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LAB - 14 CLASSIFICATION OF CIFAR-10 DATA WITH DATA AUGMENTATION

STEP : 1

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import keras
from keras.datasets import cifar10
from keras.utils import to_categorical
from keras.backend import categorical_crossentropy
from keras.models import Sequential
from keras.layers import Dense, Activation, Dropout, Flatten, Conv2D, MaxPo
from keras.optimizers import RMSprop
from keras.preprocessing.image import ImageDataGenerator
```

```
C:\Users\sweth\Downloads\nlp\lib\site-packages\scipy\__init__.py:155: Use
rWarning: A NumPy version >=1.18.5 and <1.25.0 is required for this versi
on of SciPy (detected version 1.25.2
  warnings.warn(f"A NumPy version >={np_minversion} and <{np_maxversion}"
```

STEP : 2

In [2]:
```
(X_train, y_train), (X_test, y_test) = cifar10.load_data()
```

In [3]:
```
print('Shape of X_train is {}'.format(X_train.shape))
print('Shape of X_test is {}'.format(X_test.shape))
print('Shape of y_train is {}'.format(y_train.shape))
print('Shape of y_test is {}'.format(y_test.shape))
```

```
Shape of X_train is (50000, 32, 32, 3)
Shape of X_test is (10000, 32, 32, 3)
Shape of y_train is (50000, 1)
Shape of y_test is (10000, 1)
```

STEP : 3

In [4]:
```
num_classes =10
y_train = to_categorical(y_train, num_classes)
y_test = to_categorical(y_test, num_classes)
```

STEP : 4

In [5]:
```
X_train = X_train.astype('float32')
X_test = X_test.astype('float32')
X_train /= 255
X_test /= 255
```

In [6]:
```
print('Shape of one sample of X_train is {}'.format(X_train[37].shape))
print('Shape of one sample of y_train is {}'.format(y_train[37].shape))
```

```
Shape of one sample of X_train is (32, 32, 3)
Shape of one sample of y_train is (10,)
```

In [7]:
```
X_train[37]
```

Out[7]:
```
array([[[0.37254903, 0.4117647 , 0.49803922],
        [0.34509805, 0.38039216, 0.47058824],
        [0.3372549 , 0.3764706 , 0.4627451 ],
        ...,
        [0.39607844, 0.45490196, 0.5647059 ],
        [0.35686275, 0.42352942, 0.53333336],
        [0.4117647 , 0.4862745 , 0.6156863 ]],

       [[0.32156864, 0.3529412 , 0.43137255],
        [0.29411766, 0.3254902 , 0.40784314],
        [0.29803923, 0.32941177, 0.40784314],
        ...,
        [0.36862746, 0.4       , 0.48235294],
        [0.2       , 0.23921569, 0.3137255 ],
        [0.32941177, 0.38039216, 0.47843137]],

       [[0.3019608 , 0.33333334, 0.40392157],
        [0.2901961 , 0.31764707, 0.38431373],
        [0.2784314 , 0.30588236, 0.37254903],
        ...,
        [0.2784314 , 0.2901961 , 0.3372549 ],
        [0.18431373, 0.20392157, 0.24705882],
        [0.34509805, 0.37254903, 0.43529412]],

       ...,

       [[0.38039216, 0.37254903, 0.28235295],
        [0.36078432, 0.36078432, 0.27058825],
        [0.38039216, 0.3647059 , 0.27450982],
        ...,
        [0.3372549 , 0.35686275, 0.25490198],
        [0.36862746, 0.38039216, 0.28235295],
        [0.3529412 , 0.38039216, 0.2784314 ]],

       [[0.37254903, 0.3529412 , 0.25490198],
        [0.32941177, 0.3372549 , 0.23137255],
        [0.34901962, 0.34901962, 0.24313726],
        ...,
        [0.3764706 , 0.38039216, 0.29803923],
        [0.4       , 0.3764706 , 0.3019608 ],
        [0.38039216, 0.36862746, 0.28627452]],

