Deep Dive into OpNav through Image Segmentation & Object Tracking

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Introduction

- OpNav – NASA's emergency return system, uses image-based data to achieve navigation goals for The Orion Spacecraft.
- Reinforcement Learning makes it more convenient to achieve these kinds of goals are for agent's learning abilities.
- Image segmentation and tracking is necessary for learning efficiently. Convolutional Neural Network is fed with such image-based data.

Objective

- To train a model for Image Segmentation and Image Tracking.

Materials and Methods

Research
- How Image Segmentation and Object Tracking can be leveraged for OpNav.

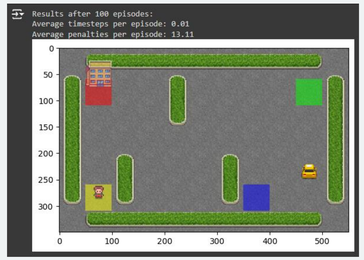
Gym AI
- Helps understand RL, its functions, and the reward system.

Libraries/Datasets
- Finding libraries and datasets that fit our need is essential.
- Datasets processed by CNN.

Coral AI
- Reinforcement Learning, Convolutional Neural Networks, Image-based datasets.
- Edge TPU.

Google Colab and Gym AI
- The Gym Environments.
- Exploration, Exploitation and Q-function.

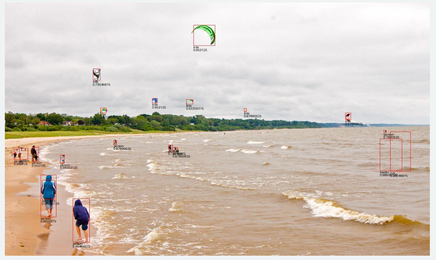
```
#variables
alpha = 0.1
gamma = 0.6
epsilon = 0.1

#empty lists for steps and penalties
all_epochs = []
all_penalties = []


for i in range(1, 100001):
  state = env.reset()
  epochs, penalties, reward = 0, 1, 0
  done = False

  while not done:
    #exploration
    if random.uniform(0, 1) < epsilon: #the chosen random val < 0.1
      action = env.action_space.sample()
    #exploitation
    else:
      action = np.argmax(q_table[state]) # to choose the action with the highest expected reward in the current state

    next_state, reward, done, info = env.step(action)
    old_value = q_table[state, action]
    next_max = np.max(q_table[next_state])
    #update and algorithm
    new_value = (1 - alpha) * old_value + alpha * (reward + gamma * next_max)
    q_table[state, action] = new_value
```



The 'Taxi' Environment
- Random start-off point.
- 4 drop-off points.
- Passenger drop-off at desired location gains maximum reward.

Results

Image-based datasets
- Various libraries with huge amounts of datasets - huge in size.
- Audi, ApolloScape, Neptune, Cityscapes, NVIDIA.
- Vision-based Autonomous Navigation – less datasets to start off on a smaller scale.



Small Object Detection

Coral's Edge TPU Accelerator
- The Pycoral Library.
- Few different kinds of image segmentation and recognition examples.
- The Edge TPU Setup.
- Running test datasets and different images.

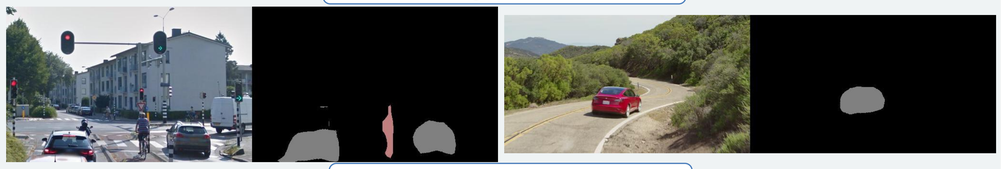


Image segmentation

The Taxi Environment
- Timesteps and penalties.
- Training and learning for the agent.
- Results and penalties per episodes.

```
Timesteps taken: 149
Penalties incurred: 45
Timesteps taken: 150
Penalties incurred: 45
Timesteps taken: 151
Penalties incurred: 45
Timesteps taken: 152
Penalties incurred: 45
Timesteps taken: 153
Penalties incurred: 45
Timesteps taken: 154
Penalties incurred: 45
Timesteps taken: 155
Penalties incurred: 46
Timesteps taken: 156
Penalties incurred: 46
Timesteps taken: 157
Penalties incurred: 47
Timesteps taken: 158
Penalties incurred: 47
Timesteps taken: 159
Penalties incurred: 47
Timesteps taken: 160
Penalties incurred: 47
```

Discussion and Conclusions

```
Episode: 100000
Training finished.

CPU times: user 1min 34s, sys: 7.73 s, total: 1min 42s
Wall time: 1min 42s
```

```
Results after 100 episodes:
Average timesteps per episode: 0.01
Average penalties per episode: 12.89
```

Edge TPU test-data
- Coral AI test-datasets were found the best to start with.
- Image-based data for autonomous driving.
- Images of low quality – less accurate results.

Difference between test data and online low-quality images

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