TRABALHO DE INTELIGÊNCIA ARTIFICIAL

DEEP LEARNING

Rock-Paper-Scissors Images DATASET (link abaixo)

https://www.kaggle.com/datasets/drgfreeman/rockpaperscissors

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https://github.com/GuilhermeZCanesin/DeepLearning-2022.1.git

In [12]:
```
import keras
import tensorflow as tf
from keras.datasets import mnist
from keras.models import Sequential
from keras.layers import Dense, Dropout, Flatten
from keras.layers import Conv2D, MaxPooling2D, AveragePooling2D
import numpy as np
import pandas as pd
from sklearn.metrics import classification_report, confusion_matrix
import matplotlib.pyplot as plt
import seaborn as sn
from tensorflow.keras.preprocessing.image import load_img, img_to_array, array_to_img
from numba import cuda
from keras.optimizers import Adam
```

2. DEFINIÇÃO DO MODELO PRÉ TREINADO

4. TAMBÉM CONGELANDO PARTE DO MODELO PARA TREINO DA ÚLTIMA CAMADA

MODELO:

- INCEPTION V3

In [22]:
```
base_model = tf.keras.applications.InceptionV3(weights='imagenet', include_top=False, input_shape=(200, 300, 3))
for layer in base_model.layers:
    layer.trainable = False
```

10. DEFINIÇÃO DE VARIÁVEIS DE MODELO

In [16]:
```
batch_size = 32
# CLASSES (PEDRA - PAPEL - TESOURA)
num_classes = 3
dropout = 0.5
```

```
epochs = 500
lr = 0.001
```

5. ATRIBUINDO A FUNÇÃO DE ATIVAÇÃO DO MODELO

FUNÇÃO

- SOFTMAX

In [23]:
```
x = Flatten()(base_model.output)
x = Dense(1024, activation='relu')(x)
x = Dropout(dropout)(x)
x = Dense(num_classes, activation='softmax')(x)
```

CRIANDO O OBJETO DO MODELO

In [24]:
```
model = tf.keras.models.Model(base_model.input, x)
model.compile(Adam(learning_rate=lr),loss='categorical_crossentropy',metrics=['accuracy'])
```

9. CRIANDO OS CONJUNTOS DE TESTE E TREINO

1. BAIXANDO O CONJUNTO DE DADOS

In [28]:
```
# INICIALIZANDO O OBJETO QUE RECUPERA AS AMOSTRAS DE TREINO COM A FUNÇÃO INCEPTIONV3
train_data_gen = tf.keras.preprocessing.image.ImageDataGenerator(validation_split=0.2, preprocessing_function=tf.keras.applications.inception_v3.preprocess_input)

# DEFININDO O CAMINHO DAS IMAGENS (PASTA INPUT), OS NOMES DAS PASTAS DEVEM TER OS MESMOS NOMES APRESENTADOS EM "classes" ABAIXO
train_generator = train_data_gen.flow_from_directory('input/',
                                                     target_size=(200, 300),
                                                     batch_size=batch_size,
                                                     class_mode="categorical",
                                                     shuffle=False,
                                                     classes=['paper', 'rock', 'scissors'],
                                                     subset='training')

# DEFININDO O CAMINHO DAS IMAGENS (PASTA INPUT), OS NOMES DAS PASTAS DEVEM TER OS MESMOS NOMES APRESENTADOS EM "classes" ABAIXO
test_generator = train_data_gen.flow_from_directory('input/',
                                                     target_size=(200, 300),
                                                     batch_size=16,
                                                     class_mode="categorical",
                                                     shuffle=False,
                                                     classes=['paper', 'rock', 'scissors'],
                                                     subset='validation')
```

```
Found 1751 images belonging to 3 classes.
Found 437 images belonging to 3 classes.
```

EXECUTANDO O TREINO DO MODELO

6. OTIMIZADOR: ADAM

7. MÉTRICA DE AVALIAÇÃO: ACURÁCIA

8. MÉTRICA DE ERRO: CATEGORICAL CROSS ENTROPY

In [29]:
```
# DEFININDO OTIMIZADOR, FUNÇÃO DE CUSTO E MÉTRICA
model.compile(optimizer='Adam',loss='categorical_crossentropy',metrics=['accuracy'])


step_size_train = train_generator.n//train_generator.batch_size
step_size_test = test_generator.n//test_generator.batch_size


history = model.fit(
        train_generator,
        steps_per_epoch=step_size_train,
        epochs=epochs,
        shuffle=True,
        validation_data=test_generator,
        validation_steps=step_size_test)
```

```
Epoch 1/500
54/54 [==============================] - 285s 5s/step - loss: 50.9279 - accuracy: 0.6521 - val_loss: 0.9280 - val_accuracy: 0.9421
Epoch 2/500
54/54 [==============================] - 274s 5s/step - loss: 0.5931 - accuracy: 0.9500 - val_loss: 0.1617 - val_accuracy: 0.9722
Epoch 3/500
54/54 [==============================] - 264s 5s/step - loss: 0.1452 - accuracy: 0.9738 - val_loss: 0.0606 - val_accuracy: 0.9792
Epoch 4/500
54/54 [==============================] - 267s 5s/step - loss: 0.0778 - accuracy: 0.9808 - val_loss: 0.0526 - val_accuracy: 0.9815
Epoch 5/500
54/54 [==============================] - 287s 5s/step - loss: 0.0349 - accuracy: 0.9889 - val_loss: 0.0355 - val_accuracy: 0.9884
Epoch 6/500
54/54 [==============================] - 249s 5s/step - loss: 0.0270 - accuracy: 0.9913 - val_loss: 0.0450 - val_accuracy: 0.9884
Epoch 7/500
54/54 [==============================] - 261s 5s/step - loss: 0.0167 - accuracy: 0.9948 - val_loss: 0.0364 - val_accuracy: 0.9861
Epoch 8/500
54/54 [==============================] - 252s 5s/step - loss: 0.0219 - accuracy: 0.9953 - val_loss: 0.0269 - val_accuracy: 0.9884
Epoch 9/500
54/54 [==============================] - 266s 5s/step - loss: 0.0121 - accuracy: 0.9959 - val_loss: 0.0224 - val_accuracy: 0.9884
Epoch 10/500
54/54 [==============================] - 273s 5s/step - loss: 0.0104 - accuracy: 0.9977 - val_loss: 0.0209 - val_accuracy: 0.9931
Epoch 11/500
54/54 [==============================] - 283s 5s/step - loss: 0.0091 - accuracy: 0.9965 - val_loss: 0.0299 - val_accuracy: 0.9884
Epoch 12/500
54/54 [==============================] - 224s 4s/step - loss: 0.0223 - accuracy: 0.9942 - val_loss: 0.0263 - val_accuracy: 0.9907
Epoch 13/500
54/54 [==============================] - 224s 4s/step - loss: 0.0074 - accuracy: 0.9971 - val_loss: 0.0287 - val_accuracy: 0.9931
Epoch 14/500
54/54 [==============================] - 221s 4s/step - loss: 0.0185 - accuracy: 0.9948 - val_loss: 0.0274 - val_accuracy: 0.9907
Epoch 15/500
54/54 [==============================] - 230s 4s/step - loss: 0.0087 - accuracy: 0.9959 - val_loss: 0.0194 - val_accuracy: 0.9931
Epoch 16/500
54/54 [==============================] - 220s 4s/step - loss: 0.0028 - accuracy: 0.9994 - val_loss: 0.0369 - val_accuracy: 0.9907
Epoch 17/500
54/54 [==============================] - 221s 4s/step - loss: 0.0127 - accuracy: 0.9953 - val_loss: 0.0228 - val_accuracy: 0.9931
Epoch 18/500
54/54 [==============================] - 219s 4s/step - loss: 0.0069 - accuracy: 0.9988 - val_loss: 0.0160 - val_accuracy: 0.9954
Epoch 19/500
54/54 [==============================] - 221s 4s/step - loss: 0.0067 - accuracy: 0.9988 - val_loss: 0.0301 - val_accuracy: 0.9954
Epoch 20/500
54/54 [==============================] - 219s 4s/step - loss: 0.0037 - accuracy: 0.9983 - val_loss: 0.0318 - val_accuracy: 0.9931
Epoch 21/500
54/54 [==============================] - 219s 4s/step - loss: 0.0085 - accuracy: 0.9983 - val_loss: 0.0255 - val_accuracy: 0.9931
Epoch 22/500
54/54 [==============================] - 220s 4s/step - loss: 0.0104 - accuracy: 0.9953 - val_loss: 0.0184 - val_accuracy: 0.9907
Epoch 23/500
54/54 [==============================] - 223s 4s/step - loss: 0.0084 - accuracy: 0.9977 - val_loss: 0.0189 - val_accuracy: 0.9954
Epoch 24/500
54/54 [==============================] - 222s 4s/step - loss: 0.0117 - accuracy: 0.9959 - val_loss: 0.0386 - val_accuracy: 0.9931
Epoch 25/500
54/54 [==============================] - 221s 4s/step - loss: 0.0094 - accuracy: 0.9959 - val_loss: 0.0297 - val_accuracy: 0.9931
Epoch 26/500
54/54 [==============================] - 220s 4s/step - loss: 0.0061 - accuracy: 0.9971 - val_loss: 0.0308 - val_accuracy: 0.9954
Epoch 27/500
54/54 [==============================] - 224s 4s/step - loss: 0.0085 - accuracy: 0.9977 - val_loss: 0.0163 - val_accuracy: 0.9977
Epoch 28/500
```

```
54/54 [==============================] - 219s 4s/step - loss: 0.0082 - accuracy: 0.9977 - val_loss: 0.0225 - val_accuracy: 0.9954
Epoch 29/500
54/54 [==============================] - 220s 4s/step - loss: 0.0056 - accuracy: 0.9959 - val_loss: 0.0238 - val_accuracy: 0.9977
Epoch 30/500
54/54 [==============================] - 222s 4s/step - loss: 0.0067 - accuracy: 0.9971 - val_loss: 0.0331 - val_accuracy: 0.9954
Epoch 31/500
54/54 [==============================] - 221s 4s/step - loss: 0.0033 - accuracy: 0.9988 - val_loss: 0.0182 - val_accuracy: 0.9977
Epoch 32/500
54/54 [==============================] - 222s 4s/step - loss: 0.0029 - accuracy: 0.9994 - val_loss: 0.0202 - val_accuracy: 0.9977
Epoch 33/500
54/54 [==============================] - 220s 4s/step - loss: 0.0051 - accuracy: 0.9988 - val_loss: 0.0807 - val_accuracy: 0.9838
Epoch 34/500
54/54 [==============================] - 222s 4s/step - loss: 0.0097 - accuracy: 0.9942 - val_loss: 0.0276 - val_accuracy: 0.9954
Epoch 35/500
54/54 [==============================] - 225s 4s/step - loss: 0.0061 - accuracy: 0.9983 - val_loss: 0.0156 - val_accuracy: 0.9977
Epoch 36/500
54/54 [==============================] - 222s 4s/step - loss: 0.0093 - accuracy: 0.9942 - val_loss: 0.0662 - val_accuracy: 0.9861
Epoch 37/500
54/54 [==============================] - 220s 4s/step - loss: 0.0250 - accuracy: 0.9924 - val_loss: 0.1188 - val_accuracy: 0.9769
Epoch 38/500
54/54 [==============================] - 220s 4s/step - loss: 0.0126 - accuracy: 0.9965 - val_loss: 0.0432 - val_accuracy: 0.9861
Epoch 39/500
54/54 [==============================] - 220s 4s/step - loss: 0.0612 - accuracy: 0.9889 - val_loss: 0.2692 - val_accuracy: 0.9560
Epoch 40/500
54/54 [==============================] - 221s 4s/step - loss: 0.2393 - accuracy: 0.9622 - val_loss: 0.0959 - val_accuracy: 0.9838
Epoch 41/500
54/54 [==============================] - 221s 4s/step - loss: 0.0954 - accuracy: 0.9668 - val_loss: 0.0403 - val_accuracy: 0.9838
Epoch 42/500
54/54 [==============================] - 219s 4s/step - loss: 0.0782 - accuracy: 0.9744 - val_loss: 0.0627 - val_accuracy: 0.9745
Epoch 43/500
54/54 [==============================] - 224s 4s/step - loss: 0.0588 - accuracy: 0.9814 - val_loss: 0.0089 - val_accuracy: 0.9977
Epoch 44/500
54/54 [==============================] - 222s 4s/step - loss: 0.0366 - accuracy: 0.9849 - val_loss: 0.0171 - val_accuracy: 0.9977
Epoch 45/500
54/54 [==============================] - 219s 4s/step - loss: 0.0590 - accuracy: 0.9820 - val_loss: 0.0049 - val_accuracy: 1.0000
Epoch 46/500
54/54 [==============================] - 219s 4s/step - loss: 0.0434 - accuracy: 0.9884 - val_loss: 0.0070 - val_accuracy: 0.9954
Epoch 47/500
54/54 [==============================] - 220s 4s/step - loss: 0.0297 - accuracy: 0.9884 - val_loss: 0.0057 - val_accuracy: 0.9977
Epoch 48/500
54/54 [==============================] - 221s 4s/step - loss: 0.0188 - accuracy: 0.9907 - val_loss: 0.0066 - val_accuracy: 0.9954
Epoch 49/500
54/54 [==============================] - 219s 4s/step - loss: 0.0457 - accuracy: 0.9878 - val_loss: 0.0078 - val_accuracy: 0.9977
Epoch 50/500
54/54 [==============================] - 220s 4s/step - loss: 0.0774 - accuracy: 0.9740 - val_loss: 0.2646 - val_accuracy: 0.9583
Epoch 51/500
54/54 [==============================] - 221s 4s/step - loss: 0.0618 - accuracy: 0.9773 - val_loss: 0.0124 - val_accuracy: 0.9954
Epoch 52/500
54/54 [==============================] - 223s 4s/step - loss: 0.0329 - accuracy: 0.9860 - val_loss: 0.0203 - val_accuracy: 0.9954
Epoch 53/500
54/54 [==============================] - 219s 4s/step - loss: 0.0161 - accuracy: 0.9930 - val_loss: 6.7486e-04 - val_accuracy: 1.0000
Epoch 54/500
54/54 [==============================] - 219s 4s/step - loss: 0.0111 - accuracy: 0.9948 - val_loss: 0.0079 - val_accuracy: 0.9977
Epoch 55/500
54/54 [==============================] - 219s 4s/step - loss: 0.0240 - accuracy: 0.9889 - val_loss: 0.0054 - val_accuracy: 0.9977
```

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Epoch 56/500
54/54 [==============================] - 223s 4s/step - loss: 0.0237 - accuracy: 0.9930 - val_loss: 0.0293 - val_accuracy: 0.9954
Epoch 57/500
54/54 [==============================] - 221s 4s/step - loss: 0.0108 - accuracy: 0.9942 - val_loss: 0.0017 - val_accuracy: 1.0000
Epoch 58/500
54/54 [==============================] - 219s 4s/step - loss: 0.0159 - accuracy: 0.9953 - val_loss: 2.5907e-04 - val_accuracy: 1.0000
Epoch 59/500
54/54 [==============================] - 220s 4s/step - loss: 0.0183 - accuracy: 0.9942 - val_loss: 0.0081 - val_accuracy: 0.9977
Epoch 60/500
54/54 [==============================] - 222s 4s/step - loss: 0.0242 - accuracy: 0.9930 - val_loss: 0.0090 - val_accuracy: 0.9931
Epoch 61/500
54/54 [==============================] - 219s 4s/step - loss: 0.0318 - accuracy: 0.9907 - val_loss: 0.0248 - val_accuracy: 0.9977
Epoch 62/500
54/54 [==============================] - 218s 4s/step - loss: 0.0526 - accuracy: 0.9860 - val_loss: 6.0541e-04 - val_accuracy: 1.0000
Epoch 63/500
54/54 [==============================] - 220s 4s/step - loss: 0.0295 - accuracy: 0.9919 - val_loss: 0.0078 - val_accuracy: 0.9977
Epoch 64/500
54/54 [==============================] - 221s 4s/step - loss: 0.0237 - accuracy: 0.9930 - val_loss: 0.0233 - val_accuracy: 0.9977
Epoch 65/500
54/54 [==============================] - 219s 4s/step - loss: 0.0148 - accuracy: 0.9948 - val_loss: 0.0182 - val_accuracy: 0.9954
Epoch 66/500
54/54 [==============================] - 221s 4s/step - loss: 0.0189 - accuracy: 0.9942 - val_loss: 0.0425 - val_accuracy: 0.9954
Epoch 67/500
54/54 [==============================] - 219s 4s/step - loss: 0.0086 - accuracy: 0.9959 - val_loss: 0.0046 - val_accuracy: 0.9977
Epoch 68/500
54/54 [==============================] - 221s 4s/step - loss: 0.0199 - accuracy: 0.9942 - val_loss: 0.0013 - val_accuracy: 1.0000
Epoch 69/500
54/54 [==============================] - 220s 4s/step - loss: 0.0153 - accuracy: 0.9948 - val_loss: 0.0089 - val_accuracy: 0.9954
Epoch 70/500
54/54 [==============================] - 219s 4s/step - loss: 0.0281 - accuracy: 0.9942 - val_loss: 0.0063 - val_accuracy: 0.9977
Epoch 71/500
54/54 [==============================] - 218s 4s/step - loss: 0.0193 - accuracy: 0.9930 - val_loss: 0.0028 - val_accuracy: 1.0000
Epoch 72/500
54/54 [==============================] - 223s 4s/step - loss: 0.0130 - accuracy: 0.9948 - val_loss: 0.0125 - val_accuracy: 0.9977
Epoch 73/500
54/54 [==============================] - 220s 4s/step - loss: 0.0220 - accuracy: 0.9965 - val_loss: 0.0152 - val_accuracy: 0.9954
Epoch 74/500
54/54 [==============================] - 220s 4s/step - loss: 0.0308 - accuracy: 0.9930 - val_loss: 0.0136 - val_accuracy: 0.9954
Epoch 75/500
54/54 [==============================] - 219s 4s/step - loss: 0.0328 - accuracy: 0.9889 - val_loss: 0.0036 - val_accuracy: 0.9977
Epoch 76/500
54/54 [==============================] - 222s 4s/step - loss: 0.0128 - accuracy: 0.9936 - val_loss: 0.0072 - val_accuracy: 0.9977
Epoch 77/500
54/54 [==============================] - 219s 4s/step - loss: 0.0077 - accuracy: 0.9965 - val_loss: 0.0077 - val_accuracy: 0.9977
Epoch 78/500
54/54 [==============================] - 219s 4s/step - loss: 0.0087 - accuracy: 0.9948 - val_loss: 0.0059 - val_accuracy: 1.0000
Epoch 79/500
54/54 [==============================] - 219s 4s/step - loss: 0.0265 - accuracy: 0.9930 - val_loss: 0.0125 - val_accuracy: 0.9931
Epoch 80/500
54/54 [==============================] - 219s 4s/step - loss: 0.0226 - accuracy: 0.9936 - val_loss: 0.0082 - val_accuracy: 0.9954
Epoch 81/500
54/54 [==============================] - 221s 4s/step - loss: 0.0092 - accuracy: 0.9971 - val_loss: 0.0016 - val_accuracy: 1.0000
Epoch 82/500
54/54 [==============================] - 219s 4s/step - loss: 0.0092 - accuracy: 0.9965 - val_loss: 0.0086 - val_accuracy: 0.9954
Epoch 83/500
```

```
54/54 [==============================] - 218s 4s/step - loss: 0.0306 - accuracy: 0.9930 - val_loss: 0.0433 - val_accuracy: 0.9907
Epoch 84/500
54/54 [==============================] - 220s 4s/step - loss: 0.0173 - accuracy: 0.9924 - val_loss: 0.0126 - val_accuracy: 0.9954
Epoch 85/500
54/54 [==============================] - 221s 4s/step - loss: 0.0247 - accuracy: 0.9907 - val_loss: 0.0164 - val_accuracy: 0.9977
Epoch 86/500
54/54 [==============================] - 219s 4s/step - loss: 0.0533 - accuracy: 0.9843 - val_loss: 0.0524 - val_accuracy: 0.9884
Epoch 87/500
54/54 [==============================] - 219s 4s/step - loss: 0.1811 - accuracy: 0.9628 - val_loss: 0.0611 - val_accuracy: 0.9838
Epoch 88/500
54/54 [==============================] - 219s 4s/step - loss: 0.1733 - accuracy: 0.9657 - val_loss: 0.0159 - val_accuracy: 0.9907
Epoch 89/500
54/54 [==============================] - 222s 4s/step - loss: 0.1062 - accuracy: 0.9653 - val_loss: 0.0055 - val_accuracy: 1.0000
Epoch 90/500
54/54 [==============================] - 224s 4s/step - loss: 0.0416 - accuracy: 0.9820 - val_loss: 0.0338 - val_accuracy: 0.9907
Epoch 91/500
54/54 [==============================] - 220s 4s/step - loss: 0.0501 - accuracy: 0.9821 - val_loss: 0.0210 - val_accuracy: 0.9954
Epoch 92/500
54/54 [==============================] - 220s 4s/step - loss: 0.0614 - accuracy: 0.9779 - val_loss: 0.0347 - val_accuracy: 0.9884
Epoch 93/500
54/54 [==============================] - 221s 4s/step - loss: 0.0372 - accuracy: 0.9855 - val_loss: 0.0133 - val_accuracy: 0.9977
Epoch 94/500
54/54 [==============================] - 220s 4s/step - loss: 0.0326 - accuracy: 0.9872 - val_loss: 0.0133 - val_accuracy: 0.9907
Epoch 95/500
54/54 [==============================] - 232s 4s/step - loss: 0.0475 - accuracy: 0.9849 - val_loss: 0.0071 - val_accuracy: 0.9977
Epoch 96/500
54/54 [==============================] - 219s 4s/step - loss: 0.0393 - accuracy: 0.9878 - val_loss: 0.0450 - val_accuracy: 0.9907
Epoch 97/500
54/54 [==============================] - 222s 4s/step - loss: 0.0484 - accuracy: 0.9867 - val_loss: 0.0173 - val_accuracy: 0.9954
Epoch 98/500
54/54 [==============================] - 220s 4s/step - loss: 0.0211 - accuracy: 0.9948 - val_loss: 0.0024 - val_accuracy: 1.0000
Epoch 99/500
54/54 [==============================] - 219s 4s/step - loss: 0.0196 - accuracy: 0.9924 - val_loss: 7.7546e-04 - val_accuracy: 1.0000
Epoch 100/500
54/54 [==============================] - 222s 4s/step - loss: 0.0215 - accuracy: 0.9913 - val_loss: 0.0107 - val_accuracy: 0.9954
Epoch 101/500
54/54 [==============================] - 222s 4s/step - loss: 0.0396 - accuracy: 0.9919 - val_loss: 0.1728 - val_accuracy: 0.9884
Epoch 102/500
54/54 [==============================] - 219s 4s/step - loss: 0.1536 - accuracy: 0.9738 - val_loss: 0.5487 - val_accuracy: 0.9306
Epoch 103/500
54/54 [==============================] - 219s 4s/step - loss: 0.1381 - accuracy: 0.9680 - val_loss: 0.0145 - val_accuracy: 0.9931
Epoch 104/500
54/54 [==============================] - 219s 4s/step - loss: 0.0751 - accuracy: 0.9727 - val_loss: 0.0185 - val_accuracy: 0.9954
Epoch 105/500
54/54 [==============================] - 221s 4s/step - loss: 0.0748 - accuracy: 0.9744 - val_loss: 0.0224 - val_accuracy: 0.9954
Epoch 106/500
54/54 [==============================] - 220s 4s/step - loss: 0.0800 - accuracy: 0.9767 - val_loss: 0.0075 - val_accuracy: 0.9977
Epoch 107/500
54/54 [==============================] - 220s 4s/step - loss: 0.0276 - accuracy: 0.9878 - val_loss: 0.0068 - val_accuracy: 0.9977
Epoch 108/500
54/54 [==============================] - 222s 4s/step - loss: 0.0435 - accuracy: 0.9802 - val_loss: 0.0275 - val_accuracy: 0.9884
Epoch 109/500
54/54 [==============================] - 221s 4s/step - loss: 0.0376 - accuracy: 0.9831 - val_loss: 0.0115 - val_accuracy: 0.9954
Epoch 110/500
54/54 [==============================] - 221s 4s/step - loss: 0.0303 - accuracy: 0.9872 - val_loss: 0.0103 - val_accuracy: 0.9977
```

```
Epoch 111/500
54/54 [==============================] - 229s 4s/step - loss: 0.0400 - accuracy: 0.9872 - val_loss: 0.0103 - val_accuracy: 0.9977
Epoch 112/500
54/54 [==============================] - 222s 4s/step - loss: 0.0284 - accuracy: 0.9895 - val_loss: 0.0127 - val_accuracy: 0.9977
Epoch 113/500
54/54 [==============================] - 221s 4s/step - loss: 0.0568 - accuracy: 0.9884 - val_loss: 0.0455 - val_accuracy: 0.9884
Epoch 114/500
54/54 [==============================] - 219s 4s/step - loss: 0.0614 - accuracy: 0.9837 - val_loss: 0.0085 - val_accuracy: 0.9977
Epoch 115/500
54/54 [==============================] - 219s 4s/step - loss: 0.0357 - accuracy: 0.9831 - val_loss: 0.0069 - val_accuracy: 0.9977
Epoch 116/500
54/54 [==============================] - 221s 4s/step - loss: 0.0634 - accuracy: 0.9808 - val_loss: 0.0320 - val_accuracy: 0.9931
Epoch 117/500
54/54 [==============================] - 221s 4s/step - loss: 0.0343 - accuracy: 0.9866 - val_loss: 0.0166 - val_accuracy: 0.9977
Epoch 118/500
54/54 [==============================] - 219s 4s/step - loss: 0.0391 - accuracy: 0.9860 - val_loss: 0.0129 - val_accuracy: 0.9977
Epoch 119/500
54/54 [==============================] - 219s 4s/step - loss: 0.0190 - accuracy: 0.9907 - val_loss: 0.0064 - val_accuracy: 0.9977
Epoch 120/500
54/54 [==============================] - 222s 4s/step - loss: 0.0263 - accuracy: 0.9889 - val_loss: 0.0088 - val_accuracy: 0.9977
Epoch 121/500
54/54 [==============================] - 222s 4s/step - loss: 0.0244 - accuracy: 0.9901 - val_loss: 0.0134 - val_accuracy: 0.9977
Epoch 122/500
54/54 [==============================] - 222s 4s/step - loss: 0.0335 - accuracy: 0.9884 - val_loss: 0.0032 - val_accuracy: 0.9977
Epoch 123/500
54/54 [==============================] - 219s 4s/step - loss: 0.0168 - accuracy: 0.9919 - val_loss: 0.0014 - val_accuracy: 1.0000
Epoch 124/500
54/54 [==============================] - 219s 4s/step - loss: 0.0402 - accuracy: 0.9837 - val_loss: 0.0305 - val_accuracy: 0.9954
Epoch 125/500
54/54 [==============================] - 222s 4s/step - loss: 0.0238 - accuracy: 0.9913 - val_loss: 0.0109 - val_accuracy: 0.9931
Epoch 126/500
54/54 [==============================] - 221s 4s/step - loss: 0.0228 - accuracy: 0.9924 - val_loss: 0.0016 - val_accuracy: 1.0000
Epoch 127/500
54/54 [==============================] - 219s 4s/step - loss: 0.0148 - accuracy: 0.9936 - val_loss: 0.0056 - val_accuracy: 0.9954
Epoch 128/500
54/54 [==============================] - 220s 4s/step - loss: 0.0228 - accuracy: 0.9919 - val_loss: 0.0070 - val_accuracy: 0.9954
Epoch 129/500
54/54 [==============================] - 221s 4s/step - loss: 0.0274 - accuracy: 0.9901 - val_loss: 0.0073 - val_accuracy: 0.9954
Epoch 130/500
54/54 [==============================] - 223s 4s/step - loss: 0.0439 - accuracy: 0.9849 - val_loss: 0.0959 - val_accuracy: 0.9815
Epoch 131/500
54/54 [==============================] - 220s 4s/step - loss: 0.0745 - accuracy: 0.9744 - val_loss: 0.0027 - val_accuracy: 1.0000
Epoch 132/500
54/54 [==============================] - 219s 4s/step - loss: 0.0684 - accuracy: 0.9727 - val_loss: 0.0132 - val_accuracy: 0.9954
Epoch 133/500
54/54 [==============================] - 233s 4s/step - loss: 0.0332 - accuracy: 0.9860 - val_loss: 0.0083 - val_accuracy: 0.9977
Epoch 134/500
54/54 [==============================] - 219s 4s/step - loss: 0.0213 - accuracy: 0.9936 - val_loss: 0.0097 - val_accuracy: 0.9977
Epoch 135/500
54/54 [==============================] - 220s 4s/step - loss: 0.0255 - accuracy: 0.9913 - val_loss: 0.0062 - val_accuracy: 0.9977
Epoch 136/500
54/54 [==============================] - 220s 4s/step - loss: 0.0206 - accuracy: 0.9930 - val_loss: 0.0982 - val_accuracy: 0.9907
Epoch 137/500
54/54 [==============================] - 219s 4s/step - loss: 0.0413 - accuracy: 0.9878 - val_loss: 0.0267 - val_accuracy: 0.9931
Epoch 138/500
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54/54 [==============================] - 223s 4s/step - loss: 0.0267 - accuracy: 0.9907 - val_loss: 0.0188 - val_accuracy: 0.9954
Epoch 139/500
54/54 [==============================] - 220s 4s/step - loss: 0.0157 - accuracy: 0.9953 - val_loss: 0.0459 - val_accuracy: 0.9884
Epoch 140/500
54/54 [==============================] - 219s 4s/step - loss: 0.0267 - accuracy: 0.9884 - val_loss: 0.0013 - val_accuracy: 1.0000
Epoch 141/500
54/54 [==============================] - 220s 4s/step - loss: 0.0178 - accuracy: 0.9919 - val_loss: 0.0036 - val_accuracy: 0.9977
Epoch 142/500
54/54 [==============================] - 221s 4s/step - loss: 0.0282 - accuracy: 0.9878 - val_loss: 0.0033 - val_accuracy: 1.0000
Epoch 143/500
54/54 [==============================] - 219s 4s/step - loss: 0.0136 - accuracy: 0.9959 - val_loss: 0.0029 - val_accuracy: 1.0000
Epoch 144/500
54/54 [==============================] - 219s 4s/step - loss: 0.0188 - accuracy: 0.9942 - val_loss: 3.3289e-04 - val_accuracy: 1.0000
Epoch 145/500
54/54 [==============================] - 220s 4s/step - loss: 0.0116 - accuracy: 0.9977 - val_loss: 2.1942e-05 - val_accuracy: 1.0000
Epoch 146/500
54/54 [==============================] - 222s 4s/step - loss: 0.0098 - accuracy: 0.9988 - val_loss: 0.0078 - val_accuracy: 0.9977
Epoch 147/500
54/54 [==============================] - 219s 4s/step - loss: 0.0087 - accuracy: 0.9977 - val_loss: 0.0078 - val_accuracy: 0.9977
Epoch 148/500
54/54 [==============================] - 219s 4s/step - loss: 0.0168 - accuracy: 0.9953 - val_loss: 1.5914e-04 - val_accuracy: 1.0000
Epoch 149/500
54/54 [==============================] - 220s 4s/step - loss: 0.0373 - accuracy: 0.9919 - val_loss: 0.0021 - val_accuracy: 1.0000
Epoch 150/500
54/54 [==============================] - 222s 4s/step - loss: 0.0179 - accuracy: 0.9959 - val_loss: 0.0040 - val_accuracy: 0.9977
Epoch 151/500
54/54 [==============================] - 219s 4s/step - loss: 0.0219 - accuracy: 0.9924 - val_loss: 0.0041 - val_accuracy: 0.9977
Epoch 152/500
54/54 [==============================] - 219s 4s/step - loss: 0.0415 - accuracy: 0.9924 - val_loss: 0.0187 - val_accuracy: 0.9931
Epoch 153/500
54/54 [==============================] - 220s 4s/step - loss: 0.0442 - accuracy: 0.9889 - val_loss: 0.0055 - val_accuracy: 0.9977
Epoch 154/500
54/54 [==============================] - 221s 4s/step - loss: 0.0216 - accuracy: 0.9930 - val_loss: 0.0067 - val_accuracy: 0.9977
Epoch 155/500
54/54 [==============================] - 219s 4s/step - loss: 0.0283 - accuracy: 0.9901 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 156/500
54/54 [==============================] - 219s 4s/step - loss: 0.0125 - accuracy: 0.9959 - val_loss: 9.7528e-04 - val_accuracy: 1.0000
Epoch 157/500
54/54 [==============================] - 220s 4s/step - loss: 0.0232 - accuracy: 0.9936 - val_loss: 0.0435 - val_accuracy: 0.9931
Epoch 158/500
54/54 [==============================] - 222s 4s/step - loss: 0.0256 - accuracy: 0.9919 - val_loss: 0.0068 - val_accuracy: 0.9977
Epoch 159/500
54/54 [==============================] - 219s 4s/step - loss: 0.0638 - accuracy: 0.9919 - val_loss: 0.0042 - val_accuracy: 0.9977
Epoch 160/500
54/54 [==============================] - 221s 4s/step - loss: 0.0409 - accuracy: 0.9907 - val_loss: 0.0104 - val_accuracy: 0.9977
Epoch 161/500
54/54 [==============================] - 221s 4s/step - loss: 0.0928 - accuracy: 0.9866 - val_loss: 0.0699 - val_accuracy: 0.9884
Epoch 162/500
54/54 [==============================] - 223s 4s/step - loss: 0.1016 - accuracy: 0.9855 - val_loss: 0.0159 - val_accuracy: 0.9954
Epoch 163/500
54/54 [==============================] - 221s 4s/step - loss: 0.0584 - accuracy: 0.9849 - val_loss: 0.0411 - val_accuracy: 0.9907
Epoch 164/500
54/54 [==============================] - 220s 4s/step - loss: 0.0307 - accuracy: 0.9866 - val_loss: 0.0281 - val_accuracy: 0.9954
Epoch 165/500
54/54 [==============================] - 223s 4s/step - loss: 0.0486 - accuracy: 0.9895 - val_loss: 0.0068 - val_accuracy: 0.9977
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Epoch 166/500
54/54 [==============================] - 223s 4s/step - loss: 0.0307 - accuracy: 0.9924 - val_loss: 0.0153 - val_accuracy: 0.9931
Epoch 167/500
54/54 [==============================] - 223s 4s/step - loss: 0.0690 - accuracy: 0.9825 - val_loss: 1.9901e-04 - val_accuracy: 1.0000
Epoch 168/500
54/54 [==============================] - 229s 4s/step - loss: 0.0378 - accuracy: 0.9843 - val_loss: 0.0030 - val_accuracy: 1.0000
Epoch 169/500
54/54 [==============================] - 221s 4s/step - loss: 0.0453 - accuracy: 0.9837 - val_loss: 0.0315 - val_accuracy: 0.9907
Epoch 170/500
54/54 [==============================] - 224s 4s/step - loss: 0.0371 - accuracy: 0.9860 - val_loss: 0.0043 - val_accuracy: 1.0000
Epoch 171/500
54/54 [==============================] - 222s 4s/step - loss: 0.0176 - accuracy: 0.9942 - val_loss: 0.0048 - val_accuracy: 0.9977
Epoch 172/500
54/54 [==============================] - 226s 4s/step - loss: 0.0298 - accuracy: 0.9889 - val_loss: 0.0151 - val_accuracy: 0.9954
Epoch 173/500
54/54 [==============================] - 228s 4s/step - loss: 0.0119 - accuracy: 0.9971 - val_loss: 0.0076 - val_accuracy: 0.9954
Epoch 174/500
54/54 [==============================] - 223s 4s/step - loss: 0.0315 - accuracy: 0.9895 - val_loss: 0.0109 - val_accuracy: 0.9954
Epoch 175/500
54/54 [==============================] - 219s 4s/step - loss: 0.0218 - accuracy: 0.9901 - val_loss: 0.0300 - val_accuracy: 0.9954
Epoch 176/500
54/54 [==============================] - 219s 4s/step - loss: 0.0140 - accuracy: 0.9936 - val_loss: 0.0111 - val_accuracy: 0.9977
Epoch 177/500
54/54 [==============================] - 218s 4s/step - loss: 0.0226 - accuracy: 0.9901 - val_loss: 0.0124 - val_accuracy: 0.9977
Epoch 178/500
54/54 [==============================] - 222s 4s/step - loss: 0.0142 - accuracy: 0.9948 - val_loss: 0.0262 - val_accuracy: 0.9954
Epoch 179/500
54/54 [==============================] - 220s 4s/step - loss: 0.0233 - accuracy: 0.9895 - val_loss: 3.5600e-04 - val_accuracy: 1.0000
Epoch 180/500
54/54 [==============================] - 219s 4s/step - loss: 0.0520 - accuracy: 0.9907 - val_loss: 0.0419 - val_accuracy: 0.9954
Epoch 181/500
54/54 [==============================] - 219s 4s/step - loss: 0.0396 - accuracy: 0.9919 - val_loss: 0.0290 - val_accuracy: 0.9907
Epoch 182/500
54/54 [==============================] - 222s 4s/step - loss: 0.0157 - accuracy: 0.9936 - val_loss: 0.0150 - val_accuracy: 0.9977
Epoch 183/500
54/54 [==============================] - 219s 4s/step - loss: 0.0533 - accuracy: 0.9878 - val_loss: 0.0014 - val_accuracy: 1.0000
Epoch 184/500
54/54 [==============================] - 218s 4s/step - loss: 0.0630 - accuracy: 0.9901 - val_loss: 0.0054 - val_accuracy: 0.9977
Epoch 185/500
54/54 [==============================] - 219s 4s/step - loss: 0.0173 - accuracy: 0.9953 - val_loss: 0.0049 - val_accuracy: 0.9977
Epoch 186/500
54/54 [==============================] - 221s 4s/step - loss: 0.0222 - accuracy: 0.9942 - val_loss: 0.0040 - val_accuracy: 0.9977
Epoch 187/500
54/54 [==============================] - 219s 4s/step - loss: 0.0256 - accuracy: 0.9913 - val_loss: 0.0062 - val_accuracy: 0.9977
Epoch 188/500
54/54 [==============================] - 221s 4s/step - loss: 0.0138 - accuracy: 0.9953 - val_loss: 0.0098 - val_accuracy: 0.9954
Epoch 189/500
54/54 [==============================] - 219s 4s/step - loss: 0.0478 - accuracy: 0.9895 - val_loss: 0.0174 - val_accuracy: 0.9931
Epoch 190/500
54/54 [==============================] - 219s 4s/step - loss: 0.0335 - accuracy: 0.9907 - val_loss: 0.0100 - val_accuracy: 0.9931
Epoch 191/500
54/54 [==============================] - 221s 4s/step - loss: 0.0271 - accuracy: 0.9913 - val_loss: 0.0113 - val_accuracy: 0.9954
Epoch 192/500
54/54 [==============================] - 219s 4s/step - loss: 0.0271 - accuracy: 0.9913 - val_loss: 0.0166 - val_accuracy: 0.9954
Epoch 193/500
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54/54 [==============================] - 219s 4s/step - loss: 0.0268 - accuracy: 0.9924 - val_loss: 0.0043 - val_accuracy: 1.0000
Epoch 194/500
54/54 [==============================] - 220s 4s/step - loss: 0.0164 - accuracy: 0.9959 - val_loss: 0.0028 - val_accuracy: 1.0000
Epoch 195/500
54/54 [==============================] - 221s 4s/step - loss: 0.0219 - accuracy: 0.9924 - val_loss: 0.0027 - val_accuracy: 0.9977
Epoch 196/500
54/54 [==============================] - 220s 4s/step - loss: 0.0125 - accuracy: 0.9965 - val_loss: 0.0026 - val_accuracy: 0.9977
Epoch 197/500
54/54 [==============================] - 219s 4s/step - loss: 0.0160 - accuracy: 0.9936 - val_loss: 0.0025 - val_accuracy: 0.9977
Epoch 198/500
54/54 [==============================] - 219s 4s/step - loss: 0.0185 - accuracy: 0.9953 - val_loss: 8.9049e-04 - val_accuracy: 1.0000
Epoch 199/500
54/54 [==============================] - 221s 4s/step - loss: 0.0136 - accuracy: 0.9965 - val_loss: 0.0026 - val_accuracy: 0.9977
Epoch 200/500
54/54 [==============================] - 220s 4s/step - loss: 0.0174 - accuracy: 0.9953 - val_loss: 0.0026 - val_accuracy: 0.9977
Epoch 201/500
54/54 [==============================] - 219s 4s/step - loss: 0.0139 - accuracy: 0.9965 - val_loss: 0.0027 - val_accuracy: 0.9977
Epoch 202/500
54/54 [==============================] - 220s 4s/step - loss: 0.0118 - accuracy: 0.9971 - val_loss: 0.0027 - val_accuracy: 0.9977
Epoch 203/500
54/54 [==============================] - 222s 4s/step - loss: 0.0158 - accuracy: 0.9954 - val_loss: 0.0026 - val_accuracy: 0.9977
Epoch 204/500
54/54 [==============================] - 221s 4s/step - loss: 0.0112 - accuracy: 0.9965 - val_loss: 0.0025 - val_accuracy: 0.9977
Epoch 205/500
54/54 [==============================] - 220s 4s/step - loss: 0.0339 - accuracy: 0.9930 - val_loss: 0.0073 - val_accuracy: 0.9954
Epoch 206/500
54/54 [==============================] - 220s 4s/step - loss: 0.0156 - accuracy: 0.9953 - val_loss: 0.0058 - val_accuracy: 0.9954
Epoch 207/500
54/54 [==============================] - 222s 4s/step - loss: 0.0190 - accuracy: 0.9936 - val_loss: 0.0027 - val_accuracy: 0.9977
Epoch 208/500
54/54 [==============================] - 219s 4s/step - loss: 0.0130 - accuracy: 0.9965 - val_loss: 0.0025 - val_accuracy: 0.9977
Epoch 209/500
54/54 [==============================] - 219s 4s/step - loss: 0.0164 - accuracy: 0.9948 - val_loss: 0.0025 - val_accuracy: 0.9977
Epoch 210/500
54/54 [==============================] - 219s 4s/step - loss: 0.0200 - accuracy: 0.9953 - val_loss: 0.0025 - val_accuracy: 0.9977
Epoch 211/500
54/54 [==============================] - 221s 4s/step - loss: 0.0108 - accuracy: 0.9965 - val_loss: 5.5992e-04 - val_accuracy: 1.0000
Epoch 212/500
54/54 [==============================] - 219s 4s/step - loss: 0.0290 - accuracy: 0.9907 - val_loss: 0.0070 - val_accuracy: 0.9977
Epoch 213/500
54/54 [==============================] - 219s 4s/step - loss: 0.0182 - accuracy: 0.9953 - val_loss: 3.3793e-04 - val_accuracy: 1.0000
Epoch 214/500
54/54 [==============================] - 219s 4s/step - loss: 0.0124 - accuracy: 0.9953 - val_loss: 0.0069 - val_accuracy: 0.9977
Epoch 215/500
54/54 [==============================] - 222s 4s/step - loss: 0.0280 - accuracy: 0.9942 - val_loss: 0.0075 - val_accuracy: 0.9977
Epoch 216/500
54/54 [==============================] - 219s 4s/step - loss: 0.0228 - accuracy: 0.9913 - val_loss: 7.2722e-04 - val_accuracy: 1.0000
Epoch 217/500
54/54 [==============================] - 219s 4s/step - loss: 0.0324 - accuracy: 0.9878 - val_loss: 0.0174 - val_accuracy: 0.9954
Epoch 218/500
54/54 [==============================] - 219s 4s/step - loss: 0.0287 - accuracy: 0.9907 - val_loss: 0.0397 - val_accuracy: 0.9954
Epoch 219/500
54/54 [==============================] - 222s 4s/step - loss: 0.0398 - accuracy: 0.9907 - val_loss: 0.0146 - val_accuracy: 0.9954
Epoch 220/500
54/54 [==============================] - 221s 4s/step - loss: 0.0318 - accuracy: 0.9907 - val_loss: 0.0119 - val_accuracy: 0.9954
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Epoch 221/500
54/54 [==============================] - 220s 4s/step - loss: 0.0329 - accuracy: 0.9919 - val_loss: 0.0630 - val_accuracy: 0.9931
Epoch 222/500
54/54 [==============================] - 221s 4s/step - loss: 0.0432 - accuracy: 0.9884 - val_loss: 0.0451 - val_accuracy: 0.9954
Epoch 223/500
54/54 [==============================] - 226s 4s/step - loss: 0.0568 - accuracy: 0.9889 - val_loss: 0.0040 - val_accuracy: 0.9977
Epoch 224/500
54/54 [==============================] - 222s 4s/step - loss: 0.0660 - accuracy: 0.9820 - val_loss: 0.0109 - val_accuracy: 0.9954
Epoch 225/500
54/54 [==============================] - 221s 4s/step - loss: 0.0267 - accuracy: 0.9930 - val_loss: 0.0193 - val_accuracy: 0.9931
Epoch 226/500
54/54 [==============================] - 221s 4s/step - loss: 0.0279 - accuracy: 0.9919 - val_loss: 0.0049 - val_accuracy: 0.9977
Epoch 227/500
54/54 [==============================] - 223s 4s/step - loss: 0.0295 - accuracy: 0.9930 - val_loss: 0.0058 - val_accuracy: 0.9954
Epoch 228/500
54/54 [==============================] - 223s 4s/step - loss: 0.0251 - accuracy: 0.9913 - val_loss: 0.1050 - val_accuracy: 0.9907
Epoch 229/500
54/54 [==============================] - 221s 4s/step - loss: 0.0357 - accuracy: 0.9924 - val_loss: 0.0041 - val_accuracy: 0.9977
Epoch 230/500
54/54 [==============================] - 224s 4s/step - loss: 0.0234 - accuracy: 0.9907 - val_loss: 0.0041 - val_accuracy: 0.9977
Epoch 231/500
54/54 [==============================] - 231s 4s/step - loss: 0.0386 - accuracy: 0.9901 - val_loss: 0.0042 - val_accuracy: 0.9977
Epoch 232/500
54/54 [==============================] - 223s 4s/step - loss: 0.0659 - accuracy: 0.9884 - val_loss: 0.0042 - val_accuracy: 0.9977
Epoch 233/500
54/54 [==============================] - 219s 4s/step - loss: 0.0319 - accuracy: 0.9884 - val_loss: 0.0085 - val_accuracy: 0.9954
Epoch 234/500
54/54 [==============================] - 219s 4s/step - loss: 0.0329 - accuracy: 0.9936 - val_loss: 0.0029 - val_accuracy: 1.0000
Epoch 235/500
54/54 [==============================] - 222s 4s/step - loss: 0.0271 - accuracy: 0.9889 - val_loss: 0.0045 - val_accuracy: 0.9977
Epoch 236/500
54/54 [==============================] - 221s 4s/step - loss: 0.0185 - accuracy: 0.9942 - val_loss: 0.0038 - val_accuracy: 0.9977
Epoch 237/500
54/54 [==============================] - 220s 4s/step - loss: 0.0234 - accuracy: 0.9936 - val_loss: 0.0041 - val_accuracy: 0.9977
Epoch 238/500
54/54 [==============================] - 219s 4s/step - loss: 0.0189 - accuracy: 0.9936 - val_loss: 0.0011 - val_accuracy: 1.0000
Epoch 239/500
54/54 [==============================] - 224s 4s/step - loss: 0.0201 - accuracy: 0.9919 - val_loss: 6.9230e-04 - val_accuracy: 1.0000
Epoch 240/500
54/54 [==============================] - 218s 4s/step - loss: 0.0127 - accuracy: 0.9953 - val_loss: 0.0011 - val_accuracy: 1.0000
Epoch 241/500
54/54 [==============================] - 219s 4s/step - loss: 0.0187 - accuracy: 0.9936 - val_loss: 0.0113 - val_accuracy: 0.9977
Epoch 242/500
54/54 [==============================] - 220s 4s/step - loss: 0.0132 - accuracy: 0.9948 - val_loss: 6.4353e-04 - val_accuracy: 1.0000
Epoch 243/500
54/54 [==============================] - 220s 4s/step - loss: 0.0114 - accuracy: 0.9953 - val_loss: 6.2864e-04 - val_accuracy: 1.0000
Epoch 244/500
54/54 [==============================] - 221s 4s/step - loss: 0.0142 - accuracy: 0.9936 - val_loss: 0.0103 - val_accuracy: 0.9977
Epoch 245/500
54/54 [==============================] - 219s 4s/step - loss: 0.0192 - accuracy: 0.9924 - val_loss: 0.0045 - val_accuracy: 0.9977
Epoch 246/500
54/54 [==============================] - 219s 4s/step - loss: 0.0128 - accuracy: 0.9942 - val_loss: 0.0029 - val_accuracy: 1.0000
Epoch 247/500
54/54 [==============================] - 219s 4s/step - loss: 0.0169 - accuracy: 0.9948 - val_loss: 0.0010 - val_accuracy: 1.0000
Epoch 248/500
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54/54 [==============================] - 221s 4s/step - loss: 0.0134 - accuracy: 0.9965 - val_loss: 9.3474e-04 - val_accuracy: 1.0000
Epoch 249/500
54/54 [==============================] - 219s 4s/step - loss: 0.0174 - accuracy: 0.9930 - val_loss: 9.3033e-04 - val_accuracy: 1.0000
Epoch 250/500
54/54 [==============================] - 219s 4s/step - loss: 0.0209 - accuracy: 0.9913 - val_loss: 9.3031e-04 - val_accuracy: 1.0000
Epoch 251/500
54/54 [==============================] - 219s 4s/step - loss: 0.0470 - accuracy: 0.9924 - val_loss: 0.0264 - val_accuracy: 0.9977
Epoch 252/500
54/54 [==============================] - 221s 4s/step - loss: 0.0404 - accuracy: 0.9901 - val_loss: 0.2214 - val_accuracy: 0.9838
Epoch 253/500
54/54 [==============================] - 221s 4s/step - loss: 0.0605 - accuracy: 0.9901 - val_loss: 0.0178 - val_accuracy: 0.9954
Epoch 254/500
54/54 [==============================] - 219s 4s/step - loss: 0.0525 - accuracy: 0.9866 - val_loss: 0.0901 - val_accuracy: 0.9815
Epoch 255/500
54/54 [==============================] - 219s 4s/step - loss: 0.0400 - accuracy: 0.9837 - val_loss: 6.7354e-04 - val_accuracy: 1.0000
Epoch 256/500
54/54 [==============================] - 221s 4s/step - loss: 0.0255 - accuracy: 0.9884 - val_loss: 0.0174 - val_accuracy: 0.9954
Epoch 257/500
54/54 [==============================] - 219s 4s/step - loss: 0.0154 - accuracy: 0.9936 - val_loss: 0.0130 - val_accuracy: 0.9977
Epoch 258/500
54/54 [==============================] - 219s 4s/step - loss: 0.0406 - accuracy: 0.9895 - val_loss: 0.0247 - val_accuracy: 0.9931
Epoch 259/500
54/54 [==============================] - 220s 4s/step - loss: 0.0457 - accuracy: 0.9849 - val_loss: 0.0108 - val_accuracy: 0.9954
Epoch 260/500
54/54 [==============================] - 221s 4s/step - loss: 0.0318 - accuracy: 0.9895 - val_loss: 1.9965e-04 - val_accuracy: 1.0000
Epoch 261/500
54/54 [==============================] - 219s 4s/step - loss: 0.0208 - accuracy: 0.9913 - val_loss: 0.0017 - val_accuracy: 1.0000
Epoch 262/500
54/54 [==============================] - 219s 4s/step - loss: 0.0192 - accuracy: 0.9919 - val_loss: 0.0113 - val_accuracy: 0.9954
Epoch 263/500
54/54 [==============================] - 219s 4s/step - loss: 0.0234 - accuracy: 0.9901 - val_loss: 0.0014 - val_accuracy: 1.0000
Epoch 264/500
54/54 [==============================] - 221s 4s/step - loss: 0.0179 - accuracy: 0.9919 - val_loss: 5.2017e-05 - val_accuracy: 1.0000
Epoch 265/500
54/54 [==============================] - 219s 4s/step - loss: 0.0252 - accuracy: 0.9919 - val_loss: 1.1094e-05 - val_accuracy: 1.0000
Epoch 266/500
54/54 [==============================] - 218s 4s/step - loss: 0.0660 - accuracy: 0.9942 - val_loss: 0.0046 - val_accuracy: 0.9977
Epoch 267/500
54/54 [==============================] - 219s 4s/step - loss: 0.0160 - accuracy: 0.9953 - val_loss: 0.0386 - val_accuracy: 0.9954
Epoch 268/500
54/54 [==============================] - 221s 4s/step - loss: 0.0227 - accuracy: 0.9930 - val_loss: 1.8389e-05 - val_accuracy: 1.0000
Epoch 269/500
54/54 [==============================] - 221s 4s/step - loss: 0.0263 - accuracy: 0.9930 - val_loss: 0.0072 - val_accuracy: 0.9977
Epoch 270/500
54/54 [==============================] - 219s 4s/step - loss: 0.0162 - accuracy: 0.9930 - val_loss: 0.0029 - val_accuracy: 0.9977
Epoch 271/500
54/54 [==============================] - 219s 4s/step - loss: 0.0166 - accuracy: 0.9924 - val_loss: 0.0036 - val_accuracy: 0.9977
Epoch 272/500
54/54 [==============================] - 221s 4s/step - loss: 0.0146 - accuracy: 0.9930 - val_loss: 0.0371 - val_accuracy: 0.9954
Epoch 273/500
54/54 [==============================] - 219s 4s/step - loss: 0.0215 - accuracy: 0.9930 - val_loss: 0.0205 - val_accuracy: 0.9977
Epoch 274/500
54/54 [==============================] - 219s 4s/step - loss: 0.0202 - accuracy: 0.9930 - val_loss: 2.0696e-08 - val_accuracy: 1.0000
Epoch 275/500
54/54 [==============================] - 219s 4s/step - loss: 0.0281 - accuracy: 0.9930 - val_loss: 2.5497e-04 - val_accuracy: 1.0000
```

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Epoch 276/500
54/54 [==============================] - 222s 4s/step - loss: 0.0303 - accuracy: 0.9936 - val_loss: 0.0523 - val_accuracy: 0.9931
Epoch 277/500
54/54 [==============================] - 219s 4s/step - loss: 0.0243 - accuracy: 0.9919 - val_loss: 1.3592e-06 - val_accuracy: 1.0000
Epoch 278/500
54/54 [==============================] - 220s 4s/step - loss: 0.0280 - accuracy: 0.9895 - val_loss: 0.0055 - val_accuracy: 0.9977
Epoch 279/500
54/54 [==============================] - 219s 4s/step - loss: 0.0379 - accuracy: 0.9895 - val_loss: 0.0015 - val_accuracy: 1.0000
Epoch 280/500
54/54 [==============================] - 222s 4s/step - loss: 0.0204 - accuracy: 0.9895 - val_loss: 3.2765e-04 - val_accuracy: 1.0000
Epoch 281/500
54/54 [==============================] - 219s 4s/step - loss: 0.0197 - accuracy: 0.9901 - val_loss: 2.7557e-06 - val_accuracy: 1.0000
Epoch 282/500
54/54 [==============================] - 219s 4s/step - loss: 0.0231 - accuracy: 0.9936 - val_loss: 9.2923e-05 - val_accuracy: 1.0000
Epoch 283/500
54/54 [==============================] - 219s 4s/step - loss: 0.0155 - accuracy: 0.9936 - val_loss: 3.1260e-06 - val_accuracy: 1.0000
Epoch 284/500
54/54 [==============================] - 219s 4s/step - loss: 0.0167 - accuracy: 0.9930 - val_loss: 2.8025e-06 - val_accuracy: 1.0000
Epoch 285/500
54/54 [==============================] - 221s 4s/step - loss: 0.0167 - accuracy: 0.9959 - val_loss: 0.0000e+00 - val_accuracy: 1.0000
Epoch 286/500
54/54 [==============================] - 221s 4s/step - loss: 0.0248 - accuracy: 0.9971 - val_loss: 0.0044 - val_accuracy: 0.9977
Epoch 287/500
54/54 [==============================] - 221s 4s/step - loss: 0.0402 - accuracy: 0.9872 - val_loss: 0.0130 - val_accuracy: 0.9954
Epoch 288/500
54/54 [==============================] - 220s 4s/step - loss: 0.0173 - accuracy: 0.9924 - val_loss: 0.0093 - val_accuracy: 0.9931
Epoch 289/500
54/54 [==============================] - 220s 4s/step - loss: 0.0150 - accuracy: 0.9930 - val_loss: 0.0432 - val_accuracy: 0.9977
Epoch 290/500
54/54 [==============================] - 219s 4s/step - loss: 0.0286 - accuracy: 0.9913 - val_loss: 0.0169 - val_accuracy: 0.9954
Epoch 291/500
54/54 [==============================] - 219s 4s/step - loss: 0.0128 - accuracy: 0.9965 - val_loss: 0.0274 - val_accuracy: 0.9954
Epoch 292/500
54/54 [==============================] - 219s 4s/step - loss: 0.0183 - accuracy: 0.9924 - val_loss: 0.0056 - val_accuracy: 0.9977
Epoch 293/500
54/54 [==============================] - 221s 4s/step - loss: 0.0138 - accuracy: 0.9936 - val_loss: 0.0029 - val_accuracy: 0.9977
Epoch 294/500
54/54 [==============================] - 219s 4s/step - loss: 0.0156 - accuracy: 0.9919 - val_loss: 0.0031 - val_accuracy: 0.9977
Epoch 295/500
54/54 [==============================] - 219s 4s/step - loss: 0.0291 - accuracy: 0.9913 - val_loss: 0.0217 - val_accuracy: 0.9931
Epoch 296/500
54/54 [==============================] - 221s 4s/step - loss: 0.0199 - accuracy: 0.9942 - val_loss: 0.0026 - val_accuracy: 1.0000
Epoch 297/500
54/54 [==============================] - 223s 4s/step - loss: 0.0147 - accuracy: 0.9953 - val_loss: 0.0028 - val_accuracy: 1.0000
Epoch 298/500
54/54 [==============================] - 220s 4s/step - loss: 0.0117 - accuracy: 0.9953 - val_loss: 0.0022 - val_accuracy: 1.0000
Epoch 299/500
54/54 [==============================] - 219s 4s/step - loss: 0.0088 - accuracy: 0.9971 - val_loss: 0.0010 - val_accuracy: 1.0000
Epoch 300/500
54/54 [==============================] - 219s 4s/step - loss: 0.0087 - accuracy: 0.9959 - val_loss: 0.0011 - val_accuracy: 1.0000
Epoch 301/500
54/54 [==============================] - 221s 4s/step - loss: 0.0151 - accuracy: 0.9936 - val_loss: 0.0011 - val_accuracy: 1.0000
Epoch 302/500
54/54 [==============================] - 220s 4s/step - loss: 0.0096 - accuracy: 0.9965 - val_loss: 0.0061 - val_accuracy: 0.9977
Epoch 303/500
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54/54 [==============================] - 225s 4s/step - loss: 0.0157 - accuracy: 0.9930 - val_loss: 0.0055 - val_accuracy: 0.9977
Epoch 304/500
54/54 [==============================] - 221s 4s/step - loss: 0.0116 - accuracy: 0.9959 - val_loss: 0.0044 - val_accuracy: 0.9977
Epoch 305/500
54/54 [==============================] - 222s 4s/step - loss: 0.0138 - accuracy: 0.9924 - val_loss: 0.0043 - val_accuracy: 0.9977
Epoch 306/500
54/54 [==============================] - 220s 4s/step - loss: 0.0159 - accuracy: 0.9924 - val_loss: 0.0043 - val_accuracy: 0.9977
Epoch 307/500
54/54 [==============================] - 220s 4s/step - loss: 0.0137 - accuracy: 0.9942 - val_loss: 0.0042 - val_accuracy: 0.9977
Epoch 308/500
54/54 [==============================] - 221s 4s/step - loss: 0.0073 - accuracy: 0.9971 - val_loss: 0.0050 - val_accuracy: 0.9977
Epoch 309/500
54/54 [==============================] - 221s 4s/step - loss: 0.0136 - accuracy: 0.9953 - val_loss: 0.0458 - val_accuracy: 0.9954
Epoch 310/500
54/54 [==============================] - 219s 4s/step - loss: 0.0386 - accuracy: 0.9930 - val_loss: 0.0066 - val_accuracy: 0.9977
Epoch 311/500
54/54 [==============================] - 219s 4s/step - loss: 0.0461 - accuracy: 0.9913 - val_loss: 3.8561e-04 - val_accuracy: 1.0000
Epoch 312/500
54/54 [==============================] - 220s 4s/step - loss: 0.0471 - accuracy: 0.9907 - val_loss: 4.2198e-05 - val_accuracy: 1.0000
Epoch 313/500
54/54 [==============================] - 237s 4s/step - loss: 0.1223 - accuracy: 0.9889 - val_loss: 0.0317 - val_accuracy: 0.9977
Epoch 314/500
54/54 [==============================] - 229s 4s/step - loss: 0.1045 - accuracy: 0.9831 - val_loss: 0.0268 - val_accuracy: 0.9954
Epoch 315/500
54/54 [==============================] - 220s 4s/step - loss: 0.0323 - accuracy: 0.9889 - val_loss: 0.0286 - val_accuracy: 0.9954
Epoch 316/500
54/54 [==============================] - 219s 4s/step - loss: 0.0175 - accuracy: 0.9913 - val_loss: 0.0361 - val_accuracy: 0.9954
Epoch 317/500
54/54 [==============================] - 222s 4s/step - loss: 0.0220 - accuracy: 0.9919 - val_loss: 0.0164 - val_accuracy: 0.9931
Epoch 318/500
54/54 [==============================] - 222s 4s/step - loss: 0.0215 - accuracy: 0.9901 - val_loss: 0.0133 - val_accuracy: 0.9954
Epoch 319/500
54/54 [==============================] - 220s 4s/step - loss: 0.0158 - accuracy: 0.9930 - val_loss: 0.0132 - val_accuracy: 0.9954
Epoch 320/500
54/54 [==============================] - 235s 4s/step - loss: 0.0161 - accuracy: 0.9913 - val_loss: 0.0133 - val_accuracy: 0.9954
Epoch 321/500
54/54 [==============================] - 265s 5s/step - loss: 0.0290 - accuracy: 0.9930 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 322/500
54/54 [==============================] - 282s 5s/step - loss: 0.0107 - accuracy: 0.9942 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 323/500
54/54 [==============================] - 348s 6s/step - loss: 0.0208 - accuracy: 0.9965 - val_loss: 0.0032 - val_accuracy: 0.9977
Epoch 324/500
54/54 [==============================] - 272s 5s/step - loss: 0.0086 - accuracy: 0.9959 - val_loss: 0.0099 - val_accuracy: 0.9977
Epoch 325/500
54/54 [==============================] - 267s 5s/step - loss: 0.0198 - accuracy: 0.9924 - val_loss: 0.0099 - val_accuracy: 0.9977
Epoch 326/500
54/54 [==============================] - 261s 5s/step - loss: 0.0115 - accuracy: 0.9959 - val_loss: 0.0100 - val_accuracy: 0.9977
Epoch 327/500
54/54 [==============================] - 241s 4s/step - loss: 0.0117 - accuracy: 0.9953 - val_loss: 0.0101 - val_accuracy: 0.9977
Epoch 328/500
54/54 [==============================] - 242s 4s/step - loss: 0.0102 - accuracy: 0.9959 - val_loss: 0.0566 - val_accuracy: 0.9954
Epoch 329/500
54/54 [==============================] - 249s 5s/step - loss: 0.0325 - accuracy: 0.9953 - val_loss: 0.0056 - val_accuracy: 0.9954
Epoch 330/500
54/54 [==============================] - 245s 5s/step - loss: 0.0149 - accuracy: 0.9942 - val_loss: 0.0032 - val_accuracy: 0.9977
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Epoch 331/500
54/54 [==============================] - 242s 4s/step - loss: 0.0097 - accuracy: 0.9971 - val_loss: 0.0032 - val_accuracy: 0.9977
Epoch 332/500
54/54 [==============================] - 255s 5s/step - loss: 0.0134 - accuracy: 0.9953 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 333/500
54/54 [==============================] - 254s 5s/step - loss: 0.0107 - accuracy: 0.9953 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 334/500
54/54 [==============================] - 267s 5s/step - loss: 0.0095 - accuracy: 0.9965 - val_loss: 0.0036 - val_accuracy: 0.9977
Epoch 335/500
54/54 [==============================] - 282s 5s/step - loss: 0.0060 - accuracy: 0.9977 - val_loss: 2.3730e-05 - val_accuracy: 1.0000
Epoch 336/500
54/54 [==============================] - 279s 5s/step - loss: 0.0085 - accuracy: 0.9977 - val_loss: 6.9528e-05 - val_accuracy: 1.0000
Epoch 337/500
54/54 [==============================] - 261s 5s/step - loss: 0.0238 - accuracy: 0.9942 - val_loss: 0.0032 - val_accuracy: 0.9977
Epoch 338/500
54/54 [==============================] - 300s 6s/step - loss: 0.0116 - accuracy: 0.9954 - val_loss: 0.0058 - val_accuracy: 0.9954
Epoch 339/500
54/54 [==============================] - 270s 5s/step - loss: 0.0117 - accuracy: 0.9953 - val_loss: 0.0056 - val_accuracy: 0.9954
Epoch 340/500
54/54 [==============================] - 265s 5s/step - loss: 0.0099 - accuracy: 0.9965 - val_loss: 0.0061 - val_accuracy: 0.9954
Epoch 341/500
54/54 [==============================] - 260s 5s/step - loss: 0.0177 - accuracy: 0.9936 - val_loss: 0.0038 - val_accuracy: 0.9977
Epoch 342/500
54/54 [==============================] - 250s 5s/step - loss: 0.0093 - accuracy: 0.9977 - val_loss: 0.0023 - val_accuracy: 0.9977
Epoch 343/500
54/54 [==============================] - 261s 5s/step - loss: 0.0102 - accuracy: 0.9965 - val_loss: 0.0023 - val_accuracy: 0.9977
Epoch 344/500
54/54 [==============================] - 279s 5s/step - loss: 0.0101 - accuracy: 0.9959 - val_loss: 0.0023 - val_accuracy: 0.9977
Epoch 345/500
54/54 [==============================] - 244s 5s/step - loss: 0.0073 - accuracy: 0.9971 - val_loss: 0.0022 - val_accuracy: 0.9977
Epoch 346/500
54/54 [==============================] - 249s 5s/step - loss: 0.0047 - accuracy: 0.9983 - val_loss: 0.0022 - val_accuracy: 0.9977
Epoch 347/500
54/54 [==============================] - 250s 5s/step - loss: 0.0096 - accuracy: 0.9959 - val_loss: 5.3305e-04 - val_accuracy: 1.0000
Epoch 348/500
54/54 [==============================] - 231s 4s/step - loss: 0.0103 - accuracy: 0.9965 - val_loss: 3.9813e-04 - val_accuracy: 1.0000
Epoch 349/500
54/54 [==============================] - 227s 4s/step - loss: 0.0059 - accuracy: 0.9977 - val_loss: 3.9850e-04 - val_accuracy: 1.0000
Epoch 350/500
54/54 [==============================] - 225s 4s/step - loss: 0.0114 - accuracy: 0.9953 - val_loss: 0.0270 - val_accuracy: 0.9954
Epoch 351/500
54/54 [==============================] - 225s 4s/step - loss: 0.0104 - accuracy: 0.9977 - val_loss: 4.0436e-04 - val_accuracy: 1.0000
Epoch 352/500
54/54 [==============================] - 228s 4s/step - loss: 0.0088 - accuracy: 0.9965 - val_loss: 0.0068 - val_accuracy: 0.9977
Epoch 353/500
54/54 [==============================] - 225s 4s/step - loss: 0.1057 - accuracy: 0.9942 - val_loss: 0.0120 - val_accuracy: 0.9977
Epoch 354/500
54/54 [==============================] - 225s 4s/step - loss: 0.0325 - accuracy: 0.9948 - val_loss: 0.0586 - val_accuracy: 0.9907
Epoch 355/500
54/54 [==============================] - 225s 4s/step - loss: 0.0434 - accuracy: 0.9936 - val_loss: 1.6133e-04 - val_accuracy: 1.0000
Epoch 356/500
54/54 [==============================] - 232s 4s/step - loss: 0.0114 - accuracy: 0.9965 - val_loss: 1.4358e-04 - val_accuracy: 1.0000
Epoch 357/500
54/54 [==============================] - 227s 4s/step - loss: 0.0208 - accuracy: 0.9965 - val_loss: 2.4197e-04 - val_accuracy: 1.0000
Epoch 358/500
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54/54 [==============================] - 226s 4s/step - loss: 0.0468 - accuracy: 0.9919 - val_loss: 0.1461 - val_accuracy: 0.9931
Epoch 359/500
54/54 [==============================] - 225s 4s/step - loss: 0.0539 - accuracy: 0.9919 - val_loss: 0.0485 - val_accuracy: 0.9977
Epoch 360/500
54/54 [==============================] - 229s 4s/step - loss: 0.0096 - accuracy: 0.9959 - val_loss: 0.0377 - val_accuracy: 0.9977
Epoch 361/500
54/54 [==============================] - 227s 4s/step - loss: 0.0132 - accuracy: 0.9942 - val_loss: 1.8673e-05 - val_accuracy: 1.0000
Epoch 362/500
54/54 [==============================] - 226s 4s/step - loss: 0.0378 - accuracy: 0.9948 - val_loss: 0.0299 - val_accuracy: 0.9977
Epoch 363/500
54/54 [==============================] - 225s 4s/step - loss: 0.0667 - accuracy: 0.9936 - val_loss: 9.3022e-06 - val_accuracy: 1.0000
Epoch 364/500
54/54 [==============================] - 228s 4s/step - loss: 0.0341 - accuracy: 0.9930 - val_loss: 0.0128 - val_accuracy: 0.9954
Epoch 365/500
54/54 [==============================] - 227s 4s/step - loss: 0.0142 - accuracy: 0.9948 - val_loss: 7.3955e-06 - val_accuracy: 1.0000
Epoch 366/500
54/54 [==============================] - 225s 4s/step - loss: 0.0459 - accuracy: 0.9942 - val_loss: 0.0034 - val_accuracy: 0.9977
Epoch 367/500
54/54 [==============================] - 226s 4s/step - loss: 0.0200 - accuracy: 0.9953 - val_loss: 0.0034 - val_accuracy: 0.9977
Epoch 368/500
54/54 [==============================] - 228s 4s/step - loss: 0.0395 - accuracy: 0.9930 - val_loss: 0.0051 - val_accuracy: 0.9977
Epoch 369/500
54/54 [==============================] - 227s 4s/step - loss: 0.0247 - accuracy: 0.9936 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 370/500
54/54 [==============================] - 227s 4s/step - loss: 0.0119 - accuracy: 0.9936 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 371/500
54/54 [==============================] - 226s 4s/step - loss: 0.0122 - accuracy: 0.9948 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 372/500
54/54 [==============================] - 233s 4s/step - loss: 0.0139 - accuracy: 0.9948 - val_loss: 0.0033 - val_accuracy: 0.9977
Epoch 373/500
54/54 [==============================] - 227s 4s/step - loss: 0.0135 - accuracy: 0.9953 - val_loss: 0.0125 - val_accuracy: 0.9977
Epoch 374/500
54/54 [==============================] - 229s 4s/step - loss: 0.0348 - accuracy: 0.9942 - val_loss: 0.0338 - val_accuracy: 0.9977
Epoch 375/500
54/54 [==============================] - 228s 4s/step - loss: 0.0187 - accuracy: 0.9948 - val_loss: 0.0064 - val_accuracy: 0.9977
Epoch 376/500
54/54 [==============================] - 229s 4s/step - loss: 0.0270 - accuracy: 0.9959 - val_loss: 0.0057 - val_accuracy: 0.9977
Epoch 377/500
54/54 [==============================] - 228s 4s/step - loss: 0.0074 - accuracy: 0.9977 - val_loss: 0.0091 - val_accuracy: 0.9977
Epoch 378/500
54/54 [==============================] - 226s 4s/step - loss: 0.0086 - accuracy: 0.9977 - val_loss: 0.0038 - val_accuracy: 0.9977
Epoch 379/500
54/54 [==============================] - 228s 4s/step - loss: 0.0126 - accuracy: 0.9953 - val_loss: 5.0639e-05 - val_accuracy: 1.0000
Epoch 380/500
54/54 [==============================] - 231s 4s/step - loss: 0.0051 - accuracy: 0.9988 - val_loss: 5.7408e-05 - val_accuracy: 1.0000
Epoch 381/500
54/54 [==============================] - 227s 4s/step - loss: 0.0102 - accuracy: 0.9959 - val_loss: 3.5939e-05 - val_accuracy: 1.0000
Epoch 382/500
54/54 [==============================] - 227s 4s/step - loss: 0.0058 - accuracy: 0.9983 - val_loss: 8.2727e-05 - val_accuracy: 1.0000
Epoch 383/500
54/54 [==============================] - 227s 4s/step - loss: 0.0118 - accuracy: 0.9959 - val_loss: 8.7093e-05 - val_accuracy: 1.0000
Epoch 384/500
54/54 [==============================] - 229s 4s/step - loss: 0.0073 - accuracy: 0.9983 - val_loss: 9.7997e-05 - val_accuracy: 1.0000
Epoch 385/500
54/54 [==============================] - 227s 4s/step - loss: 0.0216 - accuracy: 0.9965 - val_loss: 6.3936e-04 - val_accuracy: 1.0000
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Epoch 386/500
54/54 [==============================] - 226s 4s/step - loss: 0.0118 - accuracy: 0.9942 - val_loss: 6.9829e-04 - val_accuracy: 1.0000
Epoch 387/500
54/54 [==============================] - 226s 4s/step - loss: 0.0121 - accuracy: 0.9953 - val_loss: 0.0482 - val_accuracy: 0.9977
Epoch 388/500
54/54 [==============================] - 229s 4s/step - loss: 0.0091 - accuracy: 0.9965 - val_loss: 0.0647 - val_accuracy: 0.9954
Epoch 389/500
54/54 [==============================] - 228s 4s/step - loss: 0.0124 - accuracy: 0.9965 - val_loss: 9.6671e-05 - val_accuracy: 1.0000
Epoch 390/500
54/54 [==============================] - 227s 4s/step - loss: 0.1155 - accuracy: 0.9948 - val_loss: 1.4610e-04 - val_accuracy: 1.0000
Epoch 391/500
54/54 [==============================] - 227s 4s/step - loss: 0.0094 - accuracy: 0.9965 - val_loss: 5.2445e-04 - val_accuracy: 1.0000
Epoch 392/500
54/54 [==============================] - 229s 4s/step - loss: 0.0117 - accuracy: 0.9971 - val_loss: 0.0049 - val_accuracy: 0.9977
Epoch 393/500
54/54 [==============================] - 227s 4s/step - loss: 0.0113 - accuracy: 0.9959 - val_loss: 0.0046 - val_accuracy: 0.9977
Epoch 394/500
54/54 [==============================] - 226s 4s/step - loss: 0.0356 - accuracy: 0.9977 - val_loss: 0.0031 - val_accuracy: 0.9977
Epoch 395/500
54/54 [==============================] - 241s 4s/step - loss: 0.0132 - accuracy: 0.9948 - val_loss: 0.0031 - val_accuracy: 0.9977
Epoch 396/500
54/54 [==============================] - 274s 5s/step - loss: 0.0106 - accuracy: 0.9959 - val_loss: 0.0024 - val_accuracy: 0.9977
Epoch 397/500
54/54 [==============================] - 257s 5s/step - loss: 0.0065 - accuracy: 0.9983 - val_loss: 0.0023 - val_accuracy: 0.9977
Epoch 398/500
54/54 [==============================] - 246s 5s/step - loss: 0.0674 - accuracy: 0.9953 - val_loss: 0.2197 - val_accuracy: 0.9861
Epoch 399/500
54/54 [==============================] - 229s 4s/step - loss: 0.1153 - accuracy: 0.9930 - val_loss: 0.0044 - val_accuracy: 0.9977
Epoch 400/500
54/54 [==============================] - 227s 4s/step - loss: 0.0188 - accuracy: 0.9977 - val_loss: 6.2322e-04 - val_accuracy: 1.0000
Epoch 401/500
54/54 [==============================] - 226s 4s/step - loss: 0.0080 - accuracy: 0.9977 - val_loss: 6.5578e-04 - val_accuracy: 1.0000
Epoch 402/500
54/54 [==============================] - 226s 4s/step - loss: 0.0202 - accuracy: 0.9948 - val_loss: 6.0524e-04 - val_accuracy: 1.0000
Epoch 403/500
54/54 [==============================] - 228s 4s/step - loss: 0.0077 - accuracy: 0.9977 - val_loss: 3.8210e-05 - val_accuracy: 1.0000
Epoch 404/500
54/54 [==============================] - 227s 4s/step - loss: 0.0160 - accuracy: 0.9959 - val_loss: 4.8841e-04 - val_accuracy: 1.0000
Epoch 405/500
54/54 [==============================] - 226s 4s/step - loss: 0.0081 - accuracy: 0.9965 - val_loss: 5.9236e-04 - val_accuracy: 1.0000
Epoch 406/500
54/54 [==============================] - 226s 4s/step - loss: 0.0097 - accuracy: 0.9965 - val_loss: 0.0058 - val_accuracy: 0.9954
Epoch 407/500
54/54 [==============================] - 229s 4s/step - loss: 0.0036 - accuracy: 0.9994 - val_loss: 0.0013 - val_accuracy: 1.0000
Epoch 408/500
54/54 [==============================] - 248s 5s/step - loss: 0.0072 - accuracy: 0.9965 - val_loss: 3.6061e-04 - val_accuracy: 1.0000
Epoch 409/500
54/54 [==============================] - 280s 5s/step - loss: 0.0142 - accuracy: 0.9965 - val_loss: 0.0257 - val_accuracy: 0.9907
Epoch 410/500
54/54 [==============================] - 258s 5s/step - loss: 0.0129 - accuracy: 0.9953 - val_loss: 0.0159 - val_accuracy: 0.9954
Epoch 411/500
54/54 [==============================] - 323s 6s/step - loss: 0.0126 - accuracy: 0.9953 - val_loss: 0.0105 - val_accuracy: 0.9931
Epoch 412/500
54/54 [==============================] - 288s 5s/step - loss: 0.0120 - accuracy: 0.9977 - val_loss: 0.0105 - val_accuracy: 0.9931
Epoch 413/500
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54/54 [==============================] - 256s 5s/step - loss: 0.0116 - accuracy: 0.9948 - val_loss: 0.0145 - val_accuracy: 0.9907
Epoch 414/500
54/54 [==============================] - 253s 5s/step - loss: 0.0112 - accuracy: 0.9953 - val_loss: 0.0104 - val_accuracy: 0.9931
Epoch 415/500
54/54 [==============================] - 281s 5s/step - loss: 0.0163 - accuracy: 0.9930 - val_loss: 0.0475 - val_accuracy: 0.9907
Epoch 416/500
54/54 [==============================] - 228s 4s/step - loss: 0.0113 - accuracy: 0.9971 - val_loss: 0.0105 - val_accuracy: 0.9931
Epoch 417/500
54/54 [==============================] - 234s 4s/step - loss: 0.0077 - accuracy: 0.9971 - val_loss: 0.0051 - val_accuracy: 0.9977
Epoch 418/500
54/54 [==============================] - 227s 4s/step - loss: 0.0080 - accuracy: 0.9971 - val_loss: 0.0036 - val_accuracy: 0.9977
Epoch 419/500
54/54 [==============================] - 227s 4s/step - loss: 0.0098 - accuracy: 0.9959 - val_loss: 1.0191e-06 - val_accuracy: 1.0000
Epoch 420/500
54/54 [==============================] - 226s 4s/step - loss: 0.0062 - accuracy: 0.9988 - val_loss: 0.0036 - val_accuracy: 0.9977
Epoch 421/500
54/54 [==============================] - 229s 4s/step - loss: 0.0102 - accuracy: 0.9959 - val_loss: 7.6652e-07 - val_accuracy: 1.0000
Epoch 422/500
54/54 [==============================] - 226s 4s/step - loss: 0.0037 - accuracy: 0.9994 - val_loss: 3.3304e-07 - val_accuracy: 1.0000
Epoch 423/500
54/54 [==============================] - 226s 4s/step - loss: 0.0124 - accuracy: 0.9953 - val_loss: 0.0027 - val_accuracy: 0.9977
Epoch 424/500
54/54 [==============================] - 229s 4s/step - loss: 0.0147 - accuracy: 0.9953 - val_loss: 0.0435 - val_accuracy: 0.9977
Epoch 425/500
54/54 [==============================] - 229s 4s/step - loss: 0.2075 - accuracy: 0.9913 - val_loss: 0.1020 - val_accuracy: 0.9977
Epoch 426/500
54/54 [==============================] - 227s 4s/step - loss: 0.0860 - accuracy: 0.9931 - val_loss: 0.0061 - val_accuracy: 0.9977
Epoch 427/500
54/54 [==============================] - 225s 4s/step - loss: 0.0056 - accuracy: 0.9988 - val_loss: 0.0076 - val_accuracy: 0.9977
Epoch 428/500
54/54 [==============================] - 226s 4s/step - loss: 0.0064 - accuracy: 0.9977 - val_loss: 0.0078 - val_accuracy: 0.9977
Epoch 429/500
54/54 [==============================] - 298s 6s/step - loss: 0.0184 - accuracy: 0.9971 - val_loss: 2.7822e-05 - val_accuracy: 1.0000
Epoch 430/500
54/54 [==============================] - 272s 5s/step - loss: 0.1515 - accuracy: 0.9930 - val_loss: 0.0224 - val_accuracy: 0.9977
Epoch 431/500
54/54 [==============================] - 272s 5s/step - loss: 0.0337 - accuracy: 0.9965 - val_loss: 1.3004e-04 - val_accuracy: 1.0000
Epoch 432/500
54/54 [==============================] - 255s 5s/step - loss: 0.0093 - accuracy: 0.9965 - val_loss: 1.1702e-04 - val_accuracy: 1.0000
Epoch 433/500
54/54 [==============================] - 291s 5s/step - loss: 0.0096 - accuracy: 0.9977 - val_loss: 0.0093 - val_accuracy: 0.9977
Epoch 434/500
54/54 [==============================] - 313s 6s/step - loss: 0.0164 - accuracy: 0.9959 - val_loss: 0.0479 - val_accuracy: 0.9954
Epoch 435/500
54/54 [==============================] - 265s 5s/step - loss: 0.0115 - accuracy: 0.9983 - val_loss: 0.0609 - val_accuracy: 0.9977
Epoch 436/500
54/54 [==============================] - 264s 5s/step - loss: 0.0155 - accuracy: 0.9971 - val_loss: 0.0054 - val_accuracy: 0.9977
Epoch 437/500
54/54 [==============================] - 250s 5s/step - loss: 0.0191 - accuracy: 0.9965 - val_loss: 0.0465 - val_accuracy: 0.9954
Epoch 438/500
54/54 [==============================] - 256s 5s/step - loss: 0.0235 - accuracy: 0.9965 - val_loss: 9.8287e-05 - val_accuracy: 1.0000
Epoch 439/500
54/54 [==============================] - 270s 5s/step - loss: 0.0157 - accuracy: 0.9936 - val_loss: 5.1326e-08 - val_accuracy: 1.0000
Epoch 440/500
54/54 [==============================] - 299s 6s/step - loss: 0.0106 - accuracy: 0.9965 - val_loss: 1.4625e-08 - val_accuracy: 1.0000
```

```
Epoch 441/500
54/54 [==============================] - 265s 5s/step - loss: 0.0072 - accuracy: 0.9977 - val_loss: 1.4349e-08 - val_accuracy: 1.0000
Epoch 442/500
54/54 [==============================] - 266s 5s/step - loss: 0.0076 - accuracy: 0.9983 - val_loss: 1.4625e-08 - val_accuracy: 1.0000
Epoch 443/500
54/54 [==============================] - 258s 5s/step - loss: 0.0164 - accuracy: 0.9924 - val_loss: 8.8303e-09 - val_accuracy: 1.0000
Epoch 444/500
54/54 [==============================] - 284s 5s/step - loss: 0.0220 - accuracy: 0.9959 - val_loss: 0.0037 - val_accuracy: 0.9977
Epoch 445/500
54/54 [==============================] - 243s 5s/step - loss: 0.0245 - accuracy: 0.9971 - val_loss: 3.1781e-05 - val_accuracy: 1.0000
Epoch 446/500
54/54 [==============================] - 229s 4s/step - loss: 0.0136 - accuracy: 0.9936 - val_loss: 8.2784e-10 - val_accuracy: 1.0000
Epoch 447/500
54/54 [==============================] - 259s 5s/step - loss: 0.0177 - accuracy: 0.9936 - val_loss: 0.0038 - val_accuracy: 0.9977
Epoch 448/500
54/54 [==============================] - 322s 6s/step - loss: 0.0199 - accuracy: 0.9965 - val_loss: 7.1153e-06 - val_accuracy: 1.0000
Epoch 449/500
54/54 [==============================] - 270s 5s/step - loss: 0.0106 - accuracy: 0.9959 - val_loss: 1.3910e-05 - val_accuracy: 1.0000
Epoch 450/500
54/54 [==============================] - 273s 5s/step - loss: 0.0089 - accuracy: 0.9971 - val_loss: 1.3883e-05 - val_accuracy: 1.0000
Epoch 451/500
54/54 [==============================] - 259s 5s/step - loss: 0.0109 - accuracy: 0.9959 - val_loss: 1.3667e-05 - val_accuracy: 1.0000
Epoch 452/500
54/54 [==============================] - 288s 5s/step - loss: 0.0088 - accuracy: 0.9965 - val_loss: 1.3654e-05 - val_accuracy: 1.0000
Epoch 453/500
54/54 [==============================] - 341s 6s/step - loss: 0.0074 - accuracy: 0.9971 - val_loss: 1.0883e-05 - val_accuracy: 1.0000
Epoch 454/500
54/54 [==============================] - 337s 6s/step - loss: 0.0077 - accuracy: 0.9965 - val_loss: 1.0802e-05 - val_accuracy: 1.0000
Epoch 455/500
54/54 [==============================] - 287s 5s/step - loss: 0.0080 - accuracy: 0.9965 - val_loss: 2.8418e-06 - val_accuracy: 1.0000
Epoch 456/500
54/54 [==============================] - 261s 5s/step - loss: 0.0072 - accuracy: 0.9977 - val_loss: 2.5632e-06 - val_accuracy: 1.0000
Epoch 457/500
54/54 [==============================] - 236s 4s/step - loss: 0.0091 - accuracy: 0.9971 - val_loss: 1.9720e-06 - val_accuracy: 1.0000
Epoch 458/500
54/54 [==============================] - 236s 4s/step - loss: 0.0094 - accuracy: 0.9959 - val_loss: 1.8507e-06 - val_accuracy: 1.0000
Epoch 459/500
54/54 [==============================] - 236s 4s/step - loss: 0.0057 - accuracy: 0.9983 - val_loss: 1.8305e-06 - val_accuracy: 1.0000
Epoch 460/500
54/54 [==============================] - 235s 4s/step - loss: 0.0074 - accuracy: 0.9977 - val_loss: 0.0606 - val_accuracy: 0.9977
Epoch 461/500
54/54 [==============================] - 234s 4s/step - loss: 0.0053 - accuracy: 0.9988 - val_loss: 2.7348e-04 - val_accuracy: 1.0000
Epoch 462/500
54/54 [==============================] - 233s 4s/step - loss: 0.0196 - accuracy: 0.9965 - val_loss: 0.0282 - val_accuracy: 0.9977
Epoch 463/500
54/54 [==============================] - 269s 5s/step - loss: 0.0084 - accuracy: 0.9959 - val_loss: 0.0938 - val_accuracy: 0.9954
Epoch 464/500
54/54 [==============================] - 340s 6s/step - loss: 0.0303 - accuracy: 0.9965 - val_loss: 0.0124 - val_accuracy: 0.9977
Epoch 465/500
54/54 [