Spring 2024: CS5720 Neural Networks & Deep Learning - ICP-7
Assignment-7
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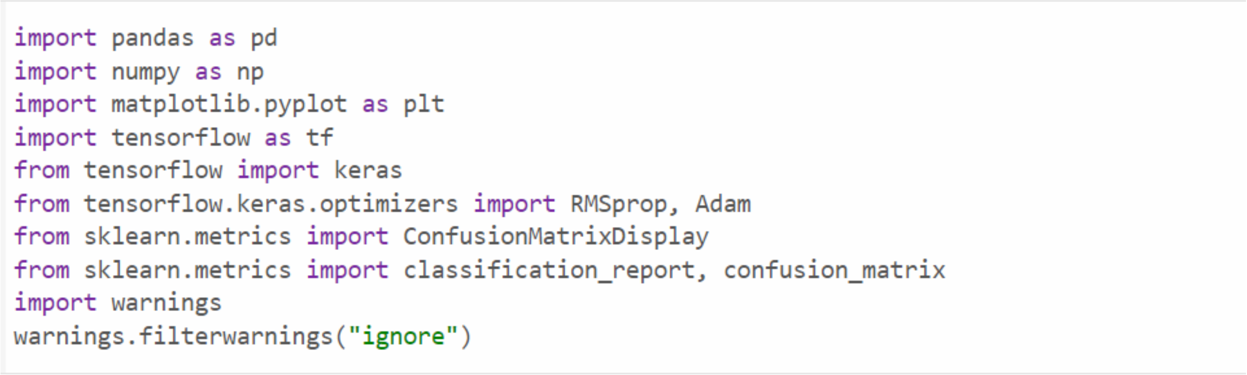
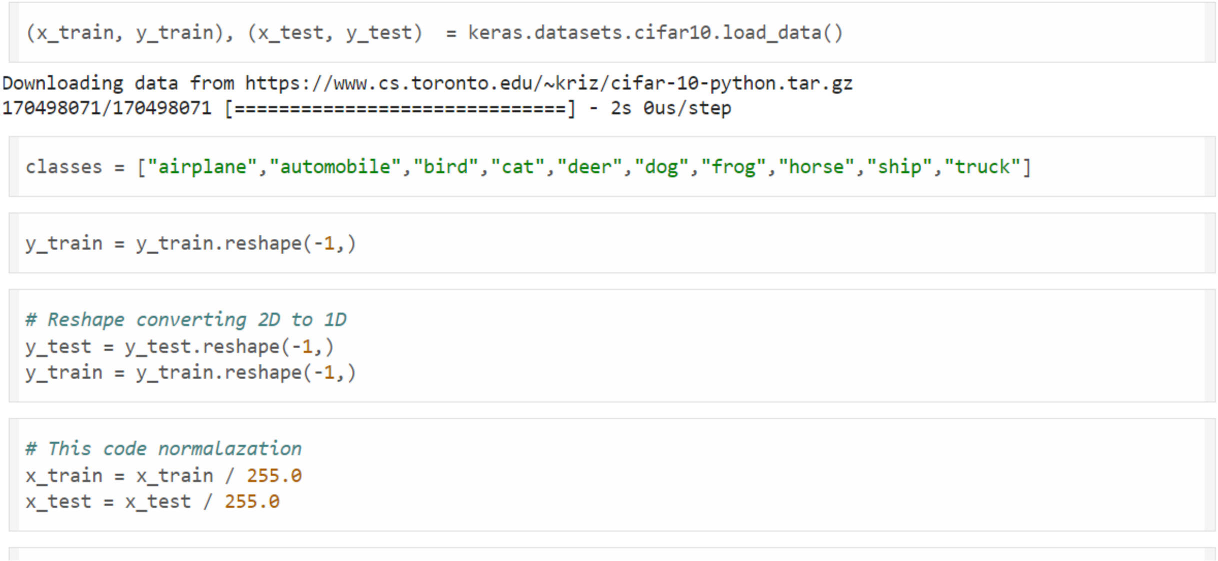
Github Link:

https://github.com/ruchithasurakanti/NN-assignment-2/blob/main/Neuralnetworks_Assignment7(1).ipynb



```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.optimizers import RMSprop, Adam
from sklearn.metrics import ConfusionMatrixDisplay
from sklearn.metrics import classification_report, confusion_matrix
import warnings
warnings.filterwarnings("ignore")
```



```
(x_train, y_train), (x_test, y_test)  = keras.datasets.cifar10.load_data()
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170498071/170498071 [==============================] - 2s 0us/step
```

```
classes = ["airplane","automobile","bird","cat","deer","dog","frog","horse","ship","truck"]
```

```
y_train = y_train.reshape(-1,)
```

```
# Reshape converting 2D to 1D
y_test = y_test.reshape(-1,)
y_train = y_train.reshape(-1,)
```

