

# Semantic Segmentation using AWS Sagemaker

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- Semantic segmentation is a deep learning method that classifies pixels within an image as the foreground, the background, or the boundary. This is useful within different sectors, such as in autonomous self-driving cars, medical image analysis, or filters for social media and photography applications.
- The pet images and annotation datasets were retrieved from:  
<https://www.robots.ox.ac.uk/~vgg/data/pets/>
- In this project, I finetuned Sagemaker's semantic-segmentation pretrained model to outline the boundary of each pet

## Download the Data

```
!pip3 install tqdm
!pip3 install pillow --upgrade

Requirement already satisfied: tqdm in
/home/ec2-user/anaconda3/envs/python3/lib/python3.10/site-packages
(4.66.5)
Requirement already satisfied: pillow in
/home/ec2-user/anaconda3/envs/python3/lib/python3.10/site-packages
(11.0.0)

%matplotlib inline

import os
import io
import tarfile
import urllib
import shutil
import json
import random
import numpy as np
import boto3
import sagemaker

from tqdm import tqdm
from sagemaker.amazon.amazon_estimator import get_image_uri
from matplotlib import pyplot as plt
from xml.etree import ElementTree as ET
from PIL import Image, ImageDraw, ImageFont

urls =
['http://www.robots.ox.ac.uk/~vgg/data/pets/data/images.tar.gz',
```

```

'http://www.robots.ox.ac.uk/~vgg/data/pets/data/annotations.tar.gz']

def download_and_extract(data_dir, download_dir):
    for url in urls:
        target_file = url.split('/')[-1]
        if target_file not in os.listdir(download_dir):
            print('Downloading', url)
            urllib.request.urlretrieve(url, os.path.join(download_dir,
target_file))
            tf = tarfile.open(url.split('/')[-1])
            tf.extractall(data_dir)
        else:
            print('Already downloaded', url)

if not os.path.isdir('data'):
    os.mkdir('data')

download_and_extract('data', '.')

Already downloaded
http://www.robots.ox.ac.uk/~vgg/data/pets/data/images.tar.gz
Already downloaded
http://www.robots.ox.ac.uk/~vgg/data/pets/data/annotations.tar.gz

```

## Visualize Data

```

trimaps_dir = 'data/annotations/trimaps/'

maps = [x for x in os.listdir(trimaps_dir) if x[-3:] == 'png']
print(len(maps))

14780

image_dir = 'data/images/'

images = [x for x in os.listdir(image_dir) if x[-3:] == 'jpg']
print(len(images))

7390

plt.figure(figsize=(12, 12))

for i in range(0, 4):
    index = random.randint(0, len(images) - 1)
    image_name = images[index]
    map_name = images[index].split('.')[0] + '.png'

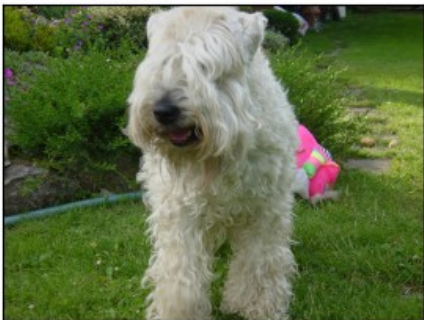
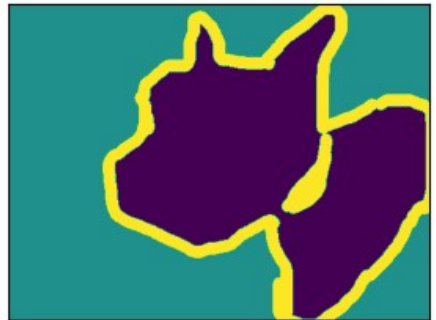
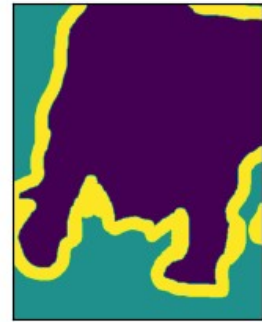
    # showing the pet

```

```
plt.subplot(4, 2, 1 + i*2)
plt.xticks([])
plt.yticks([])
plt.imshow(plt.imread(os.path.join(image_dir, image_name)))

# showing the segmented borders of the pet
plt.subplot(4, 2, 2 + i*2)
plt.xticks([])
plt.yticks([])
plt.imshow(plt.imread(os.path.join(trimaps_dir, map_name)))

plt.show()
```



```
# there are only three unique values within the trimaps
img = Image.open(os.path.join(trimaps_dir, maps[0]))
print(np.unique(img))

[1 2 3]
```

