

```
In [ ]: # import some Libraries
import numpy as np
import tensorflow as tf
from sklearn.model_selection import train_test_split
import matplotlib.pyplot as plt
```

```
In [ ]: # Load the dataset
num_classes = 10
cifar10 = tf.keras.datasets.cifar10
(x_learn, y_learn), (x_test, y_test) = cifar10.load_data()

# Normalize the data in [0 1]
print("Normalizing training set..")
x_learn = np.asarray(x_learn, dtype=np.float32) / 255 # Normalizing training set
print("Normalizing test set..")
x_test = np.asarray(x_test, dtype=np.float32) / 255 # Normalizing test set
```

Normalizing training set..  
Normalizing test set..

```
In [ ]: # split in training and validation
x_train, x_val, y_train, y_val = train_test_split(x_learn, y_learn, test_size=0.25, rando
```

```
In [ ]: # Standardizing the data
def standardize_dataset(X):
    image_means = []
    image_stds = []

    for image in X:
        image_means.append(np.mean(image)) # Computing the image mean
        image_stds.append(np.std(image)) # Computing the image standard deviation

    dataset_mean = np.mean(image_means) # Computing the dataset mean
    dataset_std = np.mean(image_stds) # Computing the dataset standard deviation
    return [dataset_mean, dataset_std] # For every image we subtract to it the dataset mean and divide by the dataset std

dataset_mean, dataset_std = standardize_dataset(x_train)

print("Standardizing training set..")
x_train = (x_train-dataset_mean)/dataset_std # Standardizing the training set
print("Standardizing validation set..")
x_val = (x_val-dataset_mean)/dataset_std # Standardizing the test set
print("Standardizing test set..")
x_test = (x_test-dataset_mean)/dataset_std # Standardizing the test set

# one hot encode target values
y_train = tf.keras.utils.to_categorical(y_train)
y_val = tf.keras.utils.to_categorical(y_val)
y_test = tf.keras.utils.to_categorical(y_test)

print("Size of the training set")
print("x_train", x_train.shape)
print("y_train", y_train.shape)

print("Size of the validation set")
print("x_val", x_val.shape)
print("y_val", y_val.shape)
```

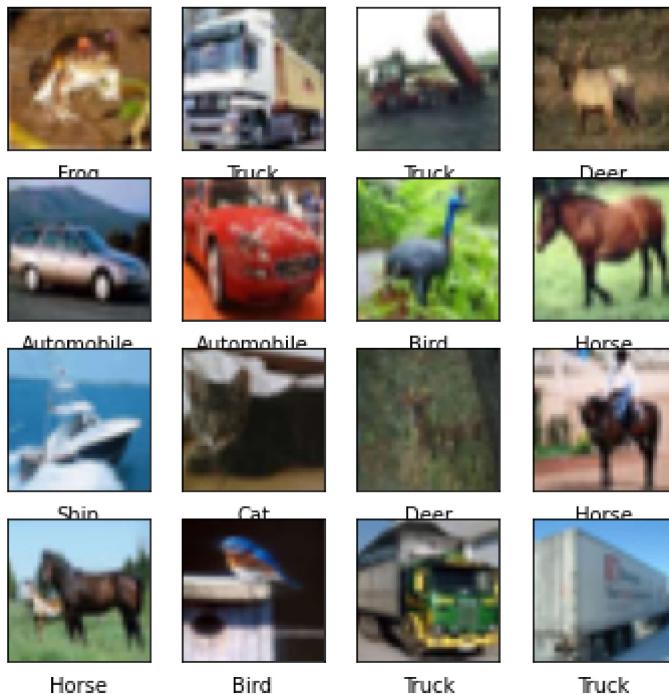
```
print("Size of the test set")
print("x_test", x_test.shape)
print("y_test", y_test.shape)
```

```
Standardizing training set..
Standardizing validation set..
Standardizing test set..
Size of the training set
x_train (37500, 32, 32, 3)
y_train (37500, 10)
Size of the validation set
x_val (12500, 32, 32, 3)
y_val (12500, 10)
Size of the test set
x_test (10000, 32, 32, 3)
y_test (10000, 10)
```

## Plot some sample from the training set

```
In [ ]: class_names = ['Airplane', 'Automobile', 'Bird', 'Cat', 'Deer',
                    'Dog', 'Frog', 'Horse', 'Ship', 'Truck']

plt.figure(figsize=(6,6))
for i in range(16):
    plt.subplot(4,4,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(x_learn[i], cmap=plt.cm.binary)
    plt.xlabel(class_names[y_learn[i,0]])
plt.show()
```



```
In [ ]: from tensorflow import keras
from keras.layers import Flatten
from keras.models import Sequential
```

```
from keras.layers import Dense
from keras import layers,regularizers
from keras.layers import Dropout,BatchNormalization

tf.keras.backend.clear_session()
np.random.seed(42)
tf.random.set_seed(42)

l2_norm = .0001

# Add a Dense layer with number of neurons equal to the number of classes, with softmax
model = Sequential()
model.add(Flatten(input_shape=(32,32,3)))
## you may add here dense layers, using for instance model.add(Dense(64, activation='relu'))
model.add(Dense(768,activation='relu',kernel_initializer='he_normal',
               kernel_regularizer=regularizers.l2(l2_norm)))
model.add(BatchNormalization())
model.add(Dropout(.2))
model.add(Dense(384,activation='relu',kernel_initializer='he_normal',
               kernel_regularizer=keras.regularizers.l2(l2_norm)))
model.add(BatchNormalization())
model.add(Dropout(.5))
model.add(Dense(num_classes, activation='softmax'))
```

```
In [ ]: from keras.optimizers import Adam, SGD, Adadelta, Adagrad, Adamax, Nadam, RMSprop  
  
sgd = SGD(learning_rate=0.001, momentum=0.09, decay=0.0000, nesterov=True)  
loss = ['categorical_crossentropy']  
  
metrics = ['accuracy']
```

```
In [ ]: model.compile(optimizer=sgd,  
                      loss=loss[0],  
                      metrics=[metrics[0]]),  
                  )
```

```
In [ ]: batch_size = 128
epochs = 200
from tensorflow import keras
from keras.callbacks import ModelCheckpoint, EarlyStopping
import os

es_callback = EarlyStopping(monitor='val_accuracy', patience=3, verbose=1)

checkpoint_path = "output1/cp.ckpt"
checkpoint_dir = os.path.dirname(checkpoint_path)
cp_callback = ModelCheckpoint(checkpoint_path, monitor='val_accuracy', save_best_only=True)

history = model.fit(x_train, y_train, batch_size=batch_size, validation_data =(x_val,
callbacks=[es_callback, cp_callback]))
```

Epoch 1/200  
293/293 [=====] - ETA: 0s - loss: 3.2264 - accuracy: 0.1911I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 45ms/step - loss: 3.2264 - accuracy: 0.1911 - val\_loss: 2.2748 - val\_accuracy: 0.3107  
Epoch 2/200  
292/293 [=====>.] - ETA: 0s - loss: 2.7906 - accuracy: 0.2574I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 2.7913 - accuracy: 0.2573 - val\_loss: 2.1151 - val\_accuracy: 0.3606  
Epoch 3/200  
293/293 [=====] - ETA: 0s - loss: 2.6263 - accuracy: 0.2877I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 2.6263 - accuracy: 0.2877 - val\_loss: 2.0404 - val\_accuracy: 0.3834  
Epoch 4/200  
293/293 [=====] - ETA: 0s - loss: 2.5211 - accuracy: 0.3103I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 40ms/step - loss: 2.5211 - accuracy: 0.3103 - val\_loss: 1.9888 - val\_accuracy: 0.3993  
Epoch 5/200  
293/293 [=====] - ETA: 0s - loss: 2.4404 - accuracy: 0.3201I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 46ms/step - loss: 2.4404 - accuracy: 0.3201 - val\_loss: 1.9463 - val\_accuracy: 0.4128  
Epoch 6/200  
292/293 [=====>.] - ETA: 0s - loss: 2.3665 - accuracy: 0.3372I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 15s 51ms/step - loss: 2.3667 - accuracy: 0.3370 - val\_loss: 1.9209 - val\_accuracy: 0.4204  
Epoch 7/200  
292/293 [=====>.] - ETA: 0s - loss: 2.3151 - accuracy: 0.3422I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 47ms/step - loss: 2.3144 - accuracy: 0.3423 - val\_loss: 1.8943 - val\_accuracy: 0.4255  
Epoch 8/200  
293/293 [=====] - ETA: 0s - loss: 2.2645 - accuracy: 0.3519I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 45ms/step - loss: 2.2645 - accuracy: 0.3519 - val\_loss: 1.8776 - val\_accuracy: 0.4317  
Epoch 9/200  
293/293 [=====] - ETA: 0s - loss: 2.2238 - accuracy: 0.3575I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 2.2238 - accuracy: 0.3575 - val\_loss: 1.8561 - val\_accuracy: 0.4357  
Epoch 10/200  
293/293 [=====] - ETA: 0s - loss: 2.1865 - accuracy: 0.3664I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 48ms/step - loss: 2.1865 - accuracy: 0.3664 - val\_loss: 1.8419 - val\_accuracy: 0.4394  
Epoch 11/200  
293/293 [=====] - ETA: 0s - loss: 2.1406 - accuracy: 0.3751I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 48ms/step - loss: 2.1406 - accuracy: 0.3751 - val\_loss: 1.8300 - val\_accuracy: 0.4428  
Epoch 12/200  
293/293 [=====] - ETA: 0s - loss: 2.1258 - accuracy: 0.3764I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 47ms/step - loss: 2.1258 - accuracy: 0.3764 - val\_loss: 1.8152 - val\_accuracy: 0.4451

Epoch 13/200  
292/293 [=====>.] - ETA: 0s - loss: 2.0957 - accuracy: 0.3838I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 2.0965 - accuracy: 0.3834 - val\_loss: 1.8067 - val\_accuracy: 0.4484  
Epoch 14/200  
292/293 [=====>.] - ETA: 0s - loss: 2.0715 - accuracy: 0.3849I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 2.0717 - accuracy: 0.3849 - val\_loss: 1.7950 - val\_accuracy: 0.4515  
Epoch 15/200  
293/293 [=====] - ETA: 0s - loss: 2.0474 - accuracy: 0.3925I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 2.0474 - accuracy: 0.3925 - val\_loss: 1.7862 - val\_accuracy: 0.4543  
Epoch 16/200  
292/293 [=====>.] - ETA: 0s - loss: 2.0182 - accuracy: 0.3972I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 41ms/step - loss: 2.0187 - accuracy: 0.3971 - val\_loss: 1.7775 - val\_accuracy: 0.4572  
Epoch 17/200  
292/293 [=====>.] - ETA: 0s - loss: 1.9949 - accuracy: 0.4029I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 1.9948 - accuracy: 0.4029 - val\_loss: 1.7706 - val\_accuracy: 0.4590  
Epoch 18/200  
293/293 [=====] - ETA: 0s - loss: 1.9830 - accuracy: 0.4047I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 45ms/step - loss: 1.9830 - accuracy: 0.4047 - val\_loss: 1.7627 - val\_accuracy: 0.4605  
