DL Assignment 1-Group 299

Question No.1

NLP Dataset: Dataset consisting of 20k reviews from trip advisor.

Links to an external site. (Links to an external site.) : https://www.kaggle.com/datasets/andrewmvd/trip-advisor-hotel-reviews

(6 marks)

Import Libraries/Dataset (0 mark) Import the required libraries and the dataset (use Google Drive if required). Check the GPU available (recommended- use free GPU provided by Google Colab).

Data Visualization (0.75 mark) Print at least two records from each class of the dataset, for a sanity check that labels match the text. Plot a bar graph of class distribution in the dataset. Each bar depicts the number of records belonging to a particular class in the dataset. (recommended - matplotlib/seaborn libraries) Any other visualizations that seem appropriate for this problem are encouraged but not necessary, for the points. Print the shapes of train and test data.

Data Pre-processing (0.25 mark) Need for this Step- Since the models we use cannot accept string inputs or cannot be of the string format. We have to come up with a way of handling this step. The discussion of different ways of handling this step is out of the scope of this assignment. Please usethis pre-trained embedding layer (Links to an external site.) : https://tfhub.dev/google/nnlm-en-dim128/2 Links to an external site. (Links to an external site.) : https://tfhub.dev/google/nnlm-en-dim128/2 from TensorFlow hub for this assignment. This link also has a code snippet on how to convert a sentence to a vector. Refer to that for further clarity on this subject. Bring the train and test data in the required format.

Model Building (0.2*5 = 1 mark) Sequential Model layers- Use AT LEAST 5 hidden layers with appropriate input for each. Choose the best number for hidden units and give reasons. Add L1 regularization to all the layers. Add one layer of dropout at the appropriate position and give reasons. Choose the appropriate activation function for all the layers. Print the model summary.

Model Compilation (0.25 mark) Compile the model with the appropriate loss function. Use an appropriate optimizer. Give reasons for the choice of learning rate and its value. Use accuracy as a metric.

Model Training (0.5 + 0.25 = 0.75 mark) Train the model for an appropriate number of epochs. Print the train and validation accuracy and loss for each epoch. Use the appropriate

batch size. Plot the loss and accuracy history graphs for both train and validation set. Print the total time taken for training.

Model Evaluation (0.5 + 0.5 = 1 mark) Print the final train and validation loss and accuracy. Print confusion matrix and classification report for the validation dataset. Analyse and report the best and worst performing class. Print the two most incorrectly classified records for each class in the test dataset.

Hyperparameter Tuning- Build two more models by changing the following hyperparameters one at a time. Write the code for Model Building, Model Compilation, Model Training and Model Evaluation as given in the instructions above for each additional model. (1 + 1 = 2 marks)

Regularization: Train a model without regularization

Dropout:Change the position and value of dropout layer Write a comparison between each model and give reasons for the difference in results.

-- coding: utf-8 --

Indentation: Jupyter Notebook

version='1.0.0' **author**="Sourav Raj, Nitin Agarwal, Anusha linda kostka j e" **email**="2020sc04304@wilp.bits-pilani.ac.in; 2020sc04557@wilp.bits-pilani.ac.in; 2020sc04900@wilp.bits-pilani.ac.in"

In [162…
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
import random
import warnings
warnings.filterwarnings('ignore')

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, MinMaxScaler
from wordcloud import WordCloud,STOPWORDS
# ANN
import keras
import tensorflow as tf
from keras.callbacks import ModelCheckpoint
from keras.models import Sequential
from keras.layers import BatchNormalization
from keras.layers import Dense, Activation, Flatten, Dropout
from keras.callbacks import ReduceLROnPlateau
from keras.callbacks import EarlyStopping
from tensorflow.keras.optimizers import Adam, SGD
from keras.callbacks import ModelCheckpoint
from keras.callbacks import ReduceLROnPlateau
from keras.callbacks import EarlyStopping
from keras import regularizers
import tensorflow_hub as hub
from sklearn.metrics import classification_report,confusion_matrix
```

In [2]:
```
random.seed(42)          # Initialize the random number generator.
np.random.seed(42)       # With the seed reset, the same set of
                         # numbers will appear every time.
```

```
#tf.set_random_seed(42)  # sets the graph-level random seed
tf.random.set_seed(42)
```

Import data

In [3]:
```
data = pd.read_csv('tripadvisor_hotel_reviews.csv')
print(data.shape)
data.head(2)
```

```
(20491, 2)
```

Out[3]:

	Review	Rating
0	nice hotel expensive parking got good deal sta...	4
1	ok nothing special charge diamond member hilto...	2

Data Exploration

In [4]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 20491 entries, 0 to 20490
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   Review  20491 non-null  object
 1   Rating  20491 non-null  int64 
dtypes: int64(1), object(1)
memory usage: 320.3+ KB
```

In [6]:
```
data.isnull().sum()
#No data Missing
```

Out[6]:
```
Review    0
Rating    0
dtype: int64
```

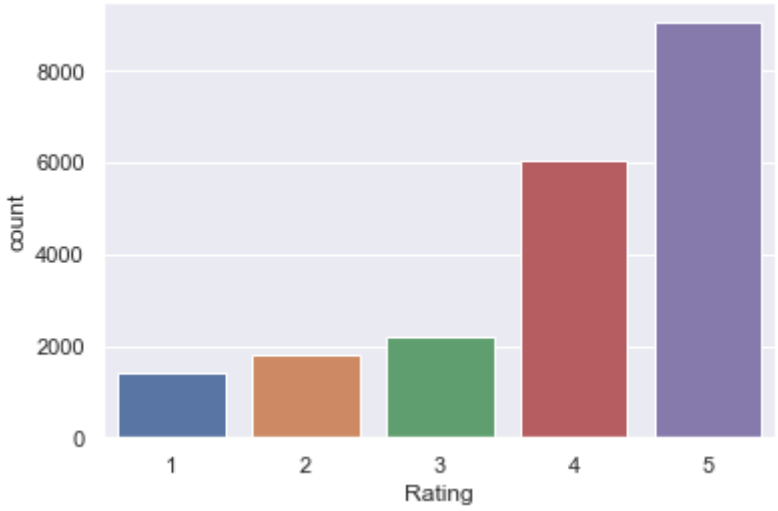
In [8]:
```
data['Rating'].unique()
#Five Labels for Classification
```

Out[8]:
```
array([4, 2, 3, 5, 1], dtype=int64)
```

In [10]:
```
#checking counts for each label
data['Rating'].value_counts()
#Maximum is 5 Min is 1
```

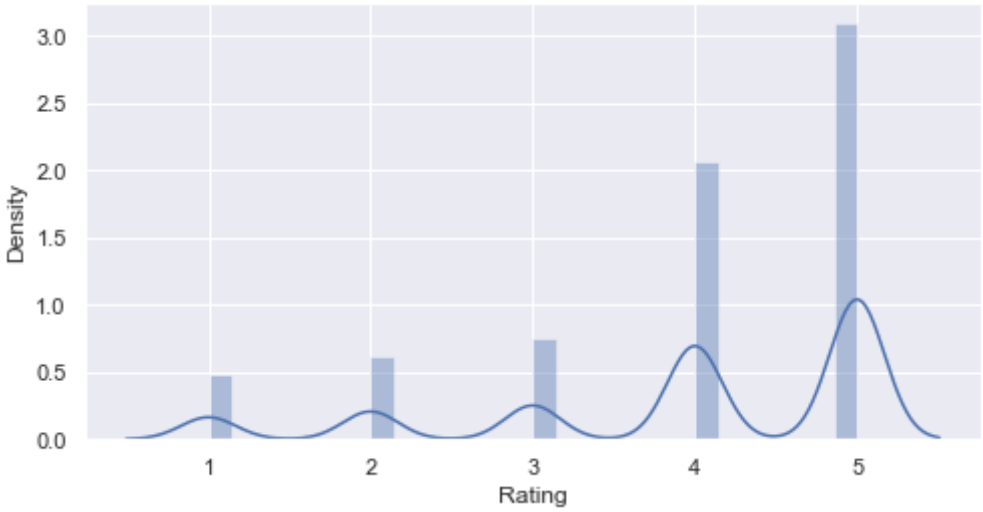
Out[10]:
```
5    9054
4    6039
3    2184
2    1793
1    1421
Name: Rating, dtype: int64
```

In [12]:
```
#Plotting Class labels on a Graph
sns.set_theme(style="darkgrid")
ax = sns.countplot(x="Rating", data=data)
```



In [13]:
```
fig, ax = plt.subplots(1,1, figsize=(8, 4))
sns.distplot(data['Rating'])
```

Out[13]:
```
<AxesSubplot:xlabel='Rating', ylabel='Density'>
```



In [163…
```
#Word Cloud generator for Reviews
wordcloud = WordCloud(width = 800, height = 800, background_color ='white', min_fo
plt.figure(figsize = (8, 8), facecolor = None)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.tight_layout(pad = 0)
plt.title("Top Words",fontsize=30)
plt.show()
```

In [21]:
```
for i in range(1,6):
    print(data.loc[data['Rating'] == i].head(2))
```

```
                                               Review  Rating
15  horrible customer service hotel stay february ...       1
32  noise airconditioner-a standard, arranged stay...       1
                                               Review  Rating
1   ok nothing special charge diamond member hilto...       2
10  poor value stayed monaco seattle july, nice ho...       2
                                               Review  Rating
2   nice rooms not 4* experience hotel monaco seat...       3
13  nice hotel not nice staff hotel lovely staff q...       3
                                              Review  Rating
0  nice hotel expensive parking got good deal sta...       4
7  excellent staff, housekeeping quality hotel ch...       4
                                              Review  Rating
3  unique, great stay, wonderful time hotel monac...       5
4  great stay great stay, went seahawk game aweso...       5
```

Data Preprocessing

Splitting the data into two parts 70% for training and 30% for validation

In [167…
```
Predictor=data.loc[:,['Review']].values
Target=data.loc[:,'Rating'].values

X_train, X_test, y_train, y_test = train_test_split(Predictor, Target, test_size=0
print(f'Shape of Training data is {len(X_train), len(X_train[0])}')
print(f'Shape of Testing data is {len(X_test), len(X_test[0])}')
```

```
Shape of Training data is (14343, 1)
Shape of Testing data is (6148, 1)
```

In [168…
```
X_train = np.reshape(X_train,len(X_train))
X_test = np.reshape(X_test,len(X_test))
#Pre-trained text embedding

embed = hub.load("https://tfhub.dev/google/nnlm-en-dim128/2")
X_train = embed(X_train)
X_test = embed(X_test)
```

```
WARNING:tensorflow:8 out of the last 11 calls to <function recreate_function.<loca
ls>.restored_function_body at 0x00000204E16813A8> triggered tf.function retracing.
Tracing is expensive and the excessive number of tracings could be due to (1) crea
ting @tf.function repeatedly in a loop, (2) passing tensors with different shapes,
(3) passing Python objects instead of tensors. For (1), please define your @tf.fun
ction outside of the loop. For (2), @tf.function has experimental_relax_shapes=Tru
e option that relaxes argument shapes that can avoid unnecessary retracing. For
(3), please refer to https://www.tensorflow.org/tutorials/customization/performanc
e#python_or_tensor_args and https://www.tensorflow.org/api_docs/python/tf/function
for  more details.
```


```
WARNING:tensorflow:8 out of the last 11 calls to <function recreate_function.<loca
ls>.restored_function_body at 0x00000204E16813A8> triggered tf.function retracing.
Tracing is expensive and the excessive number of tracings could be due to (1) crea
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e option that relaxes argument shapes that can avoid unnecessary retracing. For
(3), please refer to https://www.tensorflow.org/tutorials/customization/performanc
e#python_or_tensor_args and https://www.tensorflow.org/api_docs/python/tf/function
for  more details.
```


```
WARNING:tensorflow:9 out of the last 12 calls to <function recreate_function.<loca
ls>.restored_function_body at 0x00000204C0B30678> triggered tf.function retracing.
Tracing is expensive and the excessive number of tracings could be due to (1) crea
ting @tf.function repeatedly in a loop, (2) passing tensors with different shapes,
(3) passing Python objects instead of tensors. For (1), please define your @tf.fun
ction outside of the loop. For (2), @tf.function has experimental_relax_shapes=Tru
e option that relaxes argument shapes that can avoid unnecessary retracing. For
(3), please refer to https://www.tensorflow.org/tutorials/customization/performanc
e#python_or_tensor_args and https://www.tensorflow.org/api_docs/python/tf/function
for  more details.
```


```
WARNING:tensorflow:9 out of the last 12 calls to <function recreate_function.<loca
ls>.restored_function_body at 0x00000204C0B30678> triggered tf.function retracing.
Tracing is expensive and the excessive number of tracings could be due to (1) crea
ting @tf.function repeatedly in a loop, (2) passing tensors with different shapes,
(3) passing Python objects instead of tensors. For (1), please define your @tf.fun
ction outside of the loop. For (2), @tf.function has experimental_relax_shapes=Tru
e option that relaxes argument shapes that can avoid unnecessary retracing. For
(3), please refer to https://www.tensorflow.org/tutorials/customization/performanc
e#python_or_tensor_args and https://www.tensorflow.org/api_docs/python/tf/function
for  more details.
```

```
WARNING:tensorflow:10 out of the last 13 calls to <function recreate_function.<locals>.restored_function_body at 0x00000204E16814C8> triggered tf.function retracing. Tracing is expensive and the excessive number of tracings could be due to (1) creating @tf.function repeatedly in a loop, (2) passing tensors with different shapes, (3) passing Python objects instead of tensors. For (1), please define your @tf.function outside of the loop. For (2), @tf.function has experimental_relax_shapes=True option that relaxes argument shapes that can avoid unnecessary retracing. For (3), please refer to https://www.tensorflow.org/tutorials/customization/performance#python_or_tensor_args and https://www.tensorflow.org/api_docs/python/tf/function for  more details.
```


```
WARNING:tensorflow:10 out of the last 13 calls to <function recreate_function.<locals>.restored_function_body at 0x00000204E16814C8> triggered tf.function retracing. Tracing is expensive and the excessive number of tracings could be due to (1) creating @tf.function repeatedly in a loop, (2) passing tensors with different shapes, (3) passing Python objects instead of tensors. For (1), please define your @tf.function outside of the loop. For (2), @tf.function has experimental_relax_shapes=True option that relaxes argument shapes that can avoid unnecessary retracing. For (3), please refer to https://www.tensorflow.org/tutorials/customization/performance#python_or_tensor_args and https://www.tensorflow.org/api_docs/python/tf/function for  more details.
```


In [169…

```
print(f'Shape of Training data is {len(X_train), len(X_train[0])}')
print(f'Shape of Testing data is {len(X_test), len(X_test[0])}')
```

```
Shape of Training data is (14343, 128)
Shape of Testing data is (6148, 128)
```

In [170…

```
# changing the labels to arrays of hot encoding using keras utility
y_train, y_test=y_train-1, y_test-1
y_train = tf.keras.utils.to_categorical(y_train, num_classes=5)
y_test = tf.keras.utils.to_categorical(y_test, num_classes=5)
print(y_train[0], y_test[0])
```

```
[0. 0. 0. 1. 0.] [0. 0. 0. 1. 0.]
```

Model Building

learning rate: The range of values to consider for the learning rate should be between 10^-6 to 1. A traditional default value for the learning rate is 0.1 or 0.01 which is a good starting point for any problem and this can be further optimize with Hyper parameter tuning. In this problem after several iteration & testing we are taking 0.001 as starting point as its convergence is faster.

Activation function: As this problem is binary classification problem, we choose sigmoid in the output layer and relu in the hidden layer as its performance is better and doesn't have exploding/vanishing gradient problem. In addition we can also choose hidden layer activation function using hyper parameter tuning.

loss function: Binary crossentropy is used as a loss function for this problem as we have binary class at the target variable.

optimizer: Adam optimizer is used which generally prefer over others.

In addition variable learning rate with factor of 0.5 is used if val_loss is not improving for 10 consecutive patience.

Early Stopping criteria is used if val_loss is not improving for 50 patience.

Dropout layer of 0.1 is also added to avoid overfitting in the model

Model Iteration #1 - Baseline

As we have 128 feature, we choose 128 in the starting layer & increased to 256 for better hidden features collection and consquently to achieve better accuracy. Further we reduced the number of nodes in consequent layers to achieve lighter network architecture.

Activation function for output layer has been choosen to softmax as it is multiclass problem and for hidden layer, relu is used as it doesn't have vanishing gradient problem & its convergence is faster.

In [91]:
```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(64,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.1))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(16,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))

# The Output Layer :
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())
```

```
Model: "sequential_7"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_30 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_31 (Dense)             (None, 256)               33024
_________________________________________________________________
dense_32 (Dense)             (None, 64)                16448
_________________________________________________________________
dropout_4 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_33 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_34 (Dense)             (None, 32)                1056
_________________________________________________________________
dense_35 (Dense)             (None, 16)                528
_________________________________________________________________
dense_36 (Dense)             (None, 5)                 85
=================================================================
Total params: 69,733
Trainable params: 69,733
Non-trainable params: 0
_________________________________________________________________
None
```

Model Compilation

Learning rate: The range of values to consider for the learning rate should be between 10^-6 to 1. A traditional default value for the learning rate is 0.1 or 0.01 which is a good starting point for any problem and this can be further optimize with Hyper parameter tuning. In this problem after several iteration & testing we are taking 0.0001 as starting point as its convergence is faster.

Optimizer: Adam is used as its performance is better as Adam realizes the benefits of both AdaGrad and RMSProp.

In [92]:
```
adam=Adam(learning_rate=0.0001)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a
```

Model Training

In [93]:
```
start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validati
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model training is started at 1656181888.305475
Epoch 1/200
225/225 [==============================] - 1s 6ms/step - loss: 4.6561 - accuracy:
0.3800 - val_loss: 4.0541 - val_accuracy: 0.4419
Epoch 2/200
225/225 [==============================] - 1s 5ms/step - loss: 3.5657 - accuracy:
0.4603 - val_loss: 3.1248 - val_accuracy: 0.4893
Epoch 3/200
225/225 [==============================] - 1s 5ms/step - loss: 2.7792 - accuracy:
0.5035 - val_loss: 2.4596 - val_accuracy: 0.5054
Epoch 4/200
225/225 [==============================] - 1s 5ms/step - loss: 2.2081 - accuracy:
0.5140 - val_loss: 1.9799 - val_accuracy: 0.5091
Epoch 5/200
225/225 [==============================] - 1s 5ms/step - loss: 1.8145 - accuracy:
0.5196 - val_loss: 1.6716 - val_accuracy: 0.5128
Epoch 6/200
225/225 [==============================] - 1s 5ms/step - loss: 1.5866 - accuracy:
0.5218 - val_loss: 1.5233 - val_accuracy: 0.5120
Epoch 7/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4805 - accuracy:
0.5249 - val_loss: 1.4486 - val_accuracy: 0.5198
Epoch 8/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4189 - accuracy:
0.5282 - val_loss: 1.3942 - val_accuracy: 0.5194
Epoch 9/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3698 - accuracy:
0.5289 - val_loss: 1.3578 - val_accuracy: 0.5202
Epoch 10/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3332 - accuracy:
0.5320 - val_loss: 1.3222 - val_accuracy: 0.5226
Epoch 11/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3052 - accuracy:
0.5338 - val_loss: 1.2963 - val_accuracy: 0.5241
Epoch 12/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2835 - accuracy:
0.5345 - val_loss: 1.2770 - val_accuracy: 0.5283
Epoch 13/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2644 - accuracy:
0.5402 - val_loss: 1.2647 - val_accuracy: 0.5351
Epoch 14/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2510 - accuracy:
0.5424 - val_loss: 1.2487 - val_accuracy: 0.5372
Epoch 15/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2378 - accuracy:
0.5411 - val_loss: 1.2389 - val_accuracy: 0.5335
Epoch 16/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2276 - accuracy:
0.5442 - val_loss: 1.2293 - val_accuracy: 0.5379
Epoch 17/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2211 - accuracy:
0.5438 - val_loss: 1.2211 - val_accuracy: 0.5412
Epoch 18/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2118 - accuracy:
0.5477 - val_loss: 1.2177 - val_accuracy: 0.5452
Epoch 19/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2050 - accuracy:
0.5480 - val_loss: 1.2078 - val_accuracy: 0.5436
Epoch 20/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1977 - accuracy:
0.5478 - val_loss: 1.2018 - val_accuracy: 0.5441
Epoch 21/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1920 - accuracy:
0.5519 - val_loss: 1.1966 - val_accuracy: 0.5478
```

```
Epoch 22/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1869 - accuracy:
0.5511 - val_loss: 1.1921 - val_accuracy: 0.5468
Epoch 23/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1819 - accuracy:
0.5503 - val_loss: 1.1853 - val_accuracy: 0.5485
Epoch 24/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1753 - accuracy:
0.5512 - val_loss: 1.1820 - val_accuracy: 0.5491
Epoch 25/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1725 - accuracy:
0.5560 - val_loss: 1.1781 - val_accuracy: 0.5504
Epoch 26/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1675 - accuracy:
0.5562 - val_loss: 1.1732 - val_accuracy: 0.5496
Epoch 27/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1627 - accuracy:
0.5548 - val_loss: 1.1690 - val_accuracy: 0.5490
Epoch 28/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1584 - accuracy:
0.5562 - val_loss: 1.1661 - val_accuracy: 0.5530
Epoch 29/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1559 - accuracy:
0.5576 - val_loss: 1.1625 - val_accuracy: 0.5516
Epoch 30/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1499 - accuracy:
0.5607 - val_loss: 1.1603 - val_accuracy: 0.5527
Epoch 31/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1475 - accuracy:
0.5610 - val_loss: 1.1568 - val_accuracy: 0.5506
Epoch 32/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1442 - accuracy:
0.5615 - val_loss: 1.1541 - val_accuracy: 0.5529
Epoch 33/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1433 - accuracy:
0.5589 - val_loss: 1.1502 - val_accuracy: 0.5547
Epoch 34/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1395 - accuracy:
0.5628 - val_loss: 1.1480 - val_accuracy: 0.5532
Epoch 35/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1381 - accuracy:
0.5599 - val_loss: 1.1456 - val_accuracy: 0.5550
Epoch 36/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1333 - accuracy:
0.5628 - val_loss: 1.1427 - val_accuracy: 0.5561
Epoch 37/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1311 - accuracy:
0.5645 - val_loss: 1.1412 - val_accuracy: 0.5576
Epoch 38/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1294 - accuracy:
0.5635 - val_loss: 1.1385 - val_accuracy: 0.5579
Epoch 39/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1263 - accuracy:
0.5633 - val_loss: 1.1386 - val_accuracy: 0.5582
Epoch 40/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1246 - accuracy:
0.5645 - val_loss: 1.1344 - val_accuracy: 0.5597
Epoch 41/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1218 - accuracy:
0.5661 - val_loss: 1.1327 - val_accuracy: 0.5579
Epoch 42/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1206 - accuracy:
0.5679 - val_loss: 1.1364 - val_accuracy: 0.5548
Epoch 43/200
```

```
225/225 [==============================] - 1s 5ms/step - loss: 1.1166 - accuracy:
0.5676 - val_loss: 1.1304 - val_accuracy: 0.5568
Epoch 44/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1154 - accuracy:
0.5681 - val_loss: 1.1279 - val_accuracy: 0.5576
Epoch 45/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1140 - accuracy:
0.5660 - val_loss: 1.1316 - val_accuracy: 0.5555
Epoch 46/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1117 - accuracy:
0.5676 - val_loss: 1.1273 - val_accuracy: 0.5579
Epoch 47/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1081 - accuracy:
0.5702 - val_loss: 1.1241 - val_accuracy: 0.5561
Epoch 48/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1057 - accuracy:
0.5675 - val_loss: 1.1212 - val_accuracy: 0.5564
Epoch 49/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1068 - accuracy:
0.5685 - val_loss: 1.1192 - val_accuracy: 0.5610
Epoch 50/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1043 - accuracy:
0.5690 - val_loss: 1.1177 - val_accuracy: 0.5582
Epoch 51/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1008 - accuracy:
0.5705 - val_loss: 1.1159 - val_accuracy: 0.5633
Epoch 52/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0980 - accuracy:
0.5728 - val_loss: 1.1169 - val_accuracy: 0.5610
Epoch 53/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1001 - accuracy:
0.5721 - val_loss: 1.1140 - val_accuracy: 0.5595
Epoch 54/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0941 - accuracy:
0.5718 - val_loss: 1.1140 - val_accuracy: 0.5592
Epoch 55/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0934 - accuracy:
0.5741 - val_loss: 1.1104 - val_accuracy: 0.5633
Epoch 56/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0917 - accuracy:
0.5751 - val_loss: 1.1102 - val_accuracy: 0.5620
Epoch 57/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0922 - accuracy:
0.5748 - val_loss: 1.1084 - val_accuracy: 0.5636
Epoch 58/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0906 - accuracy:
0.5752 - val_loss: 1.1114 - val_accuracy: 0.5626
Epoch 59/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0872 - accuracy:
0.5773 - val_loss: 1.1071 - val_accuracy: 0.5660
Epoch 60/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0847 - accuracy:
0.5764 - val_loss: 1.1128 - val_accuracy: 0.5644
Epoch 61/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0842 - accuracy:
0.5769 - val_loss: 1.1061 - val_accuracy: 0.5613
Epoch 62/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0803 - accuracy:
0.5790 - val_loss: 1.1035 - val_accuracy: 0.5631
Epoch 63/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0806 - accuracy:
0.5776 - val_loss: 1.1021 - val_accuracy: 0.5657
Epoch 64/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0762 - accuracy:
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0.5756 - val_loss: 1.1008 - val_accuracy: 0.5688
Epoch 65/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0764 - accuracy:
0.5797 - val_loss: 1.1002 - val_accuracy: 0.5669
Epoch 66/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0743 - accuracy:
0.5792 - val_loss: 1.0984 - val_accuracy: 0.5670
Epoch 67/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0733 - accuracy:
0.5827 - val_loss: 1.0977 - val_accuracy: 0.5670
Epoch 68/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0729 - accuracy:
0.5792 - val_loss: 1.0999 - val_accuracy: 0.5682
Epoch 69/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0717 - accuracy:
0.5790 - val_loss: 1.0960 - val_accuracy: 0.5678
Epoch 70/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0697 - accuracy:
0.5815 - val_loss: 1.0951 - val_accuracy: 0.5695
Epoch 71/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0695 - accuracy:
0.5831 - val_loss: 1.0950 - val_accuracy: 0.5677
Epoch 72/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0665 - accuracy:
0.5807 - val_loss: 1.0937 - val_accuracy: 0.5655
Epoch 73/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0645 - accuracy:
0.5834 - val_loss: 1.0935 - val_accuracy: 0.5678
Epoch 74/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0627 - accuracy:
0.5822 - val_loss: 1.0929 - val_accuracy: 0.5677
Epoch 75/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0634 - accuracy:
0.5838 - val_loss: 1.0928 - val_accuracy: 0.5696
Epoch 76/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0617 - accuracy:
0.5839 - val_loss: 1.0926 - val_accuracy: 0.5703
Epoch 77/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0613 - accuracy:
0.5822 - val_loss: 1.0903 - val_accuracy: 0.5716
Epoch 78/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0579 - accuracy:
0.5898 - val_loss: 1.0899 - val_accuracy: 0.5722
Epoch 79/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0565 - accuracy:
0.5868 - val_loss: 1.0936 - val_accuracy: 0.5698
Epoch 80/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0558 - accuracy:
0.5864 - val_loss: 1.0921 - val_accuracy: 0.5667
Epoch 81/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0550 - accuracy:
0.5870 - val_loss: 1.0879 - val_accuracy: 0.5708
Epoch 82/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0536 - accuracy:
0.5868 - val_loss: 1.0877 - val_accuracy: 0.5716
Epoch 83/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0499 - accuracy:
0.5873 - val_loss: 1.0874 - val_accuracy: 0.5724
Epoch 84/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0495 - accuracy:
0.5875 - val_loss: 1.0869 - val_accuracy: 0.5704
Epoch 85/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0485 - accuracy:
0.5889 - val_loss: 1.0873 - val_accuracy: 0.5709
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Epoch 86/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0469 - accuracy:
0.5889 - val_loss: 1.0859 - val_accuracy: 0.5732
Epoch 87/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0472 - accuracy:
0.5897 - val_loss: 1.0879 - val_accuracy: 0.5721
Epoch 88/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0444 - accuracy:
0.5891 - val_loss: 1.0855 - val_accuracy: 0.5743
Epoch 89/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0436 - accuracy:
0.5882 - val_loss: 1.0852 - val_accuracy: 0.5747
Epoch 90/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0391 - accuracy:
0.5914 - val_loss: 1.0880 - val_accuracy: 0.5703
Epoch 91/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0409 - accuracy:
0.5923 - val_loss: 1.0841 - val_accuracy: 0.5725
Epoch 92/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0394 - accuracy:
0.5919 - val_loss: 1.0838 - val_accuracy: 0.5737
Epoch 93/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0357 - accuracy:
0.5929 - val_loss: 1.0835 - val_accuracy: 0.5722
Epoch 94/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0368 - accuracy:
0.5928 - val_loss: 1.0832 - val_accuracy: 0.5737
Epoch 95/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0341 - accuracy:
0.5971 - val_loss: 1.0852 - val_accuracy: 0.5717
Epoch 96/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0313 - accuracy:
0.5944 - val_loss: 1.0856 - val_accuracy: 0.5670
Epoch 97/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0332 - accuracy:
0.5971 - val_loss: 1.0834 - val_accuracy: 0.5703
Epoch 98/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0300 - accuracy:
0.5979 - val_loss: 1.0830 - val_accuracy: 0.5698
Epoch 99/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0290 - accuracy:
0.5994 - val_loss: 1.1000 - val_accuracy: 0.5607
Epoch 100/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0283 - accuracy:
0.5964 - val_loss: 1.0845 - val_accuracy: 0.5683
Epoch 101/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0256 - accuracy:
0.5995 - val_loss: 1.0850 - val_accuracy: 0.5686
Epoch 102/200
225/225 [==============================] - 1s 5ms/step - loss: 1.0239 - accuracy:
0.5982 - val_loss: 1.0874 - val_accuracy: 0.5662
Epoch 103/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0247 - accuracy:
0.5963 - val_loss: 1.0829 - val_accuracy: 0.5683
Epoch 104/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0215 - accuracy:
0.6014 - val_loss: 1.0840 - val_accuracy: 0.5703
Epoch 105/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0211 - accuracy:
0.6026 - val_loss: 1.0829 - val_accuracy: 0.5704
Epoch 106/200
225/225 [==============================] - 1s 7ms/step - loss: 1.0178 - accuracy:
0.6002 - val_loss: 1.0842 - val_accuracy: 0.5688
Epoch 107/200
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225/225 [==============================] - 2s 7ms/step - loss: 1.0183 - accuracy:
0.5996 - val_loss: 1.0835 - val_accuracy: 0.5701
Epoch 108/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0152 - accuracy:
0.6034 - val_loss: 1.0847 - val_accuracy: 0.5670
Epoch 109/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0156 - accuracy:
0.6044 - val_loss: 1.0845 - val_accuracy: 0.5672
Epoch 110/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0129 - accuracy:
0.6022 - val_loss: 1.0841 - val_accuracy: 0.5708
Epoch 111/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0123 - accuracy:
0.6041 - val_loss: 1.0842 - val_accuracy: 0.5701
Epoch 112/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0085 - accuracy:
0.6039 - val_loss: 1.0854 - val_accuracy: 0.5673
Epoch 113/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0097 - accuracy:
0.6048 - val_loss: 1.0855 - val_accuracy: 0.5734
Epoch 114/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0063 - accuracy:
0.6061 - val_loss: 1.0861 - val_accuracy: 0.5665
Epoch 115/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0056 - accuracy:
0.6064 - val_loss: 1.0861 - val_accuracy: 0.5655
Epoch 116/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0030 - accuracy:
0.6083 - val_loss: 1.0872 - val_accuracy: 0.5703
Epoch 117/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0015 - accuracy:
0.6051 - val_loss: 1.0861 - val_accuracy: 0.5680
Epoch 118/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0014 - accuracy:
0.6065 - val_loss: 1.0873 - val_accuracy: 0.5688
Epoch 119/200
225/225 [==============================] - 1s 7ms/step - loss: 1.0010 - accuracy:
0.6103 - val_loss: 1.0876 - val_accuracy: 0.5662
Epoch 120/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9976 - accuracy:
0.6125 - val_loss: 1.0866 - val_accuracy: 0.5677
Epoch 121/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9948 - accuracy:
0.6091 - val_loss: 1.0873 - val_accuracy: 0.5670
Epoch 122/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9948 - accuracy:
0.6098 - val_loss: 1.0893 - val_accuracy: 0.5680
Epoch 123/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9934 - accuracy:
0.6124 - val_loss: 1.0892 - val_accuracy: 0.5682
Epoch 124/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9911 - accuracy:
0.6132 - val_loss: 1.0901 - val_accuracy: 0.5698
Epoch 125/200
225/225 [==============================] - 1s 6ms/step - loss: 0.9904 - accuracy:
0.6127 - val_loss: 1.0902 - val_accuracy: 0.5675
Epoch 126/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9897 - accuracy:
0.6156 - val_loss: 1.0912 - val_accuracy: 0.5680
Epoch 127/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9880 - accuracy:
0.6128 - val_loss: 1.0960 - val_accuracy: 0.5659
Epoch 128/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9887 - accuracy:
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0.6157 - val_loss: 1.0947 - val_accuracy: 0.5649
Epoch 129/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9845 - accuracy:
0.6190 - val_loss: 1.0932 - val_accuracy: 0.5686
Epoch 130/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9807 - accuracy:
0.6175 - val_loss: 1.1056 - val_accuracy: 0.5660
Epoch 131/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9822 - accuracy:
0.6223 - val_loss: 1.0968 - val_accuracy: 0.5626
Epoch 132/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9810 - accuracy:
0.6200 - val_loss: 1.0977 - val_accuracy: 0.5670
Epoch 133/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9787 - accuracy:
0.6195 - val_loss: 1.0982 - val_accuracy: 0.5647
Epoch 134/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9791 - accuracy:
0.6190 - val_loss: 1.0970 - val_accuracy: 0.5651
Epoch 135/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9775 - accuracy:
0.6195 - val_loss: 1.0981 - val_accuracy: 0.5680
Epoch 136/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9772 - accuracy:
0.6211 - val_loss: 1.1007 - val_accuracy: 0.5686
Epoch 137/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9736 - accuracy:
0.6220 - val_loss: 1.1050 - val_accuracy: 0.5688
Epoch 138/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9709 - accuracy:
0.6225 - val_loss: 1.1027 - val_accuracy: 0.5615
Epoch 139/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9690 - accuracy:
0.6241 - val_loss: 1.1054 - val_accuracy: 0.5586
Epoch 140/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9699 - accuracy:
0.6252 - val_loss: 1.1047 - val_accuracy: 0.5644
Epoch 141/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9670 - accuracy:
0.6239 - val_loss: 1.1057 - val_accuracy: 0.5621
Epoch 142/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9669 - accuracy:
0.6252 - val_loss: 1.1067 - val_accuracy: 0.5628
Epoch 143/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9654 - accuracy:
0.6249 - val_loss: 1.1058 - val_accuracy: 0.5599
Epoch 144/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9633 - accuracy:
0.6278 - val_loss: 1.1067 - val_accuracy: 0.5629
Epoch 145/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9622 - accuracy:
0.6274 - val_loss: 1.1092 - val_accuracy: 0.5602
Epoch 146/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9611 - accuracy:
0.6287 - val_loss: 1.1116 - val_accuracy: 0.5612
Epoch 147/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9580 - accuracy:
0.6262 - val_loss: 1.1111 - val_accuracy: 0.5602
Epoch 148/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9599 - accuracy:
0.6329 - val_loss: 1.1132 - val_accuracy: 0.5558
Epoch 149/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9567 - accuracy:
0.6287 - val_loss: 1.1174 - val_accuracy: 0.5628
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Epoch 150/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9559 - accuracy:
0.6303 - val_loss: 1.1167 - val_accuracy: 0.5555
Epoch 151/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9518 - accuracy:
0.6299 - val_loss: 1.1152 - val_accuracy: 0.5556
Epoch 152/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9531 - accuracy:
0.6321 - val_loss: 1.1217 - val_accuracy: 0.5608
Epoch 153/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9500 - accuracy:
0.6344 - val_loss: 1.1187 - val_accuracy: 0.5607
Epoch 154/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9471 - accuracy:
0.6361 - val_loss: 1.1256 - val_accuracy: 0.5621
Epoch 155/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9481 - accuracy:
0.6311 - val_loss: 1.1219 - val_accuracy: 0.5608
Epoch 156/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9442 - accuracy:
0.6388 - val_loss: 1.1221 - val_accuracy: 0.5571
Epoch 157/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9455 - accuracy:
0.6366 - val_loss: 1.1245 - val_accuracy: 0.5524
Epoch 158/200
225/225 [==============================] - 1s 6ms/step - loss: 0.9428 - accuracy:
0.6364 - val_loss: 1.1279 - val_accuracy: 0.5607
Epoch 159/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9416 - accuracy:
0.6356 - val_loss: 1.1335 - val_accuracy: 0.5592
Epoch 160/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9414 - accuracy:
0.6338 - val_loss: 1.1310 - val_accuracy: 0.5490
Epoch 161/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9392 - accuracy:
0.6384 - val_loss: 1.1276 - val_accuracy: 0.5555
Epoch 162/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9362 - accuracy:
0.6389 - val_loss: 1.1307 - val_accuracy: 0.5540
Epoch 163/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9331 - accuracy:
0.6418 - val_loss: 1.1366 - val_accuracy: 0.5545
Epoch 164/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9332 - accuracy:
0.6398 - val_loss: 1.1346 - val_accuracy: 0.5579
Epoch 165/200
225/225 [==============================] - 1s 7ms/step - loss: 0.9332 - accuracy:
0.6407 - val_loss: 1.1356 - val_accuracy: 0.5525
Epoch 166/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9302 - accuracy:
0.6423 - val_loss: 1.1368 - val_accuracy: 0.5558
Epoch 167/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9273 - accuracy:
0.6460 - val_loss: 1.1367 - val_accuracy: 0.5568
Epoch 168/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9287 - accuracy:
0.6430 - val_loss: 1.1519 - val_accuracy: 0.5599
Epoch 169/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9271 - accuracy:
0.6450 - val_loss: 1.1413 - val_accuracy: 0.5587
Epoch 170/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9217 - accuracy:
0.6451 - val_loss: 1.1416 - val_accuracy: 0.5504
Epoch 171/200
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225/225 [==============================] - 2s 7ms/step - loss: 0.9234 - accuracy:
0.6480 - val_loss: 1.1480 - val_accuracy: 0.5550
Epoch 172/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9198 - accuracy:
0.6449 - val_loss: 1.1472 - val_accuracy: 0.5504
Epoch 173/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9180 - accuracy:
0.6489 - val_loss: 1.1480 - val_accuracy: 0.5516
Epoch 174/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9179 - accuracy:
0.6466 - val_loss: 1.1522 - val_accuracy: 0.5467
Epoch 175/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9151 - accuracy:
0.6485 - val_loss: 1.1598 - val_accuracy: 0.5551
Epoch 176/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9149 - accuracy:
0.6550 - val_loss: 1.1681 - val_accuracy: 0.5543
Epoch 177/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9125 - accuracy:
0.6524 - val_loss: 1.1594 - val_accuracy: 0.5525
Epoch 178/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9109 - accuracy:
0.6527 - val_loss: 1.1624 - val_accuracy: 0.5530
Epoch 179/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9100 - accuracy:
0.6501 - val_loss: 1.1611 - val_accuracy: 0.5460
Epoch 180/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9092 - accuracy:
0.6520 - val_loss: 1.1632 - val_accuracy: 0.5516
Epoch 181/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9073 - accuracy:
0.6538 - val_loss: 1.1630 - val_accuracy: 0.5537
Epoch 182/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9027 - accuracy:
0.6573 - val_loss: 1.1648 - val_accuracy: 0.5465
Epoch 183/200
225/225 [==============================] - 1s 7ms/step - loss: 0.9002 - accuracy:
0.6589 - val_loss: 1.1687 - val_accuracy: 0.5428
Epoch 184/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9002 - accuracy:
0.6579 - val_loss: 1.1804 - val_accuracy: 0.5503
Epoch 185/200
225/225 [==============================] - 1s 5ms/step - loss: 0.9024 - accuracy:
0.6570 - val_loss: 1.1724 - val_accuracy: 0.5457
Epoch 186/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8995 - accuracy:
0.6579 - val_loss: 1.1738 - val_accuracy: 0.5454
Epoch 187/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8949 - accuracy:
0.6613 - val_loss: 1.2020 - val_accuracy: 0.5511
Epoch 188/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8964 - accuracy:
0.6602 - val_loss: 1.1790 - val_accuracy: 0.5433
Epoch 189/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8936 - accuracy:
0.6596 - val_loss: 1.1797 - val_accuracy: 0.5449
Epoch 190/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8933 - accuracy:
0.6586 - val_loss: 1.1871 - val_accuracy: 0.5459
Epoch 191/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8914 - accuracy:
0.6624 - val_loss: 1.1846 - val_accuracy: 0.5413
Epoch 192/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8909 - accuracy:
```
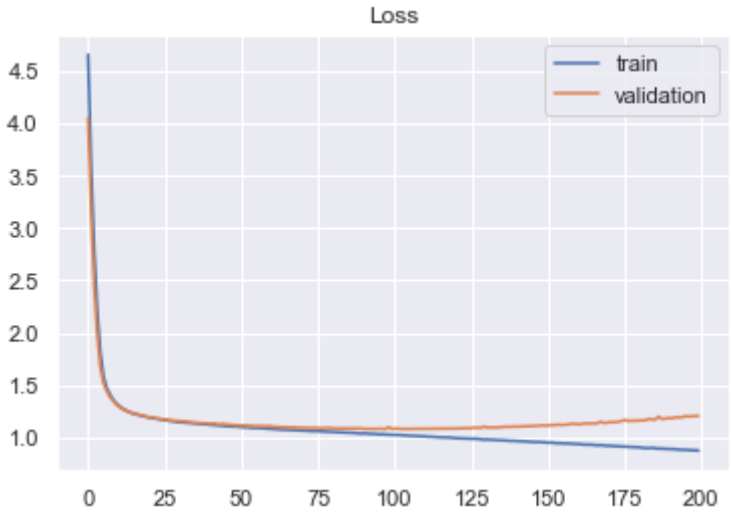
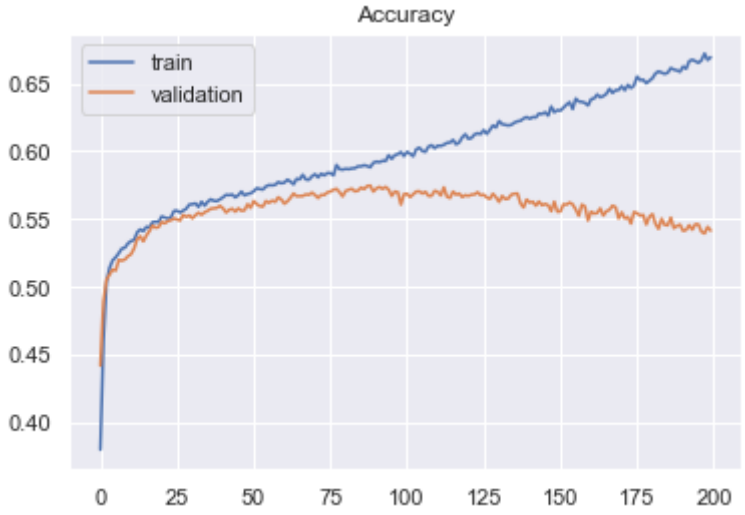

```
0.6608 - val_loss: 1.1886 - val_accuracy: 0.5420
Epoch 193/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8879 - accuracy:
0.6664 - val_loss: 1.1952 - val_accuracy: 0.5455
Epoch 194/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8852 - accuracy:
0.6674 - val_loss: 1.1919 - val_accuracy: 0.5421
Epoch 195/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8848 - accuracy:
0.6664 - val_loss: 1.1986 - val_accuracy: 0.5462
Epoch 196/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8836 - accuracy:
0.6651 - val_loss: 1.2055 - val_accuracy: 0.5460
Epoch 197/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8814 - accuracy:
0.6671 - val_loss: 1.2014 - val_accuracy: 0.5407
Epoch 198/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8796 - accuracy:
0.6720 - val_loss: 1.2052 - val_accuracy: 0.5394
Epoch 199/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8796 - accuracy:
0.6673 - val_loss: 1.2069 - val_accuracy: 0.5442
Epoch 200/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8759 - accuracy:
0.6692 - val_loss: 1.2082 - val_accuracy: 0.5415
Model training is finished at 1656182134.188967 & it took 246.0 sec
```

