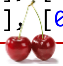
Learning rate, Evaluation

Lecture 07

Training and Test datasets

ex07_1.ipynb

```
import tensorflow as tf
x_data = [[1, 2, 1], [1, 3, 2], [1, 3, 4], [1, 5, 5], [1, 7, 5], [1, 2, 5], [1, 6, 6], [1, 7, 7]]
y_data = [[0, 0, 1], [0, 0, 1], [0, 0, 1], [0, 1, 0], [0, 1, 0], [0, 1, 0], [1, 0, 0], [1, 0, 0]]
```



```
# Evaluation our model using this test dataset
x_test = [[2, 1, 1], [3, 1, 2], [3, 3, 4]]
# y_data -> 0:apple , 1:banana, 2:chreery
y_test = [[0, 0, 1], [0, 0, 1], [0, 0, 1]] # chreery, chreery, chreery
```

0:apple , 1:banana, 2:chreery

```
X = tf.placeholder("float", [None, 3])
Y = tf.placeholder("float", [None, 3])
W = tf.Variable(tf.random_normal([3, 3]))
b = tf.Variable(tf.random_normal([3]))

hypothesis = tf.nn.softmax(tf.matmul(X, W)+b)
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)

# Correct prediction Test model
prediction = tf.arg_max(hypothesis, 1)
is_correct = tf.equal(prediction, tf.arg_max(Y, 1))
accuracy = tf.reduce_mean(tf.cast(is_correct, tf.float32))

# Launch graph
with tf.Session() as sess:
    # Initialize TensorFlow variables
    sess.run(tf.global_variables_initializer())
    for step in range(501):
        cost_val, W_val, _ = sess.run([cost, W, optimizer], feed_dict={X: x_data, Y: y_data})
        print(step, cost_val, W_val)
        print("Prediction (Training data):", sess.run(prediction, feed_dict={X: x_data}))
        print("Accuracy (Traing data) : ", sess.run(accuracy, feed_dict={X: x_data, Y: y_data}))
    # predict
    print("Prediction (Test data) :", sess.run(prediction, feed_dict={X: x_test}))
    # Calculate the accuracy
    print("Accuracy (Test data) : ", sess.run(accuracy, feed_dict={X: x_test, Y: y_test}))
```

ex07_1.ipynb Notes

```
# Launch graph
with tf.Session() as sess:
    # Initialize TensorFlow variables
    sess.run(tf.global_variables_initializer())
    for step in range(501):
        cost_val, W_val, _ = sess.run([cost, W, optimizer], feed_dict={X: x_data, Y: y_data})
        print(step, cost_val, W_val)
        print("Prediction (Training data):", sess.run(prediction, feed_dict={X: x_data}))
        print("Accuracy (Traing data) : ", sess.run(accuracy, feed_dict={X: x_data, Y: y_data}))
    # predict
    print("Prediction (Test data) :", sess.run(prediction, feed_dict={X: x_test}))
    # Calculate the accuracy
    print("Accuracy (Test data) : ", sess.run(accuracy, feed_dict={X: x_test, Y: y_test}))
```

```
0 2.2996912 [[-1.7562646   1.7202604   0.21438721]
 [ 1.4228029  -0.935836   -0.80654687]
 [-1.6507623   0.39250293 -0.16791269]]
Prediction (Training data): [0 0 1 1 0 1 1 1]
Accuracy (Traing data) :  0.25
1 1.9792893 [[-1.770933    1.6995409   0.24977517]
 [ 1.3823339  -0.988939   -0.71297485]
 [-1.6532351   0.31361917 -0.08655615]]
Prediction (Training data): [0 0 1 1 0 1 1 0]
Accuracy (Traing data) :  0.375
2 1.713191 [[-1.7902589   1.6870587   0.28158325]
 [ 1.3145436  -1.0004203  -0.6337032 ]
 [-1.6826422   0.27701578 -0.02054564]]
Prediction (Training data): [0 0 1 1 0 1 1 1]
Accuracy (Traing data) :  0.25
.
.
.
```

```
498 0.45498157 [[-3.5873568   0.9923901   2.773347  ]
 [ 0.04450103 -0.10572613 -0.25835347]
 [ 0.3373958  -0.32348207 -1.4400846 ]]
Prediction (Training data): [2 2 2 1 1 1 0 0]
Accuracy (Traing data) :  1.0
499 0.4547109 [[-3.5900013   0.9926911   2.7756906 ]
 [ 0.04449755 -0.10563093 -0.25844517]
 [ 0.3384111  -0.32359654 -1.4409854 ]]
Prediction (Training data): [2 2 2 1 1 1 0 0]
Accuracy (Traing data) :  1.0
500 0.45444074 [[-3.5926437   0.99299276  2.7780313 ]
 [ 0.04449395 -0.10553596 -0.25853655]
 [ 0.33942553 -0.3237111  -1.4418854 ]]
Prediction (Training data): [2 2 2 1 1 1 0 0]
Accuracy (Traing data) :  1.0
Prediction (Test data) : [2 2 2]
Accuracy (Test data) :  1.0
```

ex07_1(transform).ipynb (1/3)

```
import tensorflow as tf
import math
x_data = [[1, 2, 1], [1, 3, 2], [1, 3, 4], [1, 5, 5], [1, 7, 5], [1, 2, 5], [1, 6, 6], [1, 7, 7]]

# y_data -> 0:apple , 1:banana, 2:chreery
y_data = [[0, 0, 1], [0, 0, 1], [0, 0, 1], [0, 1, 0], [0, 1, 0], [0, 1, 0], [1, 0, 0], [1, 0, 0]]
```



```
# Evaluation our model using this test dataset
x_test = [[2, 1, 1], [3, 1, 2], [3, 3, 4]]
y_test = [[0, 0, 1], [0, 0, 1], [0, 0, 1]] # chreery, chreery, chreery
```

0:apple , 1:banana, 2:chreery

```
X = tf.placeholder("float", [None, 3])
Y = tf.placeholder("float", [None, 3])
W = tf.Variable(tf.random_normal([3, 3]))
b = tf.Variable(tf.random_normal([3]))

hypothesis = tf.nn.softmax(tf.matmul(X, W)+b)
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)

# Correct prediction Test model
# arg_max(hypothesis, falg) ... flag : 0 -> 열 기준, flag : 1 -> 행기준으로 max value 출력
prediction = tf.arg_max(hypothesis, 1)
is_correct = tf.equal(prediction, tf.arg_max(Y, 1))
accuracy = tf.reduce_mean(tf.cast(is_correct, tf.float32))
```

```
def is_fruit (in_x, out_y):
    for i in range (len(in_x)):
        print (i+1,"번째 x_test", in_x[i], "==> y_test", out_y[i], end="")
        if (out_y[i] == [1, 0, 0]):
            print(" ==> [0] : apple")
        elif (out_y[i] == [0, 1, 0]):
            print(" ==> [1] : banana")
        elif (out_y[i] == [0, 0, 1]):
            print(" ==> [2] : chreery")

def is_judement (result) :
    for i in range (3):
        if (result[i] == 0 ):
            print(i+1, "번째  ==> [0] : apple")
        elif (result[i] == 1 ):
            print(i+1, "번째  ==> [1] : banana")
        elif (result[i] == 2 ):
            print(i+1, "번째  ==> [2] : chreery")
```

```
# Launch graph
with tf.Session() as sess:
   # Initialize TensorFlow variables
   sess.run(tf.global_variables_initializer())
   print("<< Training Data Set >>")
   for step in range(501):
       cost_val, W_val, _ = sess.run([cost, W, optimizer], feed_dict={X: x_data, Y: y_data})
       if step % 50 == 0:
            print("Learning step :",step, " --> cost :", cost_val,"\nWeight \n",W_val,"\n", "-"*60)
   print("● Final prediction (Training data):", sess.run(prediction, feed_dict={X: x_data}))
   print("● Final accuracy (Traing data) : ", sess.run(accuracy, feed_dict={X: x_data, Y: y_data}))

   print("===== Training data status =====")
   is_fruit(x_data, y_data)
   print("===== Test data status ( Before the test ) =====")
   is_fruit(x_test, y_test)

   print("\n● After the test")
   h = sess.run(hypothesis, feed_dict={X:x_test,  Y: y_test})
   print("hypothesis \n",h, "-->", sess.run(tf.argmax(h, 1)))
   print("\n● Testing & One-hot encoding & argmax")

   j = sess.run(prediction, feed_dict={X:x_test, Y: y_test})
   print("===== Prediction (Test data):", j )
   is_judement (j)
   print("===== Accuracy (Test data) : ", sess.run(accuracy, feed_dict={X: x_test, Y: y_test}))
```

```python
# Launch graph
with tf.Session() as sess:
    # Initialize TensorFlow variables
    sess.run(tf.global_variables_initializer())
    print("<< Training Data Set >>")
    for step in range(501):
        cost_val, W_val, _ = sess.run([cost, W, optimizer], feed_dict={X: x_data, Y: y_data})
        if step % 50 == 0:
            print("Learning step :",step, " --> cost :", cost_val,"\nWeight \n",W_val,"\n", "-"*60)
```

```
<< Training Data Set >>
Learning step : 0  --> cost : 3.4696183
Weight
 [[-0.6321241  -1.109235    0.9458518 ]
 [ 0.35602173 -1.0994108  -2.0837579 ]
 [-0.5058836   0.7992822  -0.79470414]]
 ------------------------------------------------------------
Learning step : 50  --> cost : 0.7419552
Weight
 [[-1.0581461  -1.270544    1.533183  ]
 [-0.5376851  -1.1321889  -1.1572723 ]
 [-0.25241247  0.19651505 -0.445408  ]]
.
.
.
```

```
Learning step : 450  --> cost : 0.4691949
Weight
 [[-2.5302148  -1.1657758   2.900484  ]
 [-0.7867282  -0.943809   -1.0966074 ]
 [ 0.58073646  0.02327914 -1.1053201 ]]
 ------------------------------------------------------------
Learning step : 500  --> cost : 0.45514995
Weight
 [[-2.6688042  -1.1400882   3.0133858 ]
 [-0.7875462  -0.9393229  -1.100275  ]
 [ 0.63408476  0.01366759 -1.1490563 ]]
 ------------------------------------------------------------
```

```python
def is_fruit (in_x, out_y):
    for i in range (len(in_x)):
        print (i+1,"번째 x_test", in_x[i], "==> y_test", out_y[i], end="")
        if (out_y[i] == [1, 0, 0]):
            print(" ==> [0] : apple")
        elif (out_y[i] == [0, 1, 0]):
            print(" ==> [1] : banana")
        elif (out_y[i] == [0, 0, 1]):
            print(" ==> [2] : chreery")
```

```python
print("● Final prediction (Training data):",
      sess.run(prediction, feed_dict={X: x_data}))
print("● Final accuracy (Traing data) : ",
      sess.run(accuracy, feed_dict={X: x_data, Y: y_data}))

print("===== Training data status =====")
is_fruit(x_data, y_data)
print("===== Test data status ( Before the test ) =====")
is_fruit(x_test, y_test)
```

```
● Final prediction (Training data): [2 2 2 1 1 1 0 0]
● Final accuracy (Traing data) :  1.0
===== Training data status =====
1 번째 x_test [1, 2, 1] ==> y_test [0, 0, 1] ==> [2] : chreery
2 번째 x_test [1, 3, 2] ==> y_test [0, 0, 1] ==> [2] : chreery
3 번째 x_test [1, 3, 4] ==> y_test [0, 0, 1] ==> [2] : chreery
4 번째 x_test [1, 5, 5] ==> y_test [0, 1, 0] ==> [1] : banana
5 번째 x_test [1, 7, 5] ==> y_test [0, 1, 0] ==> [1] : banana
6 번째 x_test [1, 2, 5] ==> y_test [0, 1, 0] ==> [1] : banana
7 번째 x_test [1, 6, 6] ==> y_test [1, 0, 0] ==> [0] : apple
8 번째 x_test [1, 7, 7] ==> y_test [1, 0, 0] ==> [0] : apple
===== Test data status ( Before the test ) =====
1 번째 x_test [2, 1, 1] ==> y_test [0, 0, 1] ==> [2] : chreery
2 번째 x_test [3, 1, 2] ==> y_test [0, 0, 1] ==> [2] : chreery
3 번째 x_test [3, 3, 4] ==> y_test [0, 0, 1] ==> [2] : chreery
```

```python
def is_judement (result) :
    for i in range (3):
        if (result[i] == 0 ):
            print(i+1, "번째  ==> [0] : apple")
        elif (result[i] == 1 ):
            print(i+1, "번째  ==> [1] : banana")
        elif (result[i] == 2 ):
            print(i+1, "번째  ==> [2] : chreery")
```

```python
print("\n● After the test")
h = sess.run(hypothesis, feed_dict={X:x_test,  Y: y_test})
print("hypothesis \n",h, "-->", sess.run(tf.argmax(h, 1)))
print("\n● Testing & One-hot encoding & argmax")

j = sess.run(prediction, feed_dict={X:x_test, Y: y_test})

print("===== Prediction (Test data):", j )
is_judement (j)
print("===== Accuracy (Test data) : ", sess.run(accuracy, feed_dict={X: x_test, Y: y_test}))
```

```
● After the test
hypothesis
 [[3.04229353e-08 8.56510960e-05 9.99914289e-01]
 [5.11312992e-10 3.92902257e-06 9.99996066e-01]
 [1.56409740e-07 1.03688646e-04 9.99896169e-01]] --> [2 2 2]

● Testing & One-hot encoding & argmax
===== Prediction (Test data): [2 2 2]
1 번째  ==> [2] : chreery
2 번째  ==> [2] : chreery
3 번째  ==> [2] : chreery
===== Accuracy (Test data) :  1.0
```

ex07_1(transform).ipynb Notes

```
# Evaluation our model using this test dataset
x_test = [[2, 1, 1], [3, 1, 2], [3, 3, 4]]
y_test = [[0, 0, 1], [0, 0, 1], [0, 0, 1]] # chreery, chreery, banana
```

test data를

```
x_test =[1, 7, 4]
Y_test= [0, 1, 0]
```

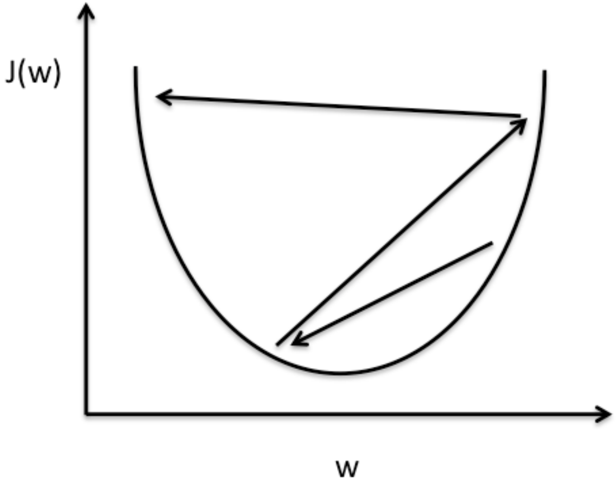
수정해보면?

`0:apple , 1:banana, 2:chreery`

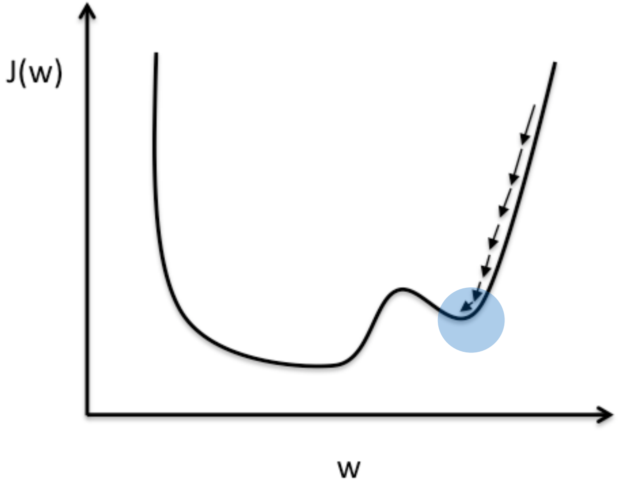
?

● Testing & One-hot encoding & argmax
===== Prediction (Test data): [2 2 1]
1 번째 ==> [2] : chreery
2 번째 ==> [2] : chreery
3 번째 ==> [1] : banana
===== Accuracy (Test data) : 1.0

Learning rate: NaN!



Large learning rate: Overshooting.



Small learning rate: Many iterations until convergence and trapping in local minima.

ex07_2.ipynb

Big learning rate

```
import tensorflow as tf
x_data = [[1, 2, 1], [1, 3, 2], [1, 3, 4], [1, 5, 5], [1, 7, 5], [1, 2, 5], [1, 6, 6], [1, 7, 7]]
y_data = [[0, 0, 1], [0, 0, 1], [0, 0, 1], [0, 1, 0], [0, 1, 0], [0, 1, 0], [1, 0, 0], [1, 0, 0]]

# Evaluation our model using this test dataset
x_test = [[2, 1, 1], [3, 1, 2], [3, 3, 4]]
y_test = [[0, 0, 1], [0, 0, 1], [0, 0, 1]]

X = tf.placeholder("float", [None, 3])
Y = tf.placeholder("float", [None, 3])
W = tf.Variable(tf.random_normal([3, 3]))
b = tf.Variable(tf.random_normal([3]))
hypothesis = tf.nn.softmax(tf.matmul(X, W)+b)
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=1.5).minimize(cost)

# Correct prediction Test model
prediction = tf.arg_max(hypothesis, 1)
is_correct = tf.equal(prediction, tf.arg_max(Y, 1))
accuracy = tf.reduce_mean(tf.cast(is_correct, tf.float32))

# Launch graph
with tf.Session() as sess:
   # Initialize TensorFlow variables
   sess.run(tf.global_variables_initializer())
   for step in range(201):
       cost_val, W_val, _ = sess.run([cost, W, optimizer], feed_dict={X: x_data, Y: y_data})
       print(step, cost_val, W_val)

   # predict
   print("Prediction:", sess.run(prediction, feed_dict={X: x_test}))
   # Calculate the accuracy
   print("Accuracy: ", sess.run(accuracy, feed_dict={X: x_test, Y: y_test}))
```

ex07_2.ipynb Notes

Big learning rate

```
0 7.69576 [[-1.86076     0.7373613   0.22763175]
 [-3.930552    2.4045415   0.76974255]
 [-1.7390196   2.5221922  -0.53009176]]
1 22.288763 [[-1.48576    -0.19887078  0.78886384]
 [-1.493052   -1.5304112   2.2671952 ]
 [ 0.69848037 -1.2265282   0.78112864]]
2 19.95736 [[-1.1107602   0.36362904 -0.1486358 ]
 [ 0.9444475   1.0945883  -2.7953038 ]
 [ 3.13598     1.5859714  -4.46887    ]]
3 10.775541 [[-1.9627129  0.6530824  0.4138636]
 [-2.49461    3.033647  -1.295305 ]
 [-0.5506878  3.96014   -3.1563706]]
.
.
.
16 18.668709 [[-3.1342359  -1.150421    3.3888903 ]
 [-0.13658166 -2.5777168   1.9580312 ]
 [ 0.8776705   0.3838768  -1.0084648 ]]
17 13.756121 [[-2.7592447  -0.58792126  2.4513993 ]
 [ 2.3009005   0.0472827  -3.1044502 ]
 [ 3.3151267   3.1963756  -6.25842    ]]
18 nan [[nan nan nan]
 [nan nan nan]
 [nan nan nan]]
```

```
19 nan [[nan nan nan]
 [nan nan nan]
 [nan nan nan]]
20 nan [[nan nan nan]
 [nan nan nan]
 [nan nan nan]]
.
.
.
199 nan [[nan nan nan]
 [nan nan nan]
 [nan nan nan]]
200 nan [[nan nan nan]
 [nan nan nan]
 [nan nan nan]]
Prediction: [0 0 0]
Accuracy:  0.0
```

Not a Number

ex07_2.ipynb

Small learning rate

```
import tensorflow as tf
x_data = [[1, 2, 1], [1, 3, 2], [1, 3, 4], [1, 5, 5], [1, 7, 5], [1, 2, 5], [1, 6, 6], [1, 7, 7]]
y_data = [[0, 0, 1], [0, 0, 1], [0, 0, 1], [0, 1, 0], [0, 1, 0], [0, 1, 0], [1, 0, 0], [1, 0, 0]]

# Evaluation our model using this test dataset
x_test = [[2, 1, 1], [3, 1, 2], [3, 3, 4]]
y_test = [[0, 0, 1], [0, 0, 1], [0, 0, 1]]
X = tf.placeholder("float", [None, 3])
Y = tf.placeholder("float", [None, 3])
W = tf.Variable(tf.random_normal([3, 3]))
b = tf.Variable(tf.random_normal([3]))
hypothesis = tf.nn.softmax(tf.matmul(X, W)+b)
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=1e-10).minimize(cost)

# Correct prediction Test model
prediction = tf.arg_max(hypothesis, 1)
is_correct = tf.equal(prediction, tf.arg_max(Y, 1))
accuracy = tf.reduce_mean(tf.cast(is_correct, tf.float32))

# Launch graph
with tf.Session() as sess:
   # Initialize TensorFlow variables
   sess.run(tf.global_variables_initializer())
   for step in range(201):
       cost_val, W_val, _ = sess.run([cost, W, optimizer], feed_dict={X: x_data, Y: y_data})
       print(step, cost_val, W_val)

   # predict
   print("Prediction:", sess.run(prediction, feed_dict={X: x_test}))
   # Calculate the accuracy
   print("Accuracy: ", sess.run(accuracy, feed_dict={X: x_test, Y: y_test}))
```

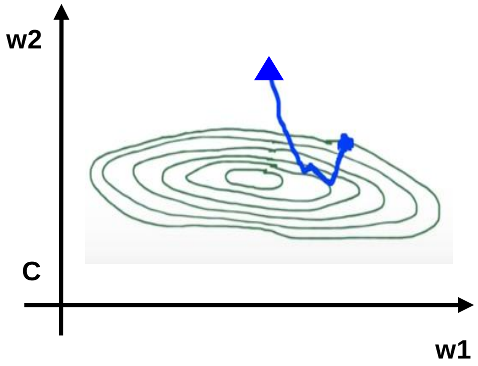
Learning rate을
수정해보면?

```
0 2.5269933 [[-0.8000901  -0.03641263 -0.5059993 ]
 [ 0.01268478 -1.2704163  -0.01171977]
 [ 1.73678     1.8877689   0.05738154]]
1 2.5269933 [[-0.8000901  -0.03641263 -0.5059993 ]
 [ 0.01268478 -1.2704163  -0.01171977]
 [ 1.73678     1.8877689   0.05738154]]
2 2.5269933 [[-0.8000901  -0.03641263 -0.5059993 ]
 [ 0.01268478 -1.2704163  -0.01171977]
 [ 1.73678     1.8877689   0.05738154]]
3 2.5269933 [[-0.8000901  -0.03641263 -0.5059993 ]
 [ 0.01268478 -1.2704163  -0.01171977]
 [ 1.73678     1.8877689   0.05738154]].
.
.
.
198 2.5269933 [[-0.8000901  -0.03641263 -0.5059993 ]
 [ 0.01268478 -1.2704163  -0.01171977]
 [ 1.73678     1.8877689   0.05738154]]
199 2.5269933 [[-0.8000901  -0.03641263 -0.5059993 ]
 [ 0.01268478 -1.2704163  -0.01171977]
 [ 1.73678     1.8877689   0.05738154]]
200 2.5269933 [[-0.8000901  -0.03641263 -0.5059993 ]
 [ 0.01268478 -1.2704163  -0.01171977]
 [ 1.73678     1.8877689   0.05738154]]
Prediction: [1 1 1]
Accuracy:  0.0
```

Small learning rate

Non-normalized inputs

```
xy = np.array([[828.659973, 833.450012, 908100, 828.349976, 831.659973],
               [823.02002, 828.070007, 1828100, 821.655029, 828.070007],
               [819.929993, 824.400024, 1438100, 818.97998, 824.159973],
               [816, 820.958984, 1008100, 815.48999, 819.23999],
               [819.359985, 823, 1188100, 818.469971, 818.97998],
               [819, 823, 1198100, 816, 820.450012],
               [811.700012, 815.25, 1098100, 809.780029, 813.669983],
               [809.51001, 816.659973, 1398100, 804.539978, 809.559998]])
```



ex07_3.ipynb

```
import tensorflow as tf
import numpy as np
xy = np.array([[828.659973, 833.450012, 908100, 828.349976, 831.659973],
               [823.02002, 828.070007, 1828100, 821.655029, 828.070007],
               [819.929993, 824.400024, 1438100, 818.97998, 824.159973],
               [816, 820.958984, 1008100, 815.48999, 819.23999],
               [819.359985, 823, 1188100, 818.469971, 818.97998],
               [819, 823, 1198100, 816, 820.450012],
               [811.700012, 815.25, 1098100, 809.780029, 813.669983],
               [809.51001, 816.659973, 1398100, 804.539978, 809.559998]])
x_data = xy[:, 0:-1]
y_data = xy[:, [-1]]
# placeholders for a tensor that will be always fed.
X = tf.placeholder(tf.float32, shape=[None, 4])
Y = tf.placeholder(tf.float32, shape=[None, 1])
W = tf.Variable(tf.random_normal([4, 1]), name='weight')
b = tf.Variable(tf.random_normal([1]), name='bias')

hypothesis = tf.matmul(X, W) + b
cost = tf.reduce_mean(tf.square(hypothesis - Y))
# Minimize
optimizer = tf.train.GradientDescentOptimizer(learning_rate=1e-5)
train = optimizer.minimize(cost)
sess = tf.Session()
sess.run(tf.global_variables_initializer())
for step in range(2001):
   cost_val, hy_val, _ = sess.run(
       [cost, hypothesis, train], feed_dict={X: x_data, Y: y_data})
   print(step, "Cost: ", cost_val, "\nPrediction:\n", hy_val)
```

Non-normalized inputs

ex07_3.ipynb Notes

Non-normalized inputs

0 Cost: 1042318700000.0
Prediction:
[[-719781.6]
[-1448409.4]
[-1139530.9]
[-798971.8]
[-941533.1]
[-949452.]
[-870248.3]
[-1107841.5]]
1 Cost: 1.145175e+27
Prediction:
[[2.3870814e+13]
[4.8054397e+13]
[3.7802658e+13]
[2.6499464e+13]
[3.1231035e+13]
[3.1493900e+13]
[2.8865250e+13]
[3.6751200e+13]]
2 Cost: inf

infinit

Prediction:
[[-7.9123031e+20]
[-1.5928278e+21]
[-1.2530202e+21]
[-8.7836054e+20]
[-1.0351948e+21]
[-1.0439078e+21]
[-9.5677764e+20]
[-1.2181681e+21]]

3 Cost: inf
Prediction:
[[2.6226397e+28]
[5.2796426e+28]
[4.1533043e+28]
[2.9114442e+28]
[3.4312927e+28]
[3.4601733e+28]
[3.1713685e+28]
[4.0377825e+28]]
4 Cost: inf
Prediction:
[[-8.69309384e+35]
[-1.75000877e+36]
[-1.37666887e+36]
[-9.65037524e+35]
[-1.13734824e+36]
[-1.14692106e+36]
[-1.05119292e+36]
[-1.33837758e+36]]
5 Cost: inf
Prediction:
[[inf]
[inf]
[inf]
[inf]
[inf]
[inf]
[inf]
[inf]]

6 Cost: nan
Prediction:
[[nan]
[nan]
[nan]
[nan]
[nan]
[nan]
[nan]
[nan]]

.
.
.

1999 Cost: nan
Prediction:
[[nan]
[nan]
[nan]
[nan]
[nan]
[nan]
[nan]
[nan]]

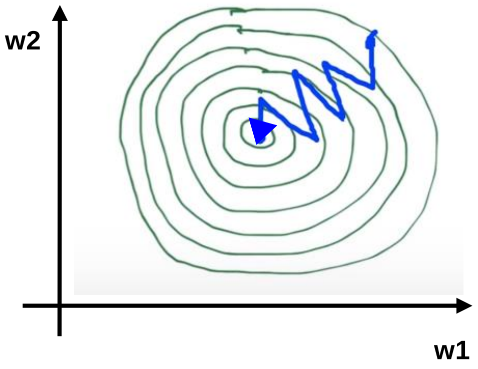
2000 Cost: nan
Prediction:
[[nan]
[nan]
[nan]
[nan]
[nan]
[nan]
[nan]
[nan]]

Normalized inputs (min-max scale)

```
xy = np.array([[828.659973, 833.450012, 908100, 828.349976, 831.659973],
               [823.02002, 828.070007, 1828100, 821.655029, 828.070007],
               [819.929993, 824.400024, 1438100, 818.97998, 824.159973],
               [816, 820.958984, 1008100, 815.48999, 819.23999],
               [819.359985, 823, 1188100, 818.469971, 818.97998],
               [819, 823, 1198100, 816, 820.450012],
               [811.700012, 815.25, 1098100, 809.780029, 813.669983],
               [809.51001, 816.659973, 1398100, 804.539978, 809.559998]])
```

```
xy = MinMaxScaler(xy)
print(xy)
```

x1	x2	x3	x4	y
[[1.	1.	0.	1.	1.]
[0.70548491	0.70439552	1.	0.71881782	0.83755791]
[0.54412549	0.50274824	0.57608696	0.606468	0.6606331]
[0.33890353	0.31368023	0.10869565	0.45989134	0.43800918]
[0.51436	0.42582389	0.30434783	0.58504805	0.42624401]
[0.49556179	0.42582389	0.31521739	0.48131134	0.49276137]
[0.11436064	0.	0.20652174	0.22007776	0.18597238]
[0.	0.07747099	0.5326087	0.	0.]]



ex07_4.ipynb

Normalized inputs

```
import tensorflow as tf
import numpy as np
from sklearn.preprocessing import MinMaxScaler
xy = np.array([[828.659973, 833.450012, 908100, 828.349976, 831.659973],
               [823.02002, 828.070007, 1828100, 821.655029, 828.070007],
               [819.929993, 824.400024, 1438100, 818.97998, 824.159973],
               [816, 820.958984, 1008100, 815.48999, 819.23999],
               [819.359985, 823, 1188100, 818.469971, 818.97998],
               [819, 823, 1198100, 816, 820.450012],
               [811.700012, 815.25, 1098100, 809.780029, 813.669983],
               [809.51001, 816.659973, 1398100, 804.539978, 809.559998]])
scaler = MinMaxScaler(feature_range=(0,1))
xy = scaler.fit_transform(xy)
print(xy)
x_data = xy[:, 0:-1]
y_data = xy[:, [-1]]
# placeholders for a tensor that will be always fed.
X = tf.placeholder(tf.float32, shape=[None, 4])
Y = tf.placeholder(tf.float32, shape=[None, 1])
W = tf.Variable(tf.random_normal([4, 1]), name='weight')
b = tf.Variable(tf.random_normal([1]), name='bias')

hypothesis = tf.matmul(X, W) + b
cost = tf.reduce_mean(tf.square(hypothesis - Y))
# Minimize
optimizer = tf.train.GradientDescentOptimizer(learning_rate=1e-5)
train = optimizer.minimize(cost)

sess = tf.Session()
sess.run(tf.global_variables_initializer())
for step in range(2001):
   cost_val, hy_val, _ = sess.run(
       [cost, hypothesis, train], feed_dict={X: x_data, Y: y_data})
   print(step, "Cost: ", cost_val, "\nPrediction:\n", hy_val)
```

```
[[1.         1.         0.         1.         1.        ]
 [0.70548491 0.70439552 1.         0.71881783 0.83755792]
 [0.54412549 0.50274824 0.57608696 0.60646801 0.6606331 ]
 [0.33890353 0.31368023 0.10869565 0.45989134 0.43800918]
 [0.51436    0.4258239  0.30434783 0.58504805 0.42624401]
 [0.49556179 0.4258239  0.31521739 0.48131134 0.49276137]
 [0.11436064 0.         0.20652174 0.22007776 0.18597238]
 [0.         0.07747099 0.5326087  0.         0.        ]]
```

ex07_4.ipynb Notes

Normalized inputs

```
0 Cost:  0.074025065
Prediction:
 [[0.9788008 ]
 [0.328222  ]
 [0.51908445]
 [0.71493864]
 [0.6580242 ]
 [0.56422794]
 [0.5497217 ]
 [0.21085313]]
1 Cost:  0.07402483
Prediction:
 [[0.9788008 ]
 [0.32822236]
 [0.5190842 ]
 [0.714938  ]
 [0.65802383]
 [0.56422746]
 [0.54972076]
 [0.21085235]]
2 Cost:  0.07402457
Prediction:
 [[0.9788008 ]
 [0.32822278]
 [0.5190841 ]
 [0.71493727]
 [0.65802336]
 [0.56422704]
 [0.5497198 ]
 [0.21085161]]
```

```
3 Cost:  0.074024335
Prediction:
 [[0.9788008 ]
 [0.32822314]
 [0.519084  ]
 [0.7149366 ]
 [0.658023  ]
 [0.5642266 ]
 [0.54971886]
 [0.21085083]]
4 Cost:  0.07402408
Prediction:
 [[0.9788008 ]
 [0.3282235 ]
 [0.51908386]
 [0.7149359 ]
 [0.65802264]
 [0.56422627]
 [0.5497179 ]
 [0.21085006]]
5 Cost:  0.07402384
Prediction:
 [[0.9788008 ]
 [0.32822385]
 [0.51908374]
 [0.7149352 ]
 [0.6580222 ]
 [0.56422585]
 [0.549717  ]
 [0.21084929]]
```

```
6 Cost:  0.07402359
Prediction:
 [[0.9788008 ]
 [0.3282242 ]
 [0.5190836 ]
 [0.7149345 ]
 [0.6580218 ]
 [0.56422544]
 [0.54971606]
 [0.21084851]]

.
.
.

1999 Cost:  0.073532164
Prediction:
 [[0.97882617]
 [0.32897308]
 [0.5188199 ]
 [0.7135573 ]
 [0.6572516 ]
 [0.56340575]
 [0.5478343 ]
 [0.2093167 ]]
```

```
2000 Cost:  0.0735319
Prediction:
 [[0.97882617]
 [0.3289735 ]
 [0.5188198 ]
 [0.7135566 ]
 [0.65725124]
 [0.5634054 ]
 [0.5478333 ]
 [0.20931596]]
```

MNIST data

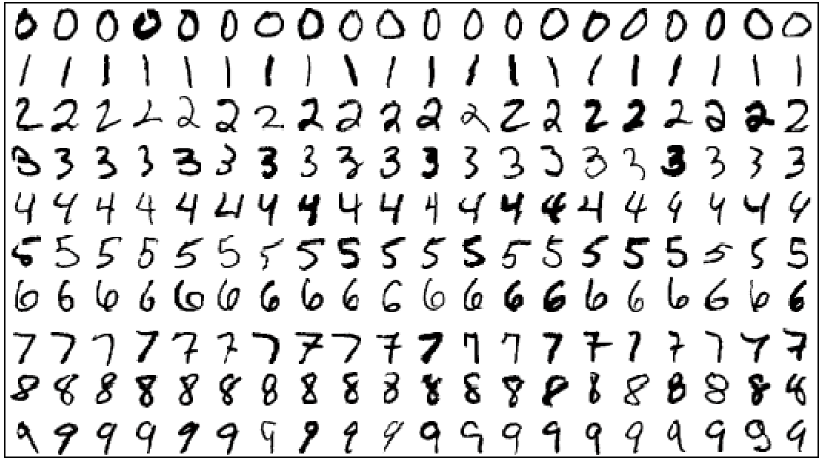
(Modified National Institute of Standards and Technology database)

https://www.tensorflow.org/tutorials/layers

http://yann.lecun.com/exdb/mnist/

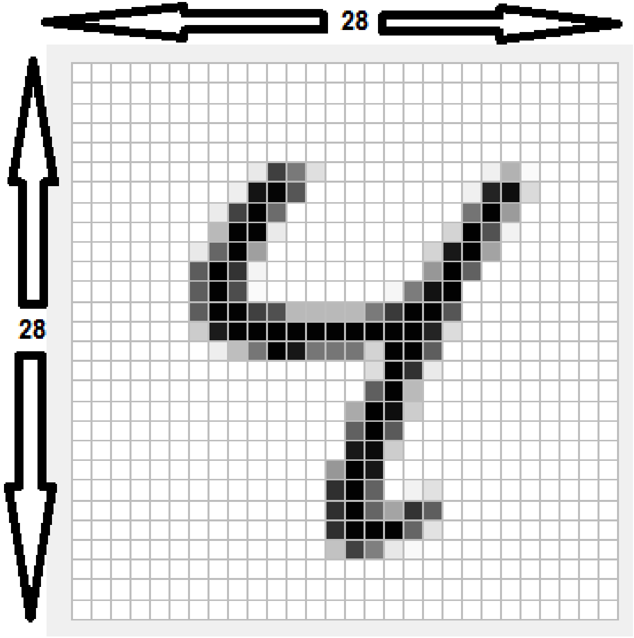
http://www.incodom.kr/MNIST

MNIST Dataset



train-images-idx3-ubyte.gz: training set images (9912422 bytes)
train-labels-idx1-ubyte.gz: training set labels (28881 bytes)
t10k-images-idx3-ubyte.gz: test set images (1648877 bytes)
t10k-labels-idx1-ubyte.gz: test set labels (4542 bytes)

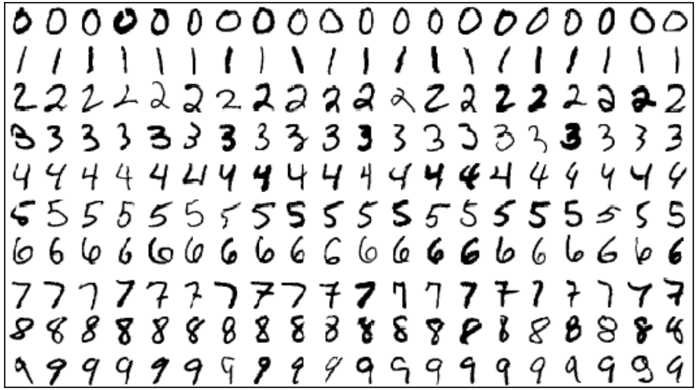
28x28x1 image




```
# MNIST data image of shape 28 * 28 = 784
X = tf.placeholder(tf.float32, [None, 784])

# 0 - 9 digits recognition = 10 classes
# one hot encoding
Y = tf.placeholder(tf.float32, [None, nb_classes])
```

Classification



MNIST Dataset

```
from tensorflow.examples.tutorials.mnist import input_data
# Check out https://www.tensorflow.org/get_started/mnist/beginners for
# more information about the mnist dataset
mnist = input_data.read_data_sets("MNIST_data/", one_hot=True)
                                            # one_hot=True로 하면 읽어올 때 one_hot으로 읽어온다.
…
batch_xs, batch_ys = mnist.train.next_batch(100) #100개씩 X,Y 데이터를 읽는다는 뜻
…
print("Accuracy: ", accuracy.eval(session=sess,                # 평가는 test데이터로 실행
          feed_dict={X: mnist.test.images, Y: mnist.test.labels}))
```

Reading data and set variables

```
from tensorflow.examples.tutorials.mnist import input_data
# Check out https://www.tensorflow.org/get_started/mnist/beginners for
# more information about the mnist dataset
mnist = input_data.read_data_sets("MNIST_data/", one_hot=True)

nb_classes = 10   # 0 ~ 9

# MNIST data image of shape 28 * 28 = 784
X = tf.placeholder(tf.float32, [None, 784])
# 0 - 9 digits recognition = 10 classes
Y = tf.placeholder(tf.float32, [None, nb_classes])

W = tf.Variable(tf.random_normal([784, nb_classes]))
b = tf.Variable(tf.random_normal([nb_classes]))
```

Softmax!

Cost
: Cross Entropy

```
# Hypothesis (using softmax)
hypothesis = tf.nn.softmax(tf.matmul(X, W) + b)

cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)

# Test model
# hypothesis와 Y는 one_hot
# tf.argmax(A , flag) : matrix A에서 flag가 0이면 column 기준,
                        1이면 row 기준으로 큰 값의 index를 반환함 (index는 0부터 시작..)

is_correct = tf.equal(tf.arg_max(hypothesis, 1), tf.arg_max(Y, 1)) # Calculate

# Calculate accuracy
accuracy = tf.reduce_mean(tf.cast(is_correct, tf.float32))
```

Training epoch/batch

```
# parameters
training_epochs = 15   # epoch을 15번
batch_size = 100 # MNIST dataset -> batch_size는 100
print("train data 라인 수? ", mnist.train.num_examples)
print("test data 라인 수? ", mnist.test.num_examples)
with tf.Session() as sess:
   # Initialize TensorFlow variables
   sess.run(tf.global_variables_initializer())
```

train data 라인 수? 55000
test data 라인 수? 10000

```
Epoch: 0001 cost = 2.634815730
Epoch: 0002 cost = 1.077760680
Epoch: 0003 cost = 0.873424181
.
.
.
Epoch: 0015 cost = 0.467620506
```

```
   # Training cycle
   for epoch in range(training_epochs):  # 15번 반복
       avg_cost = 0
       # 만약 mnist.train.num_examples이 10000 이라면 batch_size는 100으로 설정했으므로 total_batch는 100이 됨
       total_batch = int(mnist.train.num_examples / batch_size) # iterations계산

       for i in range(total_batch): # 100개씩을 iterations만큼 반복
           batch_xs, batch_ys = mnist.train.next_batch(batch_size)
           c, _ = sess.run([cost, optimizer], feed_dict={X: batch_xs, Y: batch_ys})
           avg_cost += c / total_batch

       print('Epoch:', '%04d' % (epoch + 1), 'cost =', '{:.9f}'.format(avg_cost))
```

Training epoch/batch

In the neural network terminology:

- **one epoch** = one forward pass and one backward pass of all the training examples
- **batch size** = the number of training examples in one forward/backward pass. The higher the batch size, the more memory space you'll need.
- number of **iterations** = number of passes, each pass using [batch size] number of examples. To be clear, one pass = one forward pass + one backward pass (we do not count the forward pass and backward pass as two different passes).

Example: if you have *1000 training examples*, and your *batch size is 500*, then it will take 2 iterations to complete 1 epoch.

Report results on test dataset

```
# Test the model using test sets
# sess.run(accuracy)호출하여 실행하지 않고, 지금처럼 accuracy 하나만 실행시킬 경우는 accuracy.eval로 실행할 수 도 있다.
                                                                    # 평가는 test데이터로 실행
print("Accuracy: ", accuracy.eval(session=sess,feed_dict={X: mnist.test.images, Y: mnist.test.labels}))
```

```python
import tensorflow as tf
import random
import matplotlib.pyplot as plt
tf.set_random_seed(777)  # for reproducibility

from tensorflow.examples.tutorials.mnist import input_data
# Check out https://www.tensorflow.org/get_started/mnist/beginners for
# more information about the mnist dataset
mnist = input_data.read_data_sets("MNIST_data/", one_hot=True)

nb_classes = 10

# MNIST data image of shape 28 * 28 = 784
X = tf.placeholder(tf.float32, [None, 784])
# 0 - 9 digits recognition = 10 classes
Y = tf.placeholder(tf.float32, [None, nb_classes])

W = tf.Variable(tf.random_normal([784, nb_classes]))
b = tf.Variable(tf.random_normal([nb_classes]))

# Hypothesis (using softmax)
hypothesis = tf.nn.softmax(tf.matmul(X, W) + b)

cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)

# Test model
is_correct = tf.equal(tf.arg_max(hypothesis, 1), tf.arg_max(Y, 1))
# Calculate accuracy
accuracy = tf.reduce_mean(tf.cast(is_correct, tf.float32))

# parameters
training_epochs = 15
batch_size = 100
print("train data 라인 수? ", mnist.train.num_examples)
print("test data 라인 수? ", mnist.test.num_examples)
```

```python
with tf.Session() as sess:
    # Initialize TensorFlow variables
    sess.run(tf.global_variables_initializer())

    # Training cycle
    for epoch in range(training_epochs):
        avg_cost = 0
        total_batch = int(mnist.train.num_examples / batch_size)

        for i in range(total_batch):
            batch_xs, batch_ys = mnist.train.next_batch(batch_size)
            c, _ = sess.run([cost, optimizer], feed_dict={
                            X: batch_xs, Y: batch_ys})
            avg_cost += c / total_batch

        print('Epoch:', '%04d' % (epoch + 1),
              'cost =', '{:.9f}'.format(avg_cost))

    print("Learning finished")

    # Test the model using test sets
    print("Accuracy: ", accuracy.eval(session=sess,
          feed_dict={X: mnist.test.images, Y: mnist.test.labels}))
```

슬라이드 35 참고

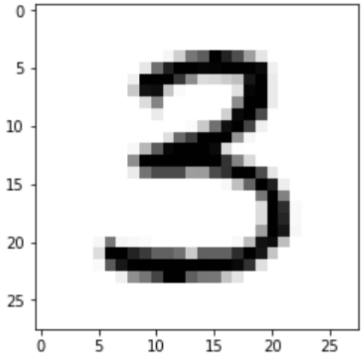
```python
    # Get one and predict
    r = random.randint(0, mnist.test.num_examples - 1)
    print("Label: ", sess.run(tf.argmax(mnist.test.labels[r:r+1], 1)))
    print("Prediction: ", sess.run(tf.argmax(hypothesis, 1),
          feed_dict={X: mnist.test.images[r:r+1]}))

    plt.imshow(mnist.test.images[r:r+1].reshape(28, 28), cmap='Greys',
               interpolation='nearest')
    plt.show()
```

ex07_5(MNIST).ipynb Notes

```
Extracting MNIST_data/train-images-idx3-ubyte.gz
Extracting MNIST_data/train-labels-idx1-ubyte.gz
Extracting MNIST_data/t10k-images-idx3-ubyte.gz
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
train data 라인 수?  55000
test data 라인 수?  10000
Epoch: 0001 cost = 2.634815730
Epoch: 0002 cost = 1.077760680
Epoch: 0003 cost = 0.873424181
Epoch: 0004 cost = 0.767336464
Epoch: 0005 cost = 0.699621943
Epoch: 0006 cost = 0.650446147
Epoch: 0007 cost = 0.613367878
Epoch: 0008 cost = 0.583544073
Epoch: 0009 cost = 0.558514040
Epoch: 0010 cost = 0.537824098
Epoch: 0011 cost = 0.520229367
Epoch: 0012 cost = 0.504439400
Epoch: 0013 cost = 0.490998493
Epoch: 0014 cost = 0.479148924
Epoch: 0015 cost = 0.467620506
Learning finished
Accuracy:  0.8902
```

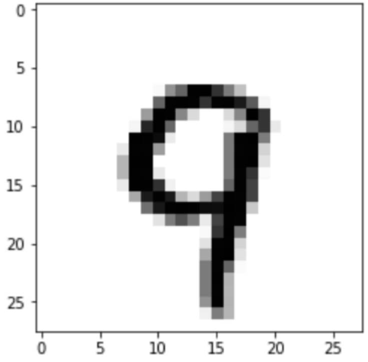
Label: [3]
Prediction: [3]



ex07_5(MNIST).ipynb Notes

```
Extracting MNIST_data/train-images-idx3-ubyte.gz
Extracting MNIST_data/train-labels-idx1-ubyte.gz
Extracting MNIST_data/t10k-images-idx3-ubyte.gz
Extracting MNIST_data/t10k-labels-idx1-ubyte.gz
train data 라인 수?  55000
test data 라인 수?  10000
Epoch: 0001 cost = 2.830286795
Epoch: 0002 cost = 1.076869145
Epoch: 0003 cost = 0.867981110
Epoch: 0004 cost = 0.764389601
Epoch: 0005 cost = 0.697936169
Epoch: 0006 cost = 0.650696784
Epoch: 0007 cost = 0.614819005
Epoch: 0008 cost = 0.585748923
Epoch: 0009 cost = 0.561699718
Epoch: 0010 cost = 0.541536403
Epoch: 0011 cost = 0.523699328
Epoch: 0012 cost = 0.508244300
Epoch: 0013 cost = 0.494522717
Epoch: 0014 cost = 0.482683731
Epoch: 0015 cost = 0.470785214
Learning finished
Accuracy:  0.889
```

Label: [9]
Prediction: [9]



Sample image show and prediction

```
# Get one and predict
    r = random.randint(0, mnist.test.num_examples - 1)

    print("test data 에서 랜덤으로 선택된 레이블 [r:r+1] (one-hot) : " , mnist.test.labels[r:r+1]) # 적절한 shape (O)
    print("test data 에서 랜덤으로 선택된 레이블 [r] (one-hot) : " , mnist.test.labels[r]) # shape (x), 확인 후 삭제
    print("test data 에서 랜덤으로 선택된 값의 레이블 (argmax) : ", sess.run(tf.argmax(mnist.test.labels[r:r+1], 1)))
    pred = sess.run(tf.argmax(hypothesis, 1), feed_dict={X: mnist.test.images[r:r+1]}) # 반드시 label이 아닌 image를 실행해야 됨
    print("예측된 데이터 값 (argmax) : ", pred)

    plt.imshow( mnist.test.images[r:r+1].reshape(28, 28),cmap='Greys',interpolation='nearest')
    plt.show()
```

test data 에서 랜덤으로 선택된 레이블 [r:r+1] (one-hot) : [[0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]]
test data 에서 랜덤으로 선택된 레이블 [r] (one-hot) : [0. 0. 0. 0. 0. 0. 0. 0. 1. 0.]
test data 에서 랜덤으로 선택된 값의 레이블 (argmax) : [8]
예측된 데이터 값 (argmax) : [8]