

# XRay\_Analysis

March 4, 2021

## 0.1 Predicting Pneumonia from Chest X-Rays

### 0.1.1 Chris Goodwin - DSC680

In the final project of the semester, we will be taking a look at some chest x-rays and building a model that can predict whether or not the patient has pneumonia. We start by simply loading all of the necessary packages.

```
[4]: import numpy as np
import os
import pandas as pd
from sklearn.metrics import confusion_matrix, classification_report
import seaborn as sns; sns.set(font_scale=1.4)
from sklearn.utils import shuffle
import matplotlib.pyplot as plt
import cv2
import tensorflow as tf
from tqdm import tqdm
```

```
[7]: class_names = ['NORMAL', 'PNEUMONIA']
class_names_label = {class_name:i for i, class_name in enumerate(class_names)}
nb_classes = len(class_names)
IMAGE_SIZE = (150, 150)
```

```
[14]: def mylistdir(directory):
    """A specialized version of os.listdir() that ignores files that
    start with a leading period."""
    filelist = os.listdir(directory)
    return [x for x in filelist
            if not (x.startswith('.'))]
```

```
[15]: def load_data():

    datasets = ['C:/Users/goodw/Downloads/XRays/chest_xray/chest_xray/train',
↪ 'C:/Users/goodw/Downloads/XRays/chest_xray/chest_xray/test']
    output = []

    # Iterate through training and test sets
    for dataset in datasets:
```

```

images = []
labels = []

print("Loading {}".format(dataset))

# Iterate through each folder corresponding to a category
for folder in mylistdir(dataset):
    label = class_names_label[folder]

    # Iterate through each image in our folder
    for file in tqdm(mylistdir(os.path.join(dataset, folder))):

        # Get the path name of the image
        img_path = os.path.join(os.path.join(dataset, folder), file)

        # Open and resize the img
        image = cv2.imread(img_path)
        image = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
        image = cv2.resize(image, IMAGE_SIZE)

        # Append the image and its corresponding label to the output
        images.append(image)
        labels.append(label)

images = np.array(images, dtype = 'float32')
labels = np.array(labels, dtype = 'int32')

output.append((images, labels))

return output

```

```
[16]: (train_images, train_labels), (test_images, test_labels) = load_data()
```

```
Loading C:/Users/goodw/Downloads/XRays/chest_xray/chest_xray/train
```

```
100%|      | 1341/1341 [01:31<00:00, 14.73it/s]
```

```
100%|      | 3875/3875 [02:03<00:00, 31.33it/s]
```

```
Loading C:/Users/goodw/Downloads/XRays/chest_xray/chest_xray/test
```

```
100%|      | 234/234 [00:18<00:00, 12.46it/s]
```

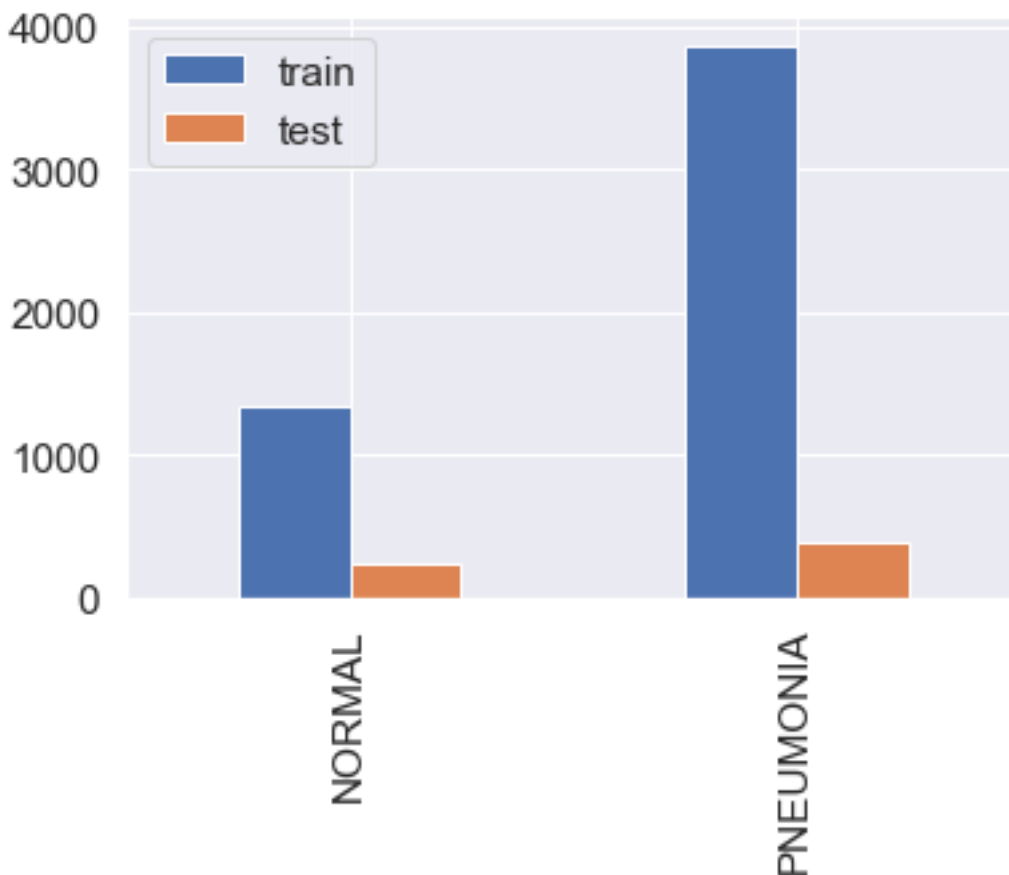
```
100%|      | 390/390 [00:10<00:00, 36.02it/s]
```

```
[17]: train_images.shape, test_images.shape
```

```
[17]: ((5216, 150, 150, 3), (624, 150, 150, 3))
```

```
[18]: train_images, train_labels = shuffle(train_images, train_labels,
↳ random_state=25)
```

```
[19]: _, train_counts = np.unique(train_labels, return_counts=True)
_, test_counts = np.unique(test_labels, return_counts=True)
pd.DataFrame({'train': train_counts,
              'test': test_counts},
              index=class_names
              ).plot.bar()
plt.show()
```



```
[20]: train_images = train_images / 255.0
test_images = test_images / 255.0
```

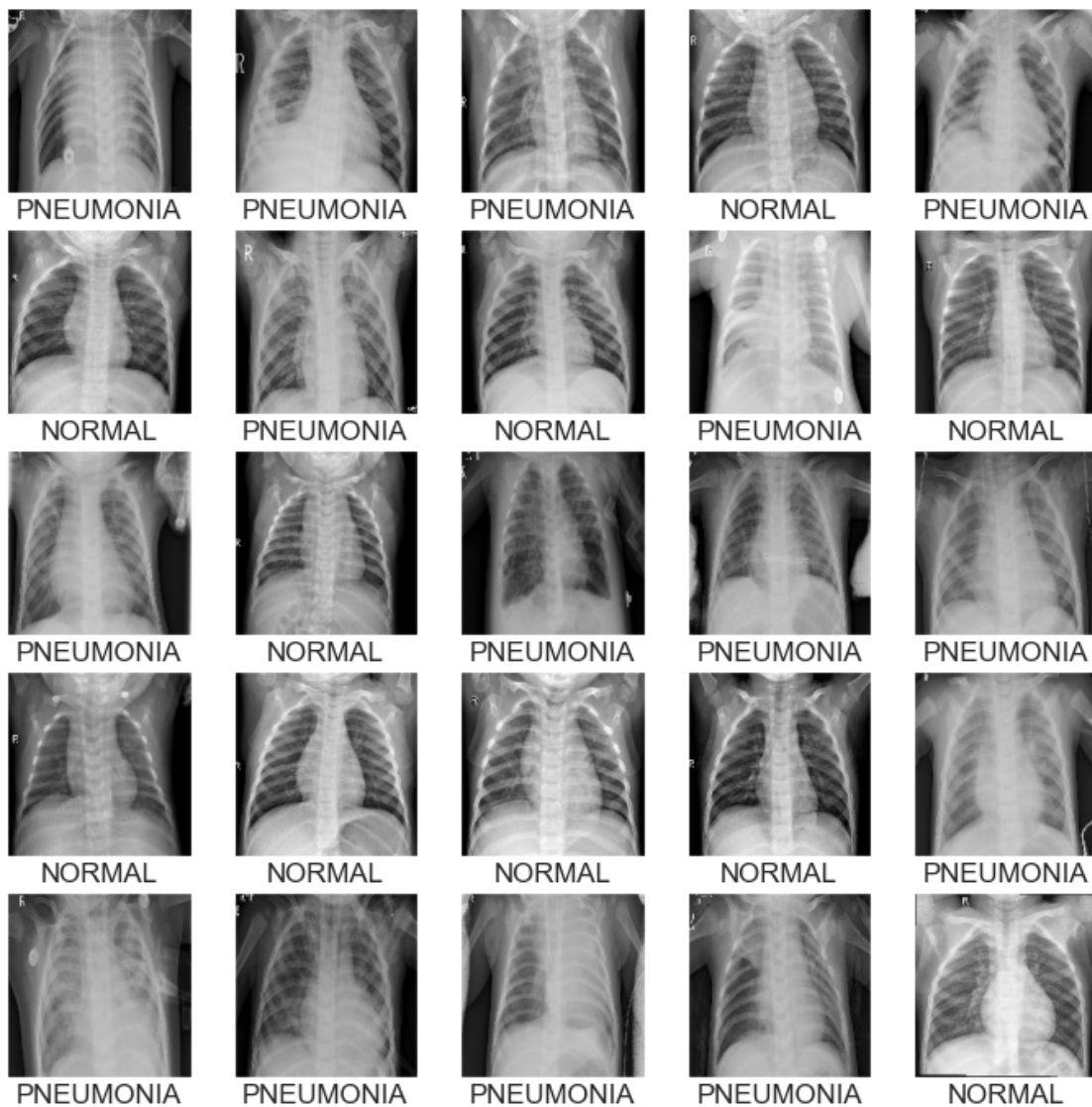
```
[21]: def display_examples(class_names, images, labels):

    fig = plt.figure(figsize=(12,12))
    fig.suptitle("Some examples of images of the dataset", fontsize=16)
    for i in range(25):
```

```
plt.subplot(5,5,i+1)
plt.xticks([])
plt.yticks([])
plt.grid(False)
plt.imshow(images[i], cmap=plt.cm.binary)
plt.xlabel(class_names[labels[i]])
plt.show()
```

```
[22]: display_examples(class_names, train_images, train_labels)
```

Some examples of images of the dataset



```
[38]: model = tf.keras.Sequential([
    tf.keras.layers.Conv2D(32, (3, 3), activation = 'relu',
                           input_shape = (150, 150, 3)),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Conv2D(32, (3, 3), activation = 'relu'),
    tf.keras.layers.MaxPooling2D(2,2),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(128, activation=tf.nn.relu),
    tf.keras.layers.Dense(6, activation=tf.nn.softmax)
])
```

```
[39]: model.compile(optimizer = 'adam', loss = 'sparse_categorical_crossentropy',
    ↪metrics=['accuracy'])
```

```
[40]: history = model.fit(train_images, train_labels, batch_size=64, epochs=15,
    ↪validation_split = 0.2)
```