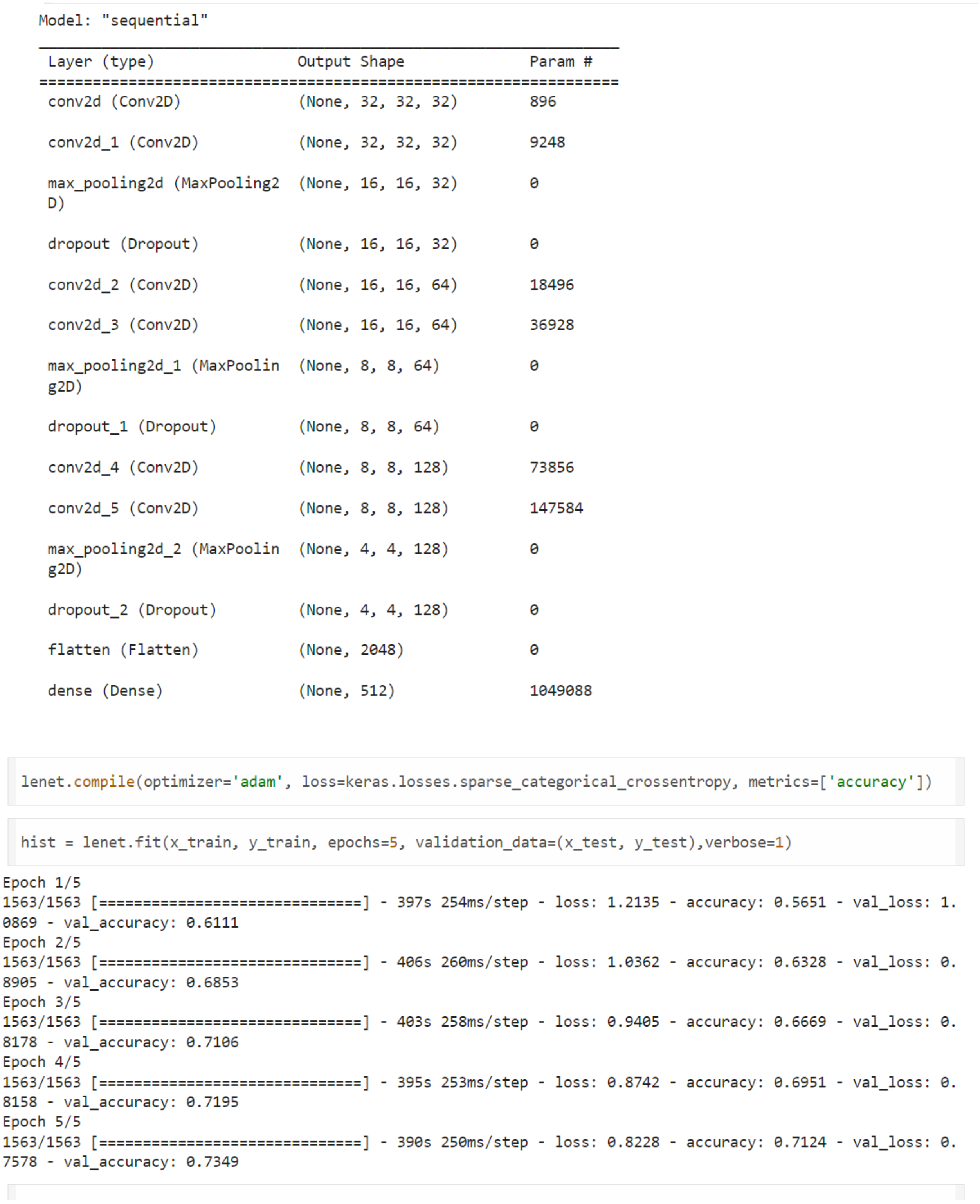
```
# This code normalazation
x_train = x_train / 255.0
x_test = x_test / 255.0
```

```
x_train.shape
```

```
(50000, 32, 32, 3)
```

```
from tensorflow.keras import layers, models
lenet = keras.models.Sequential([
    keras.layers.Conv2D(32, kernel_size=3, strides=1,  activation='relu', input_shape=(32,32,3), padding='sa
    keras.layers.Conv2D(32, kernel_size=3, strides=1, activation='relu', padding='same'), #C2
    keras.layers.MaxPooling2D(pool_size=2, strides=2), #S1
    keras.layers.Dropout(0.25),
    keras.layers.Conv2D(64, kernel_size=3, strides=1, activation='relu', padding='same'), #C3
    keras.layers.Conv2D(64, kernel_size=3, strides=1, activation='relu', padding='same'), #C4
    keras.layers.MaxPooling2D(pool_size=2, strides=2), #S2
    keras.layers.Dropout(0.25),
    keras.layers.Conv2D(128, kernel_size=3, strides=1, activation='relu', padding='same'), #C5
    keras.layers.Conv2D(128, kernel_size=3, strides=1, activation='relu', padding='same'), #C6
    keras.layers.MaxPooling2D(pool_size=2, strides=2), #S3
    keras.layers.Dropout(0.25),
    keras.layers.Flatten(), #Flatten
    keras.layers.Dense(512, activation='relu'), #F1
    keras.layers.Dropout(0.5),
    keras.layers.Dense(10, activation='softmax') #Output layer
])
```

```
lenet.summary()
```

