```
import tensorflow as tf
from keras.preprocessing.image import ImageDataGenerator
```

```
print(tf.__version__)
```

```
     2.11.0
```

```
from google.colab import drive
drive.mount('/content/gdrive')
```

```
     Mounted at /content/gdrive
```

```
!unzip /content/gdrive/MyDrive/Dataset1/CNN_dataset.zip
```

```
       inflating: CNN_dataset/CXR/006149.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._006149.jpeg
       inflating: CNN_dataset/CXR/004174.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._004174.jpeg
       inflating: CNN_dataset/CXR/000137.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._000137.jpeg
       inflating: CNN_dataset/CXR/008507.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._008507.jpeg
       inflating: CNN_dataset/CXR/005335.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._005335.jpeg
       inflating: CNN_dataset/CXR/007308.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._007308.jpeg
       inflating: CNN_dataset/CXR/000567.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._000567.jpeg
       inflating: CNN_dataset/CXR/008157.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._008157.jpeg
       inflating: CNN_dataset/CXR/004877.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._004877.jpeg
       inflating: CNN_dataset/CXR/005765.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._005765.jpeg
       inflating: CNN_dataset/CXR/007758.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._007758.jpeg
       inflating: CNN_dataset/CXR/005270.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._005270.jpeg
       inflating: CNN_dataset/CXR/000588.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._000588.jpeg
       inflating: CNN_dataset/CXR/004898.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._004898.jpeg
       inflating: CNN_dataset/CXR/000072.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._000072.jpeg
       inflating: CNN_dataset/CXR/008442.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._008442.jpeg
       inflating: CNN_dataset/CXR/004932.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._004932.jpeg
```

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```
                                     05620.jpeg
                                     set/CXR/._005620.jpeg
                                     00422.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._000422.jpeg
       inflating: CNN_dataset/CXR/008012.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._008012.jpeg
       inflating: CNN_dataset/CXR/004461.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._004461.jpeg
       inflating: CNN_dataset/CXR/001399.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._001399.jpeg
       inflating: CNN_dataset/CXR/000971.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._000971.jpeg
       inflating: CNN_dataset/CXR/001663.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._001663.jpeg
       inflating: CNN_dataset/CXR/009253.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._009253.jpeg
       inflating: CNN_dataset/CXR/004031.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._004031.jpeg
       inflating: CNN_dataset/CXR/001233.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._001233.jpeg
       inflating: CNN_dataset/CXR/008911.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._008911.jpeg
       inflating: CNN_dataset/CXR/009603.jpeg
       inflating: __MACOSX/CNN_dataset/CXR/._009603.jpeg
```

```
import os

path = "/content/Validation_data"
path1 = "/content/Validation_data/AbdomenCT"
path2 = "/content/Validation_data/ChestCT"
path3 = "/content/Validation_data/CXR"
path4 = "/content/Validation_data/Hand"
path5 = "/content/Validation_data/HeadCT"
```

```
os.mkdir(path)
os.mkdir(path1)
os.mkdir(path2)
os.mkdir(path3)
os.mkdir(path4)
os.mkdir(path5)


import os

path = "/content/test_data"
path1 = "/content/test_data/AbdomenCT"
path2 = "/content/test_data/ChestCT"
path3 = "/content/test_data/CXR"
path4 = "/content/test_data/Hand"
path5 = "/content/test_data/HeadCT"

os.mkdir(path)
os.mkdir(path1)
os.mkdir(path2)
os.mkdir(path3)
os.mkdir(path4)
os.mkdir(path5)


import shutil
x = 7000

for i in range(7001,8999):
  shutil.move("/content/CNN_dataset/AbdomenCT/00"+str(x)+".jpeg", "/content/Validation_data/AbdomenCT/00"+str(x)+".jpeg")
  x+=1

x = 7000

for i in range(7001,8999):
  shutil.move("/content/CNN_dataset/CXR/00"+str(x)+".jpeg", "/content/Validation_data/CXR/00"+str(x)+".jpeg")
  x+=1

x = 7000

for i in range(7001,8999):
  shutil.move("/content/CNN_dataset/ChestCT/00"+str(x)+".jpeg", "/content/Validation_data/ChestCT/00"+str(x)+".jpeg")
  x+=1

x = 7000

for i in range(7001,8999):
  shutil.move("/content/CNN_dataset/Hand/00"+str(x)+".jpeg", "/content/Validation_data/Hand/00"+str(x)+".jpeg")
```

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```
x = 7000

for i in range(7001,8999):
  shutil.move("/content/CNN_dataset/HeadCT/00"+str(x)+".jpeg", "/content/Validation_data/HeadCT/00"+str(x)+".jpeg")
  x+=1


import shutil
x = 9000

for i in range(9000,9999):
  shutil.move("/content/CNN_dataset/AbdomenCT/00"+str(x)+".jpeg", "/content/test_data/AbdomenCT/00"+str(x)+".jpeg")
  x+=1

x = 9000

for i in range(9000,9999):
  shutil.move("/content/CNN_dataset/CXR/00"+str(x)+".jpeg", "/content/test_data/CXR/00"+str(x)+".jpeg")
  x+=1

x = 9000

for i in range(9000,9999):
  shutil.move("/content/CNN_dataset/ChestCT/00"+str(x)+".jpeg", "/content/test_data/ChestCT/00"+str(x)+".jpeg")
  x+=1

x = 9000

for i in range(9000,9999):
  shutil.move("/content/CNN_dataset/Hand/00"+str(x)+".jpeg", "/content/test_data/Hand/00"+str(x)+".jpeg")
  x+=1
```

```
x = 9000

for i in range(9000,9999):
  shutil.move("/content/CNN_dataset/HeadCT/00"+str(x)+".jpeg", "/content/test_data/HeadCT/00"+str(x)+".jpeg")
  x+=1
```

```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline

import cv2
import os
os.environ["TF_CPP_MIN_LOG_LEVEL"] = "2"
import warnings
warnings.filterwarnings('ignore')

from sklearn.metrics import confusion_matrix, classification_report

import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Activation, BatchNormalization, Conv2D, Dense, Dropout, Flatten, MaxPooling2D
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.losses import CategoricalCrossentropy
from tensorflow.keras.regularizers import l2
from tensorflow.keras.callbacks import ReduceLROnPlateau, EarlyStopping
```

```
train_dataset_path = '/content/CNN_dataset'
validation_dataset_path = '/content/Validation_data'
```

```
IMG_WIDTH = 32
IMG_HEIGHT = 32
BATCH_SIZE = 32
```

```
train_datagen = ImageDataGenerator(rescale=1.0/255,
                                  zoom_range=0.2,
                                  width_shift_range=0.2,
                                  height_shift_range=0.2,
                                  fill_mode='nearest')
train_generator = train_datagen.flow_from_directory(train_dataset_path,
                                                   target_size=(IMG_WIDTH, IMG_HEIGHT),
                                                   batch_size=BATCH_SIZE,
                                                   class_mode='categorical',
                                                   shuffle=True)
```

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```
o 5 classes.
```

```
validation_datagen = ImageDataGenerator(rescale=1.0/255)
validation_generator = validation_datagen.flow_from_directory(validation_dataset_path,
                                                             target_size=(IMG_WIDTH, IMG_HEIGHT),
                                                             batch_size=BATCH_SIZE,
                                                             class_mode='categorical',
                                                             shuffle=True)
```

```
Found 9990 images belonging to 5 classes.
```

```
labels = {value: key for key, value in train_generator.class_indices.items()}

print("Label Mappings for classes present in the training and validation datasets\n")
for key, value in labels.items():
    print(f"{key} : {value}")
```

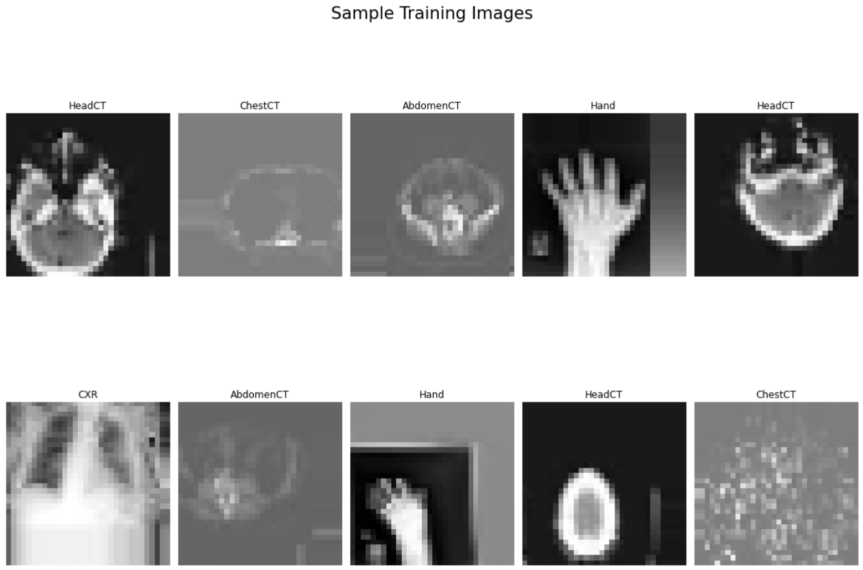
```
Label Mappings for classes present in the training and validation datasets

0 : AbdomenCT
1 : CXR
2 : ChestCT
3 : Hand
4 : HeadCT
```

```
fig, ax = plt.subplots(nrows=2, ncols=5, figsize=(15, 12))
idx = 0

for i in range(2):
    for j in range(5):
        label = labels[np.argmax(train_generator[0][1][idx])]
        ax[i, j].set_title(f"{label}")
        ax[i, j].imshow(train_generator[0][0][idx][:, :, :])
        ax[i, j].axis("off")
        idx += 1

plt.tight_layout()
plt.suptitle("Sample Training Images", fontsize=21)
plt.show()
```



```
def create_model():
```

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```
                                   size=(5, 5), padding='valid', input_shape=(IMG_WIDTH, IMG_HEIGHT, 3)),
        Activation('relu'),
        MaxPooling2D(pool_size=(2, 2)),
        BatchNormalization(),

        Conv2D(filters=64, kernel_size=(3, 3), padding='valid', kernel_regularizer=l2(0.00005)),
        Activation('relu'),
        MaxPooling2D(pool_size=(2, 2)),
        BatchNormalization(),

        Conv2D(filters=32, kernel_size=(3, 3), padding='valid', kernel_regularizer=l2(0.00005)),
        Activation('relu'),
        MaxPooling2D(pool_size=(2, 2)),
        BatchNormalization(),

        Flatten(),

        Dense(units=256, activation='relu'),
        Dropout(0.5),
        Dense(units=5, activation='softmax')
    ])

    return model


cnn_model = create_model()


print(cnn_model.summary())
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #   
=================================================================
 conv2d (Conv2D)             (None, 28, 28, 128)       9728

 activation (Activation)     (None, 28, 28, 128)       0

 max_pooling2d (MaxPooling2D  (None, 14, 14, 128)      0
 )

 batch_normalization (BatchN  (None, 14, 14, 128)      512
 ormalization)

 conv2d_1 (Conv2D)           (None, 12, 12, 64)        73792

 activation_1 (Activation)   (None, 12, 12, 64)        0

 max_pooling2d_1 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 batch_normalization_1 (Batc  (None, 6, 6, 64)         256
 hNormalization)

 conv2d_2 (Conv2D)           (None, 4, 4, 32)          18464

 activation_2 (Activation)   (None, 4, 4, 32)          0

 max_pooling2d_2 (MaxPooling  (None, 2, 2, 32)         0
 2D)

 batch_normalization_2 (Batc  (None, 2, 2, 32)         128
 hNormalization)

 flatten (Flatten)           (None, 128)               0

 dense (Dense)               (None, 256)               33024

 dropout (Dropout)           (None, 256)               0

 dense_1 (Dense)             (None, 5)                 1285

=================================================================
Total params: 137,189
Trainable params: 136,741
Non-trainable params: 448
_________________________________________________________________
None
```

```
reduce_lr = ReduceLROnPlateau(monitor='val_loss', factor=np.sqrt(0.1), patience=5)
```

```
optimizer = Adam(learning_rate=0.001)
```

```
cnn_model.compile(optimizer=optimizer, loss=CategoricalCrossentropy(), metrics=['accuracy'])
```

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```
history = cnn_model.fit(train_generator, epochs=10, validation_data=validation_generator,
                       verbose=2,
                       callbacks=[reduce_lr])
```

```
Epoch 1/10
1095/1095 - 38s - loss: 0.0081 - accuracy: 0.9992 - val_loss: 0.0063 - val_accuracy: 0.9997 - lr: 3.1623e-04 - 38s/epoch - 35ms/ste
Epoch 2/10
1095/1095 - 39s - loss: 0.0084 - accuracy: 0.9989 - val_loss: 0.0056 - val_accuracy: 0.9999 - lr: 3.1623e-04 - 39s/epoch - 36ms/ste
Epoch 3/10
1095/1095 - 39s - loss: 0.0077 - accuracy: 0.9993 - val_loss: 0.0052 - val_accuracy: 1.0000 - lr: 3.1623e-04 - 39s/epoch - 35ms/ste
Epoch 4/10
1095/1095 - 38s - loss: 0.0080 - accuracy: 0.9992 - val_loss: 0.0052 - val_accuracy: 0.9999 - lr: 3.1623e-04 - 38s/epoch - 35ms/ste
Epoch 5/10
1095/1095 - 38s - loss: 0.0073 - accuracy: 0.9991 - val_loss: 0.0049 - val_accuracy: 1.0000 - lr: 3.1623e-04 - 38s/epoch - 35ms/ste
Epoch 6/10
1095/1095 - 38s - loss: 0.0113 - accuracy: 0.9985 - val_loss: 0.0055 - val_accuracy: 0.9997 - lr: 3.1623e-04 - 38s/epoch - 35ms/ste
Epoch 7/10
1095/1095 - 38s - loss: 0.0068 - accuracy: 0.9996 - val_loss: 0.0049 - val_accuracy: 1.0000 - lr: 3.1623e-04 - 38s/epoch - 35ms/ste
Epoch 8/10
1095/1095 - 38s - loss: 0.0059 - accuracy: 0.9995 - val_loss: 0.0046 - val_accuracy: 1.0000 - lr: 3.1623e-04 - 38s/epoch - 34ms/ste
Epoch 9/10
1095/1095 - 39s - loss: 0.0067 - accuracy: 0.9993 - val_loss: 0.0110 - val_accuracy: 0.9973 - lr: 3.1623e-04 - 39s/epoch - 36ms/ste
Epoch 10/10
1095/1095 - 39s - loss: 0.0060 - accuracy: 0.9995 - val_loss: 0.0045 - val_accuracy: 1.0000 - lr: 3.1623e-04 - 39s/epoch - 36ms/ste
```

```
train_accuracy = history.history['accuracy']
val_accuracy = history.history['val_accuracy']

train_loss = history.history['loss']
val_loss = history.history['val_loss']

learning_rate = history.history['lr']
```

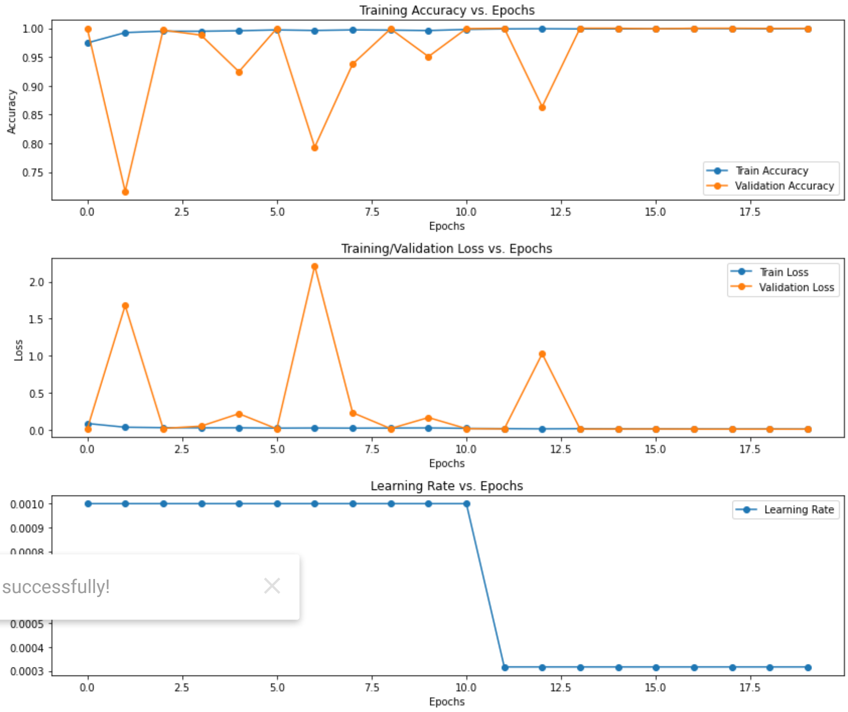
```
fig, ax = plt.subplots(nrows=3, ncols=1, figsize=(12, 10))

ax[0].set_title('Training Accuracy vs. Epochs')
ax[0].plot(train_accuracy, 'o-', label='Train Accuracy')
ax[0].plot(val_accuracy, 'o-', label='Validation Accuracy')
ax[0].set_xlabel('Epochs')
ax[0].set_ylabel('Accuracy')
ax[0].legend(loc='best')

ax[1].set_title('Training/Validation Loss vs. Epochs')
ax[1].plot(train_loss, 'o-', label='Train Loss')
ax[1].plot(val_loss, 'o-', label='Validation Loss')
ax[1].set_xlabel('Epochs')
ax[1].set_ylabel('Loss')
ax[1].legend(loc='best')

ax[2].set_title('Learning Rate vs. Epochs')
ax[2].plot(learning_rate, 'o-', label='Learning Rate')
ax[2].set_xlabel('Epochs')
ax[2].set_ylabel('Loss')
ax[2].legend(loc='best')

plt.tight_layout()
plt.show()
```



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```
test_dataset = '/content/test_data/'
```

```
test_datagen = ImageDataGenerator(rescale=1.0/255)

test_generator = test_datagen.flow_from_directory(test_dataset,
                                                  shuffle=False,
                                                  batch_size=BATCH_SIZE,
                                                  target_size = (IMG_WIDTH, IMG_HEIGHT),
                                                  class_mode='categorical')
```

```
Found 4995 images belonging to 5 classes.
```

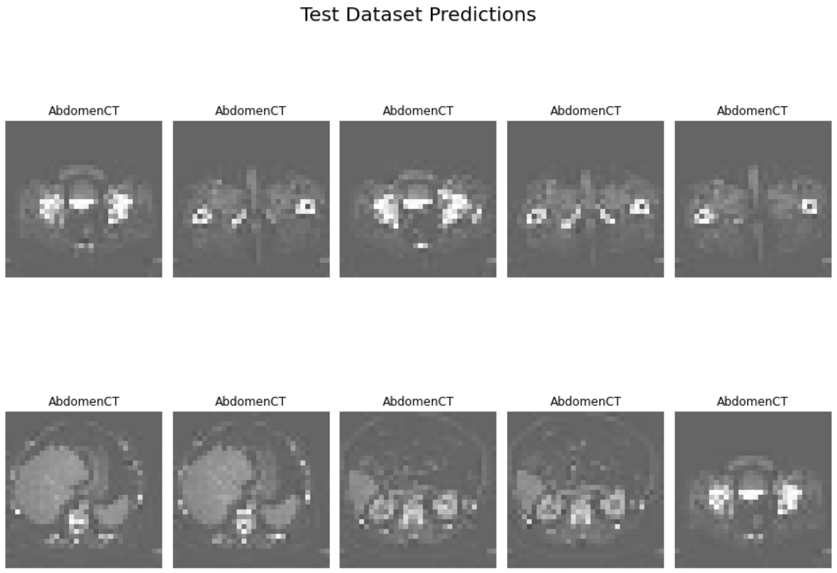
```
predictions = cnn_model.predict(test_generator)
```

```
157/157 [==============================] - 2s 15ms/step
```

```
fig, ax = plt.subplots(nrows=2, ncols=5, figsize=(12, 10))
idx = 0

for i in range(2):
    for j in range(5):
        predicted_label = labels[np.argmax(predictions[idx])]
        ax[i, j].set_title(f"{predicted_label}")
        ax[i, j].imshow(test_generator[0][0][idx])
        ax[i, j].axis("off")
        idx += 1

plt.tight_layout()
plt.suptitle("Test Dataset Predictions", fontsize=20)
plt.show()
```



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```
l.evaluate(test_generator, batch_size=BATCH_SIZE)

=========] - 3s 17ms/step - loss: 0.0055 - accuracy: 0.9998
```

```
print(f"Test Loss:     {test_loss}")
print(f"Test Accuracy: {test_accuracy}")
```

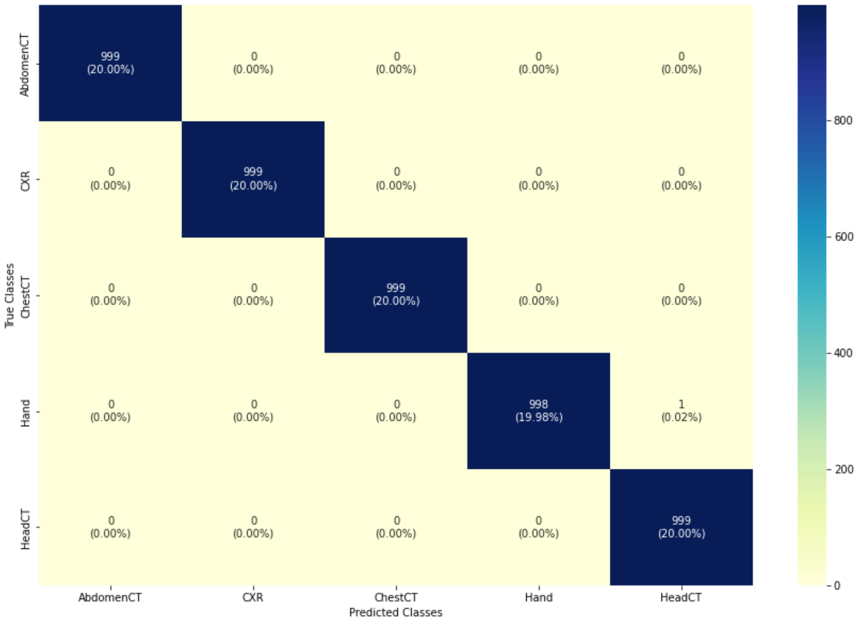
```
     Test Loss:     0.005519106052815914
     Test Accuracy: 0.9997997879981995
```

```
y_pred = np.argmax(predictions, axis=1)
y_true = test_generator.classes
```

```
cf_mtx = confusion_matrix(y_true, y_pred)

group_counts·=·["{0:0.0f}".format(value)·for·value·in·cf_mtx.flatten()]
group_percentages·=·["{0:.2%}".format(value)·for·value·in·cf_mtx.flatten()/np.sum(cf_mtx)]
box_labels·=·[f"{v1}\n({v2})"·for·v1,·v2·in·zip(group_counts,·group_percentages)]
box_labels·=·np.asarray(box_labels).reshape(5,·5)

plt.figure(figsize·=·(15,·10))
sns.heatmap(cf_mtx,·xticklabels=labels.values(),·yticklabels=labels.values(),
··········cmap="YlGnBu",·fmt="",·annot=box_labels)
plt.xlabel('Predicted·Classes')
plt.ylabel('True·Classes')
plt.show()
```



True Classes \ Predicted Classes	AbdomenCT	CXR	ChestCT	Hand	HeadCT
AbdomenCT	999 (20.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
CXR	0 (0.00%)	999 (20.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)
ChestCT	0 (0.00%)	0 (0.00%)	999 (20.00%)	0 (0.00%)	0 (0.00%)
Hand	0 (0.00%)	0 (0.00%)	0 (0.00%)	998 (19.98%)	1 (0.02%)
HeadCT	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	999 (20.00%)

✓ 0s completed at 23:20 ● ✕

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