Train on 4172 samples, validate on 1044 samples

Epoch 1/15

```
4172/4172 [=====] - ETA: 2:44 - loss: 1.8219 -
accuracy: 0.0000e+ - ETA: 1:52 - loss: 2.0791 - accuracy: 0.3516 - ETA: 1:35 -
loss: 1.6771 - accuracy: 0.48 - ETA: 1:25 - loss: 1.4000 - accuracy: 0.57 - ETA:
1:19 - loss: 1.2457 - accuracy: 0.60 - ETA: 1:15 - loss: 1.1359 - accuracy: 0.62
- ETA: 1:11 - loss: 1.0619 - accuracy: 0.63 - ETA: 1:08 - loss: 0.9945 -
accuracy: 0.64 - ETA: 1:06 - loss: 0.9443 - accuracy: 0.66 - ETA: 1:04 - loss:
0.8954 - accuracy: 0.66 - ETA: 1:02 - loss: 0.8502 - accuracy: 0.67 - ETA: 1:01
- loss: 0.8091 - accuracy: 0.69 - ETA: 59s - loss: 0.7747 - accuracy: 0.7019 -
ETA: 58s - loss: 0.7488 - accuracy: 0.713 - ETA: 56s - loss: 0.7271 - accuracy:
0.715 - ETA: 55s - loss: 0.6979 - accuracy: 0.724 - ETA: 53s - loss: 0.6708 -
accuracy: 0.737 - ETA: 52s - loss: 0.6499 - accuracy: 0.746 - ETA: 50s - loss:
0.6401 - accuracy: 0.745 - ETA: 49s - loss: 0.6189 - accuracy: 0.753 - ETA: 48s
- loss: 0.6042 - accuracy: 0.761 - ETA: 46s - loss: 0.5842 - accuracy: 0.769 -
ETA: 45s - loss: 0.5724 - accuracy: 0.773 - ETA: 44s - loss: 0.5566 - accuracy:
0.778 - ETA: 43s - loss: 0.5424 - accuracy: 0.785 - ETA: 42s - loss: 0.5266 -
accuracy: 0.790 - ETA: 41s - loss: 0.5171 - accuracy: 0.793 - ETA: 39s - loss:
0.5116 - accuracy: 0.795 - ETA: 38s - loss: 0.5002 - accuracy: 0.800 - ETA: 37s
- loss: 0.4894 - accuracy: 0.804 - ETA: 36s - loss: 0.4899 - accuracy: 0.804 -
ETA: 35s - loss: 0.4814 - accuracy: 0.808 - ETA: 34s - loss: 0.4759 - accuracy:
0.811 - ETA: 33s - loss: 0.4678 - accuracy: 0.813 - ETA: 31s - loss: 0.4591 -
accuracy: 0.817 - ETA: 30s - loss: 0.4543 - accuracy: 0.820 - ETA: 29s - loss:
0.4457 - accuracy: 0.823 - ETA: 28s - loss: 0.4383 - accuracy: 0.826 - ETA: 27s
- loss: 0.4292 - accuracy: 0.830 - ETA: 26s - loss: 0.4207 - accuracy: 0.833 -
ETA: 25s - loss: 0.4151 - accuracy: 0.835 - ETA: 24s - loss: 0.4104 - accuracy:
0.836 - ETA: 23s - loss: 0.4045 - accuracy: 0.838 - ETA: 22s - loss: 0.3979 -
accuracy: 0.841 - ETA: 21s - loss: 0.3915 - accuracy: 0.844 - ETA: 20s - loss:
0.3849 - accuracy: 0.847 - ETA: 19s - loss: 0.3803 - accuracy: 0.849 - ETA: 17s
```

- loss: 0.3737 - accuracy: 0.852 - ETA: 16s - loss: 0.3689 - accuracy: 0.854 -  
ETA: 15s - loss: 0.3629 - accuracy: 0.856 - ETA: 14s - loss: 0.3584 - accuracy:  
0.858 - ETA: 13s - loss: 0.3562 - accuracy: 0.859 - ETA: 12s - loss: 0.3531 -  
accuracy: 0.861 - ETA: 11s - loss: 0.3478 - accuracy: 0.863 - ETA: 10s - loss:  
0.3440 - accuracy: 0.864 - ETA: 9s - loss: 0.3393 - accuracy: 0.866 - ETA: 8s -  
loss: 0.3340 - accuracy: 0.86 - ETA: 7s - loss: 0.3295 - accuracy: 0.87 - ETA:  
6s - loss: 0.3251 - accuracy: 0.87 - ETA: 5s - loss: 0.3204 - accuracy: 0.87 -  
ETA: 4s - loss: 0.3178 - accuracy: 0.87 - ETA: 3s - loss: 0.3143 - accuracy:  
0.87 - ETA: 2s - loss: 0.3118 - accuracy: 0.87 - ETA: 1s - loss: 0.3079 -  
accuracy: 0.87 - ETA: 0s - loss: 0.3044 - accuracy: 0.87 - 75s 18ms/sample -  
loss: 0.3037 - accuracy: 0.8802 - val\_loss: 0.1184 - val\_accuracy: 0.9607

Epoch 2/15

4172/4172 [=====] - ETA: 1:07 - loss: 0.1442 -  
accuracy: 0.93 - ETA: 1:07 - loss: 0.1023 - accuracy: 0.95 - ETA: 1:06 - loss:  
0.1039 - accuracy: 0.95 - ETA: 1:03 - loss: 0.0967 - accuracy: 0.96 - ETA: 1:02  
- loss: 0.0849 - accuracy: 0.96 - ETA: 1:00 - loss: 0.0926 - accuracy: 0.96 -  
ETA: 59s - loss: 0.0861 - accuracy: 0.9688 - ETA: 58s - loss: 0.0827 - accuracy:  
0.970 - ETA: 57s - loss: 0.0805 - accuracy: 0.972 - ETA: 55s - loss: 0.0830 -  
accuracy: 0.970 - ETA: 54s - loss: 0.0782 - accuracy: 0.973 - ETA: 53s - loss:  
0.0740 - accuracy: 0.975 - ETA: 52s - loss: 0.0723 - accuracy: 0.974 - ETA: 51s  
- loss: 0.0723 - accuracy: 0.974 - ETA: 50s - loss: 0.0732 - accuracy: 0.972 -  
ETA: 49s - loss: 0.0722 - accuracy: 0.973 - ETA: 48s - loss: 0.0721 - accuracy:  
0.973 - ETA: 47s - loss: 0.0716 - accuracy: 0.974 - ETA: 46s - loss: 0.0712 -  
accuracy: 0.974 - ETA: 45s - loss: 0.0711 - accuracy: 0.974 - ETA: 44s - loss:  
0.0746 - accuracy: 0.972 - ETA: 43s - loss: 0.0801 - accuracy: 0.971 - ETA: 42s  
- loss: 0.0816 - accuracy: 0.970 - ETA: 41s - loss: 0.0849 - accuracy: 0.970 -  
ETA: 40s - loss: 0.0832 - accuracy: 0.971 - ETA: 39s - loss: 0.0846 - accuracy:  
0.970 - ETA: 38s - loss: 0.0832 - accuracy: 0.970 - ETA: 37s - loss: 0.0812 -  
accuracy: 0.971 - ETA: 36s - loss: 0.0792 - accuracy: 0.972 - ETA: 35s - loss:  
0.0824 - accuracy: 0.970 - ETA: 34s - loss: 0.0822 - accuracy: 0.970 - ETA: 33s  
- loss: 0.0810 - accuracy: 0.971 - ETA: 32s - loss: 0.0800 - accuracy: 0.972 -  
ETA: 31s - loss: 0.0789 - accuracy: 0.972 - ETA: 30s - loss: 0.0799 - accuracy:  
0.972 - ETA: 29s - loss: 0.0798 - accuracy: 0.972 - ETA: 28s - loss: 0.0797 -  
accuracy: 0.972 - ETA: 27s - loss: 0.0787 - accuracy: 0.972 - ETA: 26s - loss:  
0.0783 - accuracy: 0.972 - ETA: 25s - loss: 0.0786 - accuracy: 0.972 - ETA: 24s  
- loss: 0.0790 - accuracy: 0.972 - ETA: 23s - loss: 0.0805 - accuracy: 0.971 -  
ETA: 22s - loss: 0.0820 - accuracy: 0.970 - ETA: 21s - loss: 0.0822 - accuracy:  
0.970 - ETA: 20s - loss: 0.0843 - accuracy: 0.970 - ETA: 19s - loss: 0.0882 -  
accuracy: 0.969 - ETA: 18s - loss: 0.0906 - accuracy: 0.968 - ETA: 17s - loss:  
0.0895 - accuracy: 0.969 - ETA: 16s - loss: 0.0891 - accuracy: 0.969 - ETA: 15s  
- loss: 0.0900 - accuracy: 0.968 - ETA: 14s - loss: 0.0892 - accuracy: 0.969 -  
ETA: 13s - loss: 0.0891 - accuracy: 0.968 - ETA: 12s - loss: 0.0894 - accuracy:  
0.968 - ETA: 11s - loss: 0.0906 - accuracy: 0.967 - ETA: 10s - loss: 0.0910 -  
accuracy: 0.967 - ETA: 9s - loss: 0.0902 - accuracy: 0.968 - ETA: 8s - loss:  
0.0902 - accuracy: 0.96 - ETA: 7s - loss: 0.0914 - accuracy: 0.96 - ETA: 6s -  
loss: 0.0911 - accuracy: 0.96 - ETA: 5s - loss: 0.0906 - accuracy: 0.96 - ETA:  
4s - loss: 0.0903 - accuracy: 0.96 - ETA: 3s - loss: 0.0906 - accuracy: 0.96 -  
ETA: 2s - loss: 0.0908 - accuracy: 0.96 - ETA: 1s - loss: 0.0900 - accuracy:

0.96 - ETA: 0s - loss: 0.0889 - accuracy: 0.96 - 74s 18ms/sample - loss: 0.0887  
- accuracy: 0.9688 - val\_loss: 0.2577 - val\_accuracy: 0.9148

Epoch 3/15

4172/4172 [=====] - ETA: 1:03 - loss: 0.1094 -  
accuracy: 0.93 - ETA: 1:02 - loss: 0.1364 - accuracy: 0.95 - ETA: 1:02 - loss:  
0.1261 - accuracy: 0.96 - ETA: 1:01 - loss: 0.1079 - accuracy: 0.96 - ETA: 1:00  
- loss: 0.0967 - accuracy: 0.96 - ETA: 59s - loss: 0.0855 - accuracy: 0.9740 -  
ETA: 58s - loss: 0.0911 - accuracy: 0.966 - ETA: 57s - loss: 0.0818 - accuracy:  
0.970 - ETA: 57s - loss: 0.0797 - accuracy: 0.970 - ETA: 55s - loss: 0.0780 -  
accuracy: 0.970 - ETA: 54s - loss: 0.0729 - accuracy: 0.973 - ETA: 53s - loss:  
0.0698 - accuracy: 0.974 - ETA: 52s - loss: 0.0734 - accuracy: 0.974 - ETA: 51s  
- loss: 0.0717 - accuracy: 0.975 - ETA: 50s - loss: 0.0693 - accuracy: 0.976 -  
ETA: 49s - loss: 0.0679 - accuracy: 0.975 - ETA: 48s - loss: 0.0673 - accuracy:  
0.974 - ETA: 47s - loss: 0.0652 - accuracy: 0.975 - ETA: 46s - loss: 0.0642 -  
accuracy: 0.975 - ETA: 45s - loss: 0.0627 - accuracy: 0.976 - ETA: 44s - loss:  
0.0630 - accuracy: 0.976 - ETA: 43s - loss: 0.0629 - accuracy: 0.976 - ETA: 42s  
- loss: 0.0643 - accuracy: 0.976 - ETA: 41s - loss: 0.0634 - accuracy: 0.976 -  
ETA: 40s - loss: 0.0623 - accuracy: 0.977 - ETA: 39s - loss: 0.0628 - accuracy:  
0.977 - ETA: 38s - loss: 0.0623 - accuracy: 0.977 - ETA: 37s - loss: 0.0628 -  
accuracy: 0.976 - ETA: 36s - loss: 0.0614 - accuracy: 0.976 - ETA: 35s - loss:  
0.0600 - accuracy: 0.977 - ETA: 34s - loss: 0.0607 - accuracy: 0.977 - ETA: 33s  
- loss: 0.0602 - accuracy: 0.978 - ETA: 32s - loss: 0.0591 - accuracy: 0.978 -  
ETA: 31s - loss: 0.0585 - accuracy: 0.978 - ETA: 30s - loss: 0.0582 - accuracy:  
0.979 - ETA: 29s - loss: 0.0571 - accuracy: 0.979 - ETA: 28s - loss: 0.0567 -  
accuracy: 0.979 - ETA: 27s - loss: 0.0559 - accuracy: 0.979 - ETA: 26s - loss:  
0.0568 - accuracy: 0.979 - ETA: 25s - loss: 0.0602 - accuracy: 0.978 - ETA: 24s  
- loss: 0.0591 - accuracy: 0.979 - ETA: 23s - loss: 0.0593 - accuracy: 0.978 -  
ETA: 22s - loss: 0.0599 - accuracy: 0.978 - ETA: 21s - loss: 0.0589 - accuracy:  
0.979 - ETA: 20s - loss: 0.0598 - accuracy: 0.978 - ETA: 19s - loss: 0.0606 -  
accuracy: 0.978 - ETA: 18s - loss: 0.0611 - accuracy: 0.978 - ETA: 17s - loss:  
0.0671 - accuracy: 0.976 - ETA: 16s - loss: 0.0665 - accuracy: 0.976 - ETA: 15s  
- loss: 0.0702 - accuracy: 0.974 - ETA: 14s - loss: 0.0728 - accuracy: 0.973 -  
ETA: 13s - loss: 0.0724 - accuracy: 0.973 - ETA: 12s - loss: 0.0726 - accuracy:  
0.973 - ETA: 11s - loss: 0.0740 - accuracy: 0.972 - ETA: 10s - loss: 0.0740 -  
accuracy: 0.972 - ETA: 9s - loss: 0.0735 - accuracy: 0.972 - ETA: 8s - loss:  
0.0733 - accuracy: 0.97 - ETA: 7s - loss: 0.0730 - accuracy: 0.97 - ETA: 6s -  
loss: 0.0746 - accuracy: 0.97 - ETA: 5s - loss: 0.0739 - accuracy: 0.97 - ETA:  
4s - loss: 0.0733 - accuracy: 0.97 - ETA: 3s - loss: 0.0738 - accuracy: 0.97 -  
ETA: 2s - loss: 0.0745 - accuracy: 0.97 - ETA: 1s - loss: 0.0745 - accuracy:  
0.97 - ETA: 0s - loss: 0.0738 - accuracy: 0.97 - 73s 18ms/sample - loss: 0.0737  
- accuracy: 0.9732 - val\_loss: 0.1042 - val\_accuracy: 0.9693

Epoch 4/15

4172/4172 [=====] - ETA: 1:03 - loss: 0.0753 -  
accuracy: 0.95 - ETA: 1:02 - loss: 0.0479 - accuracy: 0.97 - ETA: 1:01 - loss:  
0.0620 - accuracy: 0.97 - ETA: 1:00 - loss: 0.0756 - accuracy: 0.97 - ETA: 59s -  
loss: 0.0751 - accuracy: 0.9719 - ETA: 58s - loss: 0.0729 - accuracy: 0.971 -  
ETA: 57s - loss: 0.0678 - accuracy: 0.973 - ETA: 56s - loss: 0.0688 - accuracy:  
0.972 - ETA: 55s - loss: 0.0731 - accuracy: 0.970 - ETA: 54s - loss: 0.0710 -

accuracy: 0.971 - ETA: 53s - loss: 0.0676 - accuracy: 0.974 - ETA: 52s - loss: 0.0642 - accuracy: 0.976 - ETA: 51s - loss: 0.0656 - accuracy: 0.974 - ETA: 50s - loss: 0.0621 - accuracy: 0.976 - ETA: 50s - loss: 0.0641 - accuracy: 0.976 - ETA: 49s - loss: 0.0623 - accuracy: 0.976 - ETA: 48s - loss: 0.0598 - accuracy: 0.977 - ETA: 47s - loss: 0.0599 - accuracy: 0.976 - ETA: 46s - loss: 0.0671 - accuracy: 0.974 - ETA: 45s - loss: 0.0693 - accuracy: 0.973 - ETA: 44s - loss: 0.0688 - accuracy: 0.973 - ETA: 43s - loss: 0.0676 - accuracy: 0.973 - ETA: 42s - loss: 0.0661 - accuracy: 0.974 - ETA: 41s - loss: 0.0666 - accuracy: 0.974 - ETA: 40s - loss: 0.0661 - accuracy: 0.975 - ETA: 39s - loss: 0.0650 - accuracy: 0.976 - ETA: 38s - loss: 0.0638 - accuracy: 0.976 - ETA: 37s - loss: 0.0654 - accuracy: 0.976 - ETA: 36s - loss: 0.0645 - accuracy: 0.976 - ETA: 35s - loss: 0.0651 - accuracy: 0.975 - ETA: 34s - loss: 0.0644 - accuracy: 0.975 - ETA: 33s - loss: 0.0631 - accuracy: 0.975 - ETA: 32s - loss: 0.0645 - accuracy: 0.975 - ETA: 31s - loss: 0.0647 - accuracy: 0.975 - ETA: 30s - loss: 0.0642 - accuracy: 0.975 - ETA: 29s - loss: 0.0663 - accuracy: 0.974 - ETA: 28s - loss: 0.0678 - accuracy: 0.973 - ETA: 27s - loss: 0.0662 - accuracy: 0.974 - ETA: 26s - loss: 0.0647 - accuracy: 0.974 - ETA: 25s - loss: 0.0639 - accuracy: 0.975 - ETA: 24s - loss: 0.0634 - accuracy: 0.975 - ETA: 23s - loss: 0.0633 - accuracy: 0.975 - ETA: 22s - loss: 0.0637 - accuracy: 0.974 - ETA: 21s - loss: 0.0635 - accuracy: 0.974 - ETA: 20s - loss: 0.0623 - accuracy: 0.974 - ETA: 19s - loss: 0.0629 - accuracy: 0.974 - ETA: 18s - loss: 0.0624 - accuracy: 0.974 - ETA: 17s - loss: 0.0634 - accuracy: 0.974 - ETA: 16s - loss: 0.0635 - accuracy: 0.973 - ETA: 15s - loss: 0.0633 - accuracy: 0.973 - ETA: 14s - loss: 0.0629 - accuracy: 0.974 - ETA: 13s - loss: 0.0621 - accuracy: 0.974 - ETA: 12s - loss: 0.0615 - accuracy: 0.974 - ETA: 11s - loss: 0.0613 - accuracy: 0.975 - ETA: 10s - loss: 0.0626 - accuracy: 0.975 - ETA: 9s - loss: 0.0637 - accuracy: 0.975 - ETA: 8s - loss: 0.0632 - accuracy: 0.97 - ETA: 7s - loss: 0.0631 - accuracy: 0.97 - ETA: 6s - loss: 0.0630 - accuracy: 0.97 - ETA: 5s - loss: 0.0629 - accuracy: 0.97 - ETA: 4s - loss: 0.0621 - accuracy: 0.97 - ETA: 3s - loss: 0.0616 - accuracy: 0.97 - ETA: 2s - loss: 0.0611 - accuracy: 0.97 - ETA: 1s - loss: 0.0602 - accuracy: 0.97 - ETA: 0s - loss: 0.0597 - accuracy: 0.97 - 74s 18ms/sample - loss: 0.0595 - accuracy: 0.9770 - val\_loss: 0.1036 - val\_accuracy: 0.9722

Epoch 5/15

4172/4172 [=====] - ETA: 1:05 - loss: 0.0340 - accuracy: 0.98 - ETA: 1:04 - loss: 0.0693 - accuracy: 0.98 - ETA: 1:05 - loss: 0.0515 - accuracy: 0.98 - ETA: 1:05 - loss: 0.0525 - accuracy: 0.98 - ETA: 1:05 - loss: 0.0445 - accuracy: 0.99 - ETA: 1:04 - loss: 0.0387 - accuracy: 0.99 - ETA: 1:02 - loss: 0.0377 - accuracy: 0.99 - ETA: 1:01 - loss: 0.0361 - accuracy: 0.99 - ETA: 59s - loss: 0.0392 - accuracy: 0.9913 - ETA: 58s - loss: 0.0383 - accuracy: 0.992 - ETA: 56s - loss: 0.0382 - accuracy: 0.991 - ETA: 55s - loss: 0.0419 - accuracy: 0.988 - ETA: 54s - loss: 0.0403 - accuracy: 0.989 - ETA: 53s - loss: 0.0386 - accuracy: 0.990 - ETA: 51s - loss: 0.0383 - accuracy: 0.988 - ETA: 50s - loss: 0.0363 - accuracy: 0.989 - ETA: 49s - loss: 0.0357 - accuracy: 0.989 - ETA: 48s - loss: 0.0349 - accuracy: 0.988 - ETA: 47s - loss: 0.0342 - accuracy: 0.989 - ETA: 46s - loss: 0.0340 - accuracy: 0.989 - ETA: 46s - loss: 0.0327 - accuracy: 0.989 - ETA: 44s - loss: 0.0324 - accuracy: 0.989 - ETA: 43s - loss: 0.0339 - accuracy: 0.988 - ETA: 42s - loss: 0.0328 - accuracy: 0.988 - ETA: 41s - loss: 0.0325 - accuracy: 0.989 - ETA: 40s - loss: 0.0316 - accuracy:



