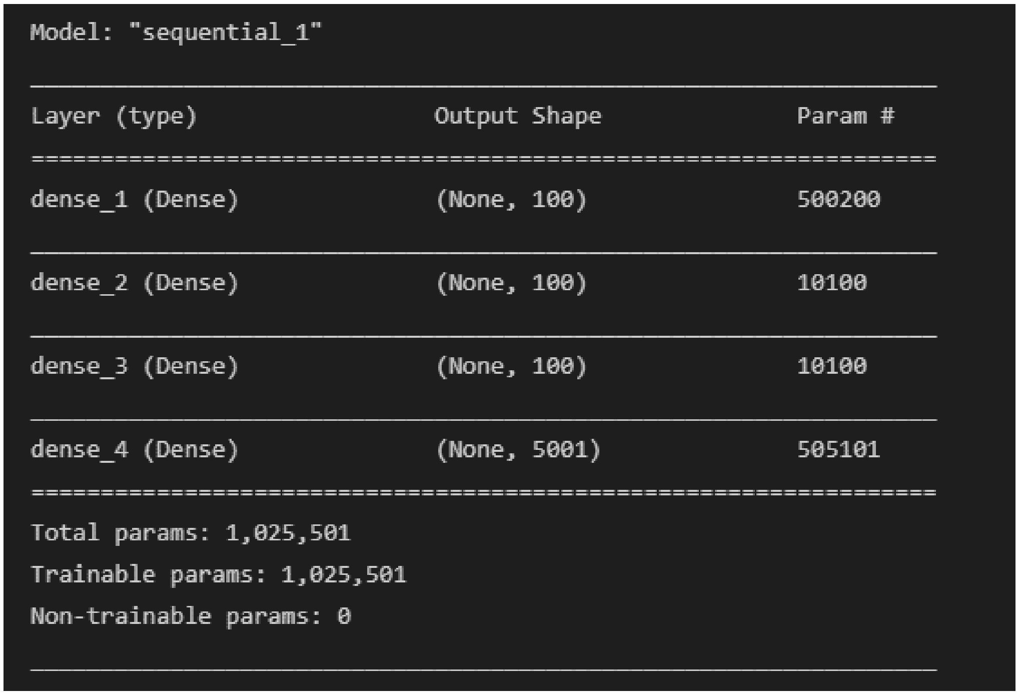
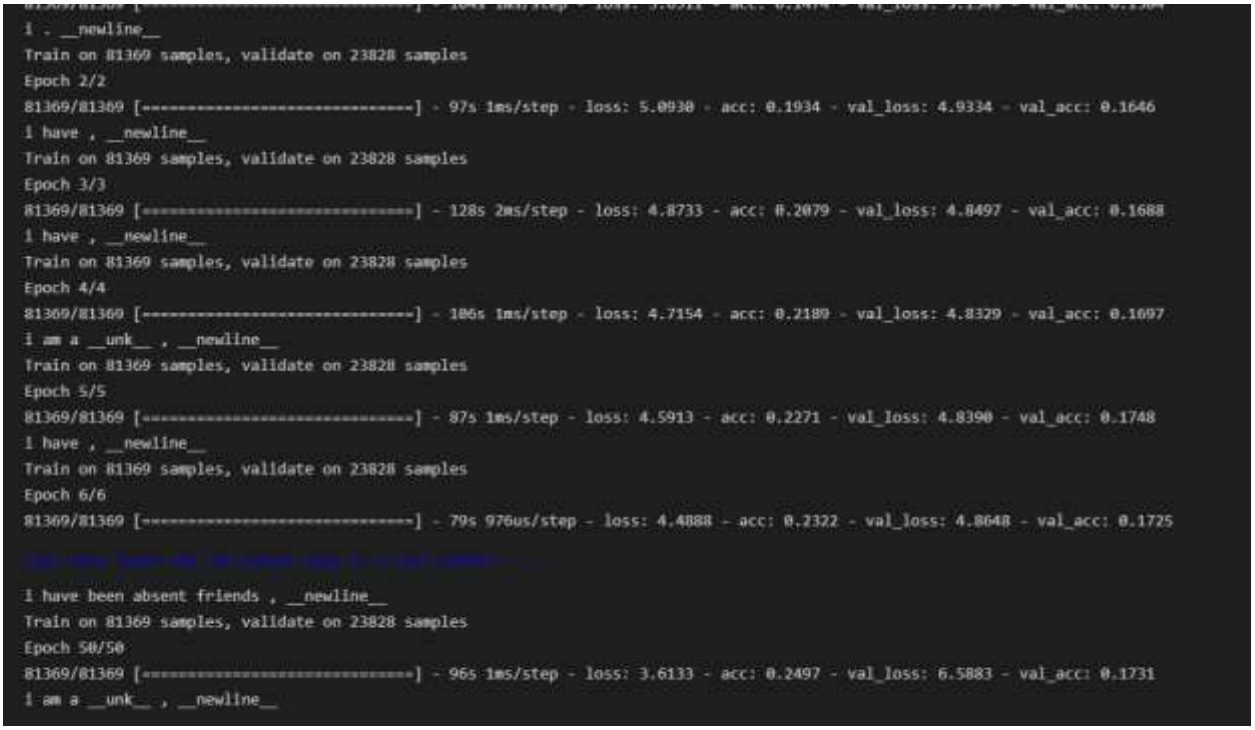
Lab sheet 11 - Deep Learning

1. Neural Network Language Model



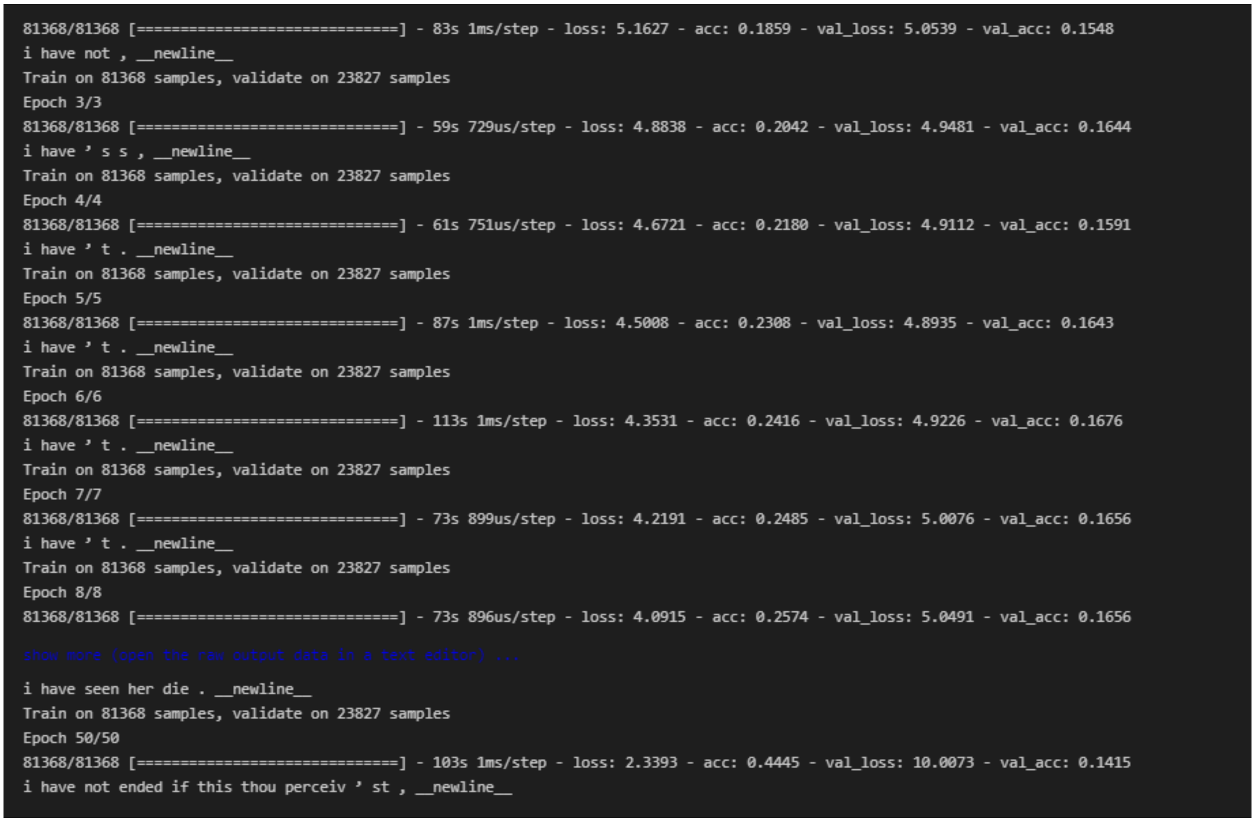
```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_1 (Dense)              (None, 100)               500200
_________________________________________________________________
dense_2 (Dense)              (None, 100)               10100
_________________________________________________________________
dense_3 (Dense)              (None, 100)               10100
_________________________________________________________________
dense_4 (Dense)              (None, 5001)              505101
=================================================================
Total params: 1,025,501
Trainable params: 1,025,501
Non-trainable params: 0
_________________________________________________________________
```

