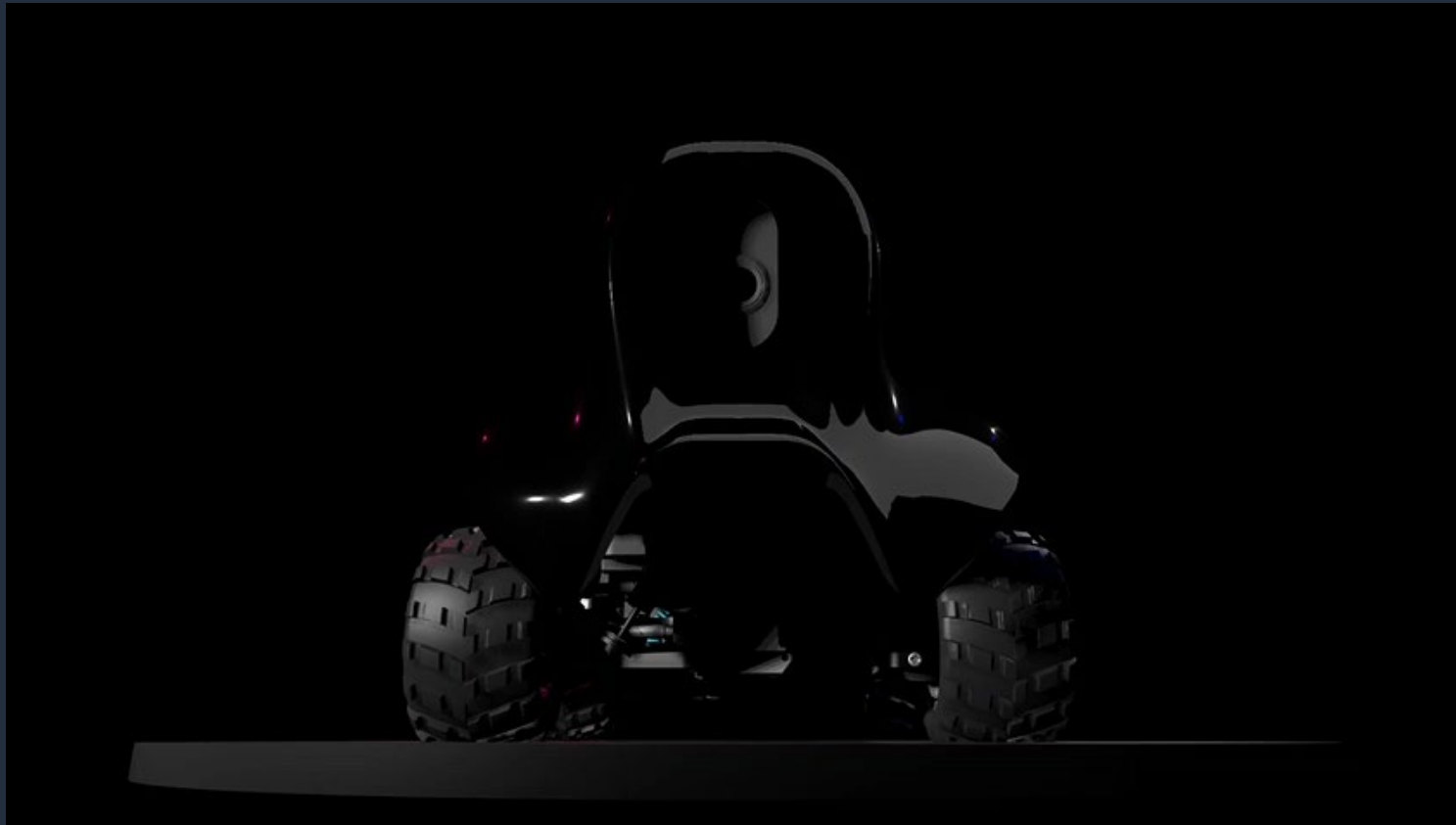
戦略

- 環境制御を実世界に近づける
- 環境にランダムな要素を追加
- モデルのモジュール化



AWS DeepRacer の構成詳細

34 AWS DeepRacer スペック



CAR: 18th scale 4WD with monster truck chassis

CPU: Intel Atom Processor

MEMORY: 4 GB RAM

STORAGE: 32 GB (expandable)

WIFI: 802.11ac

CAMERA: 4 MP camera with MJPEG

DRIVE BATTERY: 1000 mAh lithium polymer

COMPUTE BATTERY: 13600 mAh USB-C

SENSORS: Integrated accelerometer and gyroscope

PORTS: 4x USB-A, 1x USB-C, 1x Micro-USB, 1x HDMI

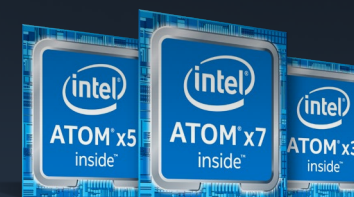
SOFTWARE: Ubuntu OS 16.04.3 LTS, Intel OpenVINO toolkit, ROS Kinetic