In [94]:

```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
plt.title(f'Accuracy')
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()
```





Model Evaluation

In [95]:
```
Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")
Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [NN
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat
```

```
Final training loss : 0.8758621215820312
Final training accuracy:  0.6692463159561157
Final validation loss : 1.2082183361053467
Final validation accuracy : 0.5414769053459167
```

In [96]:
```
testLoss, testAccuracy = NN_model.evaluate( X_test, y_test)
```

```
193/193 [==============================] - 0s 2ms/step - loss: 1.2082 - accuracy:
0.5415
```

In [103…
```
y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test_, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```

```
Confusion matrix:
[[ 255  104   25   23   19]
 [ 135  162   96  107   38]
 [  30  105  122  308   90]
 [  15   47  139  881  730]
 [   3   36   65  704 1909]]
Classification Report:
              precision    recall  f1-score   support

           0       0.58      0.60      0.59       426
           1       0.36      0.30      0.33       538
           2       0.27      0.19      0.22       655
           3       0.44      0.49      0.46      1812
           4       0.69      0.70      0.69      2717

    accuracy                           0.54      6148
   macro avg       0.47      0.45      0.46      6148
weighted avg       0.53      0.54      0.54      6148
```

From Classification Report we can say that class 4 means Reviews with rating 5 is performing quite well as its f1-score, precision & recall is quite good where as class 2 i.e. review with rating 3 has worst performance.

HyperParameter Tuning

Model Iteration #2

Regularization: Train a model without regularization

In [137…

```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu'))
NN_model.add(Dense(64,activation='relu'))
NN_model.add(Dropout(rate=0.1))
NN_model.add(Dense(32,activation='relu'))
NN_model.add(Dense(32,activation='relu'))
NN_model.add(Dense(16,activation='relu'))

# The Output Layer :
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())

### Model Compilation

adam=Adam(learning_rate=0.0001)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a

### Model Training

start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validati
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model: "sequential_4"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_30 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_31 (Dense)             (None, 256)               33024
_________________________________________________________________
dense_32 (Dense)             (None, 64)                16448
_________________________________________________________________
dropout_6 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_33 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_34 (Dense)             (None, 32)                1056
_________________________________________________________________
dense_35 (Dense)             (None, 16)                528
_________________________________________________________________
dense_36 (Dense)             (None, 5)                 85
=================================================================
Total params: 69,733
Trainable params: 69,733
Non-trainable params: 0
_________________________________________________________________
None
Model training is started at 1656233099.248859
Epoch 1/200
225/225 [==============================] - 1s 3ms/step - loss: 1.4195 - accuracy:
0.4171 - val_loss: 1.2158 - val_accuracy: 0.4639
Epoch 2/200
225/225 [==============================] - 1s 3ms/step - loss: 1.1514 - accuracy:
0.5007 - val_loss: 1.1026 - val_accuracy: 0.5163
Epoch 3/200
225/225 [==============================] - ETA: 0s - loss: 1.0910 - accuracy: 0.52
- 1s 3ms/step - loss: 1.0882 - accuracy: 0.5257 - val_loss: 1.0738 - val_accuracy:
0.5117
Epoch 4/200
225/225 [==============================] - 1s 3ms/step - loss: 1.0540 - accuracy:
0.5361 - val_loss: 1.0354 - val_accuracy: 0.5490
Epoch 5/200
225/225 [==============================] - 1s 3ms/step - loss: 1.0250 - accuracy:
0.5512 - val_loss: 1.0133 - val_accuracy: 0.5503
Epoch 6/200
225/225 [==============================] - 1s 3ms/step - loss: 1.0079 - accuracy:
0.5605 - val_loss: 1.0057 - val_accuracy: 0.5558
Epoch 7/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9904 - accuracy:
0.5652 - val_loss: 0.9919 - val_accuracy: 0.5639
Epoch 8/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9787 - accuracy:
0.5675 - val_loss: 0.9810 - val_accuracy: 0.5695
Epoch 9/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9702 - accuracy:
0.5709 - val_loss: 0.9836 - val_accuracy: 0.5649
Epoch 10/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9651 - accuracy:
0.5731 - val_loss: 0.9729 - val_accuracy: 0.5719
Epoch 11/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9560 - accuracy:
0.5805 - val_loss: 0.9690 - val_accuracy: 0.5695
Epoch 12/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9514 - accuracy:
0.5797 - val_loss: 0.9675 - val_accuracy: 0.5730
Epoch 13/200
```

```
225/225 [==============================] - 1s 3ms/step - loss: 0.9448 - accuracy:
0.5837 - val_loss: 0.9711 - val_accuracy: 0.5698
Epoch 14/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9430 - accuracy:
0.5796 - val_loss: 0.9601 - val_accuracy: 0.5755
Epoch 15/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9382 - accuracy:
0.5820 - val_loss: 0.9662 - val_accuracy: 0.5691
Epoch 16/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9342 - accuracy:
0.5861 - val_loss: 0.9592 - val_accuracy: 0.5764
Epoch 17/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9326 - accuracy:
0.5890 - val_loss: 0.9582 - val_accuracy: 0.5791
Epoch 18/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9291 - accuracy:
0.5855 - val_loss: 0.9577 - val_accuracy: 0.5841
Epoch 19/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9258 - accuracy:
0.5886 - val_loss: 0.9549 - val_accuracy: 0.5825
Epoch 20/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9242 - accuracy:
0.5897 - val_loss: 0.9560 - val_accuracy: 0.5828
Epoch 21/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9212 - accuracy:
0.5905 - val_loss: 0.9543 - val_accuracy: 0.5843
Epoch 22/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9197 - accuracy:
0.5906 - val_loss: 0.9532 - val_accuracy: 0.5826
Epoch 23/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9151 - accuracy:
0.5910 - val_loss: 0.9535 - val_accuracy: 0.5821
Epoch 24/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9133 - accuracy:
0.5947 - val_loss: 0.9583 - val_accuracy: 0.5722
Epoch 25/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9123 - accuracy:
0.5916 - val_loss: 0.9592 - val_accuracy: 0.5805
Epoch 26/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9105 - accuracy:
0.5961 - val_loss: 0.9542 - val_accuracy: 0.5830
Epoch 27/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9063 - accuracy:
0.5924 - val_loss: 0.9536 - val_accuracy: 0.5802
Epoch 28/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9050 - accuracy:
0.5976 - val_loss: 0.9558 - val_accuracy: 0.5755
Epoch 29/200
225/225 [==============================] - 1s 3ms/step - loss: 0.9014 - accuracy:
0.5985 - val_loss: 0.9633 - val_accuracy: 0.5657
Epoch 30/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8962 - accuracy:
0.5997 - val_loss: 0.9567 - val_accuracy: 0.5763
Epoch 31/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8969 - accuracy:
0.6034 - val_loss: 0.9547 - val_accuracy: 0.5789
Epoch 32/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8939 - accuracy:
0.6007 - val_loss: 0.9621 - val_accuracy: 0.5750
Epoch 33/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8930 - accuracy:
0.6011 - val_loss: 0.9555 - val_accuracy: 0.5784
Epoch 34/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8876 - accuracy:
```

```
0.6078 - val_loss: 0.9538 - val_accuracy: 0.5787
Epoch 35/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8872 - accuracy:
0.6048 - val_loss: 0.9572 - val_accuracy: 0.5791
Epoch 36/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8843 - accuracy:
0.6068 - val_loss: 0.9568 - val_accuracy: 0.5784
Epoch 37/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8804 - accuracy:
0.6093 - val_loss: 0.9605 - val_accuracy: 0.5753
Epoch 38/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8786 - accuracy:
0.6089 - val_loss: 0.9622 - val_accuracy: 0.5675
Epoch 39/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8756 - accuracy:
0.6150 - val_loss: 0.9657 - val_accuracy: 0.5717
Epoch 40/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8755 - accuracy:
0.6108 - val_loss: 0.9617 - val_accuracy: 0.5657
Epoch 41/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8709 - accuracy:
0.6110 - val_loss: 0.9627 - val_accuracy: 0.5722
Epoch 42/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8690 - accuracy:
0.6140 - val_loss: 0.9637 - val_accuracy: 0.5696
Epoch 43/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8671 - accuracy:
0.6137 - val_loss: 0.9689 - val_accuracy: 0.5667
Epoch 44/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8628 - accuracy:
0.6209 - val_loss: 0.9638 - val_accuracy: 0.5716
Epoch 45/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8582 - accuracy:
0.6151 - val_loss: 0.9683 - val_accuracy: 0.5691
Epoch 46/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8561 - accuracy:
0.6179 - val_loss: 0.9679 - val_accuracy: 0.5703
Epoch 47/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8563 - accuracy:
0.6189 - val_loss: 0.9771 - val_accuracy: 0.5597
Epoch 48/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8506 - accuracy:
0.6250 - val_loss: 0.9739 - val_accuracy: 0.5716
Epoch 49/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8479 - accuracy:
0.6268 - val_loss: 0.9834 - val_accuracy: 0.5712
Epoch 50/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8457 - accuracy:
0.6260 - val_loss: 0.9742 - val_accuracy: 0.5685
Epoch 51/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8406 - accuracy:
0.6257 - val_loss: 0.9844 - val_accuracy: 0.5717
Epoch 52/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8399 - accuracy:
0.6273 - val_loss: 0.9800 - val_accuracy: 0.5608
Epoch 53/200
225/225 [==============================] - 1s 3ms/step - loss: 0.8345 - accuracy:
0.6322 - val_loss: 0.9802 - val_accuracy: 0.5682
Epoch 54/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8336 - accuracy:
0.6305 - val_loss: 0.9946 - val_accuracy: 0.5524
Epoch 55/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8299 - accuracy:
0.6303 - val_loss: 0.9863 - val_accuracy: 0.5642
```

```
Epoch 56/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8255 - accuracy:
0.6340 - val_loss: 0.9912 - val_accuracy: 0.5603
Epoch 57/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8229 - accuracy:
0.6364 - val_loss: 0.9911 - val_accuracy: 0.5665
Epoch 58/200
225/225 [==============================] - 1s 5ms/step - loss: 0.8198 - accuracy:
0.6393 - val_loss: 0.9948 - val_accuracy: 0.5657
Epoch 59/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8151 - accuracy:
0.6380 - val_loss: 0.9997 - val_accuracy: 0.5675
Epoch 60/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8121 - accuracy:
0.6412 - val_loss: 1.0015 - val_accuracy: 0.5616
Epoch 61/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8085 - accuracy:
0.6449 - val_loss: 1.0146 - val_accuracy: 0.5677
Epoch 62/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8046 - accuracy:
0.6428 - val_loss: 1.0039 - val_accuracy: 0.5633
Epoch 63/200
225/225 [==============================] - 1s 4ms/step - loss: 0.8024 - accuracy:
0.6459 - val_loss: 1.0113 - val_accuracy: 0.5542
Epoch 64/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7965 - accuracy:
0.6483 - val_loss: 1.0109 - val_accuracy: 0.5662
Epoch 65/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7955 - accuracy:
0.6487 - val_loss: 1.0117 - val_accuracy: 0.5514
Epoch 66/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7918 - accuracy:
0.6495 - val_loss: 1.0163 - val_accuracy: 0.5579
Epoch 67/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7855 - accuracy:
0.6515 - val_loss: 1.0292 - val_accuracy: 0.5586
Epoch 68/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7835 - accuracy:
0.6556 - val_loss: 1.0310 - val_accuracy: 0.5491
Epoch 69/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7751 - accuracy:
0.6589 - val_loss: 1.0439 - val_accuracy: 0.5639
Epoch 70/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7751 - accuracy:
0.6605 - val_loss: 1.0283 - val_accuracy: 0.5581
Epoch 71/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7677 - accuracy:
0.6619 - val_loss: 1.0587 - val_accuracy: 0.5651
Epoch 72/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7674 - accuracy:
0.6640 - val_loss: 1.0424 - val_accuracy: 0.5573
Epoch 73/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7613 - accuracy:
0.6672 - val_loss: 1.0546 - val_accuracy: 0.5571
Epoch 74/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7555 - accuracy:
0.6679 - val_loss: 1.0766 - val_accuracy: 0.5607
Epoch 75/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7559 - accuracy:
0.6701 - val_loss: 1.0686 - val_accuracy: 0.5490
Epoch 76/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7479 - accuracy:
0.6739 - val_loss: 1.0771 - val_accuracy: 0.5605
Epoch 77/200
```

```
225/225 [==============================] - 1s 4ms/step - loss: 0.7456 - accuracy:
0.6755 - val_loss: 1.0690 - val_accuracy: 0.5529
Epoch 78/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7403 - accuracy:
0.6763 - val_loss: 1.0729 - val_accuracy: 0.5519
Epoch 79/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7349 - accuracy:
0.6781 - val_loss: 1.0901 - val_accuracy: 0.5447
Epoch 80/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7336 - accuracy:
0.6788 - val_loss: 1.0778 - val_accuracy: 0.5501
Epoch 81/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7335 - accuracy:
0.6793 - val_loss: 1.0885 - val_accuracy: 0.5561
Epoch 82/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7268 - accuracy:
0.6847 - val_loss: 1.0989 - val_accuracy: 0.5350
Epoch 83/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7217 - accuracy:
0.6835 - val_loss: 1.1041 - val_accuracy: 0.5488
Epoch 84/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7199 - accuracy:
0.6890 - val_loss: 1.1154 - val_accuracy: 0.5535
Epoch 85/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7126 - accuracy:
0.6899 - val_loss: 1.1451 - val_accuracy: 0.5540
Epoch 86/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7067 - accuracy:
0.6906 - val_loss: 1.1289 - val_accuracy: 0.5537
Epoch 87/200
225/225 [==============================] - 1s 4ms/step - loss: 0.7037 - accuracy:
0.6946 - val_loss: 1.1355 - val_accuracy: 0.5470
Epoch 88/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6953 - accuracy:
0.6984 - val_loss: 1.1364 - val_accuracy: 0.5465
Epoch 89/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6919 - accuracy:
0.6961 - val_loss: 1.1539 - val_accuracy: 0.5468
Epoch 90/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6875 - accuracy:
0.7029 - val_loss: 1.1409 - val_accuracy: 0.5405
Epoch 91/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6817 - accuracy:
0.7061 - val_loss: 1.1671 - val_accuracy: 0.5520
Epoch 92/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6804 - accuracy:
0.7042 - val_loss: 1.1502 - val_accuracy: 0.5439
Epoch 93/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6742 - accuracy:
0.7088 - val_loss: 1.1773 - val_accuracy: 0.5408
Epoch 94/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6703 - accuracy:
0.7108 - val_loss: 1.1759 - val_accuracy: 0.5356
Epoch 95/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6629 - accuracy:
0.7135 - val_loss: 1.1913 - val_accuracy: 0.5441
Epoch 96/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6648 - accuracy:
0.7136 - val_loss: 1.1879 - val_accuracy: 0.5438
Epoch 97/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6535 - accuracy:
0.7173 - val_loss: 1.2082 - val_accuracy: 0.5420
Epoch 98/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6545 - accuracy:
```

```
0.7201 - val_loss: 1.2286 - val_accuracy: 0.5333
Epoch 99/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6441 - accuracy:
0.7223 - val_loss: 1.2183 - val_accuracy: 0.5351
Epoch 100/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6404 - accuracy:
0.7234 - val_loss: 1.2285 - val_accuracy: 0.5259
Epoch 101/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6386 - accuracy:
0.7277 - val_loss: 1.2489 - val_accuracy: 0.5408
Epoch 102/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6305 - accuracy:
0.7280 - val_loss: 1.2692 - val_accuracy: 0.5394
Epoch 103/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6329 - accuracy:
0.7297 - val_loss: 1.2595 - val_accuracy: 0.5376
Epoch 104/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6254 - accuracy:
0.7342 - val_loss: 1.2594 - val_accuracy: 0.5346
Epoch 105/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6193 - accuracy:
0.7365 - val_loss: 1.2899 - val_accuracy: 0.5340
Epoch 106/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6134 - accuracy:
0.7405 - val_loss: 1.3169 - val_accuracy: 0.5153
Epoch 107/200
225/225 [==============================] - 1s 4ms/step - loss: 0.6092 - accuracy:
0.7391 - val_loss: 1.2985 - val_accuracy: 0.5337
Epoch 108/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5979 - accuracy:
0.7458 - val_loss: 1.3242 - val_accuracy: 0.5174
Epoch 109/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5961 - accuracy:
0.7495 - val_loss: 1.3327 - val_accuracy: 0.5319
Epoch 110/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5950 - accuracy:
0.7505 - val_loss: 1.3329 - val_accuracy: 0.5340
Epoch 111/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5890 - accuracy:
0.7506 - val_loss: 1.3695 - val_accuracy: 0.5371
Epoch 112/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5855 - accuracy:
0.7533 - val_loss: 1.3704 - val_accuracy: 0.5309
Epoch 113/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5802 - accuracy:
0.7579 - val_loss: 1.3672 - val_accuracy: 0.5270
Epoch 114/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5762 - accuracy:
0.7583 - val_loss: 1.3895 - val_accuracy: 0.5351
Epoch 115/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5755 - accuracy:
0.7559 - val_loss: 1.4040 - val_accuracy: 0.5333
Epoch 116/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5638 - accuracy:
0.7628 - val_loss: 1.4153 - val_accuracy: 0.5202
Epoch 117/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5604 - accuracy:
0.7666 - val_loss: 1.4253 - val_accuracy: 0.5290
Epoch 118/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5571 - accuracy:
0.7655 - val_loss: 1.4650 - val_accuracy: 0.5342
Epoch 119/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5507 - accuracy:
0.7713 - val_loss: 1.4500 - val_accuracy: 0.5198
```

```
Epoch 120/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5427 - accuracy:
0.7758 - val_loss: 1.4489 - val_accuracy: 0.5234
Epoch 121/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5392 - accuracy:
0.7821 - val_loss: 1.4766 - val_accuracy: 0.5270
Epoch 122/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5359 - accuracy:
0.7765 - val_loss: 1.4839 - val_accuracy: 0.5242
Epoch 123/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5277 - accuracy:
0.7857 - val_loss: 1.4934 - val_accuracy: 0.5112
Epoch 124/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5257 - accuracy:
0.7825 - val_loss: 1.5077 - val_accuracy: 0.5277
Epoch 125/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5211 - accuracy:
0.7844 - val_loss: 1.5275 - val_accuracy: 0.5156
Epoch 126/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5186 - accuracy:
0.7846 - val_loss: 1.5359 - val_accuracy: 0.5322
Epoch 127/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5125 - accuracy:
0.7906 - val_loss: 1.5767 - val_accuracy: 0.5220
Epoch 128/200
225/225 [==============================] - 1s 4ms/step - loss: 0.5018 - accuracy:
0.7961 - val_loss: 1.6379 - val_accuracy: 0.5299
Epoch 129/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4999 - accuracy:
0.7952 - val_loss: 1.6058 - val_accuracy: 0.5211
Epoch 130/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4977 - accuracy:
0.7944 - val_loss: 1.6133 - val_accuracy: 0.5224
Epoch 131/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4943 - accuracy:
0.7998 - val_loss: 1.6735 - val_accuracy: 0.5080
Epoch 132/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4900 - accuracy:
0.8022 - val_loss: 1.6624 - val_accuracy: 0.5208
Epoch 133/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4823 - accuracy:
0.8020 - val_loss: 1.6615 - val_accuracy: 0.5192
Epoch 134/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4725 - accuracy:
0.8111 - val_loss: 1.6991 - val_accuracy: 0.5192
Epoch 135/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4770 - accuracy:
0.8060 - val_loss: 1.7253 - val_accuracy: 0.5285
Epoch 136/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4651 - accuracy:
0.8128 - val_loss: 1.7145 - val_accuracy: 0.5057
Epoch 137/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4643 - accuracy:
0.8120 - val_loss: 1.7632 - val_accuracy: 0.5278
Epoch 138/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4602 - accuracy:
0.8146 - val_loss: 1.8142 - val_accuracy: 0.5265
Epoch 139/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4567 - accuracy:
0.8161 - val_loss: 1.8195 - val_accuracy: 0.5089
Epoch 140/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4481 - accuracy:
0.8232 - val_loss: 1.7944 - val_accuracy: 0.5270
Epoch 141/200
```

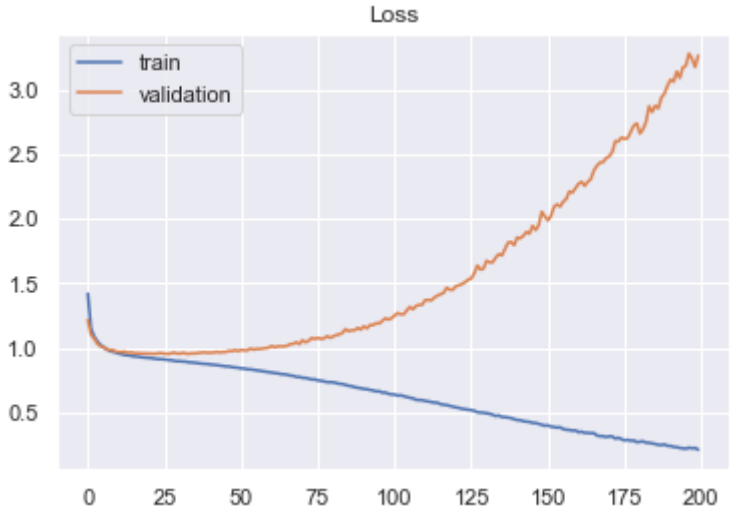
```
225/225 [==============================] - 1s 4ms/step - loss: 0.4414 - accuracy:
0.8253 - val_loss: 1.8541 - val_accuracy: 0.4959
Epoch 142/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4405 - accuracy:
0.8245 - val_loss: 1.8470 - val_accuracy: 0.5163
Epoch 143/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4325 - accuracy:
0.8254 - val_loss: 1.8674 - val_accuracy: 0.5203
Epoch 144/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4296 - accuracy:
0.8296 - val_loss: 1.8963 - val_accuracy: 0.5224
Epoch 145/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4266 - accuracy:
0.8314 - val_loss: 1.8832 - val_accuracy: 0.5089
Epoch 146/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4194 - accuracy:
0.8331 - val_loss: 1.9446 - val_accuracy: 0.5168
Epoch 147/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4187 - accuracy:
0.8330 - val_loss: 1.9108 - val_accuracy: 0.5101
Epoch 148/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4115 - accuracy:
0.8386 - val_loss: 1.9484 - val_accuracy: 0.5018
Epoch 149/200
225/225 [==============================] - 1s 4ms/step - loss: 0.4039 - accuracy:
0.8440 - val_loss: 2.0526 - val_accuracy: 0.5270
Epoch 150/200
225/225 [==============================] - 1s 5ms/step - loss: 0.3976 - accuracy:
0.8438 - val_loss: 2.0173 - val_accuracy: 0.5076
Epoch 151/200
225/225 [==============================] - 1s 5ms/step - loss: 0.4002 - accuracy:
0.8420 - val_loss: 1.9856 - val_accuracy: 0.5115
Epoch 152/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3909 - accuracy:
0.8467 - val_loss: 2.0201 - val_accuracy: 0.5054
Epoch 153/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3879 - accuracy:
0.8479 - val_loss: 2.0908 - val_accuracy: 0.5208
Epoch 154/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3834 - accuracy:
0.8510 - val_loss: 2.1099 - val_accuracy: 0.5130
Epoch 155/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3850 - accuracy:
0.8481 - val_loss: 2.0933 - val_accuracy: 0.5164
Epoch 156/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3717 - accuracy:
0.8564 - val_loss: 2.1311 - val_accuracy: 0.5101
Epoch 157/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3664 - accuracy:
0.8585 - val_loss: 2.1523 - val_accuracy: 0.5052
Epoch 158/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3648 - accuracy:
0.8580 - val_loss: 2.2097 - val_accuracy: 0.5042
Epoch 159/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3596 - accuracy:
0.8613 - val_loss: 2.2013 - val_accuracy: 0.5169
Epoch 160/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3614 - accuracy:
0.8574 - val_loss: 2.2354 - val_accuracy: 0.5054
Epoch 161/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3472 - accuracy:
0.8673 - val_loss: 2.2696 - val_accuracy: 0.4989
Epoch 162/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3513 - accuracy:
```

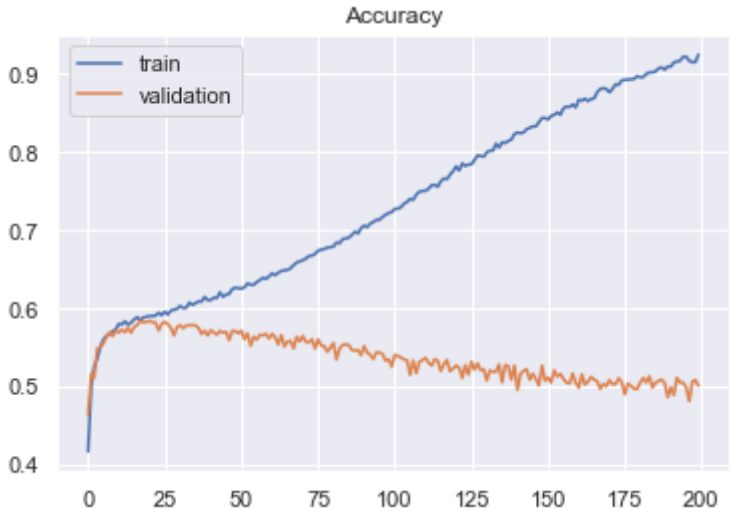
```
0.8660 - val_loss: 2.2845 - val_accuracy: 0.5159
Epoch 163/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3419 - accuracy:
0.8686 - val_loss: 2.2527 - val_accuracy: 0.5026
Epoch 164/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3430 - accuracy:
0.8656 - val_loss: 2.2851 - val_accuracy: 0.5067
Epoch 165/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3392 - accuracy:
0.8682 - val_loss: 2.3051 - val_accuracy: 0.5125
Epoch 166/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3404 - accuracy:
0.8690 - val_loss: 2.3721 - val_accuracy: 0.5093
Epoch 167/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3216 - accuracy:
0.8770 - val_loss: 2.4091 - val_accuracy: 0.5070
Epoch 168/200
225/225 [==============================] - 1s 5ms/step - loss: 0.3171 - accuracy:
0.8810 - val_loss: 2.4336 - val_accuracy: 0.4974
Epoch 169/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3164 - accuracy:
0.8820 - val_loss: 2.4372 - val_accuracy: 0.5036
Epoch 170/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3100 - accuracy:
0.8809 - val_loss: 2.4678 - val_accuracy: 0.5007
Epoch 171/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3154 - accuracy:
0.8767 - val_loss: 2.4817 - val_accuracy: 0.5086
Epoch 172/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3143 - accuracy:
0.8813 - val_loss: 2.5154 - val_accuracy: 0.5031
Epoch 173/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2976 - accuracy:
0.8869 - val_loss: 2.6002 - val_accuracy: 0.5036
Epoch 174/200
225/225 [==============================] - 1s 4ms/step - loss: 0.3047 - accuracy:
0.8864 - val_loss: 2.5969 - val_accuracy: 0.5109
Epoch 175/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2931 - accuracy:
0.8918 - val_loss: 2.6275 - val_accuracy: 0.5062
Epoch 176/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2844 - accuracy:
0.8927 - val_loss: 2.6170 - val_accuracy: 0.4904
Epoch 177/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2879 - accuracy:
0.8929 - val_loss: 2.6223 - val_accuracy: 0.5041
Epoch 178/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2818 - accuracy:
0.8934 - val_loss: 2.6706 - val_accuracy: 0.5008
Epoch 179/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2832 - accuracy:
0.8938 - val_loss: 2.7193 - val_accuracy: 0.4977
Epoch 180/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2704 - accuracy:
0.8974 - val_loss: 2.7362 - val_accuracy: 0.4971
Epoch 181/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2738 - accuracy:
0.8960 - val_loss: 2.6583 - val_accuracy: 0.5049
Epoch 182/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2767 - accuracy:
0.8963 - val_loss: 2.6905 - val_accuracy: 0.5112
Epoch 183/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2665 - accuracy:
0.9003 - val_loss: 2.7476 - val_accuracy: 0.5055
```

```
Epoch 184/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2650 - accuracy:
0.9024 - val_loss: 2.8699 - val_accuracy: 0.5133
Epoch 185/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2607 - accuracy:
0.9023 - val_loss: 2.8251 - val_accuracy: 0.4990
Epoch 186/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2562 - accuracy:
0.9035 - val_loss: 2.8730 - val_accuracy: 0.5052
Epoch 187/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2498 - accuracy:
0.9073 - val_loss: 2.8527 - val_accuracy: 0.5075
Epoch 188/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2483 - accuracy:
0.9085 - val_loss: 2.9363 - val_accuracy: 0.5093
Epoch 189/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2527 - accuracy:
0.9057 - val_loss: 2.9667 - val_accuracy: 0.5049
Epoch 190/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2415 - accuracy:
0.9099 - val_loss: 3.0280 - val_accuracy: 0.4868
Epoch 191/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2414 - accuracy:
0.9096 - val_loss: 3.0751 - val_accuracy: 0.4992
Epoch 192/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2335 - accuracy:
0.9149 - val_loss: 3.0593 - val_accuracy: 0.4893
Epoch 193/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2319 - accuracy:
0.9163 - val_loss: 3.1376 - val_accuracy: 0.5114
Epoch 194/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2256 - accuracy:
0.9170 - val_loss: 3.0883 - val_accuracy: 0.5055
Epoch 195/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2216 - accuracy:
0.9223 - val_loss: 3.1682 - val_accuracy: 0.5054
Epoch 196/200
225/225 [==============================] - 1s 5ms/step - loss: 0.2193 - accuracy:
0.9224 - val_loss: 3.1842 - val_accuracy: 0.4993
Epoch 197/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2276 - accuracy:
0.9170 - val_loss: 3.2767 - val_accuracy: 0.4816
Epoch 198/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2227 - accuracy:
0.9153 - val_loss: 3.2361 - val_accuracy: 0.5063
Epoch 199/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2259 - accuracy:
0.9155 - val_loss: 3.1727 - val_accuracy: 0.5088
Epoch 200/200
225/225 [==============================] - 1s 4ms/step - loss: 0.2122 - accuracy:
0.9248 - val_loss: 3.2611 - val_accuracy: 0.5013
Model training is finished at 1656233275.966815 & it took 177.0 sec
```

In [140…

```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
plt.title(f'Accuracy')
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()
```





In [141…

```
### Model Evaluation

Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")
Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [NN
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat

testLoss, testAccuracy = NN_model.evaluate(X_test, y_test)

y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```

```
Final training loss : 0.2121506631374359
Final training accuracy:  0.9248414039611816
Final validation loss : 3.2611422538757324
Final validation accuracy : 0.5013012290000916
193/193 [==============================] - 0s 2ms/step - loss: 3.2611 - accuracy:
0.5013
Confusion matrix:
[[ 225  123   38   30   10]
 [ 122  178   87  106   45]
 [  32  101  165  229  128]
 [  16   66  224  736  770]
 [  12   53  140  734 1778]]
Classification Report:
              precision    recall  f1-score   support

           0       0.55      0.53      0.54       426
           1       0.34      0.33      0.34       538
           2       0.25      0.25      0.25       655
           3       0.40      0.41      0.40      1812
           4       0.65      0.65      0.65      2717

    accuracy                           0.50      6148
   macro avg       0.44      0.43      0.44      6148
weighted avg       0.50      0.50      0.50      6148
```

Observation: Without regularization the model validation fails significantly.

Model Iteration #3

Dropout:Change the position and value of dropout layer. Re-introducing regularization.

In [143…

```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(64,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))

NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.5))
NN_model.add(Dense(16,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))

# The Output Layer :
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())

### Model Compilation

adam=Adam(learning_rate=0.0001)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a

### Model Training
```

```
start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validati
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model: "sequential_5"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_37 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_38 (Dense)             (None, 256)               33024
_________________________________________________________________
dense_39 (Dense)             (None, 64)                16448
_________________________________________________________________
dense_40 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_41 (Dense)             (None, 32)                1056
_________________________________________________________________
dropout_7 (Dropout)          (None, 32)                0
_________________________________________________________________
dense_42 (Dense)             (None, 16)                528
_________________________________________________________________
dense_43 (Dense)             (None, 5)                 85
=================================================================
Total params: 69,733
Trainable params: 69,733
Non-trainable params: 0
_________________________________________________________________
None
Model training is started at 1656233377.2789707
Epoch 1/200
225/225 [==============================] - 1s 6ms/step - loss: 4.6838 - accuracy:
0.3880 - val_loss: 4.0839 - val_accuracy: 0.4419
Epoch 2/200
225/225 [==============================] - 1s 5ms/step - loss: 3.6123 - accuracy:
0.4237 - val_loss: 3.1504 - val_accuracy: 0.4419
Epoch 3/200
225/225 [==============================] - 1s 5ms/step - loss: 2.8268 - accuracy:
0.4266 - val_loss: 2.4795 - val_accuracy: 0.4419
Epoch 4/200
225/225 [==============================] - 1s 5ms/step - loss: 2.2474 - accuracy:
0.4311 - val_loss: 1.9862 - val_accuracy: 0.4515
Epoch 5/200
225/225 [==============================] - 1s 5ms/step - loss: 1.8389 - accuracy:
0.4470 - val_loss: 1.6691 - val_accuracy: 0.4571
Epoch 6/200
225/225 [==============================] - 1s 5ms/step - loss: 1.5998 - accuracy:
0.4537 - val_loss: 1.5106 - val_accuracy: 0.4592
Epoch 7/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4886 - accuracy:
0.4609 - val_loss: 1.4360 - val_accuracy: 0.4641
Epoch 8/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4232 - accuracy:
0.4643 - val_loss: 1.3824 - val_accuracy: 0.4657
Epoch 9/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3733 - accuracy:
0.4711 - val_loss: 1.3375 - val_accuracy: 0.4644
Epoch 10/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3377 - accuracy:
0.4876 - val_loss: 1.3025 - val_accuracy: 0.5042
Epoch 11/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3055 - accuracy:
0.5003 - val_loss: 1.2775 - val_accuracy: 0.5008
Epoch 12/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2826 - accuracy:
0.5054 - val_loss: 1.2617 - val_accuracy: 0.5119
Epoch 13/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2668 - accuracy:
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0.5068 - val_loss: 1.2440 - val_accuracy: 0.5094
Epoch 14/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2525 - accuracy:
0.5115 - val_loss: 1.2346 - val_accuracy: 0.5159
Epoch 15/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2413 - accuracy:
0.5110 - val_loss: 1.2201 - val_accuracy: 0.5093
Epoch 16/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2315 - accuracy:
0.5135 - val_loss: 1.2126 - val_accuracy: 0.5156
Epoch 17/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2217 - accuracy:
0.5161 - val_loss: 1.2054 - val_accuracy: 0.5164
Epoch 18/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2170 - accuracy:
0.5149 - val_loss: 1.2000 - val_accuracy: 0.5174
Epoch 19/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2062 - accuracy:
0.5183 - val_loss: 1.1920 - val_accuracy: 0.5189
Epoch 20/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2011 - accuracy:
0.5168 - val_loss: 1.1843 - val_accuracy: 0.5145
Epoch 21/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1968 - accuracy:
0.5196 - val_loss: 1.1813 - val_accuracy: 0.5205
Epoch 22/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1924 - accuracy:
0.5195 - val_loss: 1.1753 - val_accuracy: 0.5221
Epoch 23/200
225/225 [==============================] - 1s 5ms/step - loss: 1.1846 - accuracy:
0.5210 - val_loss: 1.1704 - val_accuracy: 0.5213
Epoch 24/200
225/225 [==============================] - 1s 6ms/step - loss: 1.1816 - accuracy:
0.5187 - val_loss: 1.1658 - val_accuracy: 0.5208
Epoch 25/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1765 - accuracy:
0.5193 - val_loss: 1.1626 - val_accuracy: 0.5211
Epoch 26/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1720 - accuracy:
0.5239 - val_loss: 1.1575 - val_accuracy: 0.5184
Epoch 27/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1688 - accuracy:
0.5216 - val_loss: 1.1549 - val_accuracy: 0.5229
Epoch 28/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1631 - accuracy:
0.5253 - val_loss: 1.1519 - val_accuracy: 0.5237
Epoch 29/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1641 - accuracy:
0.5230 - val_loss: 1.1486 - val_accuracy: 0.5226
Epoch 30/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1602 - accuracy:
0.5222 - val_loss: 1.1472 - val_accuracy: 0.5216
Epoch 31/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1574 - accuracy:
0.5260 - val_loss: 1.1420 - val_accuracy: 0.5215
Epoch 32/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1519 - accuracy:
0.5335 - val_loss: 1.1398 - val_accuracy: 0.5329
Epoch 33/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1502 - accuracy:
0.5352 - val_loss: 1.1370 - val_accuracy: 0.5353
Epoch 34/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1480 - accuracy:
0.5375 - val_loss: 1.1355 - val_accuracy: 0.5369
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Epoch 35/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1453 - accuracy:
0.5387 - val_loss: 1.1332 - val_accuracy: 0.5379
Epoch 36/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1442 - accuracy:
0.5394 - val_loss: 1.1301 - val_accuracy: 0.5400
Epoch 37/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1416 - accuracy:
0.5382 - val_loss: 1.1280 - val_accuracy: 0.5407
Epoch 38/200
225/225 [==============================] - 1s 6ms/step - loss: 1.1364 - accuracy:
0.5433 - val_loss: 1.1255 - val_accuracy: 0.5382
Epoch 39/200
225/225 [==============================] - 1s 6ms/step - loss: 1.1381 - accuracy:
0.5400 - val_loss: 1.1236 - val_accuracy: 0.5400
Epoch 40/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1334 - accuracy:
0.5414 - val_loss: 1.1218 - val_accuracy: 0.5407
Epoch 41/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1349 - accuracy:
0.5430 - val_loss: 1.1210 - val_accuracy: 0.5429
Epoch 42/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1313 - accuracy:
0.5414 - val_loss: 1.1263 - val_accuracy: 0.5403
Epoch 43/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1304 - accuracy:
0.5456 - val_loss: 1.1184 - val_accuracy: 0.5395
Epoch 44/200
225/225 [==============================] - 1s 6ms/step - loss: 1.1295 - accuracy:
0.5405 - val_loss: 1.1156 - val_accuracy: 0.5426
Epoch 45/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1219 - accuracy:
0.5457 - val_loss: 1.1147 - val_accuracy: 0.5390
Epoch 46/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1220 - accuracy:
0.5449 - val_loss: 1.1136 - val_accuracy: 0.5418
Epoch 47/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1202 - accuracy:
0.5446 - val_loss: 1.1135 - val_accuracy: 0.5454
Epoch 48/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1189 - accuracy:
0.5477 - val_loss: 1.1120 - val_accuracy: 0.5462
Epoch 49/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1198 - accuracy:
0.5492 - val_loss: 1.1085 - val_accuracy: 0.5468
Epoch 50/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1188 - accuracy:
0.5454 - val_loss: 1.1080 - val_accuracy: 0.5459
Epoch 51/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1160 - accuracy:
0.5456 - val_loss: 1.1067 - val_accuracy: 0.5491
Epoch 52/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1140 - accuracy:
0.5460 - val_loss: 1.1070 - val_accuracy: 0.5457
Epoch 53/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1163 - accuracy:
0.5441 - val_loss: 1.1052 - val_accuracy: 0.5452
Epoch 54/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1111 - accuracy:
0.5449 - val_loss: 1.1048 - val_accuracy: 0.5473
Epoch 55/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1111 - accuracy:
0.5468 - val_loss: 1.1029 - val_accuracy: 0.5485
Epoch 56/200
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225/225 [==============================] - 2s 7ms/step - loss: 1.1132 - accuracy:
0.5449 - val_loss: 1.1024 - val_accuracy: 0.5477
Epoch 57/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1089 - accuracy:
0.5472 - val_loss: 1.1001 - val_accuracy: 0.5488
Epoch 58/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1083 - accuracy:
0.5495 - val_loss: 1.1046 - val_accuracy: 0.5468
Epoch 59/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1058 - accuracy:
0.5500 - val_loss: 1.0992 - val_accuracy: 0.5498
Epoch 60/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1060 - accuracy:
0.5502 - val_loss: 1.1021 - val_accuracy: 0.5475
Epoch 61/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1070 - accuracy:
0.5465 - val_loss: 1.1001 - val_accuracy: 0.5481
Epoch 62/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1012 - accuracy:
0.5473 - val_loss: 1.0969 - val_accuracy: 0.5483
Epoch 63/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1020 - accuracy:
0.5527 - val_loss: 1.0960 - val_accuracy: 0.5485
Epoch 64/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0961 - accuracy:
0.5488 - val_loss: 1.0967 - val_accuracy: 0.5486
Epoch 65/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0993 - accuracy:
0.5507 - val_loss: 1.0957 - val_accuracy: 0.5503
Epoch 66/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0974 - accuracy:
0.5502 - val_loss: 1.0944 - val_accuracy: 0.5498
Epoch 67/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0962 - accuracy:
0.5509 - val_loss: 1.0934 - val_accuracy: 0.5507
Epoch 68/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0969 - accuracy:
0.5485 - val_loss: 1.0970 - val_accuracy: 0.5473
Epoch 69/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0954 - accuracy:
0.5486 - val_loss: 1.0927 - val_accuracy: 0.5514
Epoch 70/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0937 - accuracy:
0.5522 - val_loss: 1.0920 - val_accuracy: 0.5519
Epoch 71/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0917 - accuracy:
0.5527 - val_loss: 1.0912 - val_accuracy: 0.5490
Epoch 72/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0906 - accuracy:
0.5518 - val_loss: 1.0925 - val_accuracy: 0.5477
Epoch 73/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0860 - accuracy:
0.5504 - val_loss: 1.0902 - val_accuracy: 0.5527
Epoch 74/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0855 - accuracy:
0.5503 - val_loss: 1.0904 - val_accuracy: 0.5488
Epoch 75/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0891 - accuracy:
0.5543 - val_loss: 1.0897 - val_accuracy: 0.5507
Epoch 76/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0869 - accuracy:
0.5528 - val_loss: 1.0892 - val_accuracy: 0.5514
Epoch 77/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0850 - accuracy:
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0.5519 - val_loss: 1.0896 - val_accuracy: 0.5490
Epoch 78/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0810 - accuracy:
0.5578 - val_loss: 1.0877 - val_accuracy: 0.5504
Epoch 79/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0817 - accuracy:
0.5539 - val_loss: 1.0931 - val_accuracy: 0.5452
Epoch 80/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0790 - accuracy:
0.5536 - val_loss: 1.0872 - val_accuracy: 0.5509
Epoch 81/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0815 - accuracy:
0.5539 - val_loss: 1.0871 - val_accuracy: 0.5519
Epoch 82/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0798 - accuracy:
0.5561 - val_loss: 1.0857 - val_accuracy: 0.5511
Epoch 83/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0782 - accuracy:
0.5569 - val_loss: 1.0907 - val_accuracy: 0.5481
Epoch 84/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0761 - accuracy:
0.5581 - val_loss: 1.0860 - val_accuracy: 0.5494
Epoch 85/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0765 - accuracy:
0.5562 - val_loss: 1.0856 - val_accuracy: 0.5525
Epoch 86/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0762 - accuracy:
0.5530 - val_loss: 1.0858 - val_accuracy: 0.5473
Epoch 87/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0695 - accuracy:
0.5575 - val_loss: 1.0869 - val_accuracy: 0.5491
Epoch 88/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0718 - accuracy:
0.5600 - val_loss: 1.0881 - val_accuracy: 0.5475
Epoch 89/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0704 - accuracy:
0.5585 - val_loss: 1.0869 - val_accuracy: 0.5478
Epoch 90/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0694 - accuracy:
0.5633 - val_loss: 1.0896 - val_accuracy: 0.5447
Epoch 91/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0675 - accuracy:
0.5626 - val_loss: 1.0843 - val_accuracy: 0.5486
Epoch 92/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0676 - accuracy:
0.5611 - val_loss: 1.0851 - val_accuracy: 0.5464
Epoch 93/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0639 - accuracy:
0.5585 - val_loss: 1.0866 - val_accuracy: 0.5473
Epoch 94/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0644 - accuracy:
0.5631 - val_loss: 1.0865 - val_accuracy: 0.5486
Epoch 95/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0608 - accuracy:
0.5661 - val_loss: 1.0901 - val_accuracy: 0.5459
Epoch 96/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0621 - accuracy:
0.5620 - val_loss: 1.0924 - val_accuracy: 0.5465
Epoch 97/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0627 - accuracy:
0.5624 - val_loss: 1.0854 - val_accuracy: 0.5472
Epoch 98/200
225/225 [==============================] - 1s 6ms/step - loss: 1.0606 - accuracy:
0.5622 - val_loss: 1.0860 - val_accuracy: 0.5483
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Epoch 99/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0618 - accuracy:
0.5656 - val_loss: 1.0936 - val_accuracy: 0.5472
Epoch 100/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0559 - accuracy:
0.5635 - val_loss: 1.0897 - val_accuracy: 0.5470
Epoch 101/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0576 - accuracy:
0.5658 - val_loss: 1.0891 - val_accuracy: 0.5468
Epoch 102/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0565 - accuracy:
0.5675 - val_loss: 1.0882 - val_accuracy: 0.5494
Epoch 103/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0567 - accuracy:
0.5673 - val_loss: 1.0858 - val_accuracy: 0.5475
Epoch 104/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0507 - accuracy:
0.5697 - val_loss: 1.0864 - val_accuracy: 0.5460
Epoch 105/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0514 - accuracy:
0.5669 - val_loss: 1.0865 - val_accuracy: 0.5449
Epoch 106/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0525 - accuracy:
0.5694 - val_loss: 1.0867 - val_accuracy: 0.5465
Epoch 107/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0469 - accuracy:
0.5714 - val_loss: 1.0906 - val_accuracy: 0.5486
Epoch 108/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0481 - accuracy:
0.5681 - val_loss: 1.0932 - val_accuracy: 0.5473
Epoch 109/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0489 - accuracy:
0.5699 - val_loss: 1.0885 - val_accuracy: 0.5434
Epoch 110/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0443 - accuracy:
0.5721 - val_loss: 1.0876 - val_accuracy: 0.5459
Epoch 111/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0467 - accuracy:
0.5718 - val_loss: 1.0892 - val_accuracy: 0.5444
Epoch 112/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0419 - accuracy:
0.5725 - val_loss: 1.0900 - val_accuracy: 0.5449
Epoch 113/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0459 - accuracy:
0.5748 - val_loss: 1.0890 - val_accuracy: 0.5457
Epoch 114/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0447 - accuracy:
0.5744 - val_loss: 1.0917 - val_accuracy: 0.5449
Epoch 115/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0398 - accuracy:
0.5710 - val_loss: 1.0944 - val_accuracy: 0.5464
Epoch 116/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0394 - accuracy:
0.5734 - val_loss: 1.0907 - val_accuracy: 0.5451
Epoch 117/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0380 - accuracy:
0.5787 - val_loss: 1.0917 - val_accuracy: 0.5444
Epoch 118/200
225/225 [==============================] - 1s 7ms/step - loss: 1.0335 - accuracy:
0.5786 - val_loss: 1.0940 - val_accuracy: 0.5447
Epoch 119/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0359 - accuracy:
0.5780 - val_loss: 1.0935 - val_accuracy: 0.5425
Epoch 120/200
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225/225 [==============================] - 2s 7ms/step - loss: 1.0331 - accuracy:
0.5760 - val_loss: 1.0941 - val_accuracy: 0.5439
Epoch 121/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0332 - accuracy:
0.5784 - val_loss: 1.0958 - val_accuracy: 0.5429
Epoch 122/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0303 - accuracy:
0.5769 - val_loss: 1.0980 - val_accuracy: 0.5431
Epoch 123/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0301 - accuracy:
0.5800 - val_loss: 1.0965 - val_accuracy: 0.5428
Epoch 124/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0302 - accuracy:
0.5804 - val_loss: 1.0991 - val_accuracy: 0.5444
Epoch 125/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0259 - accuracy:
0.5817 - val_loss: 1.0983 - val_accuracy: 0.5431
Epoch 126/200
225/225 [==============================] - 1s 6ms/step - loss: 1.0228 - accuracy:
0.5782 - val_loss: 1.0979 - val_accuracy: 0.5431
Epoch 127/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0230 - accuracy:
0.5829 - val_loss: 1.1005 - val_accuracy: 0.5436
Epoch 128/200
225/225 [==============================] - 1s 7ms/step - loss: 1.0211 - accuracy:
0.5832 - val_loss: 1.1008 - val_accuracy: 0.5418
Epoch 129/200
225/225 [==============================] - 1s 7ms/step - loss: 1.0189 - accuracy:
0.5868 - val_loss: 1.1016 - val_accuracy: 0.5416
Epoch 130/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0166 - accuracy:
0.5838 - val_loss: 1.1034 - val_accuracy: 0.5439
Epoch 131/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0192 - accuracy:
0.5871 - val_loss: 1.1034 - val_accuracy: 0.5439
Epoch 132/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0167 - accuracy:
0.5896 - val_loss: 1.1034 - val_accuracy: 0.5439
Epoch 133/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0147 - accuracy:
0.5844 - val_loss: 1.1077 - val_accuracy: 0.5428
Epoch 134/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0093 - accuracy:
0.5907 - val_loss: 1.1050 - val_accuracy: 0.5444
Epoch 135/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0112 - accuracy:
0.5874 - val_loss: 1.1065 - val_accuracy: 0.5436
Epoch 136/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0077 - accuracy:
0.5899 - val_loss: 1.1097 - val_accuracy: 0.5451
Epoch 137/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0083 - accuracy:
0.5893 - val_loss: 1.1131 - val_accuracy: 0.5460
Epoch 138/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0044 - accuracy:
0.5951 - val_loss: 1.1134 - val_accuracy: 0.5394
Epoch 139/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0049 - accuracy:
0.5917 - val_loss: 1.1237 - val_accuracy: 0.5356
Epoch 140/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0024 - accuracy:
0.5930 - val_loss: 1.1153 - val_accuracy: 0.5488
Epoch 141/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0009 - accuracy:
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0.5934 - val_loss: 1.1192 - val_accuracy: 0.5392
Epoch 142/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9999 - accuracy:
0.5938 - val_loss: 1.1193 - val_accuracy: 0.5423
Epoch 143/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9965 - accuracy:
0.5932 - val_loss: 1.1206 - val_accuracy: 0.5416
Epoch 144/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9980 - accuracy:
0.5973 - val_loss: 1.1207 - val_accuracy: 0.5394
Epoch 145/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9931 - accuracy:
0.6005 - val_loss: 1.1249 - val_accuracy: 0.5397
Epoch 146/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9926 - accuracy:
0.5985 - val_loss: 1.1254 - val_accuracy: 0.5413
Epoch 147/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9920 - accuracy:
0.5978 - val_loss: 1.1265 - val_accuracy: 0.5441
Epoch 148/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9901 - accuracy:
0.5999 - val_loss: 1.1274 - val_accuracy: 0.5418
Epoch 149/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9845 - accuracy:
0.6038 - val_loss: 1.1294 - val_accuracy: 0.5389
Epoch 150/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9893 - accuracy:
0.6012 - val_loss: 1.1304 - val_accuracy: 0.5412
Epoch 151/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9849 - accuracy:
0.6032 - val_loss: 1.1328 - val_accuracy: 0.5420
Epoch 152/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9812 - accuracy:
0.6069 - val_loss: 1.1327 - val_accuracy: 0.5425
Epoch 153/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9835 - accuracy:
0.6057 - val_loss: 1.1353 - val_accuracy: 0.5399
Epoch 154/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9820 - accuracy:
0.6026 - val_loss: 1.1388 - val_accuracy: 0.5397
Epoch 155/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9787 - accuracy:
0.6060 - val_loss: 1.1406 - val_accuracy: 0.5425
Epoch 156/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9753 - accuracy:
0.6094 - val_loss: 1.1425 - val_accuracy: 0.5395
Epoch 157/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9753 - accuracy:
0.6102 - val_loss: 1.1522 - val_accuracy: 0.5351
Epoch 158/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9736 - accuracy:
0.6111 - val_loss: 1.1477 - val_accuracy: 0.5399
Epoch 159/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9699 - accuracy:
0.6124 - val_loss: 1.1601 - val_accuracy: 0.5405
Epoch 160/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9744 - accuracy:
0.6057 - val_loss: 1.1512 - val_accuracy: 0.5390
Epoch 161/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9667 - accuracy:
0.6126 - val_loss: 1.1567 - val_accuracy: 0.5369
Epoch 162/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9654 - accuracy:
0.6130 - val_loss: 1.1536 - val_accuracy: 0.5410
```
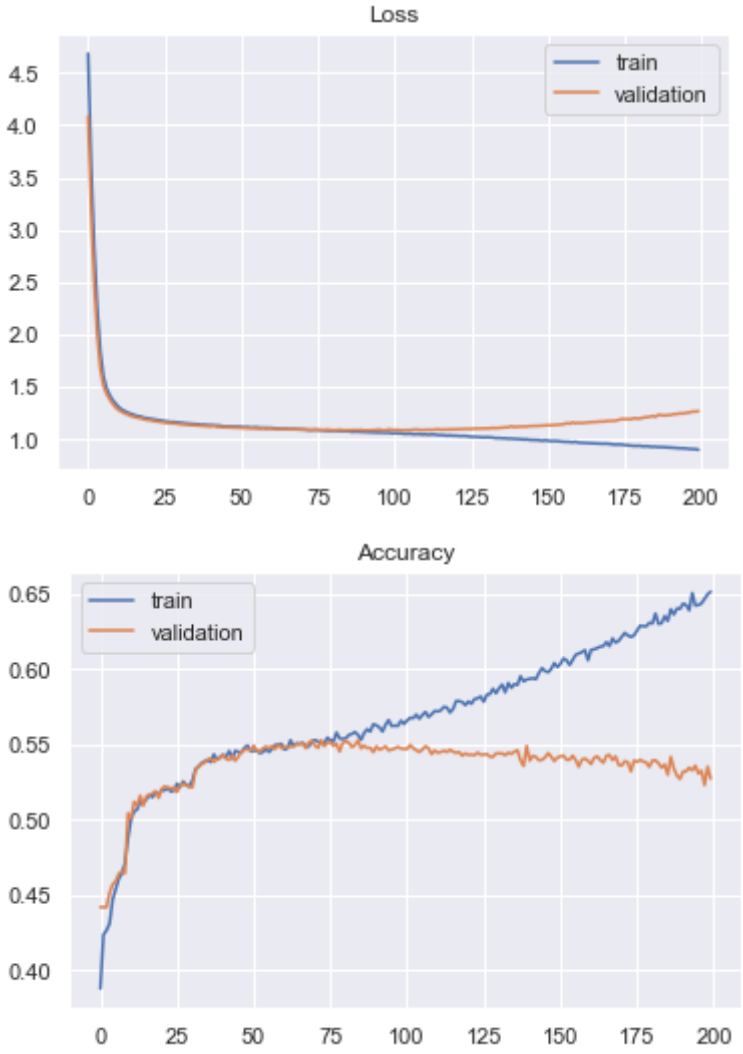

```
Epoch 163/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9640 - accuracy:
0.6139 - val_loss: 1.1572 - val_accuracy: 0.5420
Epoch 164/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9622 - accuracy:
0.6147 - val_loss: 1.1598 - val_accuracy: 0.5395
Epoch 165/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9605 - accuracy:
0.6151 - val_loss: 1.1626 - val_accuracy: 0.5377
Epoch 166/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9597 - accuracy:
0.6178 - val_loss: 1.1637 - val_accuracy: 0.5423
Epoch 167/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9577 - accuracy:
0.6151 - val_loss: 1.1650 - val_accuracy: 0.5429
Epoch 168/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9583 - accuracy:
0.6202 - val_loss: 1.1686 - val_accuracy: 0.5395
Epoch 169/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9561 - accuracy:
0.6174 - val_loss: 1.1683 - val_accuracy: 0.5420
Epoch 170/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9575 - accuracy:
0.6186 - val_loss: 1.1725 - val_accuracy: 0.5363
Epoch 171/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9538 - accuracy:
0.6211 - val_loss: 1.1740 - val_accuracy: 0.5359
Epoch 172/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9489 - accuracy:
0.6239 - val_loss: 1.1748 - val_accuracy: 0.5387
Epoch 173/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9477 - accuracy:
0.6222 - val_loss: 1.1764 - val_accuracy: 0.5381
Epoch 174/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9501 - accuracy:
0.6211 - val_loss: 1.1853 - val_accuracy: 0.5320
Epoch 175/200
225/225 [==============================] - 2s 8ms/step - loss: 0.9474 - accuracy:
0.6223 - val_loss: 1.1923 - val_accuracy: 0.5392
Epoch 176/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9440 - accuracy:
0.6253 - val_loss: 1.1923 - val_accuracy: 0.5382
Epoch 177/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9421 - accuracy:
0.6286 - val_loss: 1.1907 - val_accuracy: 0.5397
Epoch 178/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9412 - accuracy:
0.6283 - val_loss: 1.1911 - val_accuracy: 0.5385
Epoch 179/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9355 - accuracy:
0.6283 - val_loss: 1.2000 - val_accuracy: 0.5379
Epoch 180/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9364 - accuracy:
0.6306 - val_loss: 1.1968 - val_accuracy: 0.5350
Epoch 181/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9363 - accuracy:
0.6301 - val_loss: 1.1975 - val_accuracy: 0.5392
Epoch 182/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9303 - accuracy:
0.6367 - val_loss: 1.2060 - val_accuracy: 0.5394
Epoch 183/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9334 - accuracy:
0.6299 - val_loss: 1.2085 - val_accuracy: 0.5374
Epoch 184/200
```

```
225/225 [==============================] - 2s 7ms/step - loss: 0.9303 - accuracy:
0.6303 - val_loss: 1.2129 - val_accuracy: 0.5345
Epoch 185/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9266 - accuracy:
0.6350 - val_loss: 1.2215 - val_accuracy: 0.5366
Epoch 186/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9281 - accuracy:
0.6318 - val_loss: 1.2139 - val_accuracy: 0.5298
Epoch 187/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9238 - accuracy:
0.6395 - val_loss: 1.2336 - val_accuracy: 0.5416
Epoch 188/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9247 - accuracy:
0.6361 - val_loss: 1.2286 - val_accuracy: 0.5338
Epoch 189/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9225 - accuracy:
0.6400 - val_loss: 1.2271 - val_accuracy: 0.5293
Epoch 190/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9221 - accuracy:
0.6398 - val_loss: 1.2283 - val_accuracy: 0.5270
Epoch 191/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9194 - accuracy:
0.6432 - val_loss: 1.2317 - val_accuracy: 0.5319
Epoch 192/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9182 - accuracy:
0.6424 - val_loss: 1.2391 - val_accuracy: 0.5320
Epoch 193/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9156 - accuracy:
0.6388 - val_loss: 1.2401 - val_accuracy: 0.5345
Epoch 194/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9126 - accuracy:
0.6503 - val_loss: 1.2467 - val_accuracy: 0.5327
Epoch 195/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9131 - accuracy:
0.6421 - val_loss: 1.2445 - val_accuracy: 0.5358
Epoch 196/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9098 - accuracy:
0.6423 - val_loss: 1.2522 - val_accuracy: 0.5306
Epoch 197/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9086 - accuracy:
0.6434 - val_loss: 1.2535 - val_accuracy: 0.5325
Epoch 198/200
225/225 [==============================] - 1s 7ms/step - loss: 0.9050 - accuracy:
0.6465 - val_loss: 1.2641 - val_accuracy: 0.5229
Epoch 199/200
225/225 [==============================] - 2s 7ms/step - loss: 0.9044 - accuracy:
0.6494 - val_loss: 1.2626 - val_accuracy: 0.5351
Epoch 200/200
225/225 [==============================] - 2s 7ms/step - loss: 0.8996 - accuracy:
0.6512 - val_loss: 1.2685 - val_accuracy: 0.5272
Model training is finished at 1656233688.054339 & it took 311.0 sec
```

In [144…

```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
plt.title(f'Accuracy')
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()
```



In [145…

```
### Model Evaluation

Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")

Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [NN
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat

testLoss, testAccuracy = NN_model.evaluate(X_test, y_test)

y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```

```
Final training loss : 0.8996031284332275
Final training accuracy:  0.6511887311935425
Final validation loss : 1.2685205936431885
Final validation accuracy : 0.5271633267402649
193/193 [==============================] - 1s 3ms/step - loss: 1.2685 - accuracy:
0.5272
Confusion matrix:
[[ 298   59   28   37    4]
 [ 195  117   73  129   24]
 [  56  108  120  289   82]
 [  35   80  145  766  786]
 [  15   53   64  645 1940]]
Classification Report:
              precision    recall  f1-score   support

           0       0.50      0.70      0.58       426
           1       0.28      0.22      0.25       538
           2       0.28      0.18      0.22       655
           3       0.41      0.42      0.42      1812
           4       0.68      0.71      0.70      2717

    accuracy                           0.53      6148
   macro avg       0.43      0.45      0.43      6148
weighted avg       0.51      0.53      0.52      6148
```

Observation: Results have improved over previous iteration, validation is still failing.

Model Iteration #4

Dropout:Change the position to lower hidden layer and value of dropout layer.

Learning rate: reduce the learning rate

In [135…

```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.7))
NN_model.add(Dense(64,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.7))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(16,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))

# The Output Layer :
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())

### Model Compilation

adam=Adam(learning_rate=0.00005)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a
```

```
### Model Training

start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validati
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_23 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_24 (Dense)             (None, 256)               33024
_________________________________________________________________
dropout_4 (Dropout)          (None, 256)               0
_________________________________________________________________
dense_25 (Dense)             (None, 64)                16448
_________________________________________________________________
dropout_5 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_26 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_27 (Dense)             (None, 32)                1056
_________________________________________________________________
dense_28 (Dense)             (None, 16)                528
_________________________________________________________________
dense_29 (Dense)             (None, 5)                 85
=================================================================
Total params: 69,733
Trainable params: 69,733
Non-trainable params: 0
_________________________________________________________________
None
Model training is started at 1656232626.2249537
Epoch 1/200
225/225 [==============================] - 1s 6ms/step - loss: 5.0188 - accuracy:
0.3322 - val_loss: 4.7552 - val_accuracy: 0.4419
Epoch 2/200
225/225 [==============================] - 1s 5ms/step - loss: 4.5120 - accuracy:
0.4364 - val_loss: 4.2686 - val_accuracy: 0.4419
Epoch 3/200
225/225 [==============================] - 1s 5ms/step - loss: 4.0672 - accuracy:
0.4413 - val_loss: 3.8564 - val_accuracy: 0.4419
Epoch 4/200
225/225 [==============================] - 1s 5ms/step - loss: 3.6757 - accuracy:
0.4416 - val_loss: 3.4760 - val_accuracy: 0.4419
Epoch 5/200
225/225 [==============================] - 1s 5ms/step - loss: 3.3284 - accuracy:
0.4420 - val_loss: 3.1449 - val_accuracy: 0.4419
Epoch 6/200
225/225 [==============================] - 1s 5ms/step - loss: 3.0253 - accuracy:
0.4418 - val_loss: 2.8613 - val_accuracy: 0.4419
Epoch 7/200
225/225 [==============================] - 1s 5ms/step - loss: 2.7668 - accuracy:
0.4416 - val_loss: 2.6240 - val_accuracy: 0.4419
Epoch 8/200
225/225 [==============================] - 1s 5ms/step - loss: 2.5441 - accuracy:
0.4422 - val_loss: 2.4149 - val_accuracy: 0.4419
Epoch 9/200
225/225 [==============================] - 1s 5ms/step - loss: 2.3502 - accuracy:
0.4427 - val_loss: 2.2360 - val_accuracy: 0.4429
Epoch 10/200
225/225 [==============================] - 1s 5ms/step - loss: 2.1869 - accuracy:
0.4470 - val_loss: 2.0896 - val_accuracy: 0.4553
Epoch 11/200
225/225 [==============================] - 1s 5ms/step - loss: 2.0550 - accuracy:
0.4558 - val_loss: 1.9727 - val_accuracy: 0.4584
Epoch 12/200
225/225 [==============================] - 1s 5ms/step - loss: 1.9525 - accuracy:
0.4612 - val_loss: 1.8837 - val_accuracy: 0.4624
```

```
Epoch 13/200
225/225 [==============================] - 1s 5ms/step - loss: 1.8685 - accuracy:
0.4620 - val_loss: 1.8085 - val_accuracy: 0.4613
Epoch 14/200
225/225 [==============================] - 1s 5ms/step - loss: 1.8048 - accuracy:
0.4671 - val_loss: 1.7510 - val_accuracy: 0.4652
Epoch 15/200
225/225 [==============================] - 1s 5ms/step - loss: 1.7463 - accuracy:
0.4673 - val_loss: 1.6946 - val_accuracy: 0.4649
Epoch 16/200
225/225 [==============================] - 1s 5ms/step - loss: 1.6954 - accuracy:
0.4679 - val_loss: 1.6525 - val_accuracy: 0.4671
Epoch 17/200
225/225 [==============================] - 1s 5ms/step - loss: 1.6496 - accuracy:
0.4689 - val_loss: 1.6091 - val_accuracy: 0.4654
Epoch 18/200
225/225 [==============================] - 1s 5ms/step - loss: 1.6123 - accuracy:
0.4694 - val_loss: 1.5751 - val_accuracy: 0.4684
Epoch 19/200
225/225 [==============================] - 1s 5ms/step - loss: 1.5814 - accuracy:
0.4717 - val_loss: 1.5462 - val_accuracy: 0.4701
Epoch 20/200
225/225 [==============================] - 1s 5ms/step - loss: 1.5528 - accuracy:
0.4715 - val_loss: 1.5134 - val_accuracy: 0.4652
Epoch 21/200
225/225 [==============================] - 1s 5ms/step - loss: 1.5242 - accuracy:
0.4747 - val_loss: 1.4887 - val_accuracy: 0.4660
Epoch 22/200
225/225 [==============================] - 1s 5ms/step - loss: 1.5016 - accuracy:
0.4720 - val_loss: 1.4667 - val_accuracy: 0.4688
Epoch 23/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4788 - accuracy:
0.4733 - val_loss: 1.4474 - val_accuracy: 0.4697
Epoch 24/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4616 - accuracy:
0.4733 - val_loss: 1.4299 - val_accuracy: 0.4693
Epoch 25/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4411 - accuracy:
0.4753 - val_loss: 1.4147 - val_accuracy: 0.4696
Epoch 26/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4283 - accuracy:
0.4751 - val_loss: 1.3973 - val_accuracy: 0.4699
Epoch 27/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4122 - accuracy:
0.4742 - val_loss: 1.3839 - val_accuracy: 0.4697
Epoch 28/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4004 - accuracy:
0.4753 - val_loss: 1.3717 - val_accuracy: 0.4683
Epoch 29/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3842 - accuracy:
0.4745 - val_loss: 1.3611 - val_accuracy: 0.4684
Epoch 30/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3767 - accuracy:
0.4747 - val_loss: 1.3504 - val_accuracy: 0.4684
Epoch 31/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3705 - accuracy:
0.4750 - val_loss: 1.3400 - val_accuracy: 0.4671
Epoch 32/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3584 - accuracy:
0.4731 - val_loss: 1.3310 - val_accuracy: 0.4699
Epoch 33/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3514 - accuracy:
0.4760 - val_loss: 1.3228 - val_accuracy: 0.4691
Epoch 34/200
```

```
225/225 [==============================] - 1s 5ms/step - loss: 1.3426 - accuracy:
0.4757 - val_loss: 1.3177 - val_accuracy: 0.4697
Epoch 35/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3365 - accuracy:
0.4774 - val_loss: 1.3103 - val_accuracy: 0.4693
Epoch 36/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3254 - accuracy:
0.4746 - val_loss: 1.3019 - val_accuracy: 0.4683
Epoch 37/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3203 - accuracy:
0.4767 - val_loss: 1.2962 - val_accuracy: 0.4875
Epoch 38/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3189 - accuracy:
0.5030 - val_loss: 1.2907 - val_accuracy: 0.4904
Epoch 39/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3148 - accuracy:
0.5014 - val_loss: 1.2853 - val_accuracy: 0.4943
Epoch 40/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3078 - accuracy:
0.5072 - val_loss: 1.2801 - val_accuracy: 0.4937
Epoch 41/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3017 - accuracy:
0.5077 - val_loss: 1.2779 - val_accuracy: 0.5002
Epoch 42/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2965 - accuracy:
0.5103 - val_loss: 1.2723 - val_accuracy: 0.4998
Epoch 43/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2937 - accuracy:
0.5095 - val_loss: 1.2678 - val_accuracy: 0.4915
Epoch 44/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2882 - accuracy:
0.5069 - val_loss: 1.2636 - val_accuracy: 0.4972
Epoch 45/200
225/225 [==============================] - 1s 5ms/step - loss: 1.2837 - accuracy:
0.5086 - val_loss: 1.2599 - val_accuracy: 0.4937
Epoch 46/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2819 - accuracy:
0.5096 - val_loss: 1.2564 - val_accuracy: 0.4938
Epoch 47/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2775 - accuracy:
0.5102 - val_loss: 1.2557 - val_accuracy: 0.5063
Epoch 48/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2733 - accuracy:
0.5137 - val_loss: 1.2534 - val_accuracy: 0.5067
Epoch 49/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2736 - accuracy:
0.5127 - val_loss: 1.2470 - val_accuracy: 0.5026
Epoch 50/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2697 - accuracy:
0.5108 - val_loss: 1.2449 - val_accuracy: 0.5054
Epoch 51/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2646 - accuracy:
0.5117 - val_loss: 1.2411 - val_accuracy: 0.5013
Epoch 52/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2640 - accuracy:
0.5137 - val_loss: 1.2398 - val_accuracy: 0.5067
Epoch 53/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2645 - accuracy:
0.5128 - val_loss: 1.2362 - val_accuracy: 0.5046
Epoch 54/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2600 - accuracy:
0.5120 - val_loss: 1.2349 - val_accuracy: 0.5073
Epoch 55/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2569 - accuracy:
```

```
0.5156 - val_loss: 1.2309 - val_accuracy: 0.5026
Epoch 56/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2527 - accuracy:
0.5142 - val_loss: 1.2287 - val_accuracy: 0.5028
Epoch 57/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2520 - accuracy:
0.5122 - val_loss: 1.2266 - val_accuracy: 0.5039
Epoch 58/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2531 - accuracy:
0.5126 - val_loss: 1.2262 - val_accuracy: 0.5075
Epoch 59/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2459 - accuracy:
0.5145 - val_loss: 1.2227 - val_accuracy: 0.5067
Epoch 60/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2453 - accuracy:
0.5117 - val_loss: 1.2207 - val_accuracy: 0.5062
Epoch 61/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2491 - accuracy:
0.5134 - val_loss: 1.2197 - val_accuracy: 0.5070
Epoch 62/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2405 - accuracy:
0.5147 - val_loss: 1.2171 - val_accuracy: 0.5028
Epoch 63/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2418 - accuracy:
0.5150 - val_loss: 1.2169 - val_accuracy: 0.5081
Epoch 64/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2378 - accuracy:
0.5124 - val_loss: 1.2137 - val_accuracy: 0.5036
Epoch 65/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2370 - accuracy:
0.5139 - val_loss: 1.2123 - val_accuracy: 0.5055
Epoch 66/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2367 - accuracy:
0.5142 - val_loss: 1.2110 - val_accuracy: 0.5078
Epoch 67/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2303 - accuracy:
0.5145 - val_loss: 1.2091 - val_accuracy: 0.5062
Epoch 68/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2289 - accuracy:
0.5145 - val_loss: 1.2079 - val_accuracy: 0.5086
Epoch 69/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2296 - accuracy:
0.5149 - val_loss: 1.2064 - val_accuracy: 0.5081
Epoch 70/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2266 - accuracy:
0.5151 - val_loss: 1.2053 - val_accuracy: 0.5086
Epoch 71/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2282 - accuracy:
0.5120 - val_loss: 1.2037 - val_accuracy: 0.5085
Epoch 72/200
225/225 [==============================] - 2s 9ms/step - loss: 1.2268 - accuracy:
0.5131 - val_loss: 1.2022 - val_accuracy: 0.5052
Epoch 73/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2300 - accuracy:
0.5131 - val_loss: 1.2021 - val_accuracy: 0.5096
Epoch 74/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2247 - accuracy:
0.5191 - val_loss: 1.2003 - val_accuracy: 0.5111
Epoch 75/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2248 - accuracy:
0.5127 - val_loss: 1.1989 - val_accuracy: 0.5085
Epoch 76/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2240 - accuracy:
0.5150 - val_loss: 1.1980 - val_accuracy: 0.5085
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Epoch 77/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2206 - accuracy:
0.5156 - val_loss: 1.1968 - val_accuracy: 0.5093
Epoch 78/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2233 - accuracy:
0.5143 - val_loss: 1.1960 - val_accuracy: 0.5109
Epoch 79/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2199 - accuracy:
0.5160 - val_loss: 1.1956 - val_accuracy: 0.5101
Epoch 80/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2184 - accuracy:
0.5174 - val_loss: 1.1938 - val_accuracy: 0.5063
Epoch 81/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2132 - accuracy:
0.5145 - val_loss: 1.1929 - val_accuracy: 0.5104
Epoch 82/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2167 - accuracy:
0.5177 - val_loss: 1.1914 - val_accuracy: 0.5089
Epoch 83/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2140 - accuracy:
0.5185 - val_loss: 1.1913 - val_accuracy: 0.5096
Epoch 84/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2109 - accuracy:
0.5166 - val_loss: 1.1898 - val_accuracy: 0.5107
Epoch 85/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2140 - accuracy:
0.5152 - val_loss: 1.1889 - val_accuracy: 0.5117
Epoch 86/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2153 - accuracy:
0.5145 - val_loss: 1.1879 - val_accuracy: 0.5111
Epoch 87/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2111 - accuracy:
0.5187 - val_loss: 1.1877 - val_accuracy: 0.5098
Epoch 88/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2118 - accuracy:
0.5157 - val_loss: 1.1874 - val_accuracy: 0.5098
Epoch 89/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2087 - accuracy:
0.5194 - val_loss: 1.1853 - val_accuracy: 0.5096
Epoch 90/200
225/225 [==============================] - 2s 9ms/step - loss: 1.2072 - accuracy:
0.5177 - val_loss: 1.1879 - val_accuracy: 0.5132
Epoch 91/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2069 - accuracy:
0.5199 - val_loss: 1.1832 - val_accuracy: 0.5104
Epoch 92/200
225/225 [==============================] - 1s 7ms/step - loss: 1.2077 - accuracy:
0.5166 - val_loss: 1.1824 - val_accuracy: 0.5101
Epoch 93/200
225/225 [==============================] - 1s 6ms/step - loss: 1.2065 - accuracy:
0.5141 - val_loss: 1.1814 - val_accuracy: 0.5101
Epoch 94/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2056 - accuracy:
0.5170 - val_loss: 1.1814 - val_accuracy: 0.5085
Epoch 95/200
225/225 [==============================] - 1s 7ms/step - loss: 1.2070 - accuracy:
0.5151 - val_loss: 1.1800 - val_accuracy: 0.5104
Epoch 96/200
225/225 [==============================] - 1s 7ms/step - loss: 1.2013 - accuracy:
0.5166 - val_loss: 1.1806 - val_accuracy: 0.5098
Epoch 97/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2028 - accuracy:
0.5168 - val_loss: 1.1785 - val_accuracy: 0.5094
Epoch 98/200
```

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225/225 [==============================] - 2s 7ms/step - loss: 1.2051 - accuracy:
0.5177 - val_loss: 1.1780 - val_accuracy: 0.5096
Epoch 99/200
225/225 [==============================] - 1s 7ms/step - loss: 1.2023 - accuracy:
0.5149 - val_loss: 1.1776 - val_accuracy: 0.5101
Epoch 100/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2010 - accuracy:
0.5163 - val_loss: 1.1774 - val_accuracy: 0.5111
Epoch 101/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2001 - accuracy:
0.5192 - val_loss: 1.1760 - val_accuracy: 0.5099
Epoch 102/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1972 - accuracy:
0.5172 - val_loss: 1.1755 - val_accuracy: 0.5104
Epoch 103/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1968 - accuracy:
0.5155 - val_loss: 1.1746 - val_accuracy: 0.5101
Epoch 104/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1932 - accuracy:
0.5166 - val_loss: 1.1739 - val_accuracy: 0.5098
Epoch 105/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1971 - accuracy:
0.5159 - val_loss: 1.1733 - val_accuracy: 0.5091
Epoch 106/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1995 - accuracy:
0.5164 - val_loss: 1.1731 - val_accuracy: 0.5098
Epoch 107/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1967 - accuracy:
0.5174 - val_loss: 1.1731 - val_accuracy: 0.5122
Epoch 108/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1979 - accuracy:
0.5178 - val_loss: 1.1726 - val_accuracy: 0.5125
Epoch 109/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1953 - accuracy:
0.5168 - val_loss: 1.1712 - val_accuracy: 0.5111
Epoch 110/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1963 - accuracy:
0.5187 - val_loss: 1.1709 - val_accuracy: 0.5096
Epoch 111/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1933 - accuracy:
0.5205 - val_loss: 1.1696 - val_accuracy: 0.5083
Epoch 112/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1941 - accuracy:
0.5226 - val_loss: 1.1695 - val_accuracy: 0.5096
Epoch 113/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1958 - accuracy:
0.5176 - val_loss: 1.1687 - val_accuracy: 0.5099
Epoch 114/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1912 - accuracy:
0.5197 - val_loss: 1.1691 - val_accuracy: 0.5124
Epoch 115/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1921 - accuracy:
0.5180 - val_loss: 1.1686 - val_accuracy: 0.5117
Epoch 116/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1950 - accuracy:
0.5168 - val_loss: 1.1671 - val_accuracy: 0.5089
Epoch 117/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1920 - accuracy:
0.5216 - val_loss: 1.1669 - val_accuracy: 0.5109
Epoch 118/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1921 - accuracy:
0.5184 - val_loss: 1.1660 - val_accuracy: 0.5114
Epoch 119/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1892 - accuracy:
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0.5171 - val_loss: 1.1648 - val_accuracy: 0.5086
Epoch 120/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1915 - accuracy:
0.5200 - val_loss: 1.1646 - val_accuracy: 0.5112
Epoch 121/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1846 - accuracy:
0.5190 - val_loss: 1.1638 - val_accuracy: 0.5104
Epoch 122/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1880 - accuracy:
0.5216 - val_loss: 1.1646 - val_accuracy: 0.5119
Epoch 123/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1874 - accuracy:
0.5180 - val_loss: 1.1628 - val_accuracy: 0.5107
Epoch 124/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1882 - accuracy:
0.5168 - val_loss: 1.1622 - val_accuracy: 0.5091
Epoch 125/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1892 - accuracy:
0.5157 - val_loss: 1.1625 - val_accuracy: 0.5128
Epoch 126/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1879 - accuracy:
0.5156 - val_loss: 1.1617 - val_accuracy: 0.5111
Epoch 127/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1866 - accuracy:
0.5203 - val_loss: 1.1608 - val_accuracy: 0.5098
Epoch 128/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1874 - accuracy:
0.5169 - val_loss: 1.1602 - val_accuracy: 0.5096
Epoch 129/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1818 - accuracy:
0.5198 - val_loss: 1.1607 - val_accuracy: 0.5132
Epoch 130/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1807 - accuracy:
0.5212 - val_loss: 1.1596 - val_accuracy: 0.5088
Epoch 131/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1801 - accuracy:
0.5195 - val_loss: 1.1590 - val_accuracy: 0.5109
Epoch 132/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1816 - accuracy:
0.5200 - val_loss: 1.1582 - val_accuracy: 0.5101
Epoch 133/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1795 - accuracy:
0.5228 - val_loss: 1.1579 - val_accuracy: 0.5130
Epoch 134/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1816 - accuracy:
0.5196 - val_loss: 1.1575 - val_accuracy: 0.5137
Epoch 135/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1803 - accuracy:
0.5216 - val_loss: 1.1564 - val_accuracy: 0.5107
Epoch 136/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1763 - accuracy:
0.5218 - val_loss: 1.1556 - val_accuracy: 0.5114
Epoch 137/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1798 - accuracy:
0.5192 - val_loss: 1.1552 - val_accuracy: 0.5109
Epoch 138/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1798 - accuracy:
0.5191 - val_loss: 1.1549 - val_accuracy: 0.5122
Epoch 139/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1758 - accuracy:
0.5236 - val_loss: 1.1543 - val_accuracy: 0.5104
Epoch 140/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1791 - accuracy:
0.5221 - val_loss: 1.1540 - val_accuracy: 0.5102
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Epoch 141/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1801 - accuracy:
0.5163 - val_loss: 1.1534 - val_accuracy: 0.5120
Epoch 142/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1764 - accuracy:
0.5199 - val_loss: 1.1528 - val_accuracy: 0.5111
Epoch 143/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1784 - accuracy:
0.5224 - val_loss: 1.1525 - val_accuracy: 0.5117
Epoch 144/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1771 - accuracy:
0.5191 - val_loss: 1.1519 - val_accuracy: 0.5111
Epoch 145/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1771 - accuracy:
0.5221 - val_loss: 1.1517 - val_accuracy: 0.5128
Epoch 146/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1766 - accuracy:
0.5231 - val_loss: 1.1523 - val_accuracy: 0.5322
Epoch 147/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1755 - accuracy:
0.5355 - val_loss: 1.1505 - val_accuracy: 0.5117
Epoch 148/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1753 - accuracy:
0.5333 - val_loss: 1.1500 - val_accuracy: 0.5264
Epoch 149/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1763 - accuracy:
0.5318 - val_loss: 1.1506 - val_accuracy: 0.5286
Epoch 150/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1711 - accuracy:
0.5359 - val_loss: 1.1494 - val_accuracy: 0.5285
Epoch 151/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1698 - accuracy:
0.5403 - val_loss: 1.1498 - val_accuracy: 0.5317
Epoch 152/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1742 - accuracy:
0.5401 - val_loss: 1.1483 - val_accuracy: 0.5299
Epoch 153/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1751 - accuracy:
0.5352 - val_loss: 1.1482 - val_accuracy: 0.5293
Epoch 154/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1707 - accuracy:
0.5325 - val_loss: 1.1474 - val_accuracy: 0.5299
Epoch 155/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1712 - accuracy:
0.5359 - val_loss: 1.1470 - val_accuracy: 0.5293
Epoch 156/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1700 - accuracy:
0.5343 - val_loss: 1.1491 - val_accuracy: 0.5351
Epoch 157/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1751 - accuracy:
0.5325 - val_loss: 1.1466 - val_accuracy: 0.5291
Epoch 158/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1664 - accuracy:
0.5352 - val_loss: 1.1470 - val_accuracy: 0.5319
Epoch 159/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1667 - accuracy:
0.5353 - val_loss: 1.1456 - val_accuracy: 0.5277
Epoch 160/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1719 - accuracy:
0.5347 - val_loss: 1.1459 - val_accuracy: 0.5316
Epoch 161/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1654 - accuracy:
0.5376 - val_loss: 1.1454 - val_accuracy: 0.5314
Epoch 162/200
```

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225/225 [==============================] - 2s 7ms/step - loss: 1.1740 - accuracy:
0.5317 - val_loss: 1.1443 - val_accuracy: 0.5298
Epoch 163/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1647 - accuracy:
0.5353 - val_loss: 1.1438 - val_accuracy: 0.5319
Epoch 164/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1655 - accuracy:
0.5363 - val_loss: 1.1434 - val_accuracy: 0.5298
Epoch 165/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1684 - accuracy:
0.5359 - val_loss: 1.1430 - val_accuracy: 0.5303
Epoch 166/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1623 - accuracy:
0.5352 - val_loss: 1.1432 - val_accuracy: 0.5338
Epoch 167/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1687 - accuracy:
0.5343 - val_loss: 1.1428 - val_accuracy: 0.5337
Epoch 168/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1660 - accuracy:
0.5356 - val_loss: 1.1424 - val_accuracy: 0.5319
Epoch 169/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1689 - accuracy:
0.5357 - val_loss: 1.1417 - val_accuracy: 0.5306
Epoch 170/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1675 - accuracy:
0.5335 - val_loss: 1.1422 - val_accuracy: 0.5355
Epoch 171/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1628 - accuracy:
0.5374 - val_loss: 1.1412 - val_accuracy: 0.5307
Epoch 172/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1615 - accuracy:
0.5358 - val_loss: 1.1410 - val_accuracy: 0.5324
Epoch 173/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1611 - accuracy:
0.5373 - val_loss: 1.1409 - val_accuracy: 0.5304
Epoch 174/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1620 - accuracy:
0.5364 - val_loss: 1.1411 - val_accuracy: 0.5358
Epoch 175/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1622 - accuracy:
0.5396 - val_loss: 1.1401 - val_accuracy: 0.5314
Epoch 176/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1652 - accuracy:
0.5391 - val_loss: 1.1398 - val_accuracy: 0.5340
Epoch 177/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1580 - accuracy:
0.5364 - val_loss: 1.1393 - val_accuracy: 0.5312
Epoch 178/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1613 - accuracy:
0.5363 - val_loss: 1.1389 - val_accuracy: 0.5335
Epoch 179/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1623 - accuracy:
0.5371 - val_loss: 1.1398 - val_accuracy: 0.5376
Epoch 180/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1597 - accuracy:
0.5356 - val_loss: 1.1386 - val_accuracy: 0.5355
Epoch 181/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1616 - accuracy:
0.5371 - val_loss: 1.1387 - val_accuracy: 0.5371
Epoch 182/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1612 - accuracy:
0.5341 - val_loss: 1.1375 - val_accuracy: 0.5307
Epoch 183/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1610 - accuracy:
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0.5342 - val_loss: 1.1379 - val_accuracy: 0.5369
Epoch 184/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1532 - accuracy:
0.5354 - val_loss: 1.1367 - val_accuracy: 0.5348
Epoch 185/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1578 - accuracy:
0.5385 - val_loss: 1.1369 - val_accuracy: 0.5355
Epoch 186/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1562 - accuracy:
0.5374 - val_loss: 1.1369 - val_accuracy: 0.5361
Epoch 187/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1614 - accuracy:
0.5343 - val_loss: 1.1358 - val_accuracy: 0.5343
Epoch 188/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1560 - accuracy:
0.5365 - val_loss: 1.1355 - val_accuracy: 0.5346
Epoch 189/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1552 - accuracy:
0.5342 - val_loss: 1.1356 - val_accuracy: 0.5333
Epoch 190/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1568 - accuracy:
0.5372 - val_loss: 1.1348 - val_accuracy: 0.5333
Epoch 191/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1527 - accuracy:
0.5327 - val_loss: 1.1351 - val_accuracy: 0.5299
Epoch 192/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1555 - accuracy:
0.5371 - val_loss: 1.1347 - val_accuracy: 0.5381
Epoch 193/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1564 - accuracy:
0.5348 - val_loss: 1.1343 - val_accuracy: 0.5387
Epoch 194/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1571 - accuracy:
0.5361 - val_loss: 1.1334 - val_accuracy: 0.5355
Epoch 195/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1530 - accuracy:
0.5371 - val_loss: 1.1331 - val_accuracy: 0.5364
Epoch 196/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1513 - accuracy:
0.5380 - val_loss: 1.1331 - val_accuracy: 0.5372
Epoch 197/200
225/225 [==============================] - 1s 7ms/step - loss: 1.1515 - accuracy:
0.5390 - val_loss: 1.1333 - val_accuracy: 0.5381
Epoch 198/200
225/225 [==============================] - 2s 9ms/step - loss: 1.1535 - accuracy:
0.5396 - val_loss: 1.1327 - val_accuracy: 0.5368
Epoch 199/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1491 - accuracy:
0.5356 - val_loss: 1.1327 - val_accuracy: 0.5311
Epoch 200/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1536 - accuracy:
0.5380 - val_loss: 1.1321 - val_accuracy: 0.5355
Model training is finished at 1656232930.0340176 & it took 304.0 sec
```

In [136…

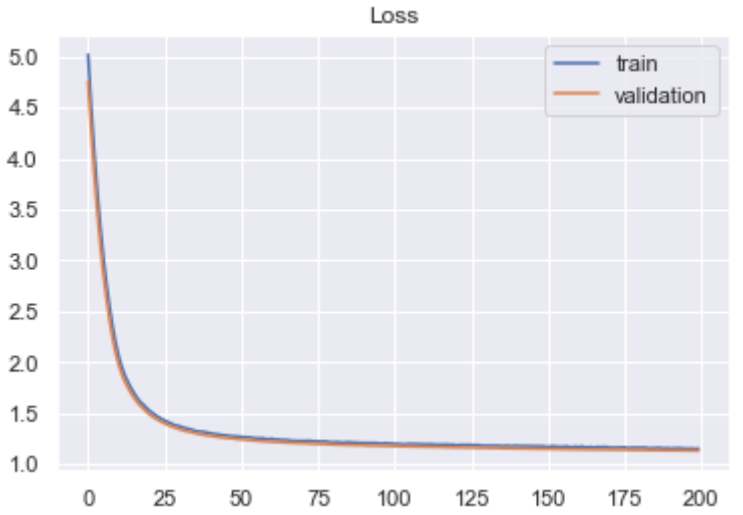
```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
plt.title(f'Accuracy')
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()
```

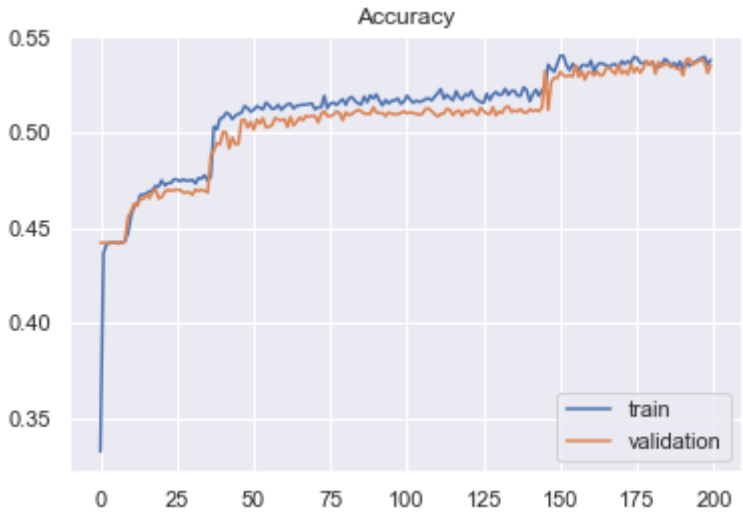
```
### Model Evaluation

Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")
Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [NN
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat

testLoss, testAccuracy = NN_model.evaluate(X_test, y_test)

y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```





```
Final training loss : 1.15363347530365
Final training accuracy:  0.5380324721336365
Final validation loss : 1.1320735216140747
Final validation accuracy : 0.5354586839675903
193/193 [==============================] - 1s 3ms/step - loss: 1.1321 - accuracy:
0.5355
Confusion matrix:
[[ 315   53    0   52    6]
 [ 216  115    0  170   37]
 [  81   67    0  324  183]
 [  26   57    0  492 1237]
 [  11   16    0  320 2370]]
Classification Report:
              precision    recall  f1-score   support

           0       0.49      0.74      0.59       426
           1       0.37      0.21      0.27       538
           2       0.00      0.00      0.00       655
           3       0.36      0.27      0.31      1812
           4       0.62      0.87      0.72      2717

    accuracy                           0.54      6148
   macro avg       0.37      0.42      0.38      6148
weighted avg       0.45      0.54      0.48      6148
```

Obseravation: Significant improvements in validation. There is not much improvement in accuracy. Also the Rating "3" is showing 0 which is an issue with the model.

Model Iteration #5

Decreasing Dropout value. Adding one more layer.

In [132…

```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(128,activation='relu', kernel_regularizer=regularizers.l1(0.001
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.5))
NN_model.add(Dense(64,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.5))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(16,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))

# The Output Layer :
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())

### Model Compilation

adam=Adam(learning_rate=0.00005)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a
```

```
### Model Training

start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validati
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model: "sequential_2"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_15 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_16 (Dense)             (None, 256)               33024
_________________________________________________________________
dense_17 (Dense)             (None, 128)               32896
_________________________________________________________________
dropout_2 (Dropout)          (None, 128)               0
_________________________________________________________________
dense_18 (Dense)             (None, 64)                8256
_________________________________________________________________
dropout_3 (Dropout)          (None, 64)                0
_________________________________________________________________
dense_19 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_20 (Dense)             (None, 32)                1056
_________________________________________________________________
dense_21 (Dense)             (None, 16)                528
_________________________________________________________________
dense_22 (Dense)             (None, 5)                 85
=================================================================
Total params: 94,437
Trainable params: 94,437
Non-trainable params: 0
_________________________________________________________________
None
Model training is started at 1656230719.211413
Epoch 1/200
225/225 [==============================] - 2s 9ms/step - loss: 6.4969 - accuracy:
0.3939 - val_loss: 6.0349 - val_accuracy: 0.4419
Epoch 2/200
225/225 [==============================] - 2s 8ms/step - loss: 5.6644 - accuracy:
0.4417 - val_loss: 5.2628 - val_accuracy: 0.4419
Epoch 3/200
225/225 [==============================] - 2s 8ms/step - loss: 4.9317 - accuracy:
0.4418 - val_loss: 4.5729 - val_accuracy: 0.4419
Epoch 4/200
225/225 [==============================] - 2s 8ms/step - loss: 4.3060 - accuracy:
0.4420 - val_loss: 4.0016 - val_accuracy: 0.4427
Epoch 5/200
225/225 [==============================] - 2s 8ms/step - loss: 3.7686 - accuracy:
0.4462 - val_loss: 3.5045 - val_accuracy: 0.4523
Epoch 6/200
225/225 [==============================] - 2s 8ms/step - loss: 3.3069 - accuracy:
0.4523 - val_loss: 3.0704 - val_accuracy: 0.4533
Epoch 7/200
225/225 [==============================] - 2s 8ms/step - loss: 2.8999 - accuracy:
0.4587 - val_loss: 2.6969 - val_accuracy: 0.4584
Epoch 8/200
225/225 [==============================] - 2s 8ms/step - loss: 2.5561 - accuracy:
0.4599 - val_loss: 2.3844 - val_accuracy: 0.4613
Epoch 9/200
225/225 [==============================] - 2s 8ms/step - loss: 2.2698 - accuracy:
0.4693 - val_loss: 2.1284 - val_accuracy: 0.4858
Epoch 10/200
225/225 [==============================] - 2s 8ms/step - loss: 2.0440 - accuracy:
0.4871 - val_loss: 1.9327 - val_accuracy: 0.4927
Epoch 11/200
225/225 [==============================] - 2s 8ms/step - loss: 1.8781 - accuracy:
0.4960 - val_loss: 1.7968 - val_accuracy: 0.4938
Epoch 12/200
```

```
225/225 [==============================] - 2s 8ms/step - loss: 1.7668 - accuracy:
0.5000 - val_loss: 1.7098 - val_accuracy: 0.4972
Epoch 13/200
225/225 [==============================] - 2s 8ms/step - loss: 1.6877 - accuracy:
0.5004 - val_loss: 1.6374 - val_accuracy: 0.4933
Epoch 14/200
225/225 [==============================] - 2s 8ms/step - loss: 1.6233 - accuracy:
0.5033 - val_loss: 1.5808 - val_accuracy: 0.4998
Epoch 15/200
225/225 [==============================] - 2s 8ms/step - loss: 1.5711 - accuracy:
0.5036 - val_loss: 1.5327 - val_accuracy: 0.4980
Epoch 16/200
225/225 [==============================] - 2s 8ms/step - loss: 1.5312 - accuracy:
0.5041 - val_loss: 1.4962 - val_accuracy: 0.5039
Epoch 17/200
225/225 [==============================] - 2s 8ms/step - loss: 1.4953 - accuracy:
0.5037 - val_loss: 1.4638 - val_accuracy: 0.5036
Epoch 18/200
225/225 [==============================] - 2s 8ms/step - loss: 1.4666 - accuracy:
0.5057 - val_loss: 1.4379 - val_accuracy: 0.5065
Epoch 19/200
225/225 [==============================] - 2s 8ms/step - loss: 1.4415 - accuracy:
0.5071 - val_loss: 1.4151 - val_accuracy: 0.5073
Epoch 20/200
225/225 [==============================] - 2s 8ms/step - loss: 1.4186 - accuracy:
0.5098 - val_loss: 1.3908 - val_accuracy: 0.5024
Epoch 21/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3995 - accuracy:
0.5098 - val_loss: 1.3719 - val_accuracy: 0.5046
Epoch 22/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3828 - accuracy:
0.5085 - val_loss: 1.3556 - val_accuracy: 0.5054
Epoch 23/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3646 - accuracy:
0.5104 - val_loss: 1.3408 - val_accuracy: 0.5054
Epoch 24/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3506 - accuracy:
0.5095 - val_loss: 1.3278 - val_accuracy: 0.5086
Epoch 25/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3348 - accuracy:
0.5087 - val_loss: 1.3181 - val_accuracy: 0.5102
Epoch 26/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3262 - accuracy:
0.5121 - val_loss: 1.3048 - val_accuracy: 0.5078
Epoch 27/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3172 - accuracy:
0.5117 - val_loss: 1.2951 - val_accuracy: 0.5081
Epoch 28/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3082 - accuracy:
0.5122 - val_loss: 1.2860 - val_accuracy: 0.5068
Epoch 29/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2977 - accuracy:
0.5138 - val_loss: 1.2782 - val_accuracy: 0.5094
Epoch 30/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2924 - accuracy:
0.5133 - val_loss: 1.2718 - val_accuracy: 0.5101
Epoch 31/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2829 - accuracy:
0.5145 - val_loss: 1.2641 - val_accuracy: 0.5093
Epoch 32/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2747 - accuracy:
0.5184 - val_loss: 1.2590 - val_accuracy: 0.5070
Epoch 33/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2738 - accuracy:
```

```
0.5137 - val_loss: 1.2520 - val_accuracy: 0.5096
Epoch 34/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2679 - accuracy:
0.5119 - val_loss: 1.2476 - val_accuracy: 0.5114
Epoch 35/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2623 - accuracy:
0.5132 - val_loss: 1.2427 - val_accuracy: 0.5106
Epoch 36/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2573 - accuracy:
0.5159 - val_loss: 1.2371 - val_accuracy: 0.5104
Epoch 37/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2532 - accuracy:
0.5157 - val_loss: 1.2329 - val_accuracy: 0.5107
Epoch 38/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2474 - accuracy:
0.5172 - val_loss: 1.2287 - val_accuracy: 0.5109
Epoch 39/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2423 - accuracy:
0.5145 - val_loss: 1.2248 - val_accuracy: 0.5124
Epoch 40/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2416 - accuracy:
0.5169 - val_loss: 1.2211 - val_accuracy: 0.5104
Epoch 41/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2359 - accuracy:
0.5174 - val_loss: 1.2182 - val_accuracy: 0.5138
Epoch 42/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2358 - accuracy:
0.5138 - val_loss: 1.2157 - val_accuracy: 0.5137
Epoch 43/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2313 - accuracy:
0.5140 - val_loss: 1.2131 - val_accuracy: 0.5094
Epoch 44/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2235 - accuracy:
0.5154 - val_loss: 1.2089 - val_accuracy: 0.5135
Epoch 45/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2250 - accuracy:
0.5159 - val_loss: 1.2073 - val_accuracy: 0.5102
Epoch 46/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2198 - accuracy:
0.5182 - val_loss: 1.2056 - val_accuracy: 0.5094
Epoch 47/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2225 - accuracy:
0.5160 - val_loss: 1.2039 - val_accuracy: 0.5158
Epoch 48/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2174 - accuracy:
0.5187 - val_loss: 1.2024 - val_accuracy: 0.5176
Epoch 49/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2161 - accuracy:
0.5186 - val_loss: 1.1966 - val_accuracy: 0.5132
Epoch 50/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2148 - accuracy:
0.5184 - val_loss: 1.1945 - val_accuracy: 0.5138
Epoch 51/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2093 - accuracy:
0.5189 - val_loss: 1.1925 - val_accuracy: 0.5137
Epoch 52/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2063 - accuracy:
0.5201 - val_loss: 1.1906 - val_accuracy: 0.5138
Epoch 53/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2072 - accuracy:
0.5222 - val_loss: 1.1891 - val_accuracy: 0.5143
Epoch 54/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2059 - accuracy:
0.5173 - val_loss: 1.1872 - val_accuracy: 0.5156
```

```
Epoch 55/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2037 - accuracy:
0.5190 - val_loss: 1.1854 - val_accuracy: 0.5135
Epoch 56/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2035 - accuracy:
0.5171 - val_loss: 1.1838 - val_accuracy: 0.5142
Epoch 57/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2014 - accuracy:
0.5187 - val_loss: 1.1823 - val_accuracy: 0.5138
Epoch 58/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1987 - accuracy:
0.5212 - val_loss: 1.1817 - val_accuracy: 0.5189
Epoch 59/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1968 - accuracy:
0.5181 - val_loss: 1.1791 - val_accuracy: 0.5143
Epoch 60/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1963 - accuracy:
0.5202 - val_loss: 1.1777 - val_accuracy: 0.5143
Epoch 61/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1940 - accuracy:
0.5217 - val_loss: 1.1765 - val_accuracy: 0.5155
Epoch 62/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1906 - accuracy:
0.5170 - val_loss: 1.1750 - val_accuracy: 0.5158
Epoch 63/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1901 - accuracy:
0.5211 - val_loss: 1.1734 - val_accuracy: 0.5153
Epoch 64/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1928 - accuracy:
0.5167 - val_loss: 1.1722 - val_accuracy: 0.5153
Epoch 65/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1860 - accuracy:
0.5220 - val_loss: 1.1706 - val_accuracy: 0.5161
Epoch 66/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1895 - accuracy:
0.5200 - val_loss: 1.1698 - val_accuracy: 0.5171
Epoch 67/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1841 - accuracy:
0.5212 - val_loss: 1.1690 - val_accuracy: 0.5155
Epoch 68/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1844 - accuracy:
0.5219 - val_loss: 1.1674 - val_accuracy: 0.5168
Epoch 69/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1845 - accuracy:
0.5197 - val_loss: 1.1663 - val_accuracy: 0.5174
Epoch 70/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1782 - accuracy:
0.5214 - val_loss: 1.1649 - val_accuracy: 0.5190
Epoch 71/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1798 - accuracy:
0.5239 - val_loss: 1.1640 - val_accuracy: 0.5187
Epoch 72/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1793 - accuracy:
0.5170 - val_loss: 1.1638 - val_accuracy: 0.5174
Epoch 73/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1749 - accuracy:
0.5216 - val_loss: 1.1620 - val_accuracy: 0.5174
Epoch 74/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1761 - accuracy:
0.5214 - val_loss: 1.1607 - val_accuracy: 0.5221
Epoch 75/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1761 - accuracy:
0.5230 - val_loss: 1.1596 - val_accuracy: 0.5220
Epoch 76/200
```

```
225/225 [==============================] - 2s 7ms/step - loss: 1.1761 - accuracy:
0.5222 - val_loss: 1.1589 - val_accuracy: 0.5233
Epoch 77/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1725 - accuracy:
0.5269 - val_loss: 1.1574 - val_accuracy: 0.5207
Epoch 78/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1731 - accuracy:
0.5218 - val_loss: 1.1566 - val_accuracy: 0.5197
Epoch 79/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1679 - accuracy:
0.5223 - val_loss: 1.1558 - val_accuracy: 0.5236
Epoch 80/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1702 - accuracy:
0.5212 - val_loss: 1.1550 - val_accuracy: 0.5192
Epoch 81/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1689 - accuracy:
0.5260 - val_loss: 1.1535 - val_accuracy: 0.5223
Epoch 82/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1669 - accuracy:
0.5240 - val_loss: 1.1527 - val_accuracy: 0.5215
Epoch 83/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1650 - accuracy:
0.5228 - val_loss: 1.1517 - val_accuracy: 0.5210
Epoch 84/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1642 - accuracy:
0.5254 - val_loss: 1.1511 - val_accuracy: 0.5246
Epoch 85/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1617 - accuracy:
0.5239 - val_loss: 1.1502 - val_accuracy: 0.5224
Epoch 86/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1638 - accuracy:
0.5242 - val_loss: 1.1497 - val_accuracy: 0.5221
Epoch 87/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1591 - accuracy:
0.5239 - val_loss: 1.1485 - val_accuracy: 0.5259
Epoch 88/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1598 - accuracy:
0.5235 - val_loss: 1.1477 - val_accuracy: 0.5272
Epoch 89/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1630 - accuracy:
0.5272 - val_loss: 1.1475 - val_accuracy: 0.5281
Epoch 90/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1594 - accuracy:
0.5261 - val_loss: 1.1487 - val_accuracy: 0.5283
Epoch 91/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1568 - accuracy:
0.5274 - val_loss: 1.1464 - val_accuracy: 0.5231
Epoch 92/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1575 - accuracy:
0.5251 - val_loss: 1.1449 - val_accuracy: 0.5220
Epoch 93/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1559 - accuracy:
0.5252 - val_loss: 1.1447 - val_accuracy: 0.5223
Epoch 94/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1574 - accuracy:
0.5252 - val_loss: 1.1441 - val_accuracy: 0.5267
Epoch 95/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1588 - accuracy:
0.5239 - val_loss: 1.1435 - val_accuracy: 0.5275
Epoch 96/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1517 - accuracy:
0.5253 - val_loss: 1.1430 - val_accuracy: 0.5273
Epoch 97/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1503 - accuracy:
```

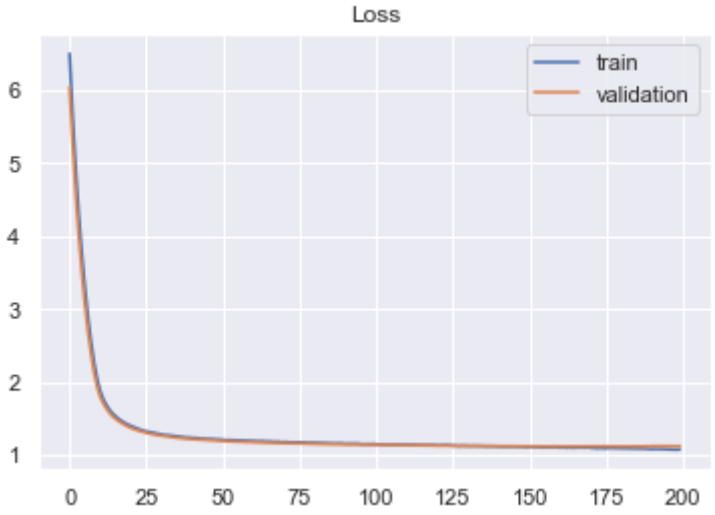
```
0.5302 - val_loss: 1.1427 - val_accuracy: 0.5224
Epoch 98/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1522 - accuracy:
0.5260 - val_loss: 1.1411 - val_accuracy: 0.5257
Epoch 99/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1507 - accuracy:
0.5262 - val_loss: 1.1407 - val_accuracy: 0.5272
Epoch 100/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1541 - accuracy:
0.5286 - val_loss: 1.1403 - val_accuracy: 0.5270
Epoch 101/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1487 - accuracy:
0.5257 - val_loss: 1.1398 - val_accuracy: 0.5247
Epoch 102/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1486 - accuracy:
0.5265 - val_loss: 1.1400 - val_accuracy: 0.5231
Epoch 103/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1482 - accuracy:
0.5280 - val_loss: 1.1389 - val_accuracy: 0.5247
Epoch 104/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1445 - accuracy:
0.5295 - val_loss: 1.1385 - val_accuracy: 0.5262
Epoch 105/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1451 - accuracy:
0.5269 - val_loss: 1.1380 - val_accuracy: 0.5234
Epoch 106/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1457 - accuracy:
0.5269 - val_loss: 1.1377 - val_accuracy: 0.5250
Epoch 107/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1450 - accuracy:
0.5414 - val_loss: 1.1370 - val_accuracy: 0.5449
Epoch 108/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1460 - accuracy:
0.5420 - val_loss: 1.1363 - val_accuracy: 0.5446
Epoch 109/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1450 - accuracy:
0.5461 - val_loss: 1.1356 - val_accuracy: 0.5441
Epoch 110/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1438 - accuracy:
0.5428 - val_loss: 1.1370 - val_accuracy: 0.5423
Epoch 111/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1432 - accuracy:
0.5449 - val_loss: 1.1349 - val_accuracy: 0.5438
Epoch 112/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1407 - accuracy:
0.5442 - val_loss: 1.1344 - val_accuracy: 0.5438
Epoch 113/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1415 - accuracy:
0.5495 - val_loss: 1.1340 - val_accuracy: 0.5454
Epoch 114/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1406 - accuracy:
0.5444 - val_loss: 1.1331 - val_accuracy: 0.5438
Epoch 115/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1394 - accuracy:
0.5454 - val_loss: 1.1335 - val_accuracy: 0.5457
Epoch 116/200
225/225 [==============================] - 2s 9ms/step - loss: 1.1384 - accuracy:
0.5417 - val_loss: 1.1338 - val_accuracy: 0.5420
Epoch 117/200
225/225 [==============================] - 2s 9ms/step - loss: 1.1376 - accuracy:
0.5460 - val_loss: 1.1322 - val_accuracy: 0.5446
Epoch 118/200
225/225 [==============================] - 2s 9ms/step - loss: 1.1373 - accuracy:
0.5385 - val_loss: 1.1320 - val_accuracy: 0.5423
```

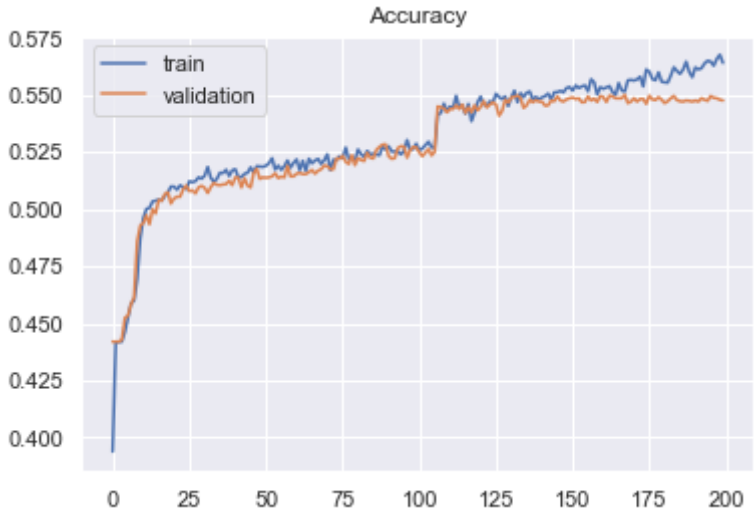
```
Epoch 119/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1360 - accuracy:
0.5421 - val_loss: 1.1313 - val_accuracy: 0.5454
Epoch 120/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1365 - accuracy:
0.5467 - val_loss: 1.1306 - val_accuracy: 0.5431
Epoch 121/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1328 - accuracy:
0.5492 - val_loss: 1.1301 - val_accuracy: 0.5447
Epoch 122/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1346 - accuracy:
0.5457 - val_loss: 1.1299 - val_accuracy: 0.5472
Epoch 123/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1347 - accuracy:
0.5453 - val_loss: 1.1295 - val_accuracy: 0.5444
Epoch 124/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1384 - accuracy:
0.5471 - val_loss: 1.1296 - val_accuracy: 0.5457
Epoch 125/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1338 - accuracy:
0.5466 - val_loss: 1.1290 - val_accuracy: 0.5467
Epoch 126/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1298 - accuracy:
0.5504 - val_loss: 1.1285 - val_accuracy: 0.5457
Epoch 127/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1294 - accuracy:
0.5490 - val_loss: 1.1299 - val_accuracy: 0.5408
Epoch 128/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1237 - accuracy:
0.5481 - val_loss: 1.1279 - val_accuracy: 0.5429
Epoch 129/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1296 - accuracy:
0.5493 - val_loss: 1.1270 - val_accuracy: 0.5478
Epoch 130/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1279 - accuracy:
0.5451 - val_loss: 1.1267 - val_accuracy: 0.5465
Epoch 131/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1290 - accuracy:
0.5490 - val_loss: 1.1264 - val_accuracy: 0.5488
Epoch 132/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1255 - accuracy:
0.5518 - val_loss: 1.1260 - val_accuracy: 0.5491
Epoch 133/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1282 - accuracy:
0.5467 - val_loss: 1.1259 - val_accuracy: 0.5496
Epoch 134/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1244 - accuracy:
0.5507 - val_loss: 1.1252 - val_accuracy: 0.5486
Epoch 135/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1263 - accuracy:
0.5490 - val_loss: 1.1254 - val_accuracy: 0.5442
Epoch 136/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1228 - accuracy:
0.5509 - val_loss: 1.1252 - val_accuracy: 0.5454
Epoch 137/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1218 - accuracy:
0.5514 - val_loss: 1.1262 - val_accuracy: 0.5478
Epoch 138/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1241 - accuracy:
0.5479 - val_loss: 1.1249 - val_accuracy: 0.5467
Epoch 139/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1225 - accuracy:
0.5490 - val_loss: 1.1236 - val_accuracy: 0.5477
Epoch 140/200
```

```
225/225 [==============================] - 2s 8ms/step - loss: 1.1206 - accuracy:
0.5481 - val_loss: 1.1235 - val_accuracy: 0.5470
Epoch 141/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1195 - accuracy:
0.5488 - val_loss: 1.1236 - val_accuracy: 0.5470
Epoch 142/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1202 - accuracy:
0.5494 - val_loss: 1.1243 - val_accuracy: 0.5452
Epoch 143/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1168 - accuracy:
0.5505 - val_loss: 1.1237 - val_accuracy: 0.5454
Epoch 144/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1182 - accuracy:
0.5479 - val_loss: 1.1233 - val_accuracy: 0.5475
Epoch 145/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1194 - accuracy:
0.5511 - val_loss: 1.1222 - val_accuracy: 0.5472
Epoch 146/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1192 - accuracy:
0.5511 - val_loss: 1.1230 - val_accuracy: 0.5493
Epoch 147/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1160 - accuracy:
0.5517 - val_loss: 1.1223 - val_accuracy: 0.5475
Epoch 148/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1145 - accuracy:
0.5511 - val_loss: 1.1216 - val_accuracy: 0.5470
Epoch 149/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1167 - accuracy:
0.5530 - val_loss: 1.1216 - val_accuracy: 0.5480
Epoch 150/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1089 - accuracy:
0.5534 - val_loss: 1.1221 - val_accuracy: 0.5485
Epoch 151/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1171 - accuracy:
0.5518 - val_loss: 1.1215 - val_accuracy: 0.5488
Epoch 152/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1123 - accuracy:
0.5541 - val_loss: 1.1208 - val_accuracy: 0.5481
Epoch 153/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1123 - accuracy:
0.5530 - val_loss: 1.1204 - val_accuracy: 0.5485
Epoch 154/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1090 - accuracy:
0.5536 - val_loss: 1.1211 - val_accuracy: 0.5467
Epoch 155/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1086 - accuracy:
0.5541 - val_loss: 1.1208 - val_accuracy: 0.5468
Epoch 156/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1066 - accuracy:
0.5516 - val_loss: 1.1215 - val_accuracy: 0.5493
Epoch 157/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1097 - accuracy:
0.5568 - val_loss: 1.1205 - val_accuracy: 0.5475
Epoch 158/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1081 - accuracy:
0.5555 - val_loss: 1.1200 - val_accuracy: 0.5483
Epoch 159/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1102 - accuracy:
0.5502 - val_loss: 1.1221 - val_accuracy: 0.5468
Epoch 160/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1074 - accuracy:
0.5533 - val_loss: 1.1204 - val_accuracy: 0.5494
Epoch 161/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1041 - accuracy:
```

```
0.5526 - val_loss: 1.1197 - val_accuracy: 0.5490
Epoch 162/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1076 - accuracy:
0.5532 - val_loss: 1.1200 - val_accuracy: 0.5468
Epoch 163/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1015 - accuracy:
0.5538 - val_loss: 1.1196 - val_accuracy: 0.5496
Epoch 164/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1070 - accuracy:
0.5513 - val_loss: 1.1197 - val_accuracy: 0.5493
Epoch 165/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1014 - accuracy:
0.5500 - val_loss: 1.1201 - val_accuracy: 0.5485
Epoch 166/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1036 - accuracy:
0.5551 - val_loss: 1.1201 - val_accuracy: 0.5485
Epoch 167/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1057 - accuracy:
0.5518 - val_loss: 1.1195 - val_accuracy: 0.5485
Epoch 168/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1041 - accuracy:
0.5515 - val_loss: 1.1204 - val_accuracy: 0.5499
Epoch 169/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1042 - accuracy:
0.5563 - val_loss: 1.1195 - val_accuracy: 0.5464
Epoch 170/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1074 - accuracy:
0.5565 - val_loss: 1.1199 - val_accuracy: 0.5470
Epoch 171/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1002 - accuracy:
0.5562 - val_loss: 1.1201 - val_accuracy: 0.5485
Epoch 172/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0992 - accuracy:
0.5567 - val_loss: 1.1216 - val_accuracy: 0.5470
Epoch 173/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0930 - accuracy:
0.5579 - val_loss: 1.1219 - val_accuracy: 0.5481
Epoch 174/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0977 - accuracy:
0.5536 - val_loss: 1.1196 - val_accuracy: 0.5481
Epoch 175/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0933 - accuracy:
0.5610 - val_loss: 1.1226 - val_accuracy: 0.5460
Epoch 176/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0934 - accuracy:
0.5601 - val_loss: 1.1206 - val_accuracy: 0.5496
Epoch 177/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0973 - accuracy:
0.5569 - val_loss: 1.1211 - val_accuracy: 0.5480
Epoch 178/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0966 - accuracy:
0.5564 - val_loss: 1.1198 - val_accuracy: 0.5477
Epoch 179/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0954 - accuracy:
0.5598 - val_loss: 1.1203 - val_accuracy: 0.5490
Epoch 180/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0932 - accuracy:
0.5557 - val_loss: 1.1196 - val_accuracy: 0.5478
Epoch 181/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0938 - accuracy:
0.5555 - val_loss: 1.1196 - val_accuracy: 0.5464
Epoch 182/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0915 - accuracy:
0.5553 - val_loss: 1.1214 - val_accuracy: 0.5472
```

```
Epoch 183/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0929 - accuracy:
0.5584 - val_loss: 1.1207 - val_accuracy: 0.5485
Epoch 184/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0919 - accuracy:
0.5620 - val_loss: 1.1207 - val_accuracy: 0.5494
Epoch 185/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0916 - accuracy:
0.5604 - val_loss: 1.1210 - val_accuracy: 0.5477
Epoch 186/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0920 - accuracy:
0.5592 - val_loss: 1.1211 - val_accuracy: 0.5472
Epoch 187/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0899 - accuracy:
0.5610 - val_loss: 1.1206 - val_accuracy: 0.5470
Epoch 188/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0867 - accuracy:
0.5645 - val_loss: 1.1219 - val_accuracy: 0.5475
Epoch 189/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0888 - accuracy:
0.5601 - val_loss: 1.1220 - val_accuracy: 0.5473
Epoch 190/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0834 - accuracy:
0.5577 - val_loss: 1.1214 - val_accuracy: 0.5470
Epoch 191/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0824 - accuracy:
0.5619 - val_loss: 1.1242 - val_accuracy: 0.5475
Epoch 192/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0850 - accuracy:
0.5611 - val_loss: 1.1236 - val_accuracy: 0.5470
Epoch 193/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0830 - accuracy:
0.5616 - val_loss: 1.1237 - val_accuracy: 0.5485
Epoch 194/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0837 - accuracy:
0.5637 - val_loss: 1.1220 - val_accuracy: 0.5478
Epoch 195/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0823 - accuracy:
0.5649 - val_loss: 1.1221 - val_accuracy: 0.5473
Epoch 196/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0832 - accuracy:
0.5645 - val_loss: 1.1230 - val_accuracy: 0.5494
Epoch 197/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0811 - accuracy:
0.5627 - val_loss: 1.1234 - val_accuracy: 0.5486
Epoch 198/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0785 - accuracy:
0.5657 - val_loss: 1.1242 - val_accuracy: 0.5485
Epoch 199/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0750 - accuracy:
0.5675 - val_loss: 1.1258 - val_accuracy: 0.5478
Epoch 200/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0815 - accuracy:
0.5640 - val_loss: 1.1237 - val_accuracy: 0.5475
Model training is finished at 1656231067.0063891 & it took 348.0 sec
```






```
Final training loss : 1.0814673900604248
Final training accuracy:  0.5639684796333313
Final validation loss : 1.1236680746078491
Final validation accuracy : 0.5474951267242432
193/193 [==============================] - 1s 3ms/step - loss: 1.1237 - accuracy:
0.5475
Confusion matrix:
[[ 315   62    2   43    4]
 [ 213  127    2  174   22]
 [  72   98    2  374  109]
 [  24   66    5  754  963]
 [  14   30    2  503 2168]]
Classification Report:
              precision    recall  f1-score   support

           0       0.49      0.74      0.59       426
           1       0.33      0.24      0.28       538
           2       0.15      0.00      0.01       655
           3       0.41      0.42      0.41      1812
           4       0.66      0.80      0.72      2717

    accuracy                           0.55      6148
   macro avg       0.41      0.44      0.40      6148
weighted avg       0.49      0.55      0.51      6148
```

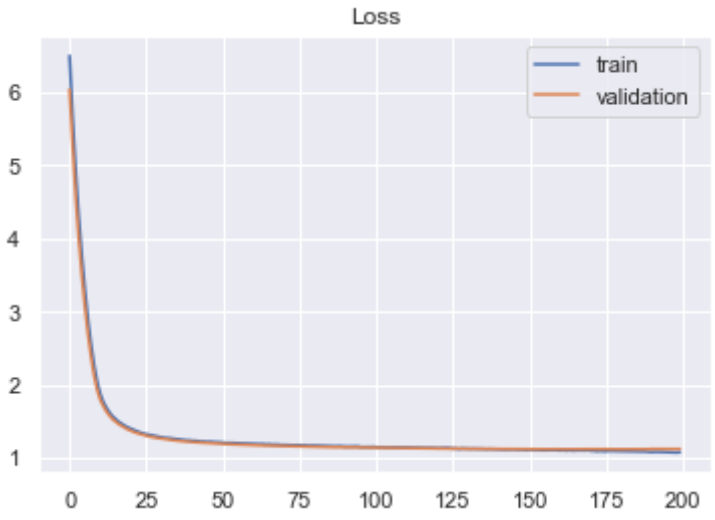
In [133…

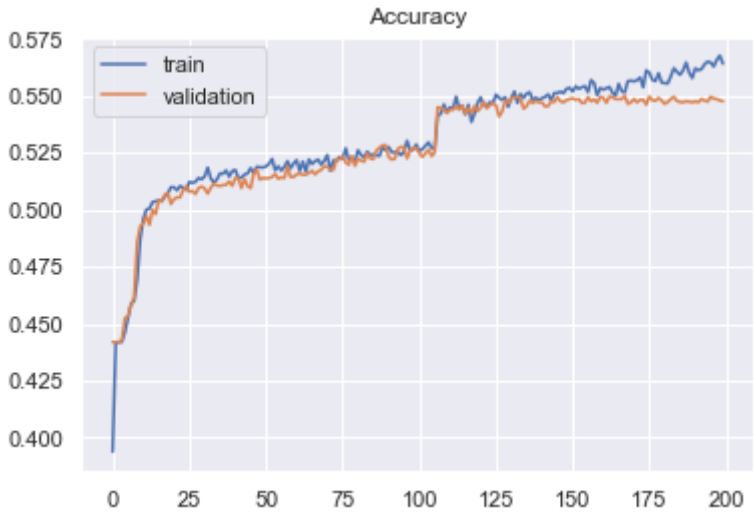
```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
```

```
plt.title(f'Accuracy')
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()

### Model Evaluation

Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")
```






```
Final training loss : 1.0814673900604248
Final training accuracy:  0.5639684796333313
Final validation loss : 1.1236680746078491
Final validation accuracy : 0.5474951267242432
```

In [134…

```
Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [NI
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat

testLoss, testAccuracy = NN_model.evaluate(X_test, y_test)

y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
```

```
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```

```
193/193 [==============================] - 0s 3ms/step - loss: 1.1237 - accuracy:
0.5475
Confusion matrix:
[[ 315   62    2   43    4]
 [ 213  127    2  174   22]
 [  72   98    2  374  109]
 [  24   66    5  754  963]
 [  14   30    2  503 2168]]
Classification Report:
              precision    recall  f1-score   support

           0       0.49      0.74      0.59       426
           1       0.33      0.24      0.28       538
           2       0.15      0.00      0.01       655
           3       0.41      0.42      0.41      1812
           4       0.66      0.80      0.72      2717

    accuracy                           0.55      6148
   macro avg       0.41      0.44      0.40      6148
weighted avg       0.49      0.55      0.51      6148
```

Observation: This iteration improves the accuracy marginally. F1 score for rating '5' is good. However rating '3' is an issue.

Model Iteration #6

Removing one dropout layer. Reducing the learning rate marginally.

In [146…

```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.6))
NN_model.add(Dense(128,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(64,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(16,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))

# The Output Layer :
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())

### Model Compilation

adam=Adam(learning_rate=0.00004)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a
```

```
### Model Training

start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validatio
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model: "sequential_6"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_44 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_45 (Dense)             (None, 256)               33024
_________________________________________________________________
dropout_8 (Dropout)          (None, 256)               0
_________________________________________________________________
dense_46 (Dense)             (None, 128)               32896
_________________________________________________________________
dense_47 (Dense)             (None, 64)                8256
_________________________________________________________________
dense_48 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_49 (Dense)             (None, 32)                1056
_________________________________________________________________
dense_50 (Dense)             (None, 16)                528
_________________________________________________________________
dense_51 (Dense)             (None, 5)                 85
=================================================================
Total params: 94,437
Trainable params: 94,437
Non-trainable params: 0
_________________________________________________________________
None
Model training is started at 1656233793.266507
Epoch 1/200
225/225 [==============================] - 1s 6ms/step - loss: 6.5962 - accuracy:
0.2927 - val_loss: 6.2333 - val_accuracy: 0.2947
Epoch 2/200
225/225 [==============================] - 1s 6ms/step - loss: 5.8971 - accuracy:
0.2947 - val_loss: 5.5540 - val_accuracy: 0.2947
Epoch 3/200
225/225 [==============================] - 1s 6ms/step - loss: 5.2536 - accuracy:
0.3387 - val_loss: 4.9347 - val_accuracy: 0.4419
Epoch 4/200
225/225 [==============================] - 1s 5ms/step - loss: 4.6574 - accuracy:
0.4418 - val_loss: 4.3629 - val_accuracy: 0.4419
Epoch 5/200
225/225 [==============================] - 1s 5ms/step - loss: 4.1288 - accuracy:
0.4418 - val_loss: 3.8786 - val_accuracy: 0.4419
Epoch 6/200
225/225 [==============================] - 1s 5ms/step - loss: 3.6794 - accuracy:
0.4418 - val_loss: 3.4587 - val_accuracy: 0.4419
Epoch 7/200
225/225 [==============================] - 1s 5ms/step - loss: 3.2804 - accuracy:
0.4418 - val_loss: 3.0850 - val_accuracy: 0.4419
Epoch 8/200
225/225 [==============================] - 1s 6ms/step - loss: 2.9256 - accuracy:
0.4524 - val_loss: 2.7535 - val_accuracy: 0.4806
Epoch 9/200
225/225 [==============================] - 1s 5ms/step - loss: 2.6152 - accuracy:
0.4747 - val_loss: 2.4654 - val_accuracy: 0.4795
Epoch 10/200
225/225 [==============================] - 1s 5ms/step - loss: 2.3474 - accuracy:
0.4781 - val_loss: 2.2166 - val_accuracy: 0.4839
Epoch 11/200
225/225 [==============================] - 1s 5ms/step - loss: 2.1159 - accuracy:
0.4816 - val_loss: 2.0092 - val_accuracy: 0.4849
Epoch 12/200
225/225 [==============================] - 1s 5ms/step - loss: 1.9305 - accuracy:
0.4839 - val_loss: 1.8432 - val_accuracy: 0.4881
```

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Epoch 13/200
225/225 [==============================] - 1s 6ms/step - loss: 1.7832 - accuracy:
0.4894 - val_loss: 1.7175 - val_accuracy: 0.4855
Epoch 14/200
225/225 [==============================] - 1s 6ms/step - loss: 1.6786 - accuracy:
0.4917 - val_loss: 1.6327 - val_accuracy: 0.4919
Epoch 15/200
225/225 [==============================] - 1s 6ms/step - loss: 1.6070 - accuracy:
0.4947 - val_loss: 1.5740 - val_accuracy: 0.4909
Epoch 16/200
225/225 [==============================] - 1s 6ms/step - loss: 1.5545 - accuracy:
0.4959 - val_loss: 1.5263 - val_accuracy: 0.4966
Epoch 17/200
225/225 [==============================] - 1s 5ms/step - loss: 1.5095 - accuracy:
0.4975 - val_loss: 1.4856 - val_accuracy: 0.4958
Epoch 18/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4735 - accuracy:
0.5011 - val_loss: 1.4525 - val_accuracy: 0.5005
Epoch 19/200
225/225 [==============================] - 1s 5ms/step - loss: 1.4440 - accuracy:
0.5037 - val_loss: 1.4252 - val_accuracy: 0.5018
Epoch 20/200
225/225 [==============================] - 1s 6ms/step - loss: 1.4171 - accuracy:
0.5048 - val_loss: 1.4002 - val_accuracy: 0.4972
Epoch 21/200
225/225 [==============================] - 1s 6ms/step - loss: 1.3961 - accuracy:
0.5053 - val_loss: 1.3809 - val_accuracy: 0.4977
Epoch 22/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3787 - accuracy:
0.5058 - val_loss: 1.3634 - val_accuracy: 0.5007
Epoch 23/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3603 - accuracy:
0.5078 - val_loss: 1.3477 - val_accuracy: 0.5036
Epoch 24/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3451 - accuracy:
0.5086 - val_loss: 1.3335 - val_accuracy: 0.5029
Epoch 25/200
225/225 [==============================] - 1s 5ms/step - loss: 1.3336 - accuracy:
0.5121 - val_loss: 1.3223 - val_accuracy: 0.5024
Epoch 26/200
225/225 [==============================] - 1s 6ms/step - loss: 1.3199 - accuracy:
0.5143 - val_loss: 1.3099 - val_accuracy: 0.5034
Epoch 27/200
225/225 [==============================] - 2s 8ms/step - loss: 1.3110 - accuracy:
0.5108 - val_loss: 1.3001 - val_accuracy: 0.5034
Epoch 28/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2996 - accuracy:
0.5108 - val_loss: 1.2910 - val_accuracy: 0.5031
Epoch 29/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2916 - accuracy:
0.5151 - val_loss: 1.2836 - val_accuracy: 0.5037
Epoch 30/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2839 - accuracy:
0.5113 - val_loss: 1.2771 - val_accuracy: 0.5028
Epoch 31/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2771 - accuracy:
0.5150 - val_loss: 1.2700 - val_accuracy: 0.5042
Epoch 32/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2706 - accuracy:
0.5150 - val_loss: 1.2653 - val_accuracy: 0.5034
Epoch 33/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2674 - accuracy:
0.5162 - val_loss: 1.2588 - val_accuracy: 0.5055
Epoch 34/200
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225/225 [==============================] - 2s 8ms/step - loss: 1.2609 - accuracy:
0.5145 - val_loss: 1.2545 - val_accuracy: 0.5059
Epoch 35/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2583 - accuracy:
0.5191 - val_loss: 1.2498 - val_accuracy: 0.5054
Epoch 36/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2510 - accuracy:
0.5146 - val_loss: 1.2453 - val_accuracy: 0.5049
Epoch 37/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2473 - accuracy:
0.5139 - val_loss: 1.2415 - val_accuracy: 0.5065
Epoch 38/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2443 - accuracy:
0.5157 - val_loss: 1.2378 - val_accuracy: 0.5076
Epoch 39/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2412 - accuracy:
0.5156 - val_loss: 1.2343 - val_accuracy: 0.5055
Epoch 40/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2389 - accuracy:
0.5180 - val_loss: 1.2310 - val_accuracy: 0.5076
Epoch 41/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2354 - accuracy:
0.5171 - val_loss: 1.2282 - val_accuracy: 0.5093
Epoch 42/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2321 - accuracy:
0.5186 - val_loss: 1.2252 - val_accuracy: 0.5091
Epoch 43/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2292 - accuracy:
0.5162 - val_loss: 1.2231 - val_accuracy: 0.5075
Epoch 44/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2282 - accuracy:
0.5144 - val_loss: 1.2194 - val_accuracy: 0.5094
Epoch 45/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2242 - accuracy:
0.5165 - val_loss: 1.2179 - val_accuracy: 0.5073
Epoch 46/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2218 - accuracy:
0.5187 - val_loss: 1.2151 - val_accuracy: 0.5094
Epoch 47/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2185 - accuracy:
0.5173 - val_loss: 1.2126 - val_accuracy: 0.5146
Epoch 48/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2149 - accuracy:
0.5170 - val_loss: 1.2112 - val_accuracy: 0.5138
Epoch 49/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2138 - accuracy:
0.5182 - val_loss: 1.2068 - val_accuracy: 0.5107
Epoch 50/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2108 - accuracy:
0.5221 - val_loss: 1.2045 - val_accuracy: 0.5115
Epoch 51/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2078 - accuracy:
0.5193 - val_loss: 1.2026 - val_accuracy: 0.5109
Epoch 52/200
225/225 [==============================] - 2s 7ms/step - loss: 1.2088 - accuracy:
0.5199 - val_loss: 1.2007 - val_accuracy: 0.5153
Epoch 53/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2085 - accuracy:
0.5189 - val_loss: 1.1988 - val_accuracy: 0.5150
Epoch 54/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2032 - accuracy:
0.5155 - val_loss: 1.1969 - val_accuracy: 0.5135
Epoch 55/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2021 - accuracy:
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0.5189 - val_loss: 1.1948 - val_accuracy: 0.5128
Epoch 56/200
225/225 [==============================] - 2s 8ms/step - loss: 1.2002 - accuracy:
0.5212 - val_loss: 1.1930 - val_accuracy: 0.5130
Epoch 57/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1998 - accuracy:
0.5199 - val_loss: 1.1911 - val_accuracy: 0.5138
Epoch 58/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1976 - accuracy:
0.5169 - val_loss: 1.1901 - val_accuracy: 0.5132
Epoch 59/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1920 - accuracy:
0.5230 - val_loss: 1.1876 - val_accuracy: 0.5148
Epoch 60/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1920 - accuracy:
0.5200 - val_loss: 1.1859 - val_accuracy: 0.5142
Epoch 61/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1923 - accuracy:
0.5189 - val_loss: 1.1844 - val_accuracy: 0.5148
Epoch 62/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1905 - accuracy:
0.5207 - val_loss: 1.1828 - val_accuracy: 0.5138
Epoch 63/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1874 - accuracy:
0.5215 - val_loss: 1.1813 - val_accuracy: 0.5146
Epoch 64/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1875 - accuracy:
0.5197 - val_loss: 1.1801 - val_accuracy: 0.5142
Epoch 65/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1857 - accuracy:
0.5198 - val_loss: 1.1784 - val_accuracy: 0.5142
Epoch 66/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1832 - accuracy:
0.5207 - val_loss: 1.1767 - val_accuracy: 0.5140
Epoch 67/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1846 - accuracy:
0.5198 - val_loss: 1.1756 - val_accuracy: 0.5151
Epoch 68/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1824 - accuracy:
0.5179 - val_loss: 1.1740 - val_accuracy: 0.5151
Epoch 69/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1794 - accuracy:
0.5208 - val_loss: 1.1728 - val_accuracy: 0.5138
Epoch 70/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1795 - accuracy:
0.5179 - val_loss: 1.1715 - val_accuracy: 0.5161
Epoch 71/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1754 - accuracy:
0.5212 - val_loss: 1.1703 - val_accuracy: 0.5166
Epoch 72/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1760 - accuracy:
0.5199 - val_loss: 1.1691 - val_accuracy: 0.5138
Epoch 73/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1763 - accuracy:
0.5168 - val_loss: 1.1676 - val_accuracy: 0.5166
Epoch 74/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1719 - accuracy:
0.5194 - val_loss: 1.1664 - val_accuracy: 0.5166
Epoch 75/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1736 - accuracy:
0.5196 - val_loss: 1.1652 - val_accuracy: 0.5158
Epoch 76/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1707 - accuracy:
0.5202 - val_loss: 1.1640 - val_accuracy: 0.5171
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Epoch 77/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1734 - accuracy:
0.5230 - val_loss: 1.1629 - val_accuracy: 0.5164
Epoch 78/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1706 - accuracy:
0.5207 - val_loss: 1.1618 - val_accuracy: 0.5171
Epoch 79/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1665 - accuracy:
0.5233 - val_loss: 1.1608 - val_accuracy: 0.5168
Epoch 80/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1676 - accuracy:
0.5212 - val_loss: 1.1600 - val_accuracy: 0.5155
Epoch 81/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1678 - accuracy:
0.5184 - val_loss: 1.1588 - val_accuracy: 0.5172
Epoch 82/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1659 - accuracy:
0.5210 - val_loss: 1.1576 - val_accuracy: 0.5143
Epoch 83/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1644 - accuracy:
0.5233 - val_loss: 1.1568 - val_accuracy: 0.5179
Epoch 84/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1608 - accuracy:
0.5239 - val_loss: 1.1560 - val_accuracy: 0.5192
Epoch 85/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1648 - accuracy:
0.5230 - val_loss: 1.1549 - val_accuracy: 0.5171
Epoch 86/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1621 - accuracy:
0.5193 - val_loss: 1.1536 - val_accuracy: 0.5161
Epoch 87/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1582 - accuracy:
0.5239 - val_loss: 1.1531 - val_accuracy: 0.5192
Epoch 88/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1604 - accuracy:
0.5227 - val_loss: 1.1526 - val_accuracy: 0.5211
Epoch 89/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1593 - accuracy:
0.5237 - val_loss: 1.1506 - val_accuracy: 0.5197
Epoch 90/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1597 - accuracy:
0.5230 - val_loss: 1.1516 - val_accuracy: 0.5228
Epoch 91/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1591 - accuracy:
0.5207 - val_loss: 1.1487 - val_accuracy: 0.5185
Epoch 92/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1526 - accuracy:
0.5252 - val_loss: 1.1475 - val_accuracy: 0.5187
Epoch 93/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1578 - accuracy:
0.5204 - val_loss: 1.1469 - val_accuracy: 0.5184
Epoch 94/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1548 - accuracy:
0.5221 - val_loss: 1.1461 - val_accuracy: 0.5205
Epoch 95/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1545 - accuracy:
0.5204 - val_loss: 1.1450 - val_accuracy: 0.5198
Epoch 96/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1526 - accuracy:
0.5205 - val_loss: 1.1452 - val_accuracy: 0.5234
Epoch 97/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1490 - accuracy:
0.5245 - val_loss: 1.1435 - val_accuracy: 0.5176
Epoch 98/200
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225/225 [==============================] - 2s 7ms/step - loss: 1.1524 - accuracy:
0.5214 - val_loss: 1.1421 - val_accuracy: 0.5213
Epoch 99/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1489 - accuracy:
0.5230 - val_loss: 1.1420 - val_accuracy: 0.5252
Epoch 100/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1489 - accuracy:
0.5256 - val_loss: 1.1409 - val_accuracy: 0.5237
Epoch 101/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1483 - accuracy:
0.5226 - val_loss: 1.1397 - val_accuracy: 0.5207
Epoch 102/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1471 - accuracy:
0.5232 - val_loss: 1.1391 - val_accuracy: 0.5184
Epoch 103/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1459 - accuracy:
0.5216 - val_loss: 1.1382 - val_accuracy: 0.5198
Epoch 104/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1445 - accuracy:
0.5239 - val_loss: 1.1378 - val_accuracy: 0.5184
Epoch 105/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1424 - accuracy:
0.5262 - val_loss: 1.1369 - val_accuracy: 0.5179
Epoch 106/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1446 - accuracy:
0.5251 - val_loss: 1.1360 - val_accuracy: 0.5213
Epoch 107/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1409 - accuracy:
0.5259 - val_loss: 1.1352 - val_accuracy: 0.5249
Epoch 108/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1414 - accuracy:
0.5279 - val_loss: 1.1346 - val_accuracy: 0.5254
Epoch 109/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1406 - accuracy:
0.5265 - val_loss: 1.1335 - val_accuracy: 0.5244
Epoch 110/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1381 - accuracy:
0.5286 - val_loss: 1.1341 - val_accuracy: 0.5184
Epoch 111/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1412 - accuracy:
0.5268 - val_loss: 1.1321 - val_accuracy: 0.5260
Epoch 112/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1372 - accuracy:
0.5283 - val_loss: 1.1313 - val_accuracy: 0.5237
Epoch 113/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1386 - accuracy:
0.5223 - val_loss: 1.1309 - val_accuracy: 0.5228
Epoch 114/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1364 - accuracy:
0.5297 - val_loss: 1.1303 - val_accuracy: 0.5272
Epoch 115/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1357 - accuracy:
0.5260 - val_loss: 1.1300 - val_accuracy: 0.5288
Epoch 116/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1348 - accuracy:
0.5250 - val_loss: 1.1290 - val_accuracy: 0.5231
Epoch 117/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1338 - accuracy:
0.5273 - val_loss: 1.1280 - val_accuracy: 0.5260
Epoch 118/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1324 - accuracy:
0.5286 - val_loss: 1.1269 - val_accuracy: 0.5259
Epoch 119/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1338 - accuracy:
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0.5227 - val_loss: 1.1266 - val_accuracy: 0.5262
Epoch 120/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1298 - accuracy:
0.5262 - val_loss: 1.1256 - val_accuracy: 0.5260
Epoch 121/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1303 - accuracy:
0.5373 - val_loss: 1.1251 - val_accuracy: 0.5395
Epoch 122/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1303 - accuracy:
0.5442 - val_loss: 1.1246 - val_accuracy: 0.5412
Epoch 123/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1313 - accuracy:
0.5453 - val_loss: 1.1239 - val_accuracy: 0.5412
Epoch 124/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1295 - accuracy:
0.5428 - val_loss: 1.1240 - val_accuracy: 0.5400
Epoch 125/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1299 - accuracy:
0.5462 - val_loss: 1.1231 - val_accuracy: 0.5423
Epoch 126/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1293 - accuracy:
0.5444 - val_loss: 1.1229 - val_accuracy: 0.5416
Epoch 127/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1303 - accuracy:
0.5441 - val_loss: 1.1239 - val_accuracy: 0.5374
Epoch 128/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1263 - accuracy:
0.5483 - val_loss: 1.1217 - val_accuracy: 0.5399
Epoch 129/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1261 - accuracy:
0.5469 - val_loss: 1.1213 - val_accuracy: 0.5442
Epoch 130/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1298 - accuracy:
0.5454 - val_loss: 1.1208 - val_accuracy: 0.5416
Epoch 131/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1248 - accuracy:
0.5455 - val_loss: 1.1198 - val_accuracy: 0.5447
Epoch 132/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1215 - accuracy:
0.5509 - val_loss: 1.1190 - val_accuracy: 0.5439
Epoch 133/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1238 - accuracy:
0.5469 - val_loss: 1.1186 - val_accuracy: 0.5442
Epoch 134/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1218 - accuracy:
0.5471 - val_loss: 1.1181 - val_accuracy: 0.5444
Epoch 135/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1229 - accuracy:
0.5458 - val_loss: 1.1179 - val_accuracy: 0.5428
Epoch 136/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1211 - accuracy:
0.5443 - val_loss: 1.1176 - val_accuracy: 0.5433
Epoch 137/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1225 - accuracy:
0.5463 - val_loss: 1.1173 - val_accuracy: 0.5425
Epoch 138/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1199 - accuracy:
0.5472 - val_loss: 1.1165 - val_accuracy: 0.5457
Epoch 139/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1183 - accuracy:
0.5469 - val_loss: 1.1157 - val_accuracy: 0.5462
Epoch 140/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1204 - accuracy:
0.5458 - val_loss: 1.1155 - val_accuracy: 0.5449
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Epoch 141/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1196 - accuracy:
0.5461 - val_loss: 1.1148 - val_accuracy: 0.5449
Epoch 142/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1186 - accuracy:
0.5490 - val_loss: 1.1145 - val_accuracy: 0.5460
Epoch 143/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1182 - accuracy:
0.5467 - val_loss: 1.1142 - val_accuracy: 0.5452
Epoch 144/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1219 - accuracy:
0.5435 - val_loss: 1.1139 - val_accuracy: 0.5481
Epoch 145/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1163 - accuracy:
0.5476 - val_loss: 1.1135 - val_accuracy: 0.5454
Epoch 146/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1147 - accuracy:
0.5470 - val_loss: 1.1138 - val_accuracy: 0.5462
Epoch 147/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1154 - accuracy:
0.5480 - val_loss: 1.1126 - val_accuracy: 0.5478
Epoch 148/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1164 - accuracy:
0.5435 - val_loss: 1.1121 - val_accuracy: 0.5470
Epoch 149/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1178 - accuracy:
0.5432 - val_loss: 1.1121 - val_accuracy: 0.5472
Epoch 150/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1138 - accuracy:
0.5464 - val_loss: 1.1114 - val_accuracy: 0.5468
Epoch 151/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1125 - accuracy:
0.5455 - val_loss: 1.1116 - val_accuracy: 0.5494
Epoch 152/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1142 - accuracy:
0.5458 - val_loss: 1.1108 - val_accuracy: 0.5490
Epoch 153/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1127 - accuracy:
0.5476 - val_loss: 1.1102 - val_accuracy: 0.5490
Epoch 154/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1110 - accuracy:
0.5462 - val_loss: 1.1097 - val_accuracy: 0.5493
Epoch 155/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1100 - accuracy:
0.5436 - val_loss: 1.1095 - val_accuracy: 0.5480
Epoch 156/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1115 - accuracy:
0.5498 - val_loss: 1.1107 - val_accuracy: 0.5465
Epoch 157/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1083 - accuracy:
0.5519 - val_loss: 1.1086 - val_accuracy: 0.5485
Epoch 158/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1101 - accuracy:
0.5451 - val_loss: 1.1089 - val_accuracy: 0.5486
Epoch 159/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1094 - accuracy:
0.5491 - val_loss: 1.1086 - val_accuracy: 0.5485
Epoch 160/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1078 - accuracy:
0.5485 - val_loss: 1.1080 - val_accuracy: 0.5503
Epoch 161/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1066 - accuracy:
0.5474 - val_loss: 1.1073 - val_accuracy: 0.5494
Epoch 162/200
```

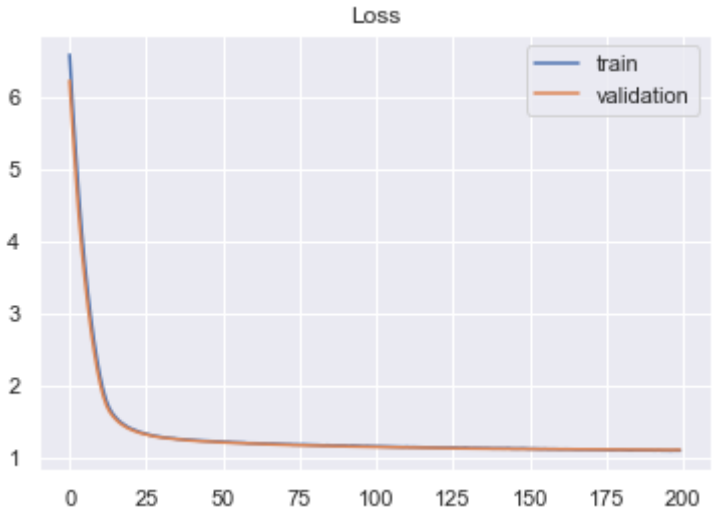
```
225/225 [==============================] - 2s 7ms/step - loss: 1.1076 - accuracy:
0.5484 - val_loss: 1.1068 - val_accuracy: 0.5499
Epoch 163/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1081 - accuracy:
0.5477 - val_loss: 1.1065 - val_accuracy: 0.5498
Epoch 164/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1057 - accuracy:
0.5483 - val_loss: 1.1065 - val_accuracy: 0.5499
Epoch 165/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1061 - accuracy:
0.5456 - val_loss: 1.1060 - val_accuracy: 0.5498
Epoch 166/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1042 - accuracy:
0.5505 - val_loss: 1.1060 - val_accuracy: 0.5472
Epoch 167/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1054 - accuracy:
0.5487 - val_loss: 1.1054 - val_accuracy: 0.5488
Epoch 168/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1035 - accuracy:
0.5502 - val_loss: 1.1054 - val_accuracy: 0.5499
Epoch 169/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1045 - accuracy:
0.5490 - val_loss: 1.1053 - val_accuracy: 0.5475
Epoch 170/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1022 - accuracy:
0.5483 - val_loss: 1.1053 - val_accuracy: 0.5477
Epoch 171/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1022 - accuracy:
0.5516 - val_loss: 1.1043 - val_accuracy: 0.5511
Epoch 172/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1035 - accuracy:
0.5518 - val_loss: 1.1047 - val_accuracy: 0.5498
Epoch 173/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1021 - accuracy:
0.5544 - val_loss: 1.1055 - val_accuracy: 0.5488
Epoch 174/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1024 - accuracy:
0.5477 - val_loss: 1.1036 - val_accuracy: 0.5481
Epoch 175/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1011 - accuracy:
0.5488 - val_loss: 1.1040 - val_accuracy: 0.5494
Epoch 176/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0995 - accuracy:
0.5532 - val_loss: 1.1030 - val_accuracy: 0.5509
Epoch 177/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0975 - accuracy:
0.5504 - val_loss: 1.1040 - val_accuracy: 0.5490
Epoch 178/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0971 - accuracy:
0.5513 - val_loss: 1.1029 - val_accuracy: 0.5514
Epoch 179/200
225/225 [==============================] - 2s 8ms/step - loss: 1.1002 - accuracy:
0.5497 - val_loss: 1.1026 - val_accuracy: 0.5483
Epoch 180/200
225/225 [==============================] - 2s 7ms/step - loss: 1.1007 - accuracy:
0.5508 - val_loss: 1.1019 - val_accuracy: 0.5506
Epoch 181/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0996 - accuracy:
0.5541 - val_loss: 1.1014 - val_accuracy: 0.5483
Epoch 182/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0986 - accuracy:
0.5486 - val_loss: 1.1020 - val_accuracy: 0.5519
Epoch 183/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0950 - accuracy:
```

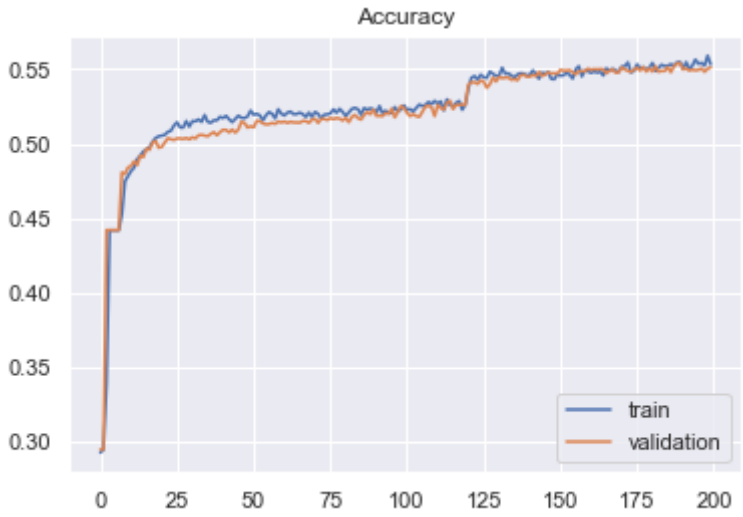
```
0.5509 - val_loss: 1.1013 - val_accuracy: 0.5481
Epoch 184/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0920 - accuracy:
0.5529 - val_loss: 1.1010 - val_accuracy: 0.5488
Epoch 185/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0954 - accuracy:
0.5519 - val_loss: 1.1009 - val_accuracy: 0.5486
Epoch 186/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0956 - accuracy:
0.5523 - val_loss: 1.1009 - val_accuracy: 0.5514
Epoch 187/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0964 - accuracy:
0.5532 - val_loss: 1.1005 - val_accuracy: 0.5478
Epoch 188/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0943 - accuracy:
0.5523 - val_loss: 1.1007 - val_accuracy: 0.5517
Epoch 189/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0932 - accuracy:
0.5544 - val_loss: 1.1009 - val_accuracy: 0.5537
Epoch 190/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0937 - accuracy:
0.5547 - val_loss: 1.1005 - val_accuracy: 0.5540
Epoch 191/200
225/225 [==============================] - 2s 8ms/step - loss: 1.0925 - accuracy:
0.5502 - val_loss: 1.1019 - val_accuracy: 0.5498
Epoch 192/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0910 - accuracy:
0.5546 - val_loss: 1.1002 - val_accuracy: 0.5504
Epoch 193/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0953 - accuracy:
0.5502 - val_loss: 1.0992 - val_accuracy: 0.5490
Epoch 194/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0904 - accuracy:
0.5521 - val_loss: 1.0994 - val_accuracy: 0.5496
Epoch 195/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0913 - accuracy:
0.5564 - val_loss: 1.0988 - val_accuracy: 0.5491
Epoch 196/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0902 - accuracy:
0.5535 - val_loss: 1.0994 - val_accuracy: 0.5494
Epoch 197/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0880 - accuracy:
0.5541 - val_loss: 1.0987 - val_accuracy: 0.5504
Epoch 198/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0908 - accuracy:
0.5523 - val_loss: 1.0986 - val_accuracy: 0.5481
Epoch 199/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0903 - accuracy:
0.5589 - val_loss: 1.1004 - val_accuracy: 0.5503
Epoch 200/200
225/225 [==============================] - 2s 7ms/step - loss: 1.0902 - accuracy:
0.5532 - val_loss: 1.0991 - val_accuracy: 0.5511
Model training is finished at 1656234125.04026 & it took 332.0 sec
```

In [147…

```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
plt.title(f'Accuracy')
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()
```

```
### Model Evaluation
```





In [148…

```
Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")
Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [NI
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat

testLoss, testAccuracy = NN_model.evaluate(X_test, y_test)

y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```

```
Final training loss : 1.0902372598648071
Final training accuracy:  0.5531617999076843
Final validation loss : 1.0990746021270752
Final validation accuracy : 0.5510734915733337
193/193 [==============================] - 1s 3ms/step - loss: 1.0991 - accuracy:
0.5511
Confusion matrix:
[[ 301   72    0   49    4]
 [ 180  156    0  179   23]
 [  57  101    0  386  111]
 [  19   59    0  723 1011]
 [   7   24    0  478 2208]]
Classification Report:
              precision    recall  f1-score   support

           0       0.53      0.71      0.61       426
           1       0.38      0.29      0.33       538
           2       0.00      0.00      0.00       655
           3       0.40      0.40      0.40      1812
           4       0.66      0.81      0.73      2717

    accuracy                           0.55      6148
   macro avg       0.39      0.44      0.41      6148
weighted avg       0.48      0.55      0.51      6148
```

Observation : This iteration improved the accuracy. Rating '3' is still an issue but have shown improvements.

Model Iteration #7

Dropout on the lower hidden layer and increasing learning rate.

In [154…

```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.6))
NN_model.add(Dense(128,activation='relu', kernel_regularizer=regularizers.l1(0.001
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(64,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(16,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))

# The Output Layer :
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())

### Model Compilation

adam=Adam(learning_rate=0.00004)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a
```

```
### Model Training

start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validatio
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model: "sequential_12"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_90 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_91 (Dense)             (None, 256)               33024
_________________________________________________________________
dropout_11 (Dropout)         (None, 256)               0
_________________________________________________________________
dense_92 (Dense)             (None, 128)               32896
_________________________________________________________________
dense_93 (Dense)             (None, 64)                8256
_________________________________________________________________
dense_94 (Dense)             (None, 32)                2080
_________________________________________________________________
dense_95 (Dense)             (None, 32)                1056
_________________________________________________________________
dense_96 (Dense)             (None, 16)                528
_________________________________________________________________
dense_97 (Dense)             (None, 5)                 85
=================================================================
Total params: 94,437
Trainable params: 94,437
Non-trainable params: 0
_________________________________________________________________
None
Model training is started at 1656248575.4053745
Epoch 1/200
225/225 [==============================] - 4s 17ms/step - loss: 6.5966 - accuracy:
0.2921 - val_loss: 6.1951 - val_accuracy: 0.2988
Epoch 2/200
225/225 [==============================] - 3s 15ms/step - loss: 5.8722 - accuracy:
0.4237 - val_loss: 5.5323 - val_accuracy: 0.4419
Epoch 3/200
225/225 [==============================] - 3s 13ms/step - loss: 5.2385 - accuracy:
0.4418 - val_loss: 4.9245 - val_accuracy: 0.4419
Epoch 4/200
225/225 [==============================] - 3s 13ms/step - loss: 4.6746 - accuracy:
0.4419 - val_loss: 4.4007 - val_accuracy: 0.4419
Epoch 5/200
225/225 [==============================] - 3s 13ms/step - loss: 4.1832 - accuracy:
0.4418 - val_loss: 3.9405 - val_accuracy: 0.4419
Epoch 6/200
225/225 [==============================] - 3s 13ms/step - loss: 3.7437 - accuracy:
0.4418 - val_loss: 3.5268 - val_accuracy: 0.4419
Epoch 7/200
225/225 [==============================] - 3s 13ms/step - loss: 3.3495 - accuracy:
0.4516 - val_loss: 3.1547 - val_accuracy: 0.4842
Epoch 8/200
225/225 [==============================] - 3s 13ms/step - loss: 2.9957 - accuracy:
0.4804 - val_loss: 2.8220 - val_accuracy: 0.4855
Epoch 9/200
225/225 [==============================] - 3s 13ms/step - loss: 2.6817 - accuracy:
0.4827 - val_loss: 2.5300 - val_accuracy: 0.4823
Epoch 10/200
225/225 [==============================] - 3s 13ms/step - loss: 2.4088 - accuracy:
0.4849 - val_loss: 2.2756 - val_accuracy: 0.4850
Epoch 11/200
225/225 [==============================] - 3s 13ms/step - loss: 2.1742 - accuracy:
0.4872 - val_loss: 2.0629 - val_accuracy: 0.4860
Epoch 12/200
225/225 [==============================] - 3s 14ms/step - loss: 1.9812 - accuracy:
0.4867 - val_loss: 1.8908 - val_accuracy: 0.4886
```

