A Comprehensive Guide to Combining R and Python with `reticulate`

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Contents

Introduction

What is `reticulate`?

The `reticulate` package is a tool that allows to combine R and Python. It allows users to call Python from R and R from Python, combining the strengths of both programming languages in a single workflow.

With this library, you can import any Python module and access its functions, classes, and objects from R, enabling a more versatile and flexible approach to data analysis, machine learning, and statistical computing.

Benefits of combining R and Python

Combining R and Python brings together the best of both worlds:

1. Choose the best tool for each task by leveraging R's statistical analysis and Python's programming and machine learning strengths.
2. Access more libraries and packages from both ecosystems.
3. Easy transfer of data between R and Python for flexible data handling in complex analysis pipelines.

Prerequisites and installation

Before using the library, make sure you have the following prerequisites:

1. R Installation: Make sure you have R installed on your system. You can download it from CRAN.
2. Python Installation: Install Python on your system.
3. RStudio (Optional but recommended): Using RStudio as your IDE can simplify the process of using `reticulate`. Download RStudio from here.

Once you have completed all the prerequisites, it is time to install the package. Use the following command in your R console:

```
install.packages("reticulate")
```

After installation, load the package using:

```
library(reticulate)
```

Basic Usage

Importing Python Modules

To import a Python module in R using the `reticulate` package, you use the `import` function. For example, to import the `numpy` library, you can use:

```
np <- import("numpy")
```

With this, you can use the `np` object to access `numpy` functions and methods just as you would in Python:

```r
# Create a numpy array
array <- np$array(c(1, 2, 3, 4, 5))
print(array)
```

```
## [1] 1 2 3 4 5
```

Running Python Code in R

Sometimes, it might be useful to execute Python code directly within an R script, and this can be easily done using the `py_run_string` function. This function allows you to run Python code as a string:

```r
py_run_string("print('Hello from Python')")
```

```
## Hello from Python
```

Alternatively, it may be more convenient to directly execute a Python script file. For this, you can use the `py_run_file` function:

```r
# py_run_file("path/to/your_script.py")
py_run_file("test.py")
```

```
## The sum of 4 and 6 is 10
```

Accessing Python Objects in R

In the same way, you can access and manipulate Python objects in R. For example, if you create a Python list, you can access it in R:

```r
# You can access a Python list
py_run_string("my_list = [1, 2, 3, 4, 5]")
my_list <- py$my_list
print(my_list)
```

```
## [1] 1 2 3 4 5
```

```r
# You can also manipulate the list
my_list[1] <- 4
print(my_list)
```

```
## [1] 4 2 3 4 5
```

You can also access Python functions and call them from R:

```r
py_run_string("
def greet(name):
  return 'Hello, ' + name + '!'
")

greet <- py$greet
print(greet("World"))
```

```
## [1] "Hello, World!"
```

```
print(greet("James"))
```

```
## [1] "Hello, James!"
```

Data Manipulation

Using Python Libraries Like NumPy and pandas

You can use Python libraries like NumPy and pandas for data manipulation in R:

```
# Import NumPy and pandas
np <- import("numpy")
pd <- import("pandas")

# Create a numpy array
array <- np$array(c(1, 2, 3, 4, 5))
print(array)
```

```
## [1] 1 2 3 4 5
```

```
# Create a pandas array
py_df <- pd$DataFrame(dict(a=np$array(c(1, 2, 3)), b=np$array(c('x', 'y', 'z'))))
print(py_df)
```

```
##   a b
## 1 1 x
## 2 2 y
## 3 3 z
```

Converting Data Types Between R and Python

It is important to know that the `reticulate` package automatically converts many data types between R and Python. For example, **R vectors become Python lists**, and **R data frames become pandas data frames**.

You can manually convert data types using specific functions if needed:

1. To convert an R data frame to a pandas data frame:

```
# Define data frame
df <- data.frame(a = 1:3, b = c('x', 'y', 'z'))

# Convert R data frame to pandas data frame
py_df <- r_to_py(df)
print(py_df)
```

```
##    a  b
## 0  1  x
## 1  2  y
## 2  3  z
```

2. To convert a pandas data frame back to an R data frame:

```
# Convert pandas data frame to R data frame
r_df <- py_to_r(py_df)
print(r_df)
```

```
##   a b
## 1 1 x
## 2 2 y
## 3 3 z
```

Visualization

Using Python Visualization Libraries

Sometimes, you might have more experience plotting in Python than in R. Thanks to this package, Python libraries like Matplotlib and Seaborn can be used:

```
# Import libraries
plt <- import("matplotlib.pyplot")
sns <- import("seaborn")

# Create a plot using Matplotlib
plt$plot(c(1, 2, 3), c(4, 5, 6))
```

```
## [[1]]
## <matplotlib.lines.Line2D object at 0x000001FF98953890>
```

```
plt$show()

# Create a plot using Seaborn
sns$set_theme()
df <- sns$load_dataset("iris")
sns$scatterplot(data=df, x="sepal_length", y="sepal_width", hue="species")
```

```
## <Axes: xlabel='sepal_length', ylabel='sepal_width'>
```

```
plt$show()
```

Machine Learning

Using Scikit-Learn for Classification

```r
# Import scikit-learn
sklearn <- import("sklearn")
datasets <- sklearn$datasets
svm <- sklearn$svm
metrics <- sklearn$metrics

# Load dataset and train a model
iris <- datasets$load_iris()
X <- iris$data
y <- iris$target
model <- svm$SVC()
model$fit(X, y)
```

```
## SVC()
```

```r
# Make predictions
predictions <- model$predict(X)

# Evaluate the model
accuracy <- metrics$accuracy_score(y, predictions)
print(paste("Accuracy:", accuracy))
```

```
## [1] "Accuracy: 0.973333333333333"
```

Building and Evaluating a Regression Model

```r
# Import necessary libraries
sklearn <- import("sklearn")
datasets <- sklearn$datasets
linear_model <- sklearn$linear_model
metrics <- sklearn$metrics

# Load the diabetes dataset
diabetes <- datasets$load_diabetes()
X <- diabetes$data
y <- diabetes$target

# Split the data into training and testing sections
library(zeallot)
```

```
## Warning: le package 'zeallot' a été compilé avec la version R 4.2.3
```

```r
train_test_split <- sklearn$model_selection$train_test_split
c(X_train, X_test, y_train, y_test) %<-% train_test_split(X, y, test_size = 0.2)

# Train a linear regression model
model <- linear_model$LinearRegression()
model$fit(X_train, y_train)
```

```
## LinearRegression()
```

```
# Make predictions
predictions <- model$predict(X_test)

# Evaluate the model
mse <- metrics$mean_squared_error(y_test, predictions)
print(paste("Mean Squared Error:", mse))
```

```
## [1] "Mean Squared Error: 4035.16406521441"
```

Using TensorFlow for Deep Learning

```
# Import TensorFlow
tf <- import("tensorflow")
keras <- import("keras")

# Load and preprocess data
mnist_data <- keras$datasets$mnist$load_data()
train_images <- mnist_data[[1]][[1]]
train_labels <- mnist_data[[1]][[2]]
test_images <- mnist_data[[2]][[1]]
test_labels <- mnist_data[[2]][[2]]
train_images <- train_images/255
test_images <- test_images/255

# Ensure the input shape is specified correctly as an integer tuple
input_shape <- as.integer(c(28, 28))

# Build the model
model <- keras$Sequential()
model$add(keras$layers$Flatten(input_shape = input_shape))
model$add(keras$layers$Dense(128, activation = "relu"))
model$add(keras$layers$Dense(10, activation = "softmax"))

# Compile the model
model$compile(optimizer = "adam", loss = "sparse_categorical_crossentropy", metrics = "accuracy")

# Train the model
model$fit(train_images, train_labels, epochs = as.integer(5))
```

```
## Epoch 1/5
##
##    1/1875 [..............................] - ETA: 20:05 - loss: 2.3579 - accuracy: 0.0312
##   20/1875 [..............................] - ETA: 4s - loss: 1.8035 - accuracy: 0.4906
##   41/1875 [..............................] - ETA: 4s - loss: 1.3704 - accuracy: 0.6364
##   61/1875 [..............................] - ETA: 4s - loss: 1.1194 - accuracy: 0.7085
##   80/1875 [>.............................] - ETA: 4s - loss: 0.9802 - accuracy: 0.7480
##  100/1875 [>.............................] - ETA: 4s - loss: 0.8865 - accuracy: 0.7728
##  120/1875 [>.............................] - ETA: 4s - loss: 0.8122 - accuracy: 0.7909
##  138/1875 [=>............................] - ETA: 4s - loss: 0.7584 - accuracy: 0.8039
```

```
##  146/1875 [=>............................] - ETA: 4s - loss: 0.7419 - accuracy: 0.8063
##  154/1875 [=>............................] - ETA: 5s - loss: 0.7238 - accuracy: 0.8101
##  162/1875 [=>............................] - ETA: 5s - loss: 0.7143 - accuracy: 0.8121
##  170/1875 [=>............................] - ETA: 5s - loss: 0.6973 - accuracy: 0.8158
##  178/1875 [=>............................] - ETA: 5s - loss: 0.6846 - accuracy: 0.8192
##  186/1875 [=>............................] - ETA: 6s - loss: 0.6725 - accuracy: 0.8219
##  194/1875 [==>...........................] - ETA: 6s - loss: 0.6596 - accuracy: 0.8255
##  202/1875 [==>...........................] - ETA: 6s - loss: 0.6489 - accuracy: 0.8284
##  211/1875 [==>...........................] - ETA: 6s - loss: 0.6353 - accuracy: 0.8315
##  223/1875 [==>...........................] - ETA: 6s - loss: 0.6183 - accuracy: 0.8353
##  235/1875 [==>...........................] - ETA: 6s - loss: 0.6062 - accuracy: 0.8386
##  246/1875 [==>...........................] - ETA: 6s - loss: 0.5913 - accuracy: 0.8418
##  254/1875 [===>..........................] - ETA: 6s - loss: 0.5829 - accuracy: 0.8444
##  262/1875 [===>..........................] - ETA: 6s - loss: 0.5749 - accuracy: 0.8460
##  271/1875 [===>..........................] - ETA: 6s - loss: 0.5664 - accuracy: 0.8485
##  279/1875 [===>..........................] - ETA: 6s - loss: 0.5599 - accuracy: 0.8500
##  287/1875 [===>..........................] - ETA: 6s - loss: 0.5560 - accuracy: 0.8515
##  295/1875 [===>..........................] - ETA: 7s - loss: 0.5517 - accuracy: 0.8528
##  303/1875 [===>..........................] - ETA: 7s - loss: 0.5456 - accuracy: 0.8542
##  311/1875 [===>..........................] - ETA: 7s - loss: 0.5393 - accuracy: 0.8556
##  319/1875 [====>.........................] - ETA: 7s - loss: 0.5319 - accuracy: 0.8576
##  327/1875 [====>.........................] - ETA: 7s - loss: 0.5271 - accuracy: 0.8584
##  335/1875 [====>.........................] - ETA: 7s - loss: 0.5224 - accuracy: 0.8595
##  343/1875 [====>.........................] - ETA: 7s - loss: 0.5162 - accuracy: 0.8612
##  352/1875 [====>.........................] - ETA: 7s - loss: 0.5116 - accuracy: 0.8624
##  360/1875 [====>.........................] - ETA: 7s - loss: 0.5068 - accuracy: 0.8635
##  369/1875 [====>.........................] - ETA: 7s - loss: 0.5002 - accuracy: 0.8653
##  378/1875 [=====>........................] - ETA: 7s - loss: 0.4946 - accuracy: 0.8669
##  390/1875 [=====>........................] - ETA: 7s - loss: 0.4889 - accuracy: 0.8682
##  401/1875 [=====>........................] - ETA: 7s - loss: 0.4833 - accuracy: 0.8697
##  409/1875 [=====>........................] - ETA: 7s - loss: 0.4805 - accuracy: 0.8699
##  417/1875 [=====>........................] - ETA: 7s - loss: 0.4772 - accuracy: 0.8707
##  426/1875 [=====>........................] - ETA: 7s - loss: 0.4748 - accuracy: 0.8711
##  434/1875 [=====>........................] - ETA: 7s - loss: 0.4708 - accuracy: 0.8724
##  442/1875 [======>.......................] - ETA: 7s - loss: 0.4690 - accuracy: 0.8727
##  450/1875 [======>.......................] - ETA: 7s - loss: 0.4657 - accuracy: 0.8735
##  458/1875 [======>.......................] - ETA: 7s - loss: 0.4616 - accuracy: 0.8742
##  466/1875 [======>.......................] - ETA: 7s - loss: 0.4587 - accuracy: 0.8751
##  475/1875 [======>.......................] - ETA: 7s - loss: 0.4542 - accuracy: 0.8765
##  483/1875 [======>.......................] - ETA: 7s - loss: 0.4525 - accuracy: 0.8771
##  491/1875 [======>.......................] - ETA: 7s - loss: 0.4500 - accuracy: 0.8774
##  499/1875 [======>.......................] - ETA: 7s - loss: 0.4481 - accuracy: 0.8778
##  507/1875 [=======>......................] - ETA: 7s - loss: 0.4449 - accuracy: 0.8786
##  515/1875 [=======>......................] - ETA: 7s - loss: 0.4429 - accuracy: 0.8793
##  523/1875 [=======>......................] - ETA: 7s - loss: 0.4402 - accuracy: 0.8797
##  531/1875 [=======>......................] - ETA: 7s - loss: 0.4368 - accuracy: 0.8808
##  540/1875 [=======>......................] - ETA: 7s - loss: 0.4328 - accuracy: 0.8819
##  551/1875 [=======>......................] - ETA: 6s - loss: 0.4288 - accuracy: 0.8828
##  560/1875 [=======>......................] - ETA: 6s - loss: 0.4263 - accuracy: 0.8831
##  568/1875 [========>.....................] - ETA: 6s - loss: 0.4237 - accuracy: 0.8837
##  577/1875 [========>.....................] - ETA: 6s - loss: 0.4205 - accuracy: 0.8843
##  585/1875 [========>.....................] - ETA: 6s - loss: 0.4195 - accuracy: 0.8847
##  593/1875 [========>.....................] - ETA: 6s - loss: 0.4176 - accuracy: 0.8852
##  601/1875 [========>.....................] - ETA: 6s - loss: 0.4156 - accuracy: 0.8857
```

```
##  609/1875 [========>.....................] - ETA: 6s - loss: 0.4150 - accuracy: 0.8860
##  617/1875 [========>.....................] - ETA: 6s - loss: 0.4128 - accuracy: 0.8865
##  625/1875 [=========>....................] - ETA: 6s - loss: 0.4110 - accuracy: 0.8870
##  633/1875 [=========>....................] - ETA: 6s - loss: 0.4091 - accuracy: 0.8873
##  641/1875 [=========>....................] - ETA: 6s - loss: 0.4066 - accuracy: 0.8881
##  649/1875 [=========>....................] - ETA: 6s - loss: 0.4041 - accuracy: 0.8886
##  657/1875 [=========>....................] - ETA: 6s - loss: 0.4019 - accuracy: 0.8892
##  665/1875 [=========>....................] - ETA: 6s - loss: 0.4002 - accuracy: 0.8897
##  673/1875 [=========>....................] - ETA: 6s - loss: 0.3987 - accuracy: 0.8899
##  681/1875 [=========>....................] - ETA: 6s - loss: 0.3961 - accuracy: 0.8906
##  689/1875 [==========>...................] - ETA: 6s - loss: 0.3943 - accuracy: 0.8912
##  699/1875 [==========>...................] - ETA: 6s - loss: 0.3921 - accuracy: 0.8917
##  710/1875 [==========>...................] - ETA: 6s - loss: 0.3907 - accuracy: 0.8921
##  719/1875 [==========>...................] - ETA: 6s - loss: 0.3879 - accuracy: 0.8927
##  727/1875 [==========>...................] - ETA: 6s - loss: 0.3862 - accuracy: 0.8931
##  735/1875 [==========>...................] - ETA: 6s - loss: 0.3843 - accuracy: 0.8935
##  743/1875 [==========>...................] - ETA: 6s - loss: 0.3827 - accuracy: 0.8940
##  751/1875 [===========>..................] - ETA: 6s - loss: 0.3808 - accuracy: 0.8946
##  759/1875 [===========>..................] - ETA: 6s - loss: 0.3800 - accuracy: 0.8950
##  768/1875 [===========>..................] - ETA: 6s - loss: 0.3785 - accuracy: 0.8953
##  777/1875 [===========>..................] - ETA: 6s - loss: 0.3768 - accuracy: 0.8958
##  786/1875 [===========>..................] - ETA: 6s - loss: 0.3747 - accuracy: 0.8965
##  794/1875 [===========>..................] - ETA: 6s - loss: 0.3731 - accuracy: 0.8970
##  802/1875 [===========>..................] - ETA: 5s - loss: 0.3714 - accuracy: 0.8974
##  810/1875 [===========>..................] - ETA: 5s - loss: 0.3707 - accuracy: 0.8975
##  818/1875 [============>.................] - ETA: 5s - loss: 0.3697 - accuracy: 0.8979
##  826/1875 [============>.................] - ETA: 5s - loss: 0.3676 - accuracy: 0.8983
##  835/1875 [============>.................] - ETA: 5s - loss: 0.3663 - accuracy: 0.8985
##  843/1875 [============>.................] - ETA: 5s - loss: 0.3662 - accuracy: 0.8982
##  851/1875 [============>.................] - ETA: 5s - loss: 0.3652 - accuracy: 0.8984
##  860/1875 [============>.................] - ETA: 5s - loss: 0.3640 - accuracy: 0.8987
##  869/1875 [============>.................] - ETA: 5s - loss: 0.3622 - accuracy: 0.8993
##  877/1875 [=============>................] - ETA: 5s - loss: 0.3604 - accuracy: 0.8998
##  885/1875 [=============>................] - ETA: 5s - loss: 0.3589 - accuracy: 0.9003
##  893/1875 [=============>................] - ETA: 5s - loss: 0.3576 - accuracy: 0.9005
##  901/1875 [=============>................] - ETA: 5s - loss: 0.3564 - accuracy: 0.9009
##  909/1875 [=============>................] - ETA: 5s - loss: 0.3550 - accuracy: 0.9014
##  917/1875 [=============>................] - ETA: 5s - loss: 0.3544 - accuracy: 0.9016
##  925/1875 [=============>................] - ETA: 5s - loss: 0.3530 - accuracy: 0.9019
##  933/1875 [=============>................] - ETA: 5s - loss: 0.3520 - accuracy: 0.9021
##  941/1875 [==============>...............] - ETA: 5s - loss: 0.3507 - accuracy: 0.9026
##  949/1875 [==============>...............] - ETA: 5s - loss: 0.3497 - accuracy: 0.9029
##  957/1875 [==============>...............] - ETA: 5s - loss: 0.3485 - accuracy: 0.9033
##  965/1875 [==============>...............] - ETA: 5s - loss: 0.3473 - accuracy: 0.9036
##  973/1875 [==============>...............] - ETA: 5s - loss: 0.3461 - accuracy: 0.9038
##  981/1875 [==============>...............] - ETA: 5s - loss: 0.3453 - accuracy: 0.9041
##  989/1875 [==============>...............] - ETA: 5s - loss: 0.3440 - accuracy: 0.9044
##  997/1875 [==============>...............] - ETA: 5s - loss: 0.3426 - accuracy: 0.9045
## 1005/1875 [===============>..............] - ETA: 5s - loss: 0.3415 - accuracy: 0.9049
## 1013/1875 [===============>..............] - ETA: 4s - loss: 0.3404 - accuracy: 0.9052
## 1022/1875 [===============>..............] - ETA: 4s - loss: 0.3389 - accuracy: 0.9055
## 1030/1875 [===============>..............] - ETA: 4s - loss: 0.3379 - accuracy: 0.9058
## 1038/1875 [===============>..............] - ETA: 4s - loss: 0.3367 - accuracy: 0.9062
## 1046/1875 [===============>..............] - ETA: 4s - loss: 0.3355 - accuracy: 0.9065
```