OpenVINO™

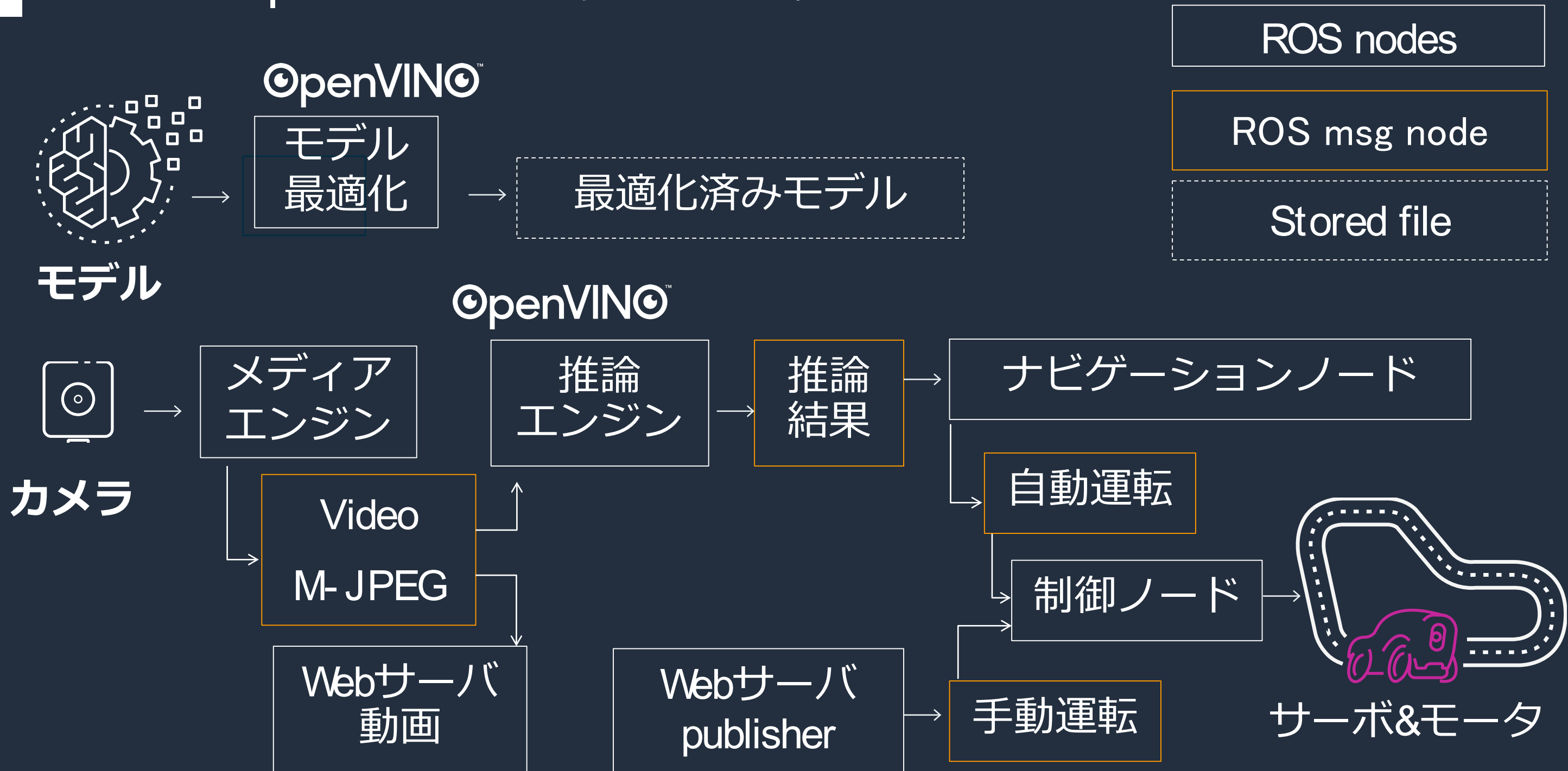
AWS DeepRacer Evo スペック

- 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 W-Fi
- Ubuntu 16.04.3 LTS
- ROS Kinetic



OpenVINO™

AWS DeepRacer アーキテクチャ



強い DeepRacer モデルを作るために

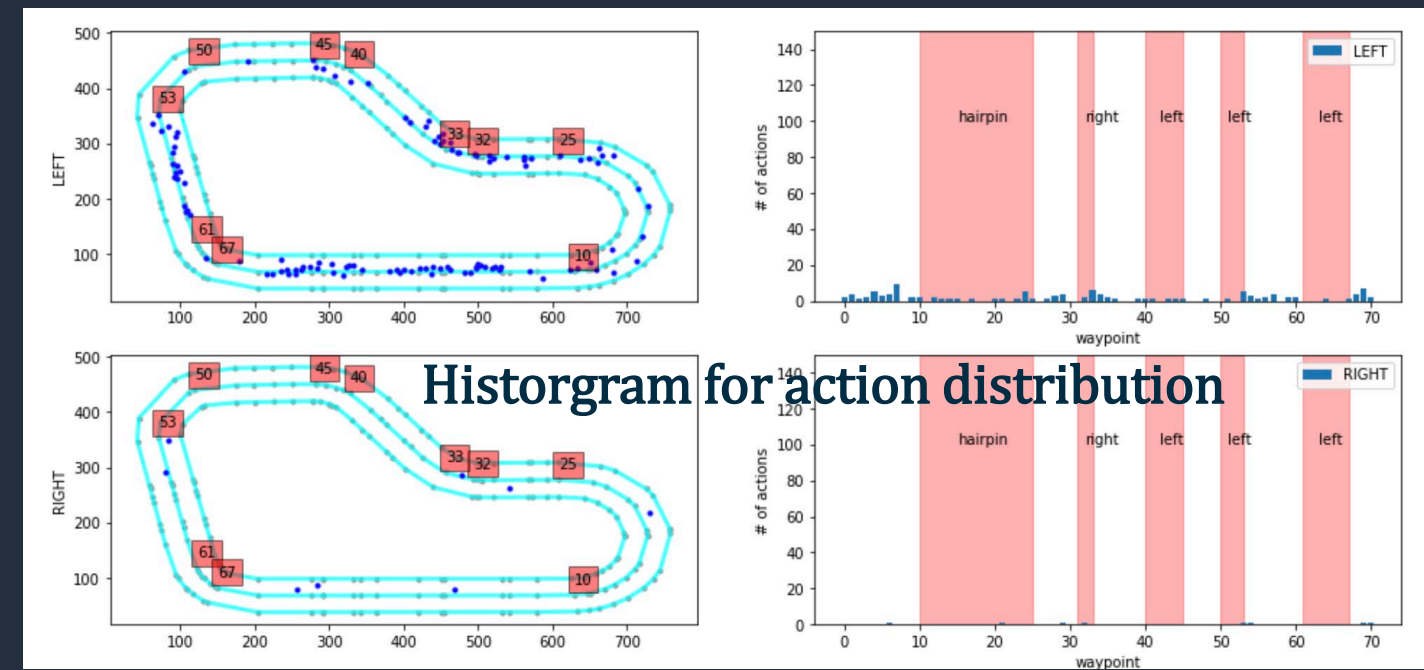
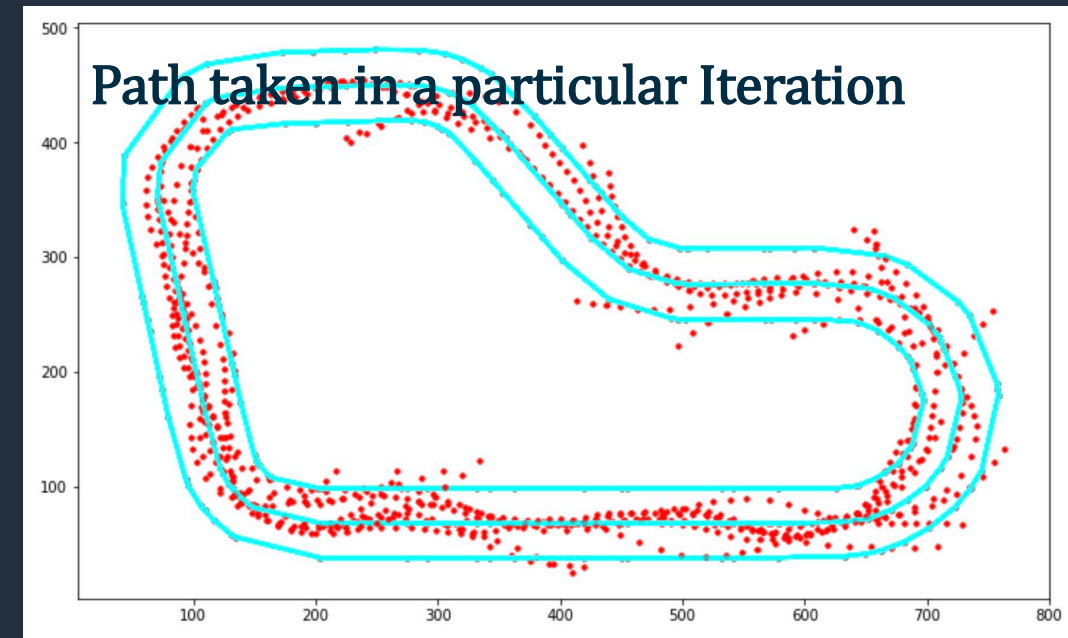
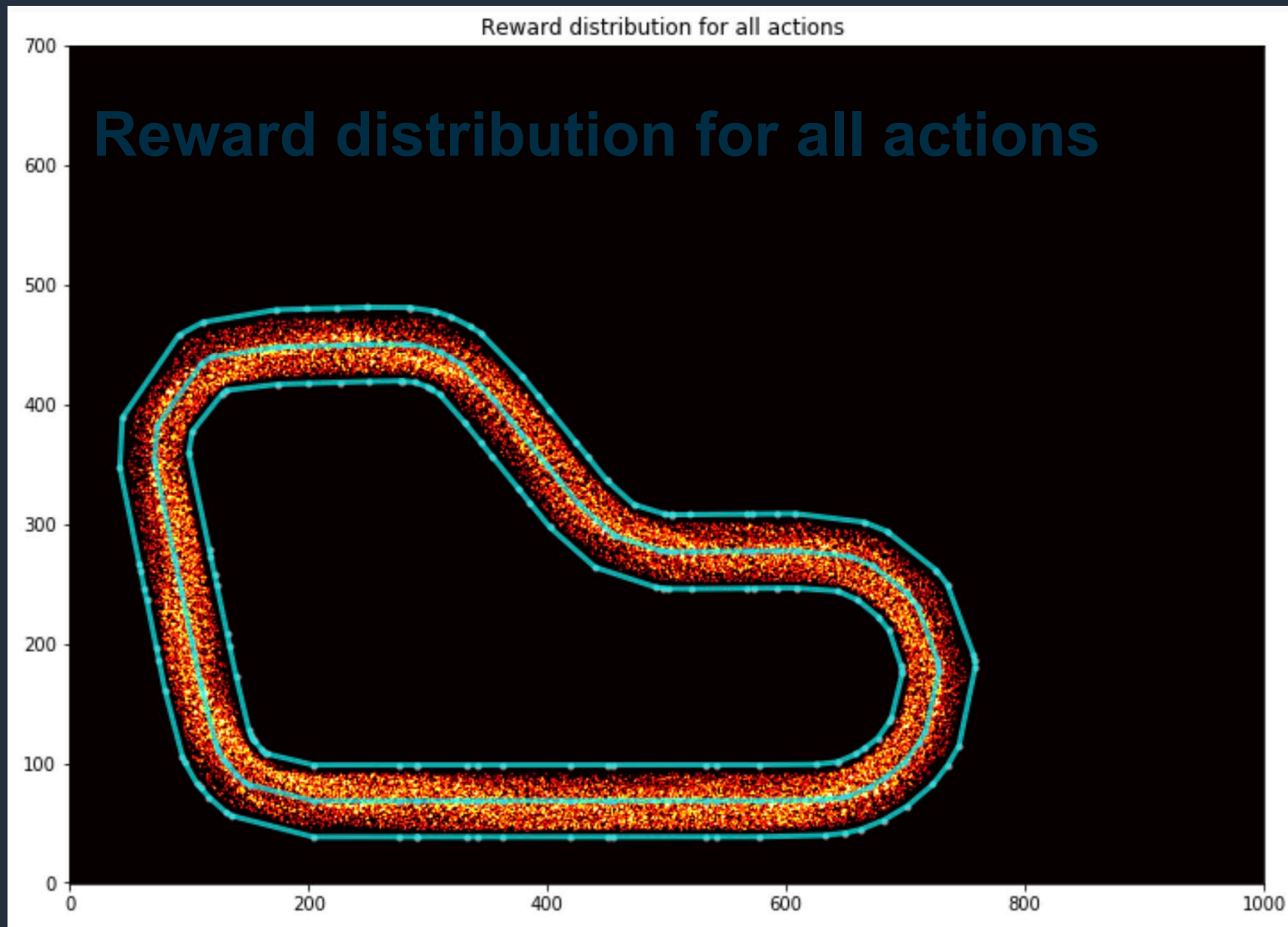
Amazon SageMaker Reinforcement Learning