Model fitting



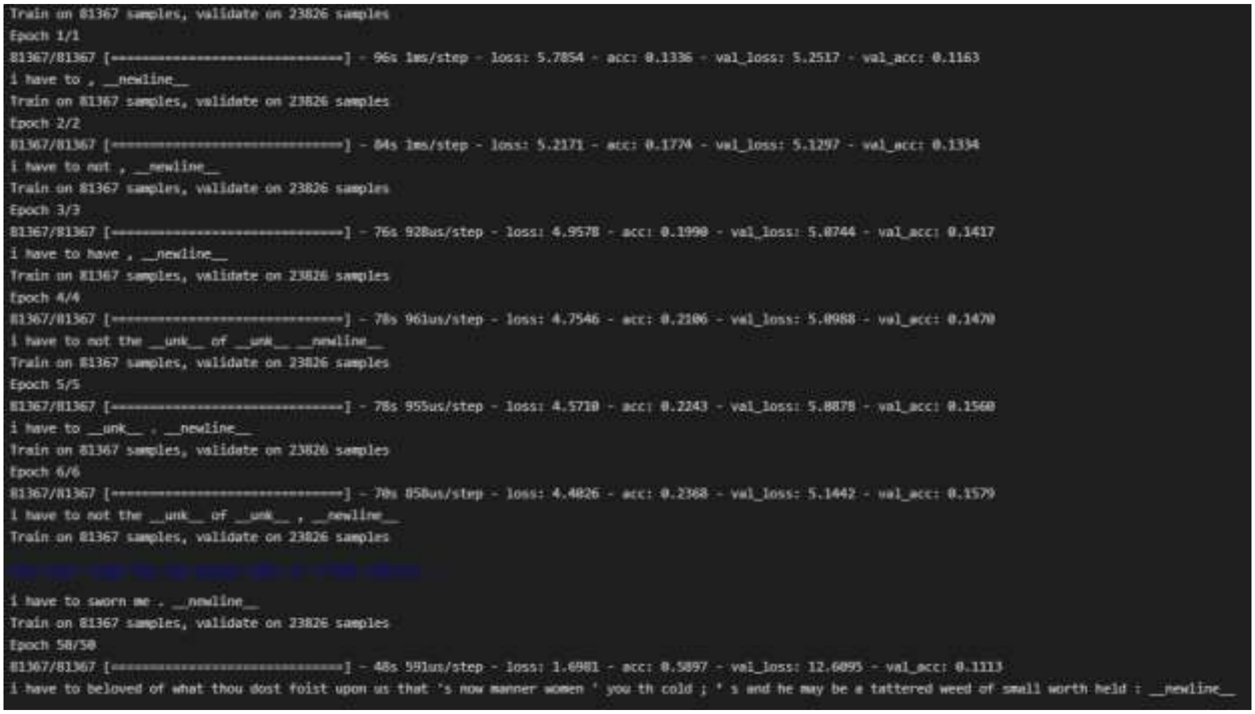
```
i . __newline__
Train on 81369 samples, validate on 23828 samples
Epoch 2/2
81369/81369 [==============================] - 97s 1ms/step - loss: 5.0930 - acc: 0.1934 - val_loss: 4.9334 - val_acc: 0.1646
i have , __newline__
Train on 81369 samples, validate on 23828 samples
Epoch 3/3
81369/81369 [==============================] - 128s 2ms/step - loss: 4.8733 - acc: 0.2079 - val_loss: 4.8497 - val_acc: 0.1688
i have , __newline__
Train on 81369 samples, validate on 23828 samples
Epoch 4/4
81369/81369 [==============================] - 106s 1ms/step - loss: 4.7154 - acc: 0.2189 - val_loss: 4.8329 - val_acc: 0.1697
i am a __unk__ , __newline__
Train on 81369 samples, validate on 23828 samples
Epoch 5/5
81369/81369 [==============================] - 87s 1ms/step - loss: 4.5913 - acc: 0.2271 - val_loss: 4.8390 - val_acc: 0.1748
i have , __newline__
Train on 81369 samples, validate on 23828 samples
Epoch 6/6
81369/81369 [==============================] - 79s 976us/step - loss: 4.4888 - acc: 0.2322 - val_loss: 4.8648 - val_acc: 0.1725

i have been absent friends , __newline__
Train on 81369 samples, validate on 23828 samples
Epoch 50/50
81369/81369 [==============================] - 96s 1ms/step - loss: 3.6133 - acc: 0.2497 - val_loss: 6.5883 - val_acc: 0.1731
i am a __unk__ , __newline__
```

Bigram model



```
81368/81368 [==============================] - 83s 1ms/step - loss: 5.1627 - acc: 0.1859 - val_loss: 5.0539 - val_acc: 0.1548
i have not , __newline__
Train on 81368 samples, validate on 23827 samples
Epoch 3/3
81368/81368 [==============================] - 59s 729us/step - loss: 4.8838 - acc: 0.2042 - val_loss: 4.9481 - val_acc: 0.1644
i have ’ s s , __newline__
Train on 81368 samples, validate on 23827 samples
Epoch 4/4
81368/81368 [==============================] - 61s 751us/step - loss: 4.6721 - acc: 0.2180 - val_loss: 4.9112 - val_acc: 0.1591
i have ’ t . __newline__
Train on 81368 samples, validate on 23827 samples
Epoch 5/5
81368/81368 [==============================] - 87s 1ms/step - loss: 4.5008 - acc: 0.2308 - val_loss: 4.8935 - val_acc: 0.1643
i have ’ t . __newline__
Train on 81368 samples, validate on 23827 samples
Epoch 6/6
81368/81368 [==============================] - 113s 1ms/step - loss: 4.3531 - acc: 0.2416 - val_loss: 4.9226 - val_acc: 0.1676
i have ’ t . __newline__
Train on 81368 samples, validate on 23827 samples
Epoch 7/7
81368/81368 [==============================] - 73s 899us/step - loss: 4.2191 - acc: 0.2485 - val_loss: 5.0076 - val_acc: 0.1656
i have ’ t . __newline__
Train on 81368 samples, validate on 23827 samples
Epoch 8/8
81368/81368 [==============================] - 73s 896us/step - loss: 4.0915 - acc: 0.2574 - val_loss: 5.0491 - val_acc: 0.1656

show more (open the raw output data in a text editor) ...

i have seen her die . __newline__
Train on 81368 samples, validate on 23827 samples
Epoch 50/50
81368/81368 [==============================] - 103s 1ms/step - loss: 2.3393 - acc: 0.4445 - val_loss: 10.0073 - val_acc: 0.1415
i have not ended if this thou perceiv ’ st , __newline__
```

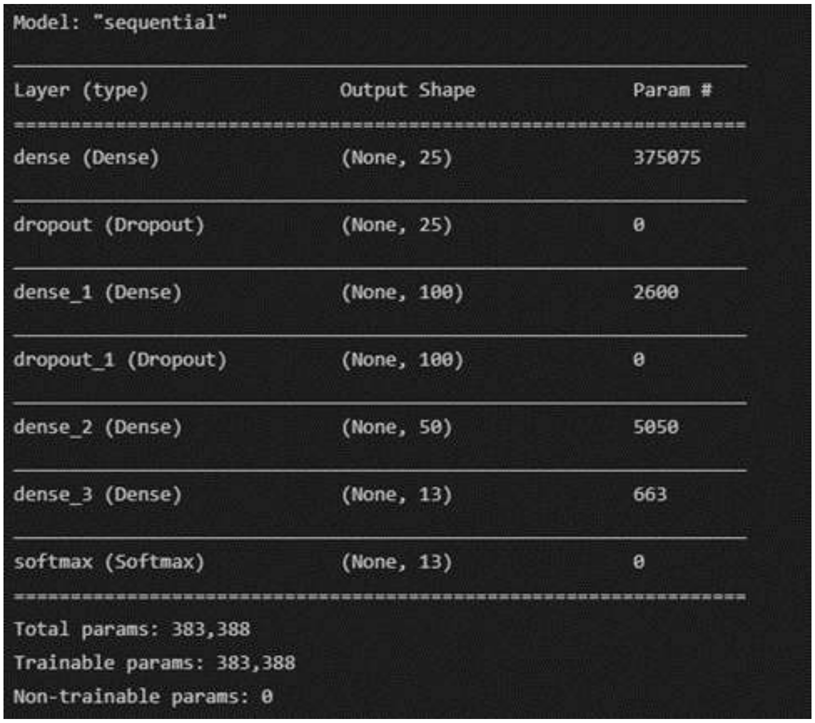
Trigram model



```
Train on 81367 samples, validate on 23826 samples
Epoch 1/1
81367/81367 [==============================] - 96s 1ms/step - loss: 5.7854 - acc: 0.1336 - val_loss: 5.2517 - val_acc: 0.1163
i have to , __newline__
Train on 81367 samples, validate on 23826 samples
Epoch 2/2
81367/81367 [==============================] - 84s 1ms/step - loss: 5.2171 - acc: 0.1774 - val_loss: 5.1297 - val_acc: 0.1334
i have to not , __newline__
Train on 81367 samples, validate on 23826 samples
Epoch 3/3
81367/81367 [==============================] - 76s 928us/step - loss: 4.9578 - acc: 0.1990 - val_loss: 5.0744 - val_acc: 0.1417
i have to have , __newline__
Train on 81367 samples, validate on 23826 samples
Epoch 4/4
81367/81367 [==============================] - 78s 961us/step - loss: 4.7546 - acc: 0.2106 - val_loss: 5.0988 - val_acc: 0.1470
i have to not the __unk__ of __unk__ __newline__
Train on 81367 samples, validate on 23826 samples
Epoch 5/5
81367/81367 [==============================] - 78s 955us/step - loss: 4.5710 - acc: 0.2243 - val_loss: 5.0878 - val_acc: 0.1560
i have to __unk__ . __newline__
Train on 81367 samples, validate on 23826 samples
Epoch 6/6
81367/81367 [==============================] - 70s 858us/step - loss: 4.4026 - acc: 0.2368 - val_loss: 5.1442 - val_acc: 0.1579
i have to not the __unk__ of __unk__ , __newline__
Train on 81367 samples, validate on 23826 samples

show more (open the raw output data in a text editor) ...

i have to sworn me . __newline__
Train on 81367 samples, validate on 23826 samples
Epoch 50/50
81367/81367 [==============================] - 48s 591us/step - loss: 1.6981 - acc: 0.5897 - val_loss: 12.6095 - val_acc: 0.1113
i have to beloved of what thou dost foist upon us that 's now manner women ' you th cold ; ' s and he may be a tattered weed of small worth held : __newline__
```