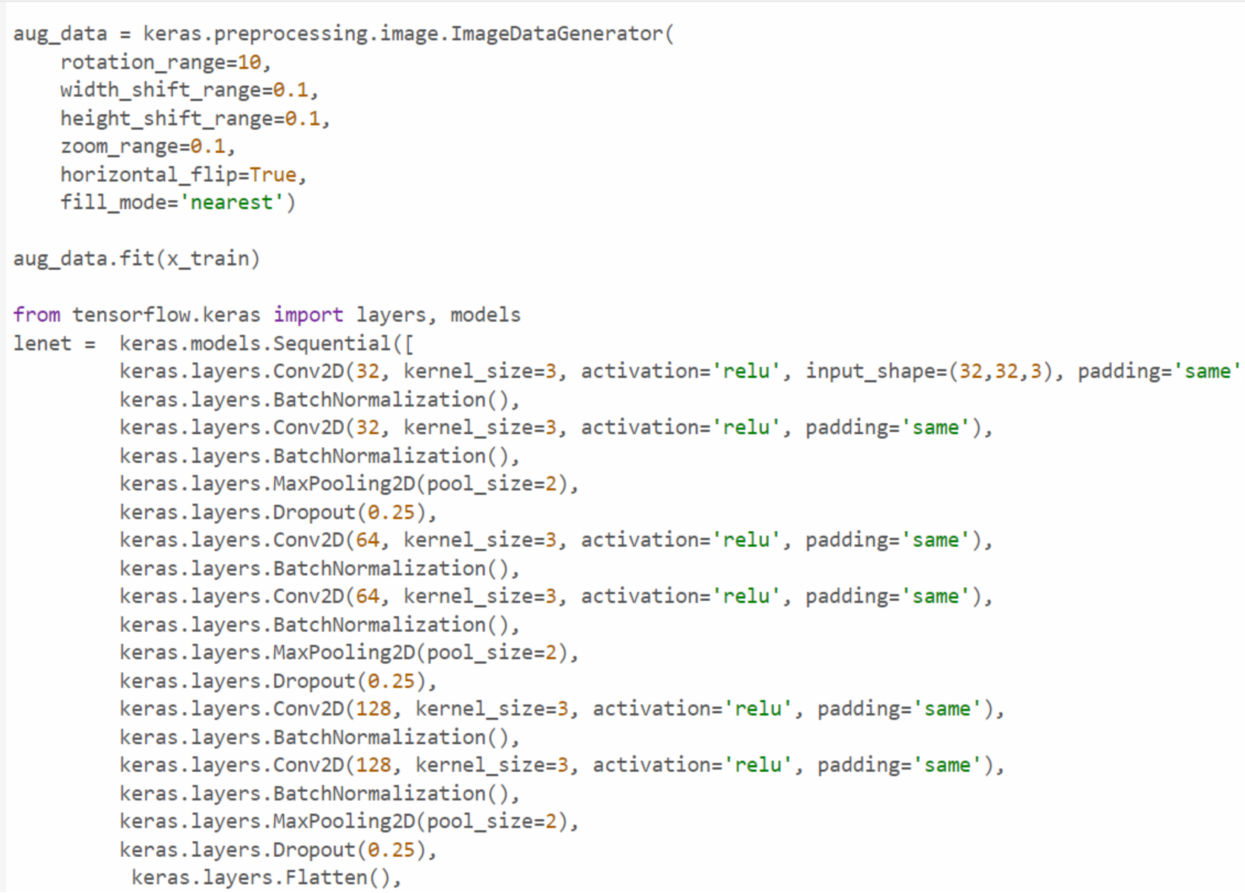


```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d (Conv2D)             (None, 32, 32, 32)        896       
                                                                 
 conv2d_1 (Conv2D)           (None, 32, 32, 32)        9248      
                                                                 
 max_pooling2d (MaxPooling2  (None, 16, 16, 32)        0         
 D)                                                              
                                                                 
 dropout (Dropout)           (None, 16, 16, 32)        0         
                                                                 
 conv2d_2 (Conv2D)           (None, 16, 16, 64)        18496     
                                                                 
 conv2d_3 (Conv2D)           (None, 16, 16, 64)        36928     
                                                                 
 max_pooling2d_1 (MaxPoolin  (None, 8, 8, 64)          0         
 g2D)                                                            
                                                                 
 dropout_1 (Dropout)         (None, 8, 8, 64)          0         
                                                                 
 conv2d_4 (Conv2D)           (None, 8, 8, 128)         73856     
                                                                 
 conv2d_5 (Conv2D)           (None, 8, 8, 128)         147584    
                                                                 
 max_pooling2d_2 (MaxPoolin  (None, 4, 4, 128)         0         
 g2D)                                                            
                                                                 
 dropout_2 (Dropout)         (None, 4, 4, 128)         0         
                                                                 
 flatten (Flatten)           (None, 2048)              0         
                                                                 
 dense (Dense)               (None, 512)               1049088   
```

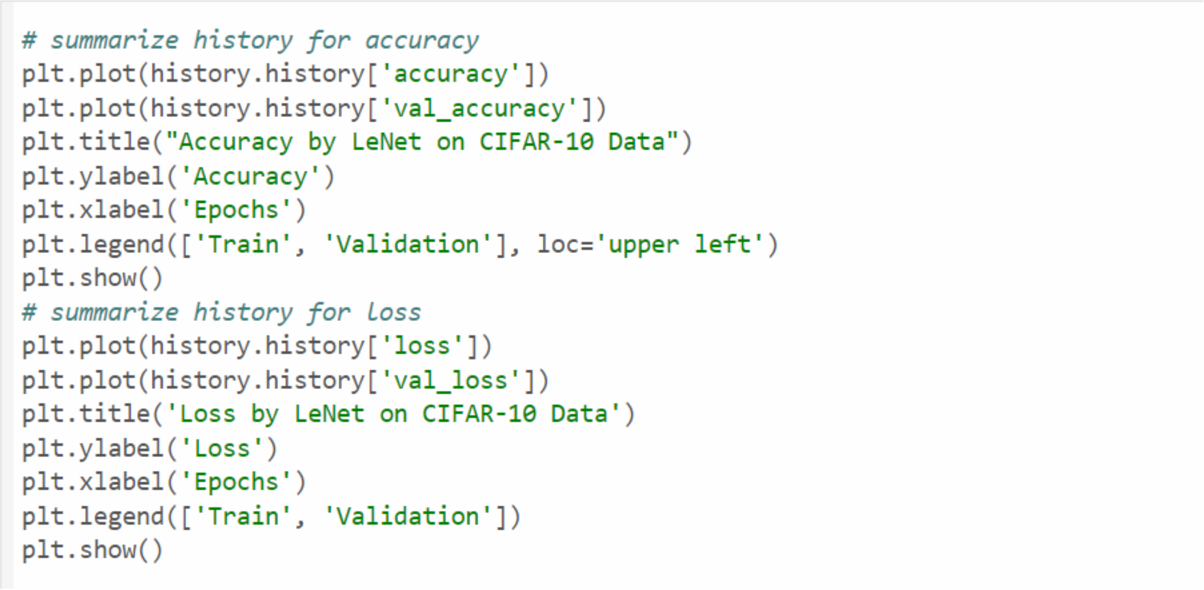
```
lenet.compile(optimizer='adam', loss=keras.losses.sparse_categorical_crossentropy, metrics=['accuracy'])
```

```
hist = lenet.fit(x_train, y_train, epochs=5, validation_data=(x_test, y_test),verbose=1)
```

```
Epoch 1/5
1563/1563 [==============================] - 397s 254ms/step - loss: 1.2135 - accuracy: 0.5651 - val_loss: 1.
0869 - val_accuracy: 0.6111
Epoch 2/5
1563/1563 [==============================] - 406s 260ms/step - loss: 1.0362 - accuracy: 0.6328 - val_loss: 0.
8905 - val_accuracy: 0.6853
Epoch 3/5
1563/1563 [==============================] - 403s 258ms/step - loss: 0.9405 - accuracy: 0.6669 - val_loss: 0.
8178 - val_accuracy: 0.7106
Epoch 4/5
1563/1563 [==============================] - 395s 253ms/step - loss: 0.8742 - accuracy: 0.6951 - val_loss: 0.
8158 - val_accuracy: 0.7195
Epoch 5/5
1563/1563 [==============================] - 390s 250ms/step - loss: 0.8228 - accuracy: 0.7124 - val_loss: 0.
7578 - val_accuracy: 0.7349
```