Epoch 19/200  
292/293 [=====>.] - ETA: 0s - loss: 1.9581 - accuracy: 0.4119I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 46ms/step - loss: 1.9588 - accuracy: 0.4117 - val\_loss: 1.7559 - val\_accuracy: 0.4626  
Epoch 20/200  
293/293 [=====] - ETA: 0s - loss: 1.9468 - accuracy: 0.4142I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 41ms/step - loss: 1.9468 - accuracy: 0.4142 - val\_loss: 1.7507 - val\_accuracy: 0.4645  
Epoch 21/200  
293/293 [=====] - ETA: 0s - loss: 1.9244 - accuracy: 0.4192I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.9244 - accuracy: 0.4192 - val\_loss: 1.7450 - val\_accuracy: 0.4688  
Epoch 22/200  
292/293 [=====>.] - ETA: 0s - loss: 1.9171 - accuracy: 0.4181I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 41ms/step - loss: 1.9167 - accuracy: 0.4182 - val\_loss: 1.7394 - val\_accuracy: 0.4703  
Epoch 23/200  
293/293 [=====] - ETA: 0s - loss: 1.8969 - accuracy: 0.4242I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.8969 - accuracy: 0.4242 - val\_loss: 1.7336 - val\_accuracy: 0.4720  
Epoch 24/200  
293/293 [=====] - ETA: 0s - loss: 1.8778 - accuracy: 0.4300I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 46ms/step - loss: 1.8778 - accuracy: 0.4300 - val\_loss: 1.7293 - val\_accuracy: 0.4749

Epoch 25/200  
293/293 [=====>.] - 12s 40ms/step - loss: 1.8785 - accuracy: 0.4333 - val\_loss: 1.7248 - val\_accuracy: 0.4746  
Epoch 26/200  
292/293 [=====>.] - ETA: 0s - loss: 1.8649 - accuracy: 0.4320I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 45ms/step - loss: 1.8648 - accuracy: 0.4321 - val\_loss: 1.7207 - val\_accuracy: 0.4764  
Epoch 27/200  
293/293 [=====] - 12s 40ms/step - loss: 1.8537 - accuracy: 0.4361 - val\_loss: 1.7163 - val\_accuracy: 0.4758  
Epoch 28/200  
293/293 [=====] - ETA: 0s - loss: 1.8364 - accuracy: 0.4401I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 45ms/step - loss: 1.8364 - accuracy: 0.4401 - val\_loss: 1.7113 - val\_accuracy: 0.4775  
Epoch 29/200  
293/293 [=====] - ETA: 0s - loss: 1.8342 - accuracy: 0.4433I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 46ms/step - loss: 1.8342 - accuracy: 0.4433 - val\_loss: 1.7066 - val\_accuracy: 0.4785  
Epoch 30/200  
293/293 [=====] - 12s 41ms/step - loss: 1.8194 - accuracy: 0.4446 - val\_loss: 1.7041 - val\_accuracy: 0.4783  
Epoch 31/200  
293/293 [=====] - ETA: 0s - loss: 1.8116 - accuracy: 0.4450I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 47ms/step - loss: 1.8116 - accuracy: 0.4450 - val\_loss: 1.7020 - val\_accuracy: 0.4807  
Epoch 32/200  
292/293 [=====>.] - ETA: 0s - loss: 1.8001 - accuracy: 0.4503I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 48ms/step - loss: 1.7999 - accuracy: 0.4504 - val\_loss: 1.6966 - val\_accuracy: 0.4810  
Epoch 33/200  
293/293 [=====] - ETA: 0s - loss: 1.7931 - accuracy: 0.4541I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 48ms/step - loss: 1.7931 - accuracy: 0.4541 - val\_loss: 1.6949 - val\_accuracy: 0.4831  
Epoch 34/200  
293/293 [=====] - 12s 41ms/step - loss: 1.7846 - accuracy: 0.4579 - val\_loss: 1.6906 - val\_accuracy: 0.4831  
Epoch 35/200  
293/293 [=====] - 12s 40ms/step - loss: 1.7763 - accuracy: 0.4547 - val\_loss: 1.6884 - val\_accuracy: 0.4826  
Epoch 36/200  
293/293 [=====] - ETA: 0s - loss: 1.7678 - accuracy: 0.4597I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 46ms/step - loss: 1.7678 - accuracy: 0.4597 - val\_loss: 1.6860 - val\_accuracy: 0.4834  
Epoch 37/200  
293/293 [=====] - ETA: 0s - loss: 1.7672 - accuracy: 0.4610I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.7672 - accuracy: 0.4610 - val\_loss: 1.6819 - val\_accuracy: 0.4854  
Epoch 38/200  
293/293 [=====] - 11s 36ms/step - loss: 1.7596 - accuracy: 0.4652 - val\_loss: 1.6803 - val\_accuracy: 0.4838  
Epoch 39/200  
293/293 [=====] - ETA: 0s - loss: 1.7473 - accuracy: 0.4652I

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NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 12s 41ms/step - loss: 1.7473 - accuracy: 0.4652 - val_loss: 1.6769 - val_accuracy: 0.4855
Epoch 40/200
293/293 [=====] - 11s 37ms/step - loss: 1.7418 - accuracy: 0.4671 - val_loss: 1.6762 - val_accuracy: 0.4854
Epoch 41/200
293/293 [=====] - ETA: 0s - loss: 1.7367 - accuracy: 0.4690I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 13s 44ms/step - loss: 1.7367 - accuracy: 0.4690 - val_loss: 1.6730 - val_accuracy: 0.4873
Epoch 42/200
292/293 [=====>.] - ETA: 0s - loss: 1.7281 - accuracy: 0.4714I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 13s 45ms/step - loss: 1.7280 - accuracy: 0.4713 - val_loss: 1.6702 - val_accuracy: 0.4885
Epoch 43/200
293/293 [=====] - ETA: 0s - loss: 1.7265 - accuracy: 0.4755I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 13s 45ms/step - loss: 1.7265 - accuracy: 0.4755 - val_loss: 1.6688 - val_accuracy: 0.4901
Epoch 44/200
292/293 [=====>.] - ETA: 0s - loss: 1.7209 - accuracy: 0.4765I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 13s 44ms/step - loss: 1.7211 - accuracy: 0.4765 - val_loss: 1.6648 - val_accuracy: 0.4913
Epoch 45/200
293/293 [=====] - 11s 38ms/step - loss: 1.7171 - accuracy: 0.4741 - val_loss: 1.6635 - val_accuracy: 0.4898
Epoch 46/200
293/293 [=====] - ETA: 0s - loss: 1.7074 - accuracy: 0.4770I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 13s 45ms/step - loss: 1.7074 - accuracy: 0.4770 - val_loss: 1.6614 - val_accuracy: 0.4914
Epoch 47/200
293/293 [=====] - ETA: 0s - loss: 1.7053 - accuracy: 0.4792I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 12s 41ms/step - loss: 1.7053 - accuracy: 0.4792 - val_loss: 1.6595 - val_accuracy: 0.4929
Epoch 48/200
292/293 [=====>.] - ETA: 0s - loss: 1.6945 - accuracy: 0.4850I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 15s 52ms/step - loss: 1.6944 - accuracy: 0.4851 - val_loss: 1.6566 - val_accuracy: 0.4954
Epoch 49/200
293/293 [=====] - 13s 44ms/step - loss: 1.6965 - accuracy: 0.4834 - val_loss: 1.6561 - val_accuracy: 0.4954
Epoch 50/200
293/293 [=====] - 11s 38ms/step - loss: 1.6878 - accuracy: 0.4852 - val_loss: 1.6539 - val_accuracy: 0.4946
Epoch 51/200
293/293 [=====] - ETA: 0s - loss: 1.6832 - accuracy: 0.4881I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 13s 46ms/step - loss: 1.6832 - accuracy: 0.4881 - val_loss: 1.6503 - val_accuracy: 0.4975
Epoch 52/200
293/293 [=====] - ETA: 0s - loss: 1.6773 - accuracy: 0.4879I
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets
293/293 [=====] - 15s 51ms/step - loss: 1.6773 - accuracy: 0.4879 - val_loss: 1.6487 - val_accuracy: 0.4982
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Epoch 53/200  
293/293 [=====] - ETA: 0s - loss: 1.6724 - accuracy: 0.4902I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 14s 47ms/step - loss: 1.6724 - accuracy: 0.4902 - val\_loss: 1.6472 - val\_accuracy: 0.5002  
Epoch 54/200  
293/293 [=====] - 11s 39ms/step - loss: 1.6691 - accuracy: 0.4924 - val\_loss: 1.6454 - val\_accuracy: 0.4998  
Epoch 55/200  
293/293 [=====] - 12s 40ms/step - loss: 1.6741 - accuracy: 0.4883 - val\_loss: 1.6438 - val\_accuracy: 0.4995  
Epoch 56/200  
293/293 [=====] - ETA: 0s - loss: 1.6608 - accuracy: 0.4944I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 43ms/step - loss: 1.6608 - accuracy: 0.4944 - val\_loss: 1.6418 - val\_accuracy: 0.5016  
Epoch 57/200  
292/293 [=====>.] - ETA: 0s - loss: 1.6616 - accuracy: 0.4935I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.6614 - accuracy: 0.4936 - val\_loss: 1.6401 - val\_accuracy: 0.5024  
Epoch 58/200  
293/293 [=====] - 11s 36ms/step - loss: 1.6601 - accuracy: 0.4948 - val\_loss: 1.6379 - val\_accuracy: 0.5021  
Epoch 59/200  
293/293 [=====] - ETA: 0s - loss: 1.6501 - accuracy: 0.4980I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.6501 - accuracy: 0.4980 - val\_loss: 1.6363 - val\_accuracy: 0.5039  
Epoch 60/200  
293/293 [=====] - ETA: 0s - loss: 1.6504 - accuracy: 0.4971I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.6504 - accuracy: 0.4971 - val\_loss: 1.6341 - val\_accuracy: 0.5050  
Epoch 61/200  
293/293 [=====] - ETA: 0s - loss: 1.6385 - accuracy: 0.4991I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.6385 - accuracy: 0.4991 - val\_loss: 1.6323 - val\_accuracy: 0.5054  
Epoch 62/200  
293/293 [=====] - ETA: 0s - loss: 1.6367 - accuracy: 0.5011I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.6367 - accuracy: 0.5011 - val\_loss: 1.6308 - val\_accuracy: 0.5080  
Epoch 63/200  
293/293 [=====] - 11s 36ms/step - loss: 1.6370 - accuracy: 0.5016 - val\_loss: 1.6295 - val\_accuracy: 0.5073  
Epoch 64/200  
293/293 [=====] - ETA: 0s - loss: 1.6346 - accuracy: 0.5027I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 45ms/step - loss: 1.6346 - accuracy: 0.5027 - val\_loss: 1.6276 - val\_accuracy: 0.5086  
Epoch 65/200  
293/293 [=====] - ETA: 0s - loss: 1.6305 - accuracy: 0.5035I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 43ms/step - loss: 1.6305 - accuracy: 0.5035 - val\_loss: 1.6258 - val\_accuracy: 0.5092  
Epoch 66/200  
293/293 [=====] - 10s 36ms/step - loss: 1.6297 - accuracy: 0.5036 - val\_loss: 1.6251 - val\_accuracy: 0.5088

Epoch 67/200  
293/293 [=====] - ETA: 0s - loss: 1.6169 - accuracy: 0.5106I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.6169 - accuracy: 0.5106 - val\_loss: 1.6227 - val\_accuracy: 0.5104  
Epoch 68/200  
293/293 [=====] - ETA: 0s - loss: 1.6197 - accuracy: 0.5049I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.6197 - accuracy: 0.5049 - val\_loss: 1.6221 - val\_accuracy: 0.5113  
Epoch 69/200  
293/293 [=====] - 11s 38ms/step - loss: 1.6204 - accuracy: 0.5096 - val\_loss: 1.6205 - val\_accuracy: 0.5089  
Epoch 70/200  
293/293 [=====] - 11s 37ms/step - loss: 1.6129 - accuracy: 0.5094 - val\_loss: 1.6186 - val\_accuracy: 0.5108  
Epoch 71/200  
293/293 [=====] - ETA: 0s - loss: 1.6106 - accuracy: 0.5106I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 1.6106 - accuracy: 0.5106 - val\_loss: 1.6163 - val\_accuracy: 0.5118  
Epoch 72/200  
293/293 [=====] - ETA: 0s - loss: 1.6080 - accuracy: 0.5073I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.6080 - accuracy: 0.5073 - val\_loss: 1.6144 - val\_accuracy: 0.5134  
Epoch 73/200  
293/293 [=====] - 11s 37ms/step - loss: 1.6033 - accuracy: 0.5142 - val\_loss: 1.6138 - val\_accuracy: 0.5131  
Epoch 74/200  
293/293 [=====] - ETA: 0s - loss: 1.5996 - accuracy: 0.5170I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.5996 - accuracy: 0.5170 - val\_loss: 1.6118 - val\_accuracy: 0.5145  
Epoch 75/200  
293/293 [=====] - 11s 38ms/step - loss: 1.5963 - accuracy: 0.5159 - val\_loss: 1.6116 - val\_accuracy: 0.5141  
Epoch 76/200  
293/293 [=====] - ETA: 0s - loss: 1.5963 - accuracy: 0.5162I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 1.5963 - accuracy: 0.5162 - val\_loss: 1.6091 - val\_accuracy: 0.5162  
Epoch 77/200  
293/293 [=====] - ETA: 0s - loss: 1.5916 - accuracy: 0.5184I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 45ms/step - loss: 1.5916 - accuracy: 0.5184 - val\_loss: 1.6073 - val\_accuracy: 0.5165  
Epoch 78/200  
293/293 [=====] - 12s 39ms/step - loss: 1.5878 - accuracy: 0.5176 - val\_loss: 1.6054 - val\_accuracy: 0.5155  
Epoch 79/200  
293/293 [=====] - ETA: 0s - loss: 1.5815 - accuracy: 0.5227I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 1.5815 - accuracy: 0.5227 - val\_loss: 1.6051 - val\_accuracy: 0.5171  
Epoch 80/200  
293/293 [=====] - 11s 37ms/step - loss: 1.5799 - accuracy: 0.5218 - val\_loss: 1.6049 - val\_accuracy: 0.5167  
Epoch 81/200  
293/293 [=====] - 12s 41ms/step - loss: 1.5783 - accuracy:

0.5228 - val\_loss: 1.6026 - val\_accuracy: 0.5166  
Epoch 82/200  
293/293 [=====] - ETA: 0s - loss: 1.5724 - accuracy: 0.5226I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 44ms/step - loss: 1.5724 - accuracy:  
0.5226 - val\_loss: 1.6011 - val\_accuracy: 0.5182  
Epoch 83/200  
293/293 [=====] - ETA: 0s - loss: 1.5723 - accuracy: 0.5240I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.5723 - accuracy:  
0.5240 - val\_loss: 1.6000 - val\_accuracy: 0.5186  
Epoch 84/200  
293/293 [=====] - ETA: 0s - loss: 1.5692 - accuracy: 0.5253I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.5692 - accuracy:  
0.5253 - val\_loss: 1.5975 - val\_accuracy: 0.5200  
Epoch 85/200  
293/293 [=====] - 11s 38ms/step - loss: 1.5629 - accuracy:  
0.5272 - val\_loss: 1.5970 - val\_accuracy: 0.5195  
Epoch 86/200  
293/293 [=====] - 11s 38ms/step - loss: 1.5628 - accuracy:  
0.5273 - val\_loss: 1.5962 - val\_accuracy: 0.5199  
Epoch 87/200  
293/293 [=====] - ETA: 0s - loss: 1.5568 - accuracy: 0.5303I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.5568 - accuracy:  
0.5303 - val\_loss: 1.5942 - val\_accuracy: 0.5212  
Epoch 88/200  
293/293 [=====] - 11s 36ms/step - loss: 1.5565 - accuracy:  
0.5306 - val\_loss: 1.5934 - val\_accuracy: 0.5207  
Epoch 89/200  
293/293 [=====] - ETA: 0s - loss: 1.5526 - accuracy: 0.5344I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 41ms/step - loss: 1.5526 - accuracy:  
0.5344 - val\_loss: 1.5923 - val\_accuracy: 0.5214  
Epoch 90/200  
293/293 [=====] - 11s 38ms/step - loss: 1.5496 - accuracy:  
0.5339 - val\_loss: 1.5921 - val\_accuracy: 0.5199  
Epoch 91/200  
293/293 [=====] - ETA: 0s - loss: 1.5480 - accuracy: 0.5348I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.5480 - accuracy:  
0.5348 - val\_loss: 1.5911 - val\_accuracy: 0.5217  
Epoch 92/200  
293/293 [=====] - 11s 38ms/step - loss: 1.5384 - accuracy:  
0.5411 - val\_loss: 1.5886 - val\_accuracy: 0.5217  
Epoch 93/200  
293/293 [=====] - ETA: 0s - loss: 1.5461 - accuracy: 0.5322I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 12s 42ms/step - loss: 1.5461 - accuracy:  
0.5322 - val\_loss: 1.5885 - val\_accuracy: 0.5220  
Epoch 94/200  
293/293 [=====] - 11s 38ms/step - loss: 1.5388 - accuracy:  
0.5357 - val\_loss: 1.5874 - val\_accuracy: 0.5218  
Epoch 95/200  
293/293 [=====] - ETA: 0s - loss: 1.5371 - accuracy: 0.5354I  
NFO:tensorflow:Assets written to: output1\cp.ckpt\assets  
293/293 [=====] - 13s 43ms/step - loss: 1.5371 - accuracy:  
0.5354 - val\_loss: 1.5863 - val\_accuracy: 0.5246  
Epoch 96/200

```
293/293 [=====] - 11s 39ms/step - loss: 1.5351 - accuracy: 0.5379 - val_loss: 1.5843 - val_accuracy: 0.5239
Epoch 97/200
293/293 [=====] - 12s 40ms/step - loss: 1.5343 - accuracy: 0.5373 - val_loss: 1.5836 - val_accuracy: 0.5233
Epoch 98/200
293/293 [=====] - 11s 37ms/step - loss: 1.5306 - accuracy: 0.5370 - val_loss: 1.5813 - val_accuracy: 0.5232
Epoch 98: early stopping
```

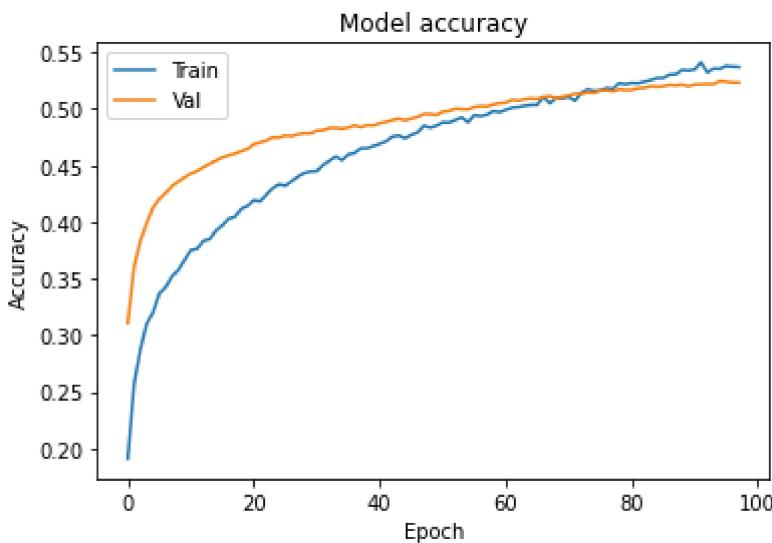
```
In [ ]: keras.models.load_model('output1\\cp.ckpt')
```

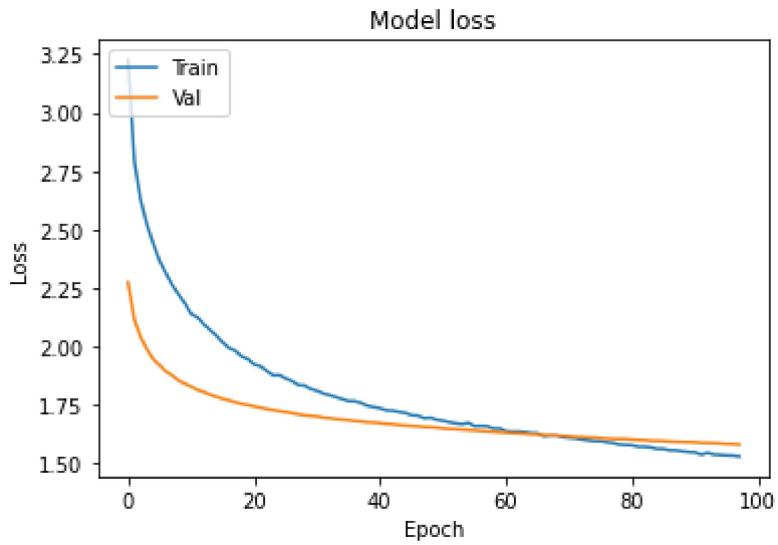
```
Out[ ]: <keras.engine.sequential.Sequential at 0x249962e8f70>
```

```
In [ ]: def plot_history(history):
    # Plot training & validation accuracy values
    plt.plot(history.history['accuracy'])
    plt.plot(history.history['val_accuracy'])
    plt.title('Model accuracy')
    plt.ylabel('Accuracy')
    plt.xlabel('Epoch')
    plt.legend(['Train', 'Val'], loc='upper left')
    plt.show()

    # Plot training & validation loss values
    plt.plot(history.history['loss'])
    plt.plot(history.history['val_loss'])
    plt.title('Model loss')
    plt.ylabel('Loss')
    plt.xlabel('Epoch')
    plt.legend(['Train', 'Val'], loc='upper left')
    plt.show()
```

```
In [ ]: plot_history(history)
```





## Evaluate the model

```
In [ ]: __, train_acc = model.evaluate(x_train, y_train, verbose=1)
__, val_acc = model.evaluate(x_val, y_val, verbose=1)

__, test_acc = model.evaluate(x_test, y_test, verbose=1)
print('Train: %.3f, val: %.3f, Test: %.3f' % (train_acc, val_acc, test_acc))

1172/1172 [=====] - 10s 8ms/step - loss: 1.3386 - accuracy: 0.6242
391/391 [=====] - 3s 8ms/step - loss: 1.5813 - accuracy: 0.5232
313/313 [=====] - 3s 8ms/step - loss: 1.5698 - accuracy: 0.5229
Train: 0.624, val: 0.523, Test: 0.523
```