In [1]:
```
# Configure matplotlib.
%matplotlib inline
```

In [2]:
```
# Import our package.
import sys, importlib
sys.path.append("/home/ubuntu/cell_counting")

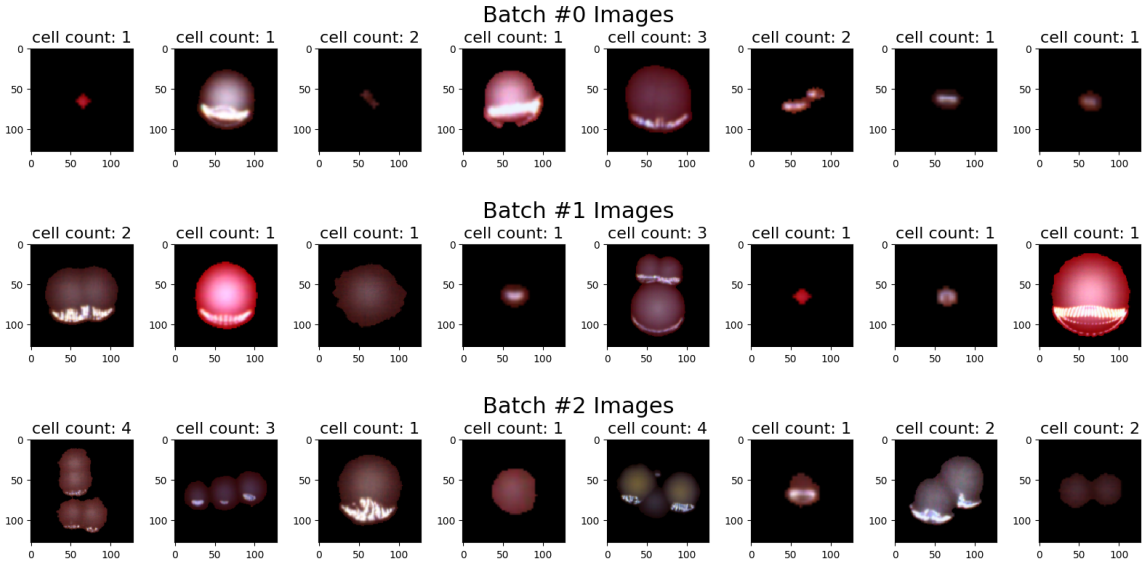
from src import dataset, visualization, preprocess, metric
from src.model import model
from src.model import neural_net
from src.model.segment_counting.convnet1 import convnet1
```

```
/home/ubuntu/anaconda3/envs/tensorflow_p36/lib/python3.6/importlib/_bootstrap.py
:219: RuntimeWarning: compiletime version 3.5 of module 'tensorflow.python.frame
work.fast_tensor_util' does not match runtime version 3.6
  return f(*args, **kwds)
```

In [ ]:
```
# (if changes are made) Re-import our package.
for module in (dataset, visualization, preprocess, metric, model, neural_net, conv
net1):
    importlib.reload(module)
```

In [3]:
```
# Load the microbia_segments dataset.
def image_path_getter(example_metadata):
    return "/home/ubuntu/cell_counting/data/microbia_segments/raw/" + example_meta
data["Segment Relative Path"]
def mask_path_getter(example_metadata):
    return "/home/ubuntu/cell_counting/data/microbia_segments/raw/" + example_meta
data["Binary Segment Relative Path"]
def label_getter(example_metadata):
    return example_metadata["data"]["segment_type"]["data"]
microbia_segments = dataset.Dataset(1000)
microbia_segments.load_images_masks_labels_from_json(
    "/home/ubuntu/cell_counting/data/microbia_segments/raw/enumeration_segments.js
on", image_path_getter,
    mask_path_getter, label_getter, (128, 128))
```

In [4]:
```
# Plot a few batches.
for batch in range(3):
    inputs, outputs = microbia_segments.get_batch(8)
    visualization.show_image_grid(inputs, 1, 8, 2.5, 16, "Batch #{0} Images".forma
t(batch),
        ["cell count: {0}".format(count + 1 if count != 7 else "<OUTLIER>") for co
unt in outputs])
```



In [5]:
```
# Make the labels one-hot.
def to_one_hot(examples):
    inputs, outputs = examples
    outputs = preprocess.one_hot_encode(outputs, 7)
    return inputs, outputs
microbia_segments.map_batch(to_one_hot)
```

In [6]:
```
# Split the dataset.
train, test = microbia_segments.split(0.1)
```

In [7]:
```
# Create the net.
import tensorflow as tf
net = convnet1.ConvNet1("saves/17-12-05-AM-08-14", 120)
```

```
INFO:tensorflow:Using config: {'_model_dir': 'saves/17-12-05-AM-08-14', '_tf_ran
dom_seed': None, '_save_summary_steps': 100, '_save_checkpoints_steps': None, '_
save_checkpoints_secs': 120, '_session_config': None, '_keep_checkpoint_max': 2,
'_keep_checkpoint_every_n_hours': 10000, '_log_step_count_steps': 100, '_service
': None, '_cluster_spec': <tensorflow.python.training.server_lib.ClusterSpec obj
ect at 0x7f83b688dc88>, '_task_type': 'worker', '_task_id': 0, '_master': '', '_
is_chief': True, '_num_ps_replicas': 0, '_num_worker_replicas': 1}
```

In [9]:
```
# Create some metrics.
train_data = train.get_batch(1000)
test_data = test.get_batch(1000)
def loss_fn(labels, predictions):
    with tf.Session() as sess:
        predictions = tf.add(predictions, tf.constant(1e-4))
        loss = tf.losses.softmax_cross_entropy(labels, predictions)
        loss = sess.run(loss)
    return loss
metrics = {
    "train_conf_mtx": metric.ConfusionMatrixMetric(train_data, 7),
    "test_conf_mtx": metric.ConfusionMatrixMetric(test_data, 7),
    "train_nx_conf_mtx": metric.NonexclusiveConfusionMatrixMetric(train_data, 7),
    "test_nx_conf_mtx": metric.NonexclusiveConfusionMatrixMetric(test_data, 7),
    "train_loss": metric.LossMetric(train_data, loss_fn),
    "test_loss": metric.LossMetric(test_data, loss_fn),
    "train_off_by_counts": metric.OffByCountMetric(train_data, 7),
    "test_off_by_counts": metric.OffByCountMetric(test_data, 7)
}
```

In [10]:
```
# Make a function for plotting the metrics.
def plot_metrics():
    train_conf_mtx = metrics["train_conf_mtx"].get_results()[1][-1]
    visualization.plot_confusion_matrix(train_conf_mtx, "Training Confusion Matrix
", 2.5, 2.5)

    test_conf_mtx = metrics["test_conf_mtx"].get_results()[1][-1]
    visualization.plot_confusion_matrix(test_conf_mtx, "Test Confusion Matrix", 2.
5, 2.5)

    train_nx_conf_mtx = metrics["train_nx_conf_mtx"].get_results()[1][-1]
    visualization.plot_confusion_matrix(train_nx_conf_mtx, "Nonexclusive Training
Confusion Matrix", 2.5, 2.5)

    test_nx_conf_mtx = metrics["test_nx_conf_mtx"].get_results()[1][-1]
    visualization.plot_confusion_matrix(test_nx_conf_mtx, "Nonexclusive Test Confu
sion Matrix", 2.5, 2.5)

    xs, ys = metrics["train_loss"].get_results()
    visualization.plot_line(xs, ys, "Training Loss", "training iterations", "cross
-entropy loss", 2.5, 12)

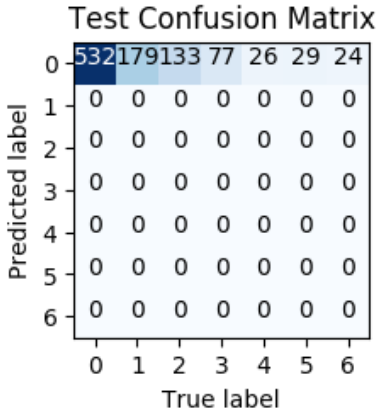
    xs, ys = metrics["test_loss"].get_results()
    visualization.plot_line(xs, ys, "Test Loss", "training iterations", "cross-ent
ropy loss", 2.5, 12)

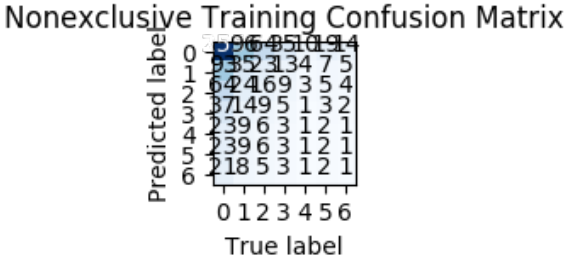
    xs, sets_of_ys = metrics["train_off_by_counts"].get_results()
    visualization.plot_lines(xs, sets_of_ys, "Training Off-By Counts", "training i
terations", "count of examples",
                             ["off by {0}".format(x) for x in range(-7, 7 + 1)], 2.
5, 12)

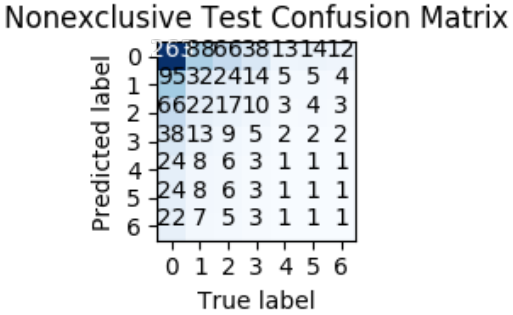
    xs, sets_of_ys = metrics["test_off_by_counts"].get_results()
    visualization.plot_lines(xs, sets_of_ys, "Test Off-By Counts", "training itera
tions", "count of examples",
                             ["off by {0}".format(x) for x in range(-7, 7 + 1)], 2.
5, 12)
```

In [11]:
```
# Alternately train and evaluate the net for 30 minutes.
for _ in range(30//3):
    net.train(train, 3*60)
    net.evaluate(metrics)
    plot_metrics()
```


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

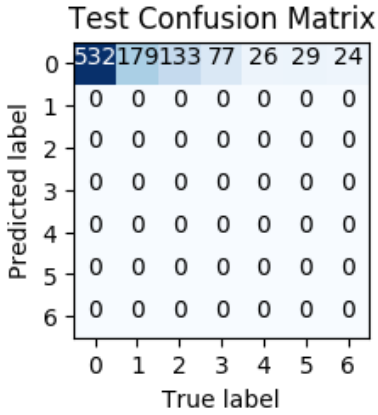

Training Loss
cross-entropy loss
11.2
11.0
10.8
10.6
10.4
10.2
285
290
295
300
305
310
315
training iterations

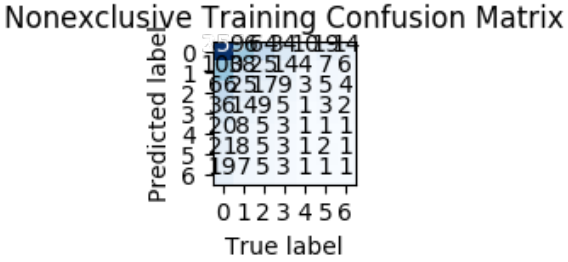

Test Loss
cross-entropy loss
11.2
11.0
10.8
10.6
10.4
10.2
285
290
295
300
305
310
315
training iterations

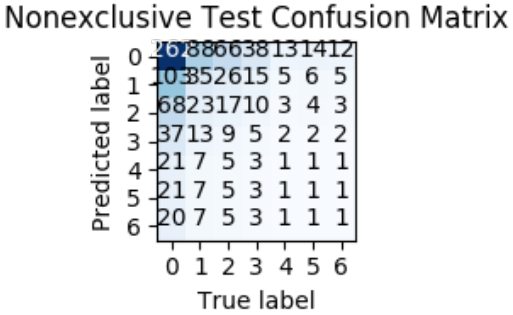

Training Off-By Counts
count of examples
500
400
300
200
100
0
285
290
295
300
305
310
315
training iterations

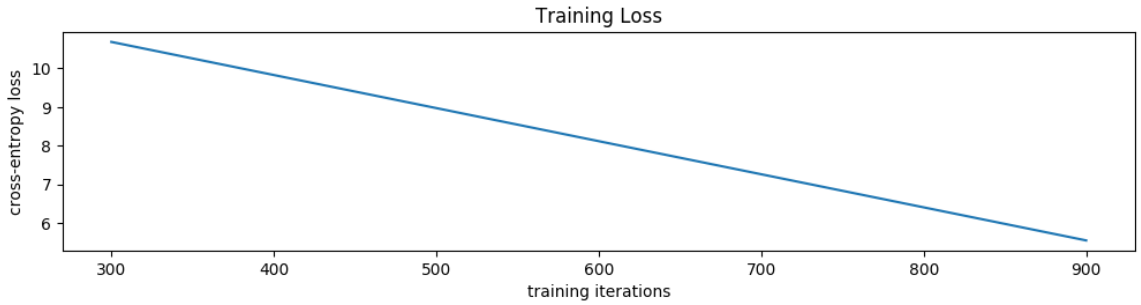

Test Off-By Counts
count of examples
500
400
300
200
100
0
285
290
295
300
305
310
315
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

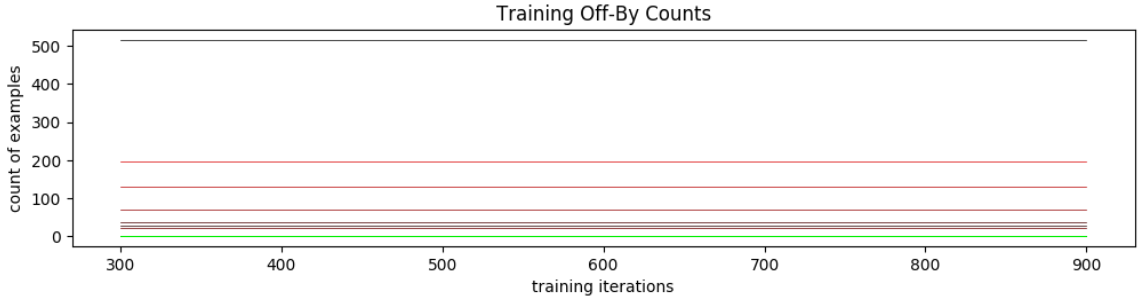

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

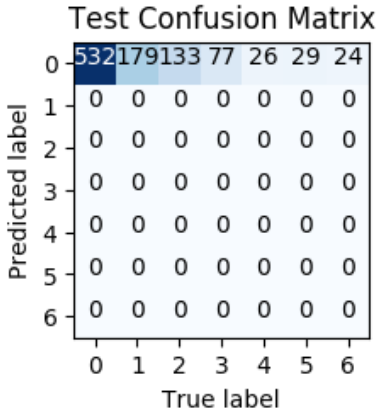

Training Loss
cross-entropy loss
10
9
8
7
6
300
400
500
600
700
800
900
training iterations

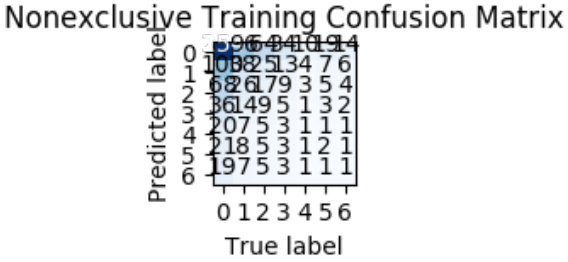

Test Loss
cross-entropy loss
10
9
8
7
6
300
400
500
600
700
800
900
training iterations

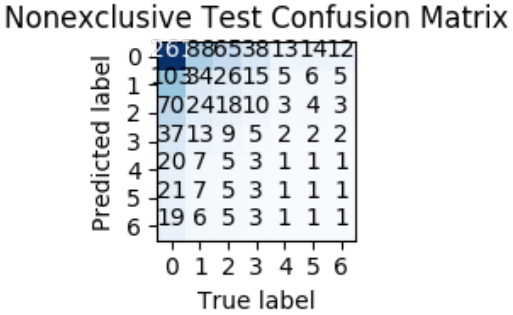

Training Off-By Counts
count of examples
500
400
300
200
100
0
300
400
500
600
700
800
900
training iterations

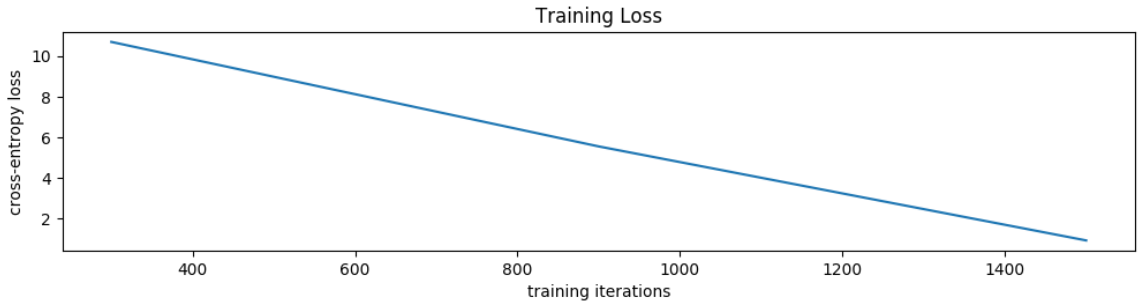

Test Off-By Counts
count of examples
500
400
300
200
100
0
300
400
500
600
700
800
900
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