0.989 - ETA: 39s - loss: 0.0315 - accuracy: 0.990 - ETA: 38s - loss: 0.0329 - accuracy: 0.990 - ETA: 37s - loss: 0.0324 - accuracy: 0.989 - ETA: 36s - loss: 0.0314 - accuracy: 0.990 - ETA: 35s - loss: 0.0310 - accuracy: 0.990 - ETA: 34s - loss: 0.0303 - accuracy: 0.990 - ETA: 33s - loss: 0.0301 - accuracy: 0.990 - ETA: 32s - loss: 0.0300 - accuracy: 0.990 - ETA: 31s - loss: 0.0295 - accuracy: 0.991 - ETA: 30s - loss: 0.0310 - accuracy: 0.990 - ETA: 29s - loss: 0.0324 - accuracy: 0.990 - ETA: 27s - loss: 0.0327 - accuracy: 0.990 - ETA: 26s - loss: 0.0329 - accuracy: 0.990 - ETA: 25s - loss: 0.0338 - accuracy: 0.989 - ETA: 24s - loss: 0.0353 - accuracy: 0.989 - ETA: 23s - loss: 0.0348 - accuracy: 0.989 - ETA: 22s - loss: 0.0359 - accuracy: 0.988 - ETA: 21s - loss: 0.0361 - accuracy: 0.988 - ETA: 20s - loss: 0.0358 - accuracy: 0.988 - ETA: 19s - loss: 0.0372 - accuracy: 0.988 - ETA: 18s - loss: 0.0373 - accuracy: 0.988 - ETA: 17s - loss: 0.0376 - accuracy: 0.987 - ETA: 16s - loss: 0.0380 - accuracy: 0.987 - ETA: 15s - loss: 0.0379 - accuracy: 0.987 - ETA: 14s - loss: 0.0375 - accuracy: 0.987 - ETA: 13s - loss: 0.0392 - accuracy: 0.986 - ETA: 12s - loss: 0.0396 - accuracy: 0.986 - ETA: 11s - loss: 0.0398 - accuracy: 0.986 - ETA: 10s - loss: 0.0393 - accuracy: 0.986 - ETA: 9s - loss: 0.0391 - accuracy: 0.986 - ETA: 8s - loss: 0.0392 - accuracy: 0.98 - ETA: 7s - loss: 0.0388 - accuracy: 0.98 - ETA: 6s - loss: 0.0384 - accuracy: 0.98 - ETA: 5s - loss: 0.0384 - accuracy: 0.98 - ETA: 4s - loss: 0.0380 - accuracy: 0.98 - ETA: 3s - loss: 0.0389 - accuracy: 0.98 - ETA: 2s - loss: 0.0387 - accuracy: 0.98 - ETA: 1s - loss: 0.0388 - accuracy: 0.98 - ETA: 0s - loss: 0.0399 - accuracy: 0.98 - 74s 18ms/sample - loss: 0.0398 - accuracy: 0.9856 - val\_loss: 0.1234 - val\_accuracy: 0.9713

Epoch 6/15

4172/4172 [=====] - ETA: 1:03 - loss: 0.0130 - accuracy: 1.00 - ETA: 1:02 - loss: 0.0348 - accuracy: 0.98 - ETA: 1:01 - loss: 0.0353 - accuracy: 0.97 - ETA: 1:01 - loss: 0.0273 - accuracy: 0.98 - ETA: 59s - loss: 0.0290 - accuracy: 0.9844 - ETA: 58s - loss: 0.0287 - accuracy: 0.987 - ETA: 57s - loss: 0.0278 - accuracy: 0.988 - ETA: 56s - loss: 0.0271 - accuracy: 0.988 - ETA: 55s - loss: 0.0280 - accuracy: 0.989 - ETA: 55s - loss: 0.0280 - accuracy: 0.990 - ETA: 54s - loss: 0.0291 - accuracy: 0.990 - ETA: 54s - loss: 0.0315 - accuracy: 0.989 - ETA: 53s - loss: 0.0298 - accuracy: 0.990 - ETA: 51s - loss: 0.0307 - accuracy: 0.990 - ETA: 50s - loss: 0.0295 - accuracy: 0.990 - ETA: 49s - loss: 0.0319 - accuracy: 0.988 - ETA: 48s - loss: 0.0310 - accuracy: 0.988 - ETA: 47s - loss: 0.0325 - accuracy: 0.986 - ETA: 46s - loss: 0.0310 - accuracy: 0.986 - ETA: 45s - loss: 0.0301 - accuracy: 0.987 - ETA: 44s - loss: 0.0301 - accuracy: 0.987 - ETA: 43s - loss: 0.0294 - accuracy: 0.987 - ETA: 42s - loss: 0.0318 - accuracy: 0.987 - ETA: 41s - loss: 0.0334 - accuracy: 0.986 - ETA: 40s - loss: 0.0327 - accuracy: 0.986 - ETA: 39s - loss: 0.0370 - accuracy: 0.983 - ETA: 38s - loss: 0.0358 - accuracy: 0.984 - ETA: 37s - loss: 0.0364 - accuracy: 0.984 - ETA: 36s - loss: 0.0372 - accuracy: 0.983 - ETA: 35s - loss: 0.0373 - accuracy: 0.983 - ETA: 34s - loss: 0.0369 - accuracy: 0.983 - ETA: 33s - loss: 0.0365 - accuracy: 0.983 - ETA: 32s - loss: 0.0363 - accuracy: 0.984 - ETA: 31s - loss: 0.0361 - accuracy: 0.984 - ETA: 30s - loss: 0.0376 - accuracy: 0.983 - ETA: 29s - loss: 0.0372 - accuracy: 0.983 - ETA: 28s - loss: 0.0374 - accuracy: 0.983 - ETA: 27s - loss: 0.0372 - accuracy: 0.984 - ETA: 26s - loss: 0.0365 - accuracy: 0.984 - ETA: 25s - loss: 0.0361 - accuracy: 0.984 - ETA: 24s - loss: 0.0355 - accuracy: 0.985 - ETA: 23s - loss: 0.0358 - accuracy: 0.984 -

ETA: 22s - loss: 0.0357 - accuracy: 0.984 - ETA: 21s - loss: 0.0350 - accuracy: 0.985 - ETA: 20s - loss: 0.0349 - accuracy: 0.984 - ETA: 19s - loss: 0.0353 - accuracy: 0.984 - ETA: 18s - loss: 0.0356 - accuracy: 0.984 - ETA: 17s - loss: 0.0369 - accuracy: 0.984 - ETA: 16s - loss: 0.0370 - accuracy: 0.984 - ETA: 15s - loss: 0.0378 - accuracy: 0.984 - ETA: 14s - loss: 0.0371 - accuracy: 0.984 - ETA: 13s - loss: 0.0367 - accuracy: 0.984 - ETA: 12s - loss: 0.0374 - accuracy: 0.984 - ETA: 11s - loss: 0.0370 - accuracy: 0.985 - ETA: 10s - loss: 0.0374 - accuracy: 0.984 - ETA: 9s - loss: 0.0369 - accuracy: 0.985 - ETA: 8s - loss: 0.0364 - accuracy: 0.98 - ETA: 7s - loss: 0.0364 - accuracy: 0.98 - ETA: 6s - loss: 0.0363 - accuracy: 0.98 - ETA: 5s - loss: 0.0369 - accuracy: 0.98 - ETA: 4s - loss: 0.0365 - accuracy: 0.98 - ETA: 3s - loss: 0.0360 - accuracy: 0.98 - ETA: 2s - loss: 0.0357 - accuracy: 0.98 - ETA: 1s - loss: 0.0361 - accuracy: 0.98 - ETA: 0s - loss: 0.0356 - accuracy: 0.98 - 73s 18ms/sample - loss: 0.0355 - accuracy: 0.9863 - val\_loss: 0.0845 - val\_accuracy: 0.9770

Epoch 7/15

4172/4172 [=====] - ETA: 1:08 - loss: 0.0084 - accuracy: 1.00 - ETA: 1:07 - loss: 0.0076 - accuracy: 1.00 - ETA: 1:05 - loss: 0.0077 - accuracy: 1.00 - ETA: 1:03 - loss: 0.0163 - accuracy: 0.99 - ETA: 1:01 - loss: 0.0142 - accuracy: 0.99 - ETA: 1:00 - loss: 0.0123 - accuracy: 0.99 - ETA: 59s - loss: 0.0157 - accuracy: 0.9933 - ETA: 57s - loss: 0.0155 - accuracy: 0.992 - ETA: 56s - loss: 0.0175 - accuracy: 0.991 - ETA: 55s - loss: 0.0183 - accuracy: 0.990 - ETA: 54s - loss: 0.0190 - accuracy: 0.991 - ETA: 53s - loss: 0.0178 - accuracy: 0.992 - ETA: 52s - loss: 0.0167 - accuracy: 0.992 - ETA: 50s - loss: 0.0179 - accuracy: 0.993 - ETA: 49s - loss: 0.0196 - accuracy: 0.992 - ETA: 48s - loss: 0.0186 - accuracy: 0.993 - ETA: 48s - loss: 0.0181 - accuracy: 0.993 - ETA: 47s - loss: 0.0190 - accuracy: 0.993 - ETA: 46s - loss: 0.0184 - accuracy: 0.993 - ETA: 45s - loss: 0.0184 - accuracy: 0.993 - ETA: 44s - loss: 0.0178 - accuracy: 0.993 - ETA: 43s - loss: 0.0194 - accuracy: 0.992 - ETA: 42s - loss: 0.0190 - accuracy: 0.993 - ETA: 41s - loss: 0.0189 - accuracy: 0.992 - ETA: 40s - loss: 0.0183 - accuracy: 0.993 - ETA: 38s - loss: 0.0178 - accuracy: 0.993 - ETA: 37s - loss: 0.0176 - accuracy: 0.993 - ETA: 36s - loss: 0.0177 - accuracy: 0.993 - ETA: 35s - loss: 0.0176 - accuracy: 0.994 - ETA: 35s - loss: 0.0171 - accuracy: 0.994 - ETA: 33s - loss: 0.0169 - accuracy: 0.994 - ETA: 33s - loss: 0.0179 - accuracy: 0.994 - ETA: 32s - loss: 0.0185 - accuracy: 0.993 - ETA: 31s - loss: 0.0185 - accuracy: 0.994 - ETA: 30s - loss: 0.0186 - accuracy: 0.993 - ETA: 29s - loss: 0.0189 - accuracy: 0.993 - ETA: 28s - loss: 0.0194 - accuracy: 0.993 - ETA: 27s - loss: 0.0191 - accuracy: 0.993 - ETA: 26s - loss: 0.0186 - accuracy: 0.993 - ETA: 25s - loss: 0.0182 - accuracy: 0.993 - ETA: 24s - loss: 0.0179 - accuracy: 0.993 - ETA: 23s - loss: 0.0177 - accuracy: 0.994 - ETA: 22s - loss: 0.0182 - accuracy: 0.993 - ETA: 21s - loss: 0.0181 - accuracy: 0.993 - ETA: 20s - loss: 0.0180 - accuracy: 0.993 - ETA: 19s - loss: 0.0177 - accuracy: 0.993 - ETA: 18s - loss: 0.0182 - accuracy: 0.993 - ETA: 17s - loss: 0.0181 - accuracy: 0.993 - ETA: 16s - loss: 0.0181 - accuracy: 0.993 - ETA: 15s - loss: 0.0179 - accuracy: 0.994 - ETA: 14s - loss: 0.0179 - accuracy: 0.994 - ETA: 13s - loss: 0.0178 - accuracy: 0.994 - ETA: 12s - loss: 0.0175 - accuracy: 0.994 - ETA: 11s - loss: 0.0172 - accuracy: 0.994 - ETA: 10s - loss: 0.0170 - accuracy: 0.994 - ETA: 9s - loss: 0.0168 - accuracy: 0.994 - ETA: 8s - loss: 0.0167 - accuracy: 0.99 - ETA: 7s - loss: 0.0165 - accuracy: 0.99 - ETA: 6s -

loss: 0.0167 - accuracy: 0.99 - ETA: 5s - loss: 0.0166 - accuracy: 0.99 - ETA:  
4s - loss: 0.0171 - accuracy: 0.99 - ETA: 3s - loss: 0.0170 - accuracy: 0.99 -  
ETA: 2s - loss: 0.0169 - accuracy: 0.99 - ETA: 1s - loss: 0.0171 - accuracy:  
0.99 - ETA: 0s - loss: 0.0171 - accuracy: 0.99 - 73s 17ms/sample - loss: 0.0170  
- accuracy: 0.9950 - val\_loss: 0.1068 - val\_accuracy: 0.9732

Epoch 8/15

4172/4172 [=====] - ETA: 1:04 - loss: 0.0050 -  
accuracy: 1.00 - ETA: 1:02 - loss: 0.0033 - accuracy: 1.00 - ETA: 1:01 - loss:  
0.0040 - accuracy: 1.00 - ETA: 1:00 - loss: 0.0050 - accuracy: 1.00 - ETA: 59s -  
loss: 0.0051 - accuracy: 1.0000 - ETA: 58s - loss: 0.0061 - accuracy: 1.000 -  
ETA: 57s - loss: 0.0057 - accuracy: 1.000 - ETA: 57s - loss: 0.0061 - accuracy:  
1.000 - ETA: 56s - loss: 0.0108 - accuracy: 0.996 - ETA: 55s - loss: 0.0116 -  
accuracy: 0.996 - ETA: 54s - loss: 0.0106 - accuracy: 0.997 - ETA: 53s - loss:  
0.0115 - accuracy: 0.996 - ETA: 52s - loss: 0.0108 - accuracy: 0.996 - ETA: 51s  
- loss: 0.0102 - accuracy: 0.996 - ETA: 50s - loss: 0.0098 - accuracy: 0.996 -  
ETA: 49s - loss: 0.0096 - accuracy: 0.997 - ETA: 48s - loss: 0.0094 - accuracy:  
0.997 - ETA: 47s - loss: 0.0095 - accuracy: 0.997 - ETA: 46s - loss: 0.0093 -  
accuracy: 0.997 - ETA: 45s - loss: 0.0089 - accuracy: 0.997 - ETA: 44s - loss:  
0.0088 - accuracy: 0.997 - ETA: 43s - loss: 0.0088 - accuracy: 0.997 - ETA: 42s  
- loss: 0.0096 - accuracy: 0.997 - ETA: 41s - loss: 0.0094 - accuracy: 0.997 -  
ETA: 40s - loss: 0.0091 - accuracy: 0.997 - ETA: 39s - loss: 0.0098 - accuracy:  
0.997 - ETA: 38s - loss: 0.0099 - accuracy: 0.997 - ETA: 37s - loss: 0.0101 -  
accuracy: 0.997 - ETA: 36s - loss: 0.0098 - accuracy: 0.997 - ETA: 35s - loss:  
0.0096 - accuracy: 0.997 - ETA: 34s - loss: 0.0094 - accuracy: 0.997 - ETA: 33s  
- loss: 0.0093 - accuracy: 0.997 - ETA: 32s - loss: 0.0098 - accuracy: 0.997 -  
ETA: 31s - loss: 0.0097 - accuracy: 0.997 - ETA: 30s - loss: 0.0095 - accuracy:  
0.997 - ETA: 29s - loss: 0.0093 - accuracy: 0.997 - ETA: 28s - loss: 0.0101 -  
accuracy: 0.996 - ETA: 27s - loss: 0.0102 - accuracy: 0.996 - ETA: 26s - loss:  
0.0102 - accuracy: 0.996 - ETA: 25s - loss: 0.0100 - accuracy: 0.996 - ETA: 24s  
- loss: 0.0099 - accuracy: 0.997 - ETA: 23s - loss: 0.0098 - accuracy: 0.997 -  
ETA: 22s - loss: 0.0098 - accuracy: 0.997 - ETA: 21s - loss: 0.0095 - accuracy:  
0.997 - ETA: 20s - loss: 0.0094 - accuracy: 0.997 - ETA: 19s - loss: 0.0094 -  
accuracy: 0.997 - ETA: 18s - loss: 0.0092 - accuracy: 0.997 - ETA: 17s - loss:  
0.0091 - accuracy: 0.997 - ETA: 16s - loss: 0.0090 - accuracy: 0.997 - ETA: 15s  
- loss: 0.0096 - accuracy: 0.997 - ETA: 14s - loss: 0.0098 - accuracy: 0.997 -  
ETA: 13s - loss: 0.0098 - accuracy: 0.997 - ETA: 12s - loss: 0.0098 - accuracy:  
0.997 - ETA: 11s - loss: 0.0096 - accuracy: 0.997 - ETA: 10s - loss: 0.0095 -  
accuracy: 0.997 - ETA: 9s - loss: 0.0099 - accuracy: 0.997 - ETA: 8s - loss:  
0.0101 - accuracy: 0.99 - ETA: 7s - loss: 0.0103 - accuracy: 0.99 - ETA: 6s -  
loss: 0.0105 - accuracy: 0.99 - ETA: 5s - loss: 0.0104 - accuracy: 0.99 - ETA:  
4s - loss: 0.0105 - accuracy: 0.99 - ETA: 3s - loss: 0.0108 - accuracy: 0.99 -  
ETA: 2s - loss: 0.0108 - accuracy: 0.99 - ETA: 1s - loss: 0.0108 - accuracy:  
0.99 - ETA: 0s - loss: 0.0112 - accuracy: 0.99 - 73s 18ms/sample - loss: 0.0112  
- accuracy: 0.9966 - val\_loss: 0.1055 - val\_accuracy: 0.9751

Epoch 9/15

4172/4172 [=====] - ETA: 1:05 - loss: 0.0036 -  
accuracy: 1.00 - ETA: 1:02 - loss: 0.0031 - accuracy: 1.00 - ETA: 1:01 - loss:  
0.0097 - accuracy: 1.00 - ETA: 1:00 - loss: 0.0121 - accuracy: 1.00 - ETA: 59s -

loss: 0.0099 - accuracy: 1.0000 - ETA: 59s - loss: 0.0099 - accuracy: 1.000 -  
 ETA: 58s - loss: 0.0087 - accuracy: 1.000 - ETA: 57s - loss: 0.0101 - accuracy:  
 0.998 - ETA: 56s - loss: 0.0093 - accuracy: 0.998 - ETA: 55s - loss: 0.0091 -  
 accuracy: 0.998 - ETA: 54s - loss: 0.0092 - accuracy: 0.998 - ETA: 53s - loss:  
 0.0090 - accuracy: 0.998 - ETA: 52s - loss: 0.0089 - accuracy: 0.998 - ETA: 51s  
 - loss: 0.0085 - accuracy: 0.998 - ETA: 50s - loss: 0.0080 - accuracy: 0.999 -  
 ETA: 49s - loss: 0.0094 - accuracy: 0.998 - ETA: 48s - loss: 0.0097 - accuracy:  
 0.997 - ETA: 47s - loss: 0.0099 - accuracy: 0.997 - ETA: 46s - loss: 0.0095 -  
 accuracy: 0.997 - ETA: 45s - loss: 0.0092 - accuracy: 0.997 - ETA: 44s - loss:  
 0.0093 - accuracy: 0.997 - ETA: 43s - loss: 0.0094 - accuracy: 0.997 - ETA: 42s  
 - loss: 0.0091 - accuracy: 0.998 - ETA: 41s - loss: 0.0095 - accuracy: 0.997 -  
 ETA: 40s - loss: 0.0103 - accuracy: 0.996 - ETA: 39s - loss: 0.0102 - accuracy:  
 0.997 - ETA: 38s - loss: 0.0099 - accuracy: 0.997 - ETA: 37s - loss: 0.0101 -  
 accuracy: 0.997 - ETA: 36s - loss: 0.0106 - accuracy: 0.996 - ETA: 35s - loss:  
 0.0105 - accuracy: 0.996 - ETA: 34s - loss: 0.0103 - accuracy: 0.997 - ETA: 33s  
 - loss: 0.0100 - accuracy: 0.997 - ETA: 32s - loss: 0.0100 - accuracy: 0.997 -  
 ETA: 31s - loss: 0.0100 - accuracy: 0.997 - ETA: 30s - loss: 0.0098 - accuracy:  
 0.997 - ETA: 29s - loss: 0.0097 - accuracy: 0.997 - ETA: 28s - loss: 0.0096 -  
 accuracy: 0.997 - ETA: 27s - loss: 0.0096 - accuracy: 0.997 - ETA: 26s - loss:  
 0.0096 - accuracy: 0.997 - ETA: 25s - loss: 0.0094 - accuracy: 0.997 - ETA: 24s  
 - loss: 0.0095 - accuracy: 0.997 - ETA: 23s - loss: 0.0093 - accuracy: 0.997 -  
 ETA: 22s - loss: 0.0093 - accuracy: 0.997 - ETA: 21s - loss: 0.0091 - accuracy:  
 0.997 - ETA: 20s - loss: 0.0093 - accuracy: 0.997 - ETA: 19s - loss: 0.0092 -  
 accuracy: 0.998 - ETA: 18s - loss: 0.0092 - accuracy: 0.998 - ETA: 17s - loss:  
 0.0090 - accuracy: 0.998 - ETA: 16s - loss: 0.0090 - accuracy: 0.998 - ETA: 15s  
 - loss: 0.0088 - accuracy: 0.998 - ETA: 14s - loss: 0.0087 - accuracy: 0.998 -  
 ETA: 13s - loss: 0.0085 - accuracy: 0.998 - ETA: 12s - loss: 0.0084 - accuracy:  
 0.998 - ETA: 11s - loss: 0.0084 - accuracy: 0.998 - ETA: 10s - loss: 0.0083 -  
 accuracy: 0.998 - ETA: 9s - loss: 0.0082 - accuracy: 0.998 - ETA: 8s - loss:  
 0.0082 - accuracy: 0.99 - ETA: 7s - loss: 0.0081 - accuracy: 0.99 - ETA: 6s -  
 loss: 0.0079 - accuracy: 0.99 - ETA: 5s - loss: 0.0079 - accuracy: 0.99 - ETA:  
 4s - loss: 0.0078 - accuracy: 0.99 - ETA: 3s - loss: 0.0078 - accuracy: 0.99 -  
 ETA: 2s - loss: 0.0078 - accuracy: 0.99 - ETA: 1s - loss: 0.0077 - accuracy:  
 0.99 - ETA: 0s - loss: 0.0078 - accuracy: 0.99 - 73s 17ms/sample - loss: 0.0078  
 - accuracy: 0.9983 - val\_loss: 0.1390 - val\_accuracy: 0.9741

Epoch 10/15

4172/4172 [=====] - ETA: 1:00 - loss: 0.0040 -  
 accuracy: 1.00 - ETA: 1:00 - loss: 0.0054 - accuracy: 1.00 - ETA: 1:00 - loss:  
 0.0070 - accuracy: 1.00 - ETA: 59s - loss: 0.0083 - accuracy: 1.0000 - ETA: 59s  
 - loss: 0.0068 - accuracy: 1.000 - ETA: 58s - loss: 0.0059 - accuracy: 1.000 -  
 ETA: 58s - loss: 0.0054 - accuracy: 1.000 - ETA: 57s - loss: 0.0049 - accuracy:  
 1.000 - ETA: 56s - loss: 0.0061 - accuracy: 0.998 - ETA: 55s - loss: 0.0061 -  
 accuracy: 0.998 - ETA: 54s - loss: 0.0059 - accuracy: 0.998 - ETA: 53s - loss:  
 0.0056 - accuracy: 0.998 - ETA: 52s - loss: 0.0052 - accuracy: 0.998 - ETA: 51s  
 - loss: 0.0050 - accuracy: 0.998 - ETA: 50s - loss: 0.0048 - accuracy: 0.999 -  
 ETA: 49s - loss: 0.0046 - accuracy: 0.999 - ETA: 48s - loss: 0.0044 - accuracy:  
 0.999 - ETA: 47s - loss: 0.0043 - accuracy: 0.999 - ETA: 46s - loss: 0.0042 -  
 accuracy: 0.999 - ETA: 45s - loss: 0.0050 - accuracy: 0.998 - ETA: 44s - loss:

0.0050 - accuracy: 0.998 - ETA: 43s - loss: 0.0051 - accuracy: 0.998 - ETA: 42s  
- loss: 0.0052 - accuracy: 0.998 - ETA: 41s - loss: 0.0051 - accuracy: 0.998 -  
ETA: 40s - loss: 0.0057 - accuracy: 0.998 - ETA: 39s - loss: 0.0056 - accuracy:  
0.998 - ETA: 38s - loss: 0.0064 - accuracy: 0.998 - ETA: 37s - loss: 0.0064 -  
accuracy: 0.998 - ETA: 36s - loss: 0.0066 - accuracy: 0.998 - ETA: 35s - loss:  
0.0068 - accuracy: 0.998 - ETA: 34s - loss: 0.0069 - accuracy: 0.998 - ETA: 33s  
- loss: 0.0070 - accuracy: 0.998 - ETA: 32s - loss: 0.0072 - accuracy: 0.998 -  
ETA: 31s - loss: 0.0070 - accuracy: 0.998 - ETA: 30s - loss: 0.0069 - accuracy:  
0.998 - ETA: 29s - loss: 0.0067 - accuracy: 0.998 - ETA: 28s - loss: 0.0066 -  
accuracy: 0.998 - ETA: 27s - loss: 0.0064 - accuracy: 0.998 - ETA: 26s - loss:  
0.0066 - accuracy: 0.998 - ETA: 25s - loss: 0.0064 - accuracy: 0.998 - ETA: 24s  
- loss: 0.0067 - accuracy: 0.998 - ETA: 23s - loss: 0.0066 - accuracy: 0.998 -  
ETA: 22s - loss: 0.0064 - accuracy: 0.998 - ETA: 21s - loss: 0.0063 - accuracy:  
0.998 - ETA: 20s - loss: 0.0063 - accuracy: 0.998 - ETA: 19s - loss: 0.0063 -  
accuracy: 0.998 - ETA: 18s - loss: 0.0062 - accuracy: 0.998 - ETA: 17s - loss:  
0.0061 - accuracy: 0.998 - ETA: 16s - loss: 0.0063 - accuracy: 0.998 - ETA: 15s  
- loss: 0.0062 - accuracy: 0.998 - ETA: 14s - loss: 0.0061 - accuracy: 0.998 -  
ETA: 13s - loss: 0.0061 - accuracy: 0.998 - ETA: 12s - loss: 0.0060 - accuracy:  
0.998 - ETA: 11s - loss: 0.0059 - accuracy: 0.998 - ETA: 10s - loss: 0.0060 -  
accuracy: 0.998 - ETA: 9s - loss: 0.0061 - accuracy: 0.998 - ETA: 8s - loss:  
0.0063 - accuracy: 0.99 - ETA: 7s - loss: 0.0062 - accuracy: 0.99 - ETA: 6s -  
loss: 0.0062 - accuracy: 0.99 - ETA: 5s - loss: 0.0062 - accuracy: 0.99 - ETA:  
4s - loss: 0.0064 - accuracy: 0.99 - ETA: 3s - loss: 0.0063 - accuracy: 0.99 -  
ETA: 2s - loss: 0.0063 - accuracy: 0.99 - ETA: 1s - loss: 0.0062 - accuracy:  
0.99 - ETA: 0s - loss: 0.0061 - accuracy: 0.99 - 73s 18ms/sample - loss: 0.0061  
- accuracy: 0.9986 - val\_loss: 0.1136 - val\_accuracy: 0.9751

Epoch 11/15

4172/4172 [=====] - ETA: 1:02 - loss: 0.0093 -  
accuracy: 1.00 - ETA: 1:02 - loss: 0.0052 - accuracy: 1.00 - ETA: 1:01 - loss:  
0.0045 - accuracy: 1.00 - ETA: 1:00 - loss: 0.0035 - accuracy: 1.00 - ETA: 59s -  
loss: 0.0030 - accuracy: 1.0000 - ETA: 58s - loss: 0.0028 - accuracy: 1.000 -  
ETA: 57s - loss: 0.0031 - accuracy: 1.000 - ETA: 56s - loss: 0.0028 - accuracy:  
1.000 - ETA: 55s - loss: 0.0025 - accuracy: 1.000 - ETA: 55s - loss: 0.0024 -  
accuracy: 1.000 - ETA: 53s - loss: 0.0025 - accuracy: 1.000 - ETA: 52s - loss:  
0.0024 - accuracy: 1.000 - ETA: 51s - loss: 0.0024 - accuracy: 1.000 - ETA: 51s  
- loss: 0.0024 - accuracy: 1.000 - ETA: 50s - loss: 0.0022 - accuracy: 1.000 -  
ETA: 49s - loss: 0.0021 - accuracy: 1.000 - ETA: 48s - loss: 0.0020 - accuracy:  
1.000 - ETA: 47s - loss: 0.0020 - accuracy: 1.000 - ETA: 46s - loss: 0.0020 -  
accuracy: 1.000 - ETA: 45s - loss: 0.0019 - accuracy: 1.000 - ETA: 44s - loss:  
0.0019 - accuracy: 1.000 - ETA: 43s - loss: 0.0018 - accuracy: 1.000 - ETA: 42s  
- loss: 0.0019 - accuracy: 1.000 - ETA: 41s - loss: 0.0019 - accuracy: 1.000 -  
ETA: 40s - loss: 0.0019 - accuracy: 1.000 - ETA: 39s - loss: 0.0019 - accuracy:  
1.000 - ETA: 38s - loss: 0.0018 - accuracy: 1.000 - ETA: 37s - loss: 0.0018 -  
accuracy: 1.000 - ETA: 36s - loss: 0.0018 - accuracy: 1.000 - ETA: 35s - loss:  
0.0018 - accuracy: 1.000 - ETA: 34s - loss: 0.0018 - accuracy: 1.000 - ETA: 33s  
- loss: 0.0018 - accuracy: 1.000 - ETA: 32s - loss: 0.0018 - accuracy: 1.000 -  
ETA: 31s - loss: 0.0017 - accuracy: 1.000 - ETA: 30s - loss: 0.0017 - accuracy:  
1.000 - ETA: 29s - loss: 0.0017 - accuracy: 1.000 - ETA: 28s - loss: 0.0017 -

accuracy: 1.000 - ETA: 27s - loss: 0.0017 - accuracy: 1.000 - ETA: 26s - loss: 0.0017 - accuracy: 1.000 - ETA: 25s - loss: 0.0016 - accuracy: 1.000 - ETA: 24s - loss: 0.0016 - accuracy: 1.000 - ETA: 23s - loss: 0.0016 - accuracy: 1.000 - ETA: 22s - loss: 0.0016 - accuracy: 1.000 - ETA: 21s - loss: 0.0017 - accuracy: 1.000 - ETA: 20s - loss: 0.0019 - accuracy: 0.999 - ETA: 19s - loss: 0.0019 - accuracy: 0.999 - ETA: 18s - loss: 0.0019 - accuracy: 0.999 - ETA: 17s - loss: 0.0019 - accuracy: 0.999 - ETA: 16s - loss: 0.0019 - accuracy: 0.999 - ETA: 15s - loss: 0.0020 - accuracy: 0.999 - ETA: 14s - loss: 0.0020 - accuracy: 0.999 - ETA: 13s - loss: 0.0020 - accuracy: 0.999 - ETA: 12s - loss: 0.0020 - accuracy: 0.999 - ETA: 11s - loss: 0.0020 - accuracy: 0.999 - ETA: 10s - loss: 0.0020 - accuracy: 0.999 - ETA: 9s - loss: 0.0020 - accuracy: 0.999 - ETA: 8s - loss: 0.0020 - accuracy: 0.99 - ETA: 7s - loss: 0.0020 - accuracy: 0.99 - ETA: 6s - loss: 0.0021 - accuracy: 0.99 - ETA: 5s - loss: 0.0021 - accuracy: 0.99 - ETA: 4s - loss: 0.0021 - accuracy: 0.99 - ETA: 3s - loss: 0.0021 - accuracy: 0.99 - ETA: 2s - loss: 0.0021 - accuracy: 0.99 - ETA: 1s - loss: 0.0020 - accuracy: 0.99 - ETA: 0s - loss: 0.0020 - accuracy: 0.99 - 73s 17ms/sample - loss: 0.0020 - accuracy: 0.9998 - val\_loss: 0.1255 - val\_accuracy: 0.9761

Epoch 12/15

4172/4172 [=====] - ETA: 1:01 - loss: 0.0012 - accuracy: 1.00 - ETA: 1:01 - loss: 0.0010 - accuracy: 1.00 - ETA: 1:01 - loss: 0.0014 - accuracy: 1.00 - ETA: 1:00 - loss: 0.0012 - accuracy: 1.00 - ETA: 1:01 - loss: 0.0012 - accuracy: 1.00 - ETA: 59s - loss: 9.9697e-04 - accuracy: 1.000 - ETA: 58s - loss: 8.6597e-04 - accuracy: 1.000 - ETA: 57s - loss: 9.7914e-04 - accuracy: 1.000 - ETA: 56s - loss: 0.0010 - accuracy: 1.0000 - ETA: 55s - loss: 0.0011 - accuracy: 1.000 - ETA: 54s - loss: 0.0010 - accuracy: 1.000 - ETA: 53s - loss: 0.0011 - accuracy: 1.000 - ETA: 52s - loss: 0.0010 - accuracy: 1.000 - ETA: 51s - loss: 0.0010 - accuracy: 1.000 - ETA: 50s - loss: 9.7353e-04 - accuracy: 1.000 - ETA: 49s - loss: 0.0010 - accuracy: 1.0000 - ETA: 47s - loss: 0.0010 - accuracy: 1.000 - ETA: 46s - loss: 9.7254e-04 - accuracy: 1.000 - ETA: 45s - loss: 9.8407e-04 - accuracy: 1.000 - ETA: 44s - loss: 9.8717e-04 - accuracy: 1.000 - ETA: 44s - loss: 0.0010 - accuracy: 1.0000 - ETA: 43s - loss: 0.0010 - accuracy: 1.000 - ETA: 42s - loss: 9.7728e-04 - accuracy: 1.000 - ETA: 41s - loss: 9.5353e-04 - accuracy: 1.000 - ETA: 40s - loss: 9.3062e-04 - accuracy: 1.000 - ETA: 39s - loss: 9.0694e-04 - accuracy: 1.000 - ETA: 38s - loss: 8.9875e-04 - accuracy: 1.000 - ETA: 37s - loss: 8.8613e-04 - accuracy: 1.000 - ETA: 36s - loss: 9.2385e-04 - accuracy: 1.000 - ETA: 35s - loss: 9.1479e-04 - accuracy: 1.000 - ETA: 34s - loss: 9.1754e-04 - accuracy: 1.000 - ETA: 33s - loss: 9.1583e-04 - accuracy: 1.000 - ETA: 32s - loss: 9.1882e-04 - accuracy: 1.000 - ETA: 31s - loss: 9.0521e-04 - accuracy: 1.000 - ETA: 30s - loss: 9.2906e-04 - accuracy: 1.000 - ETA: 29s - loss: 9.3825e-04 - accuracy: 1.000 - ETA: 28s - loss: 9.2666e-04 - accuracy: 1.000 - ETA: 27s - loss: 9.5788e-04 - accuracy: 1.000 - ETA: 26s - loss: 9.5729e-04 - accuracy: 1.000 - ETA: 25s - loss: 9.6261e-04 - accuracy: 1.000 - ETA: 24s - loss: 9.7602e-04 - accuracy: 1.000 - ETA: 23s - loss: 9.5687e-04 - accuracy: 1.000 - ETA: 22s - loss: 9.9405e-04 - accuracy: 1.000 - ETA: 21s - loss: 9.7706e-04 - accuracy: 1.000 - ETA: 20s - loss: 9.6594e-04 - accuracy: 1.000 - ETA: 19s - loss: 9.6375e-04 - accuracy: 1.000 - ETA: 18s - loss: 9.5500e-04 - accuracy: 1.000 - ETA: 17s - loss: 9.4000e-04 - accuracy: 1.000 - ETA: 16s - loss: 9.3991e-04 -

accuracy: 1.000 - ETA: 15s - loss: 9.4403e-04 - accuracy: 1.000 - ETA: 14s -  
loss: 9.3942e-04 - accuracy: 1.000 - ETA: 13s - loss: 9.3443e-04 - accuracy:  
1.000 - ETA: 12s - loss: 9.2814e-04 - accuracy: 1.000 - ETA: 11s - loss:  
9.1954e-04 - accuracy: 1.000 - ETA: 10s - loss: 9.0527e-04 - accuracy: 1.000 -  
ETA: 9s - loss: 9.1007e-04 - accuracy: 1.000 - ETA: 8s - loss: 9.1126e-04 -  
accuracy: 1.00 - ETA: 7s - loss: 9.1187e-04 - accuracy: 1.00 - ETA: 6s - loss:  
8.9818e-04 - accuracy: 1.00 - ETA: 5s - loss: 9.0187e-04 - accuracy: 1.00 - ETA:  
4s - loss: 8.9087e-04 - accuracy: 1.00 - ETA: 3s - loss: 8.7870e-04 - accuracy:  
1.00 - ETA: 2s - loss: 8.6973e-04 - accuracy: 1.00 - ETA: 1s - loss: 8.6021e-04  
- accuracy: 1.00 - ETA: 0s - loss: 8.5355e-04 - accuracy: 1.00 - 73s 18ms/sample  
- loss: 8.5181e-04 - accuracy: 1.0000 - val\_loss: 0.1355 - val\_accuracy: 0.9741  
Epoch 13/15

4172/4172 [=====] - ETA: 1:04 - loss: 4.9640e-04 -  
accuracy: 1.00 - ETA: 1:02 - loss: 4.9355e-04 - accuracy: 1.00 - ETA: 1:01 -  
loss: 5.5372e-04 - accuracy: 1.00 - ETA: 1:00 - loss: 5.9182e-04 - accuracy:  
1.00 - ETA: 59s - loss: 6.1165e-04 - accuracy: 1.0000 - ETA: 58s - loss:  
5.8487e-04 - accuracy: 1.000 - ETA: 57s - loss: 5.7454e-04 - accuracy: 1.000 -  
ETA: 56s - loss: 5.2466e-04 - accuracy: 1.000 - ETA: 55s - loss: 5.4254e-04 -  
accuracy: 1.000 - ETA: 54s - loss: 5.0353e-04 - accuracy: 1.000 - ETA: 54s -  
loss: 4.7566e-04 - accuracy: 1.000 - ETA: 53s - loss: 4.6598e-04 - accuracy:  
1.000 - ETA: 52s - loss: 4.5782e-04 - accuracy: 1.000 - ETA: 51s - loss:  
4.6290e-04 - accuracy: 1.000 - ETA: 50s - loss: 5.0343e-04 - accuracy: 1.000 -  
ETA: 49s - loss: 4.9917e-04 - accuracy: 1.000 - ETA: 48s - loss: 5.2413e-04 -  
accuracy: 1.000 - ETA: 47s - loss: 5.4284e-04 - accuracy: 1.000 - ETA: 46s -  
loss: 5.3989e-04 - accuracy: 1.000 - ETA: 45s - loss: 5.6354e-04 - accuracy:  
1.000 - ETA: 44s - loss: 5.5576e-04 - accuracy: 1.000 - ETA: 43s - loss:  
5.5710e-04 - accuracy: 1.000 - ETA: 42s - loss: 5.5477e-04 - accuracy: 1.000 -  
ETA: 41s - loss: 5.4333e-04 - accuracy: 1.000 - ETA: 40s - loss: 5.4729e-04 -  
accuracy: 1.000 - ETA: 39s - loss: 5.3534e-04 - accuracy: 1.000 - ETA: 38s -  
loss: 5.2159e-04 - accuracy: 1.000 - ETA: 37s - loss: 5.4677e-04 - accuracy:  
1.000 - ETA: 36s - loss: 5.5259e-04 - accuracy: 1.000 - ETA: 35s - loss:  
5.4166e-04 - accuracy: 1.000 - ETA: 34s - loss: 5.5181e-04 - accuracy: 1.000 -  
ETA: 33s - loss: 5.4227e-04 - accuracy: 1.000 - ETA: 32s - loss: 5.3624e-04 -  
accuracy: 1.000 - ETA: 31s - loss: 5.2511e-04 - accuracy: 1.000 - ETA: 30s -  
loss: 5.2012e-04 - accuracy: 1.000 - ETA: 29s - loss: 5.1108e-04 - accuracy:  
1.000 - ETA: 28s - loss: 5.0656e-04 - accuracy: 1.000 - ETA: 27s - loss:  
5.1103e-04 - accuracy: 1.000 - ETA: 26s - loss: 5.0208e-04 - accuracy: 1.000 -  
ETA: 25s - loss: 4.9378e-04 - accuracy: 1.000 - ETA: 24s - loss: 4.8414e-04 -  
accuracy: 1.000 - ETA: 23s - loss: 4.7672e-04 - accuracy: 1.000 - ETA: 22s -  
loss: 4.7253e-04 - accuracy: 1.000 - ETA: 21s - loss: 4.6907e-04 - accuracy:  
1.000 - ETA: 20s - loss: 4.6793e-04 - accuracy: 1.000 - ETA: 19s - loss:  
4.8294e-04 - accuracy: 1.000 - ETA: 18s - loss: 4.8165e-04 - accuracy: 1.000 -  
ETA: 17s - loss: 4.9176e-04 - accuracy: 1.000 - ETA: 16s - loss: 4.9274e-04 -  
accuracy: 1.000 - ETA: 15s - loss: 4.8816e-04 - accuracy: 1.000 - ETA: 14s -  
loss: 5.0705e-04 - accuracy: 1.000 - ETA: 13s - loss: 4.9966e-04 - accuracy:  
1.000 - ETA: 12s - loss: 4.9538e-04 - accuracy: 1.000 - ETA: 11s - loss:  
4.8804e-04 - accuracy: 1.000 - ETA: 10s - loss: 4.8483e-04 - accuracy: 1.000 -  
ETA: 9s - loss: 5.2542e-04 - accuracy: 1.000 - ETA: 8s - loss: 5.3077e-04 -

accuracy: 1.00 - ETA: 7s - loss: 5.2470e-04 - accuracy: 1.00 - ETA: 6s - loss:  
 5.3199e-04 - accuracy: 1.00 - ETA: 5s - loss: 5.3033e-04 - accuracy: 1.00 - ETA:  
 4s - loss: 5.2590e-04 - accuracy: 1.00 - ETA: 3s - loss: 5.3226e-04 - accuracy:  
 1.00 - ETA: 2s - loss: 5.2603e-04 - accuracy: 1.00 - ETA: 1s - loss: 5.1820e-04  
 - accuracy: 1.00 - ETA: 0s - loss: 5.4901e-04 - accuracy: 1.00 - 73s 17ms/sample  
 - loss: 5.5237e-04 - accuracy: 1.0000 - val\_loss: 0.1522 - val\_accuracy: 0.9741  
 Epoch 14/15  
 4172/4172 [=====] - ETA: 1:08 - loss: 0.0011 -  
 accuracy: 1.00 - ETA: 1:07 - loss: 7.9614e-04 - accuracy: 1.00 - ETA: 1:07 -  
 loss: 6.3867e-04 - accuracy: 1.00 - ETA: 1:05 - loss: 5.1882e-04 - accuracy:  
 1.00 - ETA: 1:03 - loss: 4.7559e-04 - accuracy: 1.00 - ETA: 1:01 - loss:  
 5.9968e-04 - accuracy: 1.00 - ETA: 1:00 - loss: 5.7680e-04 - accuracy: 1.00 -  
 ETA: 58s - loss: 5.6896e-04 - accuracy: 1.0000 - ETA: 57s - loss: 6.9218e-04 -  
 accuracy: 1.000 - ETA: 56s - loss: 7.0150e-04 - accuracy: 1.000 - ETA: 55s -  
 loss: 6.6231e-04 - accuracy: 1.000 - ETA: 53s - loss: 6.6851e-04 - accuracy:  
 1.000 - ETA: 52s - loss: 6.6855e-04 - accuracy: 1.000 - ETA: 51s - loss:  
 6.3092e-04 - accuracy: 1.000 - ETA: 50s - loss: 6.0318e-04 - accuracy: 1.000 -  
 ETA: 49s - loss: 6.0123e-04 - accuracy: 1.000 - ETA: 48s - loss: 5.7533e-04 -  
 accuracy: 1.000 - ETA: 47s - loss: 5.6813e-04 - accuracy: 1.000 - ETA: 46s -  
 loss: 5.7016e-04 - accuracy: 1.000 - ETA: 45s - loss: 5.6768e-04 - accuracy:  
 1.000 - ETA: 44s - loss: 5.7875e-04 - accuracy: 1.000 - ETA: 43s - loss:  
 5.6138e-04 - accuracy: 1.000 - ETA: 42s - loss: 5.7063e-04 - accuracy: 1.000 -  
 ETA: 41s - loss: 5.5975e-04 - accuracy: 1.000 - ETA: 40s - loss: 5.6533e-04 -  
 accuracy: 1.000 - ETA: 39s - loss: 5.7396e-04 - accuracy: 1.000 - ETA: 38s -  
 loss: 5.7995e-04 - accuracy: 1.000 - ETA: 37s - loss: 5.9160e-04 - accuracy:  
 1.000 - ETA: 36s - loss: 5.8052e-04 - accuracy: 1.000 - ETA: 35s - loss:  
 5.8367e-04 - accuracy: 1.000 - ETA: 34s - loss: 5.6829e-04 - accuracy: 1.000 -  
 ETA: 33s - loss: 5.5580e-04 - accuracy: 1.000 - ETA: 32s - loss: 5.4621e-04 -  
 accuracy: 1.000 - ETA: 31s - loss: 5.3089e-04 - accuracy: 1.000 - ETA: 30s -  
 loss: 5.3512e-04 - accuracy: 1.000 - ETA: 29s - loss: 5.2611e-04 - accuracy:  
 1.000 - ETA: 28s - loss: 5.2220e-04 - accuracy: 1.000 - ETA: 27s - loss:  
 5.5799e-04 - accuracy: 1.000 - ETA: 26s - loss: 5.4653e-04 - accuracy: 1.000 -  
 ETA: 25s - loss: 5.3760e-04 - accuracy: 1.000 - ETA: 24s - loss: 5.3933e-04 -  
 accuracy: 1.000 - ETA: 23s - loss: 5.3292e-04 - accuracy: 1.000 - ETA: 22s -  
 loss: 5.4807e-04 - accuracy: 1.000 - ETA: 21s - loss: 5.3951e-04 - accuracy:  
 1.000 - ETA: 20s - loss: 5.3329e-04 - accuracy: 1.000 - ETA: 19s - loss:  
 5.2555e-04 - accuracy: 1.000 - ETA: 18s - loss: 5.1807e-04 - accuracy: 1.000 -  
 ETA: 17s - loss: 5.1463e-04 - accuracy: 1.000 - ETA: 16s - loss: 5.0763e-04 -  
 accuracy: 1.000 - ETA: 15s - loss: 5.0677e-04 - accuracy: 1.000 - ETA: 14s -  
 loss: 5.0300e-04 - accuracy: 1.000 - ETA: 13s - loss: 4.9892e-04 - accuracy:  
 1.000 - ETA: 12s - loss: 4.9498e-04 - accuracy: 1.000 - ETA: 11s - loss:  
 4.9127e-04 - accuracy: 1.000 - ETA: 10s - loss: 5.1491e-04 - accuracy: 1.000 -  
 ETA: 9s - loss: 5.0764e-04 - accuracy: 1.000 - ETA: 8s - loss: 5.0085e-04 -  
 accuracy: 1.00 - ETA: 7s - loss: 4.9510e-04 - accuracy: 1.00 - ETA: 6s - loss:  
 4.9526e-04 - accuracy: 1.00 - ETA: 5s - loss: 4.9221e-04 - accuracy: 1.00 - ETA:  
 4s - loss: 4.9028e-04 - accuracy: 1.00 - ETA: 3s - loss: 4.8826e-04 - accuracy:  
 1.00 - ETA: 2s - loss: 4.8589e-04 - accuracy: 1.00 - ETA: 1s - loss: 4.7967e-04  
 - accuracy: 1.00 - ETA: 0s - loss: 4.8375e-04 - accuracy: 1.00 - 74s 18ms/sample



```

- loss: 4.8237e-04 - accuracy: 1.0000 - val_loss: 0.1438 - val_accuracy: 0.9741
Epoch 15/15
4172/4172 [=====] - ETA: 1:04 - loss: 3.4777e-04 -
accuracy: 1.00 - ETA: 1:03 - loss: 2.1549e-04 - accuracy: 1.00 - ETA: 1:01 -
loss: 2.9552e-04 - accuracy: 1.00 - ETA: 1:00 - loss: 3.8355e-04 - accuracy:
1.00 - ETA: 59s - loss: 3.1834e-04 - accuracy: 1.0000 - ETA: 58s - loss:
3.9545e-04 - accuracy: 1.000 - ETA: 57s - loss: 3.4455e-04 - accuracy: 1.000 -
ETA: 56s - loss: 3.3126e-04 - accuracy: 1.000 - ETA: 56s - loss: 3.1068e-04 -
accuracy: 1.000 - ETA: 55s - loss: 2.9941e-04 - accuracy: 1.000 - ETA: 54s -
loss: 3.2071e-04 - accuracy: 1.000 - ETA: 53s - loss: 3.2374e-04 - accuracy:
1.000 - ETA: 52s - loss: 3.2593e-04 - accuracy: 1.000 - ETA: 51s - loss:
3.4521e-04 - accuracy: 1.000 - ETA: 50s - loss: 3.4834e-04 - accuracy: 1.000 -
ETA: 49s - loss: 3.4345e-04 - accuracy: 1.000 - ETA: 48s - loss: 3.4465e-04 -
accuracy: 1.000 - ETA: 47s - loss: 3.3858e-04 - accuracy: 1.000 - ETA: 46s -
loss: 3.2978e-04 - accuracy: 1.000 - ETA: 45s - loss: 3.4705e-04 - accuracy:
1.000 - ETA: 44s - loss: 4.0716e-04 - accuracy: 1.000 - ETA: 43s - loss:
4.0879e-04 - accuracy: 1.000 - ETA: 42s - loss: 3.9790e-04 - accuracy: 1.000 -
ETA: 41s - loss: 4.1485e-04 - accuracy: 1.000 - ETA: 40s - loss: 4.0128e-04 -
accuracy: 1.000 - ETA: 39s - loss: 4.0666e-04 - accuracy: 1.000 - ETA: 38s -
loss: 4.3711e-04 - accuracy: 1.000 - ETA: 37s - loss: 4.4574e-04 - accuracy:
1.000 - ETA: 36s - loss: 4.5788e-04 - accuracy: 1.000 - ETA: 35s - loss:
4.5578e-04 - accuracy: 1.000 - ETA: 34s - loss: 4.4647e-04 - accuracy: 1.000 -
ETA: 33s - loss: 4.4145e-04 - accuracy: 1.000 - ETA: 32s - loss: 4.3782e-04 -
accuracy: 1.000 - ETA: 31s - loss: 4.3861e-04 - accuracy: 1.000 - ETA: 30s -
loss: 4.4671e-04 - accuracy: 1.000 - ETA: 29s - loss: 4.4711e-04 - accuracy:
1.000 - ETA: 28s - loss: 4.5180e-04 - accuracy: 1.000 - ETA: 27s - loss:
4.4303e-04 - accuracy: 1.000 - ETA: 26s - loss: 4.3384e-04 - accuracy: 1.000 -
ETA: 25s - loss: 4.2739e-04 - accuracy: 1.000 - ETA: 24s - loss: 4.2651e-04 -
accuracy: 1.000 - ETA: 23s - loss: 4.1895e-04 - accuracy: 1.000 - ETA: 22s -
loss: 4.1325e-04 - accuracy: 1.000 - ETA: 21s - loss: 4.1118e-04 - accuracy:
1.000 - ETA: 20s - loss: 4.1093e-04 - accuracy: 1.000 - ETA: 19s - loss:
4.1356e-04 - accuracy: 1.000 - ETA: 18s - loss: 4.0671e-04 - accuracy: 1.000 -
ETA: 17s - loss: 4.0371e-04 - accuracy: 1.000 - ETA: 16s - loss: 3.9910e-04 -
accuracy: 1.000 - ETA: 15s - loss: 3.9571e-04 - accuracy: 1.000 - ETA: 14s -
loss: 3.9177e-04 - accuracy: 1.000 - ETA: 13s - loss: 3.9318e-04 - accuracy:
1.000 - ETA: 12s - loss: 3.9285e-04 - accuracy: 1.000 - ETA: 11s - loss:
3.9279e-04 - accuracy: 1.000 - ETA: 10s - loss: 3.8892e-04 - accuracy: 1.000 -
ETA: 9s - loss: 3.8320e-04 - accuracy: 1.000 - ETA: 8s - loss: 3.8462e-04 -
accuracy: 1.00 - ETA: 7s - loss: 3.8729e-04 - accuracy: 1.00 - ETA: 6s - loss:
3.8805e-04 - accuracy: 1.00 - ETA: 5s - loss: 3.8255e-04 - accuracy: 1.00 - ETA:
4s - loss: 3.8594e-04 - accuracy: 1.00 - ETA: 3s - loss: 3.8132e-04 - accuracy:
1.00 - ETA: 2s - loss: 3.7812e-04 - accuracy: 1.00 - ETA: 1s - loss: 3.7682e-04
- accuracy: 1.00 - ETA: 0s - loss: 3.7577e-04 - accuracy: 1.00 - 73s 17ms/sample
- loss: 3.7486e-04 - accuracy: 1.0000 - val_loss: 0.1484 - val_accuracy: 0.9741

```

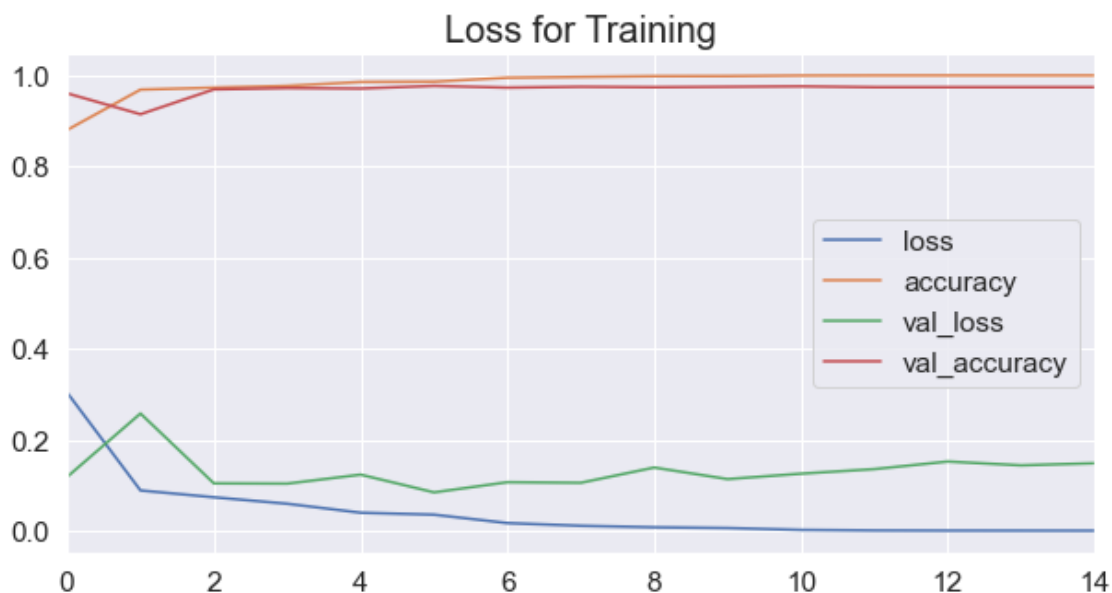
```

[41]: evaluation_metrics=pd.DataFrame(model.history.history)
      evaluation_metrics.plot(figsize=(10,5))

```

```
plt.title("Loss for Training", size = 20)
```

```
[41]: Text(0.5, 1.0, 'Loss for Training')
```



```
[53]: test_images, test_labels = shuffle(test_images, test_labels, random_state=25)
```

```
[54]: test_labels
```

```
[54]: array([1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0, 1, 1, 0, 1, 1, 0,
        0, 1, 0, 1, 1, 1, 0, 1, 0, 0, 1, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1,
        0, 1, 0, 1, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 1, 1,
        1, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1, 0, 0, 1, 0, 1, 0, 1, 0, 0, 1,
        0, 0, 1, 1, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1,
        1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 0, 1, 0, 1, 0,
        0, 1, 1, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1,
        0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1, 0,
        1, 1, 1, 1, 0, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 0, 0,
        1, 1, 1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 0, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1,
        1, 1, 1, 1, 1, 0, 0, 1, 1, 0, 1, 1, 1, 0, 0, 1, 1, 1, 1, 0, 1, 1,
        0, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 0, 0, 0, 1, 0,
        1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 1, 1, 0, 1, 0, 1, 1, 0, 0, 0, 1,
        0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1, 1,
        1, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 0, 1, 0,
        1, 0, 1, 0, 0, 1, 0, 1, 1, 0, 0, 1, 1, 0, 0, 1, 1, 0, 1, 1, 0, 1,
        1, 1, 0, 0, 1, 1, 0, 1, 1, 1, 0, 1, 0, 0, 0, 0, 1, 1, 1, 0, 1, 1,
        0, 1, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 0, 1, 0, 0, 1, 1,
        1, 1, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 1, 1, 1, 0, 1, 0, 1, 0, 1, 0,
```

```
[55]: prediction=model.predict_classes(test_images)
```

	precision	recall	f1-score	support
0	0.99	0.31	0.47	234
1	0.71	1.00	0.83	390
accuracy			0.74	624
macro avg	0.85	0.65	0.65	624
weighted avg	0.81	0.74	0.69	624

```
[57]: array([[ 72, 162],
            [  1, 389]], dtype=int64)
```

[illegible]

```
[52]: prediction
```

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[ ]: