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CMPE 258
Mid term exam - 2
Date: 04/15/2018

Best accuracy achieved with Learning rate = 0.04 and Dropout 0.8

dropout probability : 0.5
Learning rate : 0.004

Final cost : 0.05231717

Training accuracy : 99.21%
Testing accuracy : 95%

In [1]:
```
import numpy as np
import tensorflow as tf
import matplotlib.pyplot as plt
tf.set_random_seed(10)
```

1. (10pts) Define functions

You may need to define the following functions.
One-hot encoding
Create placeholders
initialize parameters
forward propagation with regularization
compute cost

In [2]:
```
def zero_pad(X,p):
    return np.pad(X, [(0,0), (p,p), (p,p), (0,0)], 'constant', constant_
values=(0))
```

In [3]:
```
def placeholder_initializer():
    X = tf.placeholder(shape=(None, 66, 66, 3), dtype=tf.float32)
    Y = tf.placeholder(shape=(None, output_neurons), dtype=tf.float32)
    dropout_probaility = tf.placeholder("float")

    return X,Y,dropout_probaility
```

In [4]:
```
def parameters_initializer():
    W_cn_1 = tf.get_variable("W_cn_1", shape=(4,4,3,8), initializer=tf.c
ontrib.layers.xavier_initializer(seed=0))
    W_cn_2 = tf.get_variable("W_cn_2", shape=(4,4,8,16), initializer=tf.
contrib.layers.xavier_initializer(seed=0))


#     B_cn_1 = tf.get_variable("B_cn_1",shape=(1,1,1,8),initializer=tf.z
eros_initializer(),dtype=tf.float32)
#     B_cn_2 = tf.get_variable("B_cn_2",shape=(1,1,1,8),initializer=tf.z
eros_initializer(),dtype=tf.float32)

    W1 = tf.get_variable("W_fc_1",shape=(input_neurons, hidden1_neurons
),dtype=tf.float32,initializer=tf.contrib.layers.xavier_initializer())
    W2 = tf.get_variable("W_fc_2",shape=(hidden1_neurons,output_neurons
),dtype=tf.float32,initializer=tf.contrib.layers.xavier_initializer())

    B1 = tf.get_variable("B_fc_1",shape=(hidden1_neurons),initializer=tf
.zeros_initializer(),dtype=tf.float32)
    B2 = tf.get_variable("B_fc_3",shape=(output_neurons),initializer=tf.
zeros_initializer(),dtype=tf.float32)


    return W_cn_1,W_cn_2, W1, W2, B1, B2
```

In [5]:
```
def one_hot_encoding(mat):
    list_of_list = []
    for i in range(0,len(mat)):
        small_list = np.zeros(np.max(mat)+1)
        small_list[mat[i]] = 1
        list_of_list.append(small_list)
    result = np.array(list_of_list)
    return result
```

In [6]:
```
def forward_pass(dropout_prob):

    global neural_dict

    Z1 = tf.nn.conv2d(
        X,
        neural_dict['Conv1']['W'],
        neural_dict['Conv1']['params']['stride'],
        padding="SAME"
    )

    A1 = tf.nn.relu(Z1)
    print("A1 shape : ", A1.shape)

    P1 = tf.nn.max_pool(
        value = A1,
        ksize = neural_dict['Pool1']['params']['f'],
        strides = neural_dict['Pool1']['params']['stride'],
        padding = "SAME"
    )
    print("P1 shape : ", P1.shape)

    Z2 = tf.nn.conv2d(
        P1,
        neural_dict['Conv2']['W'],
        neural_dict['Conv2']['params']['stride'],
        padding = 'SAME'
    )

    A2 = tf.nn.relu(Z2)
    print("A2 shape : ", A2.shape)

    P2 = tf.nn.avg_pool(
        value = A2,
        ksize = neural_dict['Pool2']['params']['f'],
        strides = neural_dict['Pool2']['params']['stride'],
        padding = 'SAME'
    )
    print("P2 shape : ", P2.shape)


    F1 = tf.layers.flatten(inputs = P2)
    print("F1 shape : ", F1.shape)


    fz_1 = tf.add(tf.matmul(F1, neural_dict['Fc1']['W']), neural_dict['F
c1']['B'])
    fa_1 = tf.nn.relu(fz_1)

    fa_1 = tf.nn.dropout(fa_1, dropout_prob)
    print("fa_1 shape : ", fa_1.shape)


    fz_2 = tf.add(tf.matmul(fa_1, neural_dict['Fc2']['W']), neural_dict[
'Fc2']['B'])
    fa_2 = tf.sigmoid(fz_2)
```

```
    return fz_2
```

2. Load data

Using Jupyter notebook, load the data.

In [7]:
```
X_train = np.load("./exam2_train_x.npy")
Y_train = np.load("./exam2_train_y.npy")
X_test = np.load("./exam2_test_x.npy")
Y_test = np.load("./exam2_test_y.npy")
print ('Train x shape :', X_train.shape)
print ('Train y shape :', Y_train.shape)

print ('Test x shape :', X_test.shape)
print ('Test y shape :', Y_test.shape)
```

```
Train x shape : (1020, 64, 64, 3)
Train y shape : (1020,)
Test x shape : (180, 64, 64, 3)
Test y shape : (180,)
```

In [8]:
```
X_train = X_train/255 - 0.5
X_test = X_test/255 - 0.5
```

In [9]:
```
Y_train_one_hot = one_hot_encoding(Y_train)
Y_test_one_hot = one_hot_encoding(Y_test)
```

In [10]:
```
X_train = zero_pad(X_train, 1)
X_test = zero_pad(X_test, 1)
```

In [11]:
```
input_neurons = 4624
hidden1_neurons = 108
output_neurons = 6
```

In [12]:
```
X,Y, dropout_prob = placeholder_initializer()
```

In [13]:
```
neural_dict = {

    'Conv1':{
        'params' : {
            'padding' : 1,
            'stride' : [1,2,2,1]
        }
    },
    'Pool1' : {
        'params' : {
            'f' : [1, 5, 5, 1],
            'stride' : [1,1,1,1]
        }
    },
    'Conv2' : {
        'params' : {
            'padding' : 0,
            'stride' : [1,2,2,1]
        }
    },
    'Pool2' : {
        'params' : {
            'f' : [1, 5, 5, 1],
            'stride' : [1,1,1,1]
        }
    },
    'Fc1' : {
    },
    'Fc2' : {
    }
}
```

3. (10pts) Initialize parameters (Weights, bias for each layer)

Please initialize weight coefficients and bias terms for each layer. Please make sure the size (dimension) of each Weights and bias. Please consider optimum initialization method depending on Activation function.

Initializing weights and biases

Note : No need to initialize biases for Convolutional layers as tf.nn automatically takes care of it.

In [14]:
```
neural_dict['Conv1']['W'], neural_dict['Conv2']['W'], neural_dict['Fc1']
['W'], neural_dict['Fc2']['W'], neural_dict['Fc1']['B'], neural_dict['Fc
2']['B'] = parameters_initializer()
```

```
WARNING:tensorflow:From /Library/Frameworks/Python.framework/Versions/
3.6/lib/python3.6/site-packages/tensorflow/contrib/learn/python/learn/d
atasets/base.py:198: retry (from tensorflow.contrib.learn.python.learn.
datasets.base) is deprecated and will be removed in a future version.
Instructions for updating:
Use the retry module or similar alternatives.
```

In [15]:
```
plot_object = {}
```

Hyper parameters

In [16]:
```
dropout_probabilities = [0.3, 0.5, 0.8, 0.9, 1]
rate = 0.004
iterations = 100
```

In [17]:
```
tf.set_random_seed(10)
forward_result = forward_pass(dropout_prob)

cost = tf.losses.softmax_cross_entropy(Y, forward_result)

optimizer = tf.train.AdamOptimizer(learning_rate=rate).minimize(cost)
init_op = tf.initialize_all_variables()


accuracy = tf.metrics.accuracy(tf.argmax(Y, 1),tf.argmax(forward_pass(dr
opout_prob), 1))
```

```
A1 shape :  (?, 33, 33, 8)
P1 shape :  (?, 33, 33, 8)
A2 shape :  (?, 17, 17, 16)
P2 shape :  (?, 17, 17, 16)
F1 shape :  (?, 4624)
fa_1 shape :  (?, 108)
WARNING:tensorflow:From /Library/Frameworks/Python.framework/Versions/
3.6/lib/python3.6/site-packages/tensorflow/python/util/tf_should_use.p
y:118: initialize_all_variables (from tensorflow.python.ops.variables)
is deprecated and will be removed after 2017-03-02.
Instructions for updating:
Use `tf.global_variables_initializer` instead.
A1 shape :  (?, 33, 33, 8)
P1 shape :  (?, 33, 33, 8)
A2 shape :  (?, 17, 17, 16)
P2 shape :  (?, 17, 17, 16)
F1 shape :  (?, 4624)
fa_1 shape :  (?, 108)
```

4. (40pts) Build Convolution Neural Network model

Please build your CNN model with forward propagation function. Implement the forward_propagation function as following: CONV2D -> Activation -> POOL -> CONV2D -> activation -> POOL -> FLATTEN -> FULLYCONNECTED -> FULLYCONNECTED

Please print (or write) your CNN architecture model as the example table (10 pts).

CNN and FC Architecture

Layer	Type	Size	Channels	Kernel_size	Stride	Padding	Functions
0	Input	64 * 64	3				
1	Convolution (C1)	33 * 33	8	4 * 4	2	1	ReLu
1	Pooling (P1)	33 * 33	16	5 * 5	1	0	Max
2	Convolution (C2)	17 * 17	16	4 * 4	2	0	ReLu
2	Pooling (P2)	17 * 17		5 * 5	1	0	Avg
3	Flatten (F1)	4624					
4	Fully Connected (FC1) (dropout)	108					ReLu
5	Fully Connected (FC2) (Output)	06					Sigmoid

5. (20pts) Optimization of Convolution Neural Network model

Please optimize your model using your preferred optimization method. Please print out cost with number of iteration as below (10 pts).

In [19]:
```
tf.set_random_seed(10)
for dropout in dropout_probabilities:
    all_costs = []
    with tf.Session() as sess:
        sess.run(init_op)
        count = 0
        print("dropout probability : ",dropout)
        print("Learning rate : ", rate)
        print ("")
        previous_cost = float('Inf')
        while count < iterations:
            result = sess.run((optimizer, cost), feed_dict = {X: X_train
, Y: Y_train_one_hot, dropout_prob: dropout})
            count +=1
            if count % 10 == 0:
                print ("At Iteration : %d Cost is %f" % (count,result[1
]))
            current_cost = result[1]
            all_costs.append(current_cost)
            if previous_cost == current_cost:
                break
            else:
                previous_cost = current_cost

        print ("")
        print("Final cost is : ", result[1])


        train_prediction = np.argmax(sess.run(forward_result, feed_dict
= {X: X_train, Y: Y_train_one_hot, dropout_prob: 1.0}),1)
        test_prediction = np.argmax(sess.run(forward_result, feed_dict =
 {X: X_test, Y: Y_test_one_hot, dropout_prob: 1.0}),1)

        Y_train_labels = np.argmax(Y_train_one_hot,1)
        Y_test_labels = np.argmax(Y_test_one_hot,1)
        train_accuracy = sess.run(tf.reduce_mean(tf.cast(sess.run(tf.equ
al(train_prediction,Y_train_labels)), tf.float32)))
        test_accuracy = sess.run(tf.reduce_mean(tf.cast(sess.run(tf.equa
l(test_prediction,Y_test_labels)), tf.float32)))

        print ("")
        print("Train accuracy : ", train_accuracy)
        print("Test accuracy : ", test_accuracy)

        plot_object[dropout] = {}
        plot_object[dropout]['cost'] = result[1]
        plot_object[dropout]['rate'] = rate
        plot_object[dropout]['train_accuracy'] = train_accuracy
        plot_object[dropout]['test_accuracy'] = test_accuracy
        plot_object[dropout]['costs'] = all_costs

        print ("")
        print ("**********")
        print ("")
        sess.close()
```

```
dropout probability :  0.3
Learning rate :  0.004

At Iteration : 10 Cost is 1.739299
At Iteration : 20 Cost is 1.310114
At Iteration : 30 Cost is 1.058070
At Iteration : 40 Cost is 0.864297
At Iteration : 50 Cost is 0.752528
At Iteration : 60 Cost is 0.672667
At Iteration : 70 Cost is 0.553175
At Iteration : 80 Cost is 0.528488
At Iteration : 90 Cost is 0.423377
At Iteration : 100 Cost is 0.438068

Final cost is :  0.43806803

Train accuracy :  0.9401961
Test accuracy :  0.9

**********

dropout probability :  0.5
Learning rate :  0.004

At Iteration : 10 Cost is 1.637487
At Iteration : 20 Cost is 1.090984
At Iteration : 30 Cost is 0.796724
At Iteration : 40 Cost is 0.561925
At Iteration : 50 Cost is 0.485758
At Iteration : 60 Cost is 0.336768
At Iteration : 70 Cost is 0.279133
At Iteration : 80 Cost is 0.226683
At Iteration : 90 Cost is 0.162964
At Iteration : 100 Cost is 0.184205

Final cost is :  0.18420486

Train accuracy :  0.9823529
Test accuracy :  0.9444444

**********

dropout probability :  0.8
Learning rate :  0.004

At Iteration : 10 Cost is 1.594522
At Iteration : 20 Cost is 1.046563
At Iteration : 30 Cost is 0.704703
At Iteration : 40 Cost is 0.501634
At Iteration : 50 Cost is 0.343734
At Iteration : 60 Cost is 0.246672
At Iteration : 70 Cost is 0.148910
At Iteration : 80 Cost is 0.113178
At Iteration : 90 Cost is 0.099396
At Iteration : 100 Cost is 0.090030

Final cost is :  0.090030484
```

```
Train accuracy :  0.99215686
Test accuracy :  0.95

**********

dropout probability :  0.9
Learning rate :  0.004

At Iteration : 10 Cost is 1.617873
At Iteration : 20 Cost is 1.066716
At Iteration : 30 Cost is 0.753206
At Iteration : 40 Cost is 0.494823
At Iteration : 50 Cost is 0.339813
At Iteration : 60 Cost is 0.308721
At Iteration : 70 Cost is 0.158017
At Iteration : 80 Cost is 0.105758
At Iteration : 90 Cost is 0.073886
At Iteration : 100 Cost is 0.052317

Final cost is :  0.05231717

Train accuracy :  0.99607843
Test accuracy :  0.9444444

**********

dropout probability :  1
Learning rate :  0.004

At Iteration : 10 Cost is 1.723538
At Iteration : 20 Cost is 1.027681
At Iteration : 30 Cost is 0.696434
At Iteration : 40 Cost is 0.495907
At Iteration : 50 Cost is 0.342841
At Iteration : 60 Cost is 0.281595
At Iteration : 70 Cost is 0.193088
At Iteration : 80 Cost is 0.136997
At Iteration : 90 Cost is 0.100048
At Iteration : 100 Cost is 0.078622

Final cost is :  0.07862222

Train accuracy :  0.97843134
Test accuracy :  0.90555555

**********
```

6. (20pts) Predictions

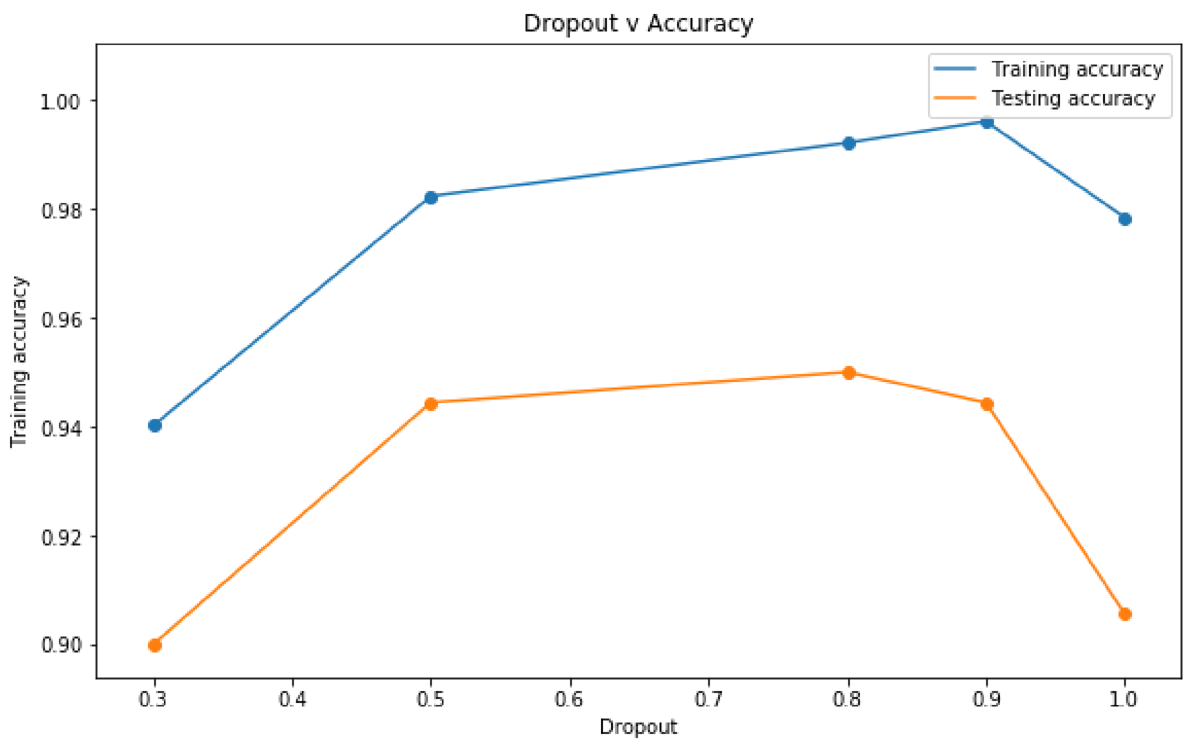
Please predict SIGNS using softmax function.

Please print out the accuracy for the prediction using training data set and testing data set.

Actual Output : dropout probability : 0.3 Learning rate : 0.004 At Iteration : 10 Cost is 1.739299 At Iteration : 20 Cost is 1.310114 At Iteration : 30 Cost is 1.058070 At Iteration : 40 Cost is 0.864297 At Iteration : 50 Cost is 0.752528 At Iteration : 60 Cost is 0.672667 At Iteration : 70 Cost is 0.553175 At Iteration : 80 Cost is 0.528488 At Iteration : 90 Cost is 0.423377 At Iteration : 100 Cost is 0.438068 Final cost is : 0.43806803 Train accuracy : 0.9401961 Test accuracy : 0.9 ********** dropout probability : 0.5 Learning rate : 0.004 At Iteration : 10 Cost is 1.637487 At Iteration : 20 Cost is 1.090984 At Iteration : 30 Cost is 0.796724 At Iteration : 40 Cost is 0.561925 At Iteration : 50 Cost is 0.485758 At Iteration : 60 Cost is 0.336768 At Iteration : 70 Cost is 0.279133 At Iteration : 80 Cost is 0.226683 At Iteration : 90 Cost is 0.162964 At Iteration : 100 Cost is 0.184205 Final cost is : 0.18420486 Train accuracy : 0.9823529 Test accuracy : 0.9444444 ********** dropout probability : 0.8 Learning rate : 0.004 At Iteration : 10 Cost is 1.594522 At Iteration : 20 Cost is 1.046563 At Iteration : 30 Cost is 0.704703 At Iteration : 40 Cost is 0.501634 At Iteration : 50 Cost is 0.343734 At Iteration : 60 Cost is 0.246672 At Iteration : 70 Cost is 0.148910 At Iteration : 80 Cost is 0.113178 At Iteration : 90 Cost is 0.099396 At Iteration : 100 Cost is 0.090030 Final cost is : 0.090030484 Train accuracy : 0.99215686 Test accuracy : 0.95 ********** dropout probability : 0.9 Learning rate : 0.004 At Iteration : 10 Cost is 1.617873 At Iteration : 20 Cost is 1.066716 At Iteration : 30 Cost is 0.753206 At Iteration : 40 Cost is 0.494823 At Iteration : 50 Cost is 0.339813 At Iteration : 60 Cost is 0.308721 At Iteration : 70 Cost is 0.158017 At Iteration : 80 Cost is 0.105758 At Iteration : 90 Cost is 0.073886 At Iteration : 100 Cost is 0.052317 Final cost is : 0.05231717 Train accuracy : 0.99607843 Test accuracy : 0.9444444 ********** dropout probability : 1 Learning rate : 0.004 At Iteration : 10 Cost is 1.723538 At Iteration : 20 Cost is 1.027681 At Iteration : 30 Cost is 0.696434 At Iteration : 40 Cost is 0.495907 At Iteration : 50 Cost is 0.342841 At Iteration : 60 Cost is 0.281595 At Iteration : 70 Cost is 0.193088 At Iteration : 80 Cost is 0.136997 At Iteration : 90 Cost is 0.100048 At Iteration : 100 Cost is 0.078622 Final cost is : 0.07862222 Train accuracy : 0.97843134 Test accuracy : 0.90555555 **********

Dropout vs Accuracy

In [20]:
```
train = []
test = []
keys = []
plt.figure(figsize=(10,6))
plt.xlabel('Dropout')
plt.ylabel('Training accuracy')
plt.title("Dropout v Accuracy")
for key, value in plot_object.items():
    keys.append(key)
    train.append(plot_object[key]['train_accuracy'])
    test.append(plot_object[key]['test_accuracy'])
plt.scatter(keys,train)
plt.scatter(keys,test)
plt.plot(keys,train,label='Training accuracy')
plt.plot(keys,test,label='Testing accuracy')
plt.legend()
plt.show()
```



Cost vs Iterations

In [22]:
```
plt.figure(figsize=(10,6))
plt.xlabel('Iternations')
plt.ylabel('Cost')
plt.title("Cost v Iterations")
for key,value in plot_object.items():
    plt.plot(range(0,len(plot_object[key]['costs'])),sorted(plot_object[
key]['costs'],reverse=True),label='drop out' + str(key))
plt.legend(dropout_probabilities,title="Drop out")
```

Out[22]: <matplotlib.legend.Legend at 0x1222fc470>