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## 1055/1875 [==============>.............] - ETA: 4s - loss: 0.3348 - accuracy: 0.9068
## 1063/1875 [==============>.............] - ETA: 4s - loss: 0.3340 - accuracy: 0.9070
## 1071/1875 [==============>.............] - ETA: 4s - loss: 0.3330 - accuracy: 0.9073
## 1080/1875 [==============>.............] - ETA: 4s - loss: 0.3316 - accuracy: 0.9076
## 1088/1875 [==============>.............] - ETA: 4s - loss: 0.3301 - accuracy: 0.9079
## 1096/1875 [==============>.............] - ETA: 4s - loss: 0.3288 - accuracy: 0.9082
## 1104/1875 [==============>.............] - ETA: 4s - loss: 0.3280 - accuracy: 0.9085
## 1112/1875 [==============>.............] - ETA: 4s - loss: 0.3266 - accuracy: 0.9088
## 1120/1875 [==============>.............] - ETA: 4s - loss: 0.3264 - accuracy: 0.9089
## 1128/1875 [==============>.............] - ETA: 4s - loss: 0.3253 - accuracy: 0.9093
## 1136/1875 [==============>.............] - ETA: 4s - loss: 0.3243 - accuracy: 0.9095
## 1144/1875 [==============>.............] - ETA: 4s - loss: 0.3230 - accuracy: 0.9099
## 1152/1875 [==============>.............] - ETA: 4s - loss: 0.3224 - accuracy: 0.9100
## 1161/1875 [==============>.............] - ETA: 4s - loss: 0.3212 - accuracy: 0.9103
## 1169/1875 [==============>.............] - ETA: 4s - loss: 0.3201 - accuracy: 0.9107
## 1178/1875 [==============>.............] - ETA: 4s - loss: 0.3193 - accuracy: 0.9111
## 1187/1875 [==============>.............] - ETA: 4s - loss: 0.3185 - accuracy: 0.9113
## 1196/1875 [==============>.............] - ETA: 3s - loss: 0.3173 - accuracy: 0.9117
## 1204/1875 [==============>.............] - ETA: 3s - loss: 0.3162 - accuracy: 0.9120
## 1212/1875 [==============>.............] - ETA: 3s - loss: 0.3154 - accuracy: 0.9122
## 1221/1875 [==============>.............] - ETA: 3s - loss: 0.3145 - accuracy: 0.9124
## 1229/1875 [==============>.............] - ETA: 3s - loss: 0.3142 - accuracy: 0.9126
## 1237/1875 [==============>.............] - ETA: 3s - loss: 0.3129 - accuracy: 0.9129
## 1245/1875 [==============>.............] - ETA: 3s - loss: 0.3124 - accuracy: 0.9130
## 1253/1875 [==============>.............] - ETA: 3s - loss: 0.3114 - accuracy: 0.9132
## 1261/1875 [==============>.............] - ETA: 3s - loss: 0.3106 - accuracy: 0.9134
## 1270/1875 [==============>.............] - ETA: 3s - loss: 0.3096 - accuracy: 0.9137
## 1278/1875 [==============>.............] - ETA: 3s - loss: 0.3088 - accuracy: 0.9139
## 1287/1875 [==============>.............] - ETA: 3s - loss: 0.3080 - accuracy: 0.9140
## 1295/1875 [==============>.............] - ETA: 3s - loss: 0.3072 - accuracy: 0.9143
## 1304/1875 [==============>.............] - ETA: 3s - loss: 0.3066 - accuracy: 0.9144
## 1312/1875 [==============>.............] - ETA: 3s - loss: 0.3058 - accuracy: 0.9147
## 1318/1875 [==============>.............] - ETA: 3s - loss: 0.3048 - accuracy: 0.9150
## 1325/1875 [==============>.............] - ETA: 3s - loss: 0.3041 - accuracy: 0.9152
## 1334/1875 [==============>.............] - ETA: 3s - loss: 0.3033 - accuracy: 0.9154
## 1342/1875 [==============>.............] - ETA: 3s - loss: 0.3026 - accuracy: 0.9157
## 1351/1875 [==============>.............] - ETA: 3s - loss: 0.3015 - accuracy: 0.9160
## 1359/1875 [==============>.............] - ETA: 3s - loss: 0.3007 - accuracy: 0.9162
## 1367/1875 [==============>.............] - ETA: 3s - loss: 0.2998 - accuracy: 0.9165
## 1375/1875 [==============>.............] - ETA: 2s - loss: 0.2989 - accuracy: 0.9167
## 1383/1875 [==============>.............] - ETA: 2s - loss: 0.2984 - accuracy: 0.9169
## 1392/1875 [==============>.............] - ETA: 2s - loss: 0.2975 - accuracy: 0.9172
## 1400/1875 [==============>.............] - ETA: 2s - loss: 0.2967 - accuracy: 0.9173
## 1409/1875 [==============>.............] - ETA: 2s - loss: 0.2963 - accuracy: 0.9174
## 1418/1875 [==============>.............] - ETA: 2s - loss: 0.2954 - accuracy: 0.9176
## 1426/1875 [==============>.............] - ETA: 2s - loss: 0.2946 - accuracy: 0.9178
## 1435/1875 [==============>.............] - ETA: 2s - loss: 0.2943 - accuracy: 0.9179
## 1444/1875 [==============>.............] - ETA: 2s - loss: 0.2938 - accuracy: 0.9180
## 1452/1875 [==============>.............] - ETA: 2s - loss: 0.2931 - accuracy: 0.9181
## 1461/1875 [==============>.............] - ETA: 2s - loss: 0.2923 - accuracy: 0.9184
## 1469/1875 [==============>.............] - ETA: 2s - loss: 0.2918 - accuracy: 0.9186
## 1477/1875 [==============>.............] - ETA: 2s - loss: 0.2913 - accuracy: 0.9187
## 1485/1875 [==============>.............] - ETA: 2s - loss: 0.2904 - accuracy: 0.9190
## 1493/1875 [==============>.............] - ETA: 2s - loss: 0.2897 - accuracy: 0.9192
```

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## 1502/1875 [=====================>......] - ETA: 2s - loss: 0.2890 - accuracy: 0.9193
## 1510/1875 [=====================>......] - ETA: 2s - loss: 0.2882 - accuracy: 0.9195
## 1518/1875 [=====================>......] - ETA: 2s - loss: 0.2877 - accuracy: 0.9195
## 1526/1875 [=====================>......] - ETA: 2s - loss: 0.2872 - accuracy: 0.9197
## 1534/1875 [=====================>......] - ETA: 2s - loss: 0.2866 - accuracy: 0.9198
## 1542/1875 [=====================>......] - ETA: 1s - loss: 0.2861 - accuracy: 0.9199
## 1550/1875 [=====================>......] - ETA: 1s - loss: 0.2857 - accuracy: 0.9201
## 1558/1875 [=====================>......] - ETA: 1s - loss: 0.2850 - accuracy: 0.9203
## 1566/1875 [=====================>.....] - ETA: 1s - loss: 0.2849 - accuracy: 0.9202
## 1574/1875 [=====================>.....] - ETA: 1s - loss: 0.2844 - accuracy: 0.9203
## 1583/1875 [=====================>.....] - ETA: 1s - loss: 0.2834 - accuracy: 0.9206
## 1591/1875 [=====================>.....] - ETA: 1s - loss: 0.2824 - accuracy: 0.9210
## 1599/1875 [=====================>.....] - ETA: 1s - loss: 0.2820 - accuracy: 0.9211
## 1607/1875 [=====================>.....] - ETA: 1s - loss: 0.2811 - accuracy: 0.9213
## 1615/1875 [=====================>.....] - ETA: 1s - loss: 0.2804 - accuracy: 0.9214
## 1623/1875 [=====================>.....] - ETA: 1s - loss: 0.2797 - accuracy: 0.9216
## 1631/1875 [======================>....] - ETA: 1s - loss: 0.2791 - accuracy: 0.9217
## 1639/1875 [======================>....] - ETA: 1s - loss: 0.2786 - accuracy: 0.9218
## 1647/1875 [======================>....] - ETA: 1s - loss: 0.2779 - accuracy: 0.9220
## 1655/1875 [======================>....] - ETA: 1s - loss: 0.2772 - accuracy: 0.9222
## 1663/1875 [======================>....] - ETA: 1s - loss: 0.2768 - accuracy: 0.9223
## 1671/1875 [======================>....] - ETA: 1s - loss: 0.2762 - accuracy: 0.9225
## 1679/1875 [======================>....] - ETA: 1s - loss: 0.2756 - accuracy: 0.9227
## 1687/1875 [======================>....] - ETA: 1s - loss: 0.2751 - accuracy: 0.9228
## 1695/1875 [======================>...] - ETA: 1s - loss: 0.2746 - accuracy: 0.9230
## 1703/1875 [======================>...] - ETA: 1s - loss: 0.2741 - accuracy: 0.9231
## 1711/1875 [======================>...] - ETA: 0s - loss: 0.2734 - accuracy: 0.9233
## 1719/1875 [======================>...] - ETA: 0s - loss: 0.2729 - accuracy: 0.9234
## 1727/1875 [======================>...] - ETA: 0s - loss: 0.2723 - accuracy: 0.9236
## 1735/1875 [======================>...] - ETA: 0s - loss: 0.2718 - accuracy: 0.9237
## 1743/1875 [======================>...] - ETA: 0s - loss: 0.2713 - accuracy: 0.9239
## 1751/1875 [======================>..] - ETA: 0s - loss: 0.2707 - accuracy: 0.9240
## 1759/1875 [======================>..] - ETA: 0s - loss: 0.2702 - accuracy: 0.9241
## 1767/1875 [======================>..] - ETA: 0s - loss: 0.2699 - accuracy: 0.9241
## 1775/1875 [======================>..] - ETA: 0s - loss: 0.2695 - accuracy: 0.9242
## 1783/1875 [======================>..] - ETA: 0s - loss: 0.2694 - accuracy: 0.9243
## 1791/1875 [======================>..] - ETA: 0s - loss: 0.2687 - accuracy: 0.9244
## 1799/1875 [======================>..] - ETA: 0s - loss: 0.2682 - accuracy: 0.9245
## 1807/1875 [======================>..] - ETA: 0s - loss: 0.2674 - accuracy: 0.9248
## 1815/1875 [======================>.] - ETA: 0s - loss: 0.2669 - accuracy: 0.9249
## 1823/1875 [======================>.] - ETA: 0s - loss: 0.2664 - accuracy: 0.9251
## 1831/1875 [======================>.] - ETA: 0s - loss: 0.2659 - accuracy: 0.9252
## 1839/1875 [======================>.] - ETA: 0s - loss: 0.2656 - accuracy: 0.9253
## 1847/1875 [======================>.] - ETA: 0s - loss: 0.2651 - accuracy: 0.9255
## 1855/1875 [======================>.] - ETA: 0s - loss: 0.2648 - accuracy: 0.9256
## 1863/1875 [======================>.] - ETA: 0s - loss: 0.2643 - accuracy: 0.9257
## 1871/1875 [======================>.] - ETA: 0s - loss: 0.2638 - accuracy: 0.9258
## 1875/1875 [==============================] - 12s 6ms/step - loss: 0.2636 - accuracy: 0.9258
## Epoch 2/5
##
##    1/1875 [..............................] - ETA: 13s - loss: 0.1325 - accuracy: 0.9375
##    9/1875 [..............................] - ETA: 12s - loss: 0.1429 - accuracy: 0.9583
##   17/1875 [..............................] - ETA: 12s - loss: 0.1399 - accuracy: 0.9596
##   25/1875 [..............................] - ETA: 12s - loss: 0.1562 - accuracy: 0.9563
```

