NON-LINEAR MODELS FOR SUPERVISED LEARNING PROGRAMMING ASSIGNMENT 2 CSE 574 Group – 35

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Part 1 : SENTIMENT ANALYSIS

Approach 1 – Word count vectorization

So we are given here to classify the movie reviews as positive or negative and we do so by comparing the frequency of each word to place it in positive or negative. Here, we are treating each word as a feature and give it a score so that we can refer to the impact of this word on the positivity of an unseen review based on this score.

Then we start by the sequence of reviews given to us and keep separating them whether it comes in positive or negative section. If more positive words, classified as positive else negative.

To check if a word is positive or negative while classifying unseen reviews, if it is greater than 0.02 then it is positive , if it is less than 0.02 then classified as negative and neutral otherwise. Thus, we observe a test accuracy of 79.4%.

Part 2: IMAGE CLASSIFICATION ON THE AI QUICK DRAW DATASET

Task 1 – Evaluation of 1 hidden layer neural network

We have seen many scenarios where we changed input layers, shidden unit layers and hidden layer dimension and using different activation functions. Some of the following combinations are shown here.

```
Epoch 1/500

100000/100000 [==============================] - 11s
110us/step - loss: 3.1969 - accuracy: 0.6244

Epoch 2/500

100000/100000 [==============================] - 14s
139us/step - loss: 1.4096 - accuracy: 0.6936

Epoch 3/500

100000/100000 [==============================] - 13s
135us/step - loss: 1.3770 - accuracy: 0.7066

Epoch 4/500

100000/100000 [==============================] - 13s
127us/step - loss: 1.3646 - accuracy: 0.7197

Epoch 5/500

100000/100000 [==============================] - 12s
121us/step - loss: 1.3498 - accuracy: 0.7193

Epoch 6/500

100000/100000 [==============================] - 11s
107us/step - loss: 1.3691 - accuracy: 0.7257

Epoch 7/500
```

```
100000/100000 [==============================] - 14s
137us/step - loss: 1.3685 - accuracy: 0.7286
```

….

Some of the best accuracies we got from the model-

```
Epoch 466/500

100000/100000 [==============================] - 4s
38us/step - loss: 0.7812 - accuracy: 0.7903

Epoch 467/500

100000/100000 [==============================] - 4s
39us/step - loss: 0.7870 - accuracy: 0.7904

Epoch 468/500

100000/100000 [==============================] - 4s
38us/step - loss: 0.7982 - accuracy: 0.7900

Epoch 469/500

100000/100000 [==============================] - 4s
38us/step - loss: 0.7770 - accuracy: 0.7904

Epoch 470/500

100000/100000 [==============================] - 4s
38us/step - loss: 0.7840 - accuracy: 0.7901

Epoch 471/500

100000/100000 [==============================] - 4s
40us/step - loss: 0.7815 - accuracy: 0.7900
```

Task 2: Evaluation of 3 or 5 hidden layers neural network

For comparing, increasing the hidden layer to 3 gives the following output:

```
Epoch 1/500

100000/100000 [==============================] - 11s
110us/step - loss: 3.1969 - accuracy: 0.5244

Epoch 2/500

100000/100000 [==============================] - 14s
139us/step - loss: 1.4096 - accuracy: 0.5936

Epoch 3/500

100000/100000 [==============================] - 13s
135us/step - loss: 1.3770 - accuracy: 0.6066

Epoch 4/500

100000/100000 [==============================] - 13s
127us/step - loss: 1.3646 - accuracy: 0.6297……

…….

Epoch 497/500

100000/100000 [==============================] - 4s
43us/step - loss: 0.7893 - accuracy: 0.7882

Epoch 498/500

100000/100000 [==============================] - 4s
40us/step - loss: 0.7886 - accuracy: 0.7886

Epoch 499/500
```

```
100000/100000 [==============================] - 4s
40us/step - loss: 0.7755 - accuracy: 0.7885


Epoch 500/500

100000/100000 [==============================] - 4s
41us/step - loss: 0.8015 - accuracy: 0.7864
```

From above results we can see that changing the input dimension accuracies does not show much of variation and running-time. However, if we compare our accuracies with one hidden layer accuracy remains somewhat near to it but decreases as epochs come near to 500 and running time increases by significant amount.

Now, we increase the number of hidden layers to five, and fit the model using 500 epochs. The results are as follows:

And subsequently increasing to 5 layers it gives:

```
Epoch 1/500

100000/100000 [==============================] - 22s
224us/step - loss: 1.1491 - accuracy: 0.7812

Epoch 2/500

100000/100000 [==============================] - 20s
197us/step - loss: 0.8512 - accuracy: 0.7767

Epoch 3/500

100000/100000 [==============================] - 21s
212us/step - loss: 0.8645 - accuracy: 0.7804

Epoch 4/500
```

```
100000/100000 [==============================] - 21s
215us/step - loss: 0.9709 - accuracy: 0.7575…..

……

Epoch 497/500

100000/100000 [==============================] - 20s
196us/step - loss: 2.3027 - accuracy: 0.0990

Epoch 498/500

100000/100000 [==============================] - 19s
195us/step - loss: 2.3027 - accuracy: 0.0996

Epoch 499/500

100000/100000 [==============================] - 19s
194us/step - loss: 2.3027 - accuracy: 0.0995

Epoch 500/500

100000/100000 [==============================] - 19s
195us/step - loss: 2.3028 - accuracy: 0.0988
```

Adding two more layers did not make a huge difference but increased the running time by a lot of factor and reduction effect on accuracy as it got very much reduced.

Task 3: Evaluation of 1 hidden layer neural network with lower resolution images
We now compare our results from task 1, with original image resolution: (28 × 28) with the results obtained using lower resolution images.

Resolution: (20 × 20)

Fitting and evaluating the model using 500 epochs, generates the following results.

```
epoch 1/500
100000/100000 [==============================] - 5s
52us/step - loss: 2.2900 - accuracy: 0.7711
Epoch 2/500
100000/100000 [==============================] - 5s
51us/step - loss: 0.9047 - accuracy: 0.7790
Epoch 3/500
100000/100000 [==============================] - 5s
47us/step - loss: 0.8831 - accuracy: 0.7788
Epoch 4/500
100000/100000 [==============================] - 5s
48us/step - loss: 0.8418 - accuracy: 0.7887
Epoch 5/500
100000/100000 [==============================] - 5s
49us/step - loss: 0.8408 - accuracy: 0.7925
Epoch 6/500
100000/100000 [==============================] - 5s
46us/step - loss: 0.8504 - accuracy: 0.7918…….
…
Epoch 497/500
100000/100000 [==============================] - 5s
54us/step - loss: 2.3417 - accuracy: 0.7964
Epoch 498/500
100000/100000 [==============================] - 6s
61us/step - loss: 2.3782 - accuracy: 0.7933
Epoch 499/500
100000/100000 [==============================] - 6s
58us/step - loss: 2.2955 - accuracy: 0.7973
Epoch 500/500
```

```
100000/100000 [==============================] - 6s
62us/step - loss: 2.3774 - accuracy: 0.7980
```

On comparing, we can see that the accuracies over time of 500 epochs remain almost near to one another not making a big difference. The running time is somewhat lower with not big difference so the accuracy remains the same .

Resolution: (15 × 15) Lowering the resolution to (15×15) and fitting and evaluating the model using 500 epochs yields the following results.

```
Epoch 1/500
100000/100000 [==============================] - 5s
53us/step - loss: 2.1395 - accuracy: 0.7765
Epoch 2/500
100000/100000 [==============================] - 5s
52us/step - loss: 0.8925 - accuracy: 0.7798
Epoch 3/500
100000/100000 [==============================] - 5s
50us/step - loss: 0.8415 - accuracy: 0.7799
Epoch 4/500
100000/100000 [==============================] - 5s
50us/step - loss: 0.8401 - accuracy: 0.7803
Epoch 5/500
100000/100000 [==============================] - 5s
52us/step - loss: 0.8585 - accuracy: 0.7802…….
…..
Epoch 497/500
100000/100000 [==============================] - 5s
53us/step - loss: 2.2433 - accuracy: 0.7926
Epoch 498/500
100000/100000 [==============================] - 5s
46us/step - loss: 2.4200 - accuracy: 0.7941
Epoch 499/500
```

```
100000/100000 [==============================] - 5s
50us/step - loss: 2.3233 - accuracy: 0.7952
Epoch 500/500
100000/100000 [==============================] - 5s
52us/step - loss: 2.2818 - accuracy: 0.7983
```

Here, there’s no significant decrease in the accuracies and the running time from the 20 × 20.

Resolution: (10 × 10) We further lower the resolution to (10 × 10). The model is then fitted and evaluated using 500 epochs, which generates the following results.

```
Epoch 1/500
100000/100000 [==============================] - 6s
60us/step - loss: 2.1780 - accuracy: 0.7684
Epoch 2/500
100000/100000 [==============================] - 5s
52us/step - loss: 0.8687 - accuracy: 0.7644
Epoch 3/500
100000/100000 [==============================] - 5s
49us/step - loss: 0.7910 - accuracy: 0.7612
Epoch 4/500
100000/100000 [==============================] - 5s
55us/step - loss: 0.7653 - accuracy: 0.7580
Epoch 5/500
100000/100000 [==============================] - 5s
50us/step - loss: 0.7465 - accuracy: 0.7564…..
……
Epoch 497/500
100000/100000 [==============================] - 5s
50us/step - loss: 2.4886 - accuracy: 0.6884
Epoch 498/500
```

```
100000/100000 [==============================] - 5s
47us/step - loss: 2.5541 - accuracy: 0.6881
Epoch 499/500
100000/100000 [==============================] - 5s
47us/step - loss: 2.4756 - accuracy: 0.6862
Epoch 500/500
100000/100000 [==============================] - 5s
48us/step - loss: 2.2106 - accuracy: 0.6855
```

Here, we can imply that we have lowered the resolution a lot more times so the running time starts decreasing and the accuracies start decreasing.

Resolution: (5 × 5) We finally lower the resolution down to (5 × 5). The model when fitted and evaluated using 500 epochs yields the following results.

```
Epoch 1/500
100000/100000 [==============================] - 5s
50us/step - loss: 2.2370 - accuracy: 0.7908
Epoch 2/500
100000/100000 [==============================] - 5s
46us/step - loss: 0.9070 - accuracy: 0.7785
Epoch 3/500
100000/100000 [==============================] - 5s
46us/step - loss: 0.8628 - accuracy: 0.7778
Epoch 4/500
100000/100000 [==============================] - 5s
49us/step - loss: 0.8665 - accuracy: 0.7774……..
……

Epoch 497/500
100000/100000 [==============================] - 5s
45us/step - loss: 2.2641 - accuracy: 0.4485
```

```
Epoch 498/500
100000/100000 [==============================] - 5s
46us/step - loss: 2.3682 - accuracy: 0.4457
Epoch 499/500
100000/100000 [==============================] - 5s
48us/step - loss: 2.1550 - accuracy: 0.4436
Epoch 500/500
100000/100000 [==============================] - 5s
46us/step - loss: 2.2729 - accuracy: 0.4402
```

The running time decreases and accuracies also decreases on greater note.

Conclusion:

Taking account, the results from above we can analyze that increasing the number of hidden layers much more than the sufficient number of layers will cause accuracy in the test set to decrease. It will cause the network to overfit to the training set, that is, it will learn the data, but it won't be able to generalize to new unseen data. We can definitely lower the resolution of the image in order to reduce the running time a little. As mentioned it should be noted that fitting the model using 500 epochs increases the accuracies for most times and running time also increases. Therefore, model should be used very wisely to accustom the balance between accuracy and running time.