- ゲームやロボットのシミュレーション環境と統合した SageMaker 上の強化学習
- 強化学習ツールキットとして Coach と RL-Ray をサポート
- AWS RoboMaker などのシミュレータを OSS OpenAI Gym インターフェース経由で利用可能. 分散学習とシミュレーションの並列化が可能

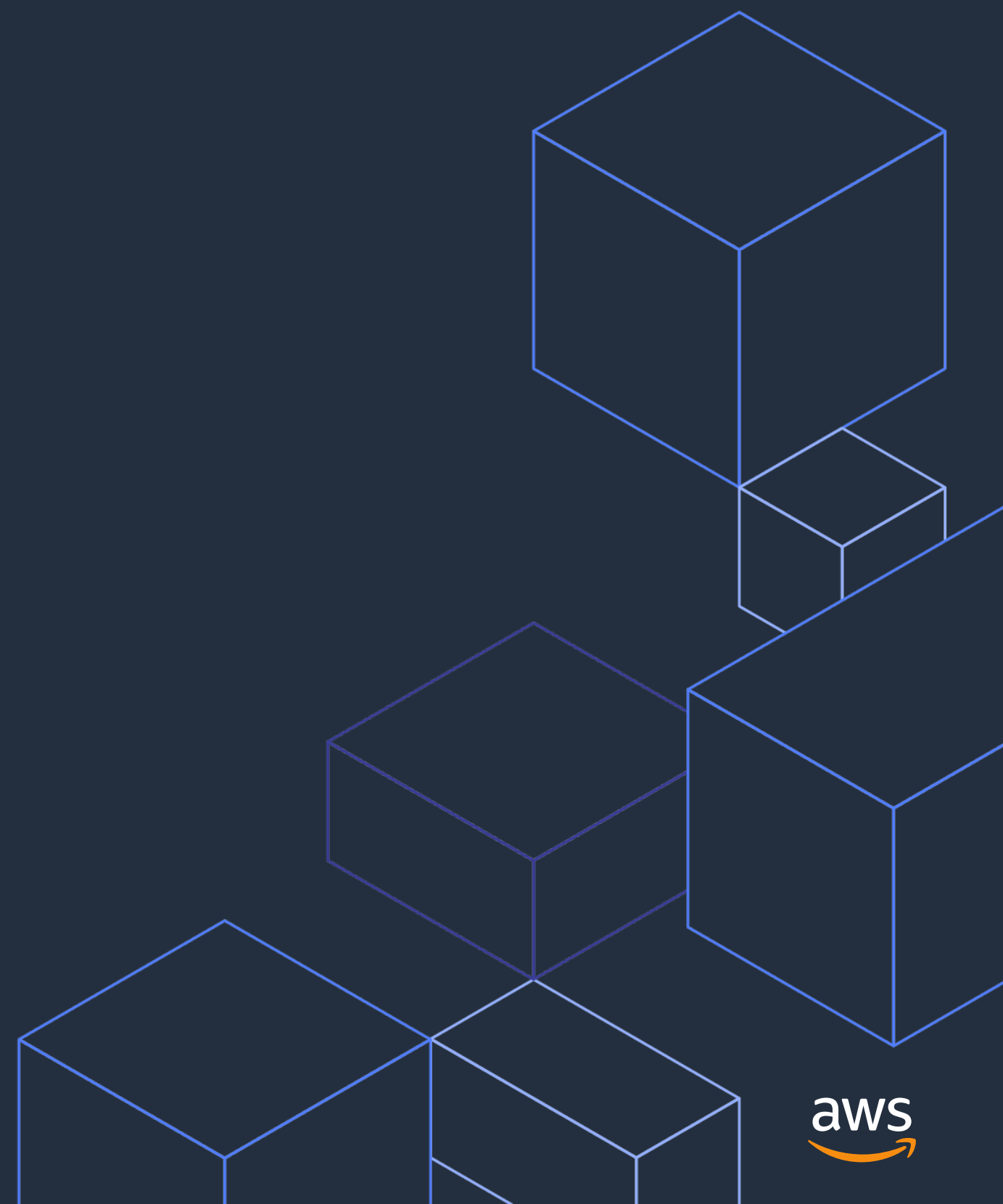


Simulation Run Log Analysis and Visualization for AWS DeepRacer

<https://github.com/aws-samples/aws-deepracer-workshops/blob/master/log-analysis/DeepRacer%20Log%20Analysis.ipynb>



ハンズオン



AWS DeepRacer workshop labs

AWS DeepRacer の強化学習モデルを構築しましょう!