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##   33/1875 [..............................] - ETA: 12s - loss: 0.1532 - accuracy: 0.9536
##   41/1875 [..............................] - ETA: 12s - loss: 0.1573 - accuracy: 0.9550
##   49/1875 [..............................] - ETA: 11s - loss: 0.1533 - accuracy: 0.9560
##   57/1875 [..............................] - ETA: 11s - loss: 0.1474 - accuracy: 0.9572
##   65/1875 [>.............................] - ETA: 11s - loss: 0.1444 - accuracy: 0.9587
##   73/1875 [>.............................] - ETA: 11s - loss: 0.1420 - accuracy: 0.9598
##   81/1875 [>.............................] - ETA: 11s - loss: 0.1366 - accuracy: 0.9618
##   89/1875 [>.............................] - ETA: 11s - loss: 0.1355 - accuracy: 0.9621
##   97/1875 [>.............................] - ETA: 11s - loss: 0.1382 - accuracy: 0.9604
##  106/1875 [>.............................] - ETA: 11s - loss: 0.1437 - accuracy: 0.9593
##  114/1875 [>.............................] - ETA: 11s - loss: 0.1443 - accuracy: 0.9575
##  122/1875 [>.............................] - ETA: 11s - loss: 0.1440 - accuracy: 0.9572
##  130/1875 [=>............................] - ETA: 11s - loss: 0.1412 - accuracy: 0.9584
##  138/1875 [=>............................] - ETA: 11s - loss: 0.1409 - accuracy: 0.9567
##  146/1875 [=>............................] - ETA: 11s - loss: 0.1421 - accuracy: 0.9568
##  154/1875 [=>............................] - ETA: 11s - loss: 0.1421 - accuracy: 0.9566
##  162/1875 [=>............................] - ETA: 11s - loss: 0.1411 - accuracy: 0.9572
##  169/1875 [=>............................] - ETA: 11s - loss: 0.1422 - accuracy: 0.9567
##  177/1875 [=>............................] - ETA: 11s - loss: 0.1423 - accuracy: 0.9564
##  185/1875 [=>............................] - ETA: 11s - loss: 0.1426 - accuracy: 0.9559
##  193/1875 [==>...........................] - ETA: 11s - loss: 0.1427 - accuracy: 0.9555
##  201/1875 [==>...........................] - ETA: 10s - loss: 0.1432 - accuracy: 0.9551
##  210/1875 [==>...........................] - ETA: 10s - loss: 0.1418 - accuracy: 0.9555
##  218/1875 [==>...........................] - ETA: 10s - loss: 0.1424 - accuracy: 0.9557
##  226/1875 [==>...........................] - ETA: 10s - loss: 0.1408 - accuracy: 0.9564
##  235/1875 [==>...........................] - ETA: 10s - loss: 0.1410 - accuracy: 0.9565
##  243/1875 [==>...........................] - ETA: 10s - loss: 0.1419 - accuracy: 0.9567
##  251/1875 [===>..........................] - ETA: 10s - loss: 0.1430 - accuracy: 0.9565
##  259/1875 [===>..........................] - ETA: 10s - loss: 0.1421 - accuracy: 0.9568
##  267/1875 [===>..........................] - ETA: 10s - loss: 0.1414 - accuracy: 0.9569
##  275/1875 [===>..........................] - ETA: 10s - loss: 0.1398 - accuracy: 0.9576
##  283/1875 [===>..........................] - ETA: 10s - loss: 0.1380 - accuracy: 0.9584
##  292/1875 [===>..........................] - ETA: 10s - loss: 0.1388 - accuracy: 0.9577
##  301/1875 [===>..........................] - ETA: 10s - loss: 0.1376 - accuracy: 0.9580
##  309/1875 [===>..........................] - ETA: 10s - loss: 0.1380 - accuracy: 0.9579
##  317/1875 [====>.........................] - ETA: 10s - loss: 0.1373 - accuracy: 0.9582
##  326/1875 [====>.........................] - ETA: 10s - loss: 0.1352 - accuracy: 0.9593
##  334/1875 [====>.........................] - ETA: 10s - loss: 0.1347 - accuracy: 0.9593
##  342/1875 [====>.........................] - ETA: 9s - loss: 0.1336 - accuracy: 0.9597
##  351/1875 [====>.........................] - ETA: 9s - loss: 0.1333 - accuracy: 0.9595
##  359/1875 [====>.........................] - ETA: 9s - loss: 0.1324 - accuracy: 0.9600
##  367/1875 [====>.........................] - ETA: 9s - loss: 0.1318 - accuracy: 0.9602
##  375/1875 [=====>........................] - ETA: 9s - loss: 0.1317 - accuracy: 0.9603
##  383/1875 [=====>........................] - ETA: 9s - loss: 0.1312 - accuracy: 0.9605
##  391/1875 [=====>........................] - ETA: 9s - loss: 0.1311 - accuracy: 0.9607
##  399/1875 [=====>........................] - ETA: 9s - loss: 0.1299 - accuracy: 0.9612
##  407/1875 [=====>........................] - ETA: 9s - loss: 0.1314 - accuracy: 0.9609
##  415/1875 [=====>........................] - ETA: 9s - loss: 0.1317 - accuracy: 0.9606
##  423/1875 [=====>........................] - ETA: 9s - loss: 0.1317 - accuracy: 0.9604
##  431/1875 [=====>........................] - ETA: 9s - loss: 0.1315 - accuracy: 0.9602
##  439/1875 [======>.......................] - ETA: 9s - loss: 0.1310 - accuracy: 0.9602
##  447/1875 [======>.......................] - ETA: 9s - loss: 0.1319 - accuracy: 0.9601
##  455/1875 [======>.......................] - ETA: 9s - loss: 0.1311 - accuracy: 0.9604
##  463/1875 [======>.......................] - ETA: 9s - loss: 0.1311 - accuracy: 0.9602
```

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##  471/1875 [======>.....................] - ETA: 9s - loss: 0.1316 - accuracy: 0.9601
##  479/1875 [======>.....................] - ETA: 9s - loss: 0.1309 - accuracy: 0.9603
##  487/1875 [======>.....................] - ETA: 9s - loss: 0.1309 - accuracy: 0.9603
##  495/1875 [======>.....................] - ETA: 8s - loss: 0.1295 - accuracy: 0.9609
##  503/1875 [=======>....................] - ETA: 8s - loss: 0.1301 - accuracy: 0.9607
##  511/1875 [=======>....................] - ETA: 8s - loss: 0.1304 - accuracy: 0.9609
##  519/1875 [=======>....................] - ETA: 8s - loss: 0.1303 - accuracy: 0.9608
##  527/1875 [=======>....................] - ETA: 8s - loss: 0.1305 - accuracy: 0.9609
##  536/1875 [=======>....................] - ETA: 8s - loss: 0.1307 - accuracy: 0.9606
##  544/1875 [=======>....................] - ETA: 8s - loss: 0.1305 - accuracy: 0.9605
##  552/1875 [=======>....................] - ETA: 8s - loss: 0.1304 - accuracy: 0.9605
##  560/1875 [=======>....................] - ETA: 8s - loss: 0.1305 - accuracy: 0.9606
##  568/1875 [========>...................] - ETA: 8s - loss: 0.1300 - accuracy: 0.9609
##  576/1875 [========>...................] - ETA: 8s - loss: 0.1310 - accuracy: 0.9606
##  584/1875 [========>...................] - ETA: 8s - loss: 0.1307 - accuracy: 0.9608
##  592/1875 [========>...................] - ETA: 8s - loss: 0.1302 - accuracy: 0.9609
##  600/1875 [========>...................] - ETA: 8s - loss: 0.1292 - accuracy: 0.9613
##  608/1875 [========>...................] - ETA: 8s - loss: 0.1291 - accuracy: 0.9613
##  616/1875 [========>...................] - ETA: 8s - loss: 0.1293 - accuracy: 0.9610
##  624/1875 [========>...................] - ETA: 8s - loss: 0.1288 - accuracy: 0.9612
##  632/1875 [=========>..................] - ETA: 8s - loss: 0.1292 - accuracy: 0.9611
##  640/1875 [=========>..................] - ETA: 8s - loss: 0.1294 - accuracy: 0.9610
##  648/1875 [=========>..................] - ETA: 7s - loss: 0.1288 - accuracy: 0.9612
##  656/1875 [=========>..................] - ETA: 7s - loss: 0.1289 - accuracy: 0.9611
##  664/1875 [=========>..................] - ETA: 7s - loss: 0.1293 - accuracy: 0.9611
##  672/1875 [=========>..................] - ETA: 7s - loss: 0.1292 - accuracy: 0.9610
##  680/1875 [=========>..................] - ETA: 7s - loss: 0.1285 - accuracy: 0.9613
##  689/1875 [==========>.................] - ETA: 7s - loss: 0.1287 - accuracy: 0.9613
##  697/1875 [==========>.................] - ETA: 7s - loss: 0.1289 - accuracy: 0.9612
##  705/1875 [==========>.................] - ETA: 7s - loss: 0.1289 - accuracy: 0.9611
##  713/1875 [==========>.................] - ETA: 7s - loss: 0.1282 - accuracy: 0.9613
##  722/1875 [==========>.................] - ETA: 7s - loss: 0.1285 - accuracy: 0.9610
##  730/1875 [==========>.................] - ETA: 7s - loss: 0.1285 - accuracy: 0.9610
##  738/1875 [==========>.................] - ETA: 7s - loss: 0.1285 - accuracy: 0.9611
##  746/1875 [==========>.................] - ETA: 7s - loss: 0.1285 - accuracy: 0.9612
##  754/1875 [===========>................] - ETA: 7s - loss: 0.1282 - accuracy: 0.9612
##  762/1875 [===========>................] - ETA: 7s - loss: 0.1286 - accuracy: 0.9612
##  770/1875 [===========>................] - ETA: 7s - loss: 0.1289 - accuracy: 0.9611
##  778/1875 [===========>................] - ETA: 7s - loss: 0.1294 - accuracy: 0.9612
##  786/1875 [===========>................] - ETA: 7s - loss: 0.1290 - accuracy: 0.9613
##  794/1875 [===========>................] - ETA: 7s - loss: 0.1293 - accuracy: 0.9614
##  802/1875 [===========>................] - ETA: 6s - loss: 0.1293 - accuracy: 0.9614
##  810/1875 [===========>................] - ETA: 6s - loss: 0.1292 - accuracy: 0.9614
##  818/1875 [============>...............] - ETA: 6s - loss: 0.1293 - accuracy: 0.9615
##  826/1875 [============>...............] - ETA: 6s - loss: 0.1289 - accuracy: 0.9615
##  835/1875 [============>...............] - ETA: 6s - loss: 0.1286 - accuracy: 0.9617
##  843/1875 [============>...............] - ETA: 6s - loss: 0.1287 - accuracy: 0.9618
##  852/1875 [============>...............] - ETA: 6s - loss: 0.1292 - accuracy: 0.9616
##  860/1875 [============>...............] - ETA: 6s - loss: 0.1295 - accuracy: 0.9614
##  868/1875 [============>...............] - ETA: 6s - loss: 0.1298 - accuracy: 0.9614
##  876/1875 [=============>..............] - ETA: 6s - loss: 0.1297 - accuracy: 0.9615
##  884/1875 [=============>..............] - ETA: 6s - loss: 0.1299 - accuracy: 0.9615
##  892/1875 [=============>..............] - ETA: 6s - loss: 0.1303 - accuracy: 0.9612
##  900/1875 [=============>..............] - ETA: 6s - loss: 0.1303 - accuracy: 0.9613
```

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##  908/1875 [============>.............] - ETA: 6s - loss: 0.1306 - accuracy: 0.9613
##  916/1875 [============>.............] - ETA: 6s - loss: 0.1304 - accuracy: 0.9613
##  925/1875 [============>.............] - ETA: 6s - loss: 0.1305 - accuracy: 0.9612
##  933/1875 [============>.............] - ETA: 6s - loss: 0.1304 - accuracy: 0.9612
##  941/1875 [=============>............] - ETA: 6s - loss: 0.1306 - accuracy: 0.9611
##  950/1875 [=============>............] - ETA: 6s - loss: 0.1304 - accuracy: 0.9613
##  958/1875 [=============>............] - ETA: 5s - loss: 0.1303 - accuracy: 0.9613
##  966/1875 [=============>............] - ETA: 5s - loss: 0.1303 - accuracy: 0.9614
##  975/1875 [=============>............] - ETA: 5s - loss: 0.1299 - accuracy: 0.9615
##  983/1875 [=============>............] - ETA: 5s - loss: 0.1295 - accuracy: 0.9617
##  991/1875 [=============>............] - ETA: 5s - loss: 0.1289 - accuracy: 0.9618
## 1000/1875 [==============>...........] - ETA: 5s - loss: 0.1294 - accuracy: 0.9616
## 1008/1875 [==============>...........] - ETA: 5s - loss: 0.1294 - accuracy: 0.9616
## 1016/1875 [==============>...........] - ETA: 5s - loss: 0.1292 - accuracy: 0.9616
## 1024/1875 [==============>...........] - ETA: 5s - loss: 0.1290 - accuracy: 0.9617
## 1032/1875 [==============>...........] - ETA: 5s - loss: 0.1288 - accuracy: 0.9617
## 1041/1875 [==============>...........] - ETA: 5s - loss: 0.1285 - accuracy: 0.9618
## 1049/1875 [==============>...........] - ETA: 5s - loss: 0.1283 - accuracy: 0.9618
## 1057/1875 [==============>...........] - ETA: 5s - loss: 0.1285 - accuracy: 0.9618
## 1065/1875 [===============>..........] - ETA: 5s - loss: 0.1285 - accuracy: 0.9617
## 1073/1875 [===============>..........] - ETA: 5s - loss: 0.1284 - accuracy: 0.9617
## 1081/1875 [===============>..........] - ETA: 5s - loss: 0.1281 - accuracy: 0.9618
## 1089/1875 [===============>..........] - ETA: 5s - loss: 0.1281 - accuracy: 0.9617
## 1097/1875 [===============>..........] - ETA: 5s - loss: 0.1280 - accuracy: 0.9616
## 1105/1875 [===============>..........] - ETA: 5s - loss: 0.1280 - accuracy: 0.9616
## 1113/1875 [===============>..........] - ETA: 4s - loss: 0.1275 - accuracy: 0.9617
## 1121/1875 [===============>..........] - ETA: 4s - loss: 0.1272 - accuracy: 0.9618
## 1129/1875 [================>.........] - ETA: 4s - loss: 0.1272 - accuracy: 0.9619
## 1137/1875 [================>.........] - ETA: 4s - loss: 0.1269 - accuracy: 0.9619
## 1145/1875 [================>.........] - ETA: 4s - loss: 0.1270 - accuracy: 0.9619
## 1153/1875 [================>.........] - ETA: 4s - loss: 0.1268 - accuracy: 0.9620
## 1161/1875 [================>.........] - ETA: 4s - loss: 0.1265 - accuracy: 0.9621
## 1169/1875 [================>.........] - ETA: 4s - loss: 0.1266 - accuracy: 0.9621
## 1177/1875 [================>.........] - ETA: 4s - loss: 0.1264 - accuracy: 0.9622
## 1185/1875 [================>.........] - ETA: 4s - loss: 0.1263 - accuracy: 0.9623
## 1193/1875 [=================>........] - ETA: 4s - loss: 0.1262 - accuracy: 0.9624
## 1201/1875 [=================>........] - ETA: 4s - loss: 0.1259 - accuracy: 0.9625
## 1209/1875 [=================>........] - ETA: 4s - loss: 0.1258 - accuracy: 0.9625
## 1217/1875 [=================>........] - ETA: 4s - loss: 0.1255 - accuracy: 0.9626
## 1225/1875 [=================>........] - ETA: 4s - loss: 0.1255 - accuracy: 0.9625
## 1233/1875 [=================>........] - ETA: 4s - loss: 0.1253 - accuracy: 0.9626
## 1241/1875 [=================>........] - ETA: 4s - loss: 0.1255 - accuracy: 0.9625
## 1249/1875 [=================>........] - ETA: 4s - loss: 0.1256 - accuracy: 0.9625
## 1257/1875 [==================>.......] - ETA: 4s - loss: 0.1254 - accuracy: 0.9625
## 1265/1875 [==================>.......] - ETA: 3s - loss: 0.1251 - accuracy: 0.9626
## 1273/1875 [==================>.......] - ETA: 3s - loss: 0.1257 - accuracy: 0.9624
## 1281/1875 [==================>.......] - ETA: 3s - loss: 0.1253 - accuracy: 0.9626
## 1289/1875 [==================>.......] - ETA: 3s - loss: 0.1254 - accuracy: 0.9626
## 1297/1875 [==================>.......] - ETA: 3s - loss: 0.1254 - accuracy: 0.9626
## 1305/1875 [==================>.......] - ETA: 3s - loss: 0.1253 - accuracy: 0.9627
## 1313/1875 [===================>......] - ETA: 3s - loss: 0.1253 - accuracy: 0.9626
## 1321/1875 [===================>......] - ETA: 3s - loss: 0.1251 - accuracy: 0.9626
## 1329/1875 [===================>......] - ETA: 3s - loss: 0.1252 - accuracy: 0.9626
## 1337/1875 [===================>......] - ETA: 3s - loss: 0.1248 - accuracy: 0.9628
```

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## 1345/1875 [==================>.........] - ETA: 3s - loss: 0.1247 - accuracy: 0.9628
## 1353/1875 [==================>.........] - ETA: 3s - loss: 0.1242 - accuracy: 0.9630
## 1361/1875 [==================>.........] - ETA: 3s - loss: 0.1242 - accuracy: 0.9630
## 1369/1875 [==================>.........] - ETA: 3s - loss: 0.1239 - accuracy: 0.9632
## 1377/1875 [===================>........] - ETA: 3s - loss: 0.1236 - accuracy: 0.9632
## 1385/1875 [===================>........] - ETA: 3s - loss: 0.1234 - accuracy: 0.9632
## 1393/1875 [===================>........] - ETA: 3s - loss: 0.1232 - accuracy: 0.9632
## 1401/1875 [===================>........] - ETA: 3s - loss: 0.1231 - accuracy: 0.9633
## 1409/1875 [===================>........] - ETA: 3s - loss: 0.1231 - accuracy: 0.9632
## 1417/1875 [===================>........] - ETA: 2s - loss: 0.1227 - accuracy: 0.9633
## 1425/1875 [===================>........] - ETA: 2s - loss: 0.1227 - accuracy: 0.9633
## 1433/1875 [===================>........] - ETA: 2s - loss: 0.1228 - accuracy: 0.9633
## 1441/1875 [====================>.......] - ETA: 2s - loss: 0.1226 - accuracy: 0.9634
## 1450/1875 [====================>.......] - ETA: 2s - loss: 0.1225 - accuracy: 0.9634
## 1458/1875 [====================>.......] - ETA: 2s - loss: 0.1225 - accuracy: 0.9634
## 1466/1875 [====================>.......] - ETA: 2s - loss: 0.1226 - accuracy: 0.9634
## 1474/1875 [====================>.......] - ETA: 2s - loss: 0.1227 - accuracy: 0.9635
## 1482/1875 [====================>.......] - ETA: 2s - loss: 0.1226 - accuracy: 0.9635
## 1491/1875 [====================>.......] - ETA: 2s - loss: 0.1222 - accuracy: 0.9637
## 1500/1875 [=====================>......] - ETA: 2s - loss: 0.1223 - accuracy: 0.9636
## 1508/1875 [=====================>......] - ETA: 2s - loss: 0.1221 - accuracy: 0.9637
## 1517/1875 [=====================>......] - ETA: 2s - loss: 0.1222 - accuracy: 0.9636
## 1525/1875 [=====================>......] - ETA: 2s - loss: 0.1220 - accuracy: 0.9637
## 1533/1875 [=====================>......] - ETA: 2s - loss: 0.1217 - accuracy: 0.9638
## 1541/1875 [=====================>......] - ETA: 2s - loss: 0.1221 - accuracy: 0.9636
## 1549/1875 [=====================>......] - ETA: 2s - loss: 0.1219 - accuracy: 0.9637
## 1557/1875 [=====================>......] - ETA: 2s - loss: 0.1218 - accuracy: 0.9638
## 1565/1875 [======================>.....] - ETA: 2s - loss: 0.1216 - accuracy: 0.9638
## 1573/1875 [======================>.....] - ETA: 1s - loss: 0.1215 - accuracy: 0.9639
## 1581/1875 [======================>.....] - ETA: 1s - loss: 0.1215 - accuracy: 0.9638
## 1589/1875 [======================>.....] - ETA: 1s - loss: 0.1216 - accuracy: 0.9638
## 1597/1875 [======================>.....] - ETA: 1s - loss: 0.1214 - accuracy: 0.9639
## 1605/1875 [======================>.....] - ETA: 1s - loss: 0.1211 - accuracy: 0.9639
## 1613/1875 [======================>.....] - ETA: 1s - loss: 0.1211 - accuracy: 0.9640
## 1621/1875 [======================>.....] - ETA: 1s - loss: 0.1209 - accuracy: 0.9640
## 1629/1875 [=======================>....] - ETA: 1s - loss: 0.1209 - accuracy: 0.9640
## 1637/1875 [=======================>....] - ETA: 1s - loss: 0.1211 - accuracy: 0.9639
## 1645/1875 [=======================>....] - ETA: 1s - loss: 0.1211 - accuracy: 0.9639
## 1653/1875 [=======================>....] - ETA: 1s - loss: 0.1210 - accuracy: 0.9639
## 1661/1875 [=======================>....] - ETA: 1s - loss: 0.1210 - accuracy: 0.9639
## 1669/1875 [=======================>....] - ETA: 1s - loss: 0.1208 - accuracy: 0.9639
## 1677/1875 [=======================>....] - ETA: 1s - loss: 0.1210 - accuracy: 0.9640
## 1685/1875 [=======================>....] - ETA: 1s - loss: 0.1209 - accuracy: 0.9640
## 1693/1875 [========================>...] - ETA: 1s - loss: 0.1211 - accuracy: 0.9639
## 1701/1875 [========================>...] - ETA: 1s - loss: 0.1211 - accuracy: 0.9639
## 1709/1875 [========================>...] - ETA: 1s - loss: 0.1212 - accuracy: 0.9639
## 1717/1875 [========================>...] - ETA: 1s - loss: 0.1210 - accuracy: 0.9640
## 1725/1875 [========================>...] - ETA: 0s - loss: 0.1208 - accuracy: 0.9640
## 1733/1875 [========================>...] - ETA: 0s - loss: 0.1206 - accuracy: 0.9641
## 1741/1875 [========================>...] - ETA: 0s - loss: 0.1205 - accuracy: 0.9641
## 1749/1875 [========================>...] - ETA: 0s - loss: 0.1204 - accuracy: 0.9642
## 1757/1875 [=========================>..] - ETA: 0s - loss: 0.1205 - accuracy: 0.9641
## 1765/1875 [=========================>..] - ETA: 0s - loss: 0.1204 - accuracy: 0.9642
## 1773/1875 [=========================>..] - ETA: 0s - loss: 0.1202 - accuracy: 0.9642
```