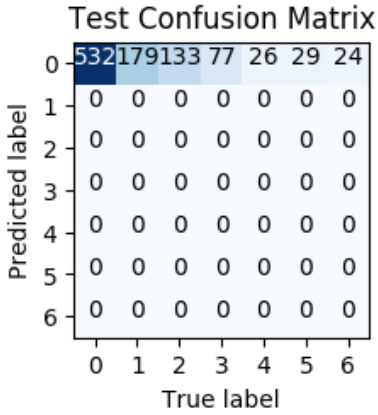

Training Loss
cross-entropy loss
training iterations

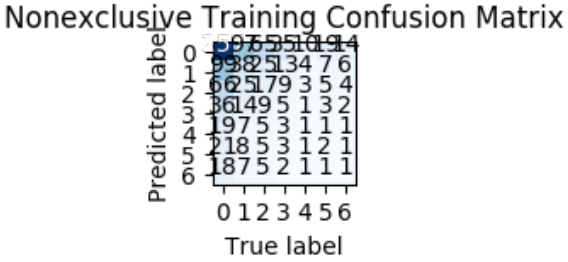

Test Loss
cross-entropy loss
training iterations

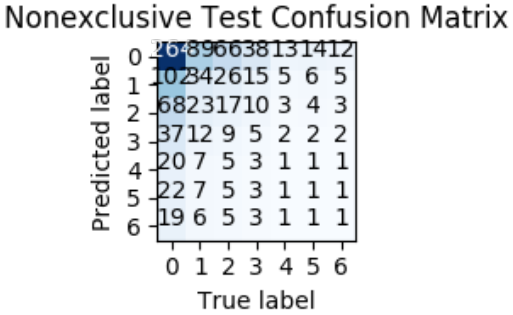

Training Off-By Counts
count of examples
training iterations

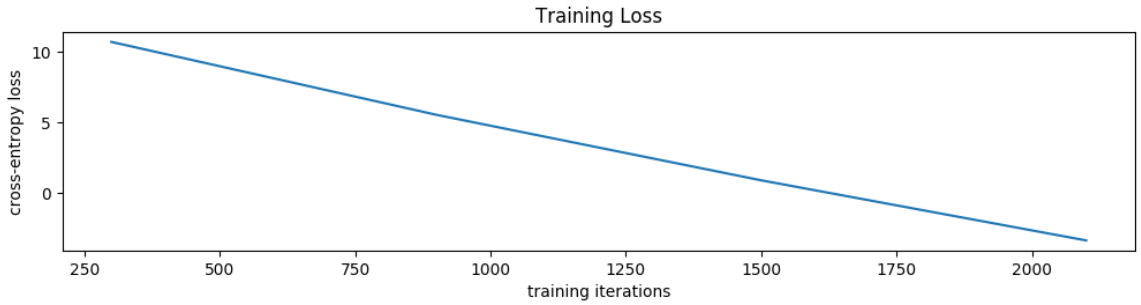

Test Off-By Counts
count of examples
training iterations

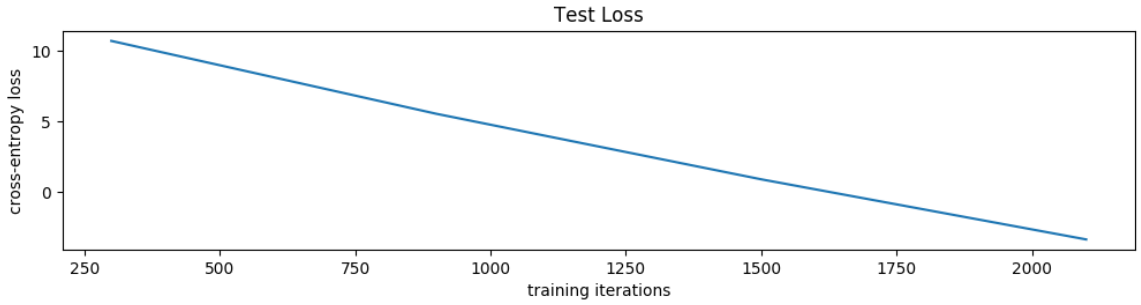

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

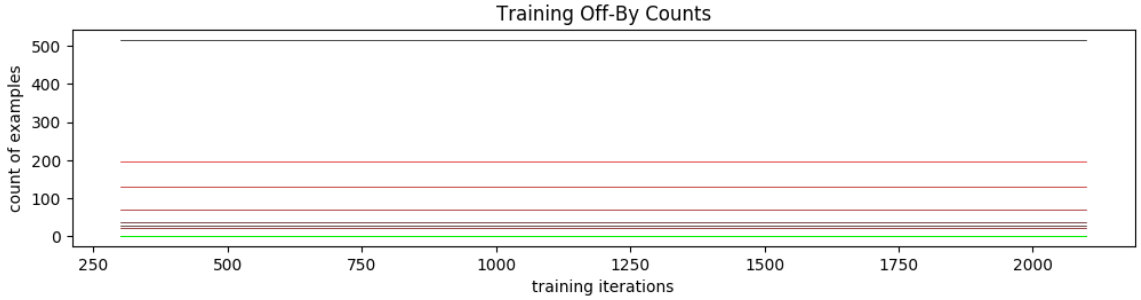

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

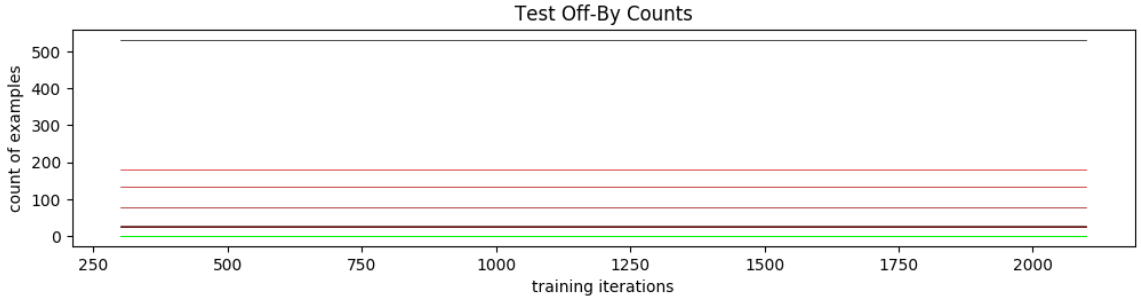

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

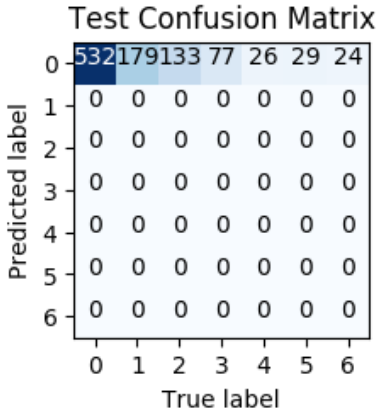

Training Loss
cross-entropy loss
10
5
0
250
500
750
1000
1250
1500
1750
2000
training iterations

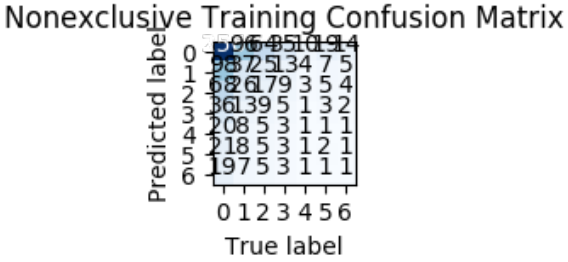

Test Loss
cross-entropy loss
10
5
0
250
500
750
1000
1250
1500
1750
2000
training iterations

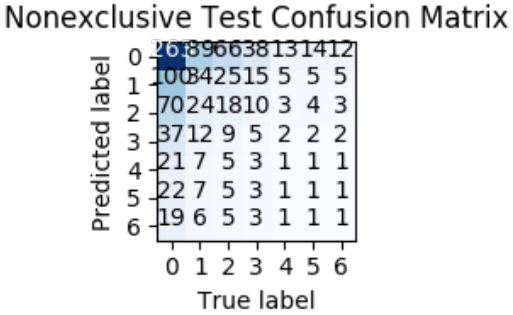

Training Off-By Counts
count of examples
500
400
300
200
100
0
250
500
750
1000
1250
1500
1750
2000
training iterations

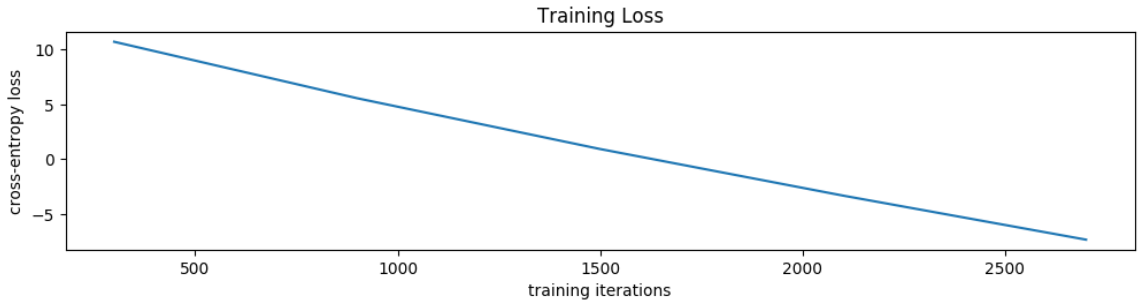

Test Off-By Counts
count of examples
500
400
300
200
100
0
250
500
750
1000
1250
1500
1750
2000
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

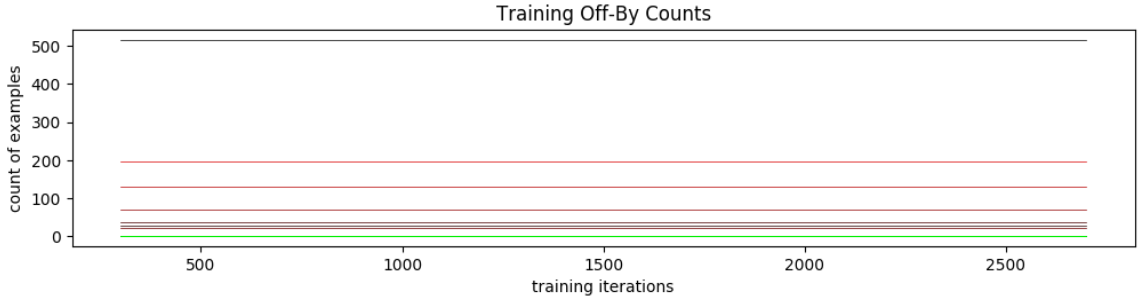

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

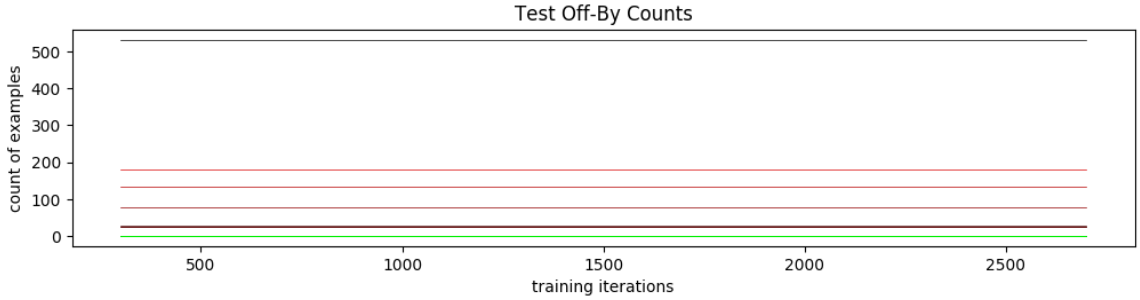

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

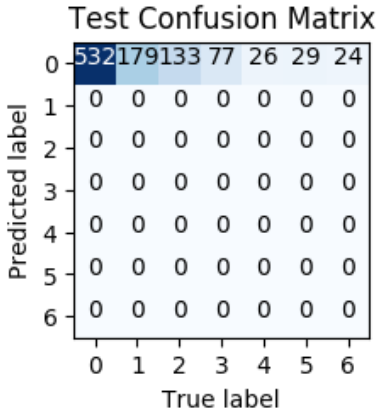

Training Loss
cross-entropy loss
10
5
0
−5
500
1000
1500
2000
2500
training iterations

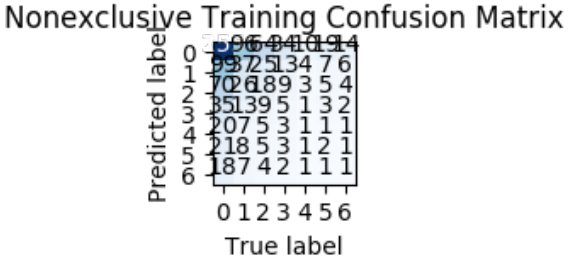

Test Loss
cross-entropy loss
10
5
0
−5
500
1000
1500
2000
2500
training iterations

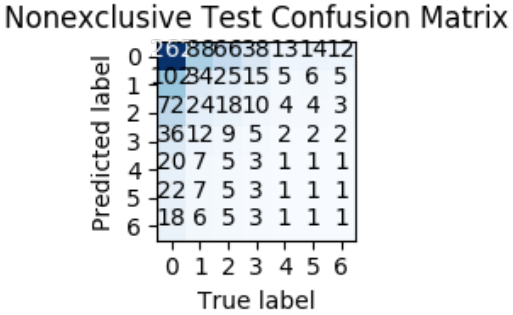

Training Off-By Counts
count of examples
500
400
300
200
100
0
500
1000
1500
2000
2500
training iterations

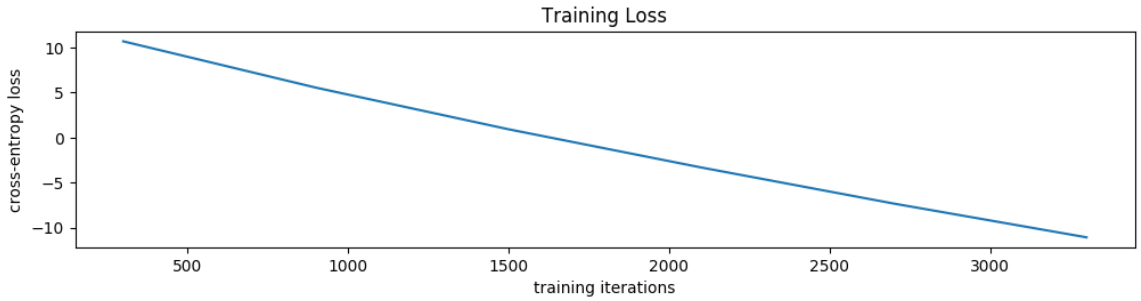

Test Off-By Counts
count of examples
500
400
300
200
100
0
500
1000
1500
2000
2500
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

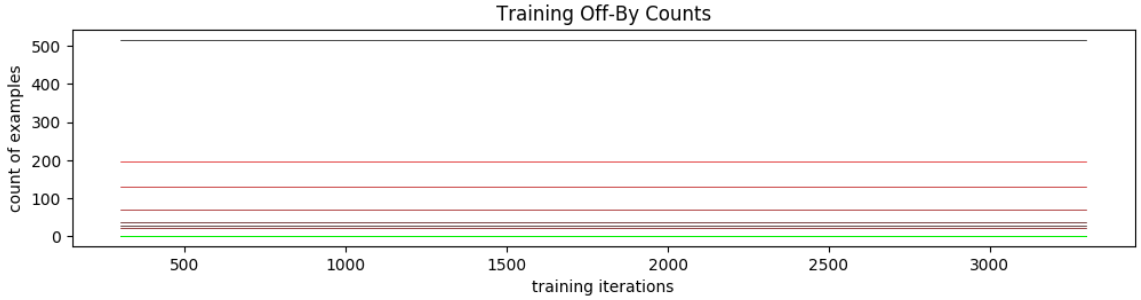

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

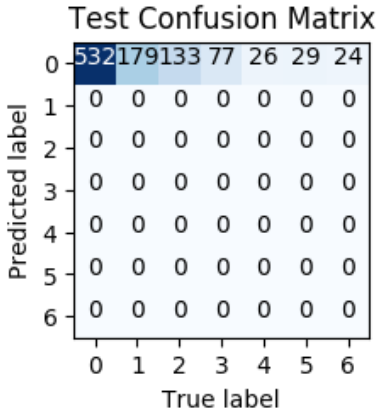

Training Loss
cross-entropy loss
10
5
0
−5
−10
500
1000
1500
2000
2500
3000
training iterations

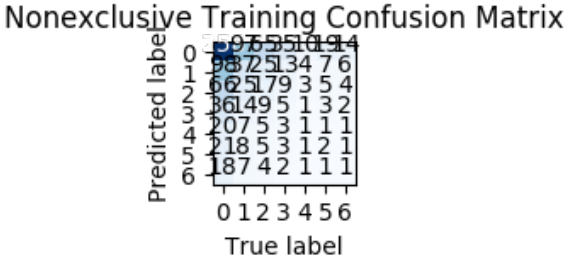

Test Loss
cross-entropy loss
10
5
0
−5
−10
500
1000
1500
2000
2500
3000
training iterations

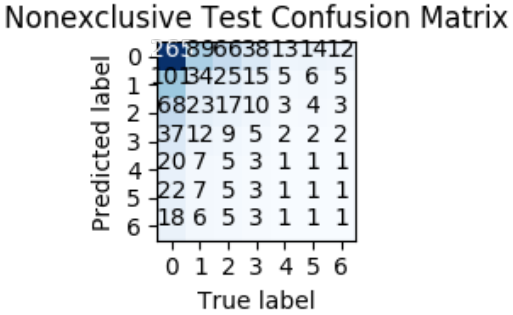

Training Off-By Counts
count of examples
500
400
300
200
100
0
500
1000
1500
2000
2500
3000
training iterations

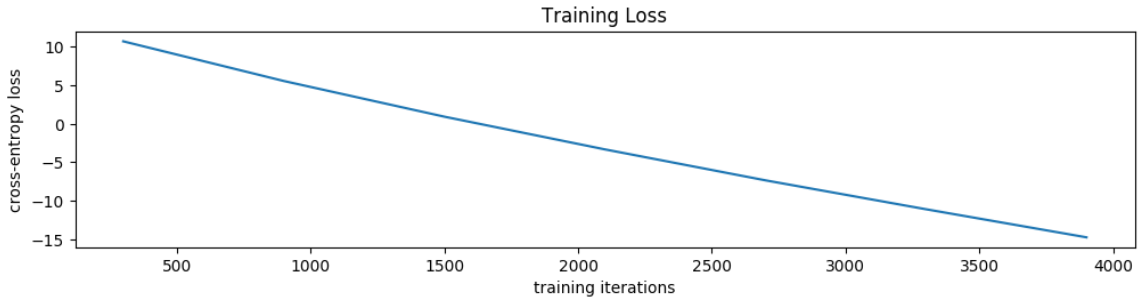

Test Off-By Counts
count of examples
500
400
300
200
100
0
500
1000
1500
2000
2500
3000
training iterations