# SageMaker Setup

```
# retrieve ECR image URIs for pre-built SageMaker Docker images

role = sagemaker.get_execution_role()
bucket_name = "petsdata"
training_img = get_image_uri(boto3.Session().region_name, "semantic-
segmentation", repo_version="latest")
print(training_img)

WARNING:sagemaker.deprecations:The method get_image_uri has been
renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
INFO:sagemaker.image_uris:Same images used for training and inference.
Defaulting to image scope: inference.
WARNING:sagemaker.image_uris:Defaulting to the only supported
framework/algorithm version: 1. Ignoring framework/algorithm version:
latest.
INFO:sagemaker.image_uris:Ignoring unnecessary instance type: None.

469771592824.dkr.ecr.ca-central-1.amazonaws.com/semantic-
segmentation:1

folders = ['train', 'train_annotation', 'validation',
'validation_annotation']

for folder in folders:
    if os.path.isdir(folder):
        shutil.rmtree(folder)
    os.mkdir(folder)
```

## Preparing Data for SageMaker

```
def get_map_file(image):
    map_file = image.split('.')[0] + '.png'
    assert map_file in maps
    return map_file

for image in tqdm(images[:500]):
    # 70% for training, 30% for testing
    target_set = 'train' if random.randint(0, 99) < 70 else
'validation'

    image_file_path = os.path.join('data/images/', image)
    image_target_path = os.path.join(target_set, image)

    map_file_path = os.path.join(trimaps_dir, get_map_file(image))
    map_target_path = os.path.join(target_set + '_annotation',
```

```

get_map_file(image))

    shutil.copy(image_file_path, image_target_path)
    shutil.copy(map_file_path, map_target_path)

100%|██████████| 500/500 [00:00<00:00, 2815.56it/s]

# Ensuring that the training images and annotations, as well as the
validation images and annotations
# are equal

train_images = os.listdir('train')
train_annots = os.listdir('train_annotation')

print(len(train_annots), len(train_images))

352 352

validation_images = os.listdir('validation')
validation_annots = os.listdir('validation_annotation')

print(len(validation_annots), len(validation_images))

148 148

```

## Uploading Data to S3

```

sesh = sagemaker.Session()
print("Starting Upload (Training Images)")
s3_train_path = sesh.upload_data(path="train", bucket="petsdata3",
key_prefix="train")

Starting Upload (Training Images)

print("Starting Upload (Training Annotation)")
s3_train_annotation_path = sesh.upload_data(path="train_annotation",
bucket="petsdata3", key_prefix="train_annotation")

Starting Upload (Training Annotation)

print("Starting Upload (Validation Images)")
s3_validation_path = sesh.upload_data(path="validation",
bucket="petsdata3", key_prefix="validation")

Starting Upload (Validation Images)

print("Starting Upload (Validation Annotation)")
s3_validation_annotation_path =
sesh.upload_data(path="validation_annotation", bucket="petsdata3",
key_prefix="validation_annotation")

```

Starting Upload (Validation Annotation)

## SageMaker Estimator

```
model = sagemaker.estimator.Estimator(  
    training_img,  
    role=role,  
    train_instance_count = 1,  
    train_instance_type = "ml.g4dn.2xlarge",  
    train_volume = 5,  
    train_max_run = 6000,  
    input_mode = "File",  
    output_model = "s3://petsdata3/output",  
    sagemaker_session = sesh  
)
```

WARNING:sagemaker.deprecations:train\_instance\_count has been renamed in sagemaker>=2.

See: <https://sagemaker.readthedocs.io/en/stable/v2.html> for details.

WARNING:sagemaker.deprecations:train\_instance\_type has been renamed in sagemaker>=2.

See: <https://sagemaker.readthedocs.io/en/stable/v2.html> for details.

WARNING:sagemaker.deprecations:train\_max\_run has been renamed in sagemaker>=2.

See: <https://sagemaker.readthedocs.io/en/stable/v2.html> for details.

## Hyperparameters

```
model.set_hyperparameters(  
    backbone="resnet-50",  
    algorithm="fcf",  
    use_pretrained_model=True,  
    crop_size=240,  
    num_classes=4,  
    epochs=10,  
    learning_rate=0.0001,  
    optimizer="rmsprop",  
    lr_scheduler="poly",  
    mini_batch_size=16,  
    validation_mini_batch_size=16,  
    num_training_samples = len(train_images)  
)
```