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## 1781/1875 [============================>..] - ETA: 0s - loss: 0.1200 - accuracy: 0.9643
## 1789/1875 [============================>..] - ETA: 0s - loss: 0.1198 - accuracy: 0.9643
## 1797/1875 [============================>..] - ETA: 0s - loss: 0.1199 - accuracy: 0.9643
## 1805/1875 [============================>..] - ETA: 0s - loss: 0.1200 - accuracy: 0.9643
## 1813/1875 [============================>.] - ETA: 0s - loss: 0.1199 - accuracy: 0.9643
## 1821/1875 [============================>.] - ETA: 0s - loss: 0.1198 - accuracy: 0.9644
## 1829/1875 [============================>.] - ETA: 0s - loss: 0.1198 - accuracy: 0.9644
## 1837/1875 [============================>.] - ETA: 0s - loss: 0.1196 - accuracy: 0.9645
## 1845/1875 [============================>.] - ETA: 0s - loss: 0.1193 - accuracy: 0.9646
## 1853/1875 [============================>.] - ETA: 0s - loss: 0.1190 - accuracy: 0.9646
## 1861/1875 [============================>.] - ETA: 0s - loss: 0.1188 - accuracy: 0.9647
## 1869/1875 [============================>.] - ETA: 0s - loss: 0.1186 - accuracy: 0.9648
## 1875/1875 [==============================] - 12s 7ms/step - loss: 0.1184 - accuracy: 0.9648
## Epoch 3/5
##
##    1/1875 [..............................] - ETA: 13s - loss: 0.1995 - accuracy: 0.9375
##    9/1875 [..............................] - ETA: 12s - loss: 0.0614 - accuracy: 0.9861
##   17/1875 [..............................] - ETA: 12s - loss: 0.0629 - accuracy: 0.9853
##   25/1875 [..............................] - ETA: 11s - loss: 0.0604 - accuracy: 0.9850
##   33/1875 [..............................] - ETA: 11s - loss: 0.0610 - accuracy: 0.9839
##   41/1875 [..............................] - ETA: 11s - loss: 0.0597 - accuracy: 0.9840
##   49/1875 [..............................] - ETA: 11s - loss: 0.0610 - accuracy: 0.9841
##   57/1875 [..............................] - ETA: 11s - loss: 0.0604 - accuracy: 0.9841
##   65/1875 [>.............................] - ETA: 11s - loss: 0.0642 - accuracy: 0.9822
##   73/1875 [>.............................] - ETA: 11s - loss: 0.0739 - accuracy: 0.9786
##   81/1875 [>.............................] - ETA: 11s - loss: 0.0708 - accuracy: 0.9796
##   89/1875 [>.............................] - ETA: 11s - loss: 0.0720 - accuracy: 0.9789
##   97/1875 [>.............................] - ETA: 11s - loss: 0.0758 - accuracy: 0.9787
##  105/1875 [>.............................] - ETA: 11s - loss: 0.0745 - accuracy: 0.9789
##  113/1875 [>.............................] - ETA: 11s - loss: 0.0766 - accuracy: 0.9779
##  121/1875 [>.............................] - ETA: 11s - loss: 0.0802 - accuracy: 0.9770
##  130/1875 [=>............................] - ETA: 11s - loss: 0.0822 - accuracy: 0.9767
##  138/1875 [=>............................] - ETA: 11s - loss: 0.0819 - accuracy: 0.9760
##  146/1875 [=>............................] - ETA: 11s - loss: 0.0817 - accuracy: 0.9760
##  154/1875 [=>............................] - ETA: 11s - loss: 0.0843 - accuracy: 0.9750
##  162/1875 [=>............................] - ETA: 11s - loss: 0.0825 - accuracy: 0.9757
##  170/1875 [=>............................] - ETA: 11s - loss: 0.0801 - accuracy: 0.9763
##  179/1875 [=>............................] - ETA: 10s - loss: 0.0793 - accuracy: 0.9764
##  187/1875 [=>............................] - ETA: 10s - loss: 0.0804 - accuracy: 0.9761
##  195/1875 [==>...........................] - ETA: 10s - loss: 0.0808 - accuracy: 0.9758
##  204/1875 [==>...........................] - ETA: 10s - loss: 0.0812 - accuracy: 0.9759
##  212/1875 [==>...........................] - ETA: 10s - loss: 0.0797 - accuracy: 0.9763
##  220/1875 [==>...........................] - ETA: 10s - loss: 0.0794 - accuracy: 0.9761
##  228/1875 [==>...........................] - ETA: 10s - loss: 0.0781 - accuracy: 0.9766
##  236/1875 [==>...........................] - ETA: 10s - loss: 0.0780 - accuracy: 0.9768
##  244/1875 [==>...........................] - ETA: 10s - loss: 0.0792 - accuracy: 0.9763
##  252/1875 [===>..........................] - ETA: 10s - loss: 0.0792 - accuracy: 0.9766
##  260/1875 [===>..........................] - ETA: 10s - loss: 0.0795 - accuracy: 0.9763
##  268/1875 [===>..........................] - ETA: 10s - loss: 0.0803 - accuracy: 0.9759
##  276/1875 [===>..........................] - ETA: 10s - loss: 0.0812 - accuracy: 0.9754
##  285/1875 [===>..........................] - ETA: 10s - loss: 0.0831 - accuracy: 0.9753
##  293/1875 [===>..........................] - ETA: 10s - loss: 0.0837 - accuracy: 0.9748
##  301/1875 [===>..........................] - ETA: 10s - loss: 0.0838 - accuracy: 0.9749
##  309/1875 [===>..........................] - ETA: 10s - loss: 0.0843 - accuracy: 0.9746
```

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##  318/1875 [====>.....................] - ETA: 10s - loss: 0.0841 - accuracy: 0.9748
##  326/1875 [====>.....................] - ETA: 10s - loss: 0.0841 - accuracy: 0.9747
##  334/1875 [====>.....................] - ETA: 9s - loss: 0.0839 - accuracy: 0.9749
##  343/1875 [====>.....................] - ETA: 9s - loss: 0.0834 - accuracy: 0.9751
##  351/1875 [====>.....................] - ETA: 9s - loss: 0.0840 - accuracy: 0.9746
##  359/1875 [====>.....................] - ETA: 9s - loss: 0.0844 - accuracy: 0.9745
##  367/1875 [====>.....................] - ETA: 9s - loss: 0.0846 - accuracy: 0.9746
##  377/1875 [=====>....................] - ETA: 9s - loss: 0.0847 - accuracy: 0.9748
##  388/1875 [=====>....................] - ETA: 9s - loss: 0.0839 - accuracy: 0.9751
##  396/1875 [=====>....................] - ETA: 9s - loss: 0.0849 - accuracy: 0.9748
##  408/1875 [=====>....................] - ETA: 9s - loss: 0.0849 - accuracy: 0.9747
##  417/1875 [=====>....................] - ETA: 9s - loss: 0.0845 - accuracy: 0.9749
##  425/1875 [=====>....................] - ETA: 9s - loss: 0.0848 - accuracy: 0.9748
##  433/1875 [=====>....................] - ETA: 9s - loss: 0.0855 - accuracy: 0.9745
##  441/1875 [======>...................] - ETA: 9s - loss: 0.0858 - accuracy: 0.9743
##  449/1875 [======>...................] - ETA: 9s - loss: 0.0857 - accuracy: 0.9740
##  458/1875 [======>...................] - ETA: 8s - loss: 0.0858 - accuracy: 0.9741
##  466/1875 [======>...................] - ETA: 8s - loss: 0.0869 - accuracy: 0.9739
##  474/1875 [======>...................] - ETA: 8s - loss: 0.0876 - accuracy: 0.9737
##  482/1875 [======>...................] - ETA: 8s - loss: 0.0871 - accuracy: 0.9740
##  490/1875 [======>...................] - ETA: 8s - loss: 0.0881 - accuracy: 0.9736
##  498/1875 [======>...................] - ETA: 8s - loss: 0.0882 - accuracy: 0.9736
##  506/1875 [=======>..................] - ETA: 8s - loss: 0.0878 - accuracy: 0.9739
##  514/1875 [=======>..................] - ETA: 8s - loss: 0.0878 - accuracy: 0.9738
##  522/1875 [=======>..................] - ETA: 8s - loss: 0.0878 - accuracy: 0.9737
##  530/1875 [=======>..................] - ETA: 8s - loss: 0.0880 - accuracy: 0.9735
##  538/1875 [=======>..................] - ETA: 8s - loss: 0.0884 - accuracy: 0.9732
##  546/1875 [=======>..................] - ETA: 8s - loss: 0.0886 - accuracy: 0.9732
##  554/1875 [=======>..................] - ETA: 8s - loss: 0.0888 - accuracy: 0.9732
##  562/1875 [=======>..................] - ETA: 8s - loss: 0.0885 - accuracy: 0.9734
##  570/1875 [========>.................] - ETA: 8s - loss: 0.0890 - accuracy: 0.9734
##  578/1875 [========>.................] - ETA: 8s - loss: 0.0893 - accuracy: 0.9732
##  586/1875 [========>.................] - ETA: 8s - loss: 0.0890 - accuracy: 0.9733
##  594/1875 [========>.................] - ETA: 8s - loss: 0.0889 - accuracy: 0.9735
##  602/1875 [========>.................] - ETA: 8s - loss: 0.0888 - accuracy: 0.9735
##  610/1875 [========>.................] - ETA: 8s - loss: 0.0891 - accuracy: 0.9735
##  618/1875 [========>.................] - ETA: 8s - loss: 0.0892 - accuracy: 0.9733
##  626/1875 [=========>................] - ETA: 7s - loss: 0.0894 - accuracy: 0.9732
##  634/1875 [=========>................] - ETA: 7s - loss: 0.0892 - accuracy: 0.9733
##  642/1875 [=========>................] - ETA: 7s - loss: 0.0887 - accuracy: 0.9735
##  650/1875 [=========>................] - ETA: 7s - loss: 0.0887 - accuracy: 0.9735
##  658/1875 [=========>................] - ETA: 7s - loss: 0.0884 - accuracy: 0.9736
##  666/1875 [=========>................] - ETA: 7s - loss: 0.0880 - accuracy: 0.9738
##  674/1875 [=========>................] - ETA: 7s - loss: 0.0876 - accuracy: 0.9739
##  682/1875 [=========>................] - ETA: 7s - loss: 0.0872 - accuracy: 0.9741
##  690/1875 [==========>...............] - ETA: 7s - loss: 0.0869 - accuracy: 0.9742
##  698/1875 [==========>...............] - ETA: 7s - loss: 0.0866 - accuracy: 0.9744
##  706/1875 [==========>...............] - ETA: 7s - loss: 0.0872 - accuracy: 0.9743
##  714/1875 [==========>...............] - ETA: 7s - loss: 0.0869 - accuracy: 0.9744
##  722/1875 [==========>...............] - ETA: 7s - loss: 0.0871 - accuracy: 0.9743
##  730/1875 [==========>...............] - ETA: 7s - loss: 0.0870 - accuracy: 0.9743
##  738/1875 [==========>...............] - ETA: 7s - loss: 0.0866 - accuracy: 0.9744
##  746/1875 [==========>...............] - ETA: 7s - loss: 0.0865 - accuracy: 0.9743
##  754/1875 [===========>..............] - ETA: 7s - loss: 0.0865 - accuracy: 0.9742
```

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##  763/1875 [==========>..................] - ETA: 7s - loss: 0.0868 - accuracy: 0.9742
##  771/1875 [==========>..................] - ETA: 7s - loss: 0.0867 - accuracy: 0.9743
##  779/1875 [==========>..................] - ETA: 7s - loss: 0.0869 - accuracy: 0.9742
##  787/1875 [==========>..................] - ETA: 6s - loss: 0.0866 - accuracy: 0.9744
##  795/1875 [==========>..................] - ETA: 6s - loss: 0.0868 - accuracy: 0.9744
##  803/1875 [==========>..................] - ETA: 6s - loss: 0.0866 - accuracy: 0.9745
##  812/1875 [==========>..................] - ETA: 6s - loss: 0.0863 - accuracy: 0.9746
##  821/1875 [===========>.................] - ETA: 6s - loss: 0.0863 - accuracy: 0.9746
##  829/1875 [===========>.................] - ETA: 6s - loss: 0.0861 - accuracy: 0.9747
##  837/1875 [===========>.................] - ETA: 6s - loss: 0.0857 - accuracy: 0.9748
##  846/1875 [===========>.................] - ETA: 6s - loss: 0.0855 - accuracy: 0.9748
##  854/1875 [===========>.................] - ETA: 6s - loss: 0.0851 - accuracy: 0.9749
##  862/1875 [===========>.................] - ETA: 6s - loss: 0.0850 - accuracy: 0.9749
##  870/1875 [===========>.................] - ETA: 6s - loss: 0.0849 - accuracy: 0.9750
##  878/1875 [============>................] - ETA: 6s - loss: 0.0851 - accuracy: 0.9749
##  886/1875 [============>................] - ETA: 6s - loss: 0.0848 - accuracy: 0.9751
##  894/1875 [============>................] - ETA: 6s - loss: 0.0848 - accuracy: 0.9749
##  902/1875 [============>................] - ETA: 6s - loss: 0.0850 - accuracy: 0.9750
##  910/1875 [============>................] - ETA: 6s - loss: 0.0851 - accuracy: 0.9750
##  918/1875 [============>................] - ETA: 6s - loss: 0.0852 - accuracy: 0.9749
##  926/1875 [============>................] - ETA: 6s - loss: 0.0848 - accuracy: 0.9751
##  934/1875 [============>................] - ETA: 6s - loss: 0.0847 - accuracy: 0.9751
##  942/1875 [=============>...............] - ETA: 6s - loss: 0.0847 - accuracy: 0.9751
##  950/1875 [=============>...............] - ETA: 5s - loss: 0.0846 - accuracy: 0.9752
##  959/1875 [=============>...............] - ETA: 5s - loss: 0.0845 - accuracy: 0.9751
##  967/1875 [=============>...............] - ETA: 5s - loss: 0.0843 - accuracy: 0.9752
##  975/1875 [=============>...............] - ETA: 5s - loss: 0.0840 - accuracy: 0.9752
##  983/1875 [=============>...............] - ETA: 5s - loss: 0.0842 - accuracy: 0.9751
##  991/1875 [=============>...............] - ETA: 5s - loss: 0.0843 - accuracy: 0.9751
##  999/1875 [=============>...............] - ETA: 5s - loss: 0.0844 - accuracy: 0.9750
## 1007/1875 [==============>..............] - ETA: 5s - loss: 0.0842 - accuracy: 0.9750
## 1015/1875 [==============>..............] - ETA: 5s - loss: 0.0840 - accuracy: 0.9750
## 1023/1875 [==============>..............] - ETA: 5s - loss: 0.0839 - accuracy: 0.9750
## 1031/1875 [==============>..............] - ETA: 5s - loss: 0.0841 - accuracy: 0.9750
## 1039/1875 [==============>..............] - ETA: 5s - loss: 0.0841 - accuracy: 0.9750
## 1047/1875 [==============>..............] - ETA: 5s - loss: 0.0840 - accuracy: 0.9750
## 1055/1875 [==============>..............] - ETA: 5s - loss: 0.0836 - accuracy: 0.9751
## 1063/1875 [===============>.............] - ETA: 5s - loss: 0.0838 - accuracy: 0.9751
## 1071/1875 [===============>.............] - ETA: 5s - loss: 0.0838 - accuracy: 0.9751
## 1079/1875 [===============>.............] - ETA: 5s - loss: 0.0836 - accuracy: 0.9752
## 1087/1875 [===============>.............] - ETA: 5s - loss: 0.0836 - accuracy: 0.9751
## 1095/1875 [===============>.............] - ETA: 5s - loss: 0.0835 - accuracy: 0.9751
## 1103/1875 [===============>.............] - ETA: 4s - loss: 0.0839 - accuracy: 0.9751
## 1112/1875 [===============>.............] - ETA: 4s - loss: 0.0839 - accuracy: 0.9750
## 1120/1875 [===============>.............] - ETA: 4s - loss: 0.0837 - accuracy: 0.9751
## 1128/1875 [================>............] - ETA: 4s - loss: 0.0834 - accuracy: 0.9751
## 1136/1875 [================>............] - ETA: 4s - loss: 0.0835 - accuracy: 0.9751
## 1144/1875 [================>............] - ETA: 4s - loss: 0.0835 - accuracy: 0.9752
## 1152/1875 [================>............] - ETA: 4s - loss: 0.0837 - accuracy: 0.9752
## 1160/1875 [================>............] - ETA: 4s - loss: 0.0836 - accuracy: 0.9752
## 1168/1875 [================>............] - ETA: 4s - loss: 0.0835 - accuracy: 0.9752
## 1176/1875 [================>............] - ETA: 4s - loss: 0.0833 - accuracy: 0.9753
## 1185/1875 [================>............] - ETA: 4s - loss: 0.0835 - accuracy: 0.9752
## 1193/1875 [=================>...........] - ETA: 4s - loss: 0.0833 - accuracy: 0.9752
```

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## 1201/1875 [==================>...........] - ETA: 4s - loss: 0.0837 - accuracy: 0.9750
## 1209/1875 [==================>...........] - ETA: 4s - loss: 0.0835 - accuracy: 0.9751
## 1217/1875 [==================>...........] - ETA: 4s - loss: 0.0835 - accuracy: 0.9751
## 1225/1875 [==================>...........] - ETA: 4s - loss: 0.0831 - accuracy: 0.9753
## 1233/1875 [==================>...........] - ETA: 4s - loss: 0.0832 - accuracy: 0.9753
## 1241/1875 [==================>...........] - ETA: 4s - loss: 0.0831 - accuracy: 0.9753
## 1249/1875 [==================>...........] - ETA: 4s - loss: 0.0832 - accuracy: 0.9753
## 1257/1875 [===================>..........] - ETA: 3s - loss: 0.0829 - accuracy: 0.9753
## 1265/1875 [===================>..........] - ETA: 3s - loss: 0.0829 - accuracy: 0.9753
## 1273/1875 [===================>..........] - ETA: 3s - loss: 0.0828 - accuracy: 0.9753
## 1281/1875 [===================>..........] - ETA: 3s - loss: 0.0828 - accuracy: 0.9753
## 1289/1875 [===================>..........] - ETA: 3s - loss: 0.0827 - accuracy: 0.9753
## 1297/1875 [===================>..........] - ETA: 3s - loss: 0.0828 - accuracy: 0.9752
## 1305/1875 [===================>..........] - ETA: 3s - loss: 0.0827 - accuracy: 0.9752
## 1313/1875 [====================>.........] - ETA: 3s - loss: 0.0827 - accuracy: 0.9752
## 1321/1875 [====================>.........] - ETA: 3s - loss: 0.0828 - accuracy: 0.9751
## 1329/1875 [====================>.........] - ETA: 3s - loss: 0.0827 - accuracy: 0.9751
## 1337/1875 [====================>.........] - ETA: 3s - loss: 0.0828 - accuracy: 0.9751
## 1345/1875 [====================>.........] - ETA: 3s - loss: 0.0826 - accuracy: 0.9751
## 1353/1875 [====================>.........] - ETA: 3s - loss: 0.0826 - accuracy: 0.9751
## 1361/1875 [====================>.........] - ETA: 3s - loss: 0.0823 - accuracy: 0.9752
## 1369/1875 [====================>.........] - ETA: 3s - loss: 0.0823 - accuracy: 0.9752
## 1377/1875 [=====================>........] - ETA: 3s - loss: 0.0825 - accuracy: 0.9751
## 1385/1875 [=====================>........] - ETA: 3s - loss: 0.0827 - accuracy: 0.9751
## 1393/1875 [=====================>........] - ETA: 3s - loss: 0.0826 - accuracy: 0.9751
## 1401/1875 [=====================>........] - ETA: 3s - loss: 0.0826 - accuracy: 0.9751
## 1409/1875 [=====================>........] - ETA: 3s - loss: 0.0825 - accuracy: 0.9751
## 1417/1875 [=====================>........] - ETA: 2s - loss: 0.0826 - accuracy: 0.9751
## 1425/1875 [=====================>........] - ETA: 2s - loss: 0.0826 - accuracy: 0.9750
## 1433/1875 [=====================>........] - ETA: 2s - loss: 0.0826 - accuracy: 0.9751
## 1441/1875 [======================>.......] - ETA: 2s - loss: 0.0826 - accuracy: 0.9750
## 1449/1875 [======================>.......] - ETA: 2s - loss: 0.0824 - accuracy: 0.9750
## 1457/1875 [======================>.......] - ETA: 2s - loss: 0.0828 - accuracy: 0.9749
## 1465/1875 [======================>.......] - ETA: 2s - loss: 0.0827 - accuracy: 0.9750
## 1473/1875 [======================>.......] - ETA: 2s - loss: 0.0829 - accuracy: 0.9749
## 1481/1875 [======================>.......] - ETA: 2s - loss: 0.0830 - accuracy: 0.9748
## 1489/1875 [======================>.......] - ETA: 2s - loss: 0.0828 - accuracy: 0.9749
## 1497/1875 [======================>.......] - ETA: 2s - loss: 0.0829 - accuracy: 0.9749
## 1505/1875 [=======================>......] - ETA: 2s - loss: 0.0827 - accuracy: 0.9749
## 1513/1875 [=======================>......] - ETA: 2s - loss: 0.0828 - accuracy: 0.9748
## 1521/1875 [=======================>......] - ETA: 2s - loss: 0.0828 - accuracy: 0.9749
## 1529/1875 [=======================>......] - ETA: 2s - loss: 0.0827 - accuracy: 0.9749
## 1537/1875 [=======================>......] - ETA: 2s - loss: 0.0826 - accuracy: 0.9750
## 1545/1875 [=======================>......] - ETA: 2s - loss: 0.0826 - accuracy: 0.9750
## 1553/1875 [=======================>......] - ETA: 2s - loss: 0.0826 - accuracy: 0.9750
## 1561/1875 [=======================>......] - ETA: 2s - loss: 0.0826 - accuracy: 0.9750
## 1569/1875 [========================>.....] - ETA: 1s - loss: 0.0826 - accuracy: 0.9749
## 1577/1875 [========================>.....] - ETA: 1s - loss: 0.0827 - accuracy: 0.9749
## 1585/1875 [========================>.....] - ETA: 1s - loss: 0.0827 - accuracy: 0.9748
## 1593/1875 [========================>.....] - ETA: 1s - loss: 0.0826 - accuracy: 0.9749
## 1601/1875 [========================>.....] - ETA: 1s - loss: 0.0824 - accuracy: 0.9749
## 1609/1875 [========================>.....] - ETA: 1s - loss: 0.0826 - accuracy: 0.9749
## 1617/1875 [========================>.....] - ETA: 1s - loss: 0.0826 - accuracy: 0.9749
## 1625/1875 [=========================>....] - ETA: 1s - loss: 0.0825 - accuracy: 0.9749
```

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## 1633/1875 [=========================>....] - ETA: 1s - loss: 0.0827 - accuracy: 0.9748
## 1641/1875 [=========================>....] - ETA: 1s - loss: 0.0827 - accuracy: 0.9748
## 1649/1875 [=========================>....] - ETA: 1s - loss: 0.0827 - accuracy: 0.9748
## 1657/1875 [=========================>....] - ETA: 1s - loss: 0.0825 - accuracy: 0.9748
## 1665/1875 [=========================>....] - ETA: 1s - loss: 0.0824 - accuracy: 0.9748
## 1673/1875 [=========================>....] - ETA: 1s - loss: 0.0825 - accuracy: 0.9747
## 1681/1875 [=========================>....] - ETA: 1s - loss: 0.0824 - accuracy: 0.9748
## 1689/1875 [==========================>...] - ETA: 1s - loss: 0.0827 - accuracy: 0.9747
## 1697/1875 [==========================>...] - ETA: 1s - loss: 0.0826 - accuracy: 0.9747
## 1705/1875 [==========================>...] - ETA: 1s - loss: 0.0824 - accuracy: 0.9748
## 1713/1875 [==========================>...] - ETA: 1s - loss: 0.0826 - accuracy: 0.9748
## 1721/1875 [==========================>...] - ETA: 0s - loss: 0.0827 - accuracy: 0.9748
## 1729/1875 [==========================>...] - ETA: 0s - loss: 0.0826 - accuracy: 0.9748
## 1737/1875 [==========================>...] - ETA: 0s - loss: 0.0828 - accuracy: 0.9748
## 1745/1875 [==========================>...] - ETA: 0s - loss: 0.0827 - accuracy: 0.9747
## 1753/1875 [==========================>..] - ETA: 0s - loss: 0.0824 - accuracy: 0.9748
## 1761/1875 [==========================>..] - ETA: 0s - loss: 0.0826 - accuracy: 0.9748
## 1769/1875 [==========================>..] - ETA: 0s - loss: 0.0825 - accuracy: 0.9748
## 1777/1875 [==========================>..] - ETA: 0s - loss: 0.0823 - accuracy: 0.9749
## 1785/1875 [==========================>..] - ETA: 0s - loss: 0.0822 - accuracy: 0.9750
## 1793/1875 [==========================>..] - ETA: 0s - loss: 0.0820 - accuracy: 0.9750
## 1801/1875 [==========================>..] - ETA: 0s - loss: 0.0820 - accuracy: 0.9751
## 1809/1875 [==========================>..] - ETA: 0s - loss: 0.0818 - accuracy: 0.9751
## 1817/1875 [===========================>.] - ETA: 0s - loss: 0.0818 - accuracy: 0.9751
## 1825/1875 [===========================>.] - ETA: 0s - loss: 0.0819 - accuracy: 0.9751
## 1833/1875 [===========================>.] - ETA: 0s - loss: 0.0820 - accuracy: 0.9750
## 1841/1875 [===========================>.] - ETA: 0s - loss: 0.0819 - accuracy: 0.9750
## 1849/1875 [===========================>.] - ETA: 0s - loss: 0.0818 - accuracy: 0.9751
## 1857/1875 [===========================>.] - ETA: 0s - loss: 0.0819 - accuracy: 0.9750
## 1865/1875 [===========================>.] - ETA: 0s - loss: 0.0818 - accuracy: 0.9751
## 1874/1875 [===========================>.] - ETA: 0s - loss: 0.0819 - accuracy: 0.9750
## 1875/1875 [==============================] - 12s 7ms/step - loss: 0.0819 - accuracy: 0.9750
## Epoch 4/5
##
##    1/1875 [..............................] - ETA: 15s - loss: 0.0157 - accuracy: 1.0000
##    9/1875 [..............................] - ETA: 12s - loss: 0.0933 - accuracy: 0.9792
##   17/1875 [..............................] - ETA: 12s - loss: 0.0759 - accuracy: 0.9798
##   25/1875 [..............................] - ETA: 12s - loss: 0.0691 - accuracy: 0.9812
##   33/1875 [..............................] - ETA: 12s - loss: 0.0620 - accuracy: 0.9830
##   41/1875 [..............................] - ETA: 12s - loss: 0.0592 - accuracy: 0.9825
##   49/1875 [..............................] - ETA: 12s - loss: 0.0545 - accuracy: 0.9841
##   57/1875 [..............................] - ETA: 12s - loss: 0.0505 - accuracy: 0.9863
##   65/1875 [>.............................] - ETA: 11s - loss: 0.0511 - accuracy: 0.9865
##   73/1875 [>.............................] - ETA: 11s - loss: 0.0553 - accuracy: 0.9859
##   81/1875 [>.............................] - ETA: 11s - loss: 0.0554 - accuracy: 0.9853
##   89/1875 [>.............................] - ETA: 11s - loss: 0.0533 - accuracy: 0.9860
##   97/1875 [>.............................] - ETA: 11s - loss: 0.0528 - accuracy: 0.9861
##  105/1875 [>.............................] - ETA: 11s - loss: 0.0535 - accuracy: 0.9854
##  113/1875 [>.............................] - ETA: 11s - loss: 0.0521 - accuracy: 0.9859
##  121/1875 [>.............................] - ETA: 11s - loss: 0.0561 - accuracy: 0.9850
##  129/1875 [=>............................] - ETA: 11s - loss: 0.0581 - accuracy: 0.9838
##  137/1875 [=>............................] - ETA: 11s - loss: 0.0563 - accuracy: 0.9845
##  145/1875 [=>............................] - ETA: 11s - loss: 0.0564 - accuracy: 0.9847
##  153/1875 [=>............................] - ETA: 11s - loss: 0.0577 - accuracy: 0.9841
```

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##  161/1875 [=>............................] - ETA: 11s - loss: 0.0575 - accuracy: 0.9841
##  169/1875 [=>............................] - ETA: 11s - loss: 0.0583 - accuracy: 0.9839
##  177/1875 [=>............................] - ETA: 11s - loss: 0.0588 - accuracy: 0.9836
##  185/1875 [=>............................] - ETA: 11s - loss: 0.0590 - accuracy: 0.9828
##  193/1875 [==>...........................] - ETA: 11s - loss: 0.0596 - accuracy: 0.9828
##  201/1875 [==>...........................] - ETA: 11s - loss: 0.0604 - accuracy: 0.9829
##  209/1875 [==>...........................] - ETA: 10s - loss: 0.0600 - accuracy: 0.9833
##  217/1875 [==>...........................] - ETA: 10s - loss: 0.0589 - accuracy: 0.9837
##  225/1875 [==>...........................] - ETA: 10s - loss: 0.0599 - accuracy: 0.9833
##  233/1875 [==>...........................] - ETA: 10s - loss: 0.0603 - accuracy: 0.9828
##  241/1875 [==>...........................] - ETA: 10s - loss: 0.0601 - accuracy: 0.9829
##  249/1875 [==>...........................] - ETA: 10s - loss: 0.0596 - accuracy: 0.9831
##  257/1875 [===>..........................] - ETA: 10s - loss: 0.0595 - accuracy: 0.9830
##  265/1875 [===>..........................] - ETA: 10s - loss: 0.0599 - accuracy: 0.9825
##  273/1875 [===>..........................] - ETA: 10s - loss: 0.0600 - accuracy: 0.9826
##  281/1875 [===>..........................] - ETA: 10s - loss: 0.0597 - accuracy: 0.9825
##  289/1875 [===>..........................] - ETA: 10s - loss: 0.0591 - accuracy: 0.9827
##  297/1875 [===>..........................] - ETA: 10s - loss: 0.0591 - accuracy: 0.9826
##  305/1875 [===>..........................] - ETA: 10s - loss: 0.0583 - accuracy: 0.9830
##  313/1875 [====>.........................] - ETA: 10s - loss: 0.0580 - accuracy: 0.9831
##  321/1875 [====>.........................] - ETA: 10s - loss: 0.0579 - accuracy: 0.9832
##  329/1875 [====>.........................] - ETA: 10s - loss: 0.0582 - accuracy: 0.9833
##  337/1875 [====>.........................] - ETA: 10s - loss: 0.0579 - accuracy: 0.9833
##  345/1875 [====>.........................] - ETA: 10s - loss: 0.0580 - accuracy: 0.9833
##  353/1875 [====>.........................] - ETA: 10s - loss: 0.0583 - accuracy: 0.9835
##  361/1875 [====>.........................] - ETA: 9s - loss: 0.0580 - accuracy: 0.9837
##  369/1875 [====>.........................] - ETA: 9s - loss: 0.0582 - accuracy: 0.9837
##  377/1875 [=====>........................] - ETA: 9s - loss: 0.0586 - accuracy: 0.9834
##  386/1875 [=====>........................] - ETA: 9s - loss: 0.0587 - accuracy: 0.9833
##  394/1875 [=====>........................] - ETA: 9s - loss: 0.0586 - accuracy: 0.9833
##  402/1875 [=====>........................] - ETA: 9s - loss: 0.0585 - accuracy: 0.9832
##  410/1875 [=====>........................] - ETA: 9s - loss: 0.0583 - accuracy: 0.9833
##  418/1875 [=====>........................] - ETA: 9s - loss: 0.0586 - accuracy: 0.9830
##  426/1875 [=====>........................] - ETA: 9s - loss: 0.0586 - accuracy: 0.9828
##  434/1875 [=====>........................] - ETA: 9s - loss: 0.0604 - accuracy: 0.9824
##  442/1875 [======>.......................] - ETA: 9s - loss: 0.0608 - accuracy: 0.9823
##  450/1875 [======>.......................] - ETA: 9s - loss: 0.0605 - accuracy: 0.9824
##  458/1875 [======>.......................] - ETA: 9s - loss: 0.0606 - accuracy: 0.9823
##  466/1875 [======>.......................] - ETA: 9s - loss: 0.0608 - accuracy: 0.9820
##  474/1875 [======>.......................] - ETA: 9s - loss: 0.0607 - accuracy: 0.9820
##  482/1875 [======>.......................] - ETA: 9s - loss: 0.0619 - accuracy: 0.9820
##  490/1875 [======>.......................] - ETA: 9s - loss: 0.0615 - accuracy: 0.9821
##  498/1875 [======>.......................] - ETA: 9s - loss: 0.0610 - accuracy: 0.9823
##  506/1875 [=======>......................] - ETA: 9s - loss: 0.0616 - accuracy: 0.9822
##  514/1875 [=======>......................] - ETA: 8s - loss: 0.0617 - accuracy: 0.9821
##  522/1875 [=======>......................] - ETA: 8s - loss: 0.0622 - accuracy: 0.9817
##  530/1875 [=======>......................] - ETA: 8s - loss: 0.0622 - accuracy: 0.9816
##  538/1875 [=======>......................] - ETA: 8s - loss: 0.0618 - accuracy: 0.9818
##  546/1875 [=======>......................] - ETA: 8s - loss: 0.0619 - accuracy: 0.9817
##  554/1875 [=======>......................] - ETA: 8s - loss: 0.0618 - accuracy: 0.9819
##  562/1875 [=======>......................] - ETA: 8s - loss: 0.0627 - accuracy: 0.9817
##  570/1875 [========>.....................] - ETA: 8s - loss: 0.0628 - accuracy: 0.9817
##  578/1875 [========>.....................] - ETA: 8s - loss: 0.0623 - accuracy: 0.9819
##  586/1875 [========>.....................] - ETA: 8s - loss: 0.0620 - accuracy: 0.9820
```

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##  594/1875 [========>.....................] - ETA: 8s - loss: 0.0622 - accuracy: 0.9818
##  602/1875 [========>.....................] - ETA: 8s - loss: 0.0621 - accuracy: 0.9819
##  610/1875 [========>.....................] - ETA: 8s - loss: 0.0623 - accuracy: 0.9818
##  618/1875 [========>.....................] - ETA: 8s - loss: 0.0622 - accuracy: 0.9818
##  626/1875 [=========>....................] - ETA: 8s - loss: 0.0627 - accuracy: 0.9816
##  634/1875 [=========>....................] - ETA: 8s - loss: 0.0622 - accuracy: 0.9818
##  642/1875 [=========>....................] - ETA: 8s - loss: 0.0620 - accuracy: 0.9819
##  650/1875 [=========>....................] - ETA: 8s - loss: 0.0621 - accuracy: 0.9820
##  658/1875 [=========>....................] - ETA: 8s - loss: 0.0628 - accuracy: 0.9818
##  666/1875 [=========>....................] - ETA: 7s - loss: 0.0626 - accuracy: 0.9818
##  673/1875 [=========>....................] - ETA: 7s - loss: 0.0627 - accuracy: 0.9817
##  681/1875 [=========>....................] - ETA: 7s - loss: 0.0626 - accuracy: 0.9817
##  689/1875 [==========>...................] - ETA: 7s - loss: 0.0626 - accuracy: 0.9817
##  697/1875 [==========>...................] - ETA: 7s - loss: 0.0623 - accuracy: 0.9818
##  705/1875 [==========>...................] - ETA: 7s - loss: 0.0625 - accuracy: 0.9817
##  713/1875 [==========>...................] - ETA: 7s - loss: 0.0622 - accuracy: 0.9818
##  721/1875 [==========>...................] - ETA: 7s - loss: 0.0627 - accuracy: 0.9818
##  729/1875 [==========>...................] - ETA: 7s - loss: 0.0627 - accuracy: 0.9817
##  737/1875 [==========>...................] - ETA: 7s - loss: 0.0625 - accuracy: 0.9817
##  745/1875 [==========>...................] - ETA: 7s - loss: 0.0625 - accuracy: 0.9818
##  753/1875 [===========>..................] - ETA: 7s - loss: 0.0622 - accuracy: 0.9819
##  761/1875 [===========>..................] - ETA: 7s - loss: 0.0621 - accuracy: 0.9818
##  769/1875 [===========>..................] - ETA: 7s - loss: 0.0621 - accuracy: 0.9818
##  777/1875 [===========>..................] - ETA: 7s - loss: 0.0620 - accuracy: 0.9819
##  785/1875 [===========>..................] - ETA: 7s - loss: 0.0616 - accuracy: 0.9821
##  794/1875 [===========>..................] - ETA: 7s - loss: 0.0615 - accuracy: 0.9821
##  802/1875 [===========>..................] - ETA: 7s - loss: 0.0616 - accuracy: 0.9819
##  810/1875 [===========>..................] - ETA: 7s - loss: 0.0614 - accuracy: 0.9819
##  818/1875 [============>.................] - ETA: 6s - loss: 0.0611 - accuracy: 0.9820
##  826/1875 [============>.................] - ETA: 6s - loss: 0.0610 - accuracy: 0.9821
##  834/1875 [============>.................] - ETA: 6s - loss: 0.0617 - accuracy: 0.9819
##  842/1875 [============>.................] - ETA: 6s - loss: 0.0618 - accuracy: 0.9819
##  850/1875 [============>.................] - ETA: 6s - loss: 0.0616 - accuracy: 0.9820
##  858/1875 [============>.................] - ETA: 6s - loss: 0.0619 - accuracy: 0.9819
##  866/1875 [============>.................] - ETA: 6s - loss: 0.0615 - accuracy: 0.9821
##  874/1875 [============>.................] - ETA: 6s - loss: 0.0615 - accuracy: 0.9821
##  882/1875 [=============>................] - ETA: 6s - loss: 0.0614 - accuracy: 0.9822
##  890/1875 [=============>................] - ETA: 6s - loss: 0.0614 - accuracy: 0.9822
##  898/1875 [=============>................] - ETA: 6s - loss: 0.0616 - accuracy: 0.9821
##  907/1875 [=============>................] - ETA: 6s - loss: 0.0620 - accuracy: 0.9819
##  915/1875 [=============>................] - ETA: 6s - loss: 0.0619 - accuracy: 0.9820
##  923/1875 [=============>................] - ETA: 6s - loss: 0.0617 - accuracy: 0.9820
##  931/1875 [=============>................] - ETA: 6s - loss: 0.0615 - accuracy: 0.9820
##  940/1875 [==============>...............] - ETA: 6s - loss: 0.0614 - accuracy: 0.9820
##  948/1875 [==============>...............] - ETA: 6s - loss: 0.0613 - accuracy: 0.9820
##  956/1875 [==============>...............] - ETA: 6s - loss: 0.0617 - accuracy: 0.9819
##  964/1875 [==============>...............] - ETA: 6s - loss: 0.0616 - accuracy: 0.9819
##  972/1875 [==============>...............] - ETA: 5s - loss: 0.0614 - accuracy: 0.9820
##  980/1875 [==============>...............] - ETA: 5s - loss: 0.0616 - accuracy: 0.9819
##  988/1875 [==============>...............] - ETA: 5s - loss: 0.0616 - accuracy: 0.9819
##  996/1875 [==============>...............] - ETA: 5s - loss: 0.0615 - accuracy: 0.9819
## 1004/1875 [===============>..............] - ETA: 5s - loss: 0.0615 - accuracy: 0.9819
## 1012/1875 [===============>..............] - ETA: 5s - loss: 0.0615 - accuracy: 0.9819
## 1020/1875 [===============>..............] - ETA: 5s - loss: 0.0614 - accuracy: 0.9819
```

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## 1028/1875 [==============>.............] - ETA: 5s - loss: 0.0614 - accuracy: 0.9819
## 1036/1875 [==============>.............] - ETA: 5s - loss: 0.0612 - accuracy: 0.9820
## 1044/1875 [==============>.............] - ETA: 5s - loss: 0.0611 - accuracy: 0.9820
## 1052/1875 [==============>.............] - ETA: 5s - loss: 0.0614 - accuracy: 0.9819
## 1059/1875 [==============>.............] - ETA: 5s - loss: 0.0613 - accuracy: 0.9819
## 1067/1875 [===============>.............] - ETA: 5s - loss: 0.0611 - accuracy: 0.9820
## 1074/1875 [===============>.............] - ETA: 5s - loss: 0.0612 - accuracy: 0.9819
## 1082/1875 [===============>.............] - ETA: 5s - loss: 0.0613 - accuracy: 0.9819
## 1090/1875 [===============>.............] - ETA: 5s - loss: 0.0612 - accuracy: 0.9819
## 1098/1875 [===============>.............] - ETA: 5s - loss: 0.0614 - accuracy: 0.9819
## 1106/1875 [===============>.............] - ETA: 5s - loss: 0.0612 - accuracy: 0.9819
## 1115/1875 [===============>.............] - ETA: 5s - loss: 0.0613 - accuracy: 0.9818
## 1124/1875 [================>............] - ETA: 4s - loss: 0.0613 - accuracy: 0.9818
## 1132/1875 [================>............] - ETA: 4s - loss: 0.0615 - accuracy: 0.9817
## 1140/1875 [================>............] - ETA: 4s - loss: 0.0617 - accuracy: 0.9817
## 1148/1875 [================>............] - ETA: 4s - loss: 0.0616 - accuracy: 0.9818
## 1156/1875 [================>............] - ETA: 4s - loss: 0.0616 - accuracy: 0.9818
## 1163/1875 [================>............] - ETA: 4s - loss: 0.0619 - accuracy: 0.9817
## 1170/1875 [================>............] - ETA: 4s - loss: 0.0620 - accuracy: 0.9817
## 1178/1875 [================>............] - ETA: 4s - loss: 0.0620 - accuracy: 0.9817
## 1186/1875 [================>............] - ETA: 4s - loss: 0.0618 - accuracy: 0.9818
## 1194/1875 [=================>............] - ETA: 4s - loss: 0.0617 - accuracy: 0.9818
## 1202/1875 [=================>............] - ETA: 4s - loss: 0.0617 - accuracy: 0.9818
## 1210/1875 [=================>............] - ETA: 4s - loss: 0.0620 - accuracy: 0.9817
## 1217/1875 [=================>............] - ETA: 4s - loss: 0.0621 - accuracy: 0.9818
## 1225/1875 [=================>............] - ETA: 4s - loss: 0.0621 - accuracy: 0.9818
## 1233/1875 [=================>............] - ETA: 4s - loss: 0.0621 - accuracy: 0.9818
## 1241/1875 [=================>............] - ETA: 4s - loss: 0.0620 - accuracy: 0.9818
## 1249/1875 [=================>............] - ETA: 4s - loss: 0.0620 - accuracy: 0.9818
## 1257/1875 [==================>...........] - ETA: 4s - loss: 0.0621 - accuracy: 0.9817
## 1265/1875 [==================>...........] - ETA: 4s - loss: 0.0624 - accuracy: 0.9816
## 1273/1875 [==================>...........] - ETA: 3s - loss: 0.0623 - accuracy: 0.9816
## 1279/1875 [==================>...........] - ETA: 3s - loss: 0.0624 - accuracy: 0.9816
## 1287/1875 [==================>...........] - ETA: 3s - loss: 0.0622 - accuracy: 0.9816
## 1294/1875 [==================>...........] - ETA: 3s - loss: 0.0623 - accuracy: 0.9815
## 1301/1875 [==================>...........] - ETA: 3s - loss: 0.0622 - accuracy: 0.9816
## 1308/1875 [==================>...........] - ETA: 3s - loss: 0.0621 - accuracy: 0.9816
## 1316/1875 [===================>..........] - ETA: 3s - loss: 0.0619 - accuracy: 0.9817
## 1324/1875 [===================>..........] - ETA: 3s - loss: 0.0618 - accuracy: 0.9817
## 1332/1875 [===================>..........] - ETA: 3s - loss: 0.0616 - accuracy: 0.9817
## 1341/1875 [===================>..........] - ETA: 3s - loss: 0.0618 - accuracy: 0.9817
## 1349/1875 [===================>..........] - ETA: 3s - loss: 0.0622 - accuracy: 0.9815
## 1356/1875 [===================>..........] - ETA: 3s - loss: 0.0621 - accuracy: 0.9816
## 1363/1875 [===================>..........] - ETA: 3s - loss: 0.0621 - accuracy: 0.9815
## 1370/1875 [====================>.........] - ETA: 3s - loss: 0.0621 - accuracy: 0.9815
## 1376/1875 [====================>.........] - ETA: 3s - loss: 0.0621 - accuracy: 0.9815
## 1383/1875 [====================>.........] - ETA: 3s - loss: 0.0620 - accuracy: 0.9815
## 1391/1875 [====================>.........] - ETA: 3s - loss: 0.0619 - accuracy: 0.9815
## 1399/1875 [====================>.........] - ETA: 3s - loss: 0.0618 - accuracy: 0.9816
## 1407/1875 [====================>.........] - ETA: 3s - loss: 0.0617 - accuracy: 0.9816
## 1416/1875 [=====================>........] - ETA: 3s - loss: 0.0616 - accuracy: 0.9816
## 1424/1875 [=====================>........] - ETA: 3s - loss: 0.0617 - accuracy: 0.9815
## 1432/1875 [=====================>........] - ETA: 2s - loss: 0.0618 - accuracy: 0.9815
## 1439/1875 [=====================>........] - ETA: 2s - loss: 0.0618 - accuracy: 0.9814
```