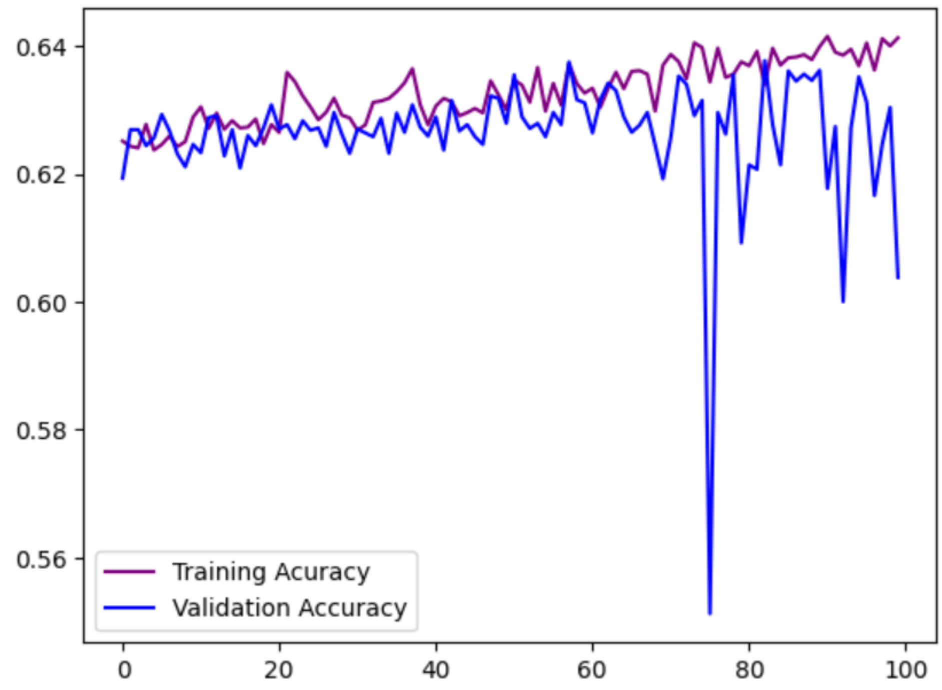


```
aug_data = keras.preprocessing.image.ImageDataGenerator(
    rotation_range=10,
    width_shift_range=0.1,
    height_shift_range=0.1,
    zoom_range=0.1,
    horizontal_flip=True,
    fill_mode='nearest')

aug_data.fit(x_train)

from tensorflow.keras import layers, models
lenet =  keras.models.Sequential([
         keras.layers.Conv2D(32, kernel_size=3, activation='relu', input_shape=(32,32,3), padding='same'
         keras.layers.BatchNormalization(),
         keras.layers.Conv2D(32, kernel_size=3, activation='relu', padding='same'),
         keras.layers.BatchNormalization(),
         keras.layers.MaxPooling2D(pool_size=2),
         keras.layers.Dropout(0.25),
         keras.layers.Conv2D(64, kernel_size=3, activation='relu', padding='same'),
         keras.layers.BatchNormalization(),
         keras.layers.Conv2D(64, kernel_size=3, activation='relu', padding='same'),
         keras.layers.BatchNormalization(),
         keras.layers.MaxPooling2D(pool_size=2),
         keras.layers.Dropout(0.25),
         keras.layers.Conv2D(128, kernel_size=3, activation='relu', padding='same'),
         keras.layers.BatchNormalization(),
         keras.layers.Conv2D(128, kernel_size=3, activation='relu', padding='same'),
         keras.layers.BatchNormalization(),
         keras.layers.MaxPooling2D(pool_size=2),
         keras.layers.Dropout(0.25),
          keras.layers.Flatten(),
```