ハンズオン手順書はこちら



<http://bit.ly/dr-ja>

DeepRacer 初回起動時の画面

Machine Learning

AWS DeepRacer

The fastest way to get rolling with machine learning, literally

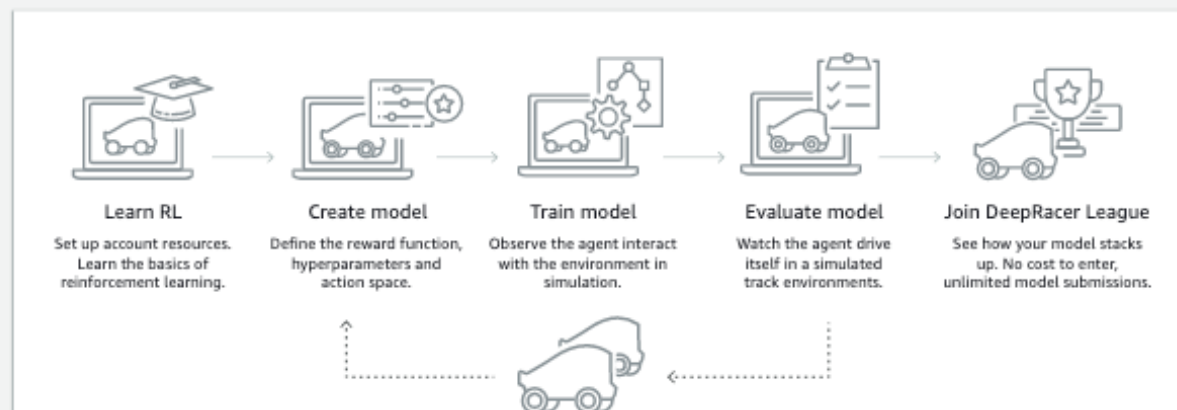
Get hands-on with a fully autonomous 1/18th scale race car driven by reinforcement learning, 3D racing simulator, and global racing league.

Get started with reinforcement learning

Build your model, evaluate its performance on a virtual track, and then compete in the AWS DeepRacer

Get started

How it works



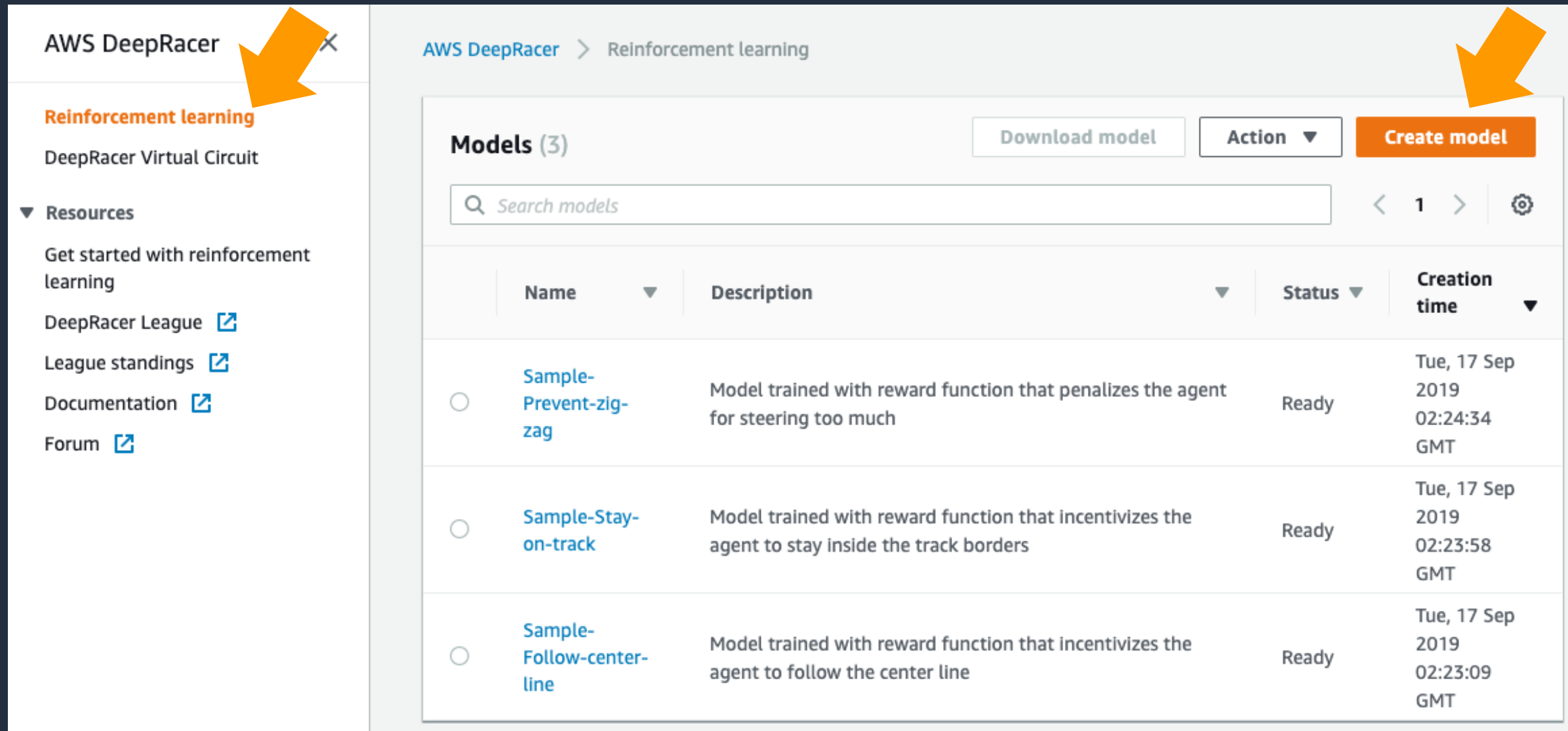
DeepRacer League



Developers, start your engines! Welcome to the world's first global autonomous racing league, open

Reinforcement learning

Create model



The screenshot displays the AWS DeepRacer Reinforcement Learning console. On the left, a navigation sidebar includes 'Reinforcement learning' (highlighted with an orange arrow), 'DeepRacer Virtual Circuit', and a 'Resources' section with links for 'Get started with reinforcement learning', 'DeepRacer League', 'League standings', 'Documentation', and 'Forum'. The main content area, titled 'AWS DeepRacer > Reinforcement learning', features a 'Models (3)' section with a search bar and a 'Create model' button (highlighted with an orange arrow). Below this is a table of three models:

	Name	Description	Status	Creation time
<input type="radio"/>	Sample-Prevent-zig-zag	Model trained with reward function that penalizes the agent for steering too much	Ready	Tue, 17 Sep 2019 02:24:34 GMT
<input type="radio"/>	Sample-Stay-on-track	Model trained with reward function that incentivizes the agent to stay inside the track borders	Ready	Tue, 17 Sep 2019 02:23:58 GMT
<input type="radio"/>	Sample-Follow-center-line	Model trained with reward function that incentivizes the agent to follow the center line	Ready	Tue, 17 Sep 2019 02:23:09 GMT

Create resources

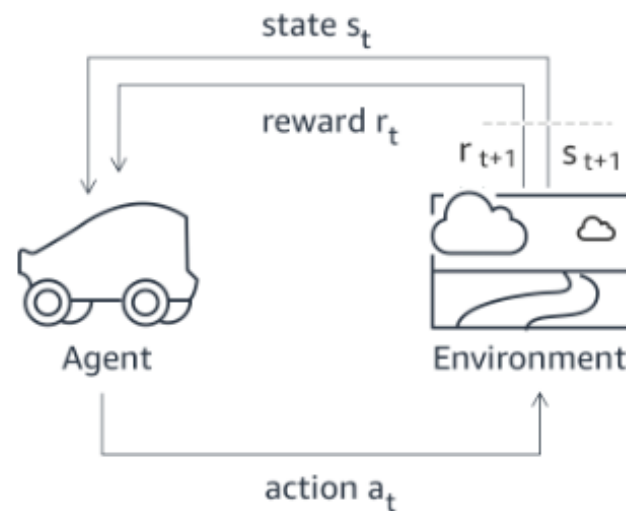
Create model

Overview [Info](#)

In reinforcement learning for AWS DeepRacer, an **agent** (vehicle) learns from an **environment** (a track) by interacting with it and receiving rewards for performing specific actions.

The model training process will simulate multiple experiences of the vehicle on the track in an attempt to find a **policy** (a function mapping the agent's current state to a driving decision) which maximizes the average total reward the agent experiences.

