# CS300-Artificial Intelligence : Đồ án cuối kì

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### 1. Tự thêm vào

### 2. Mạng nơ-ron tích chập - Convolutional Neural Network

#### a. Chuẩn bị các thư viện cần thiết

!git clone https://github.com/liem18112000/CS300\_FInalTerm.git

fatal: destination path 'CS300\_FInalTerm' already exists and is not an empty directory.

%load\_ext tensorboard

The tensorboard extension is already loaded. To reload it, use:  
 %reload\_ext tensorboard

import tensorflow as tf  
from datetime import datetime  
import os  
from tensorflow.keras.optimizers import RMSprop,Adam  
from CS300\_FInalTerm.factory import \*  
from CS300\_FInalTerm.loader import \*  
from CS300\_FInalTerm.utility import \*  
  
factory = ModelFactory.instance()  
loader = Loader()  
  
def train\_model(model):  
 model.compile(  
 optimizer ='adam',  
 loss='categorical\_crossentropy',  
 metrics=['accuracy']  
 )  
  
 # logdir = os.path.join("logs", datetime.now().strftime("%Y%m%d-%H%M%S"))  
 # tensorboard\_callback = tf.keras.callbacks.TensorBoard(logdir, histogram\_freq=1)  
  
 history = model.fit(  
 x\_train\_1, y\_train\_1,   
 validation\_data = (x\_val\_1, y\_val\_1),  
 batch\_size=BATCH\_SIZE,   
 epochs=EPOCHS,  
 # callbacks = callbacks + [tensorboard\_callback]  
 callbacks = callbacks  
 )  
  
 return history

!nvidia-smi

NVIDIA-SMI has failed because it couldn't communicate with the NVIDIA driver. Make sure that the latest NVIDIA driver is installed and running.

#### b. Dữ liệu huấn luyện : Fashion MNIST

(x\_train, y\_train), (x\_test, y\_test) = loader.load\_dataset()

Shape of original training examples: (60000, 28, 28)  
Shape of original test examples: (10000, 28, 28)  
Shape of original training result: (60000,)  
Shape of original test result: (10000,)

class\_names = ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat', 'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']  
plt.figure(figsize=(16,16))  
for i in range(25):  
 plt.subplot(5,5,i+1)  
 plt.xticks([])  
 plt.yticks([])  
 plt.grid(False)  
 plt.imshow(x\_train[i], cmap=plt.cm.binary)  
 plt.xlabel(class\_names[y\_train[i]])  
plt.show()

png

png

#### c. Các mẩu huấn luyện

(x\_train\_1, y\_train\_1), (x\_val\_1, y\_val\_1), (x\_test\_1, y\_test\_1) = loader.load\_dataset\_expanddim()

Shape of original training examples: (60000, 28, 28)  
Shape of original validation examples: (8000, 28, 28)  
Shape of original test examples: (2000, 28, 28)  
Shape of original training result: (60000, 10)  
Shape of original validation result: (8000, 10)  
Shape of original test result: (2000, 10)

BATCH\_SIZE = 4096  
EPOCHS = 200  
callbacks = [  
 tf.keras.callbacks.EarlyStopping(monitor='loss', patience=20, restore\_best\_weights= True),  
 tf.keras.callbacks.EarlyStopping(monitor='val\_loss', patience=20, restore\_best\_weights= True),  
]  
histories = {}

import sys  
print ('Running in colab:', 'google.colab' in sys.modules)

Running in colab: True

resolver = tf.distribute.cluster\_resolver.TPUClusterResolver(tpu='grpc://' + os.environ['COLAB\_TPU\_ADDR'])  
tf.config.experimental\_connect\_to\_cluster(resolver)  
tf.tpu.experimental.initialize\_tpu\_system(resolver)  
strategy = tf.distribute.TPUStrategy(resolver)  
  
with strategy.scope():  
 model = factory.createMiniVGGModel(32)  
 history = train\_model(model)

WARNING:tensorflow:TPU system grpc://10.31.158.74:8470 has already been initialized. Reinitializing the TPU can cause previously created variables on TPU to be lost.  
  
  
WARNING:tensorflow:TPU system grpc://10.31.158.74:8470 has already been initialized. Reinitializing the TPU can cause previously created variables on TPU to be lost.  
  
  
INFO:tensorflow:Initializing the TPU system: grpc://10.31.158.74:8470  
  
  
INFO:tensorflow:Initializing the TPU system: grpc://10.31.158.74:8470  
  
  
INFO:tensorflow:Clearing out eager caches  
  
  
INFO:tensorflow:Clearing out eager caches  
  
  
INFO:tensorflow:Finished initializing TPU system.  
  
  
INFO:tensorflow:Finished initializing TPU system.  
  
  
INFO:tensorflow:Found TPU system:  
  
  
INFO:tensorflow:Found TPU system:  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Workers: 1  
  
  
INFO:tensorflow:\*\*\* Num TPU Workers: 1  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores Per Worker: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores Per Worker: 8  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:localhost/replica:0/task:0/device:CPU:0, CPU, 0, 0)  
  
  
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INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:2, TPU, 0, 0)  
  
  
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INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:3, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:3, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:4, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:4, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:5, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:5, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:6, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:6, TPU, 0, 0)  
  
  
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INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU\_SYSTEM:0, TPU\_SYSTEM, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU\_SYSTEM:0, TPU\_SYSTEM, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:XLA\_CPU:0, XLA\_CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:XLA\_CPU:0, XLA\_CPU, 0, 0)  
  
