With TF 1.0!

Lab 6

Softmax Classifier

Sung Kim <hunkim+ml@gmail.com>
Code: https://github.com/hunkim/DeepLearningZeroToAll/

Call for comments

Please feel free to add comments directly on these slides

Other slides: https://goo.gl/jPtWNt

Picture from http://www.tssablog.org/archives/3280

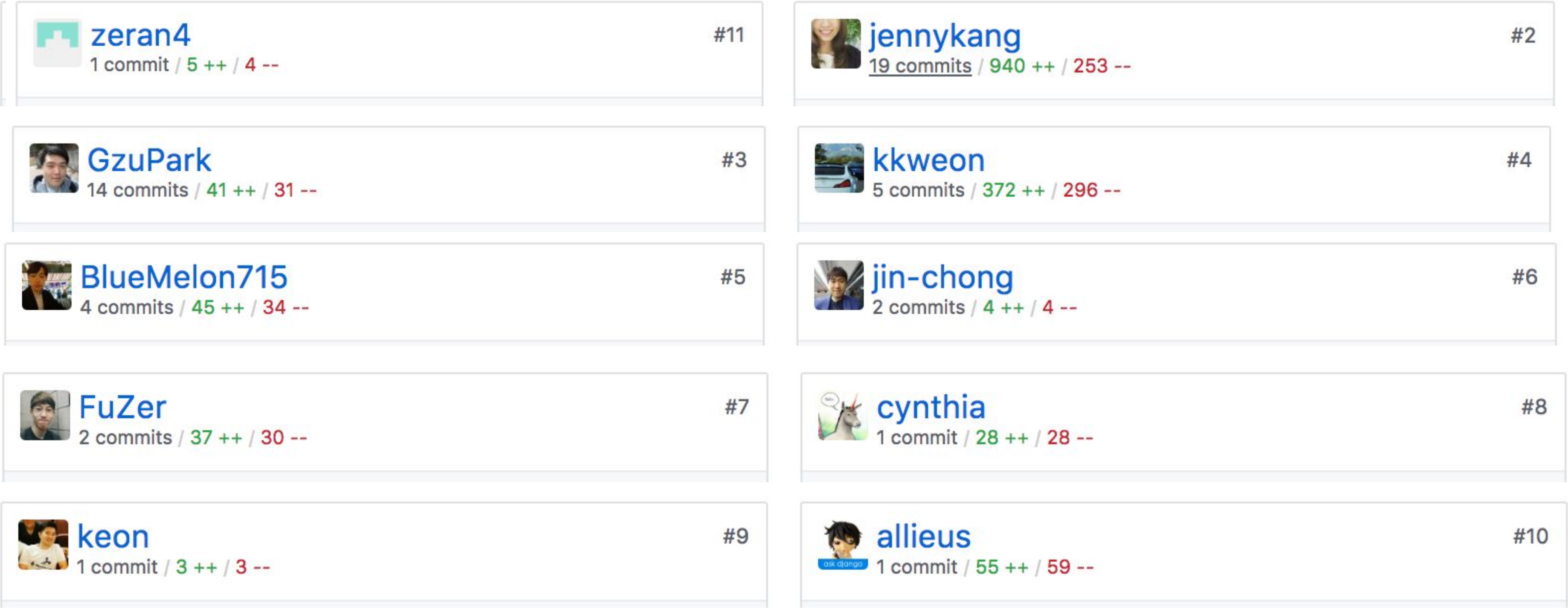
With TF 1.0!

Lab 6-1

Softmax Classifier

Sung Kim <hunkim+ml@gmail.com>
Code: https://github.com/hunkim/DeepLearningZeroToAll/

https://github.com/hunkim/DeepLearningZeroToAll/



zeran4 #11
1 commit / 5 ++ / 4 --

jennykang #2
19 commits / 940 ++ / 253 --

GzuPark #3
14 commits / 41 ++ / 31 --

kkweon #4
5 commits / 372 ++ / 296 --

BlueMelon715 #5
4 commits / 45 ++ / 34 --

jin-chong #6
2 commits / 4 ++ / 4 --

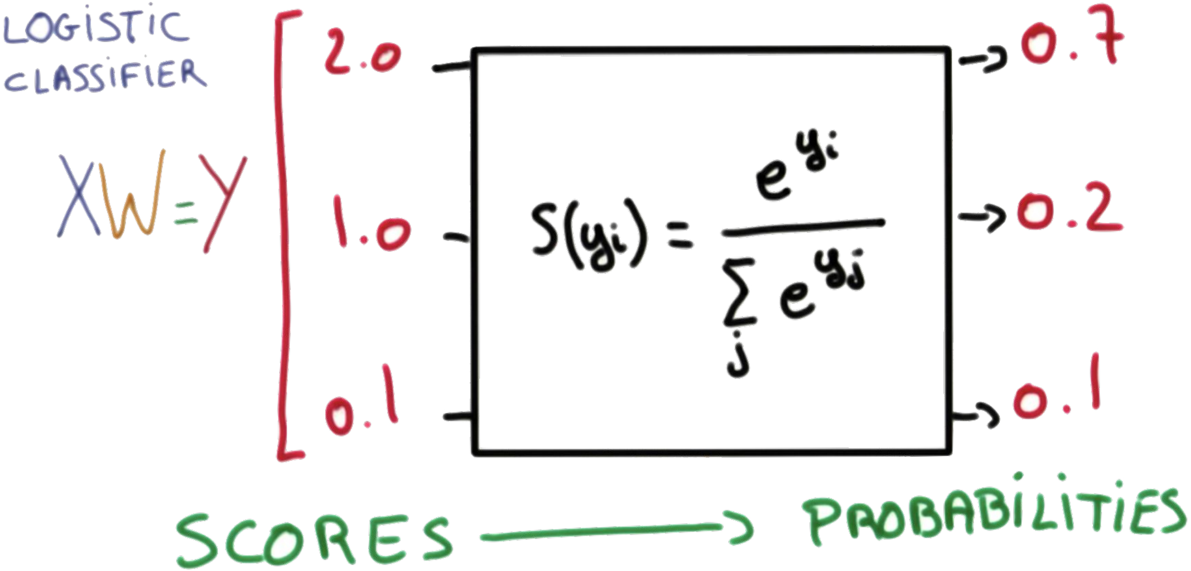
FuZer #7
2 commits / 37 ++ / 30 --

cynthia #8
1 commit / 28 ++ / 28 --

keon #9
1 commit / 3 ++ / 3 --

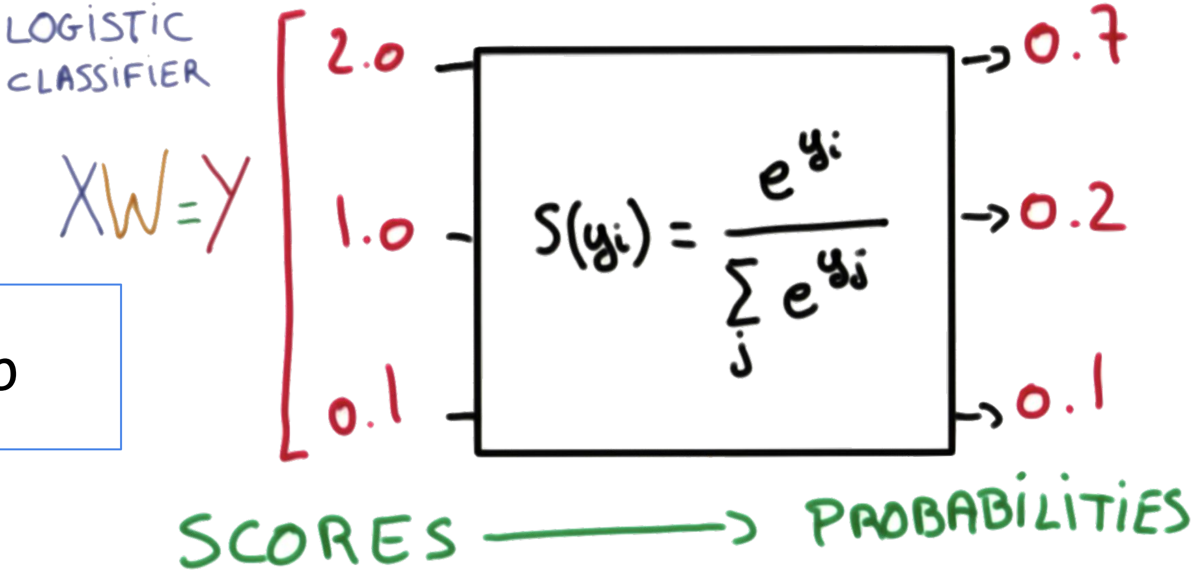
allieus #10
1 commit / 55 ++ / 59 --

Softmax function



https://www.udacity.com/course/viewer#!/c-ud730/l-6370362152/m-6379811817

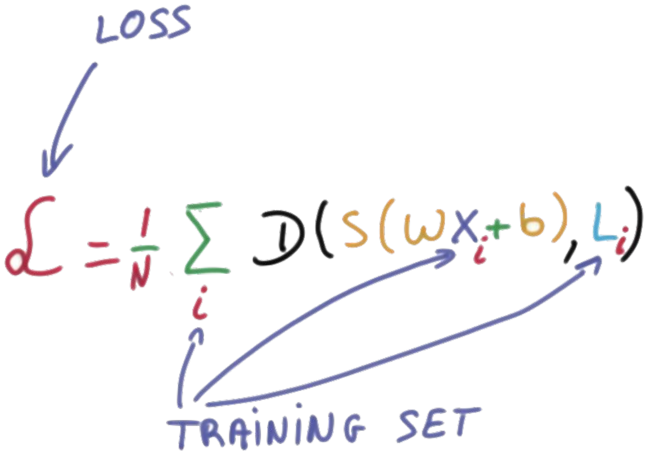
```
hypothesis = tf.nn.softmax(tf.matmul(X,W)+b)
```

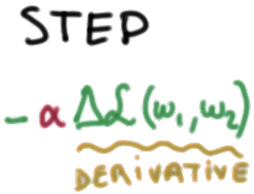


```
tf.matmul(X,W)+b
```

https://www.udacity.com/course/viewer#!/c-ud730/l-6370362152/m-6379811817

Cost function: cross entropy

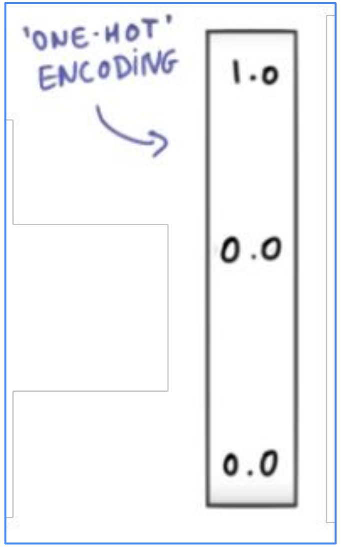




```
# Cross entropy cost/loss
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))

optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)
```

https://www.udacity.com/course/viewer#!/c-ud730/l-6370362152/m-6379811817

```
x_data = [[1, 2, 1, 1], [2, 1, 3, 2], [3, 1, 3, 4], [4, 1, 5, 5], [1, 7, 5, 5],
                                                         [1, 2, 5, 6], [1, 6, 6, 6], [1, 7, 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]]

X = tf.placeholder("float", [None, 4])
Y = tf.placeholder("float", [None, 3])
nb_classes = 3

W = tf.Variable(tf.random_normal([4, nb_classes]), name='weight')
b = tf.Variable(tf.random_normal([nb_classes]), name='bias')

# tf.nn.softmax computes softmax activations
# softmax = exp(logits) / reduce_sum(exp(logits), dim)
hypothesis = tf.nn.softmax(tf.matmul(X, W) + b)

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

# Launch graph
with tf.Session() as sess:
   sess.run(tf.global_variables_initializer())

   for step in range(2001):
       sess.run(optimizer, feed_dict={X: x_data, Y: y_data})
       if step % 200 == 0:
           print(step, sess.run(cost, feed_dict={X: x_data, Y: y_data}))
```



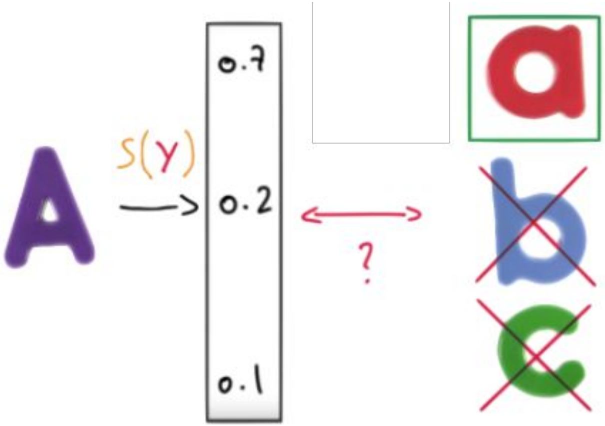
https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-06-1-softmax_classifier.py

Test & one-hot encoding

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

```
# Testing & One-hot encoding
a = sess.run(hypothesis, feed_dict={X: [[1, 11, 7, 9]
print(a, sess.run(tf.arg_max(a, 1)))
```

```
[[ 1.38904958e-03  9.98601854e-01  9.06129117e-06]] [1]
```



https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-06-1-softmax_classifier.py

Test & one-hot encoding

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

```
all = sess.run(hypothesis, feed_dict={X: [[1, 11, 7, 9],
                                          [1, 3, 4, 3],
                                          [1, 1, 0, 1]]})
print(all, sess.run(tf.arg_max(all, 1)))
```

```
[[  1.38904958e-03   9.98601854e-01   9.06129117e-06]
 [  9.31192040e-01   6.29020557e-02   5.90589503e-03]
 [  1.27327668e-08   3.34112905e-04   9.99665856e-01]]

[1 0 2]
```

https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-06-1-softmax_classifier.py

With TF 1.0!

Lab 6-2

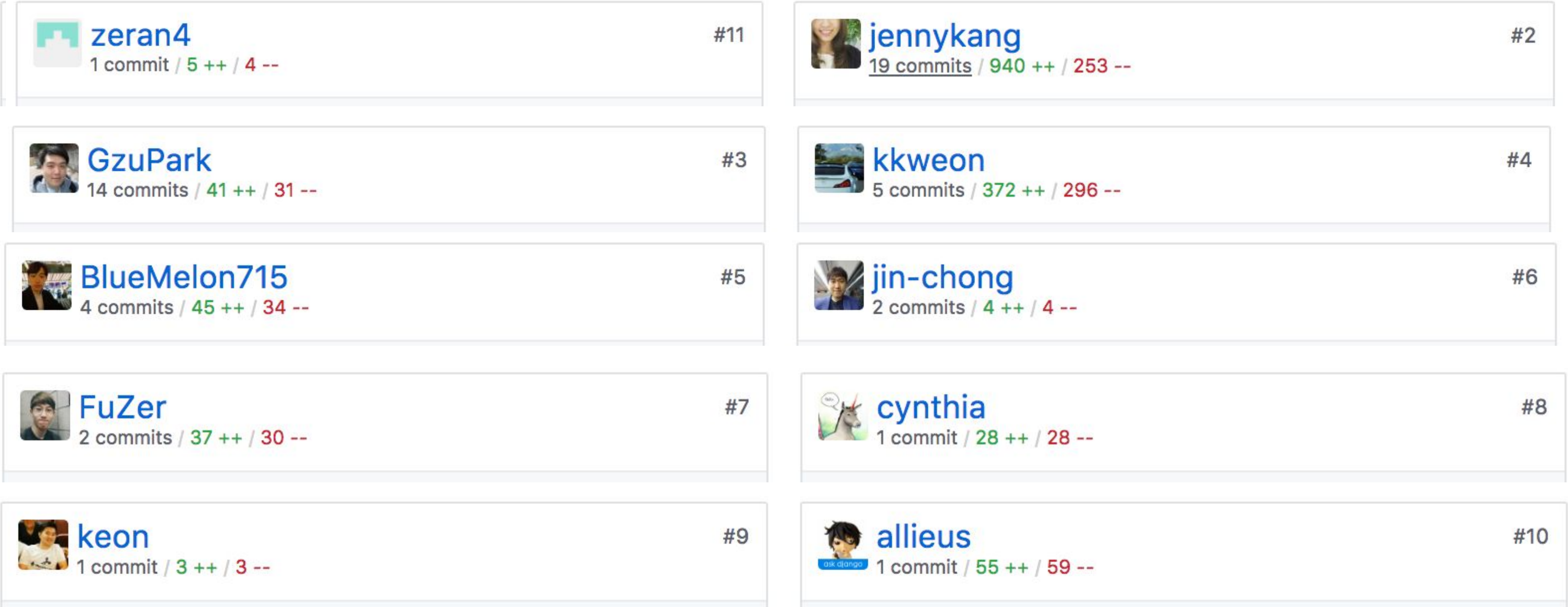
Fancy Softmax Classifier

cross_entropy, one_hot, reshape

Sung Kim <hunkim+ml@gmail.com>

Code: https://github.com/hunkim/DeepLearningZeroToAll/

https://github.com/hunkim/DeepLearningZeroToAll/



zeran4 #11
1 commit / 5 ++ / 4 --

jennykang #2
19 commits / 940 ++ / 253 --

GzuPark #3
14 commits / 41 ++ / 31 --

kkweon #4
5 commits / 372 ++ / 296 --

BlueMelon715 #5
4 commits / 45 ++ / 34 --

jin-chong #6
2 commits / 4 ++ / 4 --

FuZer #7
2 commits / 37 ++ / 30 --

cynthia #8
1 commit / 28 ++ / 28 --

keon #9
1 commit / 3 ++ / 3 --

allieus #10
1 commit / 55 ++ / 59 --

softmax_cross_entropy_with_logits

```
logits = tf.matmul(X, W) + b
hypothesis = tf.nn.softmax(logits)
```

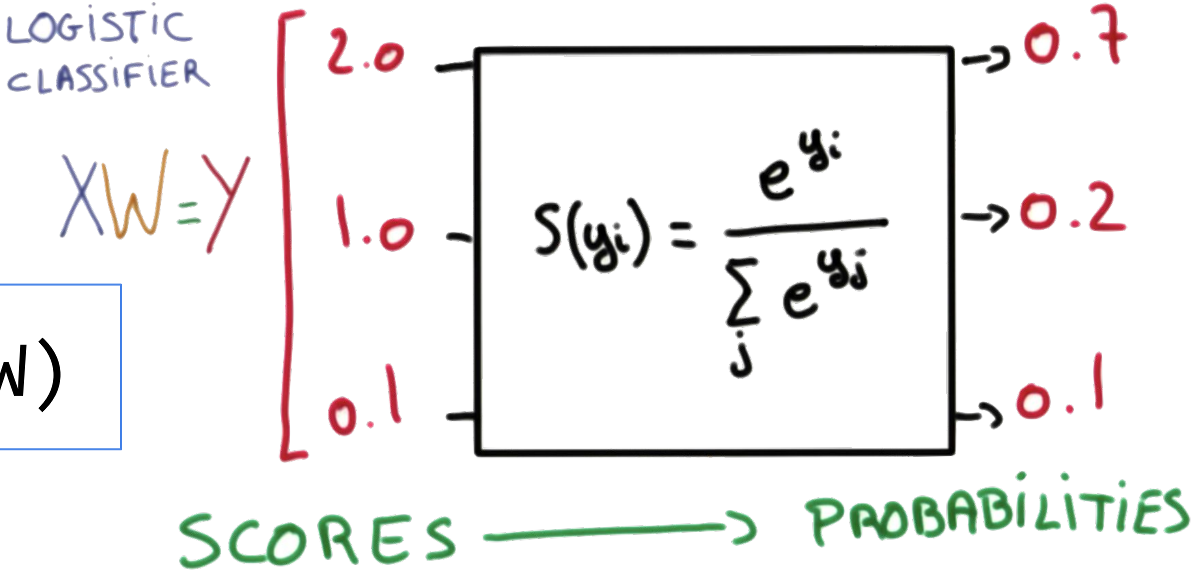
1

```
# Cross entropy cost/loss
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
```

2

```
# Cross entropy cost/loss
cost_i = tf.nn.softmax_cross_entropy_with_logits(logits=logits,
                                                 labels=Y_one_hot)
cost = tf.reduce_mean(cost_i)
```

```
hypothesis = tf.nn.softmax(tf.matmul(X,W))
```



```
tf.matmul(X,W)
```

https://www.udacity.com/course/viewer#!/c-ud730/l-6370362152/m-6379811817

softmax_cross_entropy_with_logits

```
logits = tf.matmul(X, W) + b
hypothesis = tf.nn.softmax(logits)
```

1

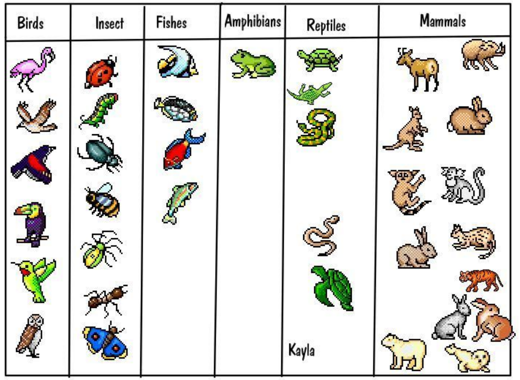
```
# Cross entropy cost/loss
cost = tf.reduce_mean(-tf.reduce_sum(Y * tf.log(hypothesis), axis=1))
```

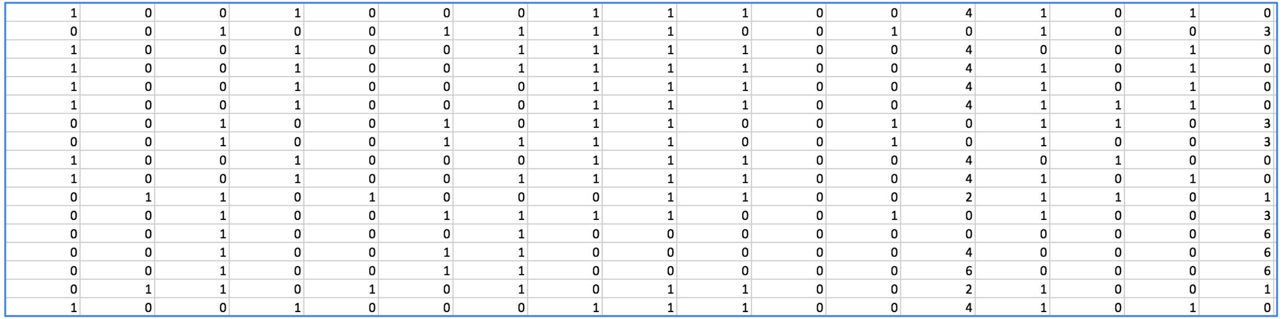
2

```
# Cross entropy cost/loss
cost_i = tf.nn.softmax_cross_entropy_with_logits(logits=logits,
                                                 labels=Y_one_hot)
cost = tf.reduce_mean(cost_i)
```

Animal classification

with *softmax_cross_entropy_with_logits*



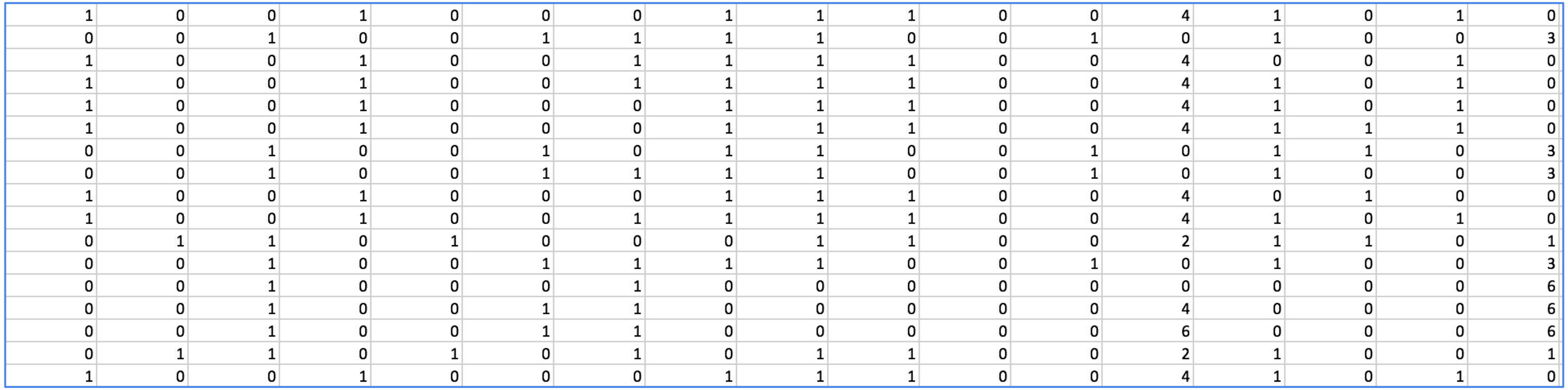


1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
1	0	0	1	0	0	1	1	1	1	0	0	4	0	0	1	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	0	1	0
1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0
1	0	0	1	0	0	0	1	1	1	0	0	4	1	1	1	0
0	0	1	0	0	1	0	1	1	0	0	1	0	1	1	0	3
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
1	0	0	1	0	0	0	1	1	1	0	0	4	0	1	0	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	0	1	0
0	1	1	0	1	0	0	0	1	1	0	0	2	1	1	0	1
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	6
0	0	1	0	0	1	1	0	0	0	0	0	4	0	0	0	6
0	0	1	0	0	1	1	0	0	0	0	0	6	0	0	0	6
0	1	1	0	1	0	1	0	1	1	0	0	2	1	0	0	1
1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0

```
# Predicting animal type based on various features
xy = np.loadtxt('data-04-zoo.csv', delimiter=',', dtype=np.float32)
x_data = xy[:, 0:-1]
y_data = xy[:, [-1]]
```

https://kr.pinterest.com/explore/animal-classification-activity/

tf.one_hot and reshape

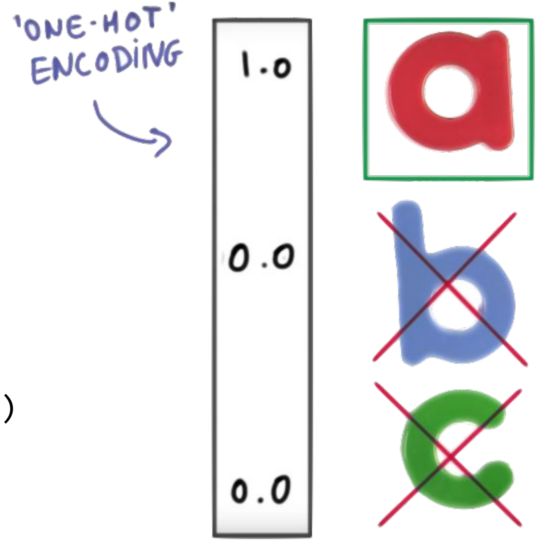


1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
1	0	0	1	0	0	1	1	1	1	0	0	4	0	0	1	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	0	1	0
1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0
1	0	0	1	0	0	0	1	1	1	0	0	4	1	1	1	0
0	0	1	0	0	1	0	1	1	0	0	1	0	1	1	0	3
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
1	0	0	1	0	0	0	1	1	1	0	0	4	0	1	0	0
1	0	0	1	0	0	1	1	1	1	0	0	4	1	0	1	0
0	1	1	0	1	0	0	0	1	1	0	0	2	1	1	0	1
0	0	1	0	0	1	1	1	1	0	0	1	0	1	0	0	3
0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	6
0	0	1	0	0	1	1	0	0	0	0	0	4	0	0	0	6
0	0	1	0	0	1	1	0	0	0	0	0	6	0	0	0	6
0	1	1	0	1	0	1	0	1	1	0	0	2	1	0	0	1
1	0	0	1	0	0	0	1	1	1	0	0	4	1	0	1	0

```
Y = tf.placeholder(tf.int32, [None, 1])  # 0 ~ 6, shape=(?, 1)
Y_one_hot = tf.one_hot(Y, nb_classes)  # one hot shape=(?, 1, 7)
Y_one_hot = tf.reshape(Y_one_hot, [-1, nb_classes]) # shape=(?, 7)
```

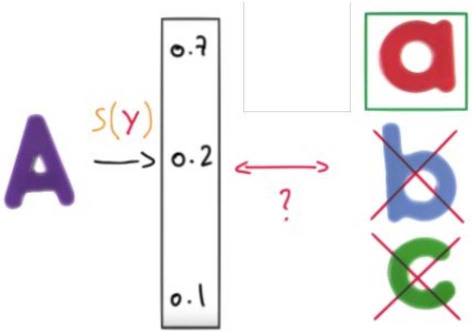
If the input indices is rank N, the output will have rank N+1. The new axis is created at dimension axis (default: the new axis is appended at the end).
https://www.tensorflow.org/api_docs/python/tf/one_hot

```
# Predicting animal type based on various features
xy = np.loadtxt('data-04-zoo.csv', delimiter=',', dtype=np.float32)
x_data = xy[:, 0:-1]
y_data = xy[:, [-1]]

nb_classes = 7  # 0 ~ 6

X = tf.placeholder(tf.float32, [None, 16])
Y = tf.placeholder(tf.int32, [None, 1])  # 0 ~ 6

Y_one_hot = tf.one_hot(Y, nb_classes)  # one hot
Y_one_hot = tf.reshape(Y_one_hot, [-1, nb_classes])

W = tf.Variable(tf.random_normal([16, nb_classes]), name='weight')
b = tf.Variable(tf.random_normal([nb_classes]), name='bias')

# tf.nn.softmax computes softmax activations
# softmax = exp(logits) / reduce_sum(exp(logits), dim)
logits = tf.matmul(X, W) + b
hypothesis = tf.nn.softmax(logits)

# Cross entropy cost/loss
cost_i = tf.nn.softmax_cross_entropy_with_logits(logits=logits,
                                                 labels=Y_one_hot)
cost = tf.reduce_mean(cost_i)
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)
```



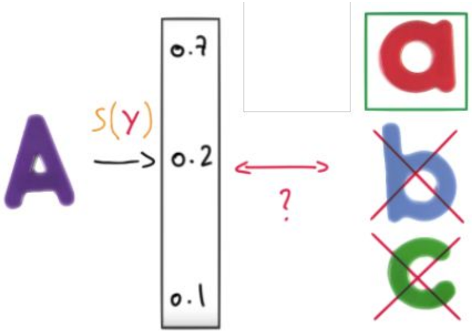
https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-06-2-softmax_zoo_classifier.py

```
cost = tf.reduce_mean(cost_i)
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)

prediction = tf.argmax(hypothesis, 1)
correct_prediction = tf.equal(prediction, tf.argmax(Y_one_hot, 1))
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
# Launch graph
with tf.Session() as sess:
   sess.run(tf.global_variables_initializer())

   for step in range(2000):
       sess.run(optimizer, feed_dict={X: x_data, Y: y_data})
       if step % 100 == 0:
           loss, acc = sess.run([cost, accuracy], feed_dict={
                                X: x_data, Y: y_data})
           print("Step: {:5}\tLoss: {:.3f}\tAcc: {:.2%}".format(
               step, loss, acc))

   # Let's see if we can predict
   pred = sess.run(prediction, feed_dict={X: x_data})
   # y_data: (N,1) = flatten => (N, ) matches pred.shape
   for p, y in zip(pred, y_data.flatten()):
       print("[{}] Prediction: {} True Y: {}".format(p == int(y), p, int(y)))
```



https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-06-2-softmax_zoo_classifier.py

```python
cost = tf.reduce_mean(cost_i)
optimizer = tf.train.GradientDescentOptimizer(learning_rate=0.1).minimize(cost)

prediction = tf.argmax(hypothesis, 1)
correct_prediction = tf.equal(prediction, tf.argmax(Y_one_hot, 1))
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32))
# Launch graph
with tf.Session() as sess:
   sess.run(tf.global_variables_initializer())

   for step in range(2000):
       sess.run(optimizer, feed_dict={X: x_data, Y: y_data})
       if step % 100 == 0:
           loss, acc = sess.run([cost, accuracy], feed_dict={
                                X: x_data, Y: y_data})
           print("Step: {:5}\tLoss: {:.3f}\tAcc: {:.2%}".format(
               step, loss, acc))

   # Let's see if we can predict
   pred = sess.run(prediction, feed_dict={X: x_data})
   # y_data: (N,1) = flatten => (N, ) matches pred.shape
   for p, y in zip(pred, y_data.flatten()):
       print("[{}] Prediction: {} True Y: {}".
             format(p == int(y), p, int(y)))
```



```
Step:  1100 Loss: 0.101 Acc: 99.01%
Step:  1200 Loss: 0.092 Acc: 100.00%
Step:  1300 Loss: 0.084 Acc: 100.00%
...
[True] Prediction: 0 True Y: 0
[True] Prediction: 0 True Y: 0
[True] Prediction: 3 True Y: 3
[True] Prediction: 0 True Y: 0
[True] Prediction: 0 True Y: 0
[True] Prediction: 0 True Y: 0
[True] Prediction: 0 True Y: 0
[True] Prediction: 3 True Y: 3
[True] Prediction: 3 True Y: 3
[True] Prediction: 0 True Y: 0
```

https://github.com/hunkim/DeepLearningZeroToAll/blob/master/lab-06-2-softmax_zoo_classifier.py

Lab 7

Learning rate, Evaluation

Sung Kim <hunkim+ml@gmail.com>