After training, you will be able to evaluate the model's performance in a new environment, deploy the model to a physical vehicle, or submit the model to a virtual circuit.



Account resources [Info](#)

To get you set up AWS DeepRacer needs to create account resources so that you can train and evaluate the models you build. Setting up account resources will not incur any charges on your account.

- IAM roles
- AWS DeepRacer resources stack

Create resources

AWS DeepRacer resources stackの生成には5分ほどかかります

Account resources [Info](#)

20191128- deepracer- workshop など

To get you set up AWS DeepRacer needs to create account resources so that you can train and evaluate the models you build. Setting up account resources will not incur any charges on your account.

- ✔ You have valid IAM roles
- ✔ You have a valid AWS DeepRacer resources stack

Having issues? Try resetting the resources created by AWS DeepRacer to start again from a clean slate. [Info](#)

[Reset resources](#)

Model details

Model name

The model name must be unique and can have up to 64 characters. Valid characters are a-z, A-Z, 0-9, and - (hyphen). No spaces or underscores.

Model description - *optional*

The model description can have up to 255 characters.

Environment simulation [Info](#)

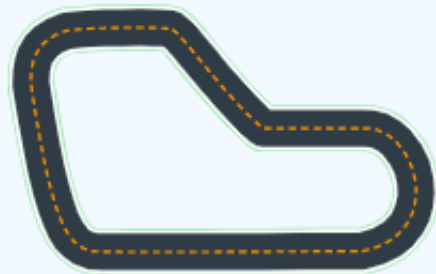
re:Invent 2018

Simulated environment emulates a track to train your model.

Choose an option

 re:Invent 2018

The official 2019 DeepRacer League Summit Circuit track. Train your model on the re:Invent 2018 track if you want to race in the Summit Circuit at one of the selected AWS Summit events.

 Cumulo Carrera Training

Train your model on this track to prepare for the Cumulo Carrera, the fifth race in the Virtual Circuit World Tour, happening throughout September 2019.

 Shanghai Sudu Training

Train your model on this track to prepare for the Shanghai Sudu race, the fourth race in the Virtual Circuit World Tour, happening throughout August 2019.

 Empire City Training

Train your model on this track to prepare for the Empire City

 Kumo Torakku Training

Train your model on this track to prepare for the Kumo

 London Loop Training

Train your model on this track to prepare for the London

Action space の設定

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

▾

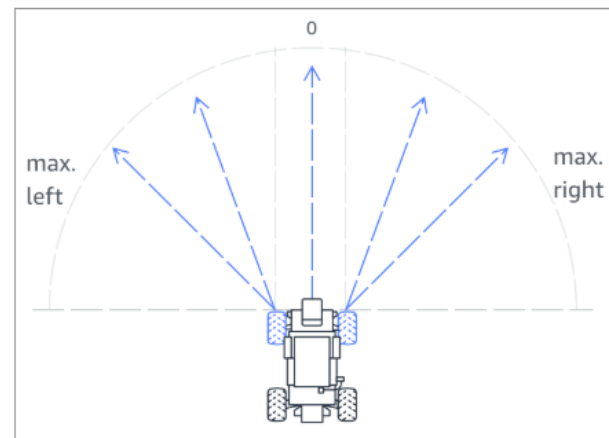
Maximum speed

m/s

Max values are between 0.8 and 8.

Speed granularity

▾



Action list

Action number	Steering	Speed
0	-30 degrees	0.5 m/s
1	-30 degrees	1 m/s
2	-15 degrees	0.5 m/s
3	-15 degrees	1 m/s
4	0 degrees	0.5 m/s
5	0 degrees	1 m/s
6	15 degrees	0.5 m/s
7	15 degrees	1 m/s
8	30 degrees	0.5 m/s
9	30 degrees	1 m/s

- Steering angle granularity

- Speed granularity

を増やすと、Action list の数が増え、より細かな車の制御が可能になる一方、学習に時間がかかるようになります。

続きはこちらで！

<http://bit.ly/dr-ja>

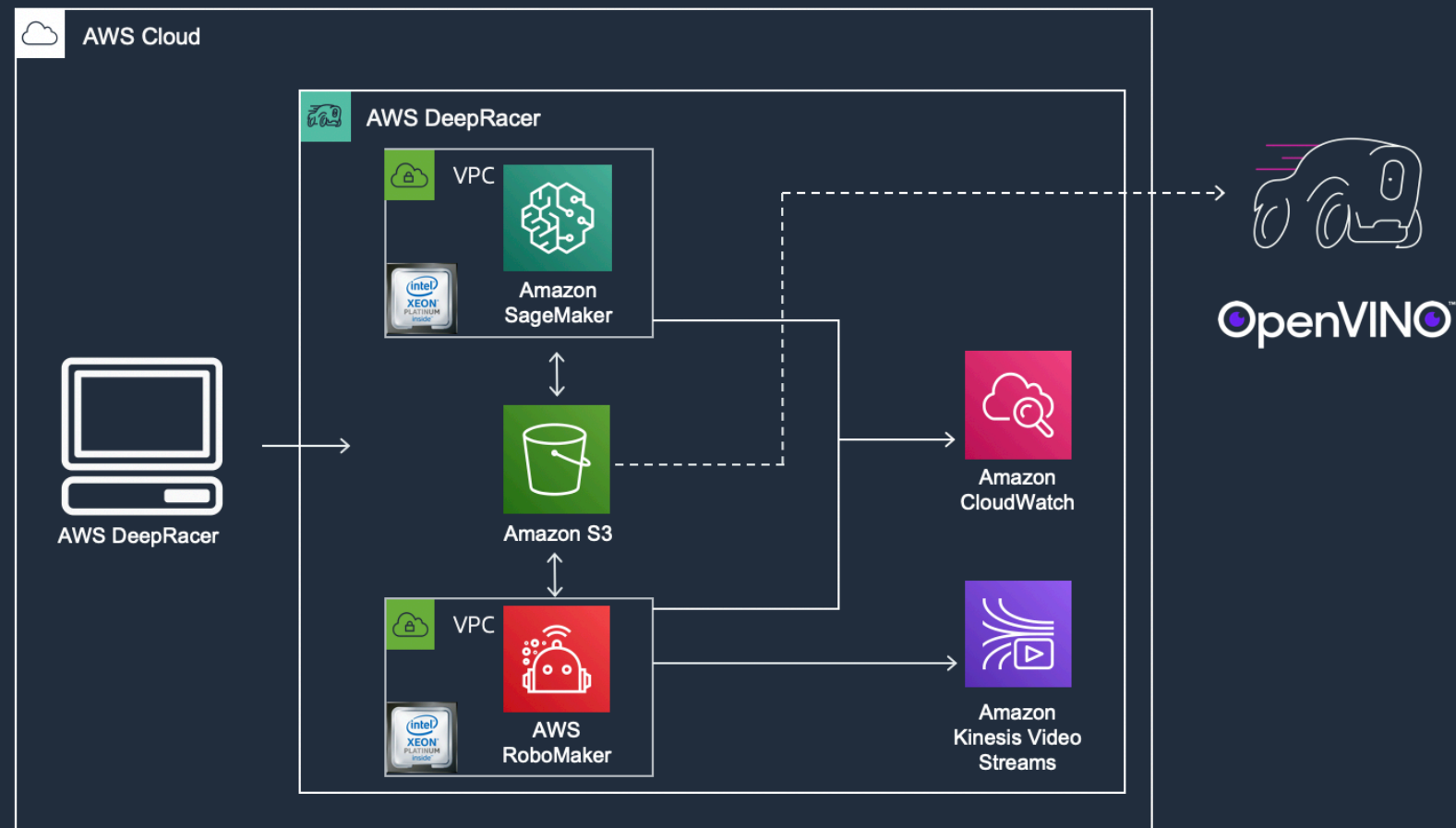
使わない際はリソースを適宜削除し、
不要な課金を防いで利用しましょう

AWS DeepRacer のリソースの削除

注) 2019年10月時点の仕様ですので、
今後変更の可能性があります

不要な課金を防ぐために

- VPC内の学習・シミュレーションに SageMaker, RoboMaker、描画、学習データの保存・データ転送に S3, Kinesis Video Stream, Data Transfer に課金が発生します。ここからは、ご利用後のリソース削除方法を紹介します。



ご利用後のリソース削除方法

- DeepRacer → Reinforcement learning → Create model を選択
- Account resources で、2つのリソースの左チェック印が**緑色**の場合、関連リソースが利用可能な状態となっています。
- 不要な課金を防ぐためには、**Reset resource** をクリックすれば、S3以外の関連リソースは削除されます。

AWS DeepRacer ×

Reinforcement learning

DeepRacer Virtual Circuit

▼ Resources

- Get started with reinforcement learning
- DeepRacer League [↗](#)
- League standings [↗](#)
- Documentation [↗](#)
- Forum [↗](#)

Create model

Overview [Info](#)

In reinforcement learning for AWS DeepRacer, an **agent** (vehicle) learns from an **environment** (a track) by interacting with it and receiving rewards for performing specific actions.

The model training process will simulate multiple experiences of the vehicle on the track in an attempt to find a **policy** (a function mapping the agent's current state to a driving decision) which maximizes the average total reward the agent experiences.

After training, you will be able to evaluate the model's performance in a new environment, deploy the model to a physical vehicle, or submit the model to a virtual circuit.

Account resources [Info](#)

To get you set up AWS DeepRacer needs to create account resources so that you can train and evaluate the models you build. Setting up account resources will not incur any charges on your account.

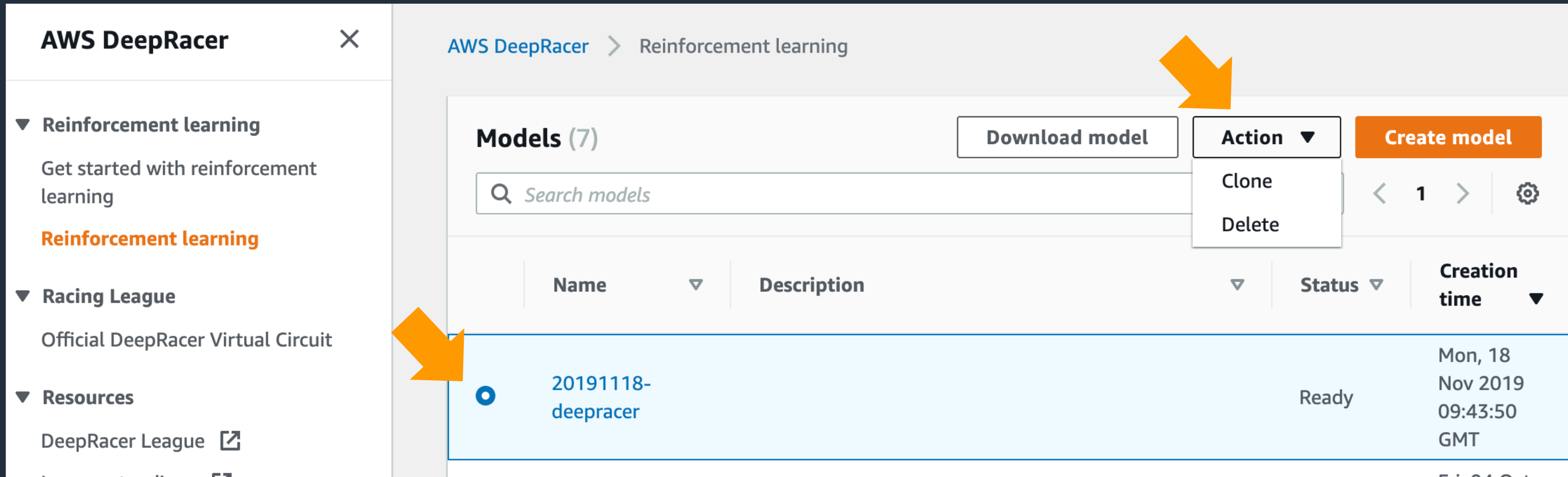
- You have valid IAM roles
- You have a valid AWS DeepRacer resources stack

Having issues? Try resetting the resources created by AWS DeepRacer to start again from a clean slate. [Info](#)

Reset resources

54 DeepRacer モデルの削除

- 削除したいモデルを選択し、Action → Delete を選択



The screenshot shows the AWS DeepRacer console interface. On the left is a navigation sidebar with 'Reinforcement learning' selected. The main content area shows the 'Models (7)' section with a search bar and a table of models. One model, '20191118-deepracer', is selected. An orange arrow points to the 'Action' dropdown menu, which is open and shows 'Delete' as an option. Another orange arrow points to the selected model row.

AWS DeepRacer ×

AWS DeepRacer > Reinforcement learning

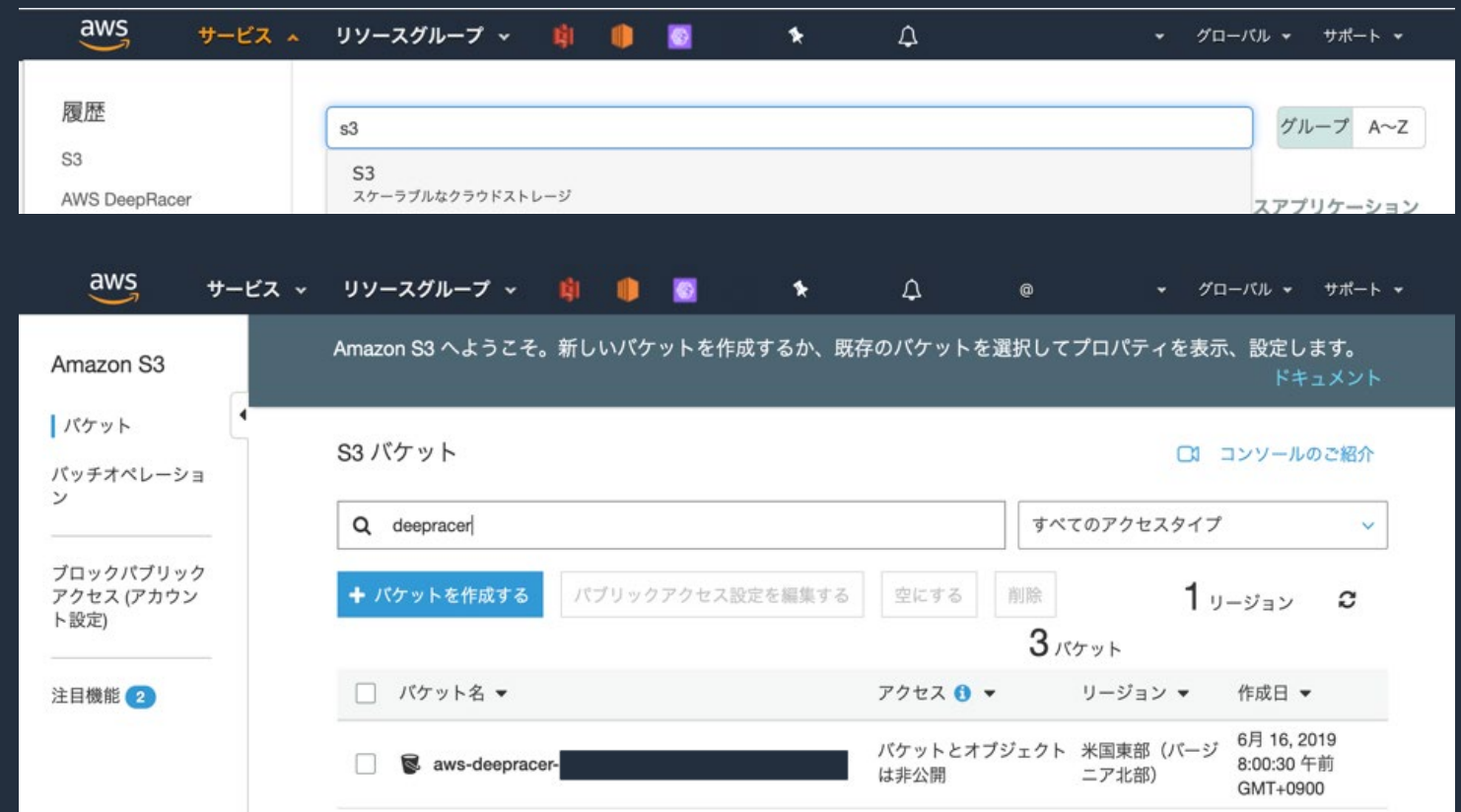
Models (7) Download model Action ▼ Create model

Search models

Name	Description	Status	Creation time
20191118-deepracer		Ready	Mon, 18 Nov 2019 09:43:50 GMT

S3 バケットの削除

- S3 バケットを削除すると、**これまで学習したモデルが復元できなくなる**ので、**ご注意ください**。S3は他のサービスに比べ安価（[料金表](#)）なので、DeepRacer を完全に使わなくなった際にこちらを実行することをお勧めします。
- サービス一覧から S3 を選択
- S3 バケット一覧で、“deepracer”と入力し、モデル作成時に自動的に作られた S3 バケットを検索
- 削除すると S3 への課金は防げますが、モデルの再構築はできなくなるのでご注意ください



ご利用後状況を確認するには



- アカウント情報をプルダウンし、マイ請求ダッシュボードから、ご利用状況を確認いただけます。左のメニュー項目の Billing → 請求書 で月ごとの詳細を見ることができます。

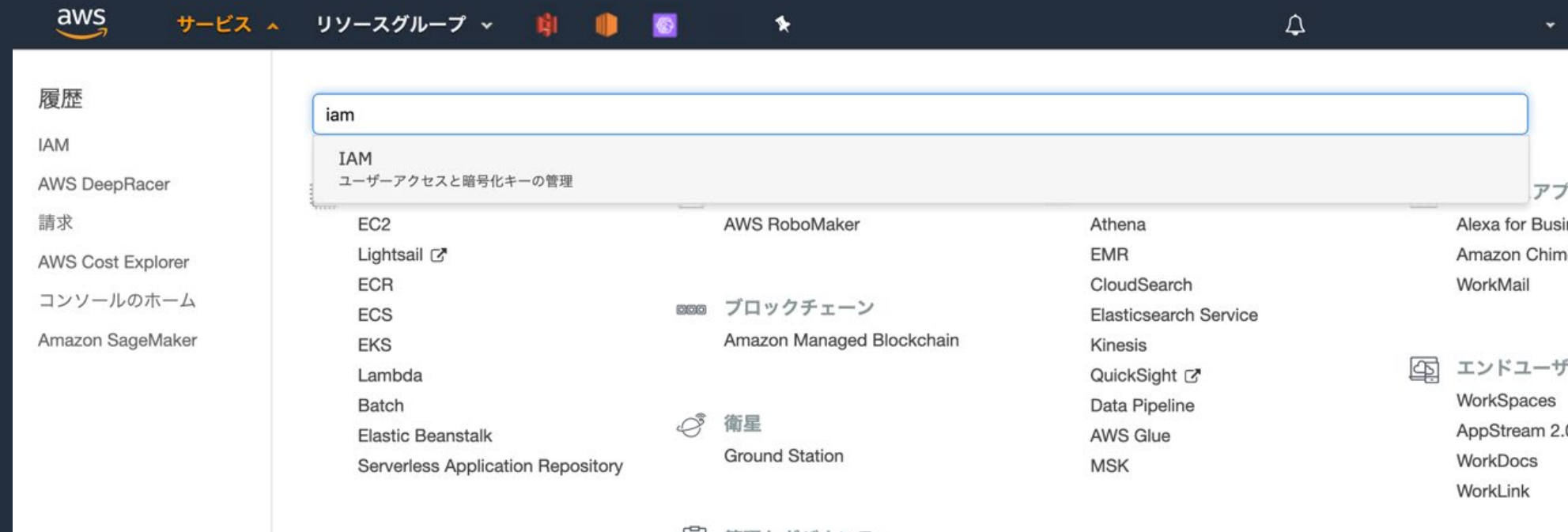
「請求書」から月ごとの概算合計が確認できます

The screenshot shows the AWS Billing console interface. The main content area displays the bill for June 2019. The total estimated amount is \$227.99. The bill is broken down into various AWS services, with several items highlighted in orange:

サービス	金額
AWS Service Charges	\$227.99
CloudTrail	\$0.00
CloudWatch	\$0.00
Data Transfer	\$22.15
Elastic Compute Cloud	\$114.21
GuardDuty	\$0.00
Key Management Service	\$0.00
Kinesis Video Streams	\$0.16
Lambda	\$0.00
RoboMaker	\$78.71
SageMaker	\$12.22
Simple Notification Service	\$0.00
Simple Queue Service	\$0.00
Simple Storage Service	\$0.54

- VPC内部の学習・シミュレーションに SageMaker, RoboMaker、描画・学習データの保存・データ転送に S3, Kinesis Video Stream, Data Transfer に課金が発生します。
- reset resource をこまめに実行することで、EC2への課金比率は抑えることができます。

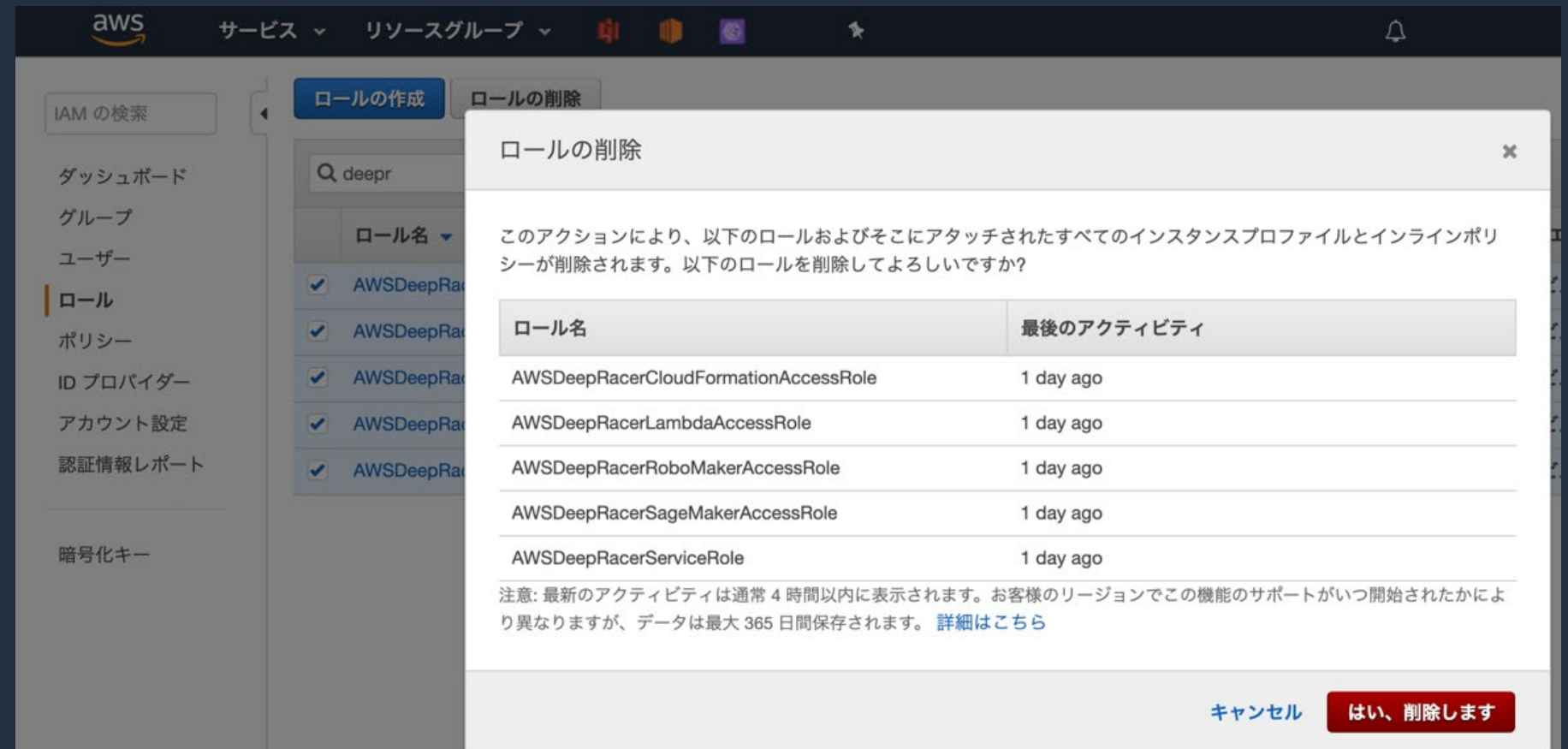
ご利用を再開される際の注意



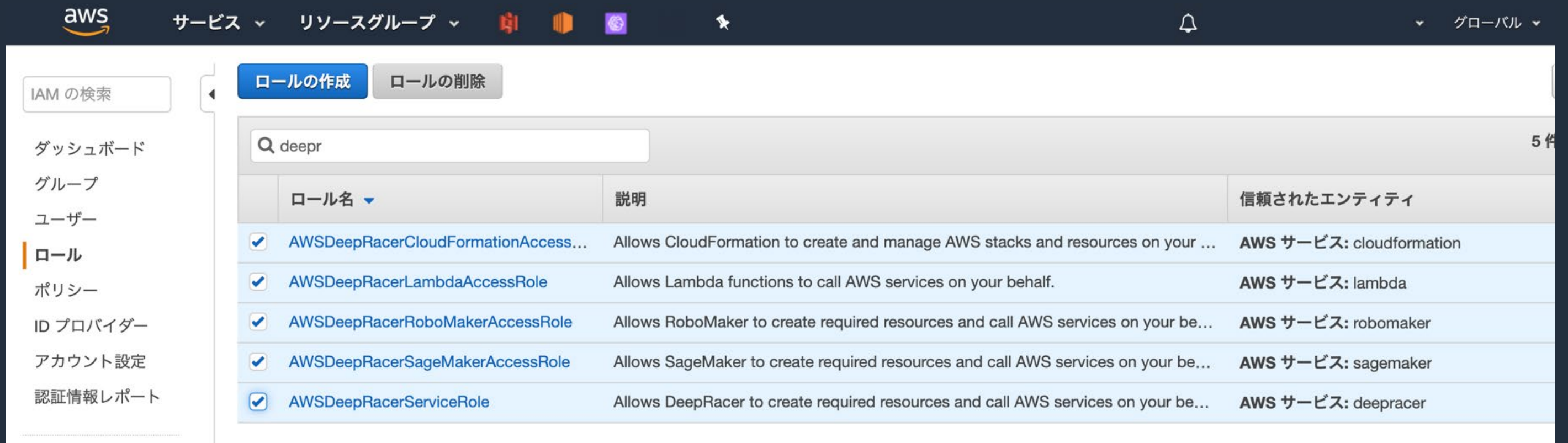
- DeepRacer の開始時、すでに DeepRacer の IAM リソースが作られている場合はエラーが発生することがあります。
- その際は、Create Resource で作成した IAM role を削除する必要があります。
- サービス一覧から IAM を選択し、左のバーからIAM ロールを選択してください。

IAM role から DeepRacer 関連のロールを削除

- DeepRacer関連のロールを削除してください。
- 参考) DeepRacer では、これらの IAM ロールが使われています。
 - Cloudformation
 - Lambda
 - RoboMaker
 - SageMaker
 - DeepRacer



DeepRacer 関連の IAM ロールを検索



The screenshot shows the AWS IAM console interface. At the top, there's a navigation bar with the AWS logo, 'サービス' (Services), 'リソースグループ' (Resource Groups), and a 'グローバル' (Global) dropdown. Below this, there are two buttons: 'ロールの作成' (Create Role) and 'ロールの削除' (Delete Role). A search bar contains the text 'deepr'. Below the search bar is a table with 5 items, each with a checked checkbox in the first column. The table columns are 'ロール名' (Role Name), '説明' (Description), and '信頼されたエンティティ' (Trusted Entity).

ロール名	説明	信頼されたエンティティ
<input checked="" type="checkbox"/> AWSDeepRacerCloudFormationAccess...	Allows CloudFormation to create and manage AWS stacks and resources on your ...	AWS サービス: cloudformation
<input checked="" type="checkbox"/> AWSDeepRacerLambdaAccessRole	Allows Lambda functions to call AWS services on your behalf.	AWS サービス: lambda
<input checked="" type="checkbox"/> AWSDeepRacerRoboMakerAccessRole	Allows RoboMaker to create required resources and call AWS services on your be...	AWS サービス: robomaker
<input checked="" type="checkbox"/> AWSDeepRacerSageMakerAccessRole	Allows SageMaker to create required resources and call AWS services on your be...	AWS サービス: sagemaker
<input checked="" type="checkbox"/> AWSDeepRacerServiceRole	Allows DeepRacer to create required resources and call AWS services on your be...	AWS サービス: deepracer

- DeepRacer 関連 IAM ロールを検索 (“deepracer” と入力)
- 該当する 5 つのロールを選択し、「ロールの削除」をクリック

Create model

Overview [Info](#)

In reinforcement learning for AWS DeepRacer, an **agent** (vehicle) learns from an **environment** (a track) by interacting with it and receiving rewards for performing specific actions.

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- IAM roles
- AWS DeepRacer resources stack

[Create resources](#)

Create resourceを実行することで、再度モデル作成が可能になります。

AWS RoboMaker : <https://aws.amazon.com/jp/robomaker/pricing/>

AWS SageMaker : <https://aws.amazon.com/jp/sagemaker/pricing/>

Amazon EC2 : <https://aws.amazon.com/jp/ec2/pricing/>

Amazon Kinesis Video Streams :
<https://aws.amazon.com/jp/kinesis/video-streams/pricing/>

Amazon S3: <https://aws.amazon.com/jp/s3/pricing/>

[Webinar] Amazon SageMaker 体験ハンズオン

Amazon SageMaker は、データサイエンティストやエンジニアが効率よく機械学習を進めるために、AWS が提供するマネージドサービスです。本セミナーでは、Amazon SageMaker の機械学習ハンズオンを Webinar で体験していただきます。

2019 年 11 月 28 日 (木) 14:00 - 15:30 13:45~14:45

https://pages.awscloud.com/HandsOn-ML-20191128.html?trk=event_webinar_page

第10回 Amazon SageMaker 事例祭り

2019年 11月 28日 (木) 13:45 -17:45 @アマゾン目黒オフィス

13:45~14:45

AWSの機械学習サービス概要とAmazon SageMakerの基礎

14:45~15:15

Amazon SageMaker の Built-in-Algorithm と
AWS Marketplace for Machine Learning

15:45~17:00 お客様事例

– 株式会社シナモン 斎藤 哲也 様

– 株式会社ミクシィ 本間 光宣 様

Thank you!

Mari Ohbuchi