```
Epoch 13/200
225/225 [==============================] - 3s 13ms/step - loss: 1.8287 - accuracy:
0.4878 - val_loss: 1.7598 - val_accuracy: 0.4862
Epoch 14/200
225/225 [==============================] - 3s 13ms/step - loss: 1.7193 - accuracy:
0.4899 - val_loss: 1.6705 - val_accuracy: 0.4907
Epoch 15/200
225/225 [==============================] - 3s 13ms/step - loss: 1.6437 - accuracy:
0.4941 - val_loss: 1.6076 - val_accuracy: 0.4915
Epoch 16/200
225/225 [==============================] - 3s 13ms/step - loss: 1.5869 - accuracy:
0.4954 - val_loss: 1.5567 - val_accuracy: 0.4925
Epoch 17/200
225/225 [==============================] - 3s 14ms/step - loss: 1.5394 - accuracy:
0.4989 - val_loss: 1.5124 - val_accuracy: 0.4938
Epoch 18/200
225/225 [==============================] - 3s 13ms/step - loss: 1.4982 - accuracy:
0.5014 - val_loss: 1.4759 - val_accuracy: 0.4985
Epoch 19/200
225/225 [==============================] - 3s 13ms/step - loss: 1.4657 - accuracy:
0.5037 - val_loss: 1.4464 - val_accuracy: 0.5039
Epoch 20/200
225/225 [==============================] - 3s 13ms/step - loss: 1.4371 - accuracy:
0.5037 - val_loss: 1.4181 - val_accuracy: 0.4995
Epoch 21/200
225/225 [==============================] - 3s 13ms/step - loss: 1.4117 - accuracy:
0.5090 - val_loss: 1.3960 - val_accuracy: 0.5037
Epoch 22/200
225/225 [==============================] - 3s 13ms/step - loss: 1.3907 - accuracy:
0.5093 - val_loss: 1.3764 - val_accuracy: 0.5057
Epoch 23/200
225/225 [==============================] - 3s 13ms/step - loss: 1.3723 - accuracy:
0.5101 - val_loss: 1.3587 - val_accuracy: 0.5075
Epoch 24/200
225/225 [==============================] - 3s 13ms/step - loss: 1.3546 - accuracy:
0.5139 - val_loss: 1.3429 - val_accuracy: 0.5078
Epoch 25/200
225/225 [==============================] - 3s 13ms/step - loss: 1.3403 - accuracy:
0.5184 - val_loss: 1.3298 - val_accuracy: 0.5112
Epoch 26/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3279 - accuracy:
0.5175 - val_loss: 1.3160 - val_accuracy: 0.5070
Epoch 27/200
225/225 [==============================] - 3s 13ms/step - loss: 1.3161 - accuracy:
0.5181 - val_loss: 1.3053 - val_accuracy: 0.5096
Epoch 28/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3047 - accuracy:
0.5194 - val_loss: 1.2948 - val_accuracy: 0.5088
Epoch 29/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2945 - accuracy:
0.5216 - val_loss: 1.2861 - val_accuracy: 0.5107
Epoch 30/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2868 - accuracy:
0.5205 - val_loss: 1.2788 - val_accuracy: 0.5117
Epoch 31/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2794 - accuracy:
0.5212 - val_loss: 1.2711 - val_accuracy: 0.5109
Epoch 32/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2746 - accuracy:
0.5231 - val_loss: 1.2651 - val_accuracy: 0.5107
Epoch 33/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2659 - accuracy:
0.5210 - val_loss: 1.2585 - val_accuracy: 0.5128
Epoch 34/200
```

```
225/225 [==============================] - 3s 13ms/step - loss: 1.2592 - accuracy:
0.5238 - val_loss: 1.2538 - val_accuracy: 0.5155
Epoch 35/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2548 - accuracy:
0.5228 - val_loss: 1.2478 - val_accuracy: 0.5143
Epoch 36/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2479 - accuracy:
0.5267 - val_loss: 1.2430 - val_accuracy: 0.5153
Epoch 37/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2442 - accuracy:
0.5259 - val_loss: 1.2388 - val_accuracy: 0.5153
Epoch 38/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2410 - accuracy:
0.5235 - val_loss: 1.2347 - val_accuracy: 0.5166
Epoch 39/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2363 - accuracy:
0.5241 - val_loss: 1.2308 - val_accuracy: 0.5159
Epoch 40/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2329 - accuracy:
0.5244 - val_loss: 1.2272 - val_accuracy: 0.5155
Epoch 41/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2328 - accuracy:
0.5266 - val_loss: 1.2244 - val_accuracy: 0.5176
Epoch 42/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2281 - accuracy:
0.5282 - val_loss: 1.2218 - val_accuracy: 0.5203
Epoch 43/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2232 - accuracy:
0.5285 - val_loss: 1.2190 - val_accuracy: 0.5190
Epoch 44/200
225/225 [==============================] - 3s 12ms/step - loss: 1.2212 - accuracy:
0.5298 - val_loss: 1.2144 - val_accuracy: 0.5200
Epoch 45/200
225/225 [==============================] - 3s 12ms/step - loss: 1.2192 - accuracy:
0.5281 - val_loss: 1.2123 - val_accuracy: 0.5192
Epoch 46/200
225/225 [==============================] - 3s 12ms/step - loss: 1.2148 - accuracy:
0.5279 - val_loss: 1.2105 - val_accuracy: 0.5197
Epoch 47/200
225/225 [==============================] - 3s 12ms/step - loss: 1.2125 - accuracy:
0.5275 - val_loss: 1.2075 - val_accuracy: 0.5231
Epoch 48/200
225/225 [==============================] - 3s 12ms/step - loss: 1.2096 - accuracy:
0.5300 - val_loss: 1.2061 - val_accuracy: 0.5244
Epoch 49/200
225/225 [==============================] - 3s 12ms/step - loss: 1.2079 - accuracy:
0.5289 - val_loss: 1.2013 - val_accuracy: 0.5215
Epoch 50/200
225/225 [==============================] - 3s 12ms/step - loss: 1.2046 - accuracy:
0.5300 - val_loss: 1.1989 - val_accuracy: 0.5229
Epoch 51/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2014 - accuracy:
0.5327 - val_loss: 1.1965 - val_accuracy: 0.5226
Epoch 52/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1992 - accuracy:
0.5313 - val_loss: 1.1944 - val_accuracy: 0.5234
Epoch 53/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1987 - accuracy:
0.5321 - val_loss: 1.1924 - val_accuracy: 0.5241
Epoch 54/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1972 - accuracy:
0.5315 - val_loss: 1.1907 - val_accuracy: 0.5231
Epoch 55/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1938 - accuracy:
```

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0.5343 - val_loss: 1.1883 - val_accuracy: 0.5249
Epoch 56/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1908 - accuracy:
0.5300 - val_loss: 1.1865 - val_accuracy: 0.5249
Epoch 57/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1909 - accuracy:
0.5336 - val_loss: 1.1846 - val_accuracy: 0.5246
Epoch 58/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1899 - accuracy:
0.5281 - val_loss: 1.1831 - val_accuracy: 0.5254
Epoch 59/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1892 - accuracy:
0.5354 - val_loss: 1.1810 - val_accuracy: 0.5236
Epoch 60/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1835 - accuracy:
0.5346 - val_loss: 1.1793 - val_accuracy: 0.5228
Epoch 61/200
225/225 [==============================] - 3s 12ms/step - loss: 1.1835 - accuracy:
0.5320 - val_loss: 1.1777 - val_accuracy: 0.5237
Epoch 62/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1817 - accuracy:
0.5331 - val_loss: 1.1761 - val_accuracy: 0.5249
Epoch 63/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1813 - accuracy:
0.5325 - val_loss: 1.1746 - val_accuracy: 0.5260
Epoch 64/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1781 - accuracy:
0.5325 - val_loss: 1.1731 - val_accuracy: 0.5275
Epoch 65/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1777 - accuracy:
0.5295 - val_loss: 1.1718 - val_accuracy: 0.5265
Epoch 66/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1743 - accuracy:
0.5355 - val_loss: 1.1704 - val_accuracy: 0.5293
Epoch 67/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1736 - accuracy:
0.5312 - val_loss: 1.1689 - val_accuracy: 0.5268
Epoch 68/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1728 - accuracy:
0.5343 - val_loss: 1.1675 - val_accuracy: 0.5301
Epoch 69/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1720 - accuracy:
0.5341 - val_loss: 1.1661 - val_accuracy: 0.5283
Epoch 70/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1715 - accuracy:
0.5362 - val_loss: 1.1652 - val_accuracy: 0.5291
Epoch 71/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1694 - accuracy:
0.5344 - val_loss: 1.1637 - val_accuracy: 0.5317
Epoch 72/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1674 - accuracy:
0.5352 - val_loss: 1.1629 - val_accuracy: 0.5294
Epoch 73/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1682 - accuracy:
0.5336 - val_loss: 1.1614 - val_accuracy: 0.5301
Epoch 74/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1658 - accuracy:
0.5328 - val_loss: 1.1599 - val_accuracy: 0.5303
Epoch 75/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1644 - accuracy:
0.5371 - val_loss: 1.1585 - val_accuracy: 0.5314
Epoch 76/200
225/225 [==============================] - 3s 12ms/step - loss: 1.1643 - accuracy:
0.5332 - val_loss: 1.1575 - val_accuracy: 0.5319
```

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Epoch 77/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1594 - accuracy:
0.5366 - val_loss: 1.1561 - val_accuracy: 0.5320
Epoch 78/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1600 - accuracy:
0.5364 - val_loss: 1.1550 - val_accuracy: 0.5307
Epoch 79/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1602 - accuracy:
0.5367 - val_loss: 1.1543 - val_accuracy: 0.5322
Epoch 80/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1592 - accuracy:
0.5370 - val_loss: 1.1537 - val_accuracy: 0.5324
Epoch 81/200
225/225 [==============================] - 3s 12ms/step - loss: 1.1574 - accuracy:
0.5378 - val_loss: 1.1521 - val_accuracy: 0.5330
Epoch 82/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1591 - accuracy:
0.5386 - val_loss: 1.1512 - val_accuracy: 0.5316
Epoch 83/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1560 - accuracy:
0.5387 - val_loss: 1.1502 - val_accuracy: 0.5335
Epoch 84/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1536 - accuracy:
0.5394 - val_loss: 1.1492 - val_accuracy: 0.5340
Epoch 85/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1558 - accuracy:
0.5379 - val_loss: 1.1482 - val_accuracy: 0.5330
Epoch 86/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1546 - accuracy:
0.5375 - val_loss: 1.1472 - val_accuracy: 0.5335
Epoch 87/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1525 - accuracy:
0.5390 - val_loss: 1.1463 - val_accuracy: 0.5392
Epoch 88/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1510 - accuracy:
0.5387 - val_loss: 1.1454 - val_accuracy: 0.5369
Epoch 89/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1500 - accuracy:
0.5386 - val_loss: 1.1444 - val_accuracy: 0.5363
Epoch 90/200
225/225 [==============================] - 3s 12ms/step - loss: 1.1488 - accuracy:
0.5424 - val_loss: 1.1454 - val_accuracy: 0.5408
Epoch 91/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1472 - accuracy:
0.5426 - val_loss: 1.1426 - val_accuracy: 0.5359
Epoch 92/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1464 - accuracy:
0.5428 - val_loss: 1.1419 - val_accuracy: 0.5364
Epoch 93/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1451 - accuracy:
0.5470 - val_loss: 1.1412 - val_accuracy: 0.5359
Epoch 94/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1473 - accuracy:
0.5389 - val_loss: 1.1401 - val_accuracy: 0.5387
Epoch 95/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1438 - accuracy:
0.5392 - val_loss: 1.1394 - val_accuracy: 0.5387
Epoch 96/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1414 - accuracy:
0.5416 - val_loss: 1.1391 - val_accuracy: 0.5428
Epoch 97/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1399 - accuracy:
0.5448 - val_loss: 1.1379 - val_accuracy: 0.5371
Epoch 98/200
```

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225/225 [==============================] - 3s 13ms/step - loss: 1.1391 - accuracy:
0.5438 - val_loss: 1.1367 - val_accuracy: 0.5399
Epoch 99/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1429 - accuracy:
0.5453 - val_loss: 1.1365 - val_accuracy: 0.5441
Epoch 100/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1361 - accuracy:
0.5443 - val_loss: 1.1355 - val_accuracy: 0.5436
Epoch 101/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1385 - accuracy:
0.5421 - val_loss: 1.1349 - val_accuracy: 0.5390
Epoch 102/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1374 - accuracy:
0.5449 - val_loss: 1.1353 - val_accuracy: 0.5369
Epoch 103/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1385 - accuracy:
0.5435 - val_loss: 1.1336 - val_accuracy: 0.5402
Epoch 104/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1368 - accuracy:
0.5414 - val_loss: 1.1332 - val_accuracy: 0.5395
Epoch 105/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1317 - accuracy:
0.5447 - val_loss: 1.1324 - val_accuracy: 0.5385
Epoch 106/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1361 - accuracy:
0.5425 - val_loss: 1.1318 - val_accuracy: 0.5394
Epoch 107/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1337 - accuracy:
0.5424 - val_loss: 1.1308 - val_accuracy: 0.5444
Epoch 108/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1328 - accuracy:
0.5464 - val_loss: 1.1302 - val_accuracy: 0.5439
Epoch 109/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1305 - accuracy:
0.5443 - val_loss: 1.1293 - val_accuracy: 0.5415
Epoch 110/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1335 - accuracy:
0.5434 - val_loss: 1.1306 - val_accuracy: 0.5368
Epoch 111/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1294 - accuracy:
0.5456 - val_loss: 1.1284 - val_accuracy: 0.5451
Epoch 112/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1292 - accuracy:
0.5442 - val_loss: 1.1278 - val_accuracy: 0.5457
Epoch 113/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1285 - accuracy:
0.5435 - val_loss: 1.1273 - val_accuracy: 0.5418
Epoch 114/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1275 - accuracy:
0.5442 - val_loss: 1.1271 - val_accuracy: 0.5459
Epoch 115/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1274 - accuracy:
0.5502 - val_loss: 1.1265 - val_accuracy: 0.5462
Epoch 116/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1276 - accuracy:
0.5432 - val_loss: 1.1273 - val_accuracy: 0.5397
Epoch 117/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1285 - accuracy:
0.5447 - val_loss: 1.1251 - val_accuracy: 0.5438
Epoch 118/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1263 - accuracy:
0.5441 - val_loss: 1.1245 - val_accuracy: 0.5433
Epoch 119/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1275 - accuracy:
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0.5418 - val_loss: 1.1241 - val_accuracy: 0.5418
Epoch 120/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1256 - accuracy:
0.5480 - val_loss: 1.1233 - val_accuracy: 0.5444
Epoch 121/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1272 - accuracy:
0.5432 - val_loss: 1.1229 - val_accuracy: 0.5467
Epoch 122/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1251 - accuracy:
0.5464 - val_loss: 1.1227 - val_accuracy: 0.5470
Epoch 123/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1223 - accuracy:
0.5448 - val_loss: 1.1226 - val_accuracy: 0.5441
Epoch 124/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1245 - accuracy:
0.5447 - val_loss: 1.1225 - val_accuracy: 0.5416
Epoch 125/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1221 - accuracy:
0.5450 - val_loss: 1.1217 - val_accuracy: 0.5481
Epoch 126/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1254 - accuracy:
0.5433 - val_loss: 1.1211 - val_accuracy: 0.5438
Epoch 127/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1239 - accuracy:
0.5502 - val_loss: 1.1221 - val_accuracy: 0.5413
Epoch 128/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1207 - accuracy:
0.5463 - val_loss: 1.1202 - val_accuracy: 0.5436
Epoch 129/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1185 - accuracy:
0.5461 - val_loss: 1.1198 - val_accuracy: 0.5481
Epoch 130/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1202 - accuracy:
0.5493 - val_loss: 1.1195 - val_accuracy: 0.5447
Epoch 131/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1176 - accuracy:
0.5481 - val_loss: 1.1185 - val_accuracy: 0.5455
Epoch 132/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1198 - accuracy:
0.5486 - val_loss: 1.1180 - val_accuracy: 0.5460
Epoch 133/200
225/225 [==============================] - 4s 19ms/step - loss: 1.1210 - accuracy:
0.5426 - val_loss: 1.1176 - val_accuracy: 0.5459
Epoch 134/200
225/225 [==============================] - 4s 17ms/step - loss: 1.1180 - accuracy:
0.5441 - val_loss: 1.1174 - val_accuracy: 0.5480
Epoch 135/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1197 - accuracy:
0.5458 - val_loss: 1.1169 - val_accuracy: 0.5460
Epoch 136/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1163 - accuracy:
0.5493 - val_loss: 1.1165 - val_accuracy: 0.5467
Epoch 137/200
225/225 [==============================] - 3s 12ms/step - loss: 1.1163 - accuracy:
0.5480 - val_loss: 1.1170 - val_accuracy: 0.5449
Epoch 138/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1178 - accuracy:
0.5498 - val_loss: 1.1156 - val_accuracy: 0.5472
Epoch 139/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1160 - accuracy:
0.5461 - val_loss: 1.1150 - val_accuracy: 0.5460
Epoch 140/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1154 - accuracy:
0.5457 - val_loss: 1.1149 - val_accuracy: 0.5438
```

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Epoch 141/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1137 - accuracy:
0.5546 - val_loss: 1.1143 - val_accuracy: 0.5452
Epoch 142/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1111 - accuracy:
0.5472 - val_loss: 1.1139 - val_accuracy: 0.5454
Epoch 143/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1130 - accuracy:
0.5464 - val_loss: 1.1133 - val_accuracy: 0.5465
Epoch 144/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1108 - accuracy:
0.5484 - val_loss: 1.1132 - val_accuracy: 0.5447
Epoch 145/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1124 - accuracy:
0.5504 - val_loss: 1.1123 - val_accuracy: 0.5481
Epoch 146/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1141 - accuracy:
0.5489 - val_loss: 1.1133 - val_accuracy: 0.5496
Epoch 147/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1107 - accuracy:
0.5490 - val_loss: 1.1122 - val_accuracy: 0.5451
Epoch 148/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1102 - accuracy:
0.5481 - val_loss: 1.1113 - val_accuracy: 0.5486
Epoch 149/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1073 - accuracy:
0.5500 - val_loss: 1.1112 - val_accuracy: 0.5490
Epoch 150/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1075 - accuracy:
0.5523 - val_loss: 1.1107 - val_accuracy: 0.5464
Epoch 151/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1102 - accuracy:
0.5470 - val_loss: 1.1101 - val_accuracy: 0.5480
Epoch 152/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1108 - accuracy:
0.5479 - val_loss: 1.1098 - val_accuracy: 0.5467
Epoch 153/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1084 - accuracy:
0.5547 - val_loss: 1.1096 - val_accuracy: 0.5480
Epoch 154/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1057 - accuracy:
0.5506 - val_loss: 1.1093 - val_accuracy: 0.5457
Epoch 155/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1058 - accuracy:
0.5495 - val_loss: 1.1088 - val_accuracy: 0.5462
Epoch 156/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1063 - accuracy:
0.5503 - val_loss: 1.1110 - val_accuracy: 0.5530
Epoch 157/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1051 - accuracy:
0.5514 - val_loss: 1.1080 - val_accuracy: 0.5490
Epoch 158/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1032 - accuracy:
0.5503 - val_loss: 1.1082 - val_accuracy: 0.5506
Epoch 159/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1042 - accuracy:
0.5525 - val_loss: 1.1077 - val_accuracy: 0.5472
Epoch 160/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1058 - accuracy:
0.5497 - val_loss: 1.1074 - val_accuracy: 0.5511
Epoch 161/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0997 - accuracy:
0.5520 - val_loss: 1.1068 - val_accuracy: 0.5499
Epoch 162/200
```

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225/225 [==============================] - 3s 13ms/step - loss: 1.1034 - accuracy:
0.5530 - val_loss: 1.1063 - val_accuracy: 0.5493
Epoch 163/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1028 - accuracy:
0.5463 - val_loss: 1.1060 - val_accuracy: 0.5486
Epoch 164/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1017 - accuracy:
0.5506 - val_loss: 1.1057 - val_accuracy: 0.5472
Epoch 165/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0993 - accuracy:
0.5493 - val_loss: 1.1052 - val_accuracy: 0.5490
Epoch 166/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0999 - accuracy:
0.5550 - val_loss: 1.1047 - val_accuracy: 0.5509
Epoch 167/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0999 - accuracy:
0.5523 - val_loss: 1.1046 - val_accuracy: 0.5507
Epoch 168/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1020 - accuracy:
0.5523 - val_loss: 1.1042 - val_accuracy: 0.5485
Epoch 169/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1001 - accuracy:
0.5521 - val_loss: 1.1043 - val_accuracy: 0.5520
Epoch 170/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1007 - accuracy:
0.5520 - val_loss: 1.1045 - val_accuracy: 0.5520
Epoch 171/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0979 - accuracy:
0.5509 - val_loss: 1.1039 - val_accuracy: 0.5491
Epoch 172/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0974 - accuracy:
0.5517 - val_loss: 1.1041 - val_accuracy: 0.5493
Epoch 173/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0966 - accuracy:
0.5543 - val_loss: 1.1047 - val_accuracy: 0.5480
Epoch 174/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0983 - accuracy:
0.5502 - val_loss: 1.1029 - val_accuracy: 0.5504
Epoch 175/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0943 - accuracy:
0.5542 - val_loss: 1.1038 - val_accuracy: 0.5454
Epoch 176/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0991 - accuracy:
0.5541 - val_loss: 1.1030 - val_accuracy: 0.5490
Epoch 177/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0964 - accuracy:
0.5527 - val_loss: 1.1031 - val_accuracy: 0.5490
Epoch 178/200
225/225 [==============================] - 3s 12ms/step - loss: 1.0951 - accuracy:
0.5511 - val_loss: 1.1022 - val_accuracy: 0.5506
Epoch 179/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0949 - accuracy:
0.5517 - val_loss: 1.1024 - val_accuracy: 0.5511
Epoch 180/200
225/225 [==============================] - 3s 12ms/step - loss: 1.0953 - accuracy:
0.5556 - val_loss: 1.1018 - val_accuracy: 0.5514
Epoch 181/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0954 - accuracy:
0.5541 - val_loss: 1.1014 - val_accuracy: 0.5509
Epoch 182/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0973 - accuracy:
0.5536 - val_loss: 1.1019 - val_accuracy: 0.5501
Epoch 183/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0918 - accuracy:
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0.5550 - val_loss: 1.1011 - val_accuracy: 0.5514
Epoch 184/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0952 - accuracy:
0.5534 - val_loss: 1.1012 - val_accuracy: 0.5512
Epoch 185/200
225/225 [==============================] - 3s 12ms/step - loss: 1.0922 - accuracy:
0.5527 - val_loss: 1.1005 - val_accuracy: 0.5512
Epoch 186/200
225/225 [==============================] - 3s 12ms/step - loss: 1.0936 - accuracy:
0.5552 - val_loss: 1.1009 - val_accuracy: 0.5524
Epoch 187/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0926 - accuracy:
0.5534 - val_loss: 1.1000 - val_accuracy: 0.5527
Epoch 188/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0904 - accuracy:
0.5532 - val_loss: 1.1001 - val_accuracy: 0.5520
Epoch 189/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0930 - accuracy:
0.5539 - val_loss: 1.1008 - val_accuracy: 0.5504
Epoch 190/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0890 - accuracy:
0.5580 - val_loss: 1.1004 - val_accuracy: 0.5516
Epoch 191/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0895 - accuracy:
0.5569 - val_loss: 1.1013 - val_accuracy: 0.5496
Epoch 192/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0897 - accuracy:
0.5572 - val_loss: 1.0999 - val_accuracy: 0.5519
Epoch 193/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0903 - accuracy:
0.5560 - val_loss: 1.0998 - val_accuracy: 0.5507
Epoch 194/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0886 - accuracy:
0.5580 - val_loss: 1.0993 - val_accuracy: 0.5517
Epoch 195/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0880 - accuracy:
0.5578 - val_loss: 1.0987 - val_accuracy: 0.5524
Epoch 196/200
225/225 [==============================] - 3s 12ms/step - loss: 1.0880 - accuracy:
0.5562 - val_loss: 1.0989 - val_accuracy: 0.5519
Epoch 197/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0849 - accuracy:
0.5567 - val_loss: 1.0985 - val_accuracy: 0.5529
Epoch 198/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0848 - accuracy:
0.5594 - val_loss: 1.0986 - val_accuracy: 0.5530
Epoch 199/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0888 - accuracy:
0.5545 - val_loss: 1.0995 - val_accuracy: 0.5507
Epoch 200/200
225/225 [==============================] - 3s 13ms/step - loss: 1.0855 - accuracy:
0.5596 - val_loss: 1.0990 - val_accuracy: 0.5517
Model training is finished at 1656249165.8831732 & it took 590.0 sec
```
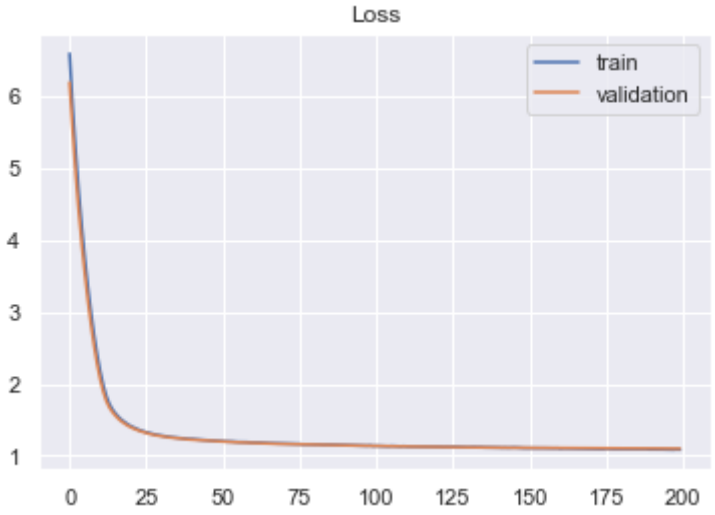
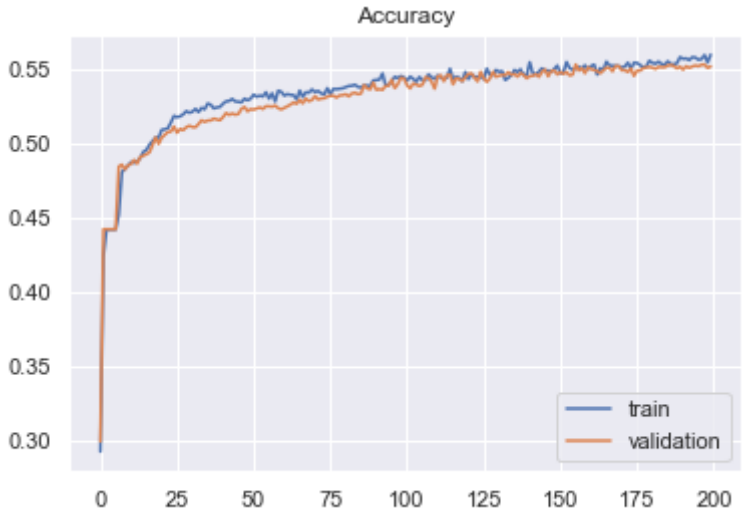

In [155…

```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
plt.title(f'Accuracy')
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()
```





In [156…

```
### Model Evaluation

Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")
Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [NN
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat

testLoss, testAccuracy = NN_model.evaluate(X_test, y_test)

y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```

```
Final training loss : 1.0854674577713013
Final training accuracy:  0.5596458315849304
Final validation loss : 1.0990360975265503
Final validation accuracy : 0.5517241358757019
  1/193 [..............................] - ETA: 0s - loss: 0.9879 - accuracy: 0.59
38WARNING:tensorflow:Callbacks method `on_test_batch_end` is slow compared to the
batch time (batch time: 0.0000s vs `on_test_batch_end` time: 0.0156s). Check your
callbacks.
WARNING:tensorflow:Callbacks method `on_test_batch_end` is slow compared to the ba
tch time (batch time: 0.0000s vs `on_test_batch_end` time: 0.0156s). Check your ca
llbacks.
193/193 [==============================] - 2s 9ms/step - loss: 1.0990 - accuracy:
0.5517
Confusion matrix:
[[ 303   76    0   43    4]
 [ 189  161    0  169   19]
 [  55  116    0  366  118]
 [  17   65    0  718 1012]
 [   7   27    0  473 2210]]
Classification Report:
              precision    recall  f1-score   support

           0       0.53      0.71      0.61       426
           1       0.36      0.30      0.33       538
           2       0.00      0.00      0.00       655
           3       0.41      0.40      0.40      1812
           4       0.66      0.81      0.73      2717

    accuracy                           0.55      6148
   macro avg       0.39      0.44      0.41      6148
weighted avg       0.48      0.55      0.51      6148
```

Observation: This model shows improved accuracy. Model validation is successful.

Model Iteration #8

Adding additional hidden layer

In [158…

```
NN_model = Sequential()

# The Input Layer :
NN_model.add(Dense(128, input_dim = 128, activation='relu'))
# The Hidden Layer :
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.6))
NN_model.add(Dense(256,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dropout(rate=0.6))
NN_model.add(Dense(128,activation='relu', kernel_regularizer=regularizers.l1(0.001)
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(64,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(32,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))
NN_model.add(Dense(16,activation='relu', kernel_regularizer=regularizers.l1(0.001),
                activity_regularizer=regularizers.l1(0.001)))

# The Output Layer :
```

```
NN_model.add(Dense(5, activation='softmax'))

print(NN_model.summary())

### Model Compilation

adam=Adam(learning_rate=0.00004)
NN_model.compile( optimizer = adam, loss = 'categorical_crossentropy', metrics=['a

### Model Training

start_=time.time()
print(f'Model training is started at {start_}')
NN_model_hist = NN_model.fit(X_train, y_train, epochs=200, batch_size=64, validati
end_=time.time()
print(f'Model training is finished at {end_} & it took {round(end_-start_, 0)} sec
```

```
Model: "sequential_13"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense_98 (Dense)             (None, 128)               16512
_________________________________________________________________
dense_99 (Dense)             (None, 256)               33024
_________________________________________________________________
dropout_12 (Dropout)         (None, 256)               0
_________________________________________________________________
dense_100 (Dense)            (None, 256)               65792
_________________________________________________________________
dropout_13 (Dropout)         (None, 256)               0
_________________________________________________________________
dense_101 (Dense)            (None, 128)               32896
_________________________________________________________________
dense_102 (Dense)            (None, 64)                8256
_________________________________________________________________
dense_103 (Dense)            (None, 32)                2080
_________________________________________________________________
dense_104 (Dense)            (None, 32)                1056
_________________________________________________________________
dense_105 (Dense)            (None, 16)                528
_________________________________________________________________
dense_106 (Dense)            (None, 5)                 85
=================================================================
Total params: 160,229
Trainable params: 160,229
Non-trainable params: 0
_________________________________________________________________
None
Model training is started at 1656249588.1997573
Epoch 1/200
225/225 [==============================] - 4s 18ms/step - loss: 9.8922 - accuracy:
0.4123 - val_loss: 9.2569 - val_accuracy: 0.4419
Epoch 2/200
225/225 [==============================] - 4s 16ms/step - loss: 8.6530 - accuracy:
0.4418 - val_loss: 8.0720 - val_accuracy: 0.4419
Epoch 3/200
225/225 [==============================] - 4s 17ms/step - loss: 7.5677 - accuracy:
0.4418 - val_loss: 7.0419 - val_accuracy: 0.4419
Epoch 4/200
225/225 [==============================] - 3s 15ms/step - loss: 6.5850 - accuracy:
0.4418 - val_loss: 6.1052 - val_accuracy: 0.4419
Epoch 5/200
225/225 [==============================] - 4s 16ms/step - loss: 5.7029 - accuracy:
0.4418 - val_loss: 5.2744 - val_accuracy: 0.4419
Epoch 6/200
225/225 [==============================] - 4s 16ms/step - loss: 4.9207 - accuracy:
0.4418 - val_loss: 4.5396 - val_accuracy: 0.4427
Epoch 7/200
225/225 [==============================] - 4s 16ms/step - loss: 4.2306 - accuracy:
0.4446 - val_loss: 3.8955 - val_accuracy: 0.4533
Epoch 8/200
225/225 [==============================] - 4s 16ms/step - loss: 3.6287 - accuracy:
0.4526 - val_loss: 3.3364 - val_accuracy: 0.4566
Epoch 9/200
225/225 [==============================] - 3s 15ms/step - loss: 3.1097 - accuracy:
0.4565 - val_loss: 2.8632 - val_accuracy: 0.4548
Epoch 10/200
225/225 [==============================] - 4s 20ms/step - loss: 2.6799 - accuracy:
0.4577 - val_loss: 2.4752 - val_accuracy: 0.4572
Epoch 11/200
225/225 [==============================] - 3s 15ms/step - loss: 2.3322 - accuracy:
```

```
0.4624 - val_loss: 2.1718 - val_accuracy: 0.4880
Epoch 12/200
225/225 [==============================] - 4s 17ms/step - loss: 2.0711 - accuracy:
0.4924 - val_loss: 1.9533 - val_accuracy: 0.4912
Epoch 13/200
225/225 [==============================] - 4s 17ms/step - loss: 1.8909 - accuracy:
0.4987 - val_loss: 1.8061 - val_accuracy: 0.4901
Epoch 14/200
225/225 [==============================] - 3s 14ms/step - loss: 1.7693 - accuracy:
0.4999 - val_loss: 1.7077 - val_accuracy: 0.4956
Epoch 15/200
225/225 [==============================] - 3s 14ms/step - loss: 1.6864 - accuracy:
0.5015 - val_loss: 1.6385 - val_accuracy: 0.4946
Epoch 16/200
225/225 [==============================] - 3s 14ms/step - loss: 1.6239 - accuracy:
0.5010 - val_loss: 1.5850 - val_accuracy: 0.4998
Epoch 17/200
225/225 [==============================] - 3s 14ms/step - loss: 1.5758 - accuracy:
0.5070 - val_loss: 1.5388 - val_accuracy: 0.4987
Epoch 18/200
225/225 [==============================] - 3s 15ms/step - loss: 1.5358 - accuracy:
0.5048 - val_loss: 1.5025 - val_accuracy: 0.5007
Epoch 19/200
225/225 [==============================] - 3s 14ms/step - loss: 1.5022 - accuracy:
0.5079 - val_loss: 1.4733 - val_accuracy: 0.5033
Epoch 20/200
225/225 [==============================] - 3s 14ms/step - loss: 1.4719 - accuracy:
0.5097 - val_loss: 1.4456 - val_accuracy: 0.5023
Epoch 21/200
225/225 [==============================] - 3s 14ms/step - loss: 1.4532 - accuracy:
0.5111 - val_loss: 1.4248 - val_accuracy: 0.5029
Epoch 22/200
225/225 [==============================] - 3s 14ms/step - loss: 1.4335 - accuracy:
0.5099 - val_loss: 1.4065 - val_accuracy: 0.5034
Epoch 23/200
225/225 [==============================] - 3s 14ms/step - loss: 1.4120 - accuracy:
0.5122 - val_loss: 1.3903 - val_accuracy: 0.5034
Epoch 24/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3981 - accuracy:
0.5115 - val_loss: 1.3755 - val_accuracy: 0.5057
Epoch 25/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3869 - accuracy:
0.5134 - val_loss: 1.3642 - val_accuracy: 0.5098
Epoch 26/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3710 - accuracy:
0.5150 - val_loss: 1.3501 - val_accuracy: 0.5042
Epoch 27/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3612 - accuracy:
0.5161 - val_loss: 1.3396 - val_accuracy: 0.5070
Epoch 28/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3510 - accuracy:
0.5176 - val_loss: 1.3294 - val_accuracy: 0.5070
Epoch 29/200
225/225 [==============================] - 3s 15ms/step - loss: 1.3421 - accuracy:
0.5152 - val_loss: 1.3217 - val_accuracy: 0.5106
Epoch 30/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3341 - accuracy:
0.5173 - val_loss: 1.3138 - val_accuracy: 0.5104
Epoch 31/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3256 - accuracy:
0.5181 - val_loss: 1.3055 - val_accuracy: 0.5099
Epoch 32/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3210 - accuracy:
0.5175 - val_loss: 1.2991 - val_accuracy: 0.5109
```

```
Epoch 33/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3134 - accuracy:
0.5184 - val_loss: 1.2929 - val_accuracy: 0.5101
Epoch 34/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3090 - accuracy:
0.5192 - val_loss: 1.2885 - val_accuracy: 0.5104
Epoch 35/200
225/225 [==============================] - 3s 14ms/step - loss: 1.3031 - accuracy:
0.5207 - val_loss: 1.2826 - val_accuracy: 0.5125
Epoch 36/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2952 - accuracy:
0.5232 - val_loss: 1.2777 - val_accuracy: 0.5133
Epoch 37/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2941 - accuracy:
0.5231 - val_loss: 1.2735 - val_accuracy: 0.5125
Epoch 38/200
225/225 [==============================] - 4s 16ms/step - loss: 1.2900 - accuracy:
0.5177 - val_loss: 1.2701 - val_accuracy: 0.5137
Epoch 39/200
225/225 [==============================] - 4s 18ms/step - loss: 1.2883 - accuracy:
0.5216 - val_loss: 1.2662 - val_accuracy: 0.5151
Epoch 40/200
225/225 [==============================] - 4s 16ms/step - loss: 1.2819 - accuracy:
0.5242 - val_loss: 1.2627 - val_accuracy: 0.5153
Epoch 41/200
225/225 [==============================] - 4s 17ms/step - loss: 1.2791 - accuracy:
0.5207 - val_loss: 1.2602 - val_accuracy: 0.5163
Epoch 42/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2802 - accuracy:
0.5219 - val_loss: 1.2574 - val_accuracy: 0.5169
Epoch 43/200
225/225 [==============================] - 4s 16ms/step - loss: 1.2749 - accuracy:
0.5213 - val_loss: 1.2545 - val_accuracy: 0.5153
Epoch 44/200
225/225 [==============================] - 4s 18ms/step - loss: 1.2744 - accuracy:
0.5217 - val_loss: 1.2512 - val_accuracy: 0.5176
Epoch 45/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2663 - accuracy:
0.5267 - val_loss: 1.2491 - val_accuracy: 0.5159
Epoch 46/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2674 - accuracy:
0.5221 - val_loss: 1.2475 - val_accuracy: 0.5171
Epoch 47/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2630 - accuracy:
0.5243 - val_loss: 1.2437 - val_accuracy: 0.5197
Epoch 48/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2627 - accuracy:
0.5239 - val_loss: 1.2438 - val_accuracy: 0.5207
Epoch 49/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2578 - accuracy:
0.5257 - val_loss: 1.2383 - val_accuracy: 0.5179
Epoch 50/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2561 - accuracy:
0.5276 - val_loss: 1.2358 - val_accuracy: 0.5189
Epoch 51/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2520 - accuracy:
0.5262 - val_loss: 1.2340 - val_accuracy: 0.5200
Epoch 52/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2513 - accuracy:
0.5236 - val_loss: 1.2318 - val_accuracy: 0.5223
Epoch 53/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2484 - accuracy:
0.5257 - val_loss: 1.2295 - val_accuracy: 0.5198
Epoch 54/200
```

```
225/225 [==============================] - 3s 14ms/step - loss: 1.2505 - accuracy:
0.5249 - val_loss: 1.2277 - val_accuracy: 0.5215
Epoch 55/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2458 - accuracy:
0.5273 - val_loss: 1.2254 - val_accuracy: 0.5211
Epoch 56/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2418 - accuracy:
0.5261 - val_loss: 1.2238 - val_accuracy: 0.5208
Epoch 57/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2431 - accuracy:
0.5262 - val_loss: 1.2219 - val_accuracy: 0.5218
Epoch 58/200
225/225 [==============================] - 3s 13ms/step - loss: 1.2399 - accuracy:
0.5281 - val_loss: 1.2203 - val_accuracy: 0.5229
Epoch 59/200
225/225 [==============================] - 3s 16ms/step - loss: 1.2395 - accuracy:
0.5264 - val_loss: 1.2180 - val_accuracy: 0.5231
Epoch 60/200
225/225 [==============================] - 4s 19ms/step - loss: 1.2344 - accuracy:
0.5260 - val_loss: 1.2162 - val_accuracy: 0.5229
Epoch 61/200
225/225 [==============================] - 4s 20ms/step - loss: 1.2353 - accuracy:
0.5267 - val_loss: 1.2146 - val_accuracy: 0.5233
Epoch 62/200
225/225 [==============================] - 4s 18ms/step - loss: 1.2339 - accuracy:
0.5286 - val_loss: 1.2131 - val_accuracy: 0.5220
Epoch 63/200
225/225 [==============================] - 4s 17ms/step - loss: 1.2325 - accuracy:
0.5312 - val_loss: 1.2115 - val_accuracy: 0.5236
Epoch 64/200
225/225 [==============================] - 3s 16ms/step - loss: 1.2309 - accuracy:
0.5259 - val_loss: 1.2102 - val_accuracy: 0.5237
Epoch 65/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2261 - accuracy:
0.5287 - val_loss: 1.2086 - val_accuracy: 0.5226
Epoch 66/200
225/225 [==============================] - 4s 17ms/step - loss: 1.2259 - accuracy:
0.5273 - val_loss: 1.2069 - val_accuracy: 0.5250
Epoch 67/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2231 - accuracy:
0.5256 - val_loss: 1.2056 - val_accuracy: 0.5252
Epoch 68/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2277 - accuracy:
0.5296 - val_loss: 1.2046 - val_accuracy: 0.5260
Epoch 69/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2201 - accuracy:
0.5311 - val_loss: 1.2029 - val_accuracy: 0.5239
Epoch 70/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2214 - accuracy:
0.5260 - val_loss: 1.2014 - val_accuracy: 0.5247
Epoch 71/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2213 - accuracy:
0.5275 - val_loss: 1.2000 - val_accuracy: 0.5250
Epoch 72/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2191 - accuracy:
0.5326 - val_loss: 1.2002 - val_accuracy: 0.5244
Epoch 73/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2183 - accuracy:
0.5276 - val_loss: 1.1982 - val_accuracy: 0.5259
Epoch 74/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2177 - accuracy:
0.5285 - val_loss: 1.1971 - val_accuracy: 0.5255
Epoch 75/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2144 - accuracy:
```

```
0.5301 - val_loss: 1.1950 - val_accuracy: 0.5262
Epoch 76/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2125 - accuracy:
0.5304 - val_loss: 1.1941 - val_accuracy: 0.5275
Epoch 77/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2113 - accuracy:
0.5313 - val_loss: 1.1925 - val_accuracy: 0.5262
Epoch 78/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2123 - accuracy:
0.5302 - val_loss: 1.1917 - val_accuracy: 0.5267
Epoch 79/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2102 - accuracy:
0.5310 - val_loss: 1.1905 - val_accuracy: 0.5267
Epoch 80/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2085 - accuracy:
0.5301 - val_loss: 1.1895 - val_accuracy: 0.5275
Epoch 81/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2088 - accuracy:
0.5278 - val_loss: 1.1882 - val_accuracy: 0.5280
Epoch 82/200
225/225 [==============================] - 4s 16ms/step - loss: 1.2103 - accuracy:
0.5314 - val_loss: 1.1875 - val_accuracy: 0.5273
Epoch 83/200
225/225 [==============================] - 5s 20ms/step - loss: 1.2058 - accuracy:
0.5284 - val_loss: 1.1863 - val_accuracy: 0.5278
Epoch 84/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2063 - accuracy:
0.5293 - val_loss: 1.1858 - val_accuracy: 0.5288
Epoch 85/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2034 - accuracy:
0.5321 - val_loss: 1.1845 - val_accuracy: 0.5280
Epoch 86/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2060 - accuracy:
0.5321 - val_loss: 1.1837 - val_accuracy: 0.5296
Epoch 87/200
225/225 [==============================] - 3s 15ms/step - loss: 1.2040 - accuracy:
0.5322 - val_loss: 1.1829 - val_accuracy: 0.5306
Epoch 88/200
225/225 [==============================] - 4s 17ms/step - loss: 1.2024 - accuracy:
0.5271 - val_loss: 1.1814 - val_accuracy: 0.5283
Epoch 89/200
225/225 [==============================] - 4s 16ms/step - loss: 1.2002 - accuracy:
0.5333 - val_loss: 1.1807 - val_accuracy: 0.5280
Epoch 90/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2031 - accuracy:
0.5285 - val_loss: 1.1820 - val_accuracy: 0.5311
Epoch 91/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1999 - accuracy:
0.5306 - val_loss: 1.1794 - val_accuracy: 0.5288
Epoch 92/200
225/225 [==============================] - 3s 14ms/step - loss: 1.2003 - accuracy:
0.5278 - val_loss: 1.1788 - val_accuracy: 0.5296
Epoch 93/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1959 - accuracy:
0.5358 - val_loss: 1.1785 - val_accuracy: 0.5301
Epoch 94/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1982 - accuracy:
0.5297 - val_loss: 1.1767 - val_accuracy: 0.5296
Epoch 95/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1964 - accuracy:
0.5328 - val_loss: 1.1759 - val_accuracy: 0.5298
Epoch 96/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1951 - accuracy:
0.5338 - val_loss: 1.1757 - val_accuracy: 0.5329
```

```
Epoch 97/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1962 - accuracy:
0.5318 - val_loss: 1.1749 - val_accuracy: 0.5304
Epoch 98/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1941 - accuracy:
0.5324 - val_loss: 1.1739 - val_accuracy: 0.5303
Epoch 99/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1918 - accuracy:
0.5325 - val_loss: 1.1728 - val_accuracy: 0.5343
Epoch 100/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1919 - accuracy:
0.5322 - val_loss: 1.1721 - val_accuracy: 0.5319
Epoch 101/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1884 - accuracy:
0.5350 - val_loss: 1.1723 - val_accuracy: 0.5306
Epoch 102/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1898 - accuracy:
0.5336 - val_loss: 1.1712 - val_accuracy: 0.5307
Epoch 103/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1901 - accuracy:
0.5320 - val_loss: 1.1706 - val_accuracy: 0.5307
Epoch 104/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1879 - accuracy:
0.5336 - val_loss: 1.1696 - val_accuracy: 0.5294
Epoch 105/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1893 - accuracy:
0.5362 - val_loss: 1.1689 - val_accuracy: 0.5303
Epoch 106/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1897 - accuracy:
0.5333 - val_loss: 1.1692 - val_accuracy: 0.5299
Epoch 107/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1852 - accuracy:
0.5356 - val_loss: 1.1672 - val_accuracy: 0.5351
Epoch 108/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1811 - accuracy:
0.5351 - val_loss: 1.1666 - val_accuracy: 0.5356
Epoch 109/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1890 - accuracy:
0.5313 - val_loss: 1.1659 - val_accuracy: 0.5311
Epoch 110/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1829 - accuracy:
0.5350 - val_loss: 1.1676 - val_accuracy: 0.5304
Epoch 111/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1838 - accuracy:
0.5301 - val_loss: 1.1649 - val_accuracy: 0.5338
Epoch 112/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1821 - accuracy:
0.5375 - val_loss: 1.1644 - val_accuracy: 0.5320
Epoch 113/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1809 - accuracy:
0.5353 - val_loss: 1.1637 - val_accuracy: 0.5335
Epoch 114/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1842 - accuracy:
0.5329 - val_loss: 1.1629 - val_accuracy: 0.5348
Epoch 115/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1795 - accuracy:
0.5339 - val_loss: 1.1623 - val_accuracy: 0.5346
Epoch 116/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1828 - accuracy:
0.5370 - val_loss: 1.1643 - val_accuracy: 0.5322
Epoch 117/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1843 - accuracy:
0.5322 - val_loss: 1.1615 - val_accuracy: 0.5350
Epoch 118/200
```

```
225/225 [==============================] - 3s 15ms/step - loss: 1.1793 - accuracy:
0.5332 - val_loss: 1.1610 - val_accuracy: 0.5355
Epoch 119/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1786 - accuracy:
0.5379 - val_loss: 1.1608 - val_accuracy: 0.5340
Epoch 120/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1779 - accuracy:
0.5355 - val_loss: 1.1599 - val_accuracy: 0.5345
Epoch 121/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1764 - accuracy:
0.5362 - val_loss: 1.1591 - val_accuracy: 0.5346
Epoch 122/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1771 - accuracy:
0.5351 - val_loss: 1.1588 - val_accuracy: 0.5338
Epoch 123/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1771 - accuracy:
0.5328 - val_loss: 1.1588 - val_accuracy: 0.5353
Epoch 124/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1724 - accuracy:
0.5334 - val_loss: 1.1588 - val_accuracy: 0.5342
Epoch 125/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1752 - accuracy:
0.5386 - val_loss: 1.1571 - val_accuracy: 0.5363
Epoch 126/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1743 - accuracy:
0.5360 - val_loss: 1.1567 - val_accuracy: 0.5351
Epoch 127/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1725 - accuracy:
0.5395 - val_loss: 1.1577 - val_accuracy: 0.5343
Epoch 128/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1732 - accuracy:
0.5376 - val_loss: 1.1556 - val_accuracy: 0.5355
Epoch 129/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1682 - accuracy:
0.5396 - val_loss: 1.1546 - val_accuracy: 0.5379
Epoch 130/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1733 - accuracy:
0.5335 - val_loss: 1.1552 - val_accuracy: 0.5368
Epoch 131/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1736 - accuracy:
0.5349 - val_loss: 1.1539 - val_accuracy: 0.5372
Epoch 132/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1737 - accuracy:
0.5388 - val_loss: 1.1533 - val_accuracy: 0.5368
Epoch 133/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1683 - accuracy:
0.5363 - val_loss: 1.1529 - val_accuracy: 0.5374
Epoch 134/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1690 - accuracy:
0.5359 - val_loss: 1.1529 - val_accuracy: 0.5377
Epoch 135/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1741 - accuracy:
0.5362 - val_loss: 1.1520 - val_accuracy: 0.5390
Epoch 136/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1698 - accuracy:
0.5389 - val_loss: 1.1519 - val_accuracy: 0.5376
Epoch 137/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1672 - accuracy:
0.5407 - val_loss: 1.1520 - val_accuracy: 0.5372
Epoch 138/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1655 - accuracy:
0.5372 - val_loss: 1.1505 - val_accuracy: 0.5368
Epoch 139/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1634 - accuracy:
```

```
0.5369 - val_loss: 1.1497 - val_accuracy: 0.5381
Epoch 140/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1646 - accuracy:
0.5391 - val_loss: 1.1499 - val_accuracy: 0.5379
Epoch 141/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1670 - accuracy:
0.5346 - val_loss: 1.1491 - val_accuracy: 0.5415
Epoch 142/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1650 - accuracy:
0.5406 - val_loss: 1.1493 - val_accuracy: 0.5395
Epoch 143/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1628 - accuracy:
0.5415 - val_loss: 1.1484 - val_accuracy: 0.5392
Epoch 144/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1665 - accuracy:
0.5379 - val_loss: 1.1484 - val_accuracy: 0.5392
Epoch 145/200
225/225 [==============================] - 4s 17ms/step - loss: 1.1623 - accuracy:
0.5413 - val_loss: 1.1471 - val_accuracy: 0.5415
Epoch 146/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1649 - accuracy:
0.5405 - val_loss: 1.1478 - val_accuracy: 0.5420
Epoch 147/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1630 - accuracy:
0.5406 - val_loss: 1.1478 - val_accuracy: 0.5399
Epoch 148/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1637 - accuracy:
0.5375 - val_loss: 1.1462 - val_accuracy: 0.5405
Epoch 149/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1581 - accuracy:
0.5398 - val_loss: 1.1456 - val_accuracy: 0.5408
Epoch 150/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1580 - accuracy:
0.5416 - val_loss: 1.1454 - val_accuracy: 0.5420
Epoch 151/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1622 - accuracy:
0.5409 - val_loss: 1.1451 - val_accuracy: 0.5426
Epoch 152/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1611 - accuracy:
0.5363 - val_loss: 1.1449 - val_accuracy: 0.5418
Epoch 153/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1560 - accuracy:
0.5407 - val_loss: 1.1441 - val_accuracy: 0.5429
Epoch 154/200
225/225 [==============================] - 4s 19ms/step - loss: 1.1577 - accuracy:
0.5384 - val_loss: 1.1440 - val_accuracy: 0.5415
Epoch 155/200
225/225 [==============================] - 4s 18ms/step - loss: 1.1574 - accuracy:
0.5387 - val_loss: 1.1437 - val_accuracy: 0.5403
Epoch 156/200
225/225 [==============================] - 4s 18ms/step - loss: 1.1546 - accuracy:
0.5412 - val_loss: 1.1451 - val_accuracy: 0.5465
Epoch 157/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1607 - accuracy:
0.5396 - val_loss: 1.1432 - val_accuracy: 0.5420
Epoch 158/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1554 - accuracy:
0.5431 - val_loss: 1.1425 - val_accuracy: 0.5423
Epoch 159/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1576 - accuracy:
0.5431 - val_loss: 1.1425 - val_accuracy: 0.5421
Epoch 160/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1532 - accuracy:
0.5433 - val_loss: 1.1419 - val_accuracy: 0.5444
```

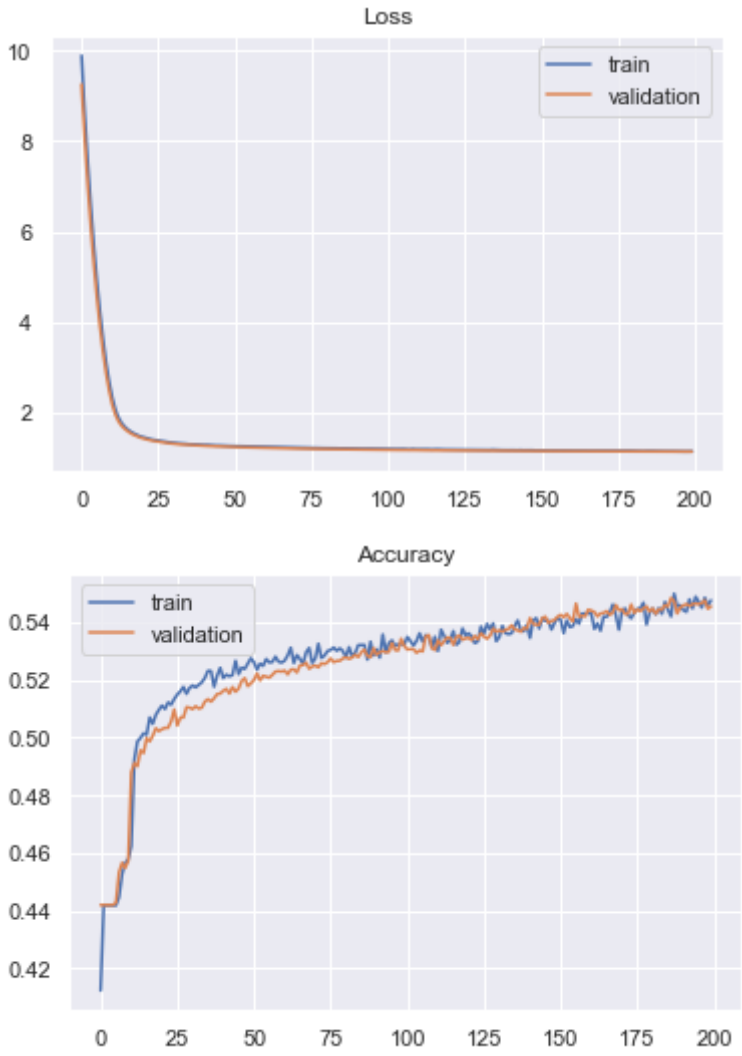
```
Epoch 161/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1531 - accuracy:
0.5430 - val_loss: 1.1419 - val_accuracy: 0.5441
Epoch 162/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1552 - accuracy:
0.5378 - val_loss: 1.1408 - val_accuracy: 0.5436
Epoch 163/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1521 - accuracy:
0.5396 - val_loss: 1.1407 - val_accuracy: 0.5421
Epoch 164/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1554 - accuracy:
0.5371 - val_loss: 1.1401 - val_accuracy: 0.5431
Epoch 165/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1520 - accuracy:
0.5420 - val_loss: 1.1395 - val_accuracy: 0.5433
Epoch 166/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1497 - accuracy:
0.5419 - val_loss: 1.1390 - val_accuracy: 0.5439
Epoch 167/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1526 - accuracy:
0.5433 - val_loss: 1.1396 - val_accuracy: 0.5426
Epoch 168/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1511 - accuracy:
0.5462 - val_loss: 1.1389 - val_accuracy: 0.5434
Epoch 169/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1511 - accuracy:
0.5425 - val_loss: 1.1385 - val_accuracy: 0.5460
Epoch 170/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1530 - accuracy:
0.5375 - val_loss: 1.1385 - val_accuracy: 0.5442
Epoch 171/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1504 - accuracy:
0.5441 - val_loss: 1.1385 - val_accuracy: 0.5446
Epoch 172/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1518 - accuracy:
0.5449 - val_loss: 1.1385 - val_accuracy: 0.5429
Epoch 173/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1467 - accuracy:
0.5425 - val_loss: 1.1390 - val_accuracy: 0.5429
Epoch 174/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1500 - accuracy:
0.5414 - val_loss: 1.1370 - val_accuracy: 0.5462
Epoch 175/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1484 - accuracy:
0.5434 - val_loss: 1.1386 - val_accuracy: 0.5433
Epoch 176/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1482 - accuracy:
0.5447 - val_loss: 1.1372 - val_accuracy: 0.5446
Epoch 177/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1483 - accuracy:
0.5449 - val_loss: 1.1378 - val_accuracy: 0.5439
Epoch 178/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1488 - accuracy:
0.5468 - val_loss: 1.1376 - val_accuracy: 0.5449
Epoch 179/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1467 - accuracy:
0.5393 - val_loss: 1.1360 - val_accuracy: 0.5455
Epoch 180/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1490 - accuracy:
0.5434 - val_loss: 1.1365 - val_accuracy: 0.5438
Epoch 181/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1459 - accuracy:
0.5448 - val_loss: 1.1355 - val_accuracy: 0.5449
Epoch 182/200
```

```
225/225 [==============================] - 3s 14ms/step - loss: 1.1449 - accuracy:
0.5428 - val_loss: 1.1372 - val_accuracy: 0.5429
Epoch 183/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1427 - accuracy:
0.5449 - val_loss: 1.1348 - val_accuracy: 0.5446
Epoch 184/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1412 - accuracy:
0.5430 - val_loss: 1.1346 - val_accuracy: 0.5444
Epoch 185/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1437 - accuracy:
0.5471 - val_loss: 1.1340 - val_accuracy: 0.5460
Epoch 186/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1452 - accuracy:
0.5444 - val_loss: 1.1340 - val_accuracy: 0.5455
Epoch 187/200
225/225 [==============================] - 3s 13ms/step - loss: 1.1436 - accuracy:
0.5421 - val_loss: 1.1335 - val_accuracy: 0.5485
Epoch 188/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1387 - accuracy:
0.5500 - val_loss: 1.1337 - val_accuracy: 0.5473
Epoch 189/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1451 - accuracy:
0.5456 - val_loss: 1.1368 - val_accuracy: 0.5431
Epoch 190/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1429 - accuracy:
0.5460 - val_loss: 1.1341 - val_accuracy: 0.5452
Epoch 191/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1392 - accuracy:
0.5442 - val_loss: 1.1347 - val_accuracy: 0.5459
Epoch 192/200
225/225 [==============================] - 4s 16ms/step - loss: 1.1409 - accuracy:
0.5437 - val_loss: 1.1326 - val_accuracy: 0.5464
Epoch 193/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1393 - accuracy:
0.5480 - val_loss: 1.1321 - val_accuracy: 0.5457
Epoch 194/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1378 - accuracy:
0.5449 - val_loss: 1.1323 - val_accuracy: 0.5464
Epoch 195/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1394 - accuracy:
0.5489 - val_loss: 1.1323 - val_accuracy: 0.5465
Epoch 196/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1387 - accuracy:
0.5472 - val_loss: 1.1324 - val_accuracy: 0.5464
Epoch 197/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1351 - accuracy:
0.5451 - val_loss: 1.1327 - val_accuracy: 0.5467
Epoch 198/200
225/225 [==============================] - 3s 14ms/step - loss: 1.1348 - accuracy:
0.5486 - val_loss: 1.1310 - val_accuracy: 0.5477
Epoch 199/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1379 - accuracy:
0.5458 - val_loss: 1.1344 - val_accuracy: 0.5447
Epoch 200/200
225/225 [==============================] - 3s 15ms/step - loss: 1.1371 - accuracy:
0.5477 - val_loss: 1.1333 - val_accuracy: 0.5455
Model training is finished at 1656250261.4146743 & it took 673.0 sec
```

In [159…

```
plt.title(f'Loss')
plt.plot(NN_model_hist.history['loss'], label='train')
plt.plot(NN_model_hist.history['val_loss'], label='validation')
plt.legend()
plt.show()
plt.title(f'Accuracy')
```

```
plt.plot(NN_model_hist.history['accuracy'], label='train')
plt.plot(NN_model_hist.history['val_accuracy'], label='validation')
plt.legend()
plt.show()
```



In [160…

```
### Model Evaluation

Evaluation_summary=pd.DataFrame()
print(f"Final training loss : {NN_model_hist.history['loss'][-1]}")
print(f"Final training accuracy:  {NN_model_hist.history['accuracy'][-1]}")
print(f"Final validation loss : {NN_model_hist.history['val_loss'][-1]}")
print(f"Final validation accuracy : {NN_model_hist.history['val_accuracy'][-1]}")
Evaluation_summary=Evaluation_summary.append(pd.DataFrame({ \
            'Train Loss':[NN_model_hist.history['loss'][-1]], 'Train Accuracy': [Nl
                'Validation Loss':[NN_model_hist.history['val_loss'][-1]], 'Validat

testLoss, testAccuracy = NN_model.evaluate(X_test, y_test)

y_pred = NN_model.predict(X_test)
y_pred=np.argmax(y_pred, axis=1)
y_test_=np.argmax(y_test, axis=1)
cm=confusion_matrix(y_test_, y_pred)
print(f'Confusion matrix:')
print(cm)
print(f'Classification Report:')
clReport=classification_report(y_test_, y_pred)
print(clReport)
```

```
Final training loss : 1.1370534896850586
Final training accuracy:  0.5476539134979248
Final validation loss : 1.133288860321045
Final validation accuracy : 0.5455432534217834
  1/193 [..............................] - ETA: 0s - loss: 1.0208 - accuracy: 0.59
38WARNING:tensorflow:Callbacks method `on_test_batch_end` is slow compared to the
batch time (batch time: 0.0000s vs `on_test_batch_end` time: 0.0157s). Check your
callbacks.
WARNING:tensorflow:Callbacks method `on_test_batch_end` is slow compared to the ba
tch time (batch time: 0.0000s vs `on_test_batch_end` time: 0.0157s). Check your ca
llbacks.
193/193 [==============================] - 1s 7ms/step - loss: 1.1333 - accuracy:
0.5455
Confusion matrix:
[[ 301   66    0   54    5]
 [ 183  135    0  194   26]
 [  60   86    0  358  151]
 [  20   59    0  625 1108]
 [   9   18    0  397 2293]]
Classification Report:
              precision    recall  f1-score   support

           0       0.53      0.71      0.60       426
           1       0.37      0.25      0.30       538
           2       0.00      0.00      0.00       655
           3       0.38      0.34      0.36      1812
           4       0.64      0.84      0.73      2717

    accuracy                           0.55      6148
   macro avg       0.38      0.43      0.40      6148
weighted avg       0.46      0.55      0.50      6148
```

Observation: Accuracy reduced marginally in this iteration. Issue with rating '3' re-occured. Adding a hidden layer had adverse impact on the model.

Hyper Parameter Tuning using Keras Tuner to find optimal number of layers, number of neuron in each layer & learning rate.

In [124…

```
from kerastuner.tuners import RandomSearch
def create_model(hp):
    model = Sequential()
    # The Input Layer :
    model.add(Dense(128, input_dim = 128, activation='relu'))
    for i in range(hp.Int('num_layers', 5, 8)):
        model.add(Dense(units=hp.Int('units_' + str(i),
                                     min_value=16,
                                     max_value=256,
                                     step=32),
                                activation='relu', kernel_regularizer=regularizers.
                  activity_regularizer=regularizers.l1(0.001)))
    model.add(Dense(5, activation='softmax'))
    model.compile(
        optimizer=Adam(
            hp.Choice('learning_rate', [0.0001, 0.0002])),
        loss='categorical_crossentropy',
        metrics=['accuracy'])
    return model
```

In [125…

```
tuner = RandomSearch(
```

```
    create_model,
    objective='val_accuracy',
    max_trials=5,
    executions_per_trial=3,
    directory='HPOptimization',
    project_name='Trip Advisor Sentiment')

tuner.search_space_summary()
```

```
Search space summary
Default search space size: 7
num_layers (Int)
{'default': None, 'conditions': [], 'min_value': 5, 'max_value': 8, 'step': 1, 'sa
mpling': None}
units_0 (Int)
{'default': None, 'conditions': [], 'min_value': 16, 'max_value': 256, 'step': 32,
'sampling': None}
units_1 (Int)
{'default': None, 'conditions': [], 'min_value': 16, 'max_value': 256, 'step': 32,
'sampling': None}
units_2 (Int)
{'default': None, 'conditions': [], 'min_value': 16, 'max_value': 256, 'step': 32,
'sampling': None}
units_3 (Int)
{'default': None, 'conditions': [], 'min_value': 16, 'max_value': 256, 'step': 32,
'sampling': None}
units_4 (Int)
{'default': None, 'conditions': [], 'min_value': 16, 'max_value': 256, 'step': 32,
'sampling': None}
learning_rate (Choice)
{'default': 0.0001, 'conditions': [], 'values': [0.0001, 0.0002], 'ordered': True}
```

In [126…

```
tuner.search(X_train, y_train,
             epochs=200, batch_size=64,
             validation_data=(X_test, y_test))
```

```
Trial 5 Complete [00h 18m 40s]
val_accuracy: 0.5571459531784058

Best val_accuracy So Far: 0.56023641427358
Total elapsed time: 01h 33m 43s
INFO:tensorflow:Oracle triggered exit
INFO:tensorflow:Oracle triggered exit
```

In [127…

```
tuner.results_summary()
```

```
Results summary
Results in HPOptimization\Trip Advisor Sentiment
Showing 10 best trials
Objective(name='val_accuracy', direction='max')
Trial summary
Hyperparameters:
num_layers: 6
units_0: 48
units_1: 16
units_2: 176
units_3: 144
units_4: 112
learning_rate: 0.0002
units_5: 144
units_6: 144
units_7: 112
Score: 0.56023641427358
Trial summary
Hyperparameters:
num_layers: 6
units_0: 240
units_1: 112
units_2: 112
units_3: 112
units_4: 48
learning_rate: 0.0001
units_5: 16
units_6: 176
Score: 0.5596399903297424
Trial summary
Hyperparameters:
num_layers: 7
units_0: 240
units_1: 112
units_2: 144
units_3: 144
units_4: 16
learning_rate: 0.0001
units_5: 208
units_6: 144
units_7: 16
Score: 0.5571459531784058
Trial summary
Hyperparameters:
num_layers: 7
units_0: 208
units_1: 176
units_2: 80
units_3: 240
units_4: 112
learning_rate: 0.0002
units_5: 16
units_6: 16
Score: 0.48080676794052124
Trial summary
Hyperparameters:
num_layers: 8
units_0: 240
units_1: 240
units_2: 240
units_3: 176
units_4: 208
learning_rate: 0.0002
units_5: 16
```

```
units_6: 144
units_7: 16
Score: 0.44193235039711
```

In [128…
```
tuner.get_best_models
```

Out[128]:
```
<bound method Tuner.get_best_models of <keras_tuner.tuners.randomsearch.RandomSear
ch object at 0x00000204F340E3C8>>
```

In [164…
```
best_model = tuner.get_best_models()[0]
best_model.build(X_train.shape)
best_model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
dense (Dense)                (None, 128)               16512
_________________________________________________________________
dense_1 (Dense)              (None, 48)                6192
_________________________________________________________________
dense_2 (Dense)              (None, 16)                784
_________________________________________________________________
dense_3 (Dense)              (None, 176)               2992
_________________________________________________________________
dense_4 (Dense)              (None, 144)               25488
_________________________________________________________________
dense_5 (Dense)              (None, 112)               16240
_________________________________________________________________
dense_6 (Dense)              (None, 144)               16272
_________________________________________________________________
dense_7 (Dense)              (None, 5)                 725
=================================================================
Total params: 85,205
Trainable params: 85,205
Non-trainable params: 0
_________________________________________________________________
```

Observation: Accuracy of best model based on keras tuner with provided set of hyper parameter is 0.56. Model 8 shows similar performance and accuracy. We can further optimize this by providing different set of hyperparameters given more time and larger set of data

Final Observations

- Learning Rate: The learning rate was varied between 0.0001 to 0.000025. It was observed that the model performed well at 0.00004.
- Regularization: Removing regularization, the model is failing while validation.
- Dropout: The drop out at earlier hidden layer has better impact on the model. The dropout rate performs better at 0.6
- Hidden Layers: Increasing hidden layers from 6 to 7 did not improve the model. Thus additional hidden layers may not improve model.
- Model Iteration #8 performed the best and its accuracy is 0.55 for validation.

In [ ]: