CS5720

Neural Networks & Deep Learning - ICP-7

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Github Link: https://github.com/vemparalahemasri/NNDL_Assignment3
Lesson Overview:
In this lesson, we are going to discuss Image classification with CNN.

Use Case Description:
Image Classification with CNN

- Training the model
- Evaluating the model

Programming elements:

- About CNN
- Hyperparameters of CNN
- Image classification with CNN

In class programming:

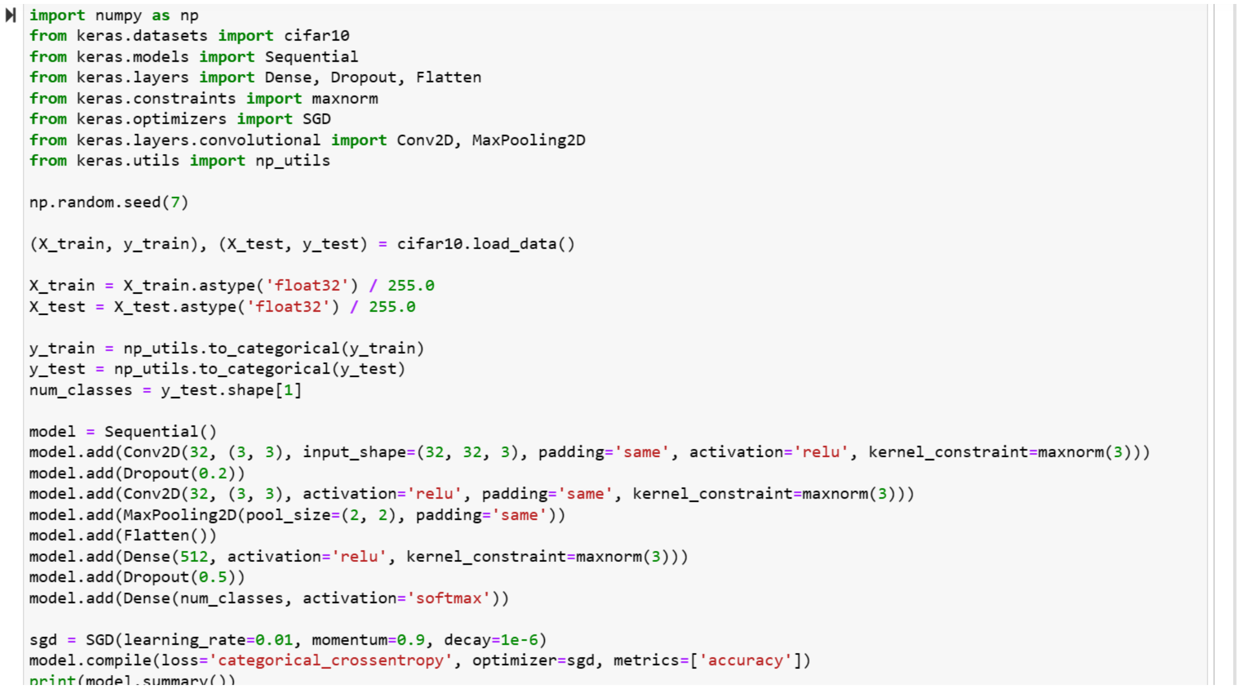
- Follow the instruction below and then report how the performance changed.(apply all at once)
- Convolutional input layer, 32 feature maps with a size of 3×3 and a rectifier activation function.
- Dropout layer at 20%.
- Convolutional layer, 32 feature maps with a size of 3×3 and a rectifier activation function.
- Max Pool layer with size 2×2.
- Convolutional layer, 64 feature maps with a size of 3×3 and a rectifier activation function.
- Dropout layer at 20%.
- Convolutional layer, 64 feature maps with a size of 3×3 and a rectifier activation function.
- Max Pool layer with size 2×2.
- Convolutional layer, 128 feature maps with a size of 3×3 and a rectifier activation function.
- Dropout layer at 20%.
- Convolutional layer,128 feature maps with a size of 3×3 and a rectifier activation function.
- Max Pool layer with size 2×2.
- Flatten layer.
- Dropout layer at 20%.
- Fully connected layer with 1024 units and a rectifier activation function.
- Dropout layer at 20%.
- Fully connected layer with 512 units and a rectifier activation function.
- Dropout layer at 20%.
- Fully connected output layer with 10 units and a Softmax activation function

Did the performance change?

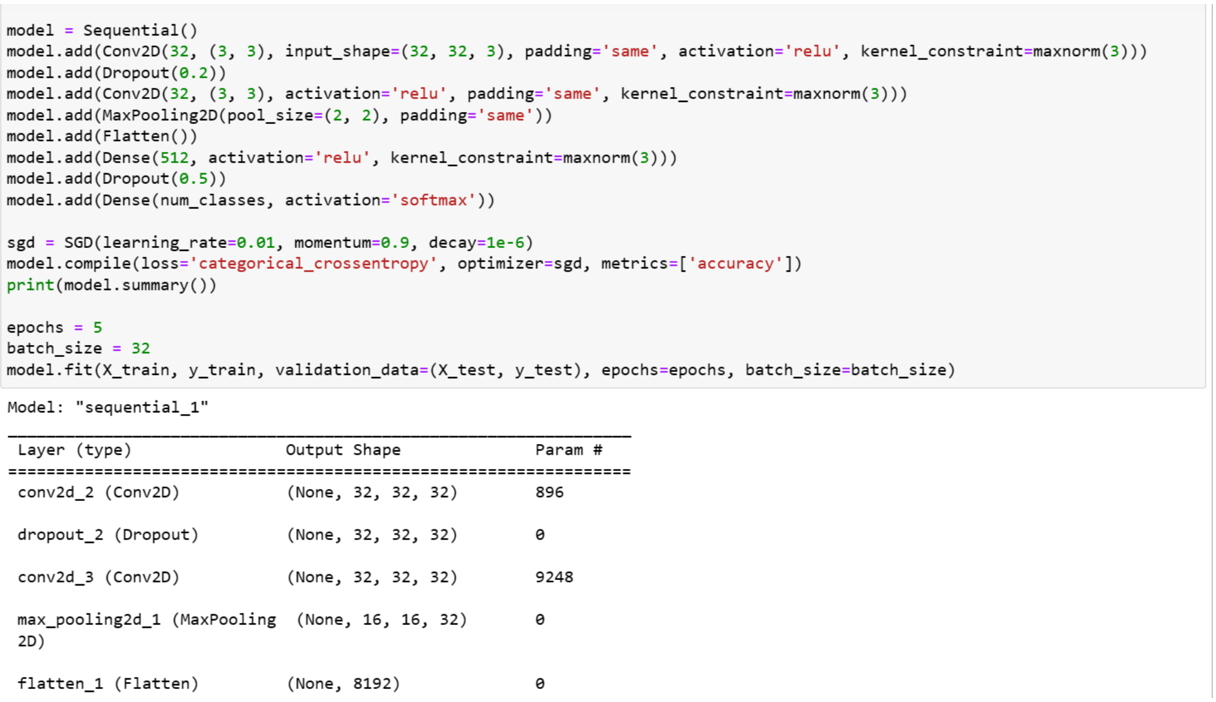
- Predict the first 4 images of the test data using the above model. Then, compare with the actual label for those 4 images to check whether or not the model has predicted correctly.
- Visualize Loss and Accuracy using the history object.

Solution:

- These are the output & result for the following:



```
import numpy as np
from keras.datasets import cifar10
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.constraints import maxnorm
from keras.optimizers import SGD
from keras.layers.convolutional import Conv2D, MaxPooling2D
from keras.utils import np_utils

np.random.seed(7)

(X_train, y_train), (X_test, y_test) = cifar10.load_data()

X_train = X_train.astype('float32') / 255.0
X_test = X_test.astype('float32') / 255.0

y_train = np_utils.to_categorical(y_train)
y_test = np_utils.to_categorical(y_test)
num_classes = y_test.shape[1]

model = Sequential()
model.add(Conv2D(32, (3, 3), input_shape=(32, 32, 3), padding='same', activation='relu', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.2))
model.add(Conv2D(32, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
model.add(MaxPooling2D(pool_size=(2, 2), padding='same'))
model.add(Flatten())
model.add(Dense(512, activation='relu', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))

sgd = SGD(learning_rate=0.01, momentum=0.9, decay=1e-6)
model.compile(loss='categorical_crossentropy', optimizer=sgd, metrics=['accuracy'])
print(model.summary())
```



```python
model = Sequential()
model.add(Conv2D(32, (3, 3), input_shape=(32, 32, 3), padding='same', activation='relu', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.2))
model.add(Conv2D(32, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
model.add(MaxPooling2D(pool_size=(2, 2), padding='same'))
model.add(Flatten())
model.add(Dense(512, activation='relu', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.5))
model.add(Dense(num_classes, activation='softmax'))

sgd = SGD(learning_rate=0.01, momentum=0.9, decay=1e-6)
model.compile(loss='categorical_crossentropy', optimizer=sgd, metrics=['accuracy'])
print(model.summary())

epochs = 5
batch_size = 32
model.fit(X_train, y_train, validation_data=(X_test, y_test), epochs=epochs, batch_size=batch_size)
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d_2 (Conv2D)           (None, 32, 32, 32)        896       
                                                                 
 dropout_2 (Dropout)         (None, 32, 32, 32)        0         
                                                                 
 conv2d_3 (Conv2D)           (None, 32, 32, 32)        9248      
                                                                 
 max_pooling2d_1 (MaxPooling  (None, 16, 16, 32)       0         
 2D)                                                             
                                                                 
 flatten_1 (Flatten)         (None, 8192)              0         
```

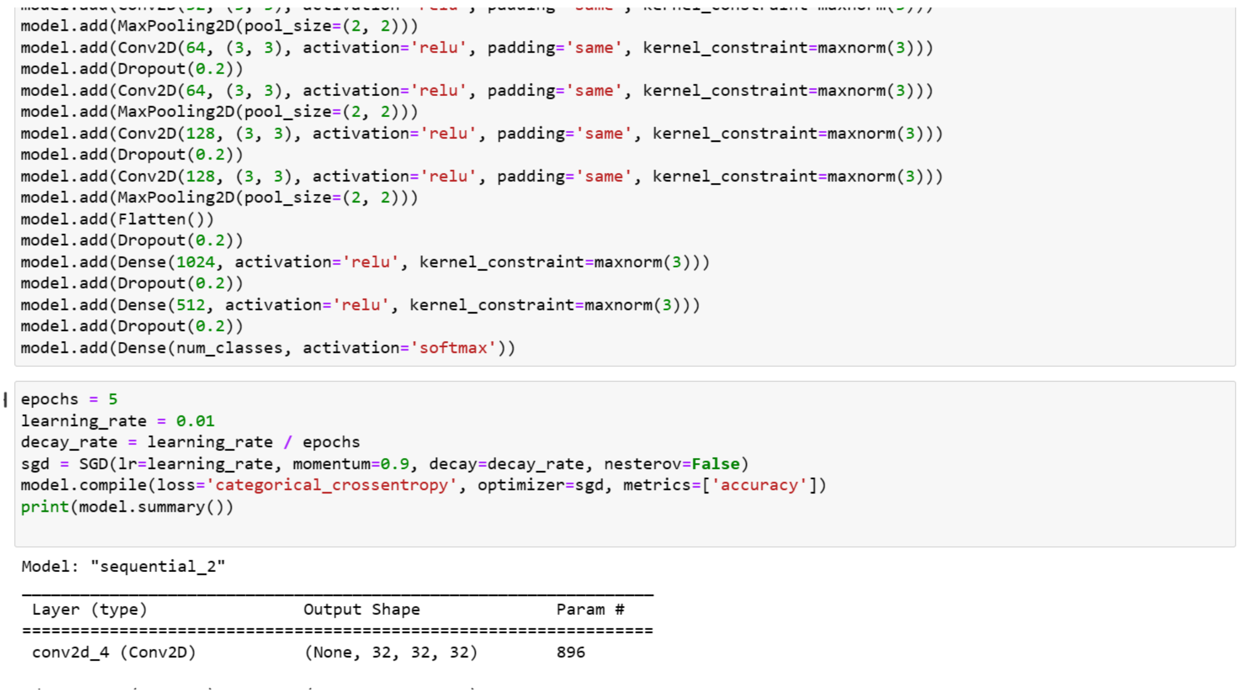
```
 dense_2 (Dense)             (None, 512)               4194816   
                                                                 
 dropout_3 (Dropout)         (None, 512)               0         
                                                                 
 dense_3 (Dense)             (None, 10)                5130      
                                                                 
=================================================================
Total params: 4,210,090
Trainable params: 4,210,090
Non-trainable params: 0
_________________________________________________________________
None
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d_2 (Conv2D)           (None, 32, 32, 32)        896       
                                                                 
 dropout_2 (Dropout)         (None, 32, 32, 32)        0         
                                                                 
 conv2d_3 (Conv2D)           (None, 32, 32, 32)        9248      
                                                                 
 max_pooling2d_1 (MaxPooling  (None, 16, 16, 32)       0         
 2D)                                                             
                                                                 
 flatten_1 (Flatten)         (None, 8192)              0         
                                                                 
 dense_2 (Dense)             (None, 512)               4194816   
 dropout_3 (Dropout)         (None, 512)               0

 dense_3 (Dense)             (None, 10)                5130

=================================================================
Total params: 4,210,090
Trainable params: 4,210,090
Non-trainable params: 0
_________________________________________________________________
None
Epoch 1/5
1563/1563 [==============================] - 164s 104ms/step - loss: 1.7320 - accuracy: 0.3701 - val_loss: 1.4194 - val_accu
racy: 0.4944
Epoch 2/5
1563/1563 [==============================] - 165s 105ms/step - loss: 1.3552 - accuracy: 0.5128 - val_loss: 1.2045 - val_accu
racy: 0.5676
Epoch 3/5
1563/1563 [==============================] - 165s 106ms/step - loss: 1.1688 - accuracy: 0.5842 - val_loss: 1.0648 - val_accu
racy: 0.6252
Epoch 4/5
1563/1563 [==============================] - 160s 102ms/step - loss: 1.0351 - accuracy: 0.6336 - val_loss: 0.9853 - val_accu
racy: 0.6544
Epoch 5/5
1563/1563 [==============================] - 165s 106ms/step - loss: 0.9280 - accuracy: 0.6732 - val_loss: 0.9793 - val_accu
racy: 0.6610
```

```
]: <keras.callbacks.History at 0x7f67c770eb80>
```

```
]:  scores = model.evaluate(X_test, y_test, verbose=0)
    print("Accuracy: %.2f%%" % (scores[1]*100))
```

```
Accuracy: 66.10%
```

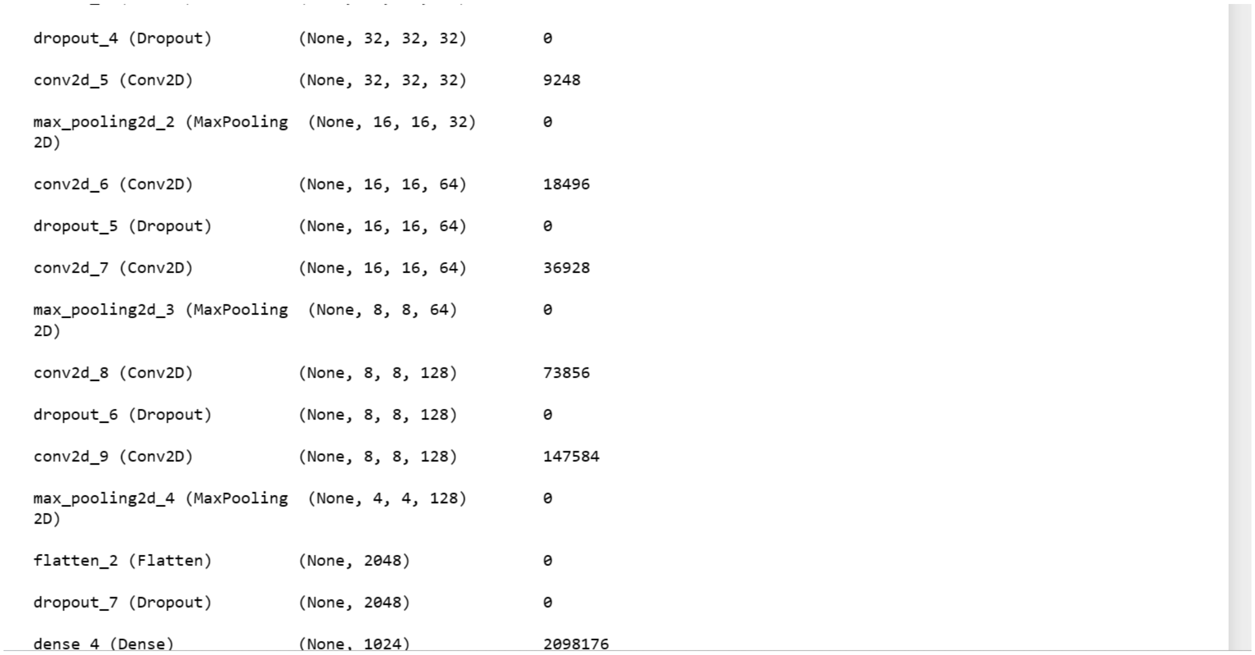
```
]:  import numpy as np
    from keras.datasets import cifar10
    from keras.models import Sequential
    from keras.layers import Dense, Dropout, Flatten
    from keras.layers.convolutional import Conv2D, MaxPooling2D
    from keras.constraints import maxnorm
    from keras.utils import np_utils
    from keras.optimizers import SGD

    seed = 7

    (X_train, y_train), (X_test, y_test) = cifar10.load_data()

    X_train = X_train.astype('float32') / 255.0
    X_test = X_test.astype('float32') / 255.0

    y_train = np_utils.to_categorical(y_train)
    y_test = np_utils.to_categorical(y_test)
    num_classes = y_test.shape[1]
    model = Sequential()
    model.add(Conv2D(32, (3, 3), input_shape=(32, 32, 3), padding='same', activation='relu', kernel_constraint=maxnorm(3)))
    model.add(Dropout(0.2))
    model.add(Conv2D(32, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
    model.add(MaxPooling2D(pool_size=(2, 2)))
    model.add(Conv2D(64, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
```



```
model.add(Conv2D(32, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Conv2D(64, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.2))
model.add(Conv2D(64, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Conv2D(128, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.2))
model.add(Conv2D(128, (3, 3), activation='relu', padding='same', kernel_constraint=maxnorm(3)))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Flatten())
model.add(Dropout(0.2))
model.add(Dense(1024, activation='relu', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.2))
model.add(Dense(512, activation='relu', kernel_constraint=maxnorm(3)))
model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax'))
```

```
epochs = 5
learning_rate = 0.01
decay_rate = learning_rate / epochs
sgd = SGD(lr=learning_rate, momentum=0.9, decay=decay_rate, nesterov=False)
model.compile(loss='categorical_crossentropy', optimizer=sgd, metrics=['accuracy'])
print(model.summary())
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d_4 (Conv2D)           (None, 32, 32, 32)        896       
```



```
 dropout_4 (Dropout)         (None, 32, 32, 32)        0         
                                                                 
 conv2d_5 (Conv2D)           (None, 32, 32, 32)        9248      
                                                                 
 max_pooling2d_2 (MaxPooling  (None, 16, 16, 32)       0         
 2D)                                                             
                                                                 
 conv2d_6 (Conv2D)           (None, 16, 16, 64)        18496     
                                                                 
 dropout_5 (Dropout)         (None, 16, 16, 64)        0         
                                                                 
 conv2d_7 (Conv2D)           (None, 16, 16, 64)        36928     
                                                                 
 max_pooling2d_3 (MaxPooling  (None, 8, 8, 64)         0         
 2D)                                                             
                                                                 
 conv2d_8 (Conv2D)           (None, 8, 8, 128)         73856     
                                                                 
 dropout_6 (Dropout)         (None, 8, 8, 128)         0         
                                                                 
 conv2d_9 (Conv2D)           (None, 8, 8, 128)         147584    
                                                                 
 max_pooling2d_4 (MaxPooling  (None, 4, 4, 128)        0         
 2D)                                                             
                                                                 
 flatten_2 (Flatten)         (None, 2048)              0         
                                                                 
 dropout_7 (Dropout)         (None, 2048)              0         
                                                                 
 dense_4 (Dense)             (None, 1024)              2098176   
 dropout_8 (Dropout)         (None, 1024)              0

 dense_5 (Dense)             (None, 512)               524800

 dropout_9 (Dropout)         (None, 512)               0

 dense_6 (Dense)             (None, 10)                5130

=================================================================
Total params: 2,915,114
Trainable params: 2,915,114
Non-trainable params: 0
_________________________________________________________________
None
```

```
/usr/local/lib/python3.9/dist-packages/keras/optimizers/optimizer_v2/gradient_descent.py:114: UserWarning: The `lr` argument
is deprecated, use `learning_rate` instead.
  super().__init__(name, **kwargs)
```

```python
history = model.fit(X_train, y_train, validation_data=(X_test, y_test), epochs=epochs, batch_size=32)

scores = model.evaluate(X_test, y_test, verbose=0)
print("Accuracy: %.2f%%" % (scores[1] * 100))
```

```
Epoch 1/5
1563/1563 [==============================] - 320s 204ms/step - loss: 1.8690 - accuracy: 0.3094 - val_loss: 1.5686 - val_accu
```

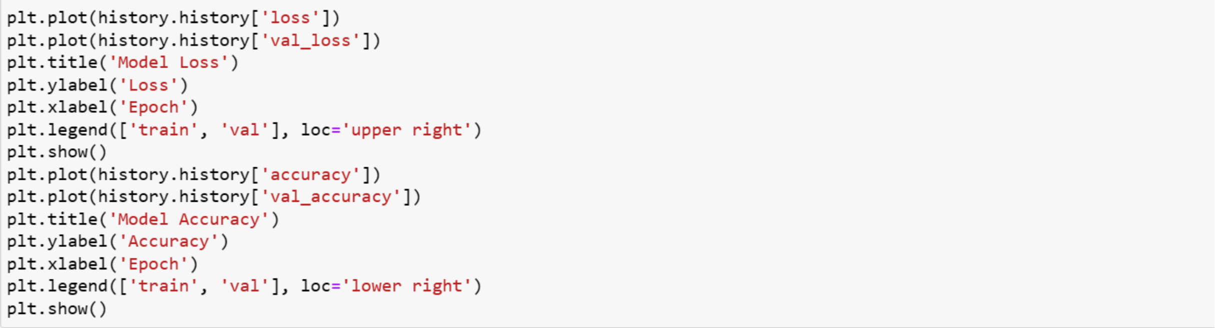
1563/1563 [==============================] - 320s 204ms/step - loss: 1.8690 - accuracy: 0.3094 - val_loss: 1.5686 - val_accu

```
racy: 0.4288
Epoch 2/5
1563/1563 [==============================] - 319s 204ms/step - loss: 1.4913 - accuracy: 0.4537 - val_loss: 1.3887 - val_accu
racy: 0.4972
Epoch 3/5
1563/1563 [==============================] - 319s 204ms/step - loss: 1.3537 - accuracy: 0.5097 - val_loss: 1.3130 - val_accu
racy: 0.5285
Epoch 4/5
1563/1563 [==============================] - 318s 203ms/step - loss: 1.2687 - accuracy: 0.5440 - val_loss: 1.1876 - val_accu
racy: 0.5719
Epoch 5/5
1563/1563 [==============================] - 318s 204ms/step - loss: 1.2044 - accuracy: 0.5676 - val_loss: 1.1627 - val_accu
racy: 0.5805
Accuracy: 58.05%
```

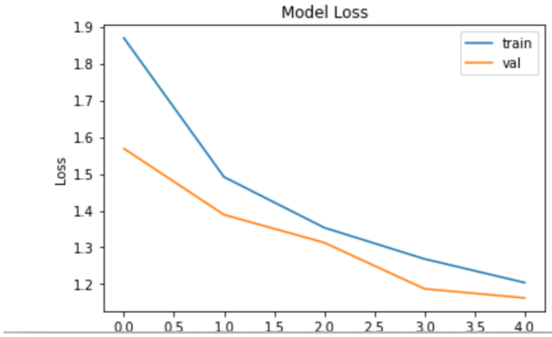
```python
import numpy as np
predictions = model.predict(X_test[:4])
predicted_labels = np.argmax(predictions, axis=1)
actual_labels = np.argmax(y_test[:4], axis=1)

print("Predicted labels:", predicted_labels)
print("Actual labels:   ", actual_labels)
```

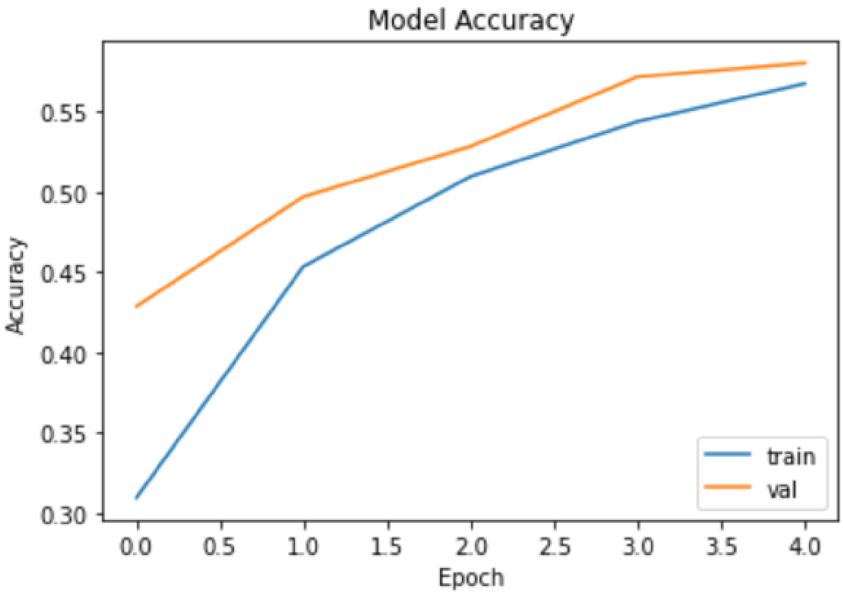
```
1/1 [==============================] - 0s 25ms/step
Predicted labels: [3 1 8 0]
Actual labels:    [3 8 8 0]
```

```python
import matplotlib.pyplot as plt
```



```
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 right')
plt.show()
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='lower right')
plt.show()
```


Model Loss
Loss
train
val


Model Accuracy
Accuracy
Epoch
train
val