

NAME: ANAND KRISHNAMOORTHY  
CSCI S-89 INTRODUCTION TO DEEP LEARNING  
ASSIGNMENT 2

### Problem 1 (15 points)

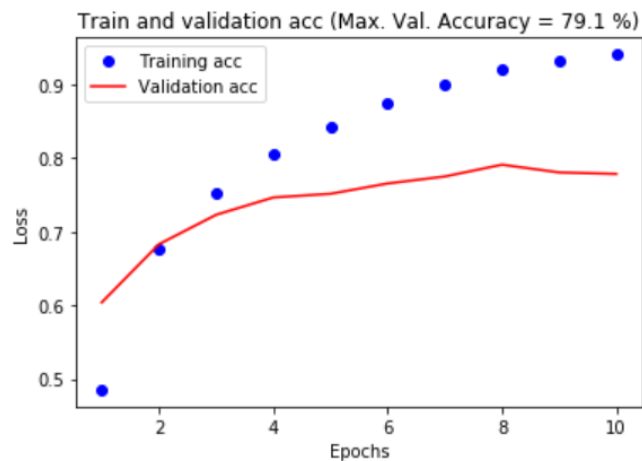
Please consider the following example of a Neural Network for text classification found in 3.6-Classifying\_newswires\_a\_multiclass\_classification\_example.ipynb:

```
model = models.Sequential()  
model.add(layers.Dense(64, activation='relu', input_shape=(10000,)))  
model.add(layers.Dense(64, activation='relu'))  
model.add(layers.Dense(46, activation='softmax'))  
  
model.compile(optimizer='rmsprop',  
              loss='categorical_crossentropy',  
              metrics=['accuracy'])  
model.fit(partial_x_train,  
          partial_y_train,  
          epochs=20,  
          batch_size=512,  
          validation_data=(x_val, y_val))  
results = model.evaluate(x_test, one_hot_test_labels)
```

Please use a train set of 6982 samples and validation set of 2000 samples to train the network. Identify the optimal number of epochs based on the validation accuracy. Plot the results for accuracy versus number of epochs. Report the test accuracy of the model when trained with the optimal number of epochs.

SOLUTION:

Architecture used : 3.6-Classifying\_newswires\_a\_multiclass\_classification\_example.ipynb.



```
from keras.callbacks import EarlyStopping, ModelCheckpoint

callbacks = [EarlyStopping(monitor='val_loss', patience=2),
             ModelCheckpoint(filepath='HW2_Q1.h5', monitor='val_loss', save_best_only=True)]
```

Using the EarlyStopping function in Keras yielded 10 as the optimal # of epochs. 8<sup>th</sup> epoch yielded the highest accuracy of 79.1%.

```
Best epoch: 8
Best Accuracy: 79.1
```

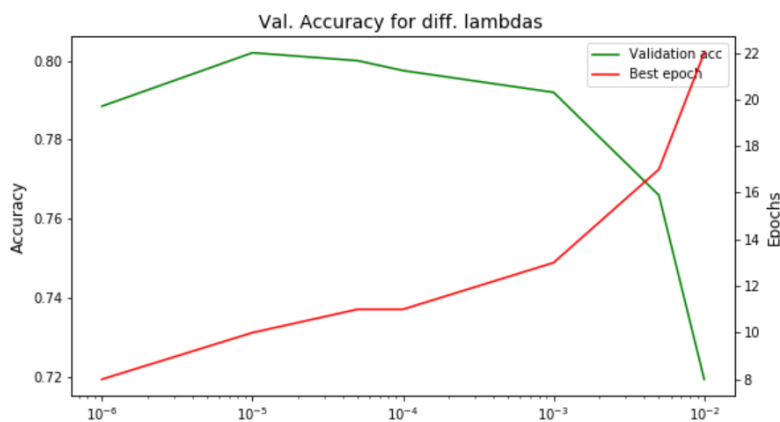
## Problem 2 (35 points)

Consider the network from Problem 1 and examine the effect of L2 regularization on the optimal number of epochs and associated (optimal) test accuracy. Plot dependence of the optimal validation accuracy on parameter  $\lambda$ . Please consider at least 5 values of parameter  $\lambda$ . What is the optimal regularization parameter  $\lambda$ ? What is the optimal validation accuracy for this optimal parameter?

SOLUTION:

Architecture used : 3.6-Classifying\_newswires\_a\_multiclass\_classification\_example.ipynb.

Lambda values considered: [0.01,0.005,0.001,0.0001,0.00005,0.00001,0.000001]



### Effect of L2 regularization on optimal # of epochs

The red line in the figure above shows the optimal number of epochs for various lambda values. The above figure indicates that for higher lambda values the convergence is slower, i.e. number of iterations for optimal epoch is higher.

### Validation Accuracy vs lambda value

The green line in the figure above shows the maximum validation accuracy obtained for various lambda values. The above figure indicates that for highest validation accuracy is obtained at  $\lambda = 10^{-5}$ .

### Optimal lambda value and corresponding validation accuracy:

Optimal lambda:  $10^{-5}$ , Corresponding validation accuracy: 80.2

Best validation accuracy: 80.2

Optimal lambda Parameter:  $1e-05$

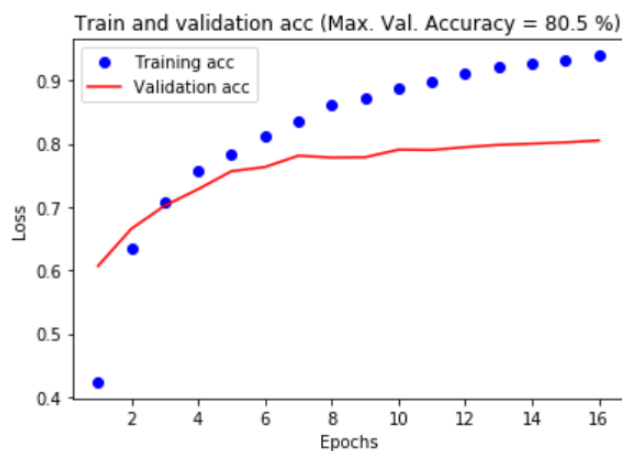
### Problem 3 (15 points)

Consider the network from Problem 1 and examine the effect of dropout regularization by adding dropout layers. What is the optimal validation accuracy when using dropouts?

SOLUTION:

Architecture used : 3.6-Classifying\_newswires\_a\_multiclass\_classification\_example.ipynb.

Dropout rate used = 0.2



Using the EarlyStopping function in Keras yielded 16 as the optimal # of epochs. Epoch 16 yielded the highest accuracy of 80.5%.

Best epoch: 16

Best Accuracy: 80.5

Among Non-Regularized, L2 regularized and dropouts, the architecture with dropouts resulted in the maximum accuracy of 80.5.