Tensorboard 활용

`Scalar`, `Histogram`, `Distribution`

- Tensorboard `Scalars`, `Histogram`, `Distribution` 탭 사용
- 텐서보드를 위한 summary data 를 파일에 기록, 확인
- 텐서보드를 위한 histogram data 를 파일에 기록, 확인

주요 메소드/단계

- `tf.summary.FileWriter(dir_path,graph)` (http://devdocs.io/tensorflow~python/tf/summary/filewriter)
- `tf.summary.scalar(a_tensor)` (http://devdocs.io/tensorflow~python/tf/summary/scalar)
- `tf.summary.histogram(a_tensor)` (http://devdocs.io/tensorflow~python/tf/summary/histogram)
- `tf.summary.merge([summary_1,summary_2,...])` (http://devdocs.io/tensorflow~python/tf/summary/merge)
- `tf.summary.merge_all()` (http://devdocs.io/tensorflow~python/tf/summary/merge_all)
- summary_op eval
- `writer.add_summary()` (http://devdocs.io/tensorflow~python/tf/summary/filewriter)

수요일 실습의 mnist_linear.py 에서 발췌

In [2]:

```
from __future__ import print_function, division
import os
import numpy as np
import tensorflow as tf
from mnist_data import load_mnist, load_mnist_t10k
```

1주차 수요일 MNIST 실습 데이터와 동일한 데이터 사용

In [3]:

```
data_dir = './mnist'
data_dir
```

Out[3]:

```
'./mnist'
```

다운로드 - 쉘 스크립트 실행

In [4]:

```
%%bash
if test ! -s ./mnist/t10k-images-idx3-ubyte
then
    mkdir -p ./mnist
    cd ./mnist
    echo "$(pwd)"
    wget -q http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz
    wget -q http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz
    wget -q http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz
    wget -q http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz
    gzip -d *.gz
fi
```

```
/Users/rhee/Build/week1-day4-tensorboard/mnist
```

MNIST 데이터 특성 및, batch size, learning rate 설정

In [5]:

```
batch_size    = 128
learning_rate = 0.05

input_size    = 28 * 28
output_size   = 10
```

MNIST 훈련용 그래프 구축

In [6]:

```
input_       = tf.placeholder(shape=[None, input_size],
                              dtype=tf.float32, name="input")
label_       = tf.placeholder(shape=[None],
                              dtype=tf.int64, name="label")

weights      = tf.Variable(tf.zeros([input_size, output_size]))
biases       = tf.Variable(tf.zeros([output_size]))
output       = tf.matmul(input_, weights) + biases
pred         = tf.nn.softmax(output)

label_onehot = tf.one_hot(label_, output_size, axis=1)
loss         = tf.reduce_mean(
                    tf.nn.softmax_cross_entropy_with_logits(
                        logits=output,
                        labels=label_onehot))
trainer      = tf.train.GradientDescentOptimizer(
                    learning_rate=learning_rate)
optimize     = trainer.minimize(loss)

correct      = tf.equal(tf.argmax(pred, axis=1), label_)
accuracy     = tf.reduce_mean(tf.cast(correct, tf.float32))
```

summary_op 텐서를 그래프에 추가

- summary_op 도 또 다른 tensor 라는 점에 유의
- 따라서 session.run() (http://devdocs.io/tensorflow~python/tf/session) 이나 eval() (http://devdocs.io/tensorflow~python/tf/tensor) 없이 직접 사용할 수 없음

In [7]:

```
tf.summary.scalar('loss',loss)
tf.summary.scalar('accuracy',accuracy)
summary_op = tf.summary.merge_all()
```

그래프는 준비되었고, 이제 훈련/테스트를 위한 루프를 작성

데이터 로딩

In [8]:

```
images, labels        = load_mnist(data_dir)
t_images, t_labels    = load_mnist_t10k(data_dir)
images                = images / 127.0 - 1.0
t_images              = t_images / 127.0 - 1.0
```

세션 설정, 세션 생성, 초기화

- 아무런 설정 없이 tensorflow session 을 생성하면, 디폴트로 사용가능한 전체 메모리를 할당 해서 독점 사용하는 모드로 동작함

> By default, TensorFlow maps nearly all of the GPU memory of all GPUs (subject to CUDA_VISIBLE_DEVICES) visible to the process. This is done to more efficiently use the relatively precious GPU memory resources on the devices by reducing memory fragmentation.

- `tf.ConfigProto()` (http://devdocs.io/tensorflow~python/tf/configproto)
  - gpu 메모리 사용에 관련된 옵션을 지정할 수 있는 기능이 있음
  - config.proto (https://www.github.com/tensorflow/tensorflow/blob/r1.2/tensorflow/core/protobuf/config.proto) 파일에 정의되어 있다고 함

- gpu_options https://www.tensorflow.org/tutorials/using_gpu (https://www.tensorflow.org/tutorials/using_gpu)

> The first is the allow_growth option, which attempts to allocate only as much GPU memory based on runtime allocations: it starts out allocating very little memory, and as Sessions get run and more GPU memory is needed, we extend the GPU memory region needed by the TensorFlow process. Note that we do not release memory, since that can lead to even worse memory fragmentation

```
config.gpu_options.allow_growth = True
```

> The second method is the per_process_gpu_memory_fraction option, which determines the fraction of the overall amount of memory that each visible GPU should be allocated

```
config.gpu_options.per_process_gpu_memory_fraction = 0.4
```

In [9]:

```
config    = tf.ConfigProto()
config.gpu_options.allow_growth = True

session   = tf.InteractiveSession(config=config)

init      = tf.global_variables_initializer()
session.run(init)
```

훈련용 배치 갯수, 테스트용 배치 갯수 계산

```
In [10]: batch_count     = 60000 // batch_size
         test_count      = 10000 // batch_size
```

summary 를 logdir 디렉토리에 저장해 주는 FileWriter 생성

```
In [11]: # 혹시 이전 실행에서 만든 결과가 파일로 저장되어 있으면 먼저 지우고 시작
         !rm -fvr logdir
```

```
In [12]: writer = tf.summary.FileWriter('logdir',graph=tf.get_default_graph(
         ))
         writer

Out[12]: <tensorflow.python.summary.writer.writer.FileWriter at 0x1120ee8d0
         >
```

summary 를 기록할 때 사용할 스텝 카운터 추가

```
In [13]: step = 1
```

훈련을 위한 루프는 화요일 실습의 mnist_linear.py 에서 발췌

- line 9,10 과 23,24 에 추가된 writer 사용방법에 주목

In [14]:

```
for ep in range(50):
    total_loss = 0
    total_acc_v = 0
    for i in range(batch_count):
        img = np.reshape(
                images[i*batch_size:(i+1)*batch_size],
                [batch_size, 28 * 28])
        lbl = (labels[i*batch_size:(i+1)*batch_size])
        _, loss_v, acc_v, summary_v = session.run([
                                        optimize, loss, accuracy, s
ummary_op], \
                                        feed_dict= {input_: img, la
bel_: lbl})

        writer.add_summary(summary_v)   # <<<===== add_summary!
        step += 1

        total_loss += loss_v
        total_acc_v += acc_v

    total_acc = 0
    for a in range(test_count):
        index = a * batch_size
        img = np.reshape(
                t_images[index:index+batch_size], \
                [batch_size, 28 * 28])
        lbl = t_labels[index:index+batch_size]
        acc,summary_t = session.run(
                            [accuracy, summary_op], \
                            feed_dict={input_:img, label_:lbl})

        writer.add_summary(summary_v)   # <<<===== add_summary!
        step += 1

        total_acc += acc

    total_acc = total_acc / test_count

    print('epoch %d: loss: %.5f acc: %.5f test_acc: %.2f%%' % (
        ep+1,
        total_loss / batch_count,
        total_acc_v / batch_count,
        total_acc * 100))
```

```
epoch 1: loss: 0.51362 acc: 0.85306 test_acc: 89.49%
epoch 2: loss: 0.34259 acc: 0.90014 test_acc: 90.27%
epoch 3: loss: 0.32064 acc: 0.90680 test_acc: 90.61%
epoch 4: loss: 0.30919 acc: 0.91017 test_acc: 90.84%
epoch 5: loss: 0.30176 acc: 0.91279 test_acc: 90.94%
epoch 6: loss: 0.29638 acc: 0.91485 test_acc: 90.95%
epoch 7: loss: 0.29221 acc: 0.91642 test_acc: 90.96%
epoch 8: loss: 0.28883 acc: 0.91779 test_acc: 91.08%
epoch 9: loss: 0.28601 acc: 0.91887 test_acc: 91.13%
epoch 10: loss: 0.28359 acc: 0.91989 test_acc: 91.18%
epoch 11: loss: 0.28148 acc: 0.92054 test_acc: 91.18%
epoch 12: loss: 0.27962 acc: 0.92111 test_acc: 91.25%
epoch 13: loss: 0.27795 acc: 0.92159 test_acc: 91.34%
epoch 14: loss: 0.27644 acc: 0.92211 test_acc: 91.35%
epoch 15: loss: 0.27507 acc: 0.92248 test_acc: 91.42%
epoch 16: loss: 0.27381 acc: 0.92286 test_acc: 91.44%
epoch 17: loss: 0.27265 acc: 0.92321 test_acc: 91.43%
epoch 18: loss: 0.27158 acc: 0.92351 test_acc: 91.43%
epoch 19: loss: 0.27058 acc: 0.92386 test_acc: 91.45%
epoch 20: loss: 0.26964 acc: 0.92420 test_acc: 91.42%
epoch 21: loss: 0.26876 acc: 0.92441 test_acc: 91.47%
epoch 22: loss: 0.26794 acc: 0.92475 test_acc: 91.47%
epoch 23: loss: 0.26716 acc: 0.92495 test_acc: 91.44%
epoch 24: loss: 0.26642 acc: 0.92518 test_acc: 91.45%
epoch 25: loss: 0.26572 acc: 0.92560 test_acc: 91.46%
epoch 26: loss: 0.26505 acc: 0.92585 test_acc: 91.48%
epoch 27: loss: 0.26442 acc: 0.92613 test_acc: 91.50%
epoch 28: loss: 0.26381 acc: 0.92627 test_acc: 91.53%
epoch 29: loss: 0.26323 acc: 0.92640 test_acc: 91.55%
epoch 30: loss: 0.26268 acc: 0.92662 test_acc: 91.57%
epoch 31: loss: 0.26214 acc: 0.92672 test_acc: 91.60%
epoch 32: loss: 0.26163 acc: 0.92690 test_acc: 91.60%
epoch 33: loss: 0.26114 acc: 0.92708 test_acc: 91.61%
epoch 34: loss: 0.26067 acc: 0.92720 test_acc: 91.62%
epoch 35: loss: 0.26021 acc: 0.92732 test_acc: 91.61%
epoch 36: loss: 0.25977 acc: 0.92742 test_acc: 91.63%
epoch 37: loss: 0.25935 acc: 0.92760 test_acc: 91.59%
epoch 38: loss: 0.25893 acc: 0.92777 test_acc: 91.61%
epoch 39: loss: 0.25854 acc: 0.92783 test_acc: 91.61%
epoch 40: loss: 0.25815 acc: 0.92793 test_acc: 91.63%
epoch 41: loss: 0.25778 acc: 0.92815 test_acc: 91.66%
epoch 42: loss: 0.25741 acc: 0.92825 test_acc: 91.69%
epoch 43: loss: 0.25706 acc: 0.92834 test_acc: 91.70%
epoch 44: loss: 0.25672 acc: 0.92844 test_acc: 91.71%
epoch 45: loss: 0.25639 acc: 0.92850 test_acc: 91.70%
epoch 46: loss: 0.25606 acc: 0.92860 test_acc: 91.71%
epoch 47: loss: 0.25575 acc: 0.92879 test_acc: 91.71%
epoch 48: loss: 0.25544 acc: 0.92877 test_acc: 91.71%
epoch 49: loss: 0.25514 acc: 0.92897 test_acc: 91.72%
epoch 50: loss: 0.25485 acc: 0.92902 test_acc: 91.73%
```

텐서보드 실행

- `SCALARS` 탭에서 그래프 확인
- `Horizontal Axis` 의 선택을 `STEP`, `RELATIVE`, `WALL` 로 전환 해 봄
- `Smoothing` 슬라이더를 움직여 봄
- `Ignore outliers` 체크박스의 효과를 확인
- `Show data download links` 및, 다운로드된 csv 파일을 다른 프로그램으로 확인
- filter 기능 확인
- 텐서보드 감상 후 정지 버튼을 누르거나 `Kernel -> Interrupt` 메뉴를 선택

In [15]:

```
!tensorboard --logdir logdir
```

```
Starting TensorBoard 54 at http://rhee-mbp.local:6006
(Press CTRL+C to quit)
^C
```

기대했던 그림이 나오지 않았을 것입니다

- add_summary() 호출시 global_step= 값을 적어 줘야 함
- 이번에는 tqdm (https://pypi.python.org/pypi/tqdm) 을 써 봅시다

In [16]:

```
# 먼저, 현재 env 에 tqdm 이 설치되어 있지 않으면 설치
# 쉘 명령어 pip 를 이용
!pip install tqdm
```

```
Requirement already satisfied: tqdm in /opt/conda/envs/tensorflow/
lib/python2.7/site-packages
```

In [17]:

```
from tqdm import tqdm
```

In [18]:

```
for ep in tqdm(range(50)):
    total_loss = 0
    total_acc_v = 0
    for i in range(batch_count):
        img = np.reshape(images[i*batch_size:(i+1)*batch_size], \
                         [batch_size, 28 * 28])
        lbl = (labels[i*batch_size:(i+1)*batch_size])
        _, loss_v, acc_v, summary_v = session.run([ \
                                        optimize, loss, accuracy, s
ummary_op], \
                                        feed_dict= {input_: img, la
bel_: lbl})

        writer.add_summary(summary_v,step)
        step += 1

        total_loss += loss_v
        total_acc_v += acc_v

    total_acc = 0
    for a in range(test_count):
        index = a * batch_size
        img = np.reshape(t_images[index:index+batch_size], \
                         [batch_size, 28 * 28])
        lbl = t_labels[index:index+batch_size]
        acc,summary_t = session.run([accuracy, summary_op], \
                                    feed_dict={input_:img, label_:l
bl})

        writer.add_summary(summary_v,step)
        step += 1

        total_acc += acc
    total_acc = total_acc / test_count

print('epoch %d: loss: %.5f acc: %.5f test_acc: %.2f%%' % (
    ep+1,
    total_loss / batch_count,
    total_acc_v / batch_count,
    total_acc * 100))
```

```
100%|██████████| 50/50 [00:24<00:00,  2.05it/s]

epoch 50: loss: 0.24566 acc: 0.93187 test_acc: 91.76%
```

In [19]:

```
!tensorboard --logdir logdir
```

```
Starting TensorBoard 54 at http://rhee-mbp.local:6006
(Press CTRL+C to quit)
^C
```

logdir 에 뭐가 들어있는지 잠깐확인

In [20]:
```
!ls -la logdir
```

```
total 6352
drwxr-xr-x   3 rhee  staff      102 Sep  7 09:02 .
drwxr-xr-x  18 rhee  staff      612 Sep  7 09:02 ..
-rw-r--r--   1 rhee  staff  3248369 Sep  7 09:03 events.out.tfeven
ts.1504742523.rhee-mbp.local
```

Histogram 기능 활용

- 특정 데이터의 히스토그램을 만들어 볼 수 있는 기능
- 활용 예:
  - 훈련용 데이터에 편향성이 있는지 테스트
  - `label_` placeholder 에 들어왔던 값들의 histogram 시각화

    ```
    label_ = tf.placeholder(shape=[None], dtype=tf.int64,
    name="label")
    ```

In [21]:
```
# logdir2 에 저장하기로
!rm -fr logdir2
```

In [22]:
```
# writer 는 새로운 logdir2 에 대해서 새로 만들어 사용
writer = tf.summary.FileWriter('logdir2',graph=tf.get_default_graph
())
```

먼저, 그래프에 histogram summary 를 추가

In [23]:
```
hist_labels    = tf.summary.histogram('labels',tf.cast(label_,tf.fl
oat32))
hist_outputs   = tf.summary.histogram('outputs',tf.argmax(output,ax
is=1))

# summary_op 를 재정의. tf.summary.merge() 를 이용
summary_op = tf.summary.merge([hist_labels, hist_outputs])
```

나머지는 이전과 동일

In [24]:
```
# 이건 텐서보드 히스토그램을 위한 변수가 아님. 용도는 끝에서 설명
label_stats = [0] * 10
```

In [25]:

```
for ep in tqdm(range(50)):
    total_loss = 0
    total_acc_v = 0
    for i in range(batch_count):
        img = np.reshape(images[i*batch_size:(i+1)*batch_size],
                         [batch_size, 28 * 28])
        lbl = (labels[i*batch_size:(i+1)*batch_size])

        for l in lbl:
            label_stats[l] += 1

        _, loss_v, acc_v, summary_v = session.run(
                                        [optimize, loss, accuracy,
summary_op],
                                        feed_dict= {input_: img, la
bel_: lbl})

        writer.add_summary(summary_v,step)
        step += 1

        total_loss += loss_v
        total_acc_v += acc_v

    total_acc = 0
    for a in range(test_count):
        index = a * batch_size
        img = np.reshape(t_images[index:index+batch_size],
                         [batch_size, 28 * 28])
        lbl = t_labels[index:index+batch_size]

        for l in lbl:
            label_stats[l] += 1

        acc,summary_t = session.run([accuracy, summary_op],
                                    feed_dict={input_:img, label_:l
bl})

        writer.add_summary(summary_v,step)
        step += 1

        total_acc += acc
    total_acc = total_acc / test_count

print('epoch %d: loss: %.5f acc: %.5f test_acc: %.2f%%' % (
    ep+1,
    total_loss / batch_count,
    total_acc_v / batch_count,
    total_acc * 100))
```

```
100%|██████████| 50/50 [00:36<00:00,  1.38it/s]
```

```
epoch 50: loss: 0.24095 acc: 0.93339 test_acc: 91.78%
```

In [26]:
```
!tensorboard --logdir logdir2
```

```
Starting TensorBoard 54 at http://rhee-mbp.local:6006
(Press CTRL+C to quit)
^C
```

그림이 좀 이상할 수 있음, 다른 방법으로 다시 확인

- 위에 이렇게 적은 부분이 있습니다

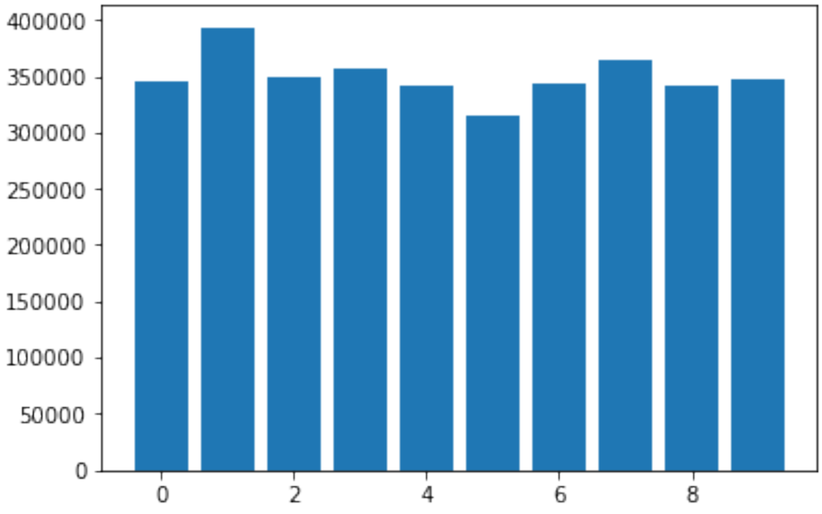
```
# 이건 텐서보드 히스토그램을 위한 변수가 아님. 용도는 끝에서 설명
label_stats = [0] * 10
```

- 학습 및 테스트 루프의 중간에 이런 코드도 있습니다

```
for l in lbl:
    label_stats[l] += 1
```

- 이렇게 파이썬 코드로 수집한 히스토그램 데이터를 그래프로 그려 봅니다

In [27]:
```
# pyplot 로 그린 그래프가 jupyter notebook 셀 내부에
# 그려지게 하려면 %matplotlib inline 이라고 적어줍니다.
# (이건 jupyter notebook 에서만 가능함. 파이썬에서 지원하는 것이 아님)
%matplotlib inline
import matplotlib.pyplot as plt
plt.bar(range(len(label_stats)),label_stats);
```



텐서보드는 다양한 범위의 데이터에 대한 히스토그램을 보여주기 위해서 몇 가지 트릭을 사용함

- exponentially distributed bins (https://www.tensorflow.org/get_started/tensorboard_histograms)
  - 0 에 가까울 수록 많은 갯수의 bin 할당 (보다 정확하게 구분되어 보임)
  - 값이 클수록 적은 갯수의 bin 할당, 따라서 많은 값들이 동일한 bins 에 포함되어 값이 뭉쳐져서 보임
  - 실제로 입력한 값들이 정수라고 해도, 히스토그램 상에서는 bin 중심과 bin 너비가 실수로 표현되고, 카운터도 실수로 표현됨

- reservoir sampling (https://en.wikipedia.org/wiki/Reservoir_sampling)
  - "Reservoir sampling is a family of randomized algorithms for randomly choosing a sample of k items from a list S containing n items, where n is either a very large or unknown number. Typically n is large enough that the list doesn't fit into main memory."