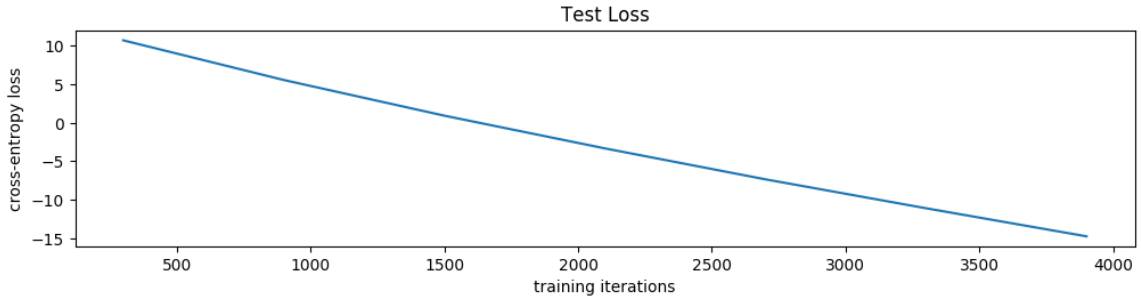

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

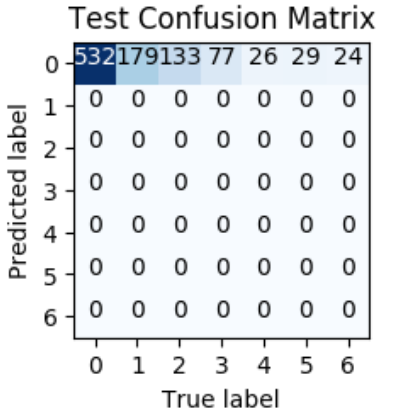

Training Loss
cross-entropy loss
training iterations

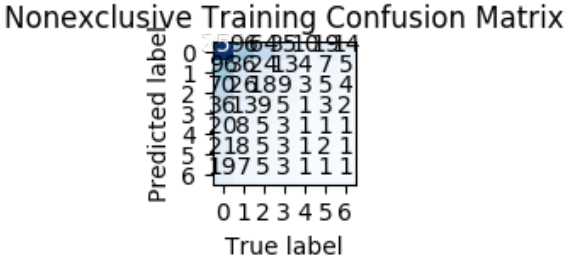

Test Loss
cross-entropy loss
training iterations

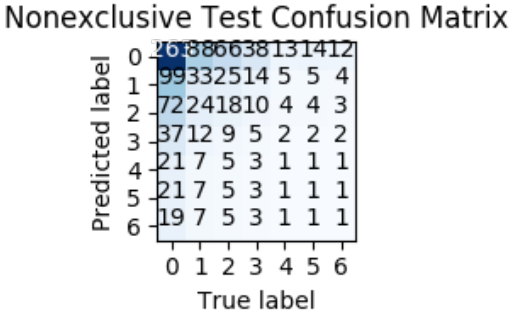

Training Off-By Counts
count of examples
training iterations

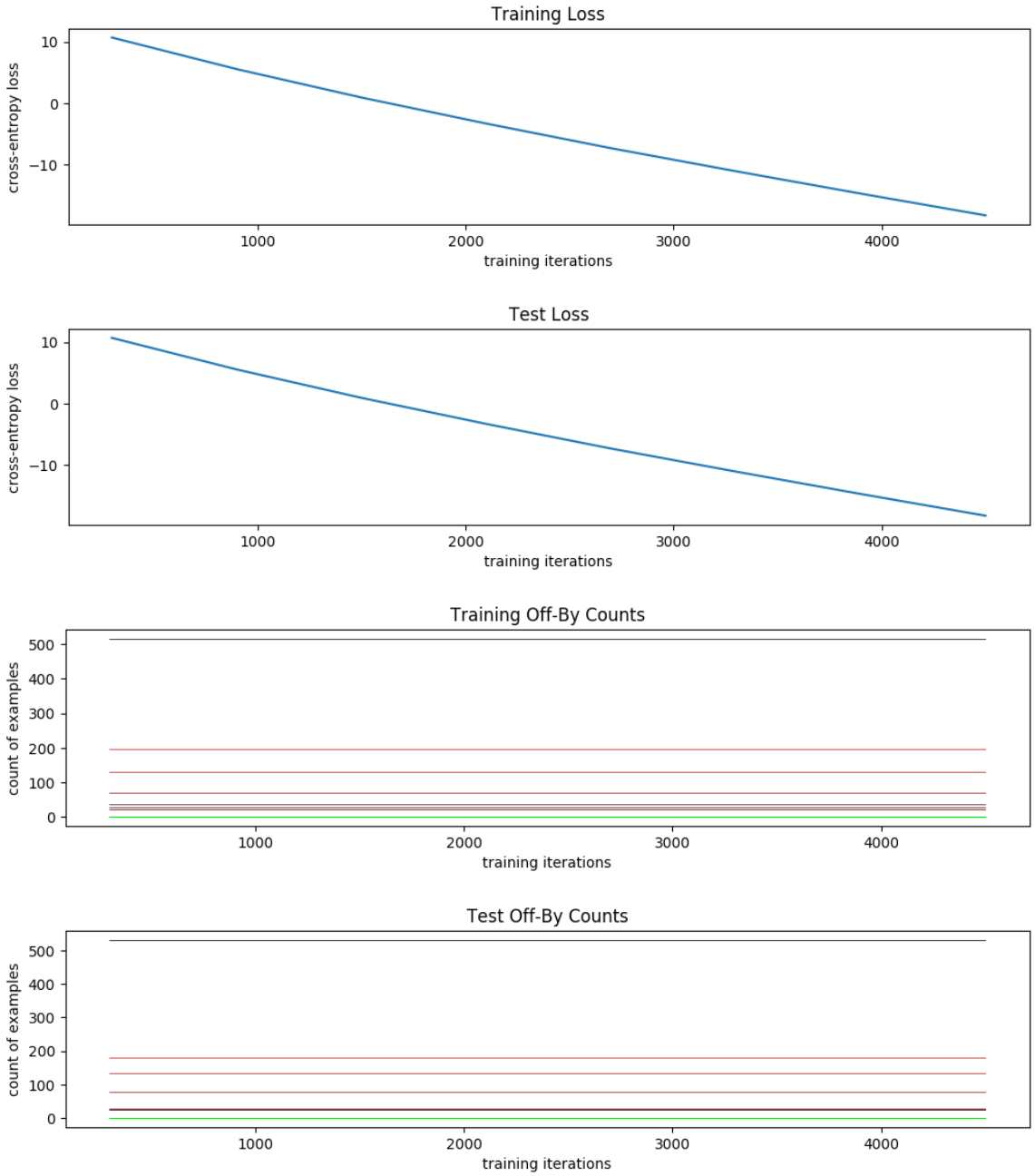

Test Off-By Counts
count of examples
training iterations


Training Confusion Matrix
Predicted label
True label

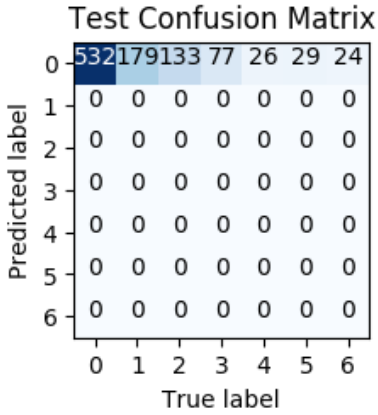

Test Confusion Matrix
Predicted label
True label

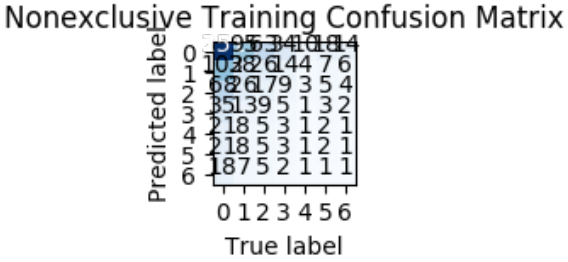

Nonexclusive Training Confusion Matrix
Predicted label
True label

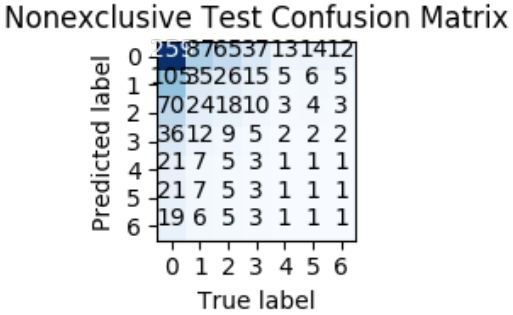

Nonexclusive Test Confusion Matrix
Predicted label
True label

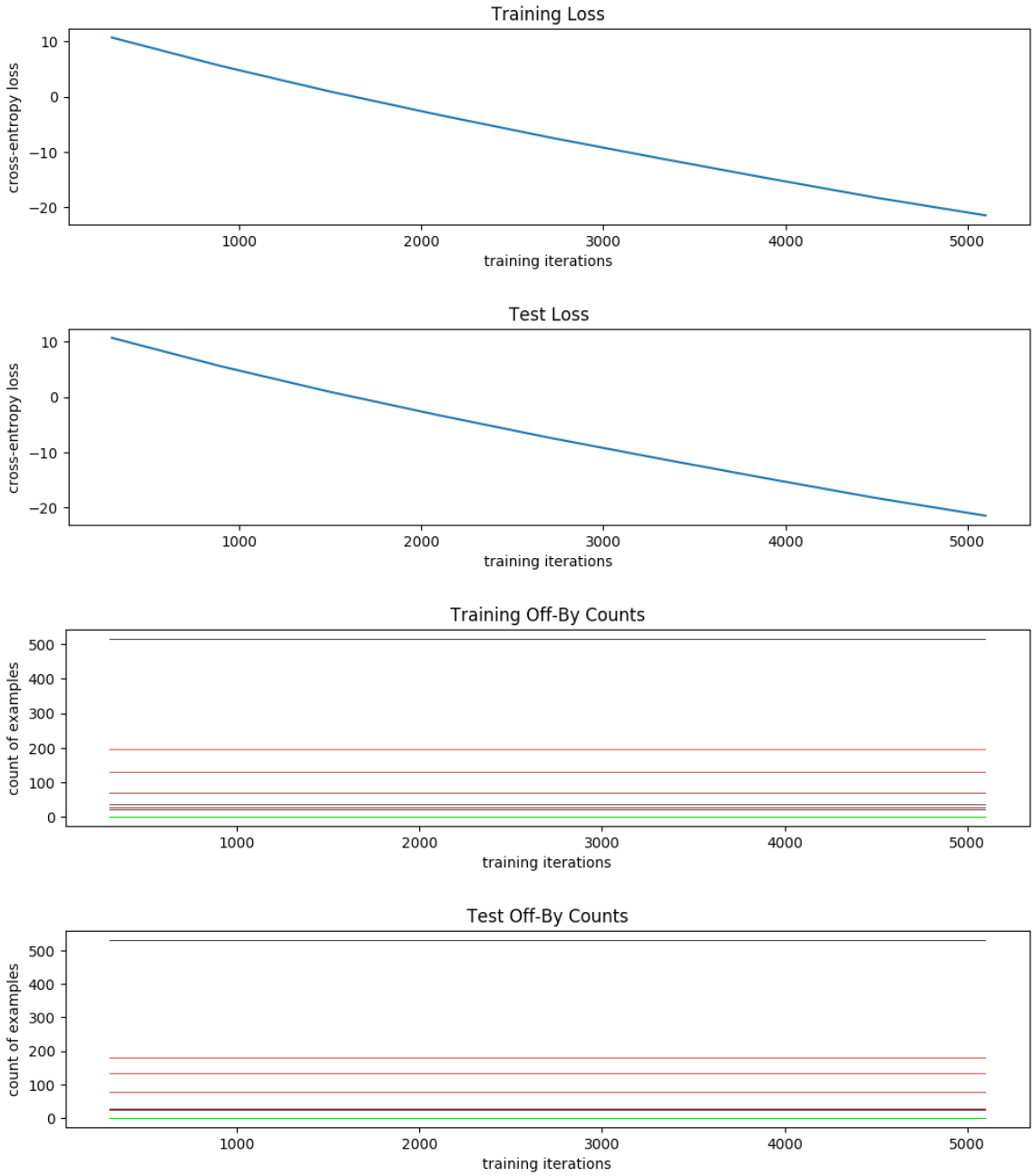

Training Loss
cross-entropy loss
10
0
−10
1000
2000
3000
4000
training iterations
Test Loss
cross-entropy loss
10
0
−10
1000
2000
3000
4000
training iterations
Training Off-By Counts
count of examples
500
400
300
200
100
0
1000
2000
3000
4000
training iterations
Test Off-By Counts
count of examples
500
400
300
200
100
0
1000
2000
3000
4000
training iterations

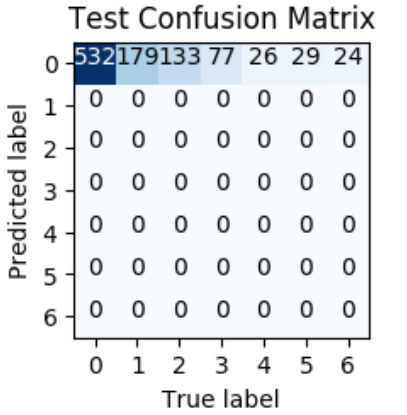

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

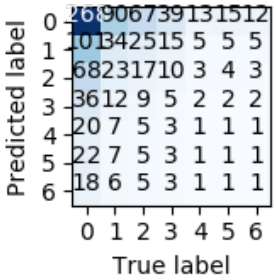

Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

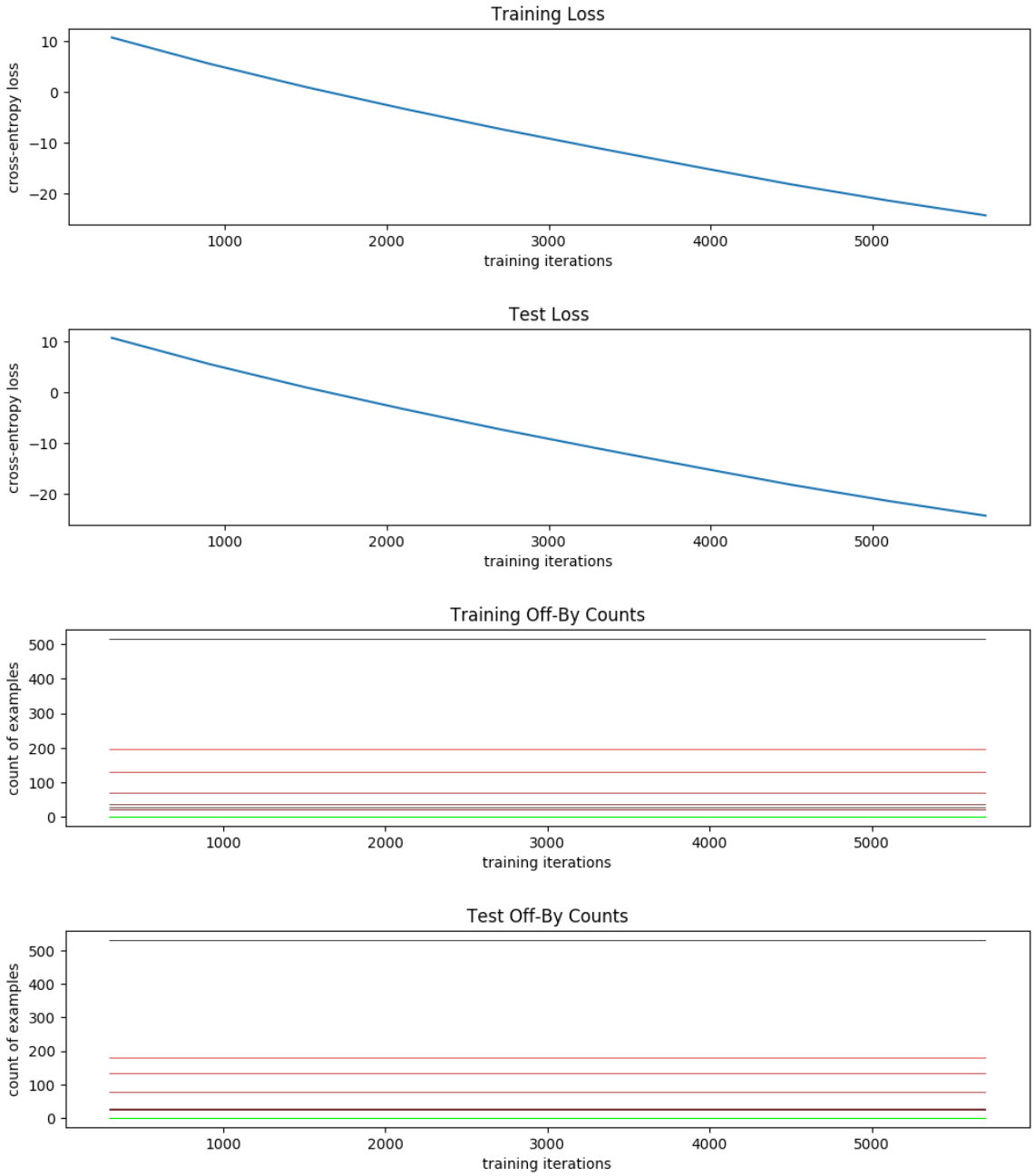

Training Loss
cross-entropy loss
10
0
−10
−20
1000
2000
3000
4000
5000
training iterations
Test Loss
cross-entropy loss
10
0
−10
−20
1000
2000
3000
4000
5000
training iterations
Training Off-By Counts
count of examples
500
400
300
200
100
0
1000
2000
3000
4000
5000
training iterations
Test Off-By Counts
count of examples
500
400
300
200
100
0
1000
2000
3000
4000
5000
training iterations



Nonexclusive Training Confusion Matrix

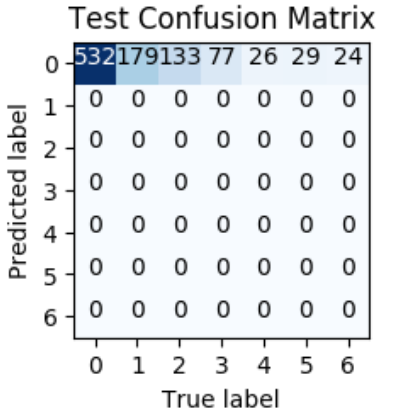
Nonexclusive Test Confusion Matrix

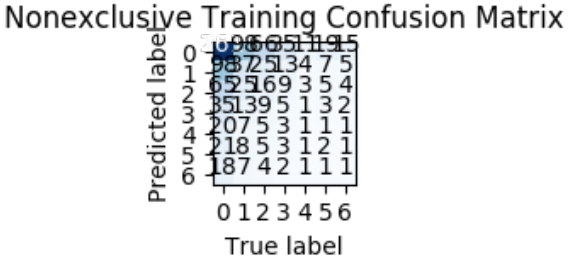


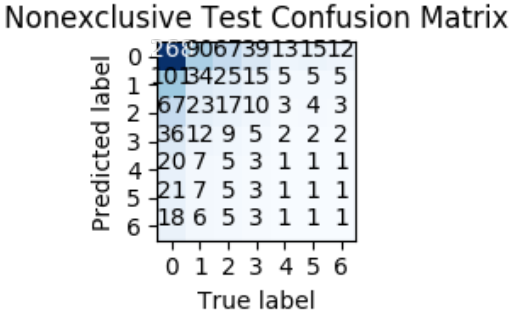

Training Loss
cross-entropy loss
10
0
−10
−20
1000
2000
3000
4000
5000
training iterations
Test Loss
cross-entropy loss
10
0
−10
−20
1000
2000
3000
4000
5000
training iterations
Training Off-By Counts
count of examples
500
400
300
200
100
0
1000
2000
3000
4000
5000
training iterations
Test Off-By Counts
count of examples
500
400
300
200
100
0
1000
2000
3000
4000
5000
training iterations

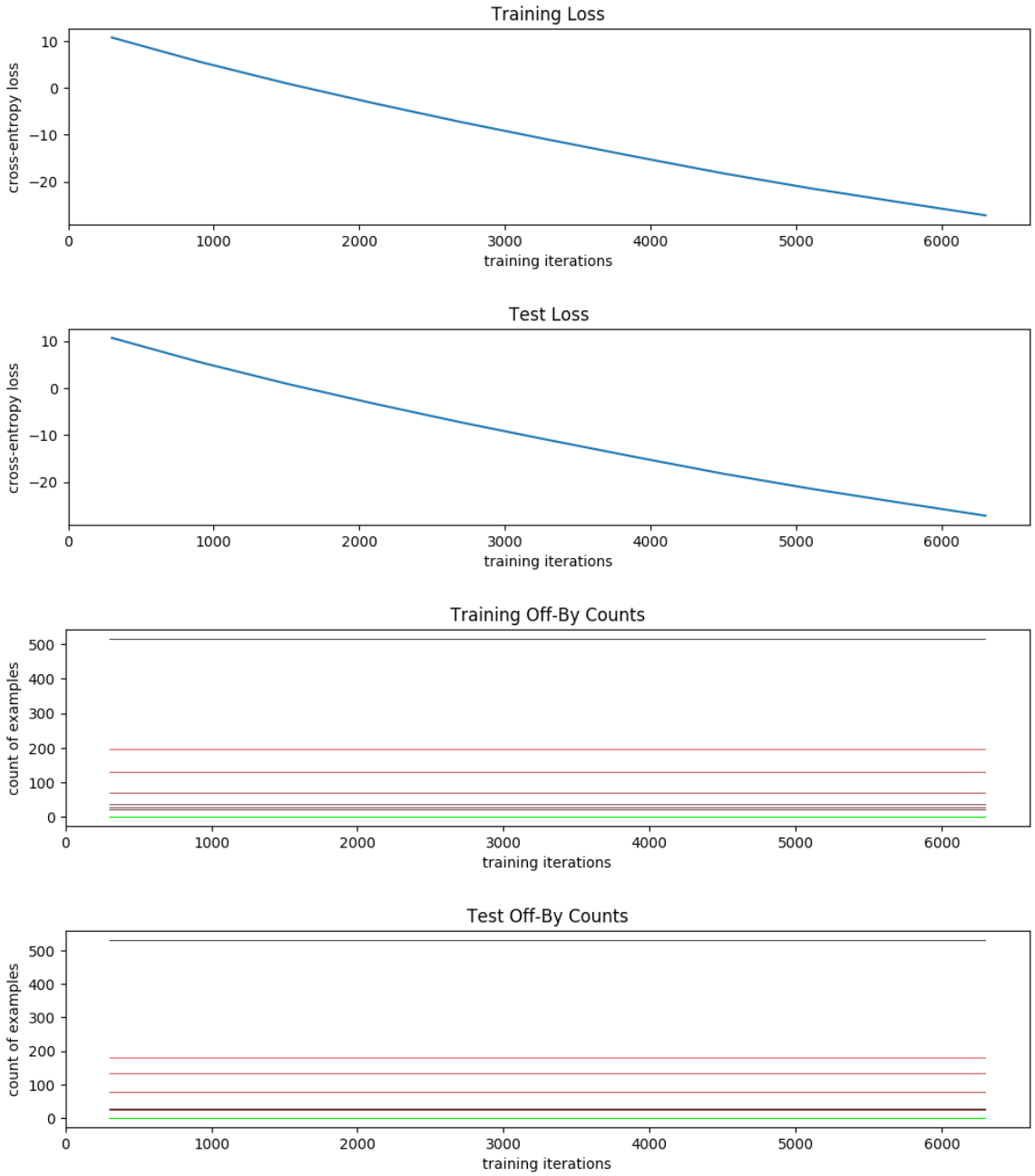
In [12]:
```
# Alternately train and evaluate the net for 30 minutes.
for _ in range(30//3):
    net.train(train, 3*60)
    net.evaluate(metrics)
    plot_metrics()
```