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## 1446/1875 [=====================>.......] - ETA: 2s - loss: 0.0619 - accuracy: 0.9815
## 1453/1875 [=====================>.......] - ETA: 2s - loss: 0.0618 - accuracy: 0.9815
## 1459/1875 [=====================>.......] - ETA: 2s - loss: 0.0617 - accuracy: 0.9816
## 1465/1875 [=====================>.......] - ETA: 2s - loss: 0.0616 - accuracy: 0.9816
## 1472/1875 [=====================>.......] - ETA: 2s - loss: 0.0615 - accuracy: 0.9816
## 1478/1875 [=====================>.......] - ETA: 2s - loss: 0.0613 - accuracy: 0.9817
## 1485/1875 [=====================>.......] - ETA: 2s - loss: 0.0613 - accuracy: 0.9817
## 1490/1875 [=====================>.......] - ETA: 2s - loss: 0.0614 - accuracy: 0.9817
## 1494/1875 [=====================>.......] - ETA: 2s - loss: 0.0613 - accuracy: 0.9817
## 1501/1875 [======================>......] - ETA: 2s - loss: 0.0616 - accuracy: 0.9816
## 1508/1875 [======================>......] - ETA: 2s - loss: 0.0616 - accuracy: 0.9817
## 1516/1875 [======================>......] - ETA: 2s - loss: 0.0618 - accuracy: 0.9816
## 1523/1875 [======================>......] - ETA: 2s - loss: 0.0618 - accuracy: 0.9817
## 1530/1875 [======================>......] - ETA: 2s - loss: 0.0616 - accuracy: 0.9817
## 1537/1875 [======================>......] - ETA: 2s - loss: 0.0615 - accuracy: 0.9818
## 1544/1875 [======================>......] - ETA: 2s - loss: 0.0617 - accuracy: 0.9817
## 1551/1875 [======================>......] - ETA: 2s - loss: 0.0616 - accuracy: 0.9817
## 1558/1875 [======================>......] - ETA: 2s - loss: 0.0616 - accuracy: 0.9817
## 1565/1875 [=======================>.....] - ETA: 2s - loss: 0.0617 - accuracy: 0.9816
## 1572/1875 [=======================>.....] - ETA: 2s - loss: 0.0616 - accuracy: 0.9817
## 1579/1875 [=======================>.....] - ETA: 2s - loss: 0.0615 - accuracy: 0.9817
## 1586/1875 [=======================>.....] - ETA: 1s - loss: 0.0614 - accuracy: 0.9818
## 1594/1875 [=======================>.....] - ETA: 1s - loss: 0.0616 - accuracy: 0.9817
## 1601/1875 [=======================>.....] - ETA: 1s - loss: 0.0615 - accuracy: 0.9817
## 1609/1875 [=======================>.....] - ETA: 1s - loss: 0.0615 - accuracy: 0.9817
## 1616/1875 [=======================>.....] - ETA: 1s - loss: 0.0614 - accuracy: 0.9818
## 1624/1875 [=======================>.....] - ETA: 1s - loss: 0.0615 - accuracy: 0.9817
## 1631/1875 [========================>....] - ETA: 1s - loss: 0.0615 - accuracy: 0.9817
## 1638/1875 [========================>....] - ETA: 1s - loss: 0.0615 - accuracy: 0.9818
## 1645/1875 [========================>....] - ETA: 1s - loss: 0.0613 - accuracy: 0.9818
## 1651/1875 [========================>....] - ETA: 1s - loss: 0.0613 - accuracy: 0.9818
## 1658/1875 [========================>....] - ETA: 1s - loss: 0.0614 - accuracy: 0.9818
## 1664/1875 [========================>....] - ETA: 1s - loss: 0.0613 - accuracy: 0.9818
## 1670/1875 [========================>....] - ETA: 1s - loss: 0.0613 - accuracy: 0.9818
## 1677/1875 [========================>....] - ETA: 1s - loss: 0.0614 - accuracy: 0.9818
## 1684/1875 [========================>....] - ETA: 1s - loss: 0.0612 - accuracy: 0.9818
## 1691/1875 [=========================>...] - ETA: 1s - loss: 0.0611 - accuracy: 0.9819
## 1698/1875 [=========================>...] - ETA: 1s - loss: 0.0611 - accuracy: 0.9819
## 1705/1875 [=========================>...] - ETA: 1s - loss: 0.0610 - accuracy: 0.9819
## 1713/1875 [=========================>...] - ETA: 1s - loss: 0.0611 - accuracy: 0.9819
## 1721/1875 [=========================>...] - ETA: 1s - loss: 0.0610 - accuracy: 0.9819
## 1730/1875 [=========================>...] - ETA: 0s - loss: 0.0610 - accuracy: 0.9819
## 1738/1875 [=========================>...] - ETA: 0s - loss: 0.0610 - accuracy: 0.9818
## 1746/1875 [=========================>...] - ETA: 0s - loss: 0.0609 - accuracy: 0.9819
## 1754/1875 [==========================>..] - ETA: 0s - loss: 0.0609 - accuracy: 0.9819
## 1762/1875 [==========================>..] - ETA: 0s - loss: 0.0610 - accuracy: 0.9819
## 1770/1875 [==========================>..] - ETA: 0s - loss: 0.0609 - accuracy: 0.9819
## 1778/1875 [==========================>..] - ETA: 0s - loss: 0.0610 - accuracy: 0.9818
## 1786/1875 [==========================>..] - ETA: 0s - loss: 0.0610 - accuracy: 0.9818
## 1794/1875 [==========================>..] - ETA: 0s - loss: 0.0612 - accuracy: 0.9817
## 1802/1875 [==========================>..] - ETA: 0s - loss: 0.0611 - accuracy: 0.9818
## 1810/1875 [==========================>..] - ETA: 0s - loss: 0.0614 - accuracy: 0.9817
## 1818/1875 [==========================>.] - ETA: 0s - loss: 0.0613 - accuracy: 0.9817
## 1826/1875 [==========================>.] - ETA: 0s - loss: 0.0612 - accuracy: 0.9817
```

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## 1834/1875 [============================>.] - ETA: 0s - loss: 0.0612 - accuracy: 0.9817
## 1842/1875 [============================>.] - ETA: 0s - loss: 0.0612 - accuracy: 0.9817
## 1850/1875 [============================>.] - ETA: 0s - loss: 0.0612 - accuracy: 0.9817
## 1858/1875 [============================>.] - ETA: 0s - loss: 0.0611 - accuracy: 0.9817
## 1866/1875 [============================>.] - ETA: 0s - loss: 0.0613 - accuracy: 0.9816
## 1875/1875 [==============================] - ETA: 0s - loss: 0.0612 - accuracy: 0.9816
## 1875/1875 [==============================] - 13s 7ms/step - loss: 0.0612 - accuracy: 0.9816
## Epoch 5/5
##
##    1/1875 [..............................] - ETA: 11s - loss: 0.0141 - accuracy: 1.0000
##    9/1875 [..............................] - ETA: 11s - loss: 0.0484 - accuracy: 0.9826
##   17/1875 [..............................] - ETA: 12s - loss: 0.0373 - accuracy: 0.9871
##   25/1875 [..............................] - ETA: 12s - loss: 0.0391 - accuracy: 0.9887
##   33/1875 [..............................] - ETA: 12s - loss: 0.0544 - accuracy: 0.9848
##   41/1875 [..............................] - ETA: 12s - loss: 0.0522 - accuracy: 0.9855
##   48/1875 [..............................] - ETA: 12s - loss: 0.0486 - accuracy: 0.9863
##   56/1875 [..............................] - ETA: 12s - loss: 0.0534 - accuracy: 0.9849
##   64/1875 [>.............................] - ETA: 12s - loss: 0.0507 - accuracy: 0.9854
##   72/1875 [>.............................] - ETA: 12s - loss: 0.0492 - accuracy: 0.9852
##   80/1875 [>.............................] - ETA: 12s - loss: 0.0489 - accuracy: 0.9859
##   88/1875 [>.............................] - ETA: 12s - loss: 0.0466 - accuracy: 0.9869
##   96/1875 [>.............................] - ETA: 12s - loss: 0.0458 - accuracy: 0.9870
##  103/1875 [>.............................] - ETA: 12s - loss: 0.0449 - accuracy: 0.9873
##  110/1875 [>.............................] - ETA: 12s - loss: 0.0445 - accuracy: 0.9875
##  117/1875 [>.............................] - ETA: 12s - loss: 0.0435 - accuracy: 0.9874
##  124/1875 [>.............................] - ETA: 12s - loss: 0.0435 - accuracy: 0.9874
##  131/1875 [=>............................] - ETA: 12s - loss: 0.0441 - accuracy: 0.9871
##  139/1875 [=>............................] - ETA: 12s - loss: 0.0445 - accuracy: 0.9872
##  147/1875 [=>............................] - ETA: 11s - loss: 0.0454 - accuracy: 0.9866
##  153/1875 [=>............................] - ETA: 12s - loss: 0.0452 - accuracy: 0.9867
##  160/1875 [=>............................] - ETA: 12s - loss: 0.0443 - accuracy: 0.9871
##  168/1875 [=>............................] - ETA: 11s - loss: 0.0441 - accuracy: 0.9870
##  176/1875 [=>............................] - ETA: 11s - loss: 0.0442 - accuracy: 0.9867
##  184/1875 [=>............................] - ETA: 11s - loss: 0.0442 - accuracy: 0.9869
##  192/1875 [==>...........................] - ETA: 11s - loss: 0.0440 - accuracy: 0.9870
##  200/1875 [==>...........................] - ETA: 11s - loss: 0.0436 - accuracy: 0.9870
##  208/1875 [==>...........................] - ETA: 11s - loss: 0.0433 - accuracy: 0.9869
##  216/1875 [==>...........................] - ETA: 11s - loss: 0.0428 - accuracy: 0.9871
##  223/1875 [==>...........................] - ETA: 11s - loss: 0.0420 - accuracy: 0.9874
##  229/1875 [==>...........................] - ETA: 11s - loss: 0.0420 - accuracy: 0.9872
##  235/1875 [==>...........................] - ETA: 11s - loss: 0.0421 - accuracy: 0.9871
##  241/1875 [==>...........................] - ETA: 11s - loss: 0.0421 - accuracy: 0.9869
##  249/1875 [==>...........................] - ETA: 11s - loss: 0.0431 - accuracy: 0.9866
##  257/1875 [===>..........................] - ETA: 11s - loss: 0.0433 - accuracy: 0.9866
##  266/1875 [===>..........................] - ETA: 11s - loss: 0.0445 - accuracy: 0.9864
##  274/1875 [===>..........................] - ETA: 11s - loss: 0.0440 - accuracy: 0.9865
##  282/1875 [===>..........................] - ETA: 11s - loss: 0.0441 - accuracy: 0.9867
##  290/1875 [===>..........................] - ETA: 11s - loss: 0.0442 - accuracy: 0.9865
##  298/1875 [===>..........................] - ETA: 10s - loss: 0.0435 - accuracy: 0.9869
##  306/1875 [===>..........................] - ETA: 10s - loss: 0.0439 - accuracy: 0.9869
##  314/1875 [====>.........................] - ETA: 10s - loss: 0.0438 - accuracy: 0.9869
##  322/1875 [====>.........................] - ETA: 10s - loss: 0.0436 - accuracy: 0.9870
##  330/1875 [====>.........................] - ETA: 10s - loss: 0.0430 - accuracy: 0.9873
##  338/1875 [====>.........................] - ETA: 10s - loss: 0.0428 - accuracy: 0.9874
```

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##  346/1875 [====>.....................] - ETA: 10s - loss: 0.0429 - accuracy: 0.9873
##  354/1875 [====>.....................] - ETA: 10s - loss: 0.0432 - accuracy: 0.9869
##  362/1875 [====>.....................] - ETA: 10s - loss: 0.0428 - accuracy: 0.9870
##  369/1875 [====>.....................] - ETA: 10s - loss: 0.0429 - accuracy: 0.9869
##  377/1875 [=====>....................] - ETA: 10s - loss: 0.0434 - accuracy: 0.9868
##  384/1875 [=====>....................] - ETA: 10s - loss: 0.0436 - accuracy: 0.9867
##  391/1875 [=====>....................] - ETA: 10s - loss: 0.0440 - accuracy: 0.9867
##  398/1875 [=====>....................] - ETA: 10s - loss: 0.0437 - accuracy: 0.9867
##  406/1875 [=====>....................] - ETA: 10s - loss: 0.0436 - accuracy: 0.9867
##  414/1875 [=====>....................] - ETA: 10s - loss: 0.0432 - accuracy: 0.9869
##  422/1875 [=====>....................] - ETA: 10s - loss: 0.0428 - accuracy: 0.9871
##  430/1875 [=====>....................] - ETA: 10s - loss: 0.0427 - accuracy: 0.9871
##  438/1875 [======>...................] - ETA: 9s - loss: 0.0433 - accuracy: 0.9872
##  446/1875 [======>...................] - ETA: 9s - loss: 0.0435 - accuracy: 0.9870
##  455/1875 [======>...................] - ETA: 9s - loss: 0.0434 - accuracy: 0.9872
##  463/1875 [======>...................] - ETA: 9s - loss: 0.0434 - accuracy: 0.9870
##  471/1875 [======>...................] - ETA: 9s - loss: 0.0435 - accuracy: 0.9869
##  479/1875 [======>...................] - ETA: 9s - loss: 0.0440 - accuracy: 0.9868
##  487/1875 [======>...................] - ETA: 9s - loss: 0.0450 - accuracy: 0.9866
##  495/1875 [======>...................] - ETA: 9s - loss: 0.0449 - accuracy: 0.9866
##  503/1875 [=======>..................] - ETA: 9s - loss: 0.0452 - accuracy: 0.9865
##  511/1875 [=======>..................] - ETA: 9s - loss: 0.0451 - accuracy: 0.9864
##  519/1875 [=======>..................] - ETA: 9s - loss: 0.0449 - accuracy: 0.9864
##  527/1875 [=======>..................] - ETA: 9s - loss: 0.0448 - accuracy: 0.9865
##  535/1875 [=======>..................] - ETA: 9s - loss: 0.0452 - accuracy: 0.9864
##  543/1875 [=======>..................] - ETA: 9s - loss: 0.0453 - accuracy: 0.9864
##  550/1875 [=======>..................] - ETA: 9s - loss: 0.0451 - accuracy: 0.9865
##  558/1875 [=======>..................] - ETA: 8s - loss: 0.0449 - accuracy: 0.9866
##  566/1875 [========>.................] - ETA: 8s - loss: 0.0448 - accuracy: 0.9867
##  574/1875 [========>.................] - ETA: 8s - loss: 0.0446 - accuracy: 0.9868
##  582/1875 [========>.................] - ETA: 8s - loss: 0.0449 - accuracy: 0.9867
##  590/1875 [========>.................] - ETA: 8s - loss: 0.0454 - accuracy: 0.9866
##  598/1875 [========>.................] - ETA: 8s - loss: 0.0459 - accuracy: 0.9865
##  606/1875 [========>.................] - ETA: 8s - loss: 0.0461 - accuracy: 0.9864
##  614/1875 [========>.................] - ETA: 8s - loss: 0.0460 - accuracy: 0.9863
##  622/1875 [========>.................] - ETA: 8s - loss: 0.0461 - accuracy: 0.9861
##  630/1875 [=========>................] - ETA: 8s - loss: 0.0461 - accuracy: 0.9861
##  638/1875 [=========>................] - ETA: 8s - loss: 0.0463 - accuracy: 0.9859
##  646/1875 [=========>................] - ETA: 8s - loss: 0.0464 - accuracy: 0.9859
##  653/1875 [=========>................] - ETA: 8s - loss: 0.0468 - accuracy: 0.9857
##  661/1875 [=========>................] - ETA: 8s - loss: 0.0468 - accuracy: 0.9857
##  669/1875 [=========>................] - ETA: 8s - loss: 0.0468 - accuracy: 0.9858
##  677/1875 [=========>................] - ETA: 8s - loss: 0.0467 - accuracy: 0.9858
##  685/1875 [=========>................] - ETA: 8s - loss: 0.0467 - accuracy: 0.9858
##  693/1875 [==========>...............] - ETA: 8s - loss: 0.0469 - accuracy: 0.9858
##  701/1875 [==========>...............] - ETA: 7s - loss: 0.0469 - accuracy: 0.9858
##  709/1875 [==========>...............] - ETA: 7s - loss: 0.0467 - accuracy: 0.9859
##  717/1875 [==========>...............] - ETA: 7s - loss: 0.0469 - accuracy: 0.9857
##  725/1875 [==========>...............] - ETA: 7s - loss: 0.0467 - accuracy: 0.9857
##  732/1875 [==========>...............] - ETA: 7s - loss: 0.0465 - accuracy: 0.9859
##  738/1875 [==========>...............] - ETA: 7s - loss: 0.0465 - accuracy: 0.9859
##  740/1875 [==========>...............] - ETA: 7s - loss: 0.0464 - accuracy: 0.9859
##  743/1875 [==========>...............] - ETA: 7s - loss: 0.0471 - accuracy: 0.9858
##  750/1875 [===========>..............] - ETA: 7s - loss: 0.0471 - accuracy: 0.9858
```

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##  758/1875 [===========>..................] - ETA: 7s - loss: 0.0473 - accuracy: 0.9857
##  765/1875 [===========>..................] - ETA: 7s - loss: 0.0472 - accuracy: 0.9857
##  771/1875 [===========>..................] - ETA: 7s - loss: 0.0471 - accuracy: 0.9857
##  778/1875 [===========>..................] - ETA: 7s - loss: 0.0470 - accuracy: 0.9858
##  785/1875 [===========>..................] - ETA: 7s - loss: 0.0472 - accuracy: 0.9857
##  791/1875 [===========>..................] - ETA: 7s - loss: 0.0472 - accuracy: 0.9857
##  798/1875 [===========>..................] - ETA: 7s - loss: 0.0472 - accuracy: 0.9857
##  804/1875 [===========>..................] - ETA: 7s - loss: 0.0473 - accuracy: 0.9857
##  810/1875 [===========>..................] - ETA: 7s - loss: 0.0471 - accuracy: 0.9858
##  817/1875 [============>.................] - ETA: 7s - loss: 0.0471 - accuracy: 0.9858
##  824/1875 [============>.................] - ETA: 7s - loss: 0.0469 - accuracy: 0.9859
##  831/1875 [============>.................] - ETA: 7s - loss: 0.0469 - accuracy: 0.9859
##  838/1875 [============>.................] - ETA: 7s - loss: 0.0468 - accuracy: 0.9859
##  844/1875 [============>.................] - ETA: 7s - loss: 0.0467 - accuracy: 0.9860
##  850/1875 [============>.................] - ETA: 7s - loss: 0.0467 - accuracy: 0.9860
##  856/1875 [============>.................] - ETA: 7s - loss: 0.0467 - accuracy: 0.9859
##  863/1875 [============>.................] - ETA: 7s - loss: 0.0468 - accuracy: 0.9860
##  869/1875 [============>.................] - ETA: 7s - loss: 0.0468 - accuracy: 0.9859
##  876/1875 [=============>................] - ETA: 7s - loss: 0.0467 - accuracy: 0.9859
##  882/1875 [=============>................] - ETA: 7s - loss: 0.0467 - accuracy: 0.9860
##  889/1875 [=============>................] - ETA: 7s - loss: 0.0469 - accuracy: 0.9860
##  896/1875 [=============>................] - ETA: 6s - loss: 0.0466 - accuracy: 0.9861
##  902/1875 [=============>................] - ETA: 6s - loss: 0.0466 - accuracy: 0.9861
##  909/1875 [=============>................] - ETA: 6s - loss: 0.0465 - accuracy: 0.9860
##  916/1875 [=============>................] - ETA: 6s - loss: 0.0467 - accuracy: 0.9860
##  923/1875 [=============>................] - ETA: 6s - loss: 0.0466 - accuracy: 0.9861
##  930/1875 [=============>................] - ETA: 6s - loss: 0.0467 - accuracy: 0.9860
##  937/1875 [=============>................] - ETA: 6s - loss: 0.0465 - accuracy: 0.9861
##  944/1875 [==============>...............] - ETA: 6s - loss: 0.0465 - accuracy: 0.9861
##  950/1875 [==============>...............] - ETA: 6s - loss: 0.0464 - accuracy: 0.9862
##  957/1875 [==============>...............] - ETA: 6s - loss: 0.0465 - accuracy: 0.9861
##  960/1875 [==============>...............] - ETA: 6s - loss: 0.0464 - accuracy: 0.9861
##  966/1875 [==============>...............] - ETA: 6s - loss: 0.0463 - accuracy: 0.9862
##  974/1875 [==============>...............] - ETA: 6s - loss: 0.0464 - accuracy: 0.9861
##  980/1875 [==============>...............] - ETA: 6s - loss: 0.0465 - accuracy: 0.9860
##  987/1875 [==============>...............] - ETA: 6s - loss: 0.0464 - accuracy: 0.9860
##  994/1875 [==============>...............] - ETA: 6s - loss: 0.0465 - accuracy: 0.9860
## 1002/1875 [===============>..............] - ETA: 6s - loss: 0.0463 - accuracy: 0.9860
## 1009/1875 [===============>..............] - ETA: 6s - loss: 0.0462 - accuracy: 0.9860
## 1017/1875 [===============>..............] - ETA: 6s - loss: 0.0463 - accuracy: 0.9860
## 1025/1875 [===============>..............] - ETA: 6s - loss: 0.0466 - accuracy: 0.9860
## 1033/1875 [===============>..............] - ETA: 6s - loss: 0.0467 - accuracy: 0.9859
## 1041/1875 [===============>..............] - ETA: 6s - loss: 0.0465 - accuracy: 0.9860
## 1049/1875 [===============>..............] - ETA: 5s - loss: 0.0465 - accuracy: 0.9860
## 1057/1875 [===============>..............] - ETA: 5s - loss: 0.0467 - accuracy: 0.9860
## 1065/1875 [================>.............] - ETA: 5s - loss: 0.0468 - accuracy: 0.9859
## 1073/1875 [================>.............] - ETA: 5s - loss: 0.0466 - accuracy: 0.9860
## 1082/1875 [================>.............] - ETA: 5s - loss: 0.0468 - accuracy: 0.9860
## 1090/1875 [================>.............] - ETA: 5s - loss: 0.0467 - accuracy: 0.9860
## 1099/1875 [================>.............] - ETA: 5s - loss: 0.0466 - accuracy: 0.9860
## 1107/1875 [================>.............] - ETA: 5s - loss: 0.0466 - accuracy: 0.9859
## 1115/1875 [================>.............] - ETA: 5s - loss: 0.0465 - accuracy: 0.9860
## 1123/1875 [================>.............] - ETA: 5s - loss: 0.0463 - accuracy: 0.9860
## 1131/1875 [=================>............] - ETA: 5s - loss: 0.0462 - accuracy: 0.9861
```

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## 1139/1875 [================>............] - ETA: 5s - loss: 0.0461 - accuracy: 0.9861
## 1147/1875 [================>............] - ETA: 5s - loss: 0.0460 - accuracy: 0.9861
## 1155/1875 [================>............] - ETA: 5s - loss: 0.0460 - accuracy: 0.9861
## 1163/1875 [================>............] - ETA: 5s - loss: 0.0462 - accuracy: 0.9860
## 1172/1875 [================>............] - ETA: 5s - loss: 0.0462 - accuracy: 0.9860
## 1181/1875 [=================>............] - ETA: 4s - loss: 0.0464 - accuracy: 0.9860
## 1188/1875 [=================>............] - ETA: 4s - loss: 0.0463 - accuracy: 0.9859
## 1198/1875 [=================>............] - ETA: 4s - loss: 0.0462 - accuracy: 0.9859
## 1207/1875 [=================>............] - ETA: 4s - loss: 0.0463 - accuracy: 0.9858
## 1216/1875 [=================>............] - ETA: 4s - loss: 0.0462 - accuracy: 0.9859
## 1226/1875 [=================>............] - ETA: 4s - loss: 0.0461 - accuracy: 0.9859
## 1234/1875 [=================>............] - ETA: 4s - loss: 0.0461 - accuracy: 0.9859
## 1244/1875 [=================>............] - ETA: 4s - loss: 0.0462 - accuracy: 0.9859
## 1254/1875 [==================>...........] - ETA: 4s - loss: 0.0463 - accuracy: 0.9859
## 1262/1875 [==================>...........] - ETA: 4s - loss: 0.0462 - accuracy: 0.9859
## 1269/1875 [==================>...........] - ETA: 4s - loss: 0.0460 - accuracy: 0.9860
## 1277/1875 [==================>...........] - ETA: 4s - loss: 0.0459 - accuracy: 0.9860
## 1285/1875 [==================>...........] - ETA: 4s - loss: 0.0458 - accuracy: 0.9860
## 1293/1875 [==================>...........] - ETA: 4s - loss: 0.0456 - accuracy: 0.9861
## 1301/1875 [==================>...........] - ETA: 4s - loss: 0.0457 - accuracy: 0.9861
## 1309/1875 [==================>...........] - ETA: 3s - loss: 0.0456 - accuracy: 0.9861
## 1317/1875 [===================>..........] - ETA: 3s - loss: 0.0456 - accuracy: 0.9861
## 1325/1875 [===================>..........] - ETA: 3s - loss: 0.0455 - accuracy: 0.9861
## 1333/1875 [===================>..........] - ETA: 3s - loss: 0.0455 - accuracy: 0.9861
## 1341/1875 [===================>..........] - ETA: 3s - loss: 0.0455 - accuracy: 0.9861
## 1349/1875 [===================>..........] - ETA: 3s - loss: 0.0454 - accuracy: 0.9862
## 1357/1875 [===================>..........] - ETA: 3s - loss: 0.0454 - accuracy: 0.9862
## 1366/1875 [===================>..........] - ETA: 3s - loss: 0.0455 - accuracy: 0.9862
## 1374/1875 [===================>..........] - ETA: 3s - loss: 0.0454 - accuracy: 0.9862
## 1382/1875 [====================>.........] - ETA: 3s - loss: 0.0457 - accuracy: 0.9861
## 1390/1875 [====================>.........] - ETA: 3s - loss: 0.0459 - accuracy: 0.9861
## 1398/1875 [====================>.........] - ETA: 3s - loss: 0.0459 - accuracy: 0.9861
## 1406/1875 [====================>.........] - ETA: 3s - loss: 0.0461 - accuracy: 0.9860
## 1415/1875 [====================>.........] - ETA: 3s - loss: 0.0463 - accuracy: 0.9860
## 1423/1875 [====================>.........] - ETA: 3s - loss: 0.0462 - accuracy: 0.9860
## 1431/1875 [====================>.........] - ETA: 3s - loss: 0.0464 - accuracy: 0.9859
## 1439/1875 [=====================>........] - ETA: 3s - loss: 0.0464 - accuracy: 0.9859
## 1447/1875 [=====================>........] - ETA: 2s - loss: 0.0463 - accuracy: 0.9860
## 1455/1875 [=====================>........] - ETA: 2s - loss: 0.0464 - accuracy: 0.9859
## 1463/1875 [=====================>........] - ETA: 2s - loss: 0.0464 - accuracy: 0.9859
## 1471/1875 [=====================>........] - ETA: 2s - loss: 0.0463 - accuracy: 0.9859
## 1479/1875 [=====================>........] - ETA: 2s - loss: 0.0463 - accuracy: 0.9859
## 1487/1875 [=====================>........] - ETA: 2s - loss: 0.0463 - accuracy: 0.9860
## 1495/1875 [=====================>........] - ETA: 2s - loss: 0.0465 - accuracy: 0.9859
## 1502/1875 [======================>.......] - ETA: 2s - loss: 0.0464 - accuracy: 0.9859
## 1510/1875 [======================>.......] - ETA: 2s - loss: 0.0464 - accuracy: 0.9859
## 1518/1875 [======================>.......] - ETA: 2s - loss: 0.0465 - accuracy: 0.9859
## 1526/1875 [======================>.......] - ETA: 2s - loss: 0.0465 - accuracy: 0.9859
## 1535/1875 [======================>.......] - ETA: 2s - loss: 0.0464 - accuracy: 0.9859
## 1543/1875 [======================>.......] - ETA: 2s - loss: 0.0467 - accuracy: 0.9858
## 1551/1875 [======================>.......] - ETA: 2s - loss: 0.0466 - accuracy: 0.9858
## 1560/1875 [======================>.......] - ETA: 2s - loss: 0.0467 - accuracy: 0.9858
## 1569/1875 [=======================>......] - ETA: 2s - loss: 0.0466 - accuracy: 0.9859
## 1577/1875 [=======================>......] - ETA: 2s - loss: 0.0466 - accuracy: 0.9859
```

```
## 1585/1875 [=======================>.....] - ETA: 2s - loss: 0.0464 - accuracy: 0.9860
## 1593/1875 [=======================>.....] - ETA: 1s - loss: 0.0464 - accuracy: 0.9860
## 1601/1875 [=======================>.....] - ETA: 1s - loss: 0.0464 - accuracy: 0.9860
## 1609/1875 [=======================>.....] - ETA: 1s - loss: 0.0465 - accuracy: 0.9860
## 1617/1875 [=======================>.....] - ETA: 1s - loss: 0.0464 - accuracy: 0.9860
## 1625/1875 [========================>....] - ETA: 1s - loss: 0.0463 - accuracy: 0.9861
## 1633/1875 [========================>....] - ETA: 1s - loss: 0.0464 - accuracy: 0.9860
## 1641/1875 [========================>....] - ETA: 1s - loss: 0.0463 - accuracy: 0.9861
## 1649/1875 [========================>....] - ETA: 1s - loss: 0.0462 - accuracy: 0.9861
## 1657/1875 [========================>....] - ETA: 1s - loss: 0.0463 - accuracy: 0.9862
## 1665/1875 [========================>....] - ETA: 1s - loss: 0.0463 - accuracy: 0.9861
## 1673/1875 [========================>....] - ETA: 1s - loss: 0.0464 - accuracy: 0.9861
## 1681/1875 [========================>....] - ETA: 1s - loss: 0.0465 - accuracy: 0.9861
## 1689/1875 [========================>...] - ETA: 1s - loss: 0.0466 - accuracy: 0.9861
## 1697/1875 [========================>...] - ETA: 1s - loss: 0.0465 - accuracy: 0.9861
## 1705/1875 [========================>...] - ETA: 1s - loss: 0.0465 - accuracy: 0.9861
## 1713/1875 [========================>...] - ETA: 1s - loss: 0.0466 - accuracy: 0.9861
## 1721/1875 [========================>...] - ETA: 1s - loss: 0.0468 - accuracy: 0.9860
## 1729/1875 [========================>...] - ETA: 1s - loss: 0.0468 - accuracy: 0.9860
## 1737/1875 [========================>...] - ETA: 0s - loss: 0.0468 - accuracy: 0.9860
## 1745/1875 [========================>...] - ETA: 0s - loss: 0.0467 - accuracy: 0.9860
## 1753/1875 [========================>..] - ETA: 0s - loss: 0.0466 - accuracy: 0.9861
## 1761/1875 [========================>..] - ETA: 0s - loss: 0.0464 - accuracy: 0.9861
## 1769/1875 [========================>..] - ETA: 0s - loss: 0.0466 - accuracy: 0.9861
## 1777/1875 [========================>..] - ETA: 0s - loss: 0.0468 - accuracy: 0.9861
## 1786/1875 [========================>..] - ETA: 0s - loss: 0.0468 - accuracy: 0.9861
## 1795/1875 [========================>..] - ETA: 0s - loss: 0.0470 - accuracy: 0.9861
## 1803/1875 [========================>..] - ETA: 0s - loss: 0.0470 - accuracy: 0.9860
## 1811/1875 [========================>..] - ETA: 0s - loss: 0.0469 - accuracy: 0.9861
## 1819/1875 [=========================>.] - ETA: 0s - loss: 0.0471 - accuracy: 0.9860
## 1827/1875 [=========================>.] - ETA: 0s - loss: 0.0471 - accuracy: 0.9860
## 1836/1875 [=========================>.] - ETA: 0s - loss: 0.0470 - accuracy: 0.9860
## 1844/1875 [=========================>.] - ETA: 0s - loss: 0.0469 - accuracy: 0.9860
## 1852/1875 [=========================>.] - ETA: 0s - loss: 0.0470 - accuracy: 0.9860
## 1860/1875 [=========================>.] - ETA: 0s - loss: 0.0470 - accuracy: 0.9860
## 1868/1875 [=========================>.] - ETA: 0s - loss: 0.0470 - accuracy: 0.9860
## 1875/1875 [==============================] - 13s 7ms/step - loss: 0.0471 - accuracy: 0.9859

## <keras.src.callbacks.History object at 0x000001FFA8412710>
```

```
# Evaluate the model
metrics <- model$evaluate(test_images, test_labels)
```

```
##
##   1/313 [..............................] - ETA: 1:35 - loss: 0.0305 - accuracy: 0.9688
##  22/313 [=>............................] - ETA: 0s - loss: 0.0709 - accuracy: 0.9716
##  39/313 [==>...........................] - ETA: 0s - loss: 0.0906 - accuracy: 0.9671
##  65/313 [=====>........................] - ETA: 0s - loss: 0.1073 - accuracy: 0.9630
##  93/313 [=======>......................] - ETA: 0s - loss: 0.1109 - accuracy: 0.9644
## 121/313 [==========>...................] - ETA: 0s - loss: 0.1092 - accuracy: 0.9667
## 148/313 [=============>................] - ETA: 0s - loss: 0.1099 - accuracy: 0.9660
## 177/313 [===============>..............] - ETA: 0s - loss: 0.1006 - accuracy: 0.9688
## 209/313 [===================>..........] - ETA: 0s - loss: 0.0974 - accuracy: 0.9701
```

```
## 239/313 [====================>.........] - ETA: 0s - loss: 0.0883 - accuracy: 0.9731
## 267/313 [=====================>.....] - ETA: 0s - loss: 0.0841 - accuracy: 0.9743
## 296/313 [=========================>..] - ETA: 0s - loss: 0.0771 - accuracy: 0.9764
## 313/313 [==============================] - 1s 2ms/step - loss: 0.0791 - accuracy: 0.9756
```

```r
test_loss <- metrics[[1]]
test_acc <- metrics[[2]]
print(paste("Test accuracy:", test_acc))
```

```
## [1] "Test accuracy: 0.975600004196167"
```

Reinforcement Learning

Using OpenAI Gym for Reinforcement Learning

```r
# Import necessary libraries
gym <- import("gym")
np <- import("numpy")

# Create the environment
env <- gym$make("CartPole-v1")

# Define the number of episodes and the maximum number of steps per episode
num_episodes <- 50
max_steps <- 100

# Initialize a list to store total rewards per episode
total_rewards <- numeric(num_episodes)

# Run episodes
for (episode in 1:num_episodes) {
  state <- env$reset()
  total_reward <- 0

  for (step in 1:max_steps) {
    # Take a random action
    action <- env$action_space$sample()

    # Perform the action in the environment
    result <- env$step(action)
    new_state <- result[[1]]
    reward <- result[[2]]
    done <- result[[3]]

    # Accumulate the reward
    total_reward <- total_reward + reward

    # Update the state
    state <- new_state
```

```
    # Break the loop if the episode is finished
    if (done) {
      break
    }
  }
  total_rewards[episode] <- total_reward
  print(paste("Episode:", episode, "Total Reward:", total_reward))
}
```

```
## [1] "Episode: 1 Total Reward: 25"
## [1] "Episode: 2 Total Reward: 25"
## [1] "Episode: 3 Total Reward: 27"
## [1] "Episode: 4 Total Reward: 12"
## [1] "Episode: 5 Total Reward: 22"
## [1] "Episode: 6 Total Reward: 15"
## [1] "Episode: 7 Total Reward: 13"
## [1] "Episode: 8 Total Reward: 18"
## [1] "Episode: 9 Total Reward: 14"
## [1] "Episode: 10 Total Reward: 20"
## [1] "Episode: 11 Total Reward: 23"
## [1] "Episode: 12 Total Reward: 11"
## [1] "Episode: 13 Total Reward: 28"
## [1] "Episode: 14 Total Reward: 47"
## [1] "Episode: 15 Total Reward: 22"
## [1] "Episode: 16 Total Reward: 15"
## [1] "Episode: 17 Total Reward: 16"
## [1] "Episode: 18 Total Reward: 58"
## [1] "Episode: 19 Total Reward: 29"
## [1] "Episode: 20 Total Reward: 11"
## [1] "Episode: 21 Total Reward: 9"
## [1] "Episode: 22 Total Reward: 38"
## [1] "Episode: 23 Total Reward: 27"
## [1] "Episode: 24 Total Reward: 38"
## [1] "Episode: 25 Total Reward: 19"
## [1] "Episode: 26 Total Reward: 13"
## [1] "Episode: 27 Total Reward: 24"
## [1] "Episode: 28 Total Reward: 12"
## [1] "Episode: 29 Total Reward: 31"
## [1] "Episode: 30 Total Reward: 15"
## [1] "Episode: 31 Total Reward: 11"
## [1] "Episode: 32 Total Reward: 18"
## [1] "Episode: 33 Total Reward: 57"
## [1] "Episode: 34 Total Reward: 16"
## [1] "Episode: 35 Total Reward: 26"
## [1] "Episode: 36 Total Reward: 10"
## [1] "Episode: 37 Total Reward: 23"
## [1] "Episode: 38 Total Reward: 17"
## [1] "Episode: 39 Total Reward: 10"
## [1] "Episode: 40 Total Reward: 19"
## [1] "Episode: 41 Total Reward: 24"
## [1] "Episode: 42 Total Reward: 38"
## [1] "Episode: 43 Total Reward: 10"
## [1] "Episode: 44 Total Reward: 14"
```

```
## [1] "Episode: 45 Total Reward: 11"
## [1] "Episode: 46 Total Reward: 36"
## [1] "Episode: 47 Total Reward: 16"
## [1] "Episode: 48 Total Reward: 12"
## [1] "Episode: 49 Total Reward: 19"
## [1] "Episode: 50 Total Reward: 27"
```

```
env$close()

# Plot the total rewards per episode
library(ggplot2)
```

```
## Warning: le package 'ggplot2' a été compilé avec la version R 4.2.3
```

```
df <- data.frame(episode = 1:num_episodes, total_reward = total_rewards)
ggplot(df, aes(x = episode, y = total_reward)) +
  geom_line() +
  labs(title = "Total Reward per Episode",
       x = "Episode",
       y = "Total Reward")
```