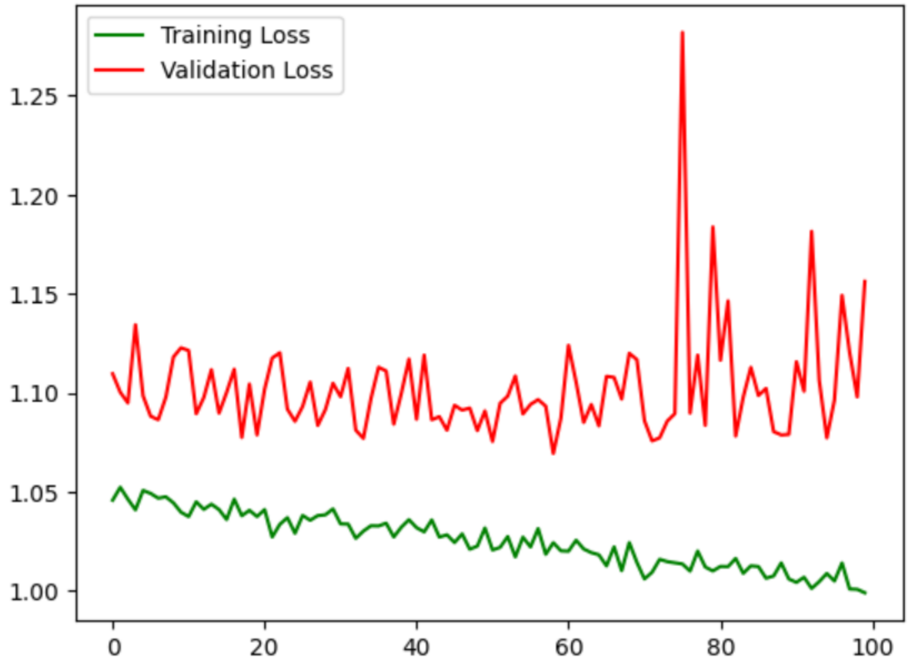


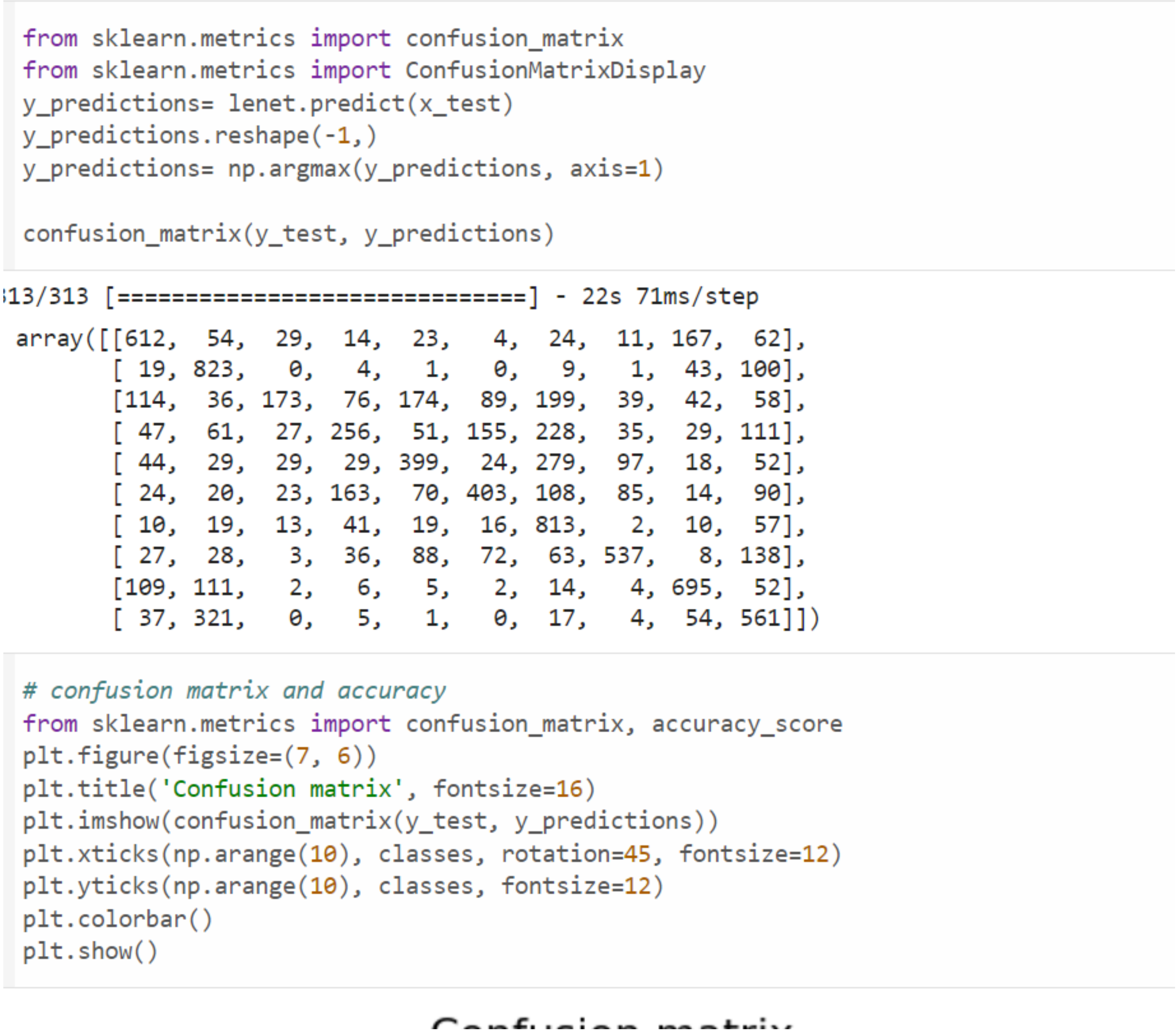
```
# summarize history for accuracy
plt.plot(history.history['accuracy'])
plt.plot(history.history['val_accuracy'])
plt.title("Accuracy by LeNet on CIFAR-10 Data")
plt.ylabel('Accuracy')
plt.xlabel('Epochs')
plt.legend(['Train', 'Validation'], loc='upper left')
plt.show()
# summarize history for loss
plt.plot(history.history['loss'])
plt.plot(history.history['val_loss'])
plt.title('Loss by LeNet on CIFAR-10 Data')
plt.ylabel('Loss')
plt.xlabel('Epochs')
plt.legend(['Train', 'Validation'])
plt.show()
```

```
<matplotlib.legend.Legend at 0x7f75101e8160>
```


0.64
0.62
0.60
0.58
0.56
Training Acuracy
Validation Accuracy
0
20
40
60
80
100

```
<matplotlib.legend.Legend at 0x7f75101e8d30>
```


Training Loss
Validation Loss
1.25
1.20
1.15
1.10
1.05
1.00
0
20
40
60
80
100

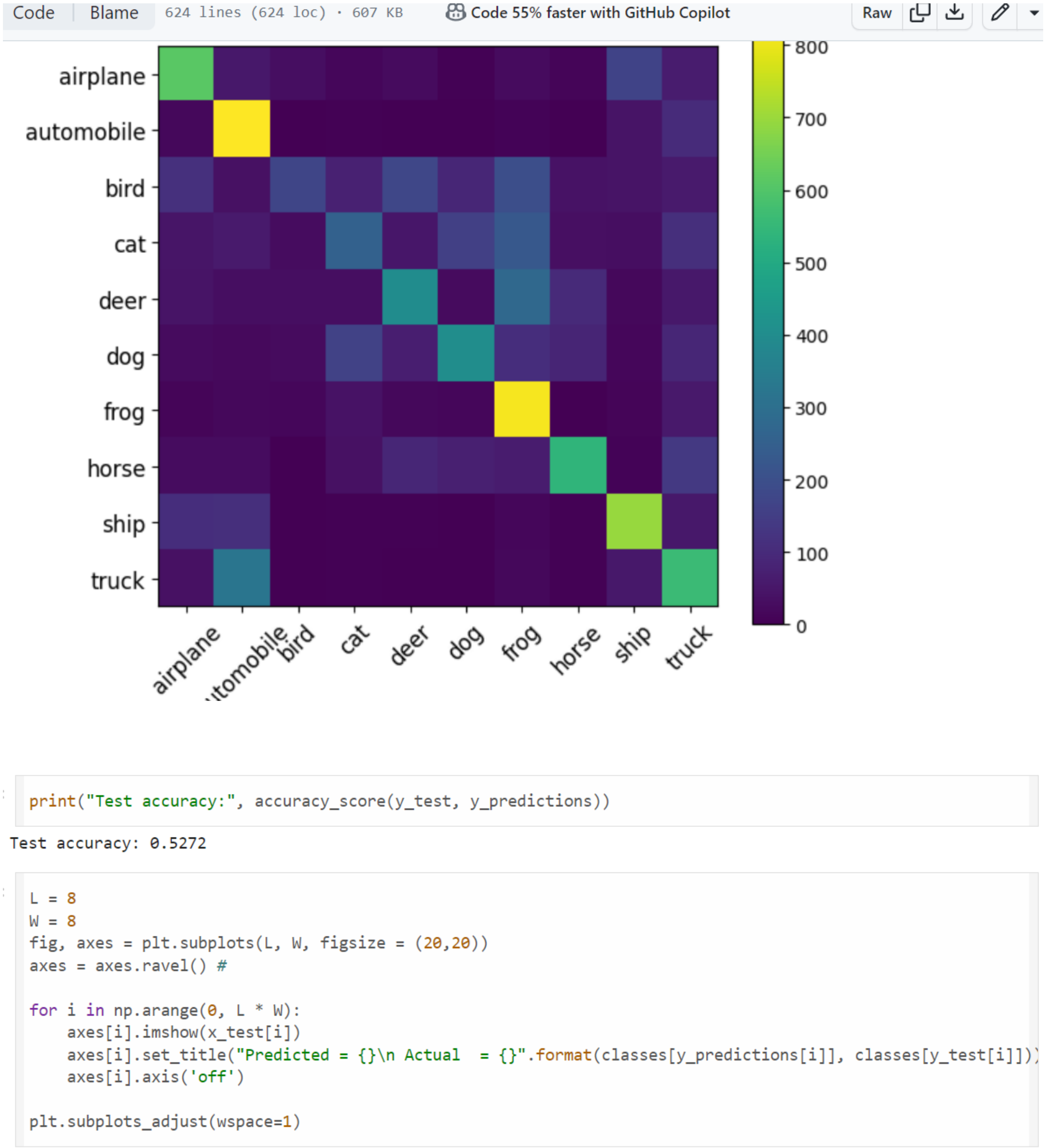


```python
from sklearn.metrics import confusion_matrix
from sklearn.metrics import ConfusionMatrixDisplay
y_predictions= lenet.predict(x_test)
y_predictions.reshape(-1,)
y_predictions= np.argmax(y_predictions, axis=1)

confusion_matrix(y_test, y_predictions)
```

```
313/313 [==============================] - 22s 71ms/step
array([[612,  54,  29,  14,  23,   4,  24,  11, 167,  62],
       [ 19, 823,   0,   4,   1,   0,   9,   1,  43, 100],
       [114,  36, 173,  76, 174,  89, 199,  39,  42,  58],
       [ 47,  61,  27, 256,  51, 155, 228,  35,  29, 111],
       [ 44,  29,  29,  29, 399,  24, 279,  97,  18,  52],
       [ 24,  20,  23, 163,  70, 403, 108,  85,  14,  90],
       [ 10,  19,  13,  41,  19,  16, 813,   2,  10,  57],
       [ 27,  28,   3,  36,  88,  72,  63, 537,   8, 138],
       [109, 111,   2,   6,   5,   2,  14,   4, 695,  52],
       [ 37, 321,   0,   5,   1,   0,  17,   4,  54, 561]])
```

```python
# confusion matrix and accuracy
from sklearn.metrics import confusion_matrix, accuracy_score
plt.figure(figsize=(7, 6))
plt.title('Confusion matrix', fontsize=16)
plt.imshow(confusion_matrix(y_test, y_predictions))
plt.xticks(np.arange(10), classes, rotation=45, fontsize=12)
plt.yticks(np.arange(10), classes, fontsize=12)
plt.colorbar()
plt.show()
```

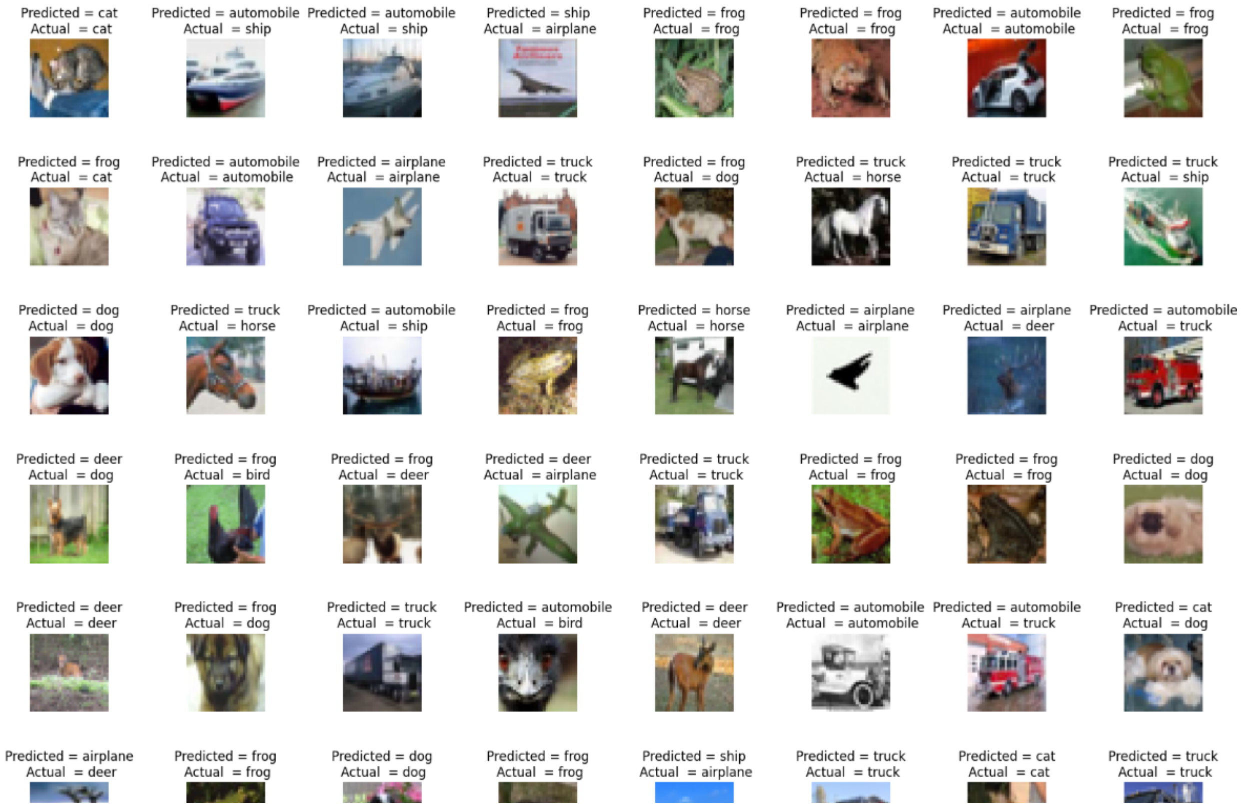
Confusion matrix



```
print("Test accuracy:", accuracy_score(y_test, y_predictions))
```

```
Test accuracy: 0.5272
```

```
L = 8
W = 8
fig, axes = plt.subplots(L, W, figsize = (20,20))
axes = axes.ravel() #

for i in np.arange(0, L * W):
    axes[i].imshow(x_test[i])
    axes[i].set_title("Predicted = {}\n Actual  = {}".format(classes[y_predictions[i]], classes[y_test[i]]))
    axes[i].axis('off')

plt.subplots_adjust(wspace=1)
```