       [[0.35686275, 0.32941177, 0.24705882],
        [0.3254902 , 0.31764707, 0.22352941],
        [0.32156864, 0.31764707, 0.21568628],
        ...,
        [0.39215687, 0.3764706 , 0.30588236],
        [0.4117647 , 0.38039216, 0.3137255 ],
        [0.42352942, 0.4       , 0.3254902 ]]], dtype=float32)
```

In [8]:
```
y_train[37]
```

Out[8]:
```
array([0., 0., 0., 0., 0., 0., 0., 1., 0., 0.], dtype=float32)
```

STEP : 5

In [9]:
```
model = Sequential()
model.add(Conv2D(32, (5,5), strides=(2,2), padding='same', input_shape=X_tr
model.add(Activation('relu'))
model.add(Conv2D(32, (5,5), strides=(2,2)))
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Dropout(0.25))
model.add(Flatten())
model.add(Dense(512))
model.add(Activation('relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes))
model.add(Activation('softmax'))
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 16, 16, 32)        2432

 activation (Activation)     (None, 16, 16, 32)        0

 conv2d_1 (Conv2D)           (None, 6, 6, 32)          25632

 activation_1 (Activation)   (None, 6, 6, 32)          0

 max_pooling2d (MaxPooling2  (None, 3, 3, 32)          0
 D)

 dropout (Dropout)           (None, 3, 3, 32)          0

 flatten (Flatten)           (None, 288)               0

 dense (Dense)               (None, 512)               147968

 activation_2 (Activation)   (None, 512)               0

 dropout_1 (Dropout)         (None, 512)               0

 dense_1 (Dense)             (None, 10)                5130

 activation_3 (Activation)   (None, 10)                0

=================================================================
Total params: 181162 (707.66 KB)
Trainable params: 181162 (707.66 KB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```

STEP : 6

In [10]:
```
# Load and preprocess the CIFAR-10 dataset
(X_train, y_train), (X_test, y_test) = cifar10.load_data()
```

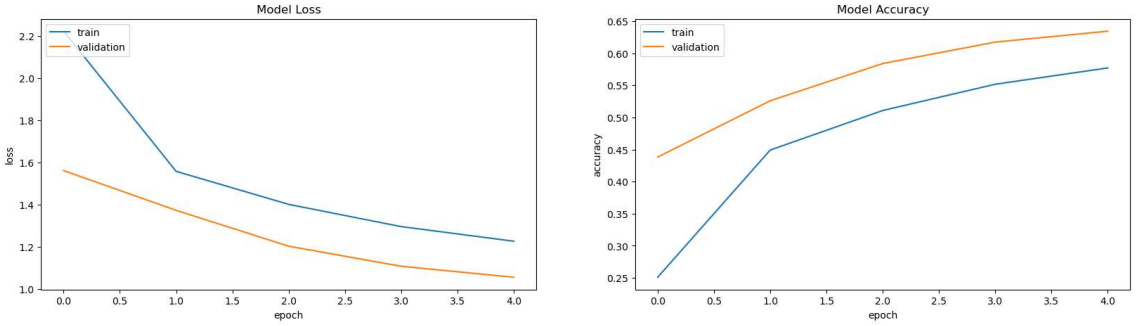
In [11]:
```
# Convert class vectors to binary class matrices (one-hot encoding)
num_classes = 10
y_train = keras.utils.to_categorical(y_train, num_classes)
y_test = keras.utils.to_categorical(y_test, num_classes)
```

In [12]:
```
# Build the neural network model
model = Sequential()
model.add(Conv2D(32, (3, 3), padding='same', input_shape=X_train.shape[1:]))
model.add(Activation('relu'))
model.add(Conv2D(32, (3, 3)))
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Conv2D(64, (3, 3), padding='same'))
model.add(Activation('relu'))
model.add(Conv2D(64, (3, 3)))
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2)))
model.add(Dropout(0.25))

model.add(Flatten())
model.add(Dense(512))
model.add(Activation('relu'))
model.add(Dropout(0.5))
model.add(Dense(num_classes))
model.add(Activation('softmax'))
```

In [13]:
```
# Compile the model
opt = RMSprop(learning_rate=0.0005)
model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['acc

# Train the model
batch_size = 32
epochs = 5
history = model.fit(X_train, y_train, batch_size=batch_size, epochs=epochs,

# Evaluate the model on the test data
score = model.evaluate(X_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
```

```
Epoch 1/5
1250/1250 - 189s - loss: 2.2229 - accuracy: 0.2510 - val_loss: 1.5620 - v
al_accuracy: 0.4383 - 189s/epoch - 151ms/step
Epoch 2/5
1250/1250 - 185s - loss: 1.5584 - accuracy: 0.4492 - val_loss: 1.3736 - v
al_accuracy: 0.5260 - 185s/epoch - 148ms/step
Epoch 3/5
1250/1250 - 188s - loss: 1.4019 - accuracy: 0.5108 - val_loss: 1.2036 - v
al_accuracy: 0.5840 - 188s/epoch - 151ms/step
Epoch 4/5
1250/1250 - 184s - loss: 1.2965 - accuracy: 0.5517 - val_loss: 1.1084 - v
al_accuracy: 0.6174 - 184s/epoch - 147ms/step
Epoch 5/5
1250/1250 - 190s - loss: 1.2272 - accuracy: 0.5771 - val_loss: 1.0564 - v
al_accuracy: 0.6344 - 190s/epoch - 152ms/step
Test loss: 1.0751452445983887
Test accuracy: 0.6255000233650208
```

In [14]:
```
fig = plt.figure(figsize=(20, 5))
fig.add_subplot(1,2,1)
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Model Loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
fig.add_subplot(1,2,2)
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title('Model Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```



STEP : 7

In [15]:
```
datagen = ImageDataGenerator(featurewise_center=False,
samplewise_center=False,

featurewise_std_normalization=False,
samplewise_std_normalization=False,
zca_whitening=False,
rotation_range=0,
width_shift_range=0.1,
height_shift_range=0.1,
horizontal_flip=True,
vertical_flip=False)

datagen.fit(X_train)
```

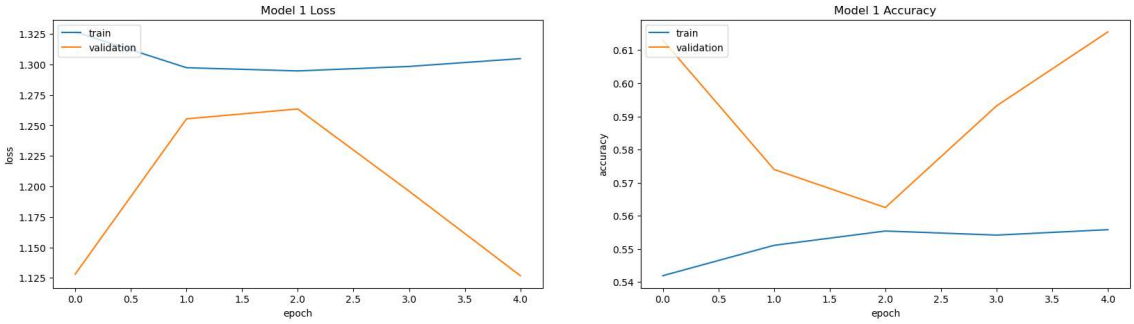
In [16]:
```
import tensorflow as tf
batch_size = 32
opt = tf.keras.optimizers.legacy.RMSprop(lr=0.0005, decay=1e-6)
model.compile(loss='categorical_crossentropy', optimizer=opt, metrics=['acc
```

```
C:\Users\sweth\Downloads\nlp\lib\site-packages\keras\src\optimizers\legac
y\rmsprop.py:144: UserWarning: The `lr` argument is deprecated, use `lear
ning_rate` instead.
  super().__init__(name, **kwargs)
```

In [17]:
```
history1 = model.fit_generator(datagen.flow(X_train, y_train, batch_size=32
steps_per_epoch=X_train.shape[0] // batch_size,
epochs=5,

validation_data=(X_test, y_test))
```

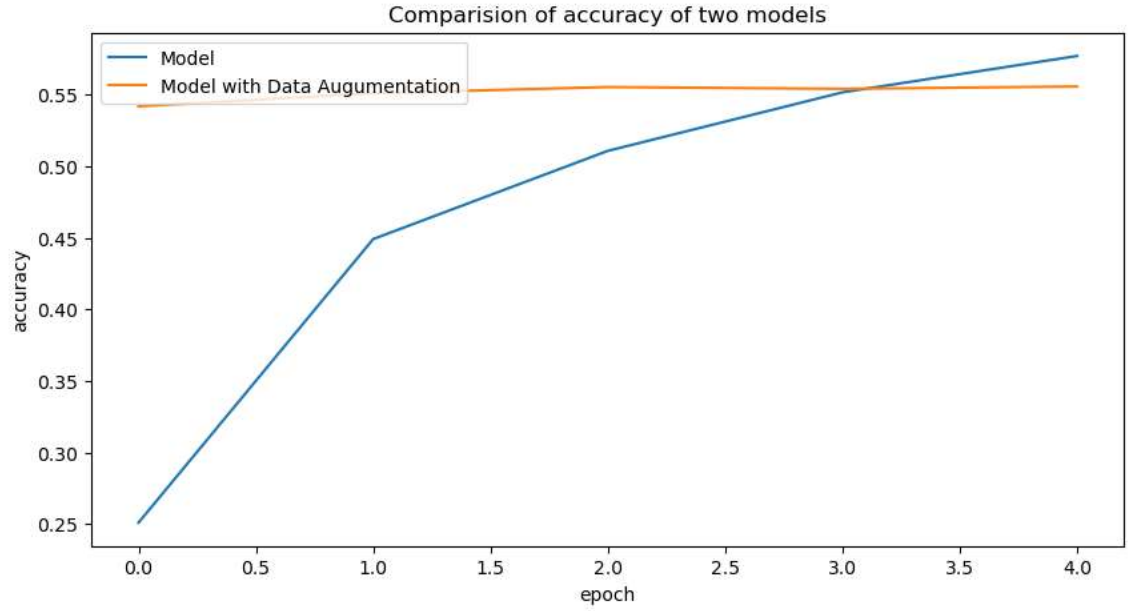
```
Epoch 1/5

C:\Users\sweth\AppData\Local\Temp\ipykernel_7224\1000390916.py:1: UserWar
ning: `Model.fit_generator` is deprecated and will be removed in a future
version. Please use `Model.fit`, which supports generators.
  history1 = model.fit_generator(datagen.flow(X_train, y_train, batch_siz
e=32),

1562/1562 [==============================] - 263s 167ms/step - loss: 1.32
67 - accuracy: 0.5419 - val_loss: 1.1281 - val_accuracy: 0.6130
Epoch 2/5
1562/1562 [==============================] - 258s 165ms/step - loss: 1.29
73 - accuracy: 0.5511 - val_loss: 1.2554 - val_accuracy: 0.5740
Epoch 3/5
1562/1562 [==============================] - 268s 172ms/step - loss: 1.29
47 - accuracy: 0.5554 - val_loss: 1.2635 - val_accuracy: 0.5625
Epoch 4/5
1562/1562 [==============================] - 260s 166ms/step - loss: 1.29
84 - accuracy: 0.5542 - val_loss: 1.1960 - val_accuracy: 0.5932
Epoch 5/5
1562/1562 [==============================] - 258s 165ms/step - loss: 1.30
48 - accuracy: 0.5558 - val_loss: 1.1268 - val_accuracy: 0.6155
```

In [18]:
```
fig = plt.figure(figsize=(20, 5))
fig.add_subplot(1,2,1)
plt.plot(history1.history['loss'])
plt.plot(history1.history['val_loss'])
plt.title('Model 1 Loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
fig.add_subplot(1,2,2)
plt.plot(history1.history['accuracy'])
plt.plot(history1.history['val_accuracy'])
plt.title('Model 1 Accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'validation'], loc='upper left')
plt.show()
```



STEP : 8

In [19]:
```
plt.figure(figsize=(10, 5))
plt.plot(history.history['accuracy'])
plt.plot(history1.history['accuracy'])
plt.title('Comparision of accuracy of two models')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['Model', 'Model with Data Augumentation'], loc='upper left')
plt.show()
```



STEP : 9

In [28]:
```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, Activation, MaxPooling2D, Flatt

# Define the input shape based on your data
input_shape = (128, 128, 3)  # Replace with your actual input dimensions

model2 = Sequential()
model2.add(Conv2D(32, (5, 5), strides=(1, 1), padding='same', activation='r
model2.add(Conv2D(32, (5, 5), strides=(1, 1)))
model2.add(Activation('relu'))
model2.add(MaxPooling2D(pool_size=(2, 2)))
model2.add(Conv2D(32, (5, 5), strides=(1, 1), padding='same', activation='r
model2.add(Conv2D(32, (5, 5), strides=(1, 1)))
model2.add(Activation('relu'))
model2.add(MaxPooling2D(pool_size=(2, 2)))

# Flatten layer should produce an output that matches the input shape of th
model2.add(Flatten())
model2.add(Dense(512, activation='relu'))  # Updated to specify activation
model2.add(Dense(num_classes, activation='softmax'))  # Updated to specify
model2.summary()
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_10 (Conv2D)          (None, 128, 128, 32)      2432

 conv2d_11 (Conv2D)          (None, 124, 124, 32)      25632

 activation_14 (Activation)  (None, 124, 124, 32)      0

 max_pooling2d_5 (MaxPoolin  (None, 62, 62, 32)        0
 g2D)

 conv2d_12 (Conv2D)          (None, 62, 62, 32)        25632

 conv2d_13 (Conv2D)          (None, 58, 58, 32)        25632

 activation_15 (Activation)  (None, 58, 58, 32)        0

 max_pooling2d_6 (MaxPoolin  (None, 29, 29, 32)        0
 g2D)

 flatten_3 (Flatten)         (None, 26912)             0

 dense_6 (Dense)             (None, 512)               13779456

 dense_7 (Dense)             (None, 10)                5130

=================================================================
Total params: 13863914 (52.89 MB)
Trainable params: 13863914 (52.89 MB)
Non-trainable params: 0 (0.00 Byte)
_________________________________________________________________
```