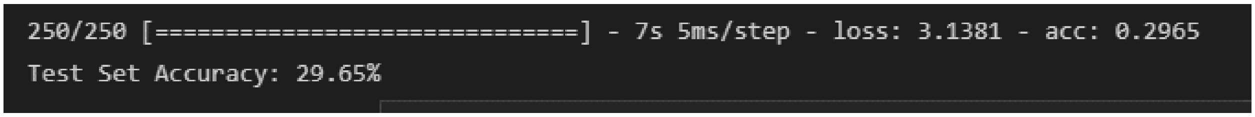
2. Sentiment Classification using Neural Network

Model architecture



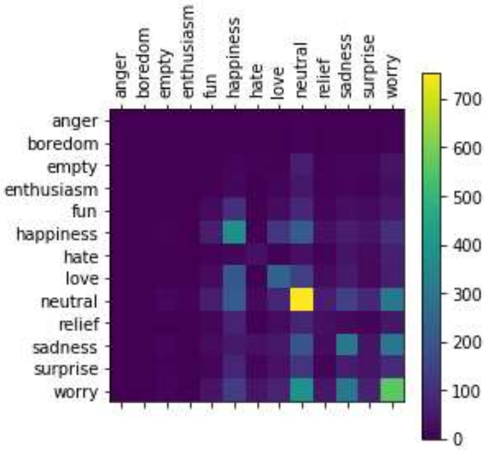
```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 25)                375075
_________________________________________________________________
dropout (Dropout)            (None, 25)                0
_________________________________________________________________
dense_1 (Dense)              (None, 100)               2600
_________________________________________________________________
dropout_1 (Dropout)          (None, 100)               0
_________________________________________________________________
dense_2 (Dense)              (None, 50)                5050
_________________________________________________________________
dense_3 (Dense)              (None, 13)                663
_________________________________________________________________
softmax (Softmax)            (None, 13)                0
=================================================================
Total params: 383,388
Trainable params: 383,388
Non-trainable params: 0
```

Test accuracy



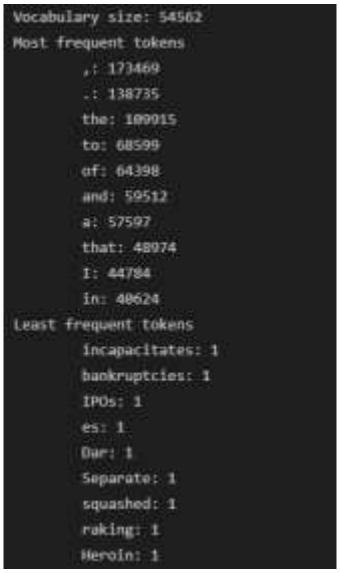
```
250/250 [==============================] - 7s 5ms/step - loss: 3.1381 - acc: 0.2965
Test Set Accuracy: 29.65%
```

Confusion matrix



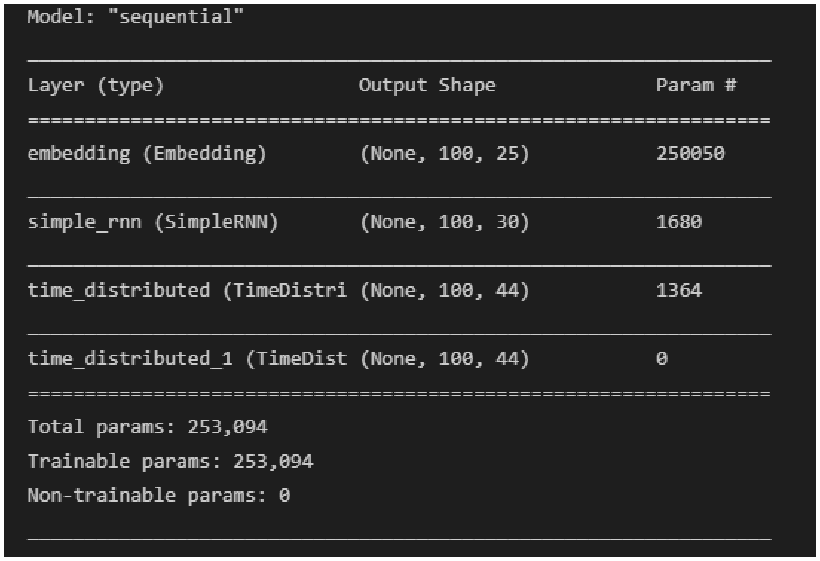
3. Per timestep prediction using Neural Network – POS tagging

Vocabulary building



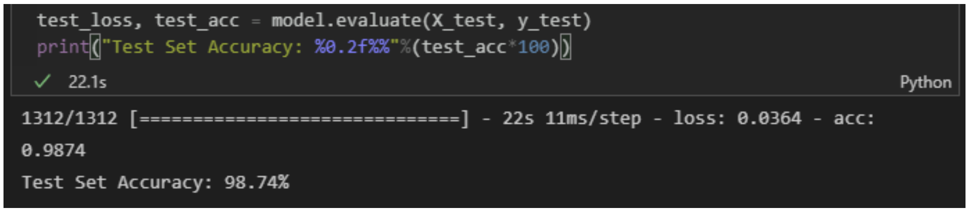
```
Vocabulary size: 54562
Most frequent tokens
        ,: 173469
        .: 138735
        the: 109915
        to: 68599
        of: 64398
        and: 59512
        a: 57597
        that: 48974
        I: 44784
        in: 40624
Least frequent tokens
        incapacitates: 1
        bankruptcies: 1
        IPOs: 1
        es: 1
        Dar: 1
        Separate: 1
        squashed: 1
        raking: 1
        Heroin: 1
```

Model Definition



```
Model: "sequential"
_________________________________________________________________
Layer (type)                Output Shape              Param #
=================================================================
embedding (Embedding)       (None, 100, 25)           250050
_________________________________________________________________
simple_rnn (SimpleRNN)      (None, 100, 30)           1680
_________________________________________________________________
time_distributed (TimeDistri (None, 100, 44)          1364
_________________________________________________________________
time_distributed_1 (TimeDist (None, 100, 44)          0
=================================================================
Total params: 253,094
Trainable params: 253,094
Non-trainable params: 0
_________________________________________________________________
```

Test set accuracy

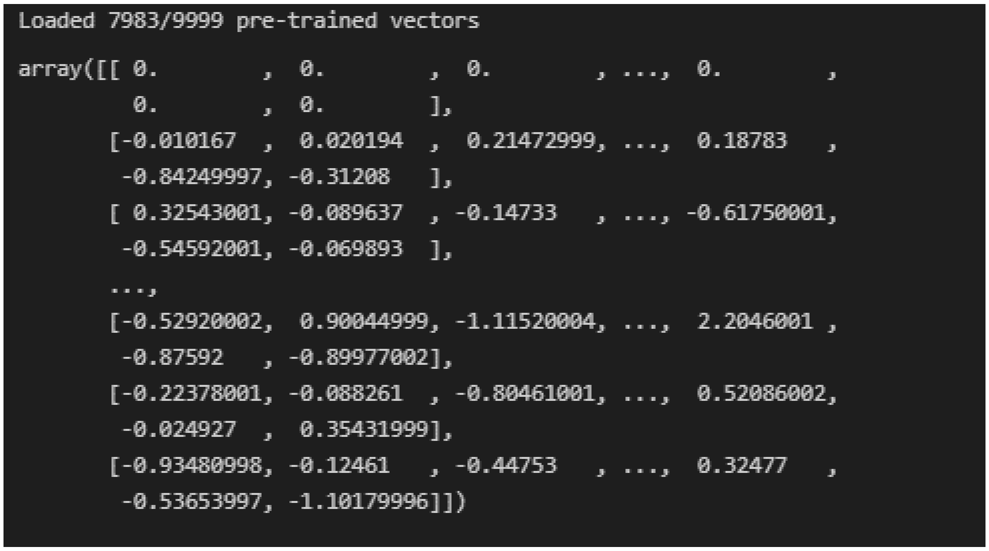


```
test_loss, test_acc = model.evaluate(X_test, y_test)
print("Test Set Accuracy: %0.2f%%"%(test_acc*100))
```

```
1312/1312 [==============================] - 22s 11ms/step - loss: 0.0364 - acc:
0.9874
Test Set Accuracy: 98.74%
```