Predicted = cat
Actual = cat

Predicted = automobile
Actual = ship

Predicted = automobile
Actual = ship

Predicted = ship
Actual = airplane

Predicted = frog
Actual = frog

Predicted = frog
Actual = frog

Predicted = automobile
Actual = automobile

Predicted = frog
Actual = frog

Predicted = frog
Actual = cat

Predicted = automobile
Actual = automobile

Predicted = airplane
Actual = airplane

Predicted = truck
Actual = truck

Predicted = frog
Actual = dog

Predicted = truck
Actual = horse

Predicted = truck
Actual = truck

Predicted = truck
Actual = ship

Predicted = dog
Actual = dog

Predicted = truck
Actual = horse

Predicted = automobile
Actual = ship

Predicted = frog
Actual = frog

Predicted = horse
Actual = horse

Predicted = airplane
Actual = airplane

Predicted = airplane
Actual = deer

Predicted = automobile
Actual = truck

Predicted = deer
Actual = dog

Predicted = frog
Actual = bird

Predicted = frog
Actual = deer

Predicted = deer
Actual = airplane

Predicted = truck
Actual = truck

Predicted = frog
Actual = frog

Predicted = frog
Actual = frog

Predicted = dog
Actual = dog

Predicted = deer
Actual = deer

Predicted = frog
Actual = dog

Predicted = truck
Actual = truck

Predicted = automobile
Actual = bird

Predicted = deer
Actual = deer

Predicted = automobile
Actual = automobile

Predicted = automobile
Actual = truck

Predicted = cat
Actual = dog

Predicted = airplane
Actual = deer

Predicted = frog
Actual = frog

Predicted = dog
Actual = dog

Predicted = frog
Actual = frog

Predicted = ship
Actual = airplane

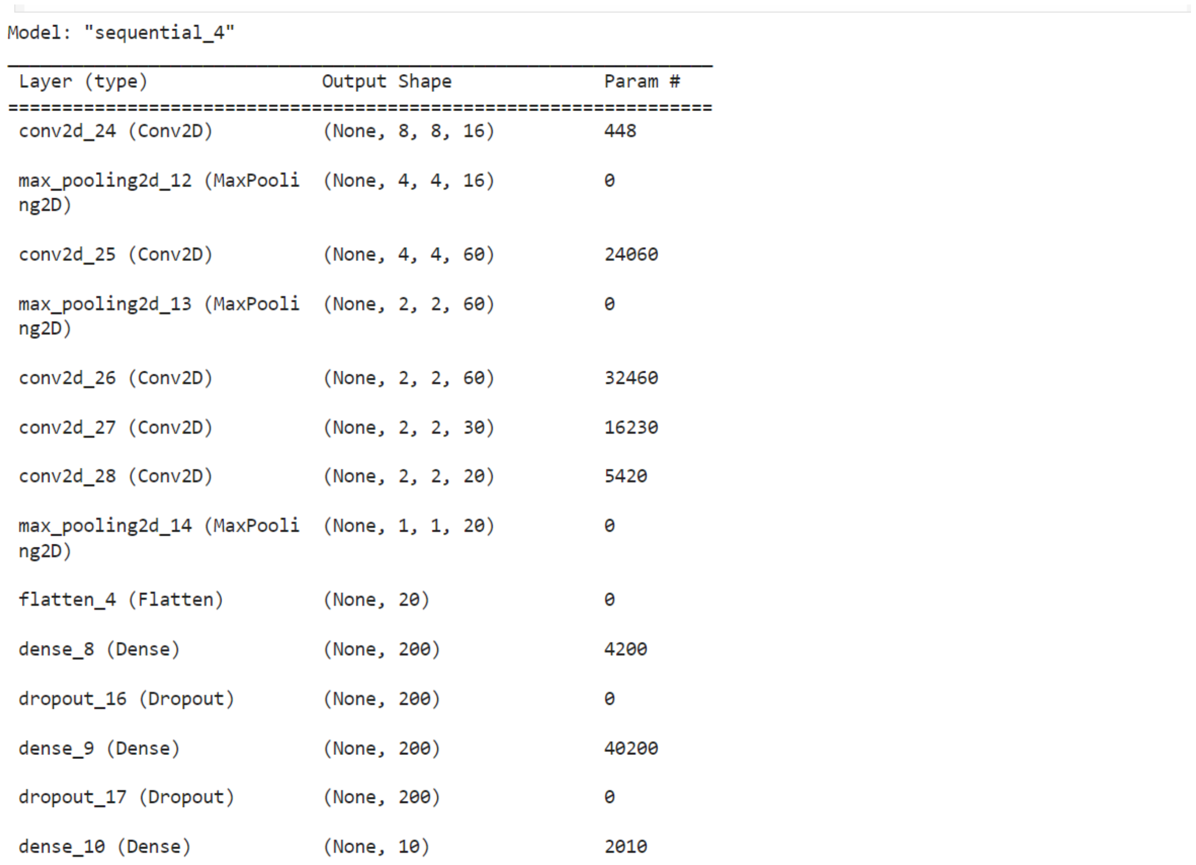
Predicted = truck
Actual = truck

Predicted = cat
Actual = cat

Predicted = truck
Actual = truck

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Conv2D, Dropout, Flatten, MaxPooling2D
from tensorflow.keras.optimizers import SGD, Adam
```

```
#Define Alexnet Model
AlexNet = Sequential()
AlexNet.add(Conv2D(filters=16,kernel_size=(3,3),strides=(4,4),input_shape=(32,32,3), activation='relu'))
AlexNet.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
AlexNet.add(Conv2D(60,(5,5),padding='same',activation='relu'))
AlexNet.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
AlexNet.add(Conv2D(60,(3,3),padding='same',activation='relu'))
AlexNet.add(Conv2D(30,(3,3),padding='same',activation='relu'))
AlexNet.add(Conv2D(20,(3,3),padding='same',activation='relu'))
AlexNet.add(MaxPooling2D(pool_size=(2,2),strides=(2,2)))
AlexNet.add(Flatten())
AlexNet.add(Dense(200, activation='relu'))
AlexNet.add(Dropout(0.1))
AlexNet.add(Dense(200, activation='relu'))
AlexNet.add(Dropout(0.1))
AlexNet.add(Dense(10,activation='softmax'))

AlexNet.compile(optimizer='SGD', loss=keras.losses.sparse_categorical_crossentropy, metrics=['accuracy'])
AlexNet.summary()
```



```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d_24 (Conv2D)          (None, 8, 8, 16)          448       
                                                                 
 max_pooling2d_12 (MaxPooli  (None, 4, 4, 16)          0         
 ng2D)                                                           
                                                                 
 conv2d_25 (Conv2D)          (None, 4, 4, 60)          24060     
                                                                 
 max_pooling2d_13 (MaxPooli  (None, 2, 2, 60)          0         
 ng2D)                                                           
                                                                 
 conv2d_26 (Conv2D)          (None, 2, 2, 60)          32460     
                                                                 
 conv2d_27 (Conv2D)          (None, 2, 2, 30)          16230     
                                                                 
 conv2d_28 (Conv2D)          (None, 2, 2, 20)          5420      
                                                                 
 max_pooling2d_14 (MaxPooli  (None, 1, 1, 20)          0         
 ng2D)                                                           
                                                                 
 flatten_4 (Flatten)         (None, 20)                0         
                                                                 
 dense_8 (Dense)             (None, 200)               4200      
                                                                 
 dropout_16 (Dropout)        (None, 200)               0         
                                                                 
 dense_9 (Dense)             (None, 200)               40200     
                                                                 
 dropout_17 (Dropout)        (None, 200)               0         
                                                                 
 dense_10 (Dense)            (None, 10)                2010      
```