# Data Channels

```
train_data = sagemaker.session.s3_input(s3_train_path,
distribution="FullyReplicated", content_type="image/jpeg",
s3_data_type="S3Prefix")
validation_data = sagemaker.session.s3_input(s3_validation_path,
distribution="FullyReplicated",
content_type="image/jpeg",
s3_data_type="S3Prefix")
train_annotation_data =
sagemaker.session.s3_input(s3_train_annotation_path,
distribution="FullyReplicated",
content_type="image/png", s3_data_type="S3Prefix")
validation_annotation_data =
sagemaker.session.s3_input(s3_validation_annotation_path,
distribution="FullyReplicated",
content_type="image/png", s3_data_type="S3Prefix")

WARNING:sagemaker.deprecations:The class sagemaker.session.s3_input
has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
WARNING:sagemaker.deprecations:The class sagemaker.session.s3_input
has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
WARNING:sagemaker.deprecations:The class sagemaker.session.s3_input
has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.
WARNING:sagemaker.deprecations:The class sagemaker.session.s3_input
has been renamed in sagemaker>=2.
See: https://sagemaker.readthedocs.io/en/stable/v2.html for details.

data_channel = {
    "train": train_data,
    "validation": validation_data,
    "train_annotation": train_annotation_data,
    "validation_annotation": validation_annotation_data
}

data_channel
{'train':
<sagemaker.deprecations.deprecated_class.<locals>.DeprecatedClass at
0x7f56ca473b80>,
'validation':
<sagemaker.deprecations.deprecated_class.<locals>.DeprecatedClass at
0x7f56e0200370>,
'train_annotation':
```



```
<sagemaker.deprecations.deprecated_class.<locals>.DeprecatedClass at
0x7f56cb889090>,
'validation_annotation':
<sagemaker.deprecations.deprecated_class.<locals>.DeprecatedClass at
0x7f56ca439e70>}
```

## Model Training

```
model.fit(inputs=data_channel, logs=True)
```

```
INFO:sagemaker:Creating training-job with name: semantic-segmentation-
2024-11-09-18-12-58-465
```

```
2024-11-09 18:13:02 Starting - Starting the training job...
```

```
2024-11-09 18:13:15 Starting - Preparing the instances for training...
```

```
2024-11-09 18:13:53 Downloading - Downloading the training
image.....
```

```
2024-11-09 18:16:19 Training - Training image download completed.
```

```
Training in progress....Docke entrypoint called with argument(s):
train
```

```
Running default environment configuration script
```

```
Nvidia gpu devices, drivers and cuda toolkit versions (only available
on hosts with GPU):
```

```
Sat Nov 9 18:16:49 2024
```

```
+-----+
+-----+
| NVIDIA-SMI 550.127.05                  Driver Version: 550.127.05
CUDA Version: 12.4                  |
|-----+-----+-----+-----+
+-----+
| GPU   Name                               Persistence-M | Bus-Id        Disp.A |
| Volatile Uncorr. ECC |
| Fan  Temp  Perf              Pwr:Usage/Cap |      Memory-Usage |
| GPU-Util  Compute M. |
|                               |                      |
MIG M. |
|
=====+=====
=====|
|  0  Tesla T4                               On  |  00000000:00:1E.0 Off |
0 |
| N/A    26C    P8              9W /   70W |      1MiB /  15360MiB |
0%      Default |
|                               |                      |
N/A |
+-----+-----+-----+-----+
+-----+
```

```

+-----+
-----+
| Processes:
|
| GPU    GI    CI          PID    Type    Process name
GPU Memory |
|          ID    ID
Usage      |
|
=====
=====|
| No running processes found
|
+-----+
-----+
Checking for nvidia driver and cuda compatibility.
CUDA Compatibility driver provided.
Proceeding with compatibility check between driver, cuda-toolkit and
cuda-compat.
Detected cuda-toolkit version: 11.1.
Detected cuda-compat version: 455.32.00.
Detected Nvidia driver version: 550.127.05.
Nvidia driver compatible with cuda-toolkit. Disabling cuda-compat.
Running custom environment configuration script
/opt/amazon/lib/python3.8/site-packages/mxnet/model.py:97:
SyntaxWarning: "is" with a literal. Did you mean "=="?
    if num_device is 1 and 'dist' not in kvstore:
/opt/amazon/lib/python3.8/site-packages/scipy/optimize/_shgo.py:495:
SyntaxWarning: "is" with a literal. Did you mean "=="?
    if cons['type'] is 'ineq':
/opt/amazon/lib/python3.8/site-packages/scipy/optimize/_shgo.py:743:
SyntaxWarning: "is not" with a literal. Did you mean "!="?
    if len(self.X_min) is not 0:
[11/09/2024 18:16:52 INFO 139667529578304] Reading default
configuration from
/opt/amazon/lib/python3.8/site-packages/algorithm/default-input.json:
{'backbone': 'resnet-50', 'algorithm': 'fcf', 'use_pretrained_model':
'True', 'crop_size': '240', 'epochs': '10', 'learning_rate': '0.001',
'optimizer': 'sgd', 'lr_scheduler': 'poly', 'lr_scheduler_factor':
'0.1', 'weight_decay': '0.0001', 'momentum': '0.9', 'gamma1': '0.9',
'gamma2': '0.9', 'mini_batch_size': '16',
'validation_mini_batch_size': '16', 'num_training_samples': '8',
'early_stopping_min_epochs': '5', 'early_stopping': 'False',
'early_stopping_patience': '4', 'early_stopping_tolerance': '0.0',
'precision_dtype': 'float32', '_kvstore': 'device', '_num_kv_servers':
'auto', 'syncbn': 'False', '_workers': '16', '_aux_loss': 'True',
'_aux_weight': '0.5', '_hybrid': 'False', '_augmentation_type':
'default', '_logging_frequency': '20'}

```

```
[11/09/2024 18:16:52 INFO 139667529578304] Merging with provided
configuration from /opt/ml/input/config/hyperparameters.json:
{'algorithm': 'fcn', 'backbone': 'resnet-50', 'crop_size': '240',
'epochs': '10', 'learning_rate': '0.0001', 'lr_scheduler': 'poly',
'mini_batch_size': '16', 'num_classes': '4', 'num_training_samples':
'352', 'optimizer': 'rmsprop', 'use_pretrained_model': 'True',
'validation_mini_batch_size': '16'}
[11/09/2024 18:16:52 INFO 139667529578304] Final configuration:
{'backbone': 'resnet-50', 'algorithm': 'fcn', 'use_pretrained_model':
'True', 'crop_size': '240', 'epochs': '10', 'learning_rate': '0.0001',
'optimizer': 'rmsprop', 'lr_scheduler': 'poly', 'lr_scheduler_factor':
'0.1', 'weight_decay': '0.0001', 'momentum': '0.9', 'gamma1': '0.9',
'gamma2': '0.9', 'mini_batch_size': '16',
'validation_mini_batch_size': '16', 'num_training_samples': '352',
'early_stopping_min_epochs': '5', 'early_stopping': 'False',
'early_stopping_patience': '4', 'early_stopping_tolerance': '0.0',
'precision_dtype': 'float32', '_kvstore': 'device', '_num_kv_servers':
'auto', 'syncbn': 'False', '_workers': '16', '_aux_loss': 'True',
'_aux_weight': '0.5', '_hybrid': 'False', '_augmentation_type':
'default', '_logging_frequency': '20', 'num_classes': '4'}
Process 13 is a worker.
[11/09/2024 18:16:52 INFO 139667529578304] Using default worker.
[11/09/2024 18:16:52 INFO 139667529578304] Loaded iterator creator
application/json for content type ('application/json', '1.0')
/opt/amazon/lib/python3.8/site-packages/matplotlib/pyplot.py:2422:
SyntaxWarning: "is" with a literal. Did you mean "=="?
    if fignum is False or fignum is 0:
/opt/amazon/lib/python3.8/site-packages/matplotlib/contour.py:871:
SyntaxWarning: "is not" with a literal. Did you mean "!="?
    if self.extend is not 'neither':
[11/09/2024 18:16:53 INFO 139667529578304] font search path
['/opt/amazon/lib/python3.8/site-packages/matplotlib/mpl-data/fonts/
ttf',
'/opt/amazon/lib/python3.8/site-packages/matplotlib/mpl-data/fonts/
afm',
'/opt/amazon/lib/python3.8/site-packages/matplotlib/mpl-data/fonts/
pdfcorefonts']
[11/09/2024 18:16:53 INFO 139667529578304] generated new fontManager
/opt/amazon/lib/python3.8/site-packages/scipy/io/netcdf.py:770:
SyntaxWarning: "is not" with a literal. Did you mean "!="?
    if typecode is not 'c':
[11/09/2024 18:16:53 INFO 139667529578304] Loaded iterator creator
application/x-image for content type ('application/x-image', '1.0')
[11/09/2024 18:16:53 INFO 139667529578304] Loaded iterator creator
application/x-recordio for content type ('application/x-recordio',
'1.0')
[11/09/2024 18:16:53 INFO 139667529578304] Loaded iterator creator
image/jpeg for content type ('image/jpeg', '1.0')
[11/09/2024 18:16:53 INFO 139667529578304] Loaded iterator creator
```

```
image/png for content type ('image/png', '1.0')
[11/09/2024 18:16:53 INFO 139667529578304] Checkpoint loading and
saving are disabled.
[11/09/2024 18:16:53 WARNING 139667529578304]
/opt/ml/input/data/train/train_annotation is not a readable image file
[11/09/2024 18:16:54 WARNING 139667529578304] label maps not provided,
using defaults.
[11/09/2024 18:16:54 INFO 139667529578304] #label_map train :{'scale':
1}
[11/09/2024 18:16:54 WARNING 139667529578304]
/opt/ml/input/data/validation/validation_annotation is not a readable
image file
[11/09/2024 18:16:54 WARNING 139667529578304] label maps not provided,
using defaults.
[11/09/2024 18:16:54 INFO 139667529578304] #label_map validation :
{'scale': 1}
/opt/amazon/python3.8/lib/python3.8/subprocess.py:848: RuntimeWarning:
line buffering (buffering=1) isn't supported in binary mode, the
default buffer size will be used
  self.stdout = io.open(c2pread, 'rb', bufsize)
[11/09/2024 18:16:54 INFO 139667529578304] nvidia-smi: took 0.056
seconds to run.
[11/09/2024 18:16:54 INFO 139667529578304] nvidia-smi identified 1
GPUs.
[11/09/2024 18:16:54 INFO 139667529578304] Number of GPUs being used:
1
[11/09/2024 18:16:54 INFO 139667529578304] Number of GPUs being used:
1
[11/09/2024 18:16:54 INFO 139667529578304] Number of GPUs being used:
1
[18:16:55]
/opt/brazil-pkg-cache/packages/AIAlgorithmsMXNet/AIAlgorithmsMXNet-
1.4.x_ecl_Cuda_11.1.x.441.0/AL2_x86_64/generic-flavor/src/src/
storage/storage.cc:108: Using GPUPooledRoundedStorageManager.
[11/09/2024 18:16:58 INFO 139667529578304] LRScheduler setup: iters
per epoch: 22, num_epochs 10
#metrics {"StartTime": 1731176218.3022597, "EndTime":
1731176218.3023772, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "Meta":
"init_train_data_iter"}, "Metrics": {"Total Records Seen": {"sum":
0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen": {"sum":
0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen Between
Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Batches
Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0},
"Reset Count": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Number
of Records Since Last Reset": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Number of Batches Since Last Reset": {"sum": 0.0, "count":
1, "min": 0, "max": 0}}
[11/09/2024 18:17:16 INFO 139667529578304] #progress_notice. epoch: 0,
```

iterations: 20 speed: 18.938330435577686 samples/sec learning\_rate: 0.000092  
[11/09/2024 18:17:25 INFO 139667529578304] #quality\_metric. host: algo-1, epoch: 0, train loss: 0.9638704180717468 .  
[11/09/2024 18:17:25 INFO 139667529578304] #throughput\_metric. host: algo-1, epoch: 0, train throughput: 18.298149494349303 samples/sec.  
[11/09/2024 18:17:32 INFO 139667529578304] #progress\_notice. epoch: 0, iterations: 20 speed: 51.68247279134745 samples/sec  
[11/09/2024 18:17:33 INFO 139667529578304] #quality\_metric. host: algo-1, epoch: 0, validation pixel\_accuracy: 0.7821400734230324 .  
[11/09/2024 18:17:33 INFO 139667529578304] #quality\_metric. host: algo-1, epoch: 0, validation mIOU: 0.43388424344473275 .  
[11/09/2024 18:17:33 INFO 139667529578304] #throughput\_metric. host: algo-1, epoch: 0, validation throughput: 51.267564628181155 samples/sec.  
[11/09/2024 18:17:33 INFO 139667529578304] Serializing model to /opt/ml/model/model\_best.params  
[11/09/2024 18:17:33 INFO 139667529578304] Serializing model to /opt/ml/model/model\_best.params  
[11/09/2024 18:17:33 INFO 139667529578304] #progress\_metric: host=algo-1, completed 10.0 % of epochs  
#metrics {"StartTime": 1731176218.3029313, "EndTime": 1731176253.9484415, "Dimensions": {"Algorithm": "AWS/Semantic Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 0, "Meta": "training\_data\_iter"}, "Metrics": {"Total Records Seen": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Reset Count": {"sum": 1.0, "count": 1, "min": 1, "max": 1}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum": 0.0, "count": 1, "min": 0, "max": 0}}}  
[11/09/2024 18:17:52 INFO 139667529578304] #progress\_notice. epoch: 1, iterations: 20 speed: 18.79109526134933 samples/sec learning\_rate: 0.000079  
[11/09/2024 18:18:01 INFO 139667529578304] #quality\_metric. host: algo-1, epoch: 1, train loss: 0.6736758082143722 .  
[11/09/2024 18:18:01 INFO 139667529578304] #throughput\_metric. host: algo-1, epoch: 1, train throughput: 18.751189733424326 samples/sec.  
[11/09/2024 18:18:08 INFO 139667529578304] #progress\_notice. epoch: 1, iterations: 20 speed: 51.46570773639847 samples/sec  
[11/09/2024 18:18:09 INFO 139667529578304] #quality\_metric. host: algo-1, epoch: 1, validation pixel\_accuracy: 0.8167285608362268 .  
[11/09/2024 18:18:09 INFO 139667529578304] #quality\_metric. host: algo-1, epoch: 1, validation mIOU: 0.4327853645987014 .  
[11/09/2024 18:18:09 INFO 139667529578304] #throughput\_metric. host: algo-1, epoch: 1, validation throughput: 51.4338266866831 samples/sec.  
[11/09/2024 18:18:09 INFO 139667529578304] #progress\_metric:

```
host=algo-1, completed 20.0 % of epochs
#metrics {"StartTime": 1731176253.9485793, "EndTime":
1731176289.5926898, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 1,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 2.0, "count": 1, "min": 2, "max":
2}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}
[11/09/2024 18:18:27 INFO 139667529578304] #progress_notice. epoch: 2,
iterations: 20 speed: 18.673978701675985 samples/sec learning_rate:
0.000066
[11/09/2024 18:18:36 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 2, train loss: 0.5572530454204928 .
[11/09/2024 18:18:36 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 2, train throughput: 18.636683590444868 samples/sec.
[11/09/2024 18:18:43 INFO 139667529578304] #progress_notice. epoch: 2,
iterations: 20 speed: 52.10562301475458 samples/sec
[11/09/2024 18:18:44 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 2, validation pixel accuracy: 0.8480364312065972 .
[11/09/2024 18:18:44 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 2, validation mIOU: 0.48994947179616605 .
[11/09/2024 18:18:44 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 2, validation throughput: 50.2354142147881 samples/sec.
[11/09/2024 18:18:44 INFO 139667529578304] Serializing model to
/opt/ml/model/model_best.params
[11/09/2024 18:18:45 INFO 139667529578304] #progress_metric:
host=algo-1, completed 30.0 % of epochs
#metrics {"StartTime": 1731176289.5928328, "EndTime":
1731176325.195197, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 2,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 3.0, "count": 1, "min": 3, "max":
3}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}
[11/09/2024 18:19:03 INFO 139667529578304] #progress_notice. epoch: 3,
iterations: 20 speed: 18.608336820202602 samples/sec learning_rate:
0.000052
[11/09/2024 18:19:12 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 3, train loss: 0.5377723718843153 .
```

```
[11/09/2024 18:19:12 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 3, train throughput: 18.59801490335535 samples/sec.
[11/09/2024 18:19:19 INFO 139667529578304] #progress_notice. epoch: 3,
iterations: 20 speed: 51.29478452156925 samples/sec
[11/09/2024 18:19:20 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 3, validation pixel_accuracy: 0.8602699110243055 .
[11/09/2024 18:19:20 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 3, validation mIOU: 0.5059277844934635 .