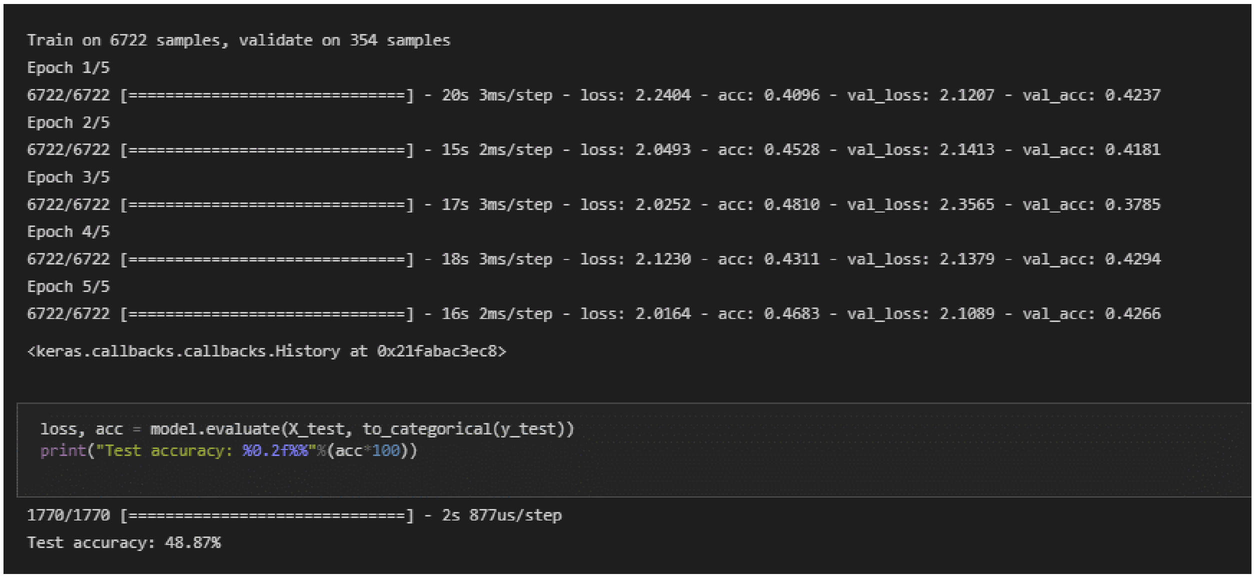
4. Pre trained embedding

Pre trained vectors



```
Loaded 7983/9999 pre-trained vectors

array([[ 0.        ,  0.        ,  0.        , ...,  0.        ,
         0.        ,  0.        ],
       [-0.010167  ,  0.020194  ,  0.21472999, ...,  0.18783   ,
        -0.84249997, -0.31208   ],
       [ 0.32543001, -0.089637  , -0.14733   , ..., -0.61750001,
        -0.54592001, -0.069893  ],
       ...,
       [-0.52920002,  0.90044999, -1.11520004, ...,  2.2046001 ,
        -0.87592   , -0.89977002],
       [-0.22378001, -0.088261  , -0.80461001, ...,  0.52086002,
        -0.024927  ,  0.35431999],
       [-0.93480998, -0.12461   , -0.44753   , ...,  0.32477   ,
        -0.53653997, -1.10179996]])
```

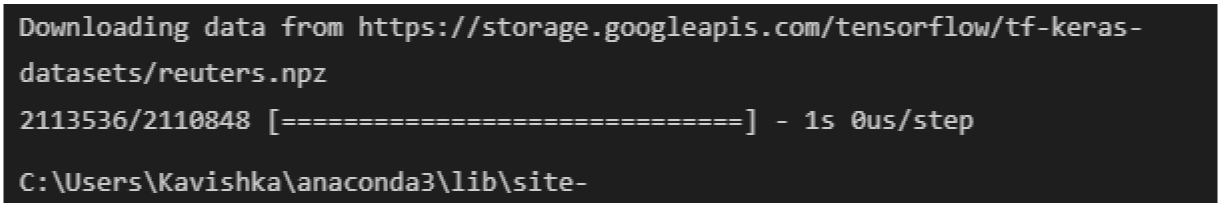
Training and testing accurcy



```
Train on 6722 samples, validate on 354 samples
Epoch 1/5
6722/6722 [==============================] - 20s 3ms/step - loss: 2.2404 - acc: 0.4096 - val_loss: 2.1207 - val_acc: 0.4237
Epoch 2/5
6722/6722 [==============================] - 15s 2ms/step - loss: 2.0493 - acc: 0.4528 - val_loss: 2.1413 - val_acc: 0.4181
Epoch 3/5
6722/6722 [==============================] - 17s 3ms/step - loss: 2.0252 - acc: 0.4810 - val_loss: 2.3565 - val_acc: 0.3785
Epoch 4/5
6722/6722 [==============================] - 18s 3ms/step - loss: 2.1230 - acc: 0.4311 - val_loss: 2.1379 - val_acc: 0.4294
Epoch 5/5
6722/6722 [==============================] - 16s 2ms/step - loss: 2.0164 - acc: 0.4683 - val_loss: 2.1089 - val_acc: 0.4266

<keras.callbacks.callbacks.History at 0x21fabac3ec8>

  loss, acc = model.evaluate(X_test, to_categorical(y_test))
  print("Test accuracy: %0.2f%%"%(acc*100))

1770/1770 [==============================] - 2s 877us/step
Test accuracy: 48.87%
```

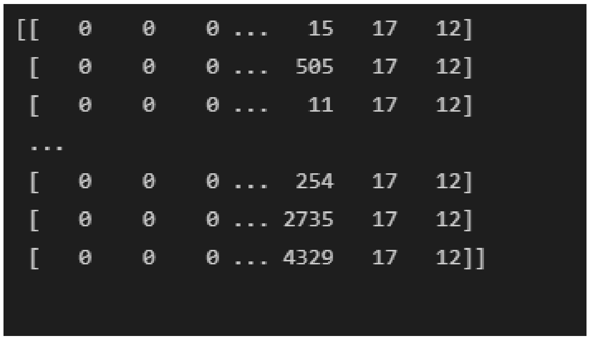
5. Recurrent Neural Network

Data Loading



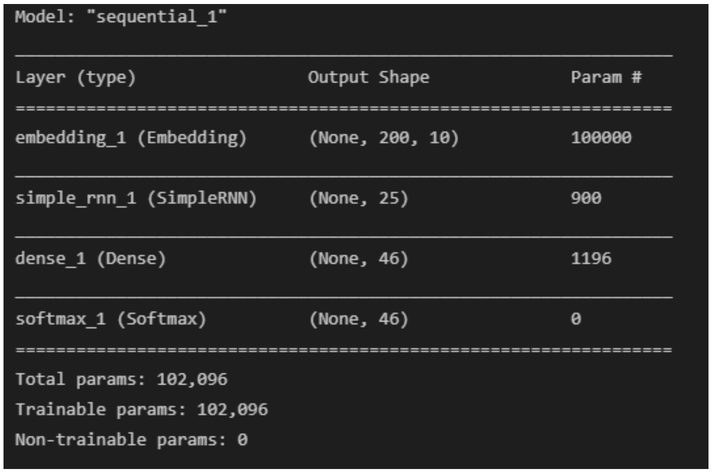
```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-
datasets/reuters.npz
2113536/2110848 [==============================] - 1s 0us/step

C:\Users\Kavishka\anaconda3\lib\site-
```

Data preparing



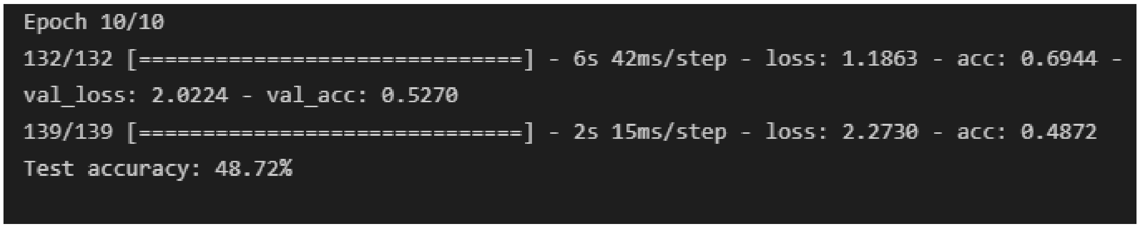
```
[[   0    0    0 ...   15   17   12]
 [   0    0    0 ...  505   17   12]
 [   0    0    0 ...   11   17   12]
 ...
 [   0    0    0 ...  254   17   12]
 [   0    0    0 ... 2735   17   12]
 [   0    0    0 ... 4329   17   12]]
```

Simple RNN



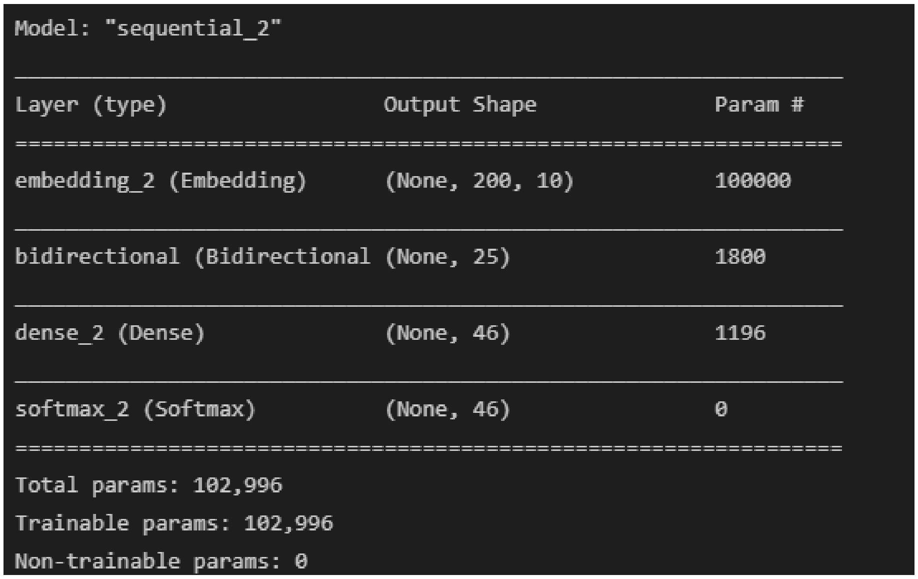
```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_1 (Embedding)      (None, 200, 10)           100000
_________________________________________________________________
simple_rnn_1 (SimpleRNN)     (None, 25)                900
_________________________________________________________________
dense_1 (Dense)              (None, 46)                1196
_________________________________________________________________
softmax_1 (Softmax)          (None, 46)                0
=================================================================
Total params: 102,096
Trainable params: 102,096
Non-trainable params: 0
```

Result



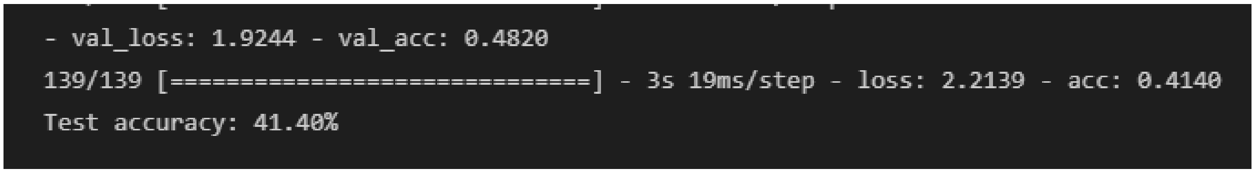
```
Epoch 10/10
132/132 [==============================] - 6s 42ms/step - loss: 1.1863 - acc: 0.6944 -
val_loss: 2.0224 - val_acc: 0.5270
139/139 [==============================] - 2s 15ms/step - loss: 2.2730 - acc: 0.4872
Test accuracy: 48.72%
```

Bidirectional RNN



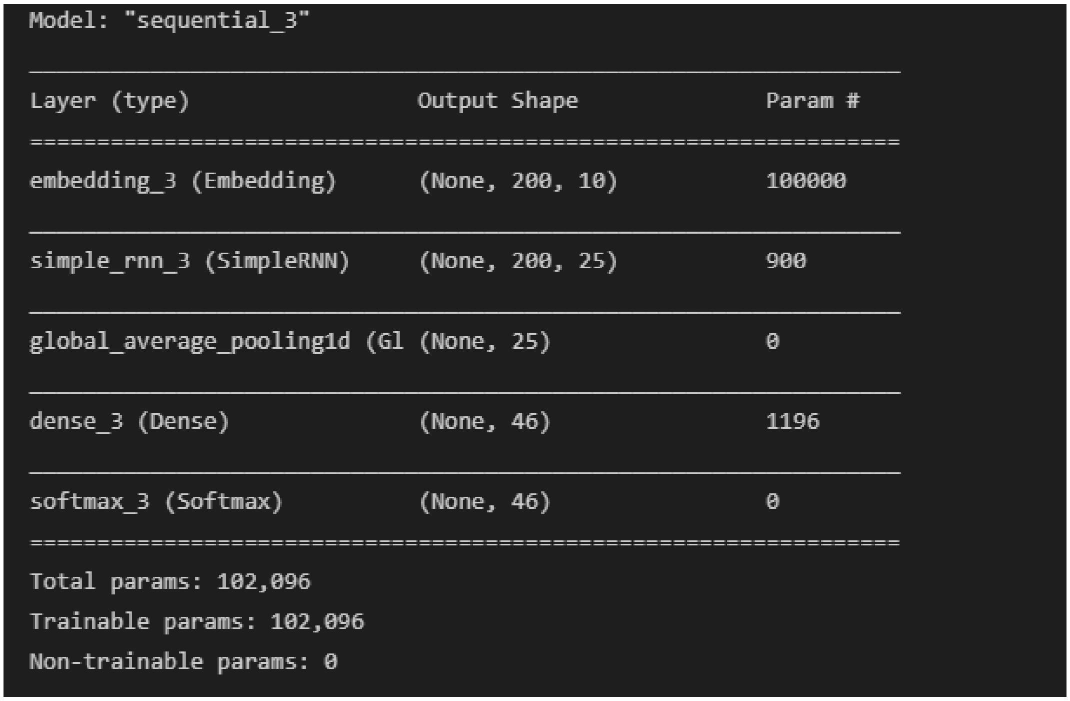
```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_2 (Embedding)      (None, 200, 10)           100000
_________________________________________________________________
bidirectional (Bidirectional (None, 25)                1800
_________________________________________________________________
dense_2 (Dense)              (None, 46)                1196
_________________________________________________________________
softmax_2 (Softmax)          (None, 46)                0
=================================================================
Total params: 102,996
Trainable params: 102,996
Non-trainable params: 0
```

Result



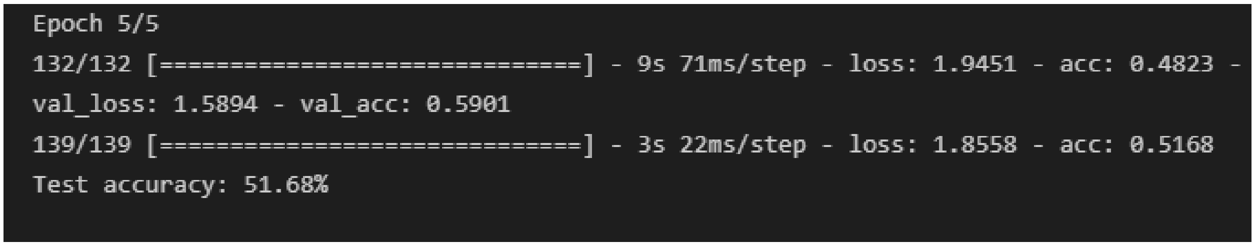
```
 - val_loss: 1.9244 - val_acc: 0.4820
139/139 [==============================] - 3s 19ms/step - loss: 2.2139 - acc: 0.4140
Test accuracy: 41.40%
```

Simple RNN with averaging



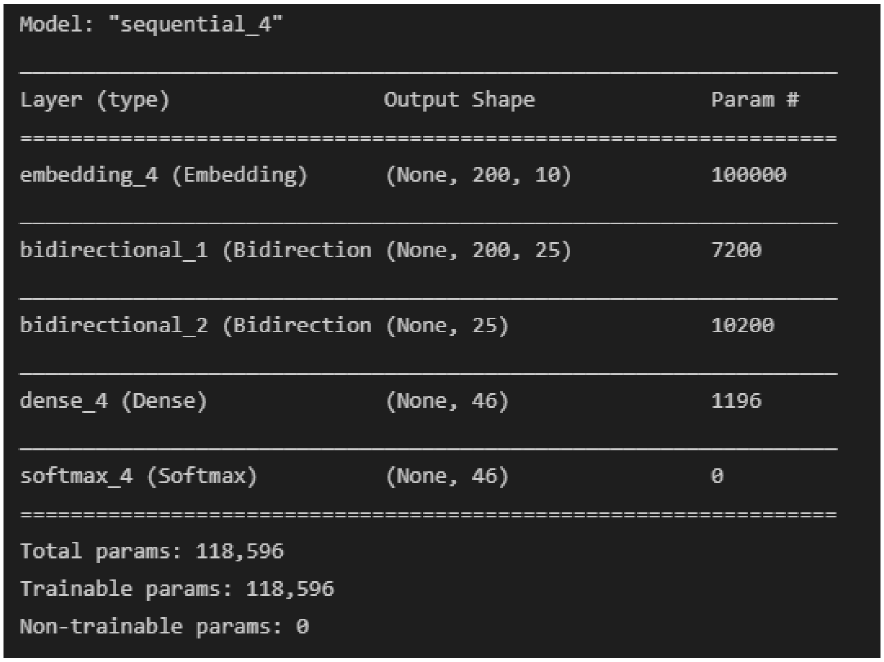
```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_3 (Embedding)      (None, 200, 10)           100000
_________________________________________________________________
simple_rnn_3 (SimpleRNN)     (None, 200, 25)           900
_________________________________________________________________
global_average_pooling1d (Gl (None, 25)                0
_________________________________________________________________
dense_3 (Dense)              (None, 46)                1196
_________________________________________________________________
softmax_3 (Softmax)          (None, 46)                0
=================================================================
Total params: 102,096
Trainable params: 102,096
Non-trainable params: 0
```

Result



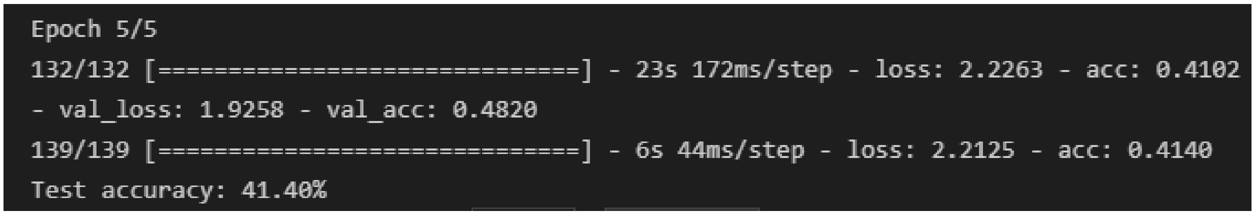
```
Epoch 5/5
132/132 [==============================] - 9s 71ms/step - loss: 1.9451 - acc: 0.4823 -
val_loss: 1.5894 - val_acc: 0.5901
139/139 [==============================] - 3s 22ms/step - loss: 1.8558 - acc: 0.5168
Test accuracy: 51.68%
```

Multilayer Bidirectional RNN



```
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_4 (Embedding)      (None, 200, 10)           100000
_________________________________________________________________
bidirectional_1 (Bidirection (None, 200, 25)           7200
_________________________________________________________________
bidirectional_2 (Bidirection (None, 25)                10200
_________________________________________________________________
dense_4 (Dense)              (None, 46)                1196
_________________________________________________________________
softmax_4 (Softmax)          (None, 46)                0
=================================================================
Total params: 118,596
Trainable params: 118,596
Non-trainable params: 0
```

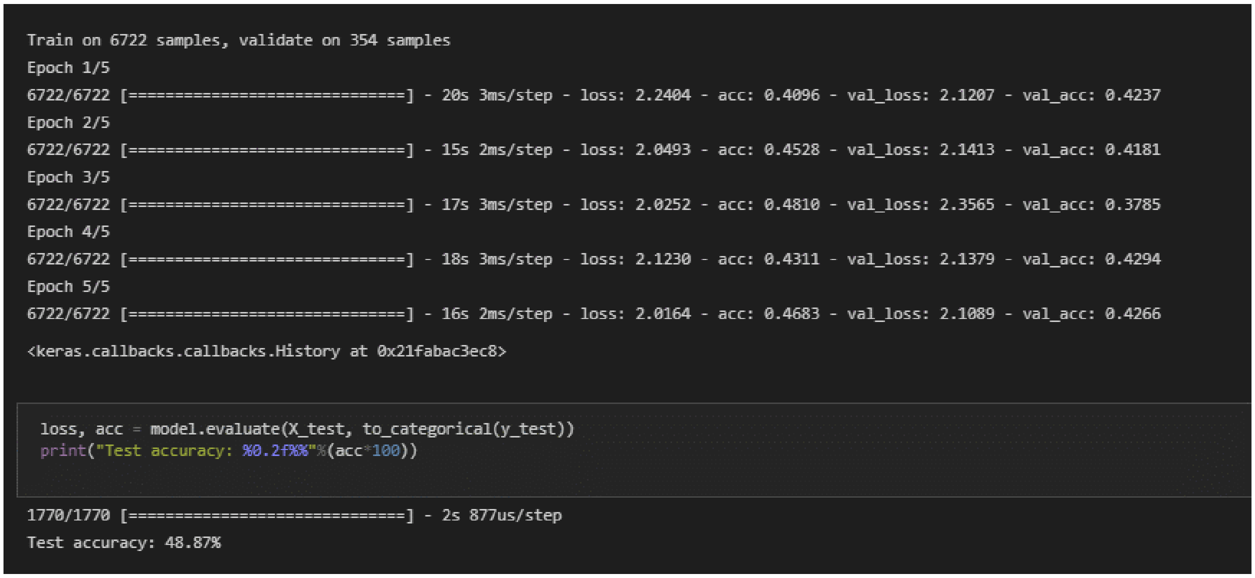
Result



```
Epoch 5/5
132/132 [==============================] - 23s 172ms/step - loss: 2.2263 - acc: 0.4102
- val_loss: 1.9258 - val_acc: 0.4820
139/139 [==============================] - 6s 44ms/step - loss: 2.2125 - acc: 0.4140
Test accuracy: 41.40%
```

6. Reuters News Classification

Data loading

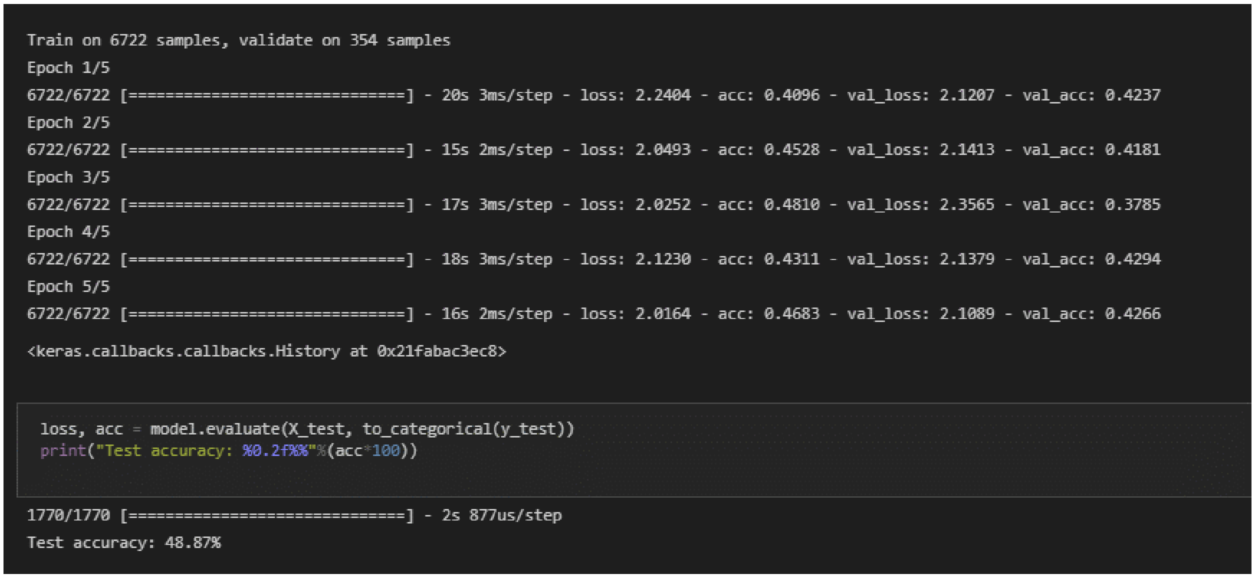


```
Train on 6722 samples, validate on 354 samples
Epoch 1/5
6722/6722 [==============================] - 20s 3ms/step - loss: 2.2404 - acc: 0.4096 - val_loss: 2.1207 - val_acc: 0.4237
Epoch 2/5
6722/6722 [==============================] - 15s 2ms/step - loss: 2.0493 - acc: 0.4528 - val_loss: 2.1413 - val_acc: 0.4181
Epoch 3/5
6722/6722 [==============================] - 17s 3ms/step - loss: 2.0252 - acc: 0.4810 - val_loss: 2.3565 - val_acc: 0.3785
Epoch 4/5
6722/6722 [==============================] - 18s 3ms/step - loss: 2.1230 - acc: 0.4311 - val_loss: 2.1379 - val_acc: 0.4294
Epoch 5/5
6722/6722 [==============================] - 16s 2ms/step - loss: 2.0164 - acc: 0.4683 - val_loss: 2.1089 - val_acc: 0.4266

<keras.callbacks.callbacks.History at 0x21fabac3ec8>
```

```python
loss, acc = model.evaluate(X_test, to_categorical(y_test))
print("Test accuracy: %0.2f%%"%(acc*100))
```

```
1770/1770 [==============================] - 2s 877us/step
Test accuracy: 48.87%
```

Dense NN model

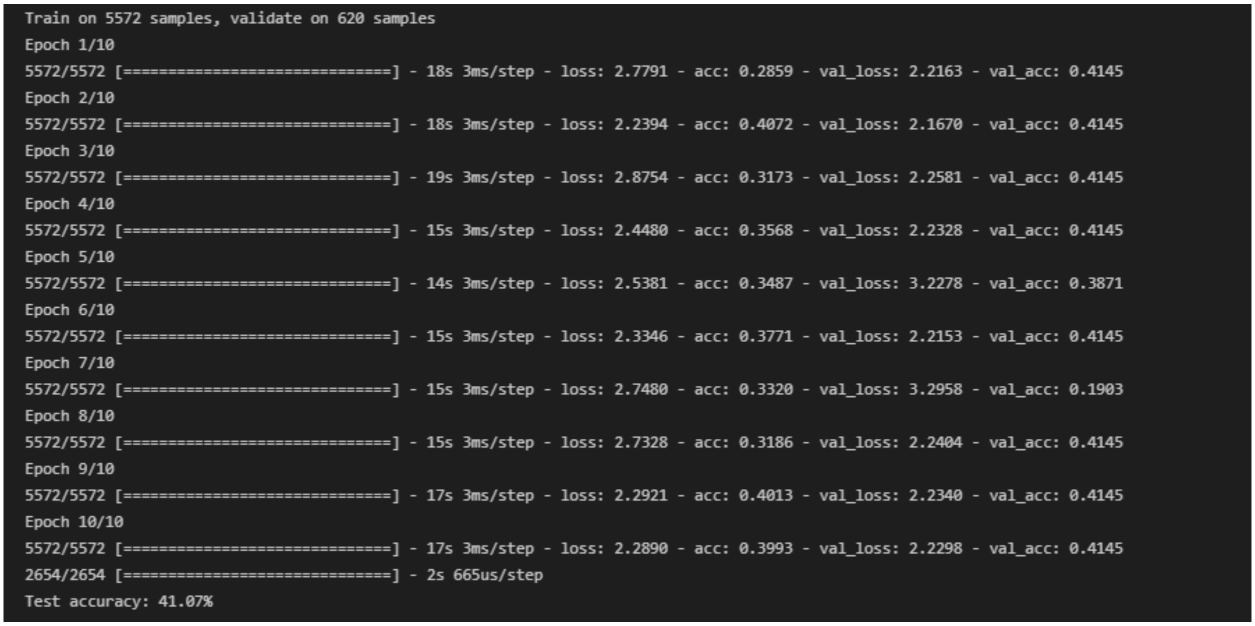


```
Train on 6722 samples, validate on 354 samples
Epoch 1/5
6722/6722 [==============================] - 20s 3ms/step - loss: 2.2404 - acc: 0.4096 - val_loss: 2.1207 - val_acc: 0.4237
Epoch 2/5
6722/6722 [==============================] - 15s 2ms/step - loss: 2.0493 - acc: 0.4528 - val_loss: 2.1413 - val_acc: 0.4181
Epoch 3/5
6722/6722 [==============================] - 17s 3ms/step - loss: 2.0252 - acc: 0.4810 - val_loss: 2.3565 - val_acc: 0.3785
Epoch 4/5
6722/6722 [==============================] - 18s 3ms/step - loss: 2.1230 - acc: 0.4311 - val_loss: 2.1379 - val_acc: 0.4294
Epoch 5/5
6722/6722 [==============================] - 16s 2ms/step - loss: 2.0164 - acc: 0.4683 - val_loss: 2.1089 - val_acc: 0.4266

<keras.callbacks.callbacks.History at 0x21fabac3ec8>
```

```python
loss, acc = model.evaluate(X_test, to_categorical(y_test))
print("Test accuracy: %0.2f%%"%(acc*100))
```

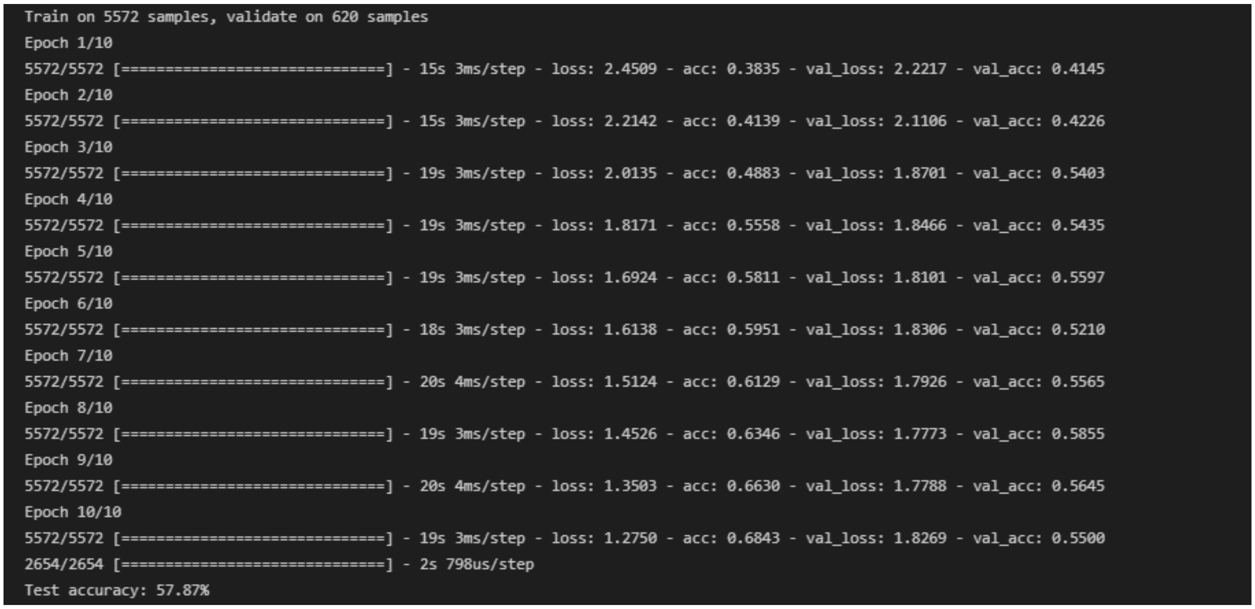
```
1770/1770 [==============================] - 2s 877us/step
Test accuracy: 48.87%
```

Vanilla RNN



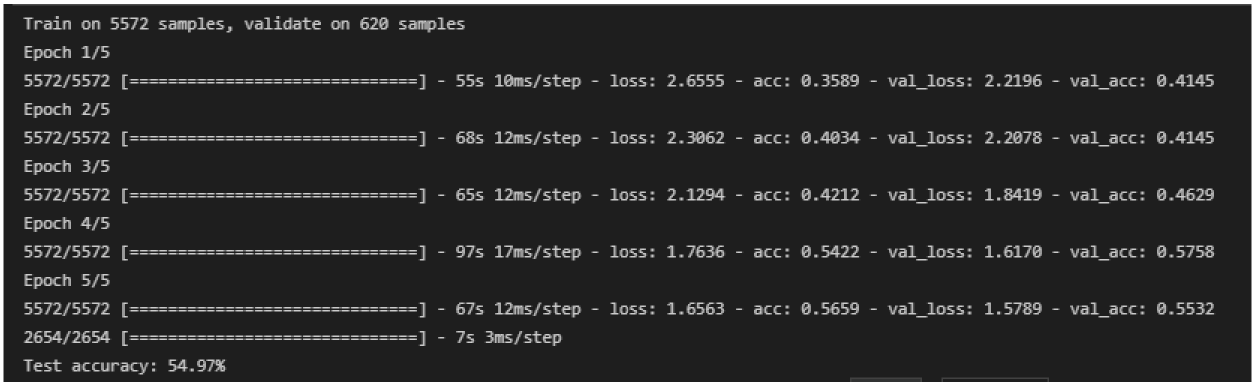
```
Train on 5572 samples, validate on 620 samples
Epoch 1/10
5572/5572 [==============================] - 18s 3ms/step - loss: 2.7791 - acc: 0.2859 - val_loss: 2.2163 - val_acc: 0.4145
Epoch 2/10
5572/5572 [==============================] - 18s 3ms/step - loss: 2.2394 - acc: 0.4072 - val_loss: 2.1670 - val_acc: 0.4145
Epoch 3/10
5572/5572 [==============================] - 19s 3ms/step - loss: 2.8754 - acc: 0.3173 - val_loss: 2.2581 - val_acc: 0.4145
Epoch 4/10
5572/5572 [==============================] - 15s 3ms/step - loss: 2.4480 - acc: 0.3568 - val_loss: 2.2328 - val_acc: 0.4145
Epoch 5/10
5572/5572 [==============================] - 14s 3ms/step - loss: 2.5381 - acc: 0.3487 - val_loss: 3.2278 - val_acc: 0.3871
Epoch 6/10
5572/5572 [==============================] - 15s 3ms/step - loss: 2.3346 - acc: 0.3771 - val_loss: 2.2153 - val_acc: 0.4145
Epoch 7/10
5572/5572 [==============================] - 15s 3ms/step - loss: 2.7480 - acc: 0.3320 - val_loss: 3.2958 - val_acc: 0.1903
Epoch 8/10
5572/5572 [==============================] - 15s 3ms/step - loss: 2.7328 - acc: 0.3186 - val_loss: 2.2404 - val_acc: 0.4145
Epoch 9/10
5572/5572 [==============================] - 17s 3ms/step - loss: 2.2921 - acc: 0.4013 - val_loss: 2.2340 - val_acc: 0.4145
Epoch 10/10
5572/5572 [==============================] - 17s 3ms/step - loss: 2.2890 - acc: 0.3993 - val_loss: 2.2298 - val_acc: 0.4145
2654/2654 [==============================] - 2s 665us/step
Test accuracy: 41.07%
```

Bidirectional RNN



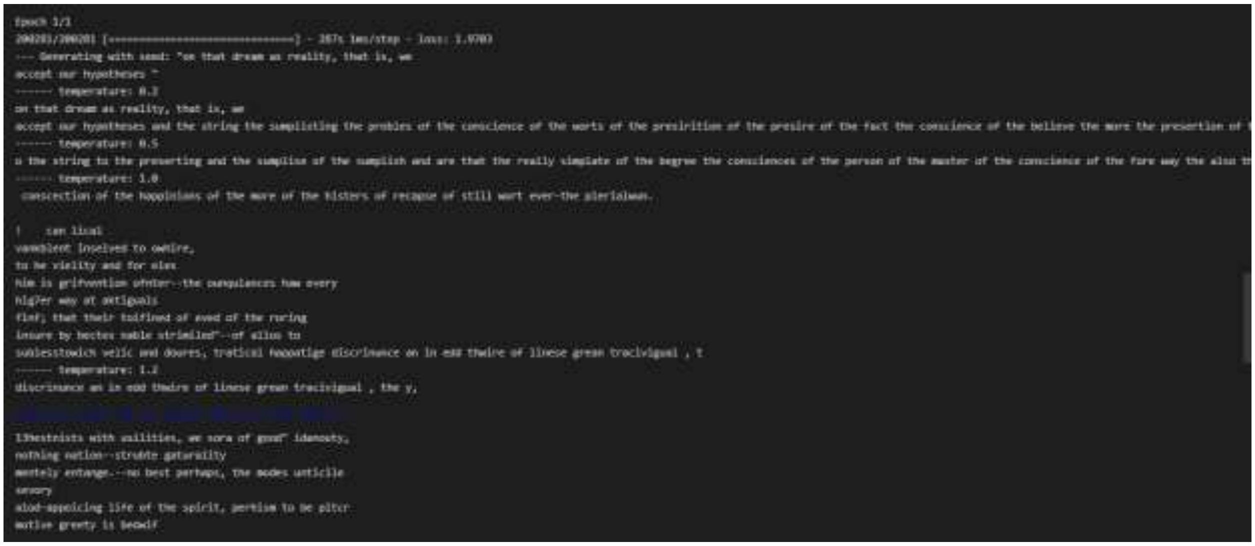
```
Train on 5572 samples, validate on 620 samples
Epoch 1/10
5572/5572 [==============================] - 15s 3ms/step - loss: 2.4509 - acc: 0.3835 - val_loss: 2.2217 - val_acc: 0.4145
Epoch 2/10
5572/5572 [==============================] - 15s 3ms/step - loss: 2.2142 - acc: 0.4139 - val_loss: 2.1106 - val_acc: 0.4226
Epoch 3/10
5572/5572 [==============================] - 19s 3ms/step - loss: 2.0135 - acc: 0.4883 - val_loss: 1.8701 - val_acc: 0.5403
Epoch 4/10
5572/5572 [==============================] - 19s 3ms/step - loss: 1.8171 - acc: 0.5558 - val_loss: 1.8466 - val_acc: 0.5435
Epoch 5/10
5572/5572 [==============================] - 19s 3ms/step - loss: 1.6924 - acc: 0.5811 - val_loss: 1.8101 - val_acc: 0.5597
Epoch 6/10
5572/5572 [==============================] - 18s 3ms/step - loss: 1.6138 - acc: 0.5951 - val_loss: 1.8306 - val_acc: 0.5210
Epoch 7/10
5572/5572 [==============================] - 20s 4ms/step - loss: 1.5124 - acc: 0.6129 - val_loss: 1.7926 - val_acc: 0.5565
Epoch 8/10
5572/5572 [==============================] - 19s 3ms/step - loss: 1.4526 - acc: 0.6346 - val_loss: 1.7773 - val_acc: 0.5855
Epoch 9/10
5572/5572 [==============================] - 20s 4ms/step - loss: 1.3503 - acc: 0.6630 - val_loss: 1.7788 - val_acc: 0.5645
Epoch 10/10
5572/5572 [==============================] - 19s 3ms/step - loss: 1.2750 - acc: 0.6843 - val_loss: 1.8269 - val_acc: 0.5500
2654/2654 [==============================] - 2s 798us/step
Test accuracy: 57.87%
```

Multilayer Bidirectional RNN



```
Train on 5572 samples, validate on 620 samples
Epoch 1/5
5572/5572 [==============================] - 55s 10ms/step - loss: 2.6555 - acc: 0.3589 - val_loss: 2.2196 - val_acc: 0.4145
Epoch 2/5
5572/5572 [==============================] - 68s 12ms/step - loss: 2.3062 - acc: 0.4034 - val_loss: 2.2078 - val_acc: 0.4145
Epoch 3/5
5572/5572 [==============================] - 65s 12ms/step - loss: 2.1294 - acc: 0.4212 - val_loss: 1.8419 - val_acc: 0.4629
Epoch 4/5
5572/5572 [==============================] - 97s 17ms/step - loss: 1.7636 - acc: 0.5422 - val_loss: 1.6170 - val_acc: 0.5758
Epoch 5/5
5572/5572 [==============================] - 67s 12ms/step - loss: 1.6563 - acc: 0.5659 - val_loss: 1.5789 - val_acc: 0.5532
2654/2654 [==============================] - 7s 3ms/step
Test accuracy: 54.97%
```

7. Text-Generation-with-LSTM



```
Epoch 1/1
200281/200281 [==============================] - 287s 1ms/step - loss: 1.9703
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------ temperature: 0.2
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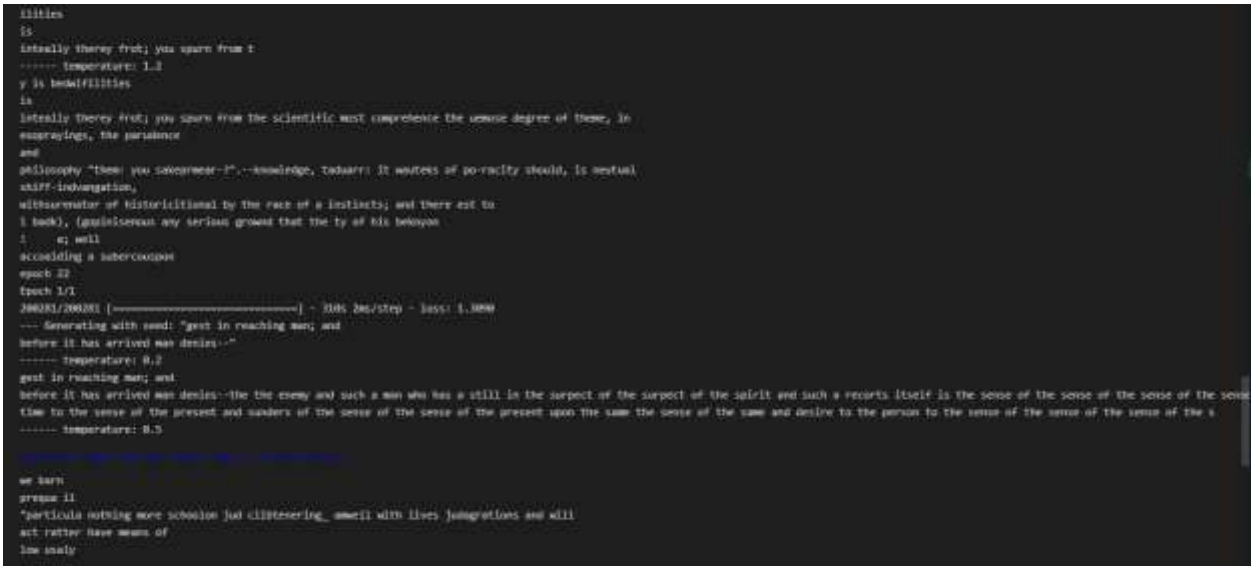

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 Epoch 1/1
 200281/200281 [==============================] - 310s 2ms/step - loss: 1.3890
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 before it has arrived man denies--"
 ------ temperature: 0.2
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 ------ temperature: 0.5

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