  
Model: "sequential\_4"  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Layer (type) Output Shape Param #   
=================================================================  
up\_sampling3d\_4 (UpSampling3 (None, 28, 28, 1) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_48 (Conv2D) (None, 28, 28, 32) 320   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_56 (Batc (None, 28, 28, 32) 112   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_49 (Conv2D) (None, 28, 28, 32) 9248   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_57 (Batc (None, 28, 28, 32) 112   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_16 (MaxPooling (None, 14, 14, 32) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_16 (Dropout) (None, 14, 14, 32) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_50 (Conv2D) (None, 14, 14, 64) 18496   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_58 (Batc (None, 14, 14, 64) 56   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_51 (Conv2D) (None, 14, 14, 64) 36928   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_59 (Batc (None, 14, 14, 64) 56   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_17 (MaxPooling (None, 7, 7, 64) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_17 (Dropout) (None, 7, 7, 64) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_52 (Conv2D) (None, 7, 7, 128) 73856   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_60 (Batc (None, 7, 7, 128) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_53 (Conv2D) (None, 7, 7, 128) 147584   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_61 (Batc (None, 7, 7, 128) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_54 (Conv2D) (None, 7, 7, 128) 147584   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_62 (Batc (None, 7, 7, 128) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_55 (Conv2D) (None, 7, 7, 128) 147584   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_63 (Batc (None, 7, 7, 128) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_18 (MaxPooling (None, 3, 3, 128) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_18 (Dropout) (None, 3, 3, 128) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_56 (Conv2D) (None, 3, 3, 256) 295168   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_64 (Batc (None, 3, 3, 256) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_57 (Conv2D) (None, 3, 3, 256) 590080   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_65 (Batc (None, 3, 3, 256) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_58 (Conv2D) (None, 3, 3, 256) 590080   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_66 (Batc (None, 3, 3, 256) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_59 (Conv2D) (None, 3, 3, 256) 590080   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_67 (Batc (None, 3, 3, 256) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_19 (MaxPooling (None, 1, 1, 256) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_19 (Dropout) (None, 1, 1, 256) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
flatten\_4 (Flatten) (None, 256) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_12 (Dense) (None, 256) 65792   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_68 (Batc (None, 256) 1024   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_13 (Dense) (None, 256) 65792   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_69 (Batc (None, 256) 1024   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_14 (Dense) (None, 10) 2570   
=================================================================  
Total params: 2,783,706  
Trainable params: 2,782,434  
Non-trainable params: 1,272  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Epoch 1/200  
15/15 [==============================] - 26s 783ms/step - loss: 1.9809 - accuracy: 0.3697 - val\_loss: 2.2771 - val\_accuracy: 0.2098  
Epoch 2/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.6759 - accuracy: 0.7405 - val\_loss: 2.3157 - val\_accuracy: 0.1598  
Epoch 3/200  
15/15 [==============================] - 1s 83ms/step - loss: 0.5523 - accuracy: 0.7941 - val\_loss: 2.3581 - val\_accuracy: 0.1585  
Epoch 4/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.4718 - accuracy: 0.8240 - val\_loss: 2.4897 - val\_accuracy: 0.1873  
Epoch 5/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.4146 - accuracy: 0.8438 - val\_loss: 2.5488 - val\_accuracy: 0.1531  
Epoch 6/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.3703 - accuracy: 0.8598 - val\_loss: 2.4771 - val\_accuracy: 0.1493  
Epoch 7/200  
15/15 [==============================] - 1s 83ms/step - loss: 0.3374 - accuracy: 0.8729 - val\_loss: 2.7591 - val\_accuracy: 0.1011  
Epoch 8/200  
15/15 [==============================] - 1s 85ms/step - loss: 0.3179 - accuracy: 0.8815 - val\_loss: 2.4321 - val\_accuracy: 0.1011  
Epoch 9/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.2908 - accuracy: 0.8915 - val\_loss: 2.2605 - val\_accuracy: 0.1300  
Epoch 10/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.2777 - accuracy: 0.8957 - val\_loss: 2.1012 - val\_accuracy: 0.2080  
Epoch 11/200  
15/15 [==============================] - 2s 105ms/step - loss: 0.2640 - accuracy: 0.9012 - val\_loss: 2.2550 - val\_accuracy: 0.2086  
Epoch 12/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.2494 - accuracy: 0.9066 - val\_loss: 2.5071 - val\_accuracy: 0.1556  
Epoch 13/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.2358 - accuracy: 0.9120 - val\_loss: 2.0407 - val\_accuracy: 0.3328  
Epoch 14/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.2306 - accuracy: 0.9142 - val\_loss: 1.8617 - val\_accuracy: 0.3283  
Epoch 15/200  
15/15 [==============================] - 1s 83ms/step - loss: 0.2169 - accuracy: 0.9196 - val\_loss: 2.1135 - val\_accuracy: 0.3524  
Epoch 16/200  
15/15 [==============================] - 1s 83ms/step - loss: 0.2092 - accuracy: 0.9221 - val\_loss: 1.6877 - val\_accuracy: 0.4415  
Epoch 17/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.2048 - accuracy: 0.9232 - val\_loss: 1.5598 - val\_accuracy: 0.5215  
Epoch 18/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.1989 - accuracy: 0.9239 - val\_loss: 1.3700 - val\_accuracy: 0.5694  
Epoch 19/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.1859 - accuracy: 0.9301 - val\_loss: 1.2765 - val\_accuracy: 0.5816  
Epoch 20/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.1897 - accuracy: 0.9302 - val\_loss: 1.2734 - val\_accuracy: 0.5614  
Epoch 21/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.1729 - accuracy: 0.9364 - val\_loss: 1.1573 - val\_accuracy: 0.6168  
Epoch 22/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.1721 - accuracy: 0.9363 - val\_loss: 0.8227 - val\_accuracy: 0.6919  
Epoch 23/200  
15/15 [==============================] - 1s 86ms/step - loss: 0.1665 - accuracy: 0.9370 - val\_loss: 0.7443 - val\_accuracy: 0.7499  
Epoch 24/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.1641 - accuracy: 0.9380 - val\_loss: 0.9059 - val\_accuracy: 0.6936  
Epoch 25/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.1524 - accuracy: 0.9436 - val\_loss: 0.6990 - val\_accuracy: 0.7663  
Epoch 26/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.1519 - accuracy: 0.9428 - val\_loss: 0.6065 - val\_accuracy: 0.8006  
Epoch 27/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.1476 - accuracy: 0.9446 - val\_loss: 0.4822 - val\_accuracy: 0.8293  
Epoch 28/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.1418 - accuracy: 0.9469 - val\_loss: 0.4741 - val\_accuracy: 0.8379  
Epoch 29/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.1321 - accuracy: 0.9495 - val\_loss: 0.5204 - val\_accuracy: 0.8284  
Epoch 30/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.1323 - accuracy: 0.9503 - val\_loss: 0.4115 - val\_accuracy: 0.8635  
Epoch 31/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.1293 - accuracy: 0.9524 - val\_loss: 0.3853 - val\_accuracy: 0.8786  
Epoch 32/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.1282 - accuracy: 0.9510 - val\_loss: 0.3952 - val\_accuracy: 0.8713  
Epoch 33/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.1288 - accuracy: 0.9507 - val\_loss: 0.3014 - val\_accuracy: 0.9019  
Epoch 34/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.1203 - accuracy: 0.9530 - val\_loss: 0.2883 - val\_accuracy: 0.9065  
Epoch 35/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.1134 - accuracy: 0.9567 - val\_loss: 0.2836 - val\_accuracy: 0.9105  
Epoch 36/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.1119 - accuracy: 0.9577 - val\_loss: 0.2601 - val\_accuracy: 0.9174  
Epoch 37/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.1057 - accuracy: 0.9594 - val\_loss: 0.2645 - val\_accuracy: 0.9203  
Epoch 38/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.1052 - accuracy: 0.9603 - val\_loss: 0.2816 - val\_accuracy: 0.9106  
Epoch 39/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.0996 - accuracy: 0.9621 - val\_loss: 0.2956 - val\_accuracy: 0.9108  
Epoch 40/200  
15/15 [==============================] - 1s 83ms/step - loss: 0.0955 - accuracy: 0.9637 - val\_loss: 0.2545 - val\_accuracy: 0.9251  
Epoch 41/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.0939 - accuracy: 0.9643 - val\_loss: 0.2971 - val\_accuracy: 0.9151  
Epoch 42/200  
15/15 [==============================] - 1s 84ms/step - loss: 0.0922 - accuracy: 0.9650 - val\_loss: 0.3201 - val\_accuracy: 0.9124  
Epoch 43/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.0885 - accuracy: 0.9663 - val\_loss: 0.2788 - val\_accuracy: 0.9236  
Epoch 44/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0868 - accuracy: 0.9667 - val\_loss: 0.2662 - val\_accuracy: 0.9250  
Epoch 45/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0846 - accuracy: 0.9676 - val\_loss: 0.2556 - val\_accuracy: 0.9315  
Epoch 46/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.0801 - accuracy: 0.9702 - val\_loss: 0.2697 - val\_accuracy: 0.9234  
Epoch 47/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.0792 - accuracy: 0.9702 - val\_loss: 0.2656 - val\_accuracy: 0.9276  
Epoch 48/200  
15/15 [==============================] - 2s 116ms/step - loss: 0.0738 - accuracy: 0.9720 - val\_loss: 0.2543 - val\_accuracy: 0.9294  
Epoch 49/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0704 - accuracy: 0.9744 - val\_loss: 0.2651 - val\_accuracy: 0.9259  
Epoch 50/200  
15/15 [==============================] - 1s 83ms/step - loss: 0.0718 - accuracy: 0.9731 - val\_loss: 0.2638 - val\_accuracy: 0.9290  
Epoch 51/200  
15/15 [==============================] - 1s 85ms/step - loss: 0.0681 - accuracy: 0.9743 - val\_loss: 0.2751 - val\_accuracy: 0.9299  
Epoch 52/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.0653 - accuracy: 0.9753 - val\_loss: 0.2788 - val\_accuracy: 0.9293  
Epoch 53/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.0632 - accuracy: 0.9748 - val\_loss: 0.2862 - val\_accuracy: 0.9281  
Epoch 54/200  
15/15 [==============================] - 1s 79ms/step - loss: 0.0605 - accuracy: 0.9779 - val\_loss: 0.2844 - val\_accuracy: 0.9346  
Epoch 55/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0604 - accuracy: 0.9772 - val\_loss: 0.2921 - val\_accuracy: 0.9278  
Epoch 56/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0565 - accuracy: 0.9784 - val\_loss: 0.2894 - val\_accuracy: 0.9296  
Epoch 57/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0589 - accuracy: 0.9772 - val\_loss: 0.2884 - val\_accuracy: 0.9284  
Epoch 58/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.0621 - accuracy: 0.9769 - val\_loss: 0.3007 - val\_accuracy: 0.9268  
Epoch 59/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.0592 - accuracy: 0.9768 - val\_loss: 0.2847 - val\_accuracy: 0.9324  
Epoch 60/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.0561 - accuracy: 0.9787 - val\_loss: 0.3094 - val\_accuracy: 0.9298  
Epoch 61/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.0470 - accuracy: 0.9821 - val\_loss: 0.3001 - val\_accuracy: 0.9306  
Epoch 62/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.0496 - accuracy: 0.9814 - val\_loss: 0.3146 - val\_accuracy: 0.9313  
Epoch 63/200  
15/15 [==============================] - 1s 79ms/step - loss: 0.0522 - accuracy: 0.9804 - val\_loss: 0.2977 - val\_accuracy: 0.9314  
Epoch 64/200  
15/15 [==============================] - 1s 79ms/step - loss: 0.0442 - accuracy: 0.9825 - val\_loss: 0.3215 - val\_accuracy: 0.9296  
Epoch 65/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0462 - accuracy: 0.9829 - val\_loss: 0.3029 - val\_accuracy: 0.9299  
Epoch 66/200  
15/15 [==============================] - 1s 82ms/step - loss: 0.0472 - accuracy: 0.9827 - val\_loss: 0.3406 - val\_accuracy: 0.9288  
Epoch 67/200  
15/15 [==============================] - 1s 80ms/step - loss: 0.0448 - accuracy: 0.9836 - val\_loss: 0.3225 - val\_accuracy: 0.9308  
Epoch 68/200  
15/15 [==============================] - 1s 81ms/step - loss: 0.0422 - accuracy: 0.9841 - val\_loss: 0.3263 - val\_accuracy: 0.9291

histories['VGG19\_32'] = (history, model.evaluate(x\_test\_1, y\_test\_1, BATCH\_SIZE))

1/1 [==============================] - 2s 2s/step - loss: 0.2290 - accuracy: 0.9370

resolver = tf.distribute.cluster\_resolver.TPUClusterResolver(tpu='grpc://' + os.environ['COLAB\_TPU\_ADDR'])  
tf.config.experimental\_connect\_to\_cluster(resolver)  
tf.tpu.experimental.initialize\_tpu\_system(resolver)  
strategy = tf.distribute.TPUStrategy(resolver)  
  
with strategy.scope():  
 model = factory.createMiniVGGModel(64)  
 history = train\_model(model)

WARNING:tensorflow:TPU system grpc://10.31.158.74:8470 has already been initialized. Reinitializing the TPU can cause previously created variables on TPU to be lost.  
  
  
WARNING:tensorflow:TPU system grpc://10.31.158.74:8470 has already been initialized. Reinitializing the TPU can cause previously created variables on TPU to be lost.  
  
  
INFO:tensorflow:Initializing the TPU system: grpc://10.31.158.74:8470  
  
  
INFO:tensorflow:Initializing the TPU system: grpc://10.31.158.74:8470  
  
  
INFO:tensorflow:Clearing out eager caches  
  
  
INFO:tensorflow:Clearing out eager caches  
  
  
INFO:tensorflow:Finished initializing TPU system.  
  
  
INFO:tensorflow:Finished initializing TPU system.  
  
  
INFO:tensorflow:Found TPU system:  
  
  
INFO:tensorflow:Found TPU system:  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Workers: 1  
  
  
INFO:tensorflow:\*\*\* Num TPU Workers: 1  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores Per Worker: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores Per Worker: 8  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:localhost/replica:0/task:0/device:CPU:0, CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:localhost/replica:0/task:0/device:CPU:0, CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:CPU:0, CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:CPU:0, CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:0, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:0, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:1, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:1, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:2, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:2, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:3, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:3, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:4, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:4, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:5, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:5, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:6, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:6, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:7, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:7, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU\_SYSTEM:0, TPU\_SYSTEM, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU\_SYSTEM:0, TPU\_SYSTEM, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:XLA\_CPU:0, XLA\_CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:XLA\_CPU:0, XLA\_CPU, 0, 0)  
  
  
Model: "sequential\_5"  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Layer (type) Output Shape Param #   
=================================================================  
up\_sampling3d\_5 (UpSampling3 (None, 28, 28, 1) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_60 (Conv2D) (None, 28, 28, 64) 640   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_70 (Batc (None, 28, 28, 64) 112   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_61 (Conv2D) (None, 28, 28, 64) 36928   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_71 (Batc (None, 28, 28, 64) 112   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_20 (MaxPooling (None, 14, 14, 64) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_20 (Dropout) (None, 14, 14, 64) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_62 (Conv2D) (None, 14, 14, 128) 73856   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_72 (Batc (None, 14, 14, 128) 56   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_63 (Conv2D) (None, 14, 14, 128) 147584   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_73 (Batc (None, 14, 14, 128) 56   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_21 (MaxPooling (None, 7, 7, 128) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_21 (Dropout) (None, 7, 7, 128) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_64 (Conv2D) (None, 7, 7, 256) 295168   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_74 (Batc (None, 7, 7, 256) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_65 (Conv2D) (None, 7, 7, 256) 590080   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_75 (Batc (None, 7, 7, 256) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_66 (Conv2D) (None, 7, 7, 256) 590080   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_76 (Batc (None, 7, 7, 256) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_67 (Conv2D) (None, 7, 7, 256) 590080   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_77 (Batc (None, 7, 7, 256) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_22 (MaxPooling (None, 3, 3, 256) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_22 (Dropout) (None, 3, 3, 256) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_68 (Conv2D) (None, 3, 3, 512) 1180160   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_78 (Batc (None, 3, 3, 512) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_69 (Conv2D) (None, 3, 3, 512) 2359808   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_79 (Batc (None, 3, 3, 512) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_70 (Conv2D) (None, 3, 3, 512) 2359808   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_80 (Batc (None, 3, 3, 512) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_71 (Conv2D) (None, 3, 3, 512) 2359808   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_81 (Batc (None, 3, 3, 512) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_23 (MaxPooling (None, 1, 1, 512) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_23 (Dropout) (None, 1, 1, 512) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
flatten\_5 (Flatten) (None, 512) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_15 (Dense) (None, 512) 262656   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_82 (Batc (None, 512) 2048   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_16 (Dense) (None, 512) 262656   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_83 (Batc (None, 512) 2048   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_17 (Dense) (None, 10) 5130   
=================================================================  
Total params: 11,119,034  
Trainable params: 11,116,738  
Non-trainable params: 2,296  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Epoch 1/200  
15/15 [==============================] - 43s 2s/step - loss: 2.1510 - accuracy: 0.3452 - val\_loss: 1.9289 - val\_accuracy: 0.2408  
Epoch 2/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.7127 - accuracy: 0.7297 - val\_loss: 3.1997 - val\_accuracy: 0.1334  
Epoch 3/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.5751 - accuracy: 0.7838 - val\_loss: 3.2515 - val\_accuracy: 0.0993  
Epoch 4/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.5137 - accuracy: 0.8082 - val\_loss: 3.0022 - val\_accuracy: 0.1066  
Epoch 5/200  
15/15 [==============================] - 2s 121ms/step - loss: 0.4632 - accuracy: 0.8268 - val\_loss: 2.8594 - val\_accuracy: 0.1374  
Epoch 6/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.4223 - accuracy: 0.8418 - val\_loss: 2.6877 - val\_accuracy: 0.1831  
Epoch 7/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.3866 - accuracy: 0.8551 - val\_loss: 3.4796 - val\_accuracy: 0.1733  
Epoch 8/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.3558 - accuracy: 0.8671 - val\_loss: 3.2986 - val\_accuracy: 0.0986  
Epoch 9/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.3256 - accuracy: 0.8777 - val\_loss: 2.9048 - val\_accuracy: 0.0336  
Epoch 10/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.3046 - accuracy: 0.8869 - val\_loss: 2.8676 - val\_accuracy: 0.1024  
Epoch 11/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.2804 - accuracy: 0.8984 - val\_loss: 2.6008 - val\_accuracy: 0.2020  
Epoch 12/200  
15/15 [==============================] - 2s 116ms/step - loss: 0.2656 - accuracy: 0.9021 - val\_loss: 2.3834 - val\_accuracy: 0.3154  
Epoch 13/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.2503 - accuracy: 0.9090 - val\_loss: 2.3958 - val\_accuracy: 0.2610  
Epoch 14/200  
15/15 [==============================] - 2s 142ms/step - loss: 0.2335 - accuracy: 0.9138 - val\_loss: 2.7149 - val\_accuracy: 0.1264  
Epoch 15/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.2260 - accuracy: 0.9166 - val\_loss: 2.6027 - val\_accuracy: 0.2435  
Epoch 16/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.2164 - accuracy: 0.9185 - val\_loss: 2.6427 - val\_accuracy: 0.1974  
Epoch 17/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.2015 - accuracy: 0.9257 - val\_loss: 2.6884 - val\_accuracy: 0.3071  
Epoch 18/200  
15/15 [==============================] - 2s 122ms/step - loss: 0.1901 - accuracy: 0.9298 - val\_loss: 2.4228 - val\_accuracy: 0.2650  
Epoch 19/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.1850 - accuracy: 0.9304 - val\_loss: 2.7339 - val\_accuracy: 0.2544  
Epoch 20/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.1838 - accuracy: 0.9307 - val\_loss: 1.5574 - val\_accuracy: 0.4418  
Epoch 21/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.1733 - accuracy: 0.9377 - val\_loss: 1.3369 - val\_accuracy: 0.5000  
Epoch 22/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.1621 - accuracy: 0.9396 - val\_loss: 1.7079 - val\_accuracy: 0.4620  
Epoch 23/200  
15/15 [==============================] - 2s 115ms/step - loss: 0.1530 - accuracy: 0.9446 - val\_loss: 1.3987 - val\_accuracy: 0.5229  
Epoch 24/200  
15/15 [==============================] - 2s 116ms/step - loss: 0.1448 - accuracy: 0.9463 - val\_loss: 1.5279 - val\_accuracy: 0.5093  
Epoch 25/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.1431 - accuracy: 0.9469 - val\_loss: 1.1812 - val\_accuracy: 0.5830  
Epoch 26/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.1362 - accuracy: 0.9492 - val\_loss: 1.0448 - val\_accuracy: 0.6384  
Epoch 27/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.1271 - accuracy: 0.9524 - val\_loss: 0.7727 - val\_accuracy: 0.7378  
Epoch 28/200  
15/15 [==============================] - 2s 120ms/step - loss: 0.1249 - accuracy: 0.9523 - val\_loss: 0.9178 - val\_accuracy: 0.6991  
Epoch 29/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.1132 - accuracy: 0.9575 - val\_loss: 0.6253 - val\_accuracy: 0.7851  
Epoch 30/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.1135 - accuracy: 0.9577 - val\_loss: 0.5432 - val\_accuracy: 0.8205  
Epoch 31/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.1041 - accuracy: 0.9607 - val\_loss: 0.6760 - val\_accuracy: 0.7851  
Epoch 32/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.1083 - accuracy: 0.9605 - val\_loss: 0.4196 - val\_accuracy: 0.8574  
Epoch 33/200  
15/15 [==============================] - 2s 121ms/step - loss: 0.1012 - accuracy: 0.9619 - val\_loss: 0.4294 - val\_accuracy: 0.8571  
Epoch 34/200  
15/15 [==============================] - 2s 116ms/step - loss: 0.0964 - accuracy: 0.9634 - val\_loss: 0.4638 - val\_accuracy: 0.8594  
Epoch 35/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0908 - accuracy: 0.9666 - val\_loss: 0.3566 - val\_accuracy: 0.8914  
Epoch 36/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0860 - accuracy: 0.9673 - val\_loss: 0.3918 - val\_accuracy: 0.8836  
Epoch 37/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0811 - accuracy: 0.9698 - val\_loss: 0.3042 - val\_accuracy: 0.9071  
Epoch 38/200  
15/15 [==============================] - 2s 115ms/step - loss: 0.0782 - accuracy: 0.9714 - val\_loss: 0.3153 - val\_accuracy: 0.9046  
Epoch 39/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0728 - accuracy: 0.9733 - val\_loss: 0.3423 - val\_accuracy: 0.9138  
Epoch 40/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0714 - accuracy: 0.9729 - val\_loss: 0.2839 - val\_accuracy: 0.9151  
Epoch 41/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0692 - accuracy: 0.9736 - val\_loss: 0.2826 - val\_accuracy: 0.9198  
Epoch 42/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.0623 - accuracy: 0.9767 - val\_loss: 0.2803 - val\_accuracy: 0.9234  
Epoch 43/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0587 - accuracy: 0.9777 - val\_loss: 0.2826 - val\_accuracy: 0.9265  
Epoch 44/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0602 - accuracy: 0.9778 - val\_loss: 0.2529 - val\_accuracy: 0.9311  
Epoch 45/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0587 - accuracy: 0.9788 - val\_loss: 0.3087 - val\_accuracy: 0.9240  
Epoch 46/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0528 - accuracy: 0.9802 - val\_loss: 0.2829 - val\_accuracy: 0.9273  
Epoch 47/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0489 - accuracy: 0.9817 - val\_loss: 0.2978 - val\_accuracy: 0.9240  
Epoch 48/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0556 - accuracy: 0.9788 - val\_loss: 0.3086 - val\_accuracy: 0.9288  
Epoch 49/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0455 - accuracy: 0.9830 - val\_loss: 0.2880 - val\_accuracy: 0.9298  
Epoch 50/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.0424 - accuracy: 0.9843 - val\_loss: 0.2999 - val\_accuracy: 0.9345  
Epoch 51/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.0434 - accuracy: 0.9845 - val\_loss: 0.2772 - val\_accuracy: 0.9354  
Epoch 52/200  
15/15 [==============================] - 2s 121ms/step - loss: 0.0379 - accuracy: 0.9865 - val\_loss: 0.2997 - val\_accuracy: 0.9341  
Epoch 53/200  
15/15 [==============================] - 2s 122ms/step - loss: 0.0342 - accuracy: 0.9877 - val\_loss: 0.3029 - val\_accuracy: 0.9335  
Epoch 54/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.0346 - accuracy: 0.9877 - val\_loss: 0.2916 - val\_accuracy: 0.9353  
Epoch 55/200  
15/15 [==============================] - 2s 117ms/step - loss: 0.0348 - accuracy: 0.9875 - val\_loss: 0.3180 - val\_accuracy: 0.9343  
Epoch 56/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0336 - accuracy: 0.9881 - val\_loss: 0.3493 - val\_accuracy: 0.9284  
Epoch 57/200  
15/15 [==============================] - 2s 116ms/step - loss: 0.0314 - accuracy: 0.9884 - val\_loss: 0.3542 - val\_accuracy: 0.9300  
Epoch 58/200  
15/15 [==============================] - 2s 159ms/step - loss: 0.0337 - accuracy: 0.9873 - val\_loss: 0.3263 - val\_accuracy: 0.9330  
Epoch 59/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0310 - accuracy: 0.9886 - val\_loss: 0.3227 - val\_accuracy: 0.9364  
Epoch 60/200  
15/15 [==============================] - 2s 119ms/step - loss: 0.0268 - accuracy: 0.9900 - val\_loss: 0.3243 - val\_accuracy: 0.9330  
Epoch 61/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0273 - accuracy: 0.9905 - val\_loss: 0.3317 - val\_accuracy: 0.9344  
Epoch 62/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0256 - accuracy: 0.9909 - val\_loss: 0.3586 - val\_accuracy: 0.9269  
Epoch 63/200  
15/15 [==============================] - 2s 116ms/step - loss: 0.0256 - accuracy: 0.9906 - val\_loss: 0.3653 - val\_accuracy: 0.9314  
Epoch 64/200  
15/15 [==============================] - 2s 118ms/step - loss: 0.0224 - accuracy: 0.9919 - val\_loss: 0.3441 - val\_accuracy: 0.9323

histories['VGG19\_64'] = (history, model.evaluate(x\_test\_1, y\_test\_1, BATCH\_SIZE))

1/1 [==============================] - 2s 2s/step - loss: 0.2600 - accuracy: 0.9250

resolver = tf.distribute.cluster\_resolver.TPUClusterResolver(tpu='grpc://' + os.environ['COLAB\_TPU\_ADDR'])  
tf.config.experimental\_connect\_to\_cluster(resolver)  
tf.tpu.experimental.initialize\_tpu\_system(resolver)  
strategy = tf.distribute.TPUStrategy(resolver)  
  
with strategy.scope():  
 model = factory.createMiniVGGModel(128)  
 history = train\_model(model)

WARNING:tensorflow:TPU system grpc://10.31.158.74:8470 has already been initialized. Reinitializing the TPU can cause previously created variables on TPU to be lost.  
  
  
WARNING:tensorflow:TPU system grpc://10.31.158.74:8470 has already been initialized. Reinitializing the TPU can cause previously created variables on TPU to be lost.  
  
  
INFO:tensorflow:Initializing the TPU system: grpc://10.31.158.74:8470  
  
  
INFO:tensorflow:Initializing the TPU system: grpc://10.31.158.74:8470  
  
  
INFO:tensorflow:Clearing out eager caches  
  
  
INFO:tensorflow:Clearing out eager caches  
  
  
INFO:tensorflow:Finished initializing TPU system.  
  
  
INFO:tensorflow:Finished initializing TPU system.  
  
  
INFO:tensorflow:Found TPU system:  
  
  
INFO:tensorflow:Found TPU system:  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Workers: 1  
  
  
INFO:tensorflow:\*\*\* Num TPU Workers: 1  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores Per Worker: 8  
  
  
INFO:tensorflow:\*\*\* Num TPU Cores Per Worker: 8  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:localhost/replica:0/task:0/device:CPU:0, CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:localhost/replica:0/task:0/device:CPU:0, CPU, 0, 0)  
  
  
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INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:0, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:0, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:1, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:1, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:2, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:2, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:3, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:3, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:4, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:4, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:5, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:5, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:6, TPU, 0, 0)  
  
  
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INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:7, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU:7, TPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU\_SYSTEM:0, TPU\_SYSTEM, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:TPU\_SYSTEM:0, TPU\_SYSTEM, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:XLA\_CPU:0, XLA\_CPU, 0, 0)  
  
  
INFO:tensorflow:\*\*\* Available Device: \_DeviceAttributes(/job:worker/replica:0/task:0/device:XLA\_CPU:0, XLA\_CPU, 0, 0)  
  
  
Model: "sequential\_6"  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Layer (type) Output Shape Param #   
=================================================================  
up\_sampling3d\_6 (UpSampling3 (None, 28, 28, 1) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_72 (Conv2D) (None, 28, 28, 128) 1280   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_84 (Batc (None, 28, 28, 128) 112   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_73 (Conv2D) (None, 28, 28, 128) 147584   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_85 (Batc (None, 28, 28, 128) 112   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_24 (MaxPooling (None, 14, 14, 128) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_24 (Dropout) (None, 14, 14, 128) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_74 (Conv2D) (None, 14, 14, 256) 295168   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_86 (Batc (None, 14, 14, 256) 56   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_75 (Conv2D) (None, 14, 14, 256) 590080   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_87 (Batc (None, 14, 14, 256) 56   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_25 (MaxPooling (None, 7, 7, 256) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_25 (Dropout) (None, 7, 7, 256) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_76 (Conv2D) (None, 7, 7, 512) 1180160   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_88 (Batc (None, 7, 7, 512) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_77 (Conv2D) (None, 7, 7, 512) 2359808   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_89 (Batc (None, 7, 7, 512) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_78 (Conv2D) (None, 7, 7, 512) 2359808   
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batch\_normalization\_90 (Batc (None, 7, 7, 512) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_79 (Conv2D) (None, 7, 7, 512) 2359808   
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batch\_normalization\_91 (Batc (None, 7, 7, 512) 28   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_26 (MaxPooling (None, 3, 3, 512) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_26 (Dropout) (None, 3, 3, 512) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_80 (Conv2D) (None, 3, 3, 1024) 4719616   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_92 (Batc (None, 3, 3, 1024) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_81 (Conv2D) (None, 3, 3, 1024) 9438208   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_93 (Batc (None, 3, 3, 1024) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_82 (Conv2D) (None, 3, 3, 1024) 9438208   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_94 (Batc (None, 3, 3, 1024) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
conv2d\_83 (Conv2D) (None, 3, 3, 1024) 9438208   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_95 (Batc (None, 3, 3, 1024) 12   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
max\_pooling2d\_27 (MaxPooling (None, 1, 1, 1024) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dropout\_27 (Dropout) (None, 1, 1, 1024) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
flatten\_6 (Flatten) (None, 1024) 0   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_18 (Dense) (None, 1024) 1049600   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_96 (Batc (None, 1024) 4096   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_19 (Dense) (None, 1024) 1049600   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
batch\_normalization\_97 (Batc (None, 1024) 4096   
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
dense\_20 (Dense) (None, 10) 10250   
=================================================================  
Total params: 44,446,074  
Trainable params: 44,441,730  
Non-trainable params: 4,344  
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Epoch 1/200  
15/15 [==============================] - 58s 2s/step - loss: 3.3322 - accuracy: 0.2095 - val\_loss: 6657.1353 - val\_accuracy: 0.1040  
Epoch 2/200  
15/15 [==============================] - 4s 237ms/step - loss: 1.2079 - accuracy: 0.5408 - val\_loss: 7004.7500 - val\_accuracy: 0.1011  
Epoch 3/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.9198 - accuracy: 0.6505 - val\_loss: 1557.5841 - val\_accuracy: 0.1011  
Epoch 4/200  
15/15 [==============================] - 4s 236ms/step - loss: 0.8217 - accuracy: 0.6896 - val\_loss: 696.1893 - val\_accuracy: 0.1011  
Epoch 5/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.7349 - accuracy: 0.7264 - val\_loss: 223.7329 - val\_accuracy: 0.1011  
Epoch 6/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.6951 - accuracy: 0.7389 - val\_loss: 70.2052 - val\_accuracy: 0.1011  
Epoch 7/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.6340 - accuracy: 0.7631 - val\_loss: 30.7393 - val\_accuracy: 0.1011  
Epoch 8/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.6020 - accuracy: 0.7808 - val\_loss: 13.4191 - val\_accuracy: 0.1011  
Epoch 9/200  
15/15 [==============================] - 3s 236ms/step - loss: 0.5553 - accuracy: 0.7993 - val\_loss: 6.7049 - val\_accuracy: 0.1011  
Epoch 10/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.5225 - accuracy: 0.8106 - val\_loss: 4.7010 - val\_accuracy: 0.1186  
Epoch 11/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.4806 - accuracy: 0.8259 - val\_loss: 4.8200 - val\_accuracy: 0.0996  
Epoch 12/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.4415 - accuracy: 0.8358 - val\_loss: 4.7842 - val\_accuracy: 0.1304  
Epoch 13/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.4202 - accuracy: 0.8438 - val\_loss: 4.8230 - val\_accuracy: 0.1004  
Epoch 14/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.3918 - accuracy: 0.8533 - val\_loss: 3.6446 - val\_accuracy: 0.2834  
Epoch 15/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.3740 - accuracy: 0.8608 - val\_loss: 6.5257 - val\_accuracy: 0.1016  
Epoch 16/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.3541 - accuracy: 0.8697 - val\_loss: 8.5842 - val\_accuracy: 0.0986  
Epoch 17/200  
15/15 [==============================] - 4s 241ms/step - loss: 0.3295 - accuracy: 0.8789 - val\_loss: 8.0173 - val\_accuracy: 0.0986  
Epoch 18/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.3099 - accuracy: 0.8841 - val\_loss: 7.5043 - val\_accuracy: 0.0986  
Epoch 19/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.2842 - accuracy: 0.8968 - val\_loss: 7.3609 - val\_accuracy: 0.0986  
Epoch 20/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.2846 - accuracy: 0.8956 - val\_loss: 7.7073 - val\_accuracy: 0.0986  
Epoch 21/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.2732 - accuracy: 0.8992 - val\_loss: 8.3935 - val\_accuracy: 0.0988  
Epoch 22/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.2452 - accuracy: 0.9100 - val\_loss: 9.0512 - val\_accuracy: 0.0986  
Epoch 23/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.2369 - accuracy: 0.9133 - val\_loss: 6.0023 - val\_accuracy: 0.1360  
Epoch 24/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.2255 - accuracy: 0.9169 - val\_loss: 5.8161 - val\_accuracy: 0.1300  
Epoch 25/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.2121 - accuracy: 0.9227 - val\_loss: 5.4429 - val\_accuracy: 0.1410  
Epoch 26/200  
15/15 [==============================] - 3s 235ms/step - loss: 0.2052 - accuracy: 0.9238 - val\_loss: 4.9381 - val\_accuracy: 0.1575  
Epoch 27/200  
15/15 [==============================] - 3s 236ms/step - loss: 0.1982 - accuracy: 0.9275 - val\_loss: 4.0295 - val\_accuracy: 0.1421  
Epoch 28/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.1893 - accuracy: 0.9312 - val\_loss: 3.0618 - val\_accuracy: 0.2571  
Epoch 29/200  
15/15 [==============================] - 3s 236ms/step - loss: 0.1733 - accuracy: 0.9371 - val\_loss: 2.9136 - val\_accuracy: 0.2790  
Epoch 30/200  
15/15 [==============================] - 3s 236ms/step - loss: 0.1771 - accuracy: 0.9347 - val\_loss: 3.0424 - val\_accuracy: 0.3558  
Epoch 31/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.1591 - accuracy: 0.9423 - val\_loss: 2.4224 - val\_accuracy: 0.4229  
Epoch 32/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.1657 - accuracy: 0.9390 - val\_loss: 2.4353 - val\_accuracy: 0.4256  
Epoch 33/200  
15/15 [==============================] - 3s 236ms/step - loss: 0.1502 - accuracy: 0.9450 - val\_loss: 2.3348 - val\_accuracy: 0.4863  
Epoch 34/200  
15/15 [==============================] - 3s 236ms/step - loss: 0.1417 - accuracy: 0.9491 - val\_loss: 1.7696 - val\_accuracy: 0.6040  
Epoch 35/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.1330 - accuracy: 0.9506 - val\_loss: 2.8136 - val\_accuracy: 0.4750  
Epoch 36/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.1306 - accuracy: 0.9517 - val\_loss: 2.0110 - val\_accuracy: 0.5296  
Epoch 37/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.1247 - accuracy: 0.9553 - val\_loss: 1.6681 - val\_accuracy: 0.5740  
Epoch 38/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.1166 - accuracy: 0.9561 - val\_loss: 0.7485 - val\_accuracy: 0.7725  
Epoch 39/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.1120 - accuracy: 0.9604 - val\_loss: 1.1749 - val\_accuracy: 0.6928  
Epoch 40/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.1039 - accuracy: 0.9618 - val\_loss: 0.4995 - val\_accuracy: 0.8439  
Epoch 41/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.1003 - accuracy: 0.9641 - val\_loss: 0.3744 - val\_accuracy: 0.8828  
Epoch 42/200  
15/15 [==============================] - 4s 237ms/step - loss: 0.1000 - accuracy: 0.9636 - val\_loss: 0.4801 - val\_accuracy: 0.8599  
Epoch 43/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0922 - accuracy: 0.9670 - val\_loss: 0.4138 - val\_accuracy: 0.8815  
Epoch 44/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0920 - accuracy: 0.9655 - val\_loss: 0.3977 - val\_accuracy: 0.8918  
Epoch 45/200  
15/15 [==============================] - 4s 242ms/step - loss: 0.0827 - accuracy: 0.9707 - val\_loss: 0.4957 - val\_accuracy: 0.8635  
Epoch 46/200  
15/15 [==============================] - 4s 243ms/step - loss: 0.0828 - accuracy: 0.9701 - val\_loss: 0.3649 - val\_accuracy: 0.9006  
Epoch 47/200  
15/15 [==============================] - 4s 241ms/step - loss: 0.0743 - accuracy: 0.9733 - val\_loss: 0.3708 - val\_accuracy: 0.8958  
Epoch 48/200  
15/15 [==============================] - 4s 242ms/step - loss: 0.0744 - accuracy: 0.9733 - val\_loss: 0.3575 - val\_accuracy: 0.9068  
Epoch 49/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0736 - accuracy: 0.9732 - val\_loss: 0.2856 - val\_accuracy: 0.9231  
Epoch 50/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0706 - accuracy: 0.9742 - val\_loss: 0.3444 - val\_accuracy: 0.9106  
Epoch 51/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0709 - accuracy: 0.9743 - val\_loss: 0.3657 - val\_accuracy: 0.9085  
Epoch 52/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0614 - accuracy: 0.9781 - val\_loss: 0.3272 - val\_accuracy: 0.9165  
Epoch 53/200  
15/15 [==============================] - 4s 242ms/step - loss: 0.0566 - accuracy: 0.9799 - val\_loss: 0.3233 - val\_accuracy: 0.9154  
Epoch 54/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0550 - accuracy: 0.9789 - val\_loss: 0.3202 - val\_accuracy: 0.9198  
Epoch 55/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0553 - accuracy: 0.9802 - val\_loss: 0.3416 - val\_accuracy: 0.9141  
Epoch 56/200  
15/15 [==============================] - 4s 242ms/step - loss: 0.0525 - accuracy: 0.9819 - val\_loss: 0.2719 - val\_accuracy: 0.9305  
Epoch 57/200  
15/15 [==============================] - 4s 247ms/step - loss: 0.0431 - accuracy: 0.9844 - val\_loss: 0.3547 - val\_accuracy: 0.9209  
Epoch 58/200  
15/15 [==============================] - 4s 241ms/step - loss: 0.0421 - accuracy: 0.9846 - val\_loss: 0.3354 - val\_accuracy: 0.9226  
Epoch 59/200  
15/15 [==============================] - 4s 242ms/step - loss: 0.0390 - accuracy: 0.9859 - val\_loss: 0.3361 - val\_accuracy: 0.9213  
Epoch 60/200  
15/15 [==============================] - 4s 241ms/step - loss: 0.0409 - accuracy: 0.9852 - val\_loss: 0.3083 - val\_accuracy: 0.9273  
Epoch 61/200  
15/15 [==============================] - 4s 242ms/step - loss: 0.0355 - accuracy: 0.9875 - val\_loss: 0.2951 - val\_accuracy: 0.9338  
Epoch 62/200  
15/15 [==============================] - 4s 294ms/step - loss: 0.0325 - accuracy: 0.9881 - val\_loss: 0.2945 - val\_accuracy: 0.9334  
Epoch 63/200  
15/15 [==============================] - 4s 242ms/step - loss: 0.0339 - accuracy: 0.9877 - val\_loss: 0.3244 - val\_accuracy: 0.9263  
Epoch 64/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0412 - accuracy: 0.9845 - val\_loss: 0.3958 - val\_accuracy: 0.9151  
Epoch 65/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.0315 - accuracy: 0.9887 - val\_loss: 0.3216 - val\_accuracy: 0.9271  
Epoch 66/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0300 - accuracy: 0.9889 - val\_loss: 0.3757 - val\_accuracy: 0.9258  
Epoch 67/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0296 - accuracy: 0.9892 - val\_loss: 0.4544 - val\_accuracy: 0.9098  
Epoch 68/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0288 - accuracy: 0.9894 - val\_loss: 0.3595 - val\_accuracy: 0.9214  
Epoch 69/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0275 - accuracy: 0.9897 - val\_loss: 0.4206 - val\_accuracy: 0.9228  
Epoch 70/200  
15/15 [==============================] - 4s 243ms/step - loss: 0.0290 - accuracy: 0.9898 - val\_loss: 0.3717 - val\_accuracy: 0.9264  
Epoch 71/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0283 - accuracy: 0.9899 - val\_loss: 0.3936 - val\_accuracy: 0.9235  
Epoch 72/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0263 - accuracy: 0.9910 - val\_loss: 0.3186 - val\_accuracy: 0.9341  
Epoch 73/200  
15/15 [==============================] - 4s 238ms/step - loss: 0.0277 - accuracy: 0.9893 - val\_loss: 0.3549 - val\_accuracy: 0.9255  
Epoch 74/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0264 - accuracy: 0.9901 - val\_loss: 0.3518 - val\_accuracy: 0.9318  
Epoch 75/200  
15/15 [==============================] - 4s 239ms/step - loss: 0.0234 - accuracy: 0.9918 - val\_loss: 0.3503 - val\_accuracy: 0.9313  
Epoch 76/200  
15/15 [==============================] - 4s 240ms/step - loss: 0.0204 - accuracy: 0.9930 - val\_loss: 0.3877 - val\_accuracy: 0.9285

histories['VGG19\_128'] = (history, model.evaluate(x\_test\_1, y\_test\_1, BATCH\_SIZE))

1/1 [==============================] - 5s 5s/step - loss: 0.2482 - accuracy: 0.9345

for model\_name, (model\_history, model\_evaluation) in histories.items():  
 print(model\_name)  
 visualize\_history(model\_history)  
 print(model\_evaluation)

VGG19\_32

png

png

png

png

[0.22895169258117676, 0.937000036239624]  
VGG19\_64

png

png

png

png

[0.26001396775245667, 0.9250000715255737]  
VGG19\_128

png

png

png

png

[0.24820923805236816, 0.9345000386238098]

## V. Đánh giá chung

## VI. Tham khảo