[11/09/2024 18:19:20 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 3, validation throughput: 50.018376654714444
samples/sec.
[11/09/2024 18:19:20 INFO 139667529578304] Serializing model to
/opt/ml/model/model_best.params
[11/09/2024 18:19:21 INFO 139667529578304] #progress_metric:
host=algo-1, completed 40.0 % of epochs
#metrics {"StartTime": 1731176325.1953485, "EndTime":
1731176361.0580134, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 3,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 4.0, "count": 1, "min": 4, "max":
4}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}
[11/09/2024 18:19:39 INFO 139667529578304] #progress_notice. epoch: 4,
iterations: 20 speed: 18.750332208648267 samples/sec learning_rate:
0.000039
[11/09/2024 18:19:48 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 4, train loss: 0.5009170876395318 .
[11/09/2024 18:19:48 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 4, train throughput: 18.54697129119777 samples/sec.
[11/09/2024 18:19:55 INFO 139667529578304] #progress_notice. epoch: 4,
iterations: 20 speed: 51.93135442453189 samples/sec
[11/09/2024 18:19:56 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 4, validation pixel_accuracy: 0.8690660264756944 .
[11/09/2024 18:19:56 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 4, validation mIOU: 0.5165404462009718 .
[11/09/2024 18:19:56 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 4, validation throughput: 50.53802000468915
samples/sec.
[11/09/2024 18:19:56 INFO 139667529578304] Serializing model to
/opt/ml/model/model_best.params
[11/09/2024 18:19:56 INFO 139667529578304] #progress_metric:
host=algo-1, completed 50.0 % of epochs
#metrics {"StartTime": 1731176361.0581667, "EndTime":
1731176396.8658202, "Dimensions": {"Algorithm": "AWS/Semantic
```

```
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 4,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 5.0, "count": 1, "min": 5, "max":
5}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}}
[11/09/2024 18:20:14 INFO 139667529578304] #progress_notice. epoch: 5,
iterations: 20 speed: 18.721338027835035 samples/sec learning_rate:
0.000024
[11/09/2024 18:20:24 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 5, train loss: 0.483743114817527 .
[11/09/2024 18:20:24 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 5, train throughput: 18.473315122044436 samples/sec.
[11/09/2024 18:20:31 INFO 139667529578304] #progress_notice. epoch: 5,
iterations: 20 speed: 51.52881700548851 samples/sec
[11/09/2024 18:20:32 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 5, validation pixel_accuracy: 0.8723816822193287 .
[11/09/2024 18:20:32 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 5, validation mIOU: 0.5253126861609658 .
[11/09/2024 18:20:32 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 5, validation throughput: 50.73769383600489
samples/sec.
[11/09/2024 18:20:32 INFO 139667529578304] Serializing model to
/opt/ml/model/model_best.params
[11/09/2024 18:20:32 INFO 139667529578304] #progress_metric:
host=algo-1, completed 60.0 % of epochs
#metrics {"StartTime": 1731176396.8659532, "EndTime":
1731176432.6926446, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 5,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 6.0, "count": 1, "min": 6, "max":
6}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}}
[11/09/2024 18:20:50 INFO 139667529578304] #progress_notice. epoch: 6,
iterations: 20 speed: 18.751029004932462 samples/sec learning_rate:
0.000008
[11/09/2024 18:21:00 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 6, train loss: 0.4880988530574306 .
[11/09/2024 18:21:00 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 6, train throughput: 18.582326083991614 samples/sec.
```



```
[11/09/2024 18:21:07 INFO 139667529578304] #progress_notice. epoch: 6,
iterations: 20 speed: 51.15347980657239 samples/sec
[11/09/2024 18:21:08 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 6, validation pixel_accuracy: 0.8727756076388888 .
[11/09/2024 18:21:08 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 6, validation mIOU: 0.5270124029232227 .
[11/09/2024 18:21:08 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 6, validation throughput: 50.19854029558871
samples/sec.
[11/09/2024 18:21:08 INFO 139667529578304] Serializing model to
/opt/ml/model/model_best.params
[11/09/2024 18:21:08 INFO 139667529578304] #progress_metric:
host=algo-1, completed 70.0 % of epochs
#metrics {"StartTime": 1731176432.6927645, "EndTime":
1731176468.5255795, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 6,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 7.0, "count": 1, "min": 7, "max":
7}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}}
[11/09/2024 18:21:26 INFO 139667529578304] #progress_notice. epoch: 7,
iterations: 20 speed: 18.840452829849667 samples/sec learning_rate:
0.000000
[11/09/2024 18:21:36 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 7, train loss: 0.46206546887274713 .
[11/09/2024 18:21:36 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 7, train throughput: 18.50358709689493 samples/sec.
[11/09/2024 18:21:42 INFO 139667529578304] #progress_notice. epoch: 7,
iterations: 20 speed: 51.70708224115587 samples/sec
[11/09/2024 18:21:44 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 7, validation pixel_accuracy: 0.8715498860677083 .
[11/09/2024 18:21:44 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 7, validation mIOU: 0.5262254036575584 .
[11/09/2024 18:21:44 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 7, validation throughput: 51.05261785553884
samples/sec.
[11/09/2024 18:21:44 INFO 139667529578304] #progress_metric:
host=algo-1, completed 80.0 % of epochs
#metrics {"StartTime": 1731176468.5257149, "EndTime":
1731176504.1426725, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 7,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
```

```
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 8.0, "count": 1, "min": 8, "max":
8}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}}]
[11/09/2024 18:22:02 INFO 139667529578304] #progress_notice. epoch: 8,
iterations: 20 speed: 18.62425301216522 samples/sec learning_rate:
0.000000
[11/09/2024 18:22:11 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 8, train loss: 0.45546001484317167 .
[11/09/2024 18:22:11 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 8, train throughput: 18.530177022697462 samples/sec.
[11/09/2024 18:22:18 INFO 139667529578304] #progress_notice. epoch: 8,
iterations: 20 speed: 51.5484887380277 samples/sec
[11/09/2024 18:22:19 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 8, validation pixel accuracy: 0.872724609375 .
[11/09/2024 18:22:19 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 8, validation mIOU: 0.5277577214850546 .
[11/09/2024 18:22:19 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 8, validation throughput: 50.72378566135644
samples/sec.
[11/09/2024 18:22:19 INFO 139667529578304] Serializing model to
/opt/ml/model/model_best.params
[11/09/2024 18:22:20 INFO 139667529578304] #progress_metric:
host=algo-1, completed 90.0 % of epochs
#metrics {"StartTime": 1731176504.1428125, "EndTime":
1731176540.0519412, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 8,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 9.0, "count": 1, "min": 9, "max":
9}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}}]
[11/09/2024 18:22:38 INFO 139667529578304] #progress_notice. epoch: 9,
iterations: 20 speed: 18.727931378313688 samples/sec learning_rate:
0.000000
[11/09/2024 18:22:47 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 9, train loss: 0.4857278341247189 .
[11/09/2024 18:22:47 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 9, train throughput: 18.536149328472984 samples/sec.

2024-11-09 18:23:03 Uploading - Uploading generated training
model[11/09/2024 18:22:54 INFO 139667529578304] #progress_notice.
epoch: 9, iterations: 20 speed: 51.32083136412788 samples/sec
```

```

[11/09/2024 18:22:55 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 9, validation pixel_accuracy: 0.8735495334201389 .
[11/09/2024 18:22:55 INFO 139667529578304] #quality_metric. host:
algo-1, epoch: 9, validation mIOU: 0.5264601580405788 .
[11/09/2024 18:22:55 INFO 139667529578304] #throughput_metric. host:
algo-1, epoch: 9, validation throughput: 50.863672477172635
samples/sec.
[11/09/2024 18:22:55 INFO 139667529578304] #progress_metric:
host=algo-1, completed 100.0 % of epochs
#metrics {"StartTime": 1731176540.052057, "EndTime":
1731176575.6292827, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training", "epoch": 9,
"Meta": "training_data_iter"}, "Metrics": {"Total Records Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Total Batches Seen":
{"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max Records Seen
Between Resets": {"sum": 0.0, "count": 1, "min": 0, "max": 0}, "Max
Batches Seen Between Resets": {"sum": 0.0, "count": 1, "min": 0,
"max": 0}, "Reset Count": {"sum": 10.0, "count": 1, "min": 10, "max":
10}, "Number of Records Since Last Reset": {"sum": 0.0, "count": 1,
"min": 0, "max": 0}, "Number of Batches Since Last Reset": {"sum":
0.0, "count": 1, "min": 0, "max": 0}}}
[11/09/2024 18:22:55 WARNING 139667529578304] wait_for_all_workers
will not sync workers since the kv store is not running distributed
[11/09/2024 18:22:55 INFO 139667529578304] Serializing model to
/opt/ml/model/model_algo-1
[11/09/2024 18:22:55 INFO 139667529578304] Test data is not provided.
#metrics {"StartTime": 1731176213.9035804, "EndTime":
1731176575.8569374, "Dimensions": {"Algorithm": "AWS/Semantic
Segmentation", "Host": "algo-1", "Operation": "training"}, "Metrics":
{"epochs": {"sum": 10.0, "count": 1, "min": 10, "max": 10},
"setuptime": {"sum": 10.637998580932617, "count": 1, "min":
10.637998580932617, "max": 10.637998580932617}, "totaltime": {"sum":
363002.09045410156, "count": 1, "min": 363002.09045410156, "max":
363002.09045410156}}}

2024-11-09 18:23:16 Completed - Training job completed
Training seconds: 579
Billable seconds: 579

```

## Deploy Model

```

deployed_model = model.deploy(initial_instance_count=1,
instance_type="ml.m4.xlarge")
print("Model is deployed")

INFO:sagemaker:Creating model with name: semantic-segmentation-2024-
11-09-18-23-59-996
INFO:sagemaker:Creating endpoint-config with name semantic-

```

```
segmentation-2024-11-09-18-23-59-996
INFO:sagemaker:Creating endpoint with name semantic-segmentation-2024-11-09-18-23-59-996
```

```
-----!Model is deployed
```

## Predictions

```
image_dir = 'validation'
images = [x for x in os.listdir(image_dir) if x[-3:] == 'jpg']
print(len(images))

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deployed_model.content_type = "image/jpeg"
deployed_model.accept = "image/png"

index = 4

image_path = os.path.join(image_dir, images[index])
# image_path = 'dog_cat.jfif'

with open(image_path, 'rb') as f:
    b = bytearray(f.read())

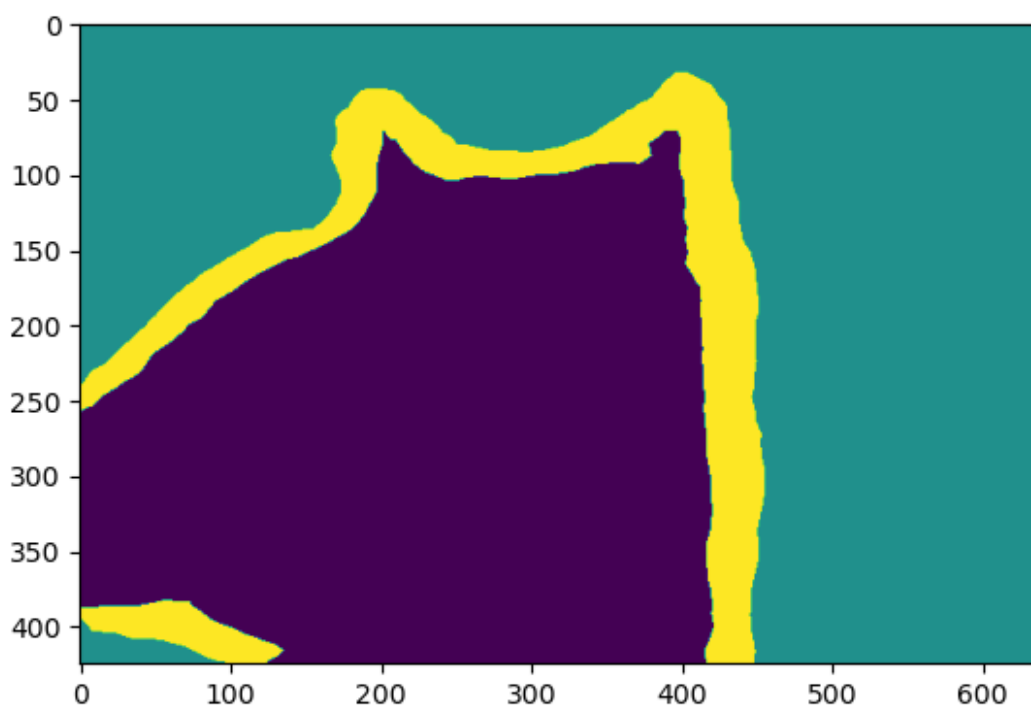
results = deployed_model.predict(b)

mask = np.array(Image.open(io.BytesIO(results)))

plt.imshow(plt.imread(image_path));
```



```
plt.imshow(mask);
```



```
sagemaker.Session().delete_endpoint(deployed_model.endpoint)
```