Training Confusion Matrix
Predicted label
True label

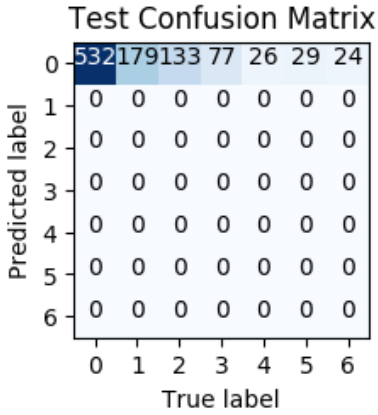

Test Confusion Matrix
Predicted label
True label

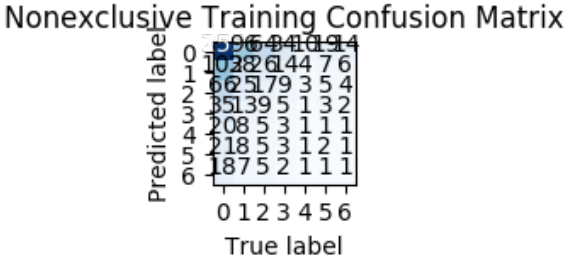

Nonexclusive Training Confusion Matrix
Predicted label
True label

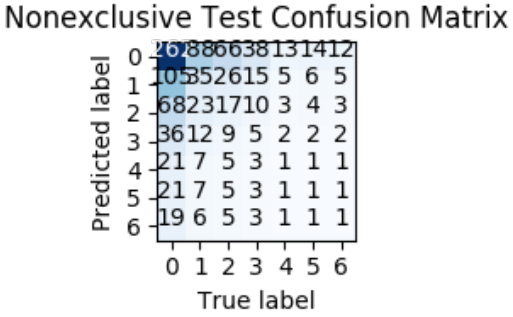

Nonexclusive Test Confusion Matrix
Predicted label
True label

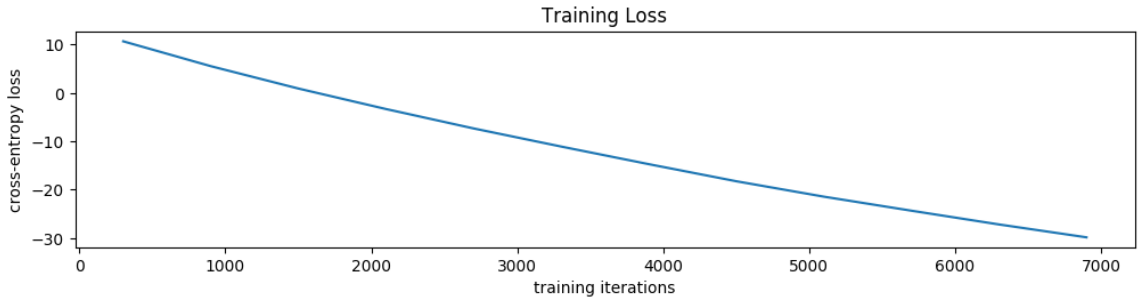

Training Loss
cross-entropy loss
training iterations
Test Loss
cross-entropy loss
training iterations
Training Off-By Counts
count of examples
training iterations
Test Off-By Counts
count of examples
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

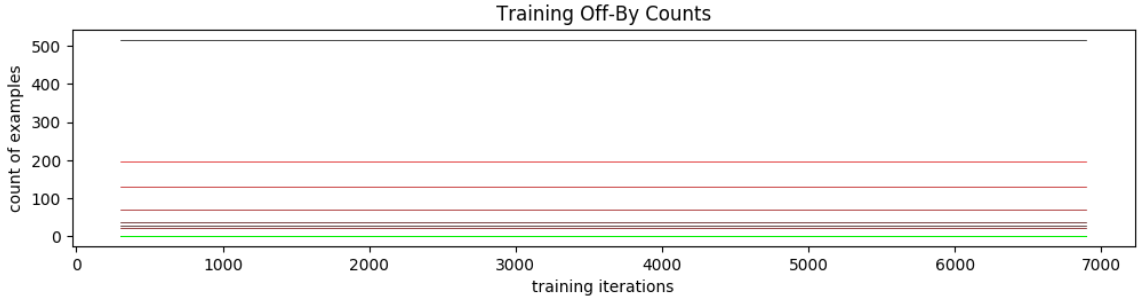

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

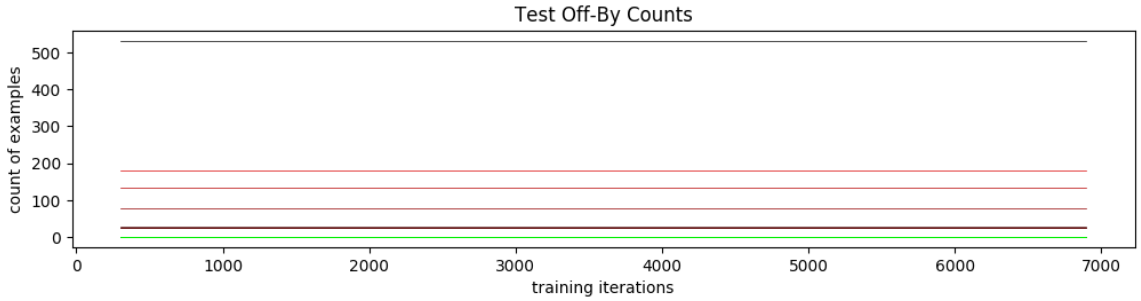

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

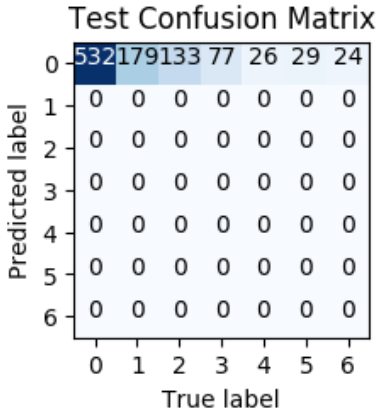

Training Loss
cross-entropy loss
10
0
−10
−20
−30
0
1000
2000
3000
4000
5000
6000
7000
training iterations

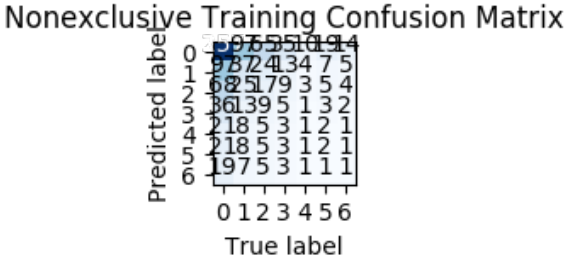

Test Loss
cross-entropy loss
10
0
−10
−20
−30
0
1000
2000
3000
4000
5000
6000
7000
training iterations

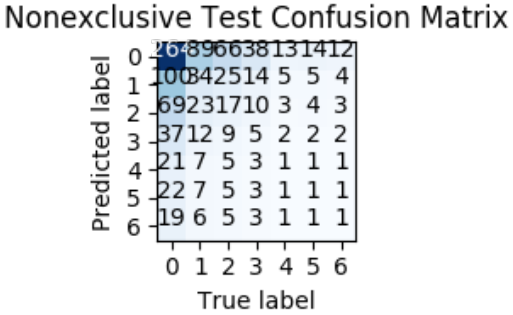

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
7000
training iterations

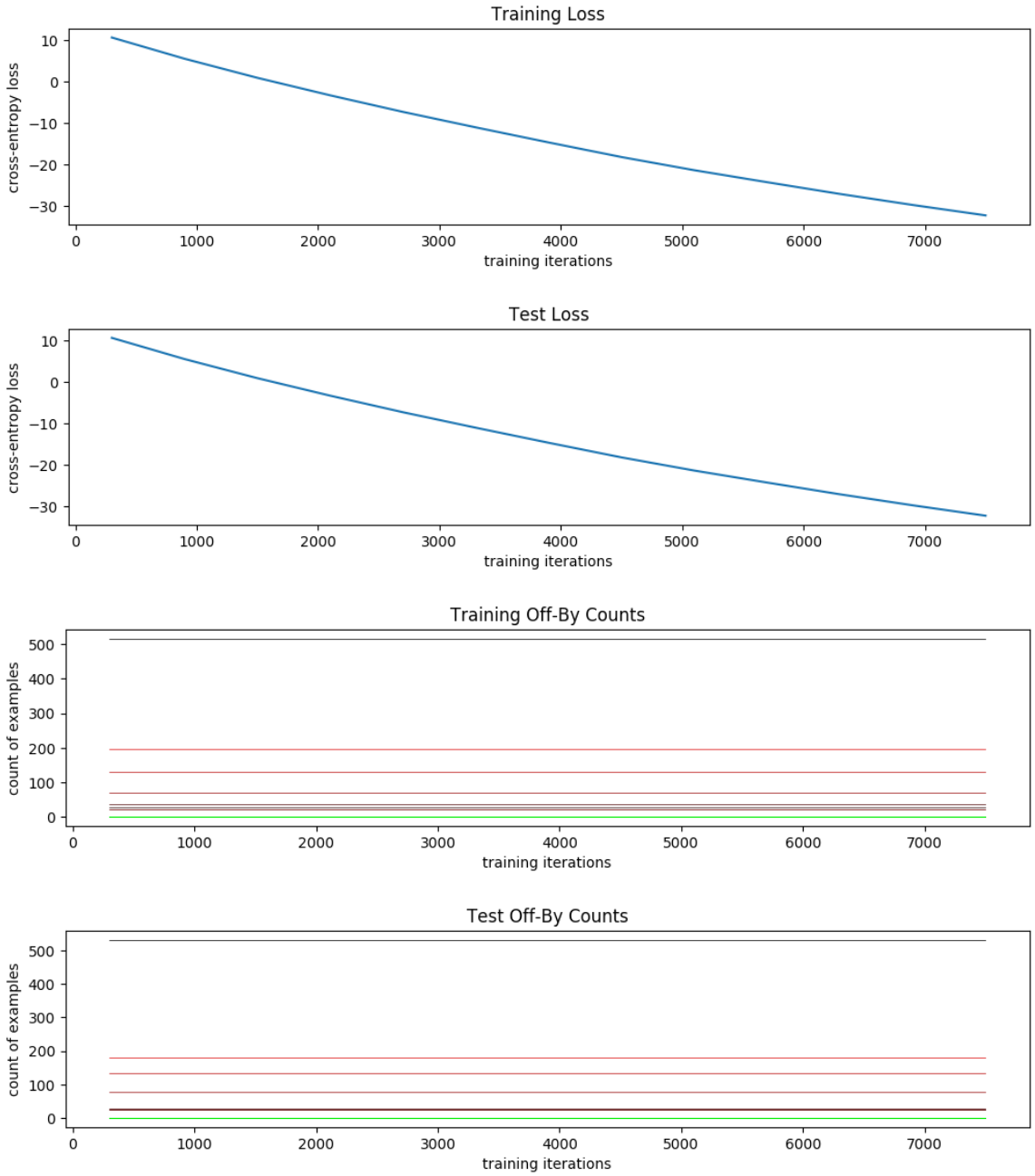

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
7000
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

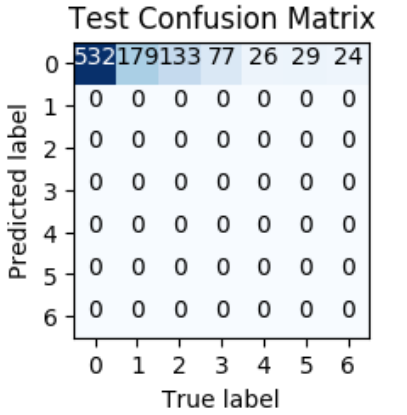

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

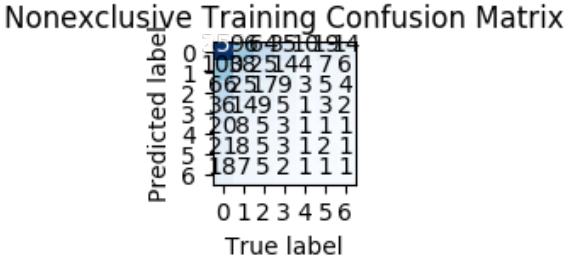

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

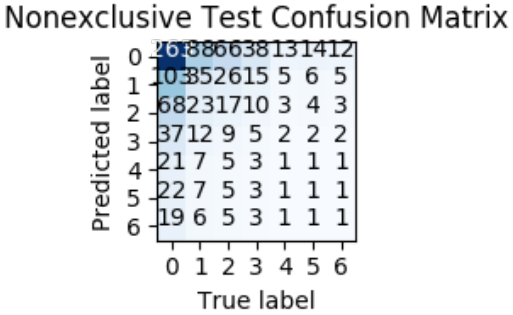

Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

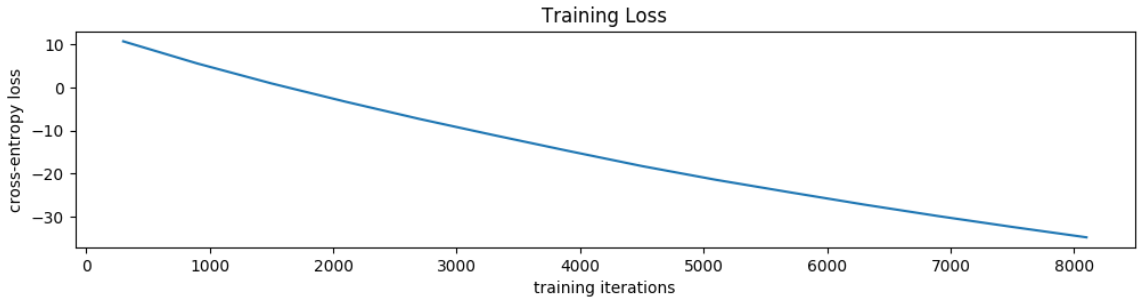

Training Loss
cross-entropy loss
training iterations
Test Loss
cross-entropy loss
training iterations
Training Off-By Counts
count of examples
training iterations
Test Off-By Counts
count of examples
training iterations

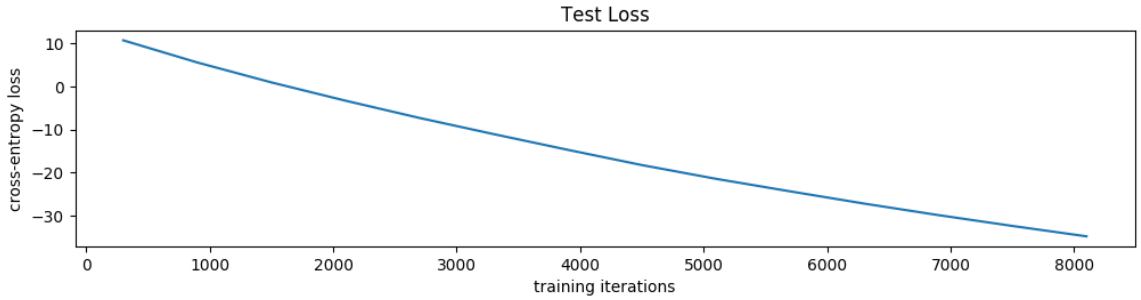

Training Confusion Matrix
Predicted label
True label

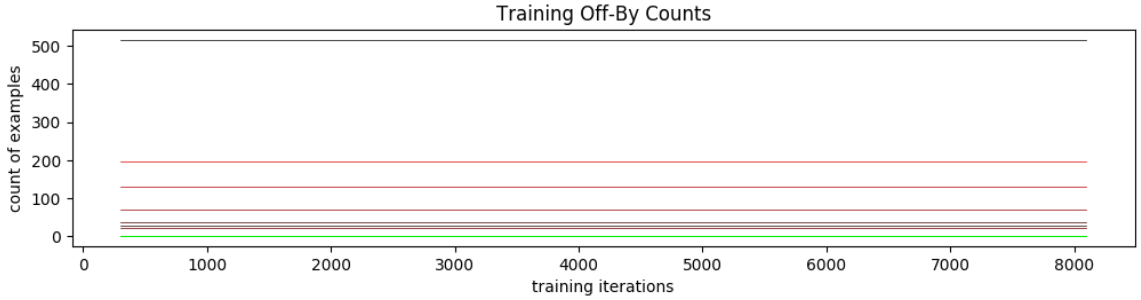

Test Confusion Matrix
Predicted label
True label

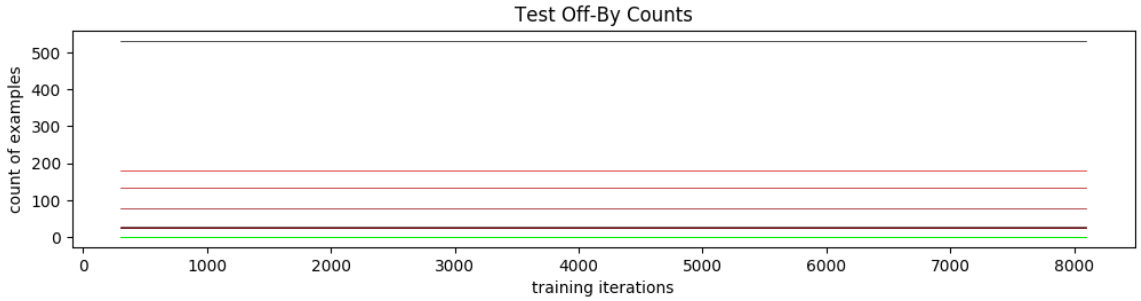

Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

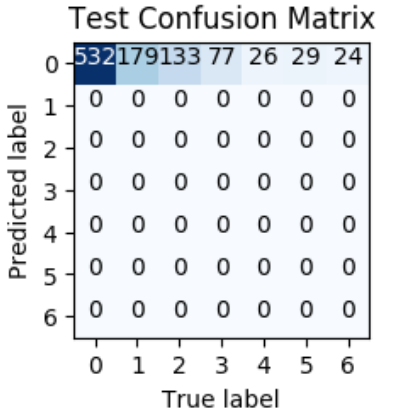

Training Loss
cross-entropy loss
10
0
−10
−20
−30
0
1000
2000
3000
4000
5000
6000
7000
8000
training iterations

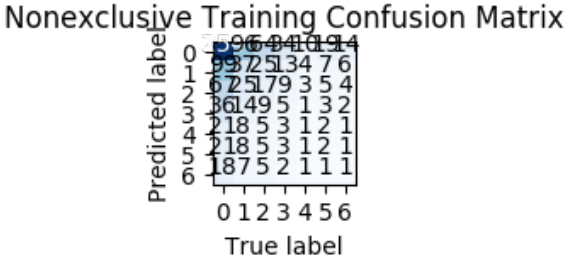

Test Loss
cross-entropy loss
10
0
−10
−20
−30
0
1000
2000
3000
4000
5000
6000
7000
8000
training iterations

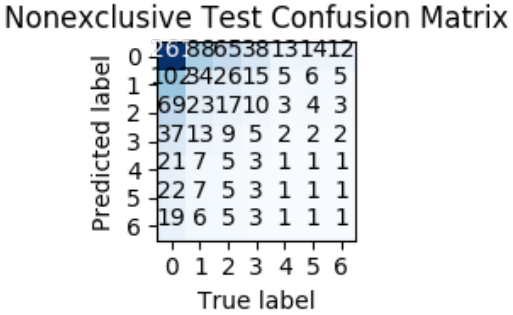

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
7000
8000
training iterations

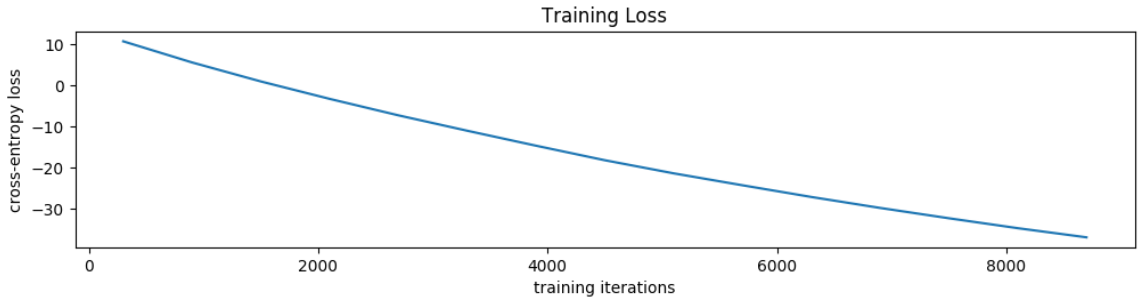

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
7000
8000
training iterations


Training Confusion Matrix
Predicted label
True label

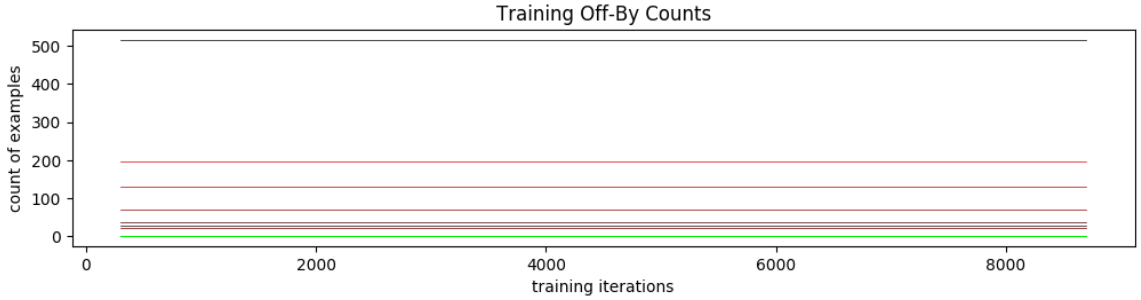

Test Confusion Matrix
Predicted label
True label

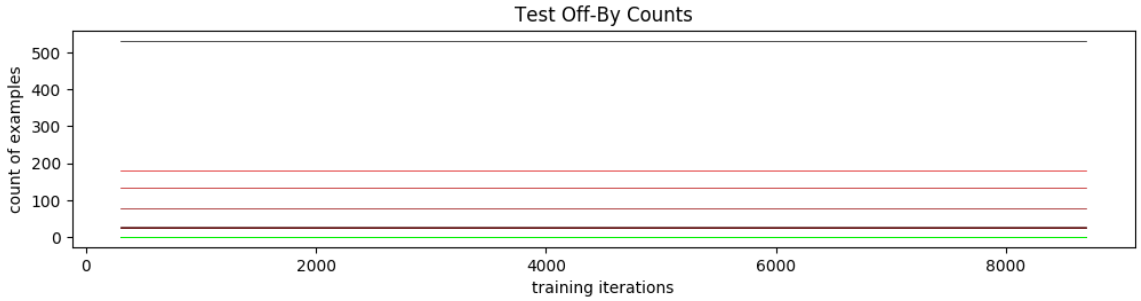

Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

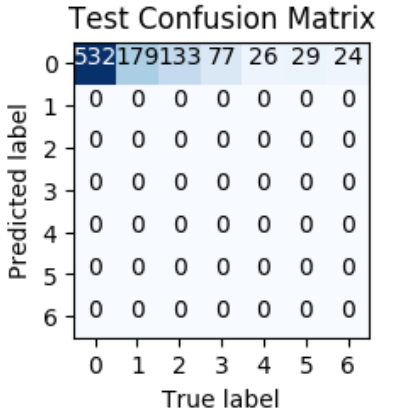

Training Loss
cross-entropy loss
10
0
−10
−20
−30
0
2000
4000
6000
8000
training iterations

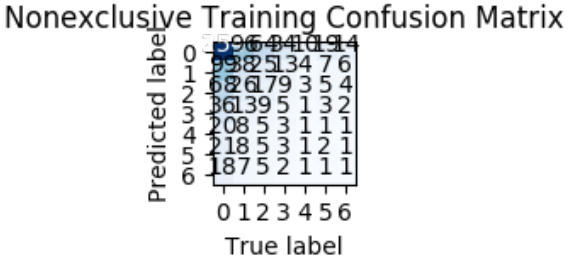

Test Loss
cross-entropy loss
10
0
−10
−20
−30
0
2000
4000
6000
8000
training iterations

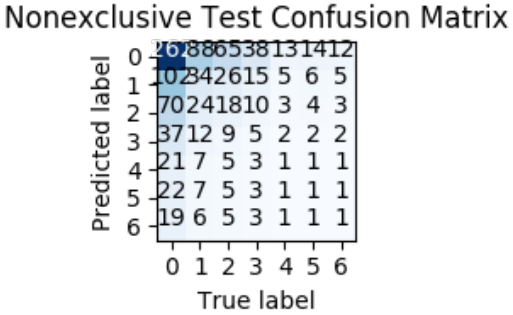

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
training iterations

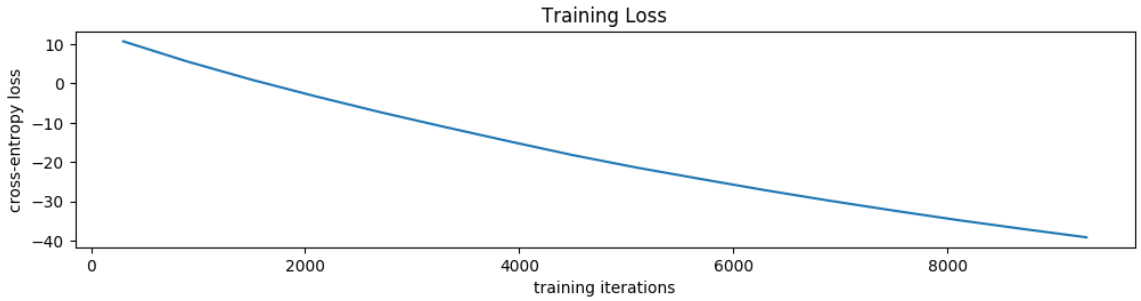

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
training iterations

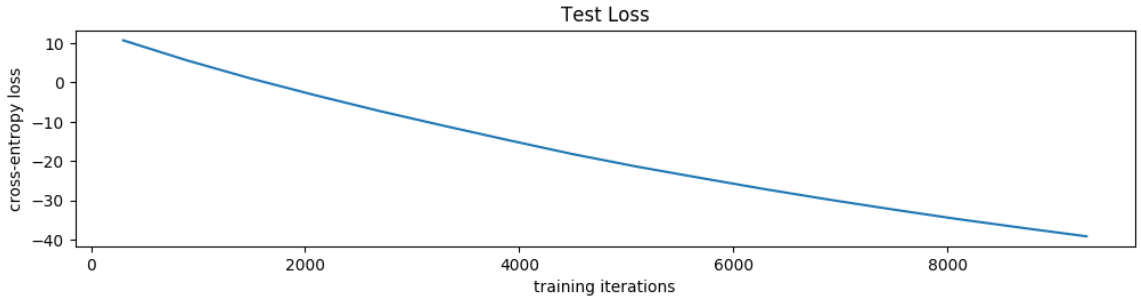

Training Confusion Matrix
Predicted label
True label


Test Confusion Matrix
Predicted label
True label


Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

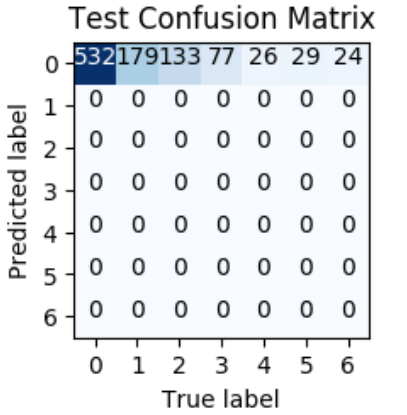

Training Loss
cross-entropy loss
10
0
−10
−20
−30
−40
0
2000
4000
6000
8000
training iterations

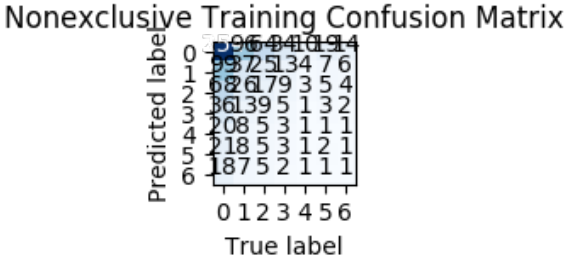

Test Loss
cross-entropy loss
10
0
−10
−20
−30
−40
0
2000
4000
6000
8000
training iterations

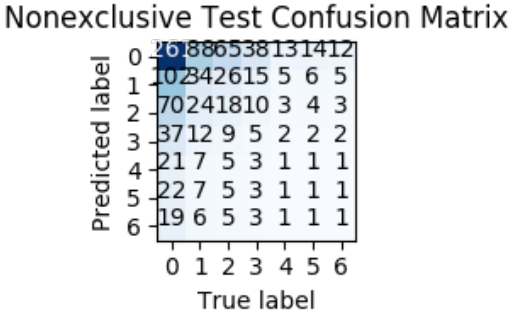

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
training iterations

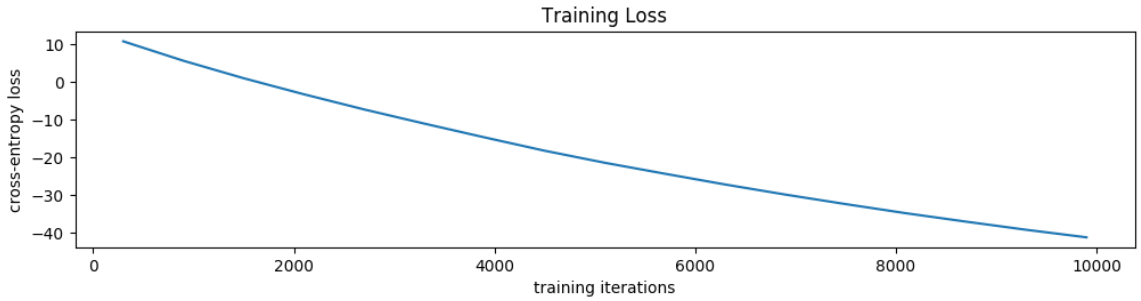

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
training iterations

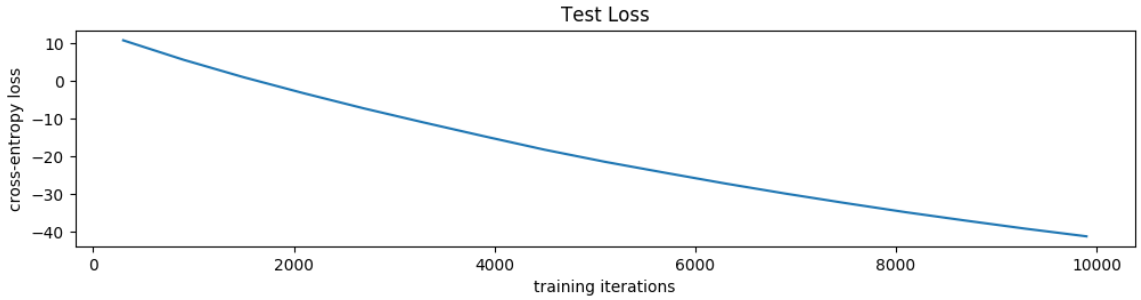

Training Confusion Matrix
Predicted label
True label


Test Confusion Matrix
Predicted label
True label


Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

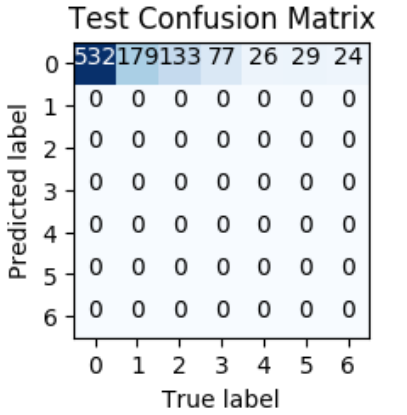

Training Loss
cross-entropy loss
10
0
−10
−20
−30
−40
0
2000
4000
6000
8000
10000
training iterations

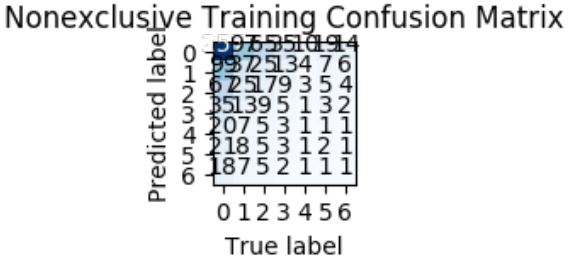

Test Loss
cross-entropy loss
10
0
−10
−20
−30
−40
0
2000
4000
6000
8000
10000
training iterations

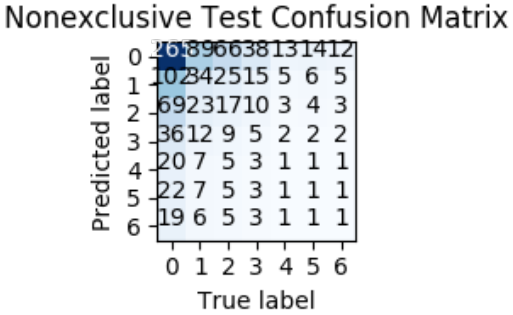

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
training iterations

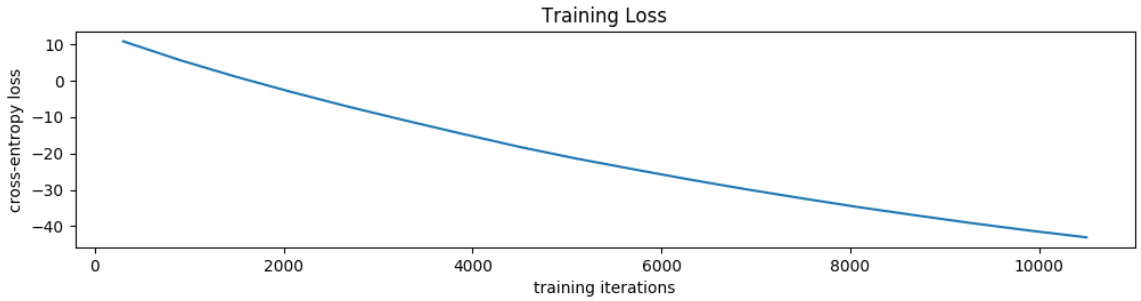

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
training iterations

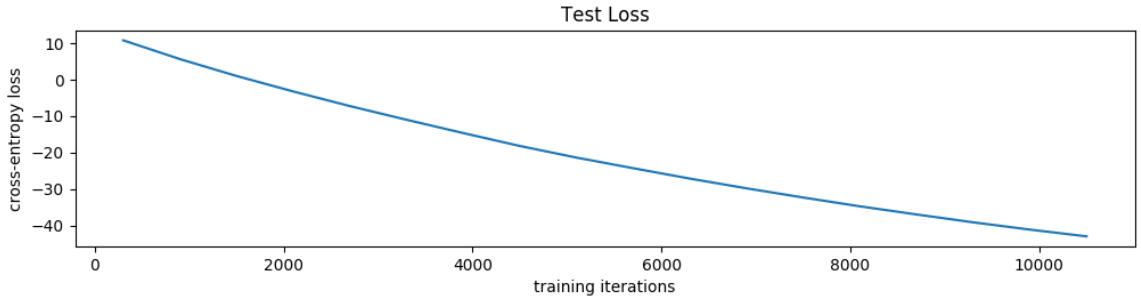

Training Confusion Matrix
Predicted label
True label

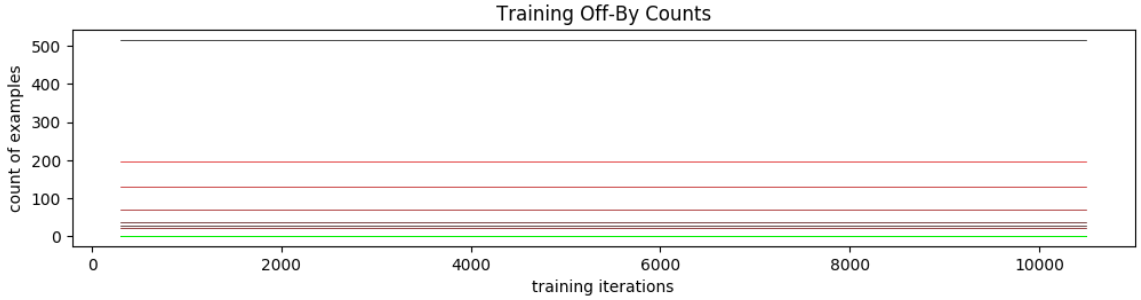

Test Confusion Matrix
Predicted label
True label


Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

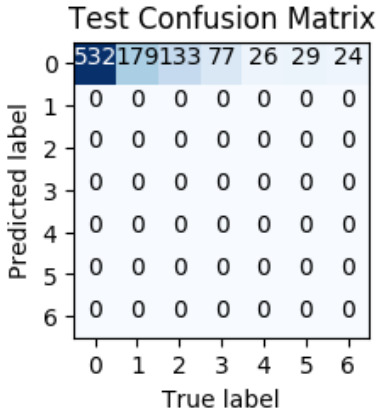

Training Loss
cross-entropy loss
10
0
−10
−20
−30
−40
0
2000
4000
6000
8000
10000
training iterations

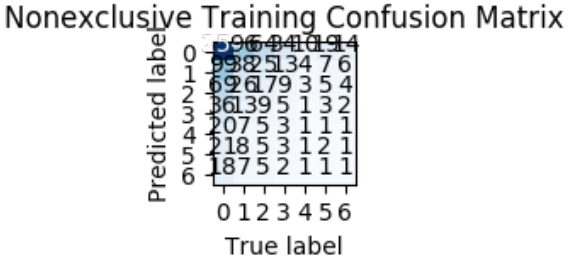

Test Loss
cross-entropy loss
10
0
−10
−20
−30
−40
0
2000
4000
6000
8000
10000
training iterations

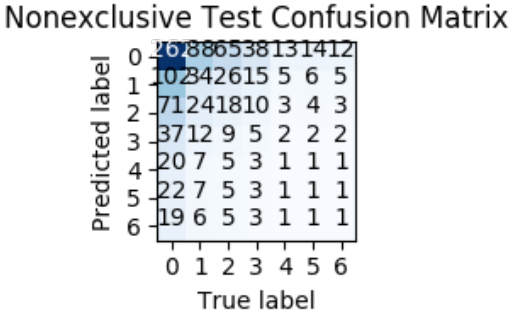

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
training iterations

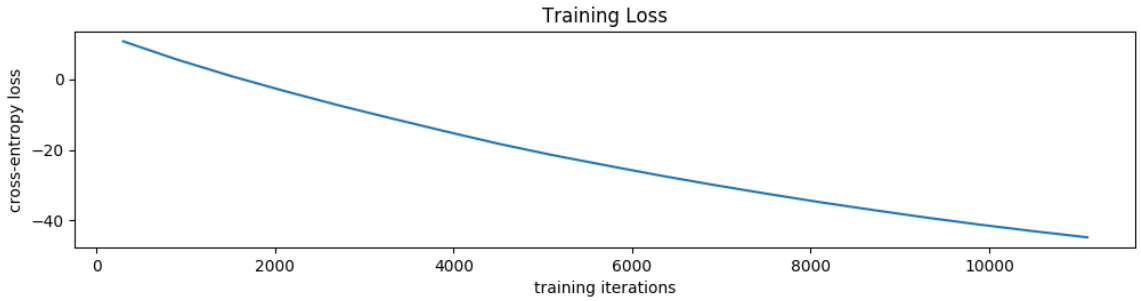

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
training iterations

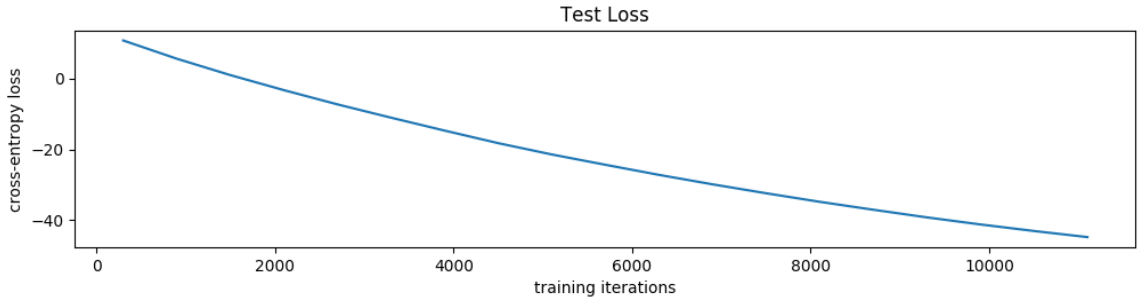

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

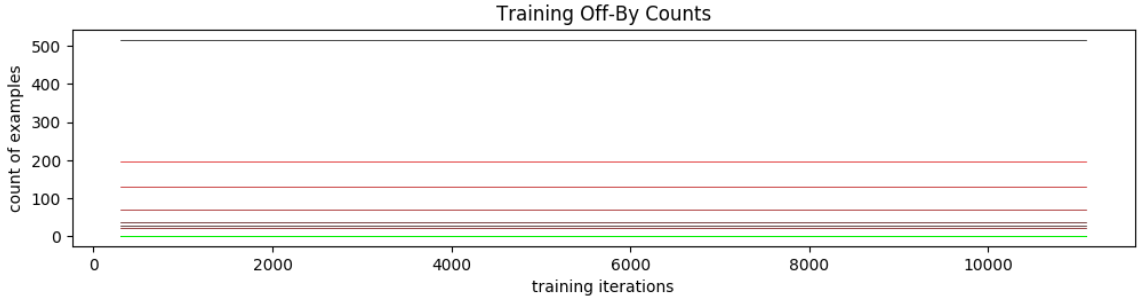

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

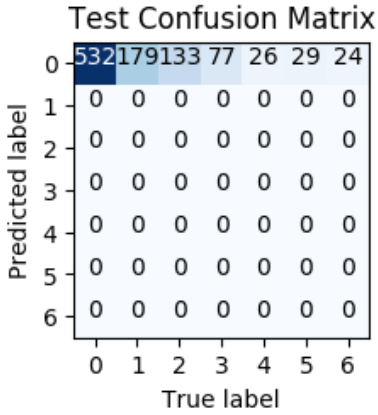

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
training iterations

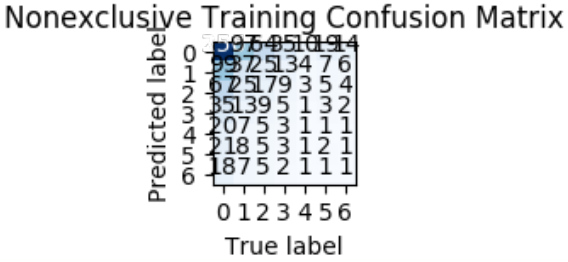

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
training iterations

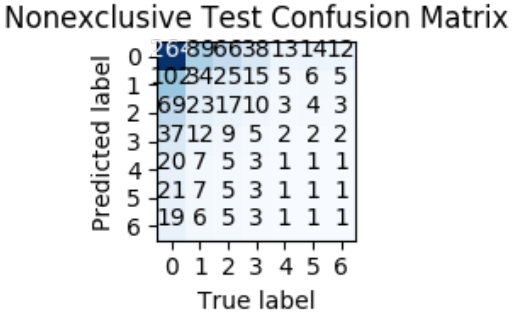

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
training iterations


Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
training iterations

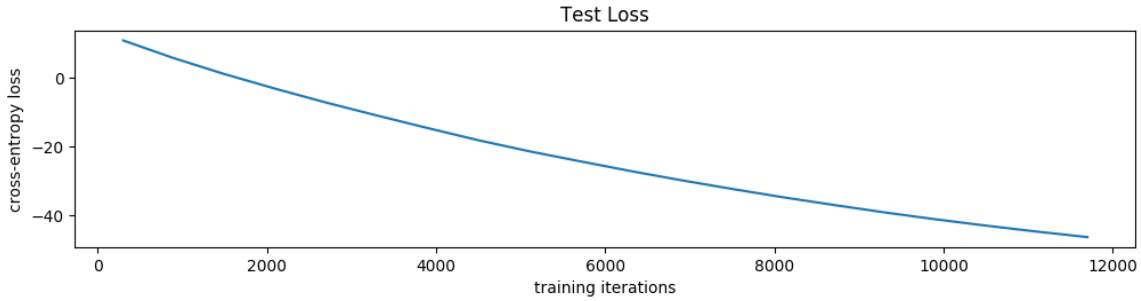

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

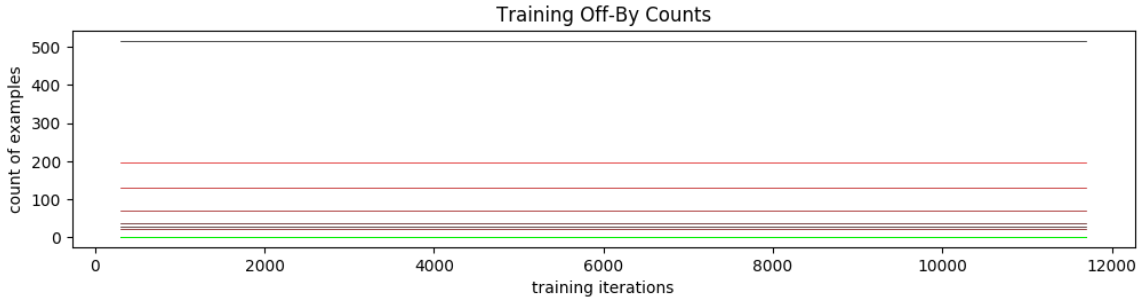

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

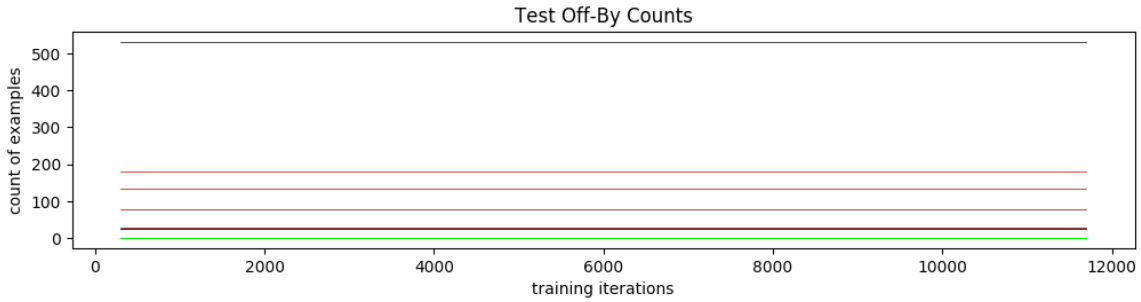

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
training iterations

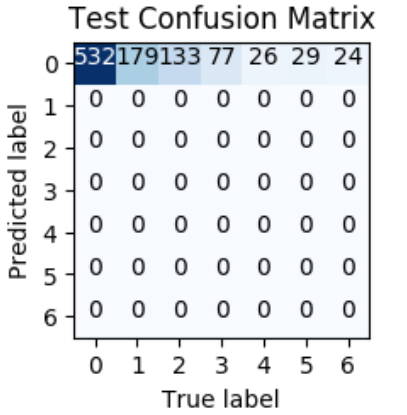

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
training iterations

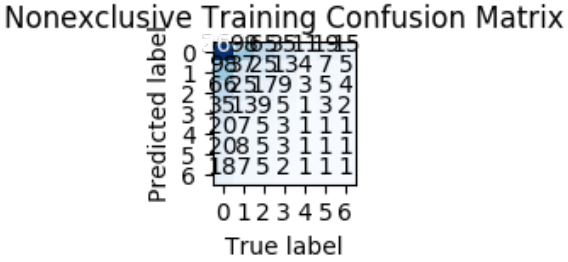

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
training iterations

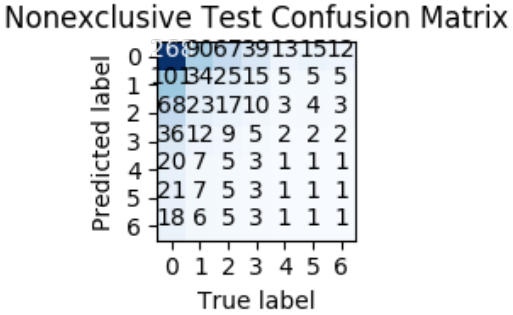

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
training iterations

In [13]:
```
# Alternately train and evaluate the net for 30 minutes.
for _ in range(30//3):
    net.train(train, 3*60)
    net.evaluate(metrics)
    plot_metrics()
```

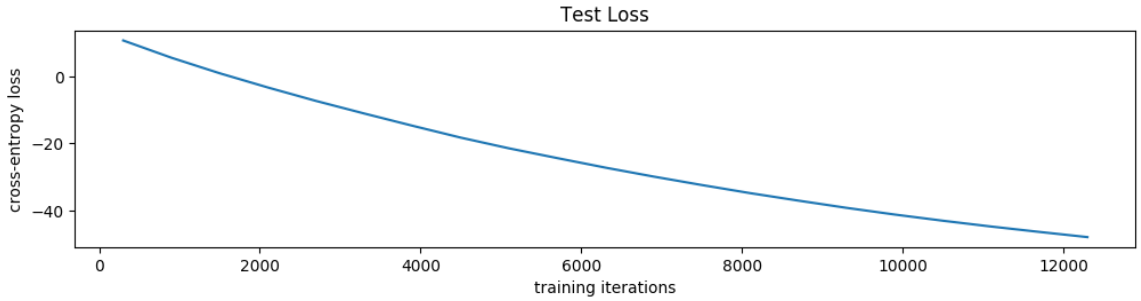

Training Confusion Matrix
Predicted label
True label

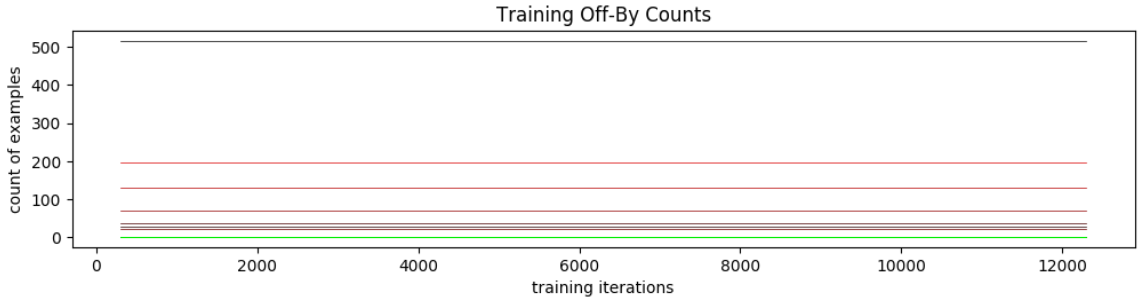

Test Confusion Matrix
Predicted label
True label

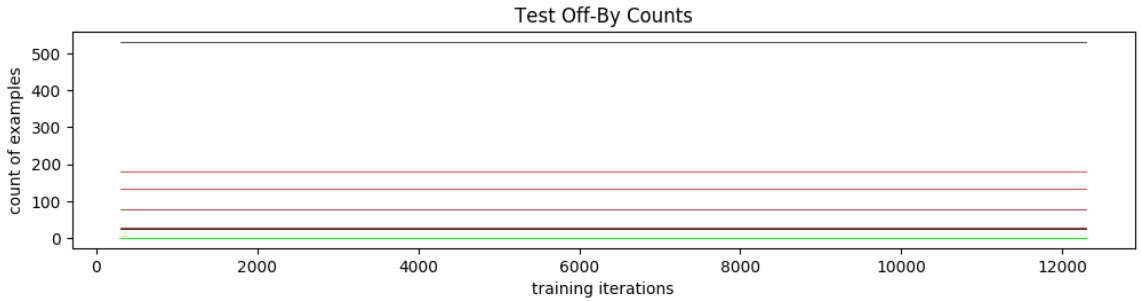

Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

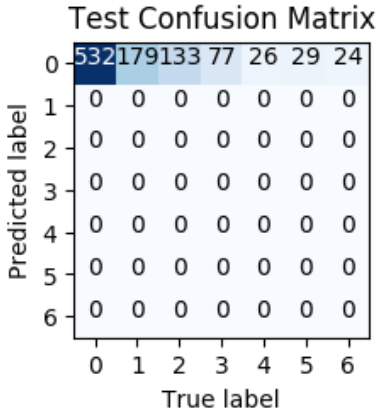

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
training iterations

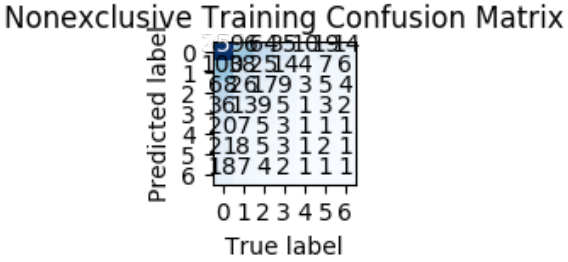

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
training iterations

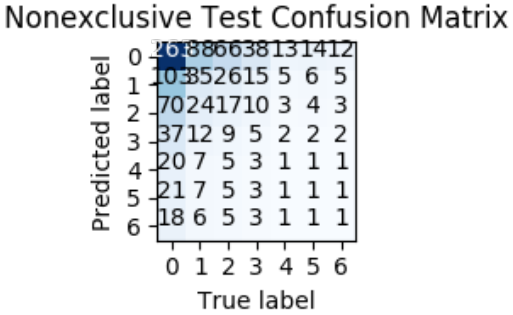

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
training iterations

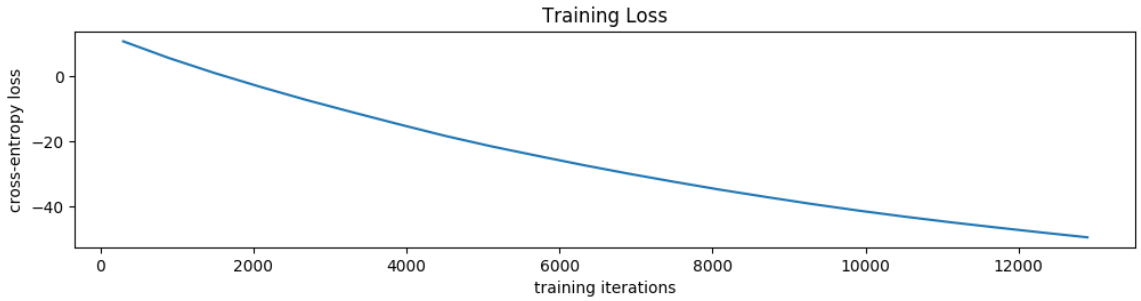

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
training iterations

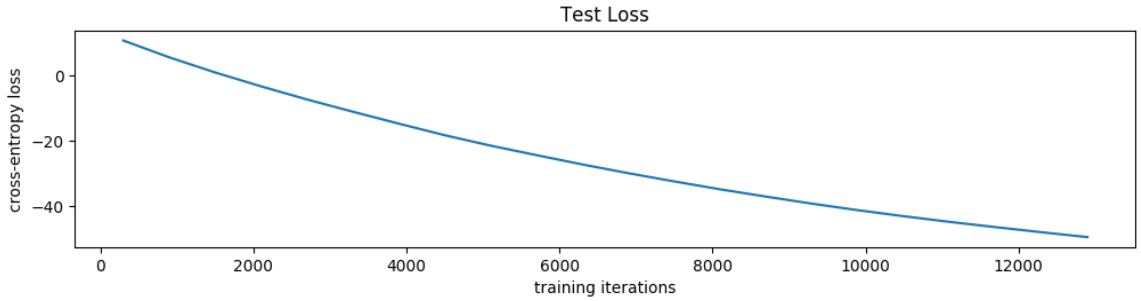

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

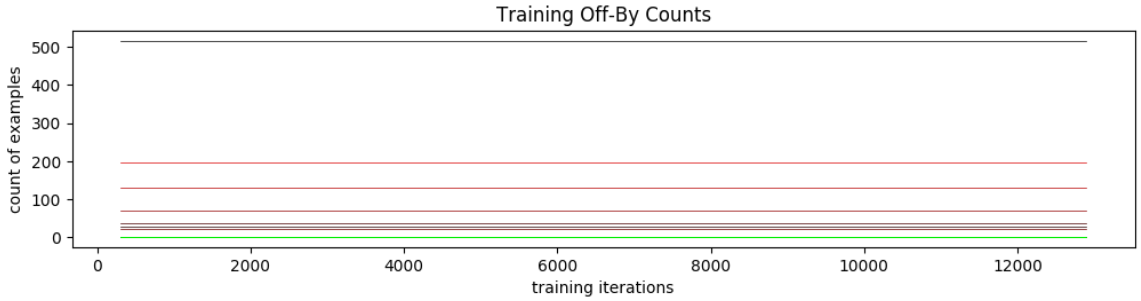

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

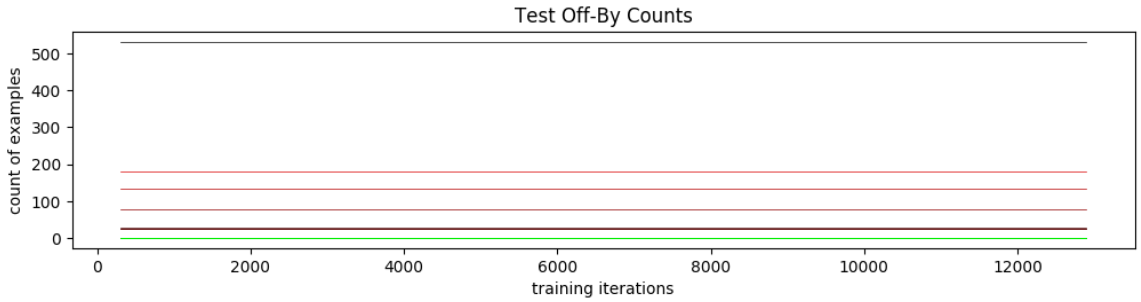

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

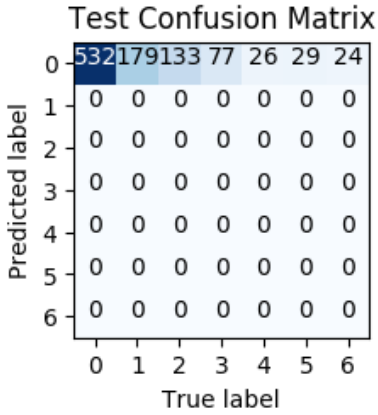

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
training iterations

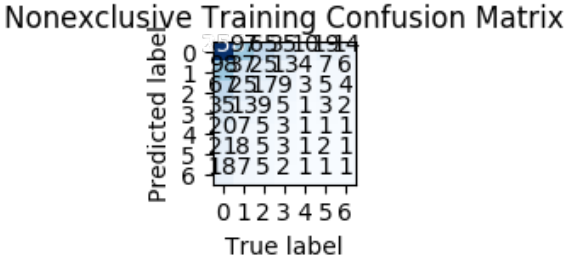

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
training iterations

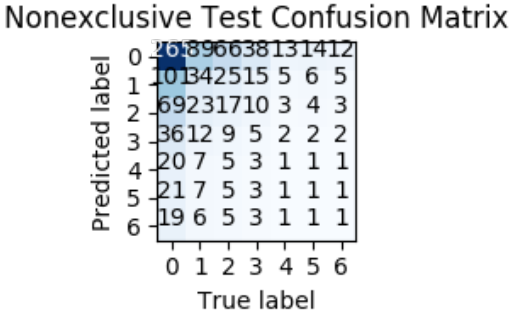

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
training iterations

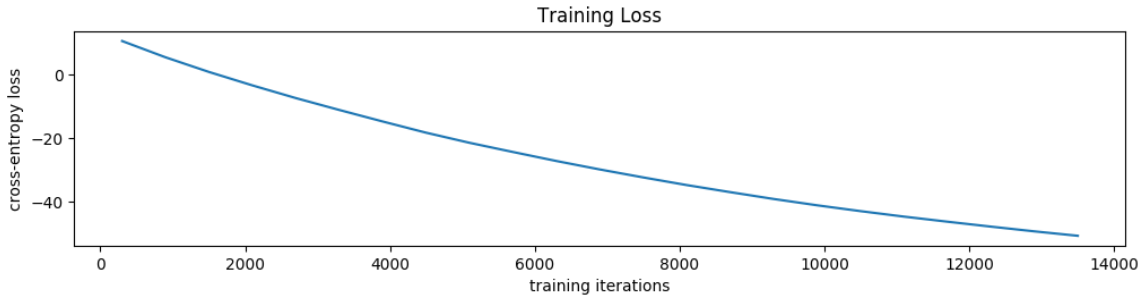

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

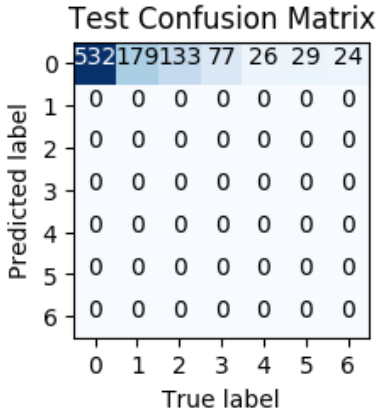

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
training iterations

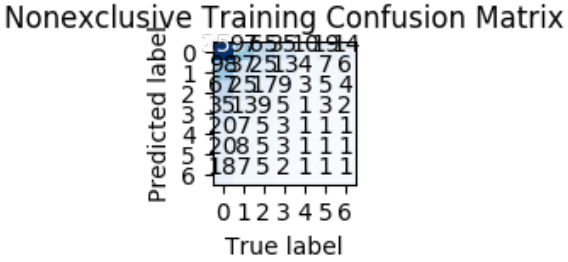

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
training iterations

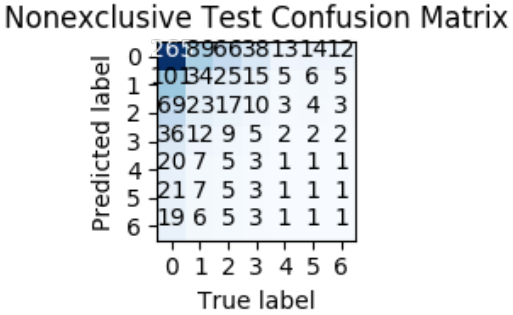

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
training iterations

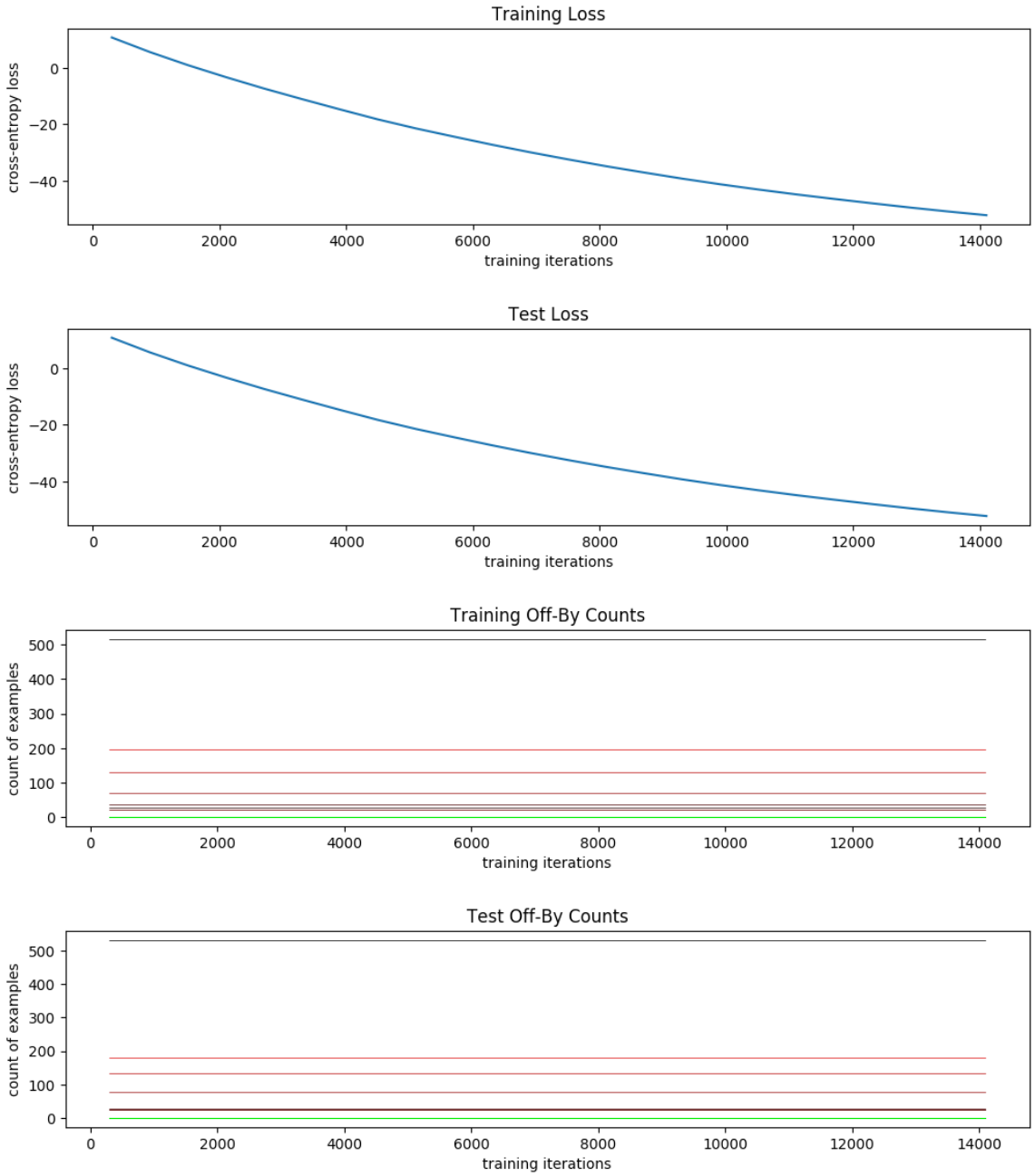

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

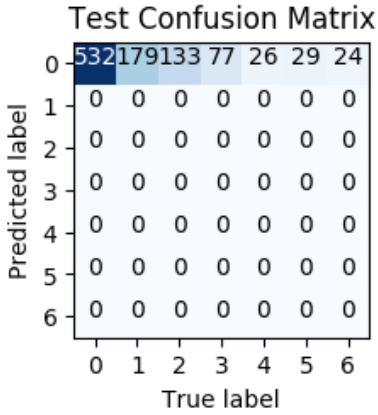

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

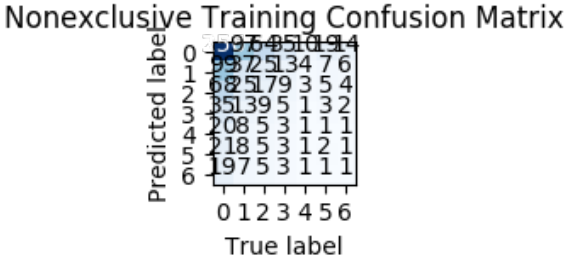

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

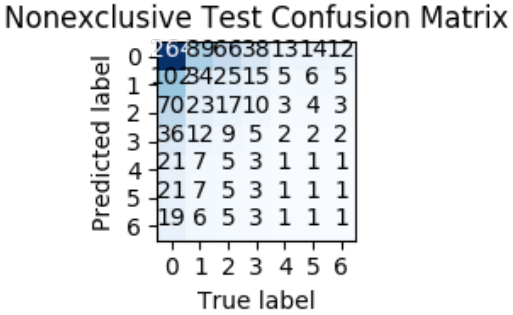

Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

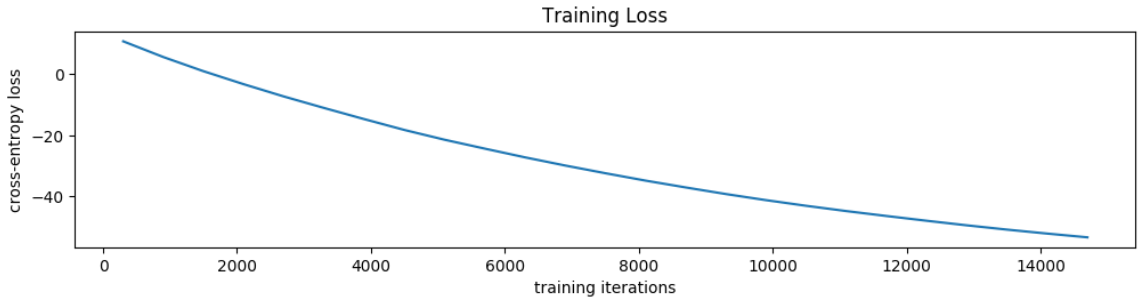

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
training iterations
Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
training iterations
Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
training iterations
Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
training iterations

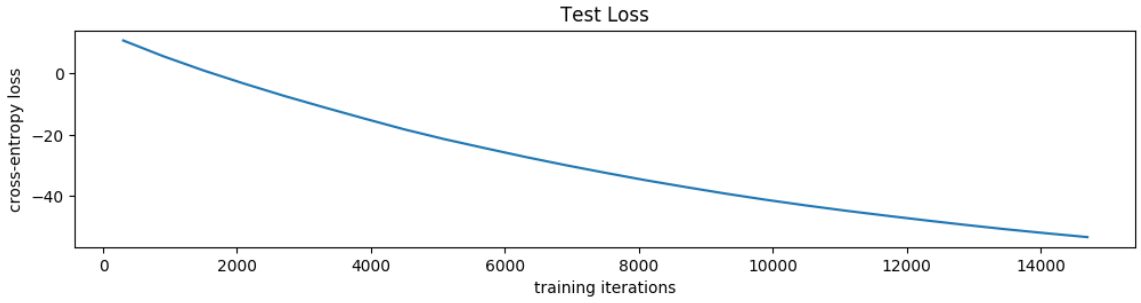

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

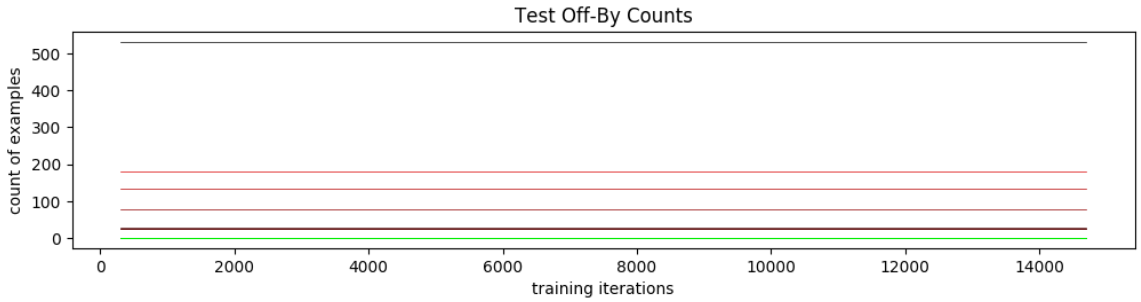

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

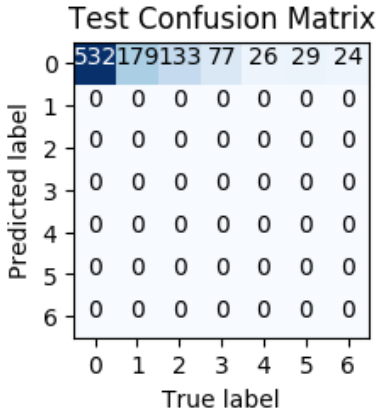

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
training iterations

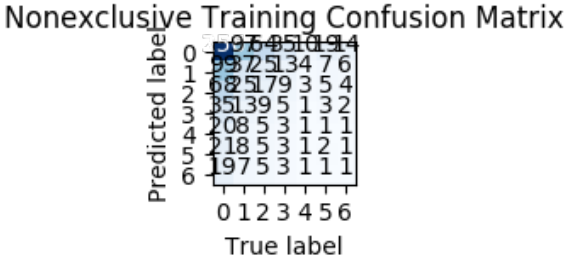

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
training iterations

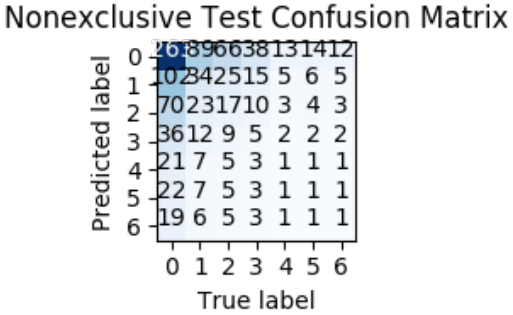

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
training iterations

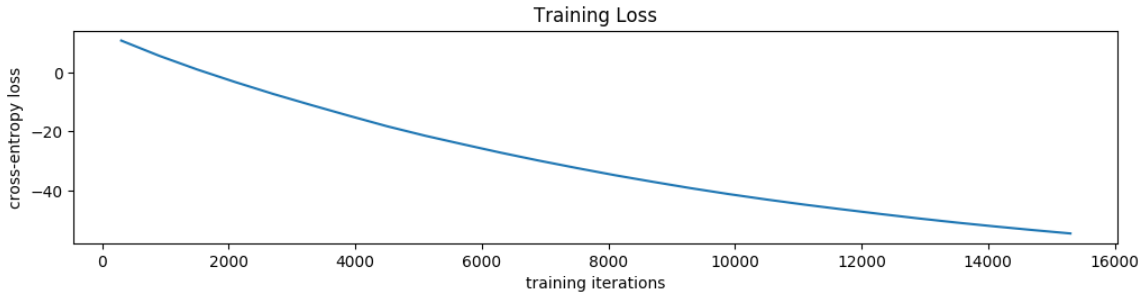

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
training iterations


Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

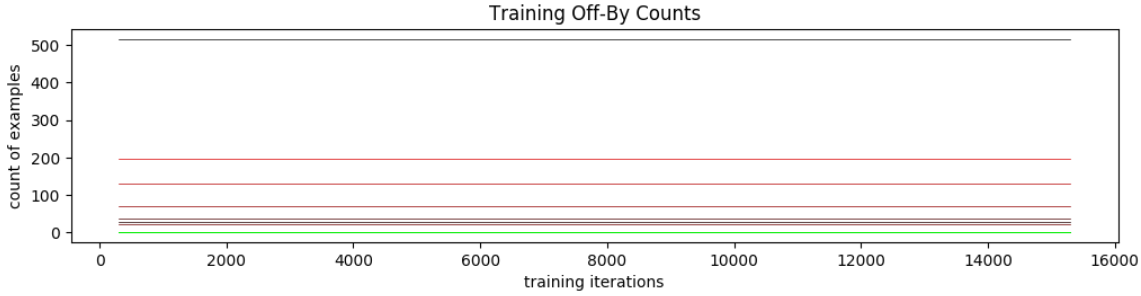

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0


Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

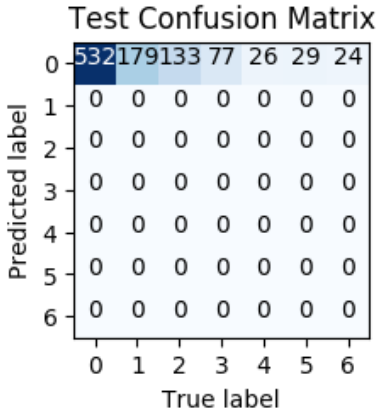

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

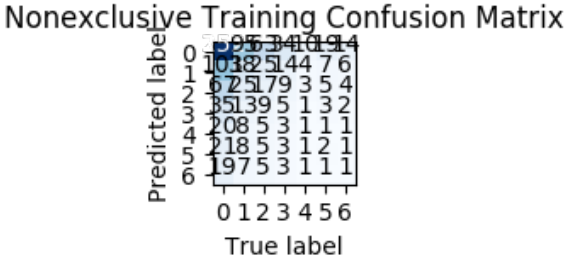

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

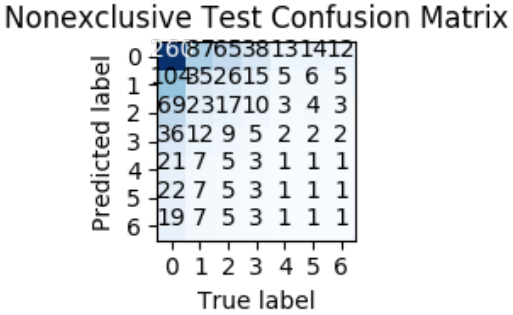

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

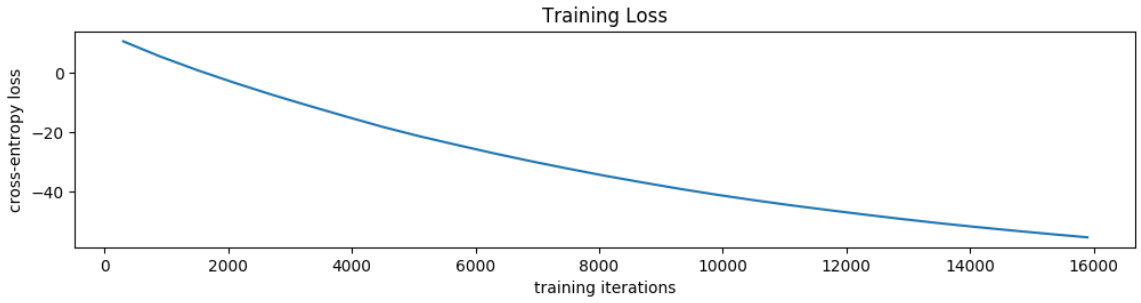

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

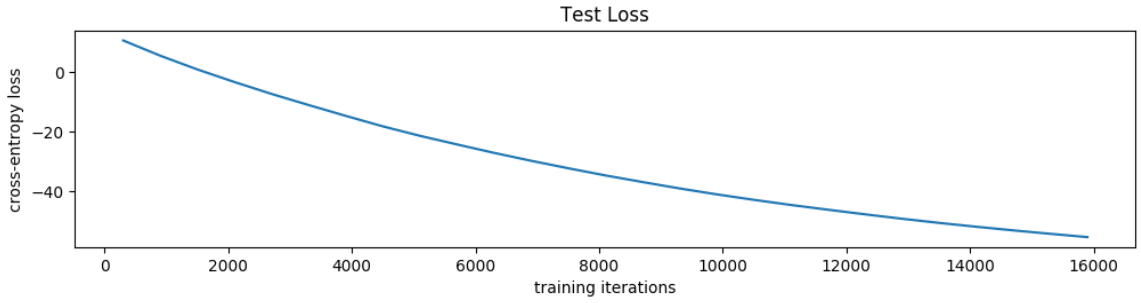

Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
517 195 130 70 21 38 29
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

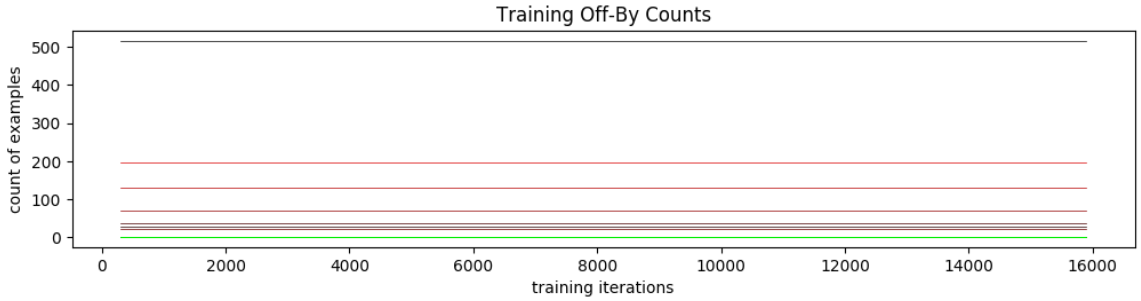

Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6
532 179 133 77 26 29 24
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0
0 0 0 0 0 0 0

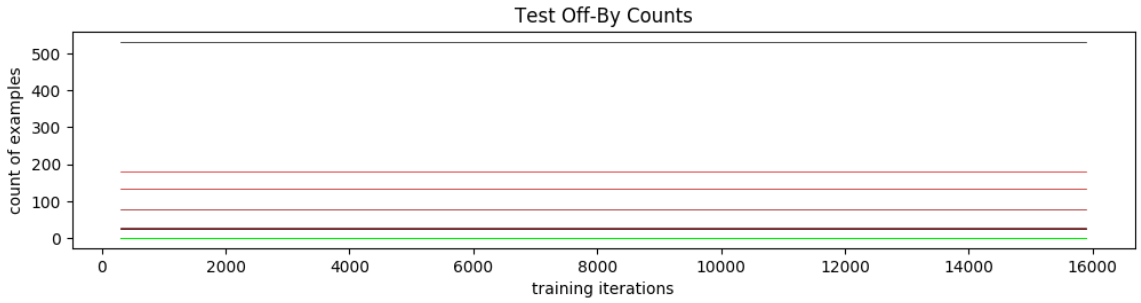

Nonexclusive Training Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6


Nonexclusive Test Confusion Matrix
Predicted label
True label
0 1 2 3 4 5 6

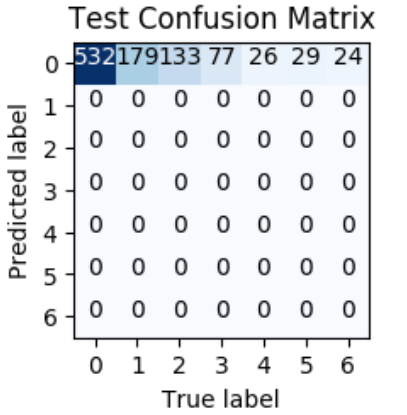

Training Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

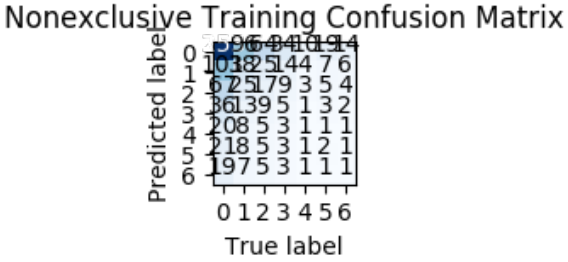

Test Loss
cross-entropy loss
0
−20
−40
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

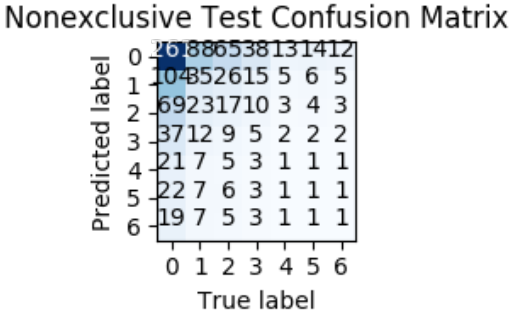

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

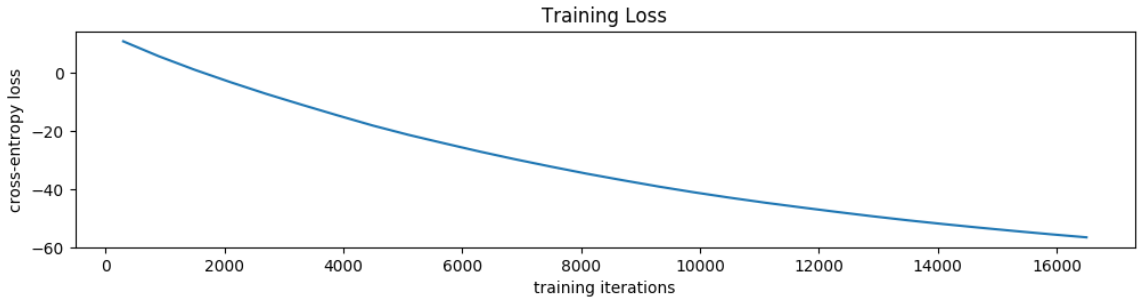

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

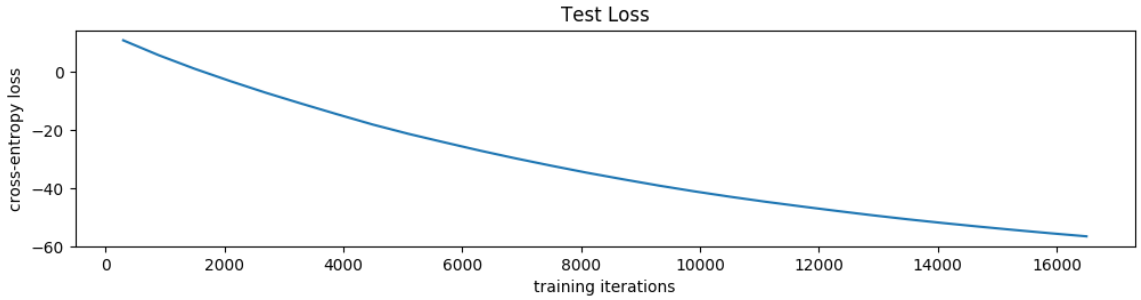

Training Confusion Matrix
Predicted label
True label

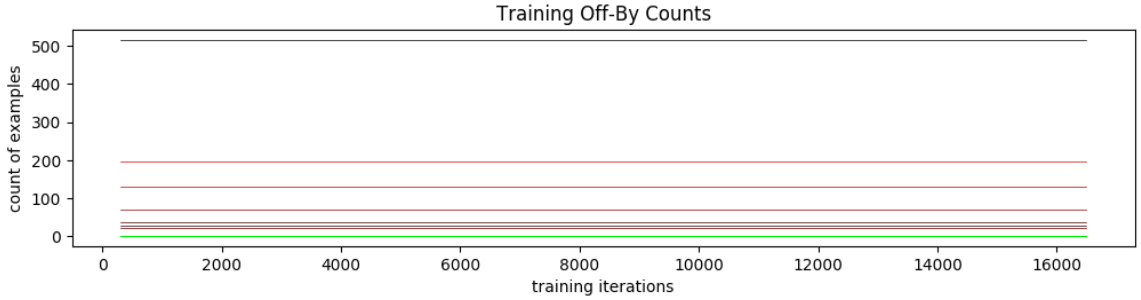

Test Confusion Matrix
Predicted label
True label

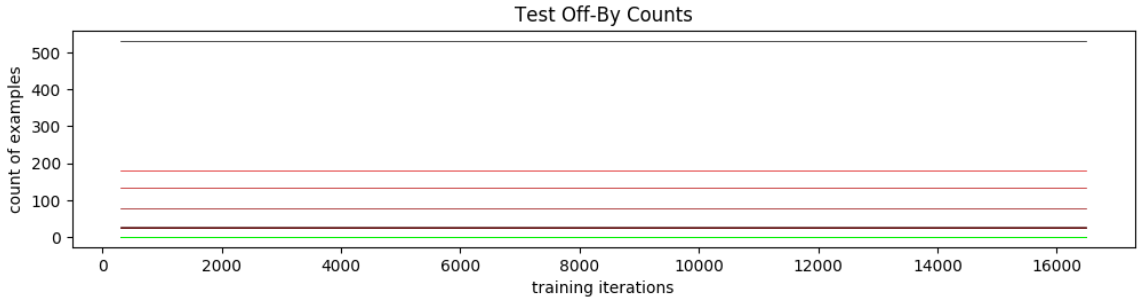

Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

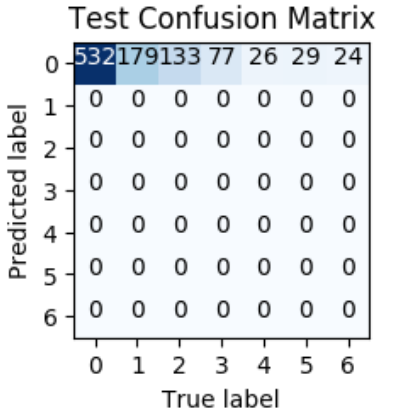

Training Loss
cross-entropy loss
0
−20
−40
−60
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

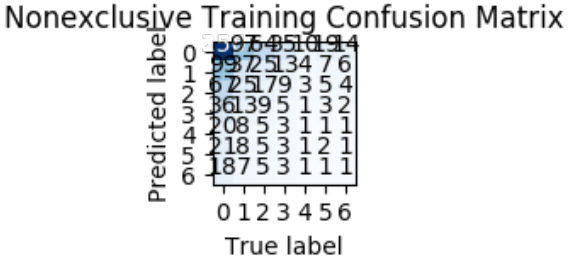

Test Loss
cross-entropy loss
0
−20
−40
−60
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

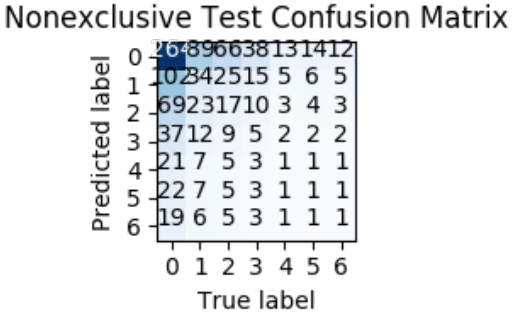

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

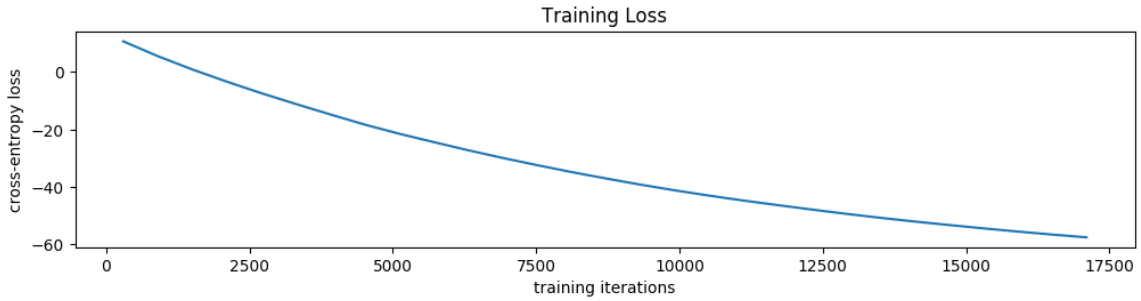

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000
16000
training iterations

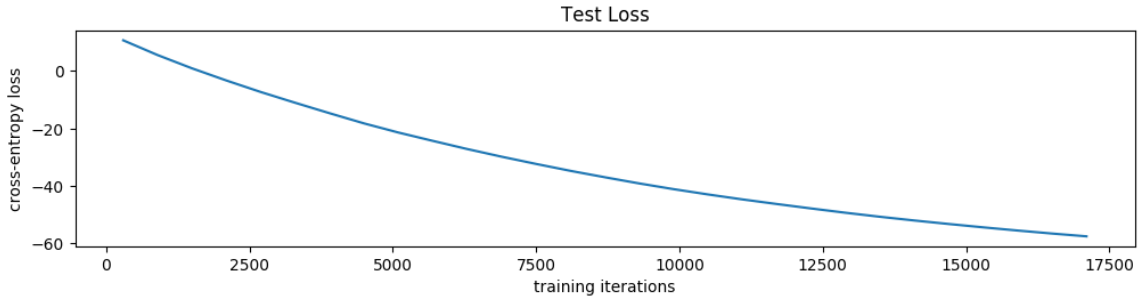

Training Confusion Matrix
Predicted label
True label

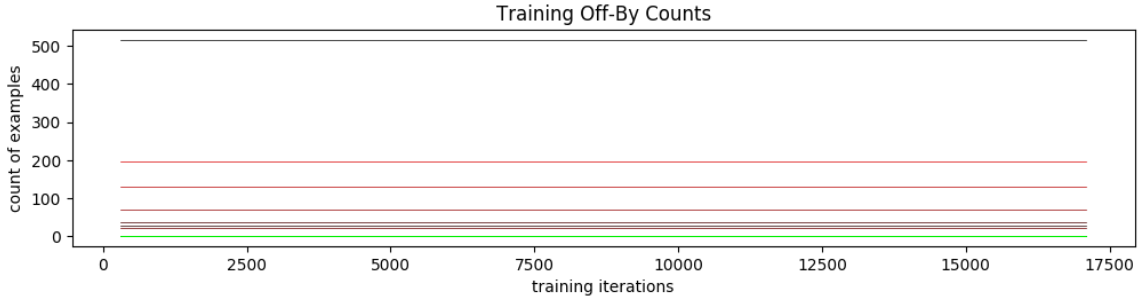

Test Confusion Matrix
Predicted label
True label

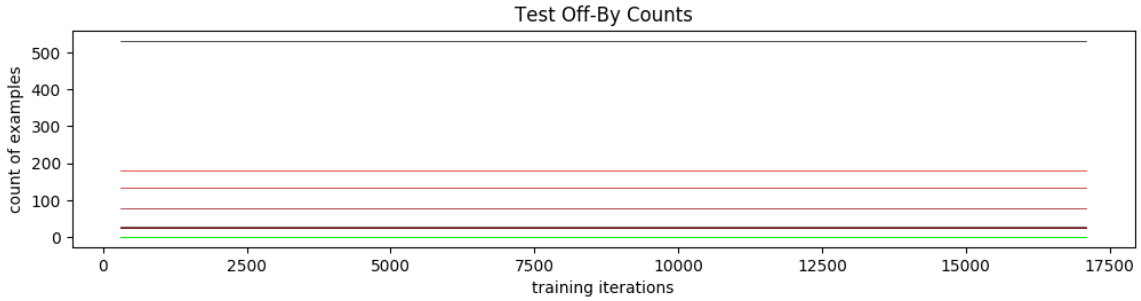

Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label

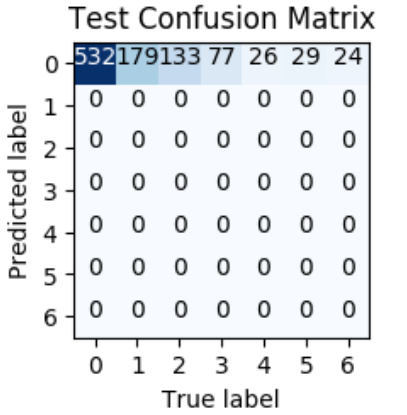

Training Loss
cross-entropy loss
0
−20
−40
−60
0
2500
5000
7500
10000
12500
15000
17500
training iterations

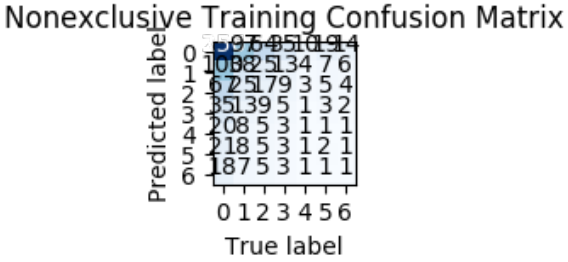

Test Loss
cross-entropy loss
0
−20
−40
−60
0
2500
5000
7500
10000
12500
15000
17500
training iterations

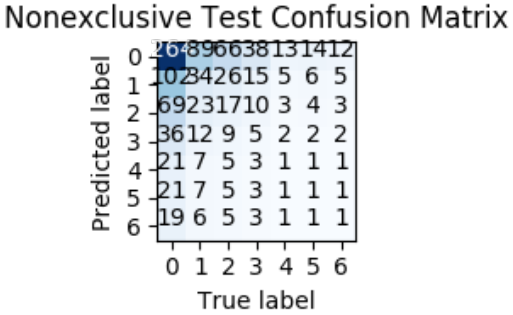

Training Off-By Counts
count of examples
500
400
300
200
100
0
0
2500
5000
7500
10000
12500
15000
17500
training iterations

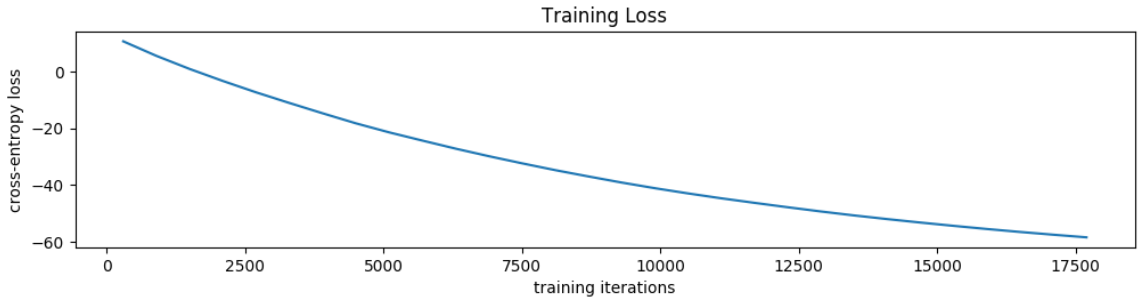

Test Off-By Counts
count of examples
500
400
300
200
100
0
0
2500
5000
7500
10000
12500
15000
17500
training iterations

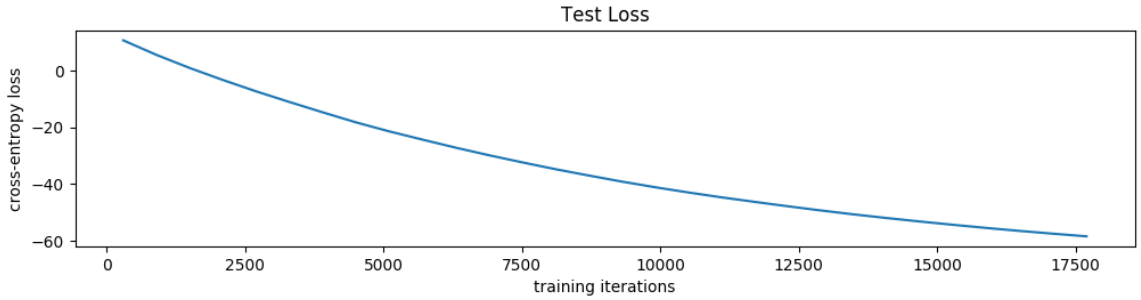

Training Confusion Matrix
Predicted label
True label

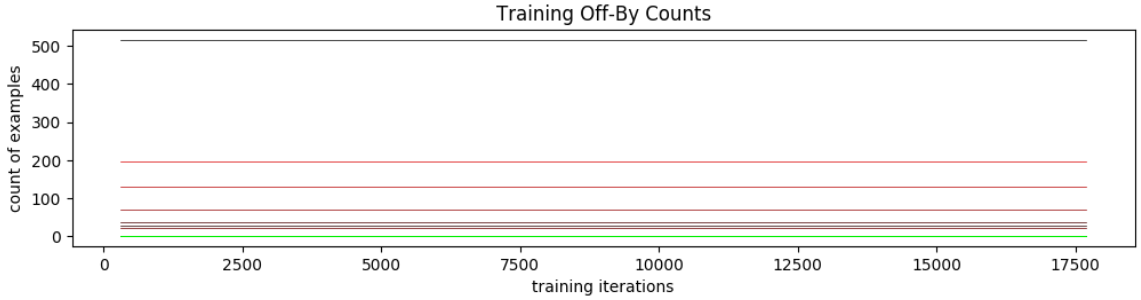

Test Confusion Matrix
Predicted label
True label

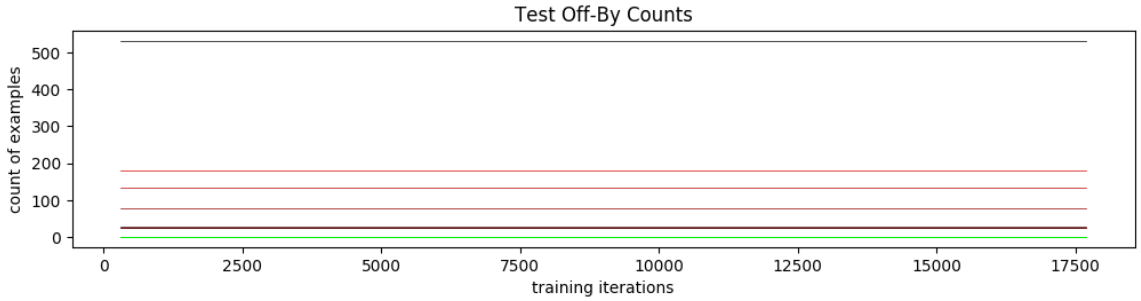

Nonexclusive Training Confusion Matrix
Predicted label
True label


Nonexclusive Test Confusion Matrix
Predicted label
True label









In [ ]:
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# Close the dataset.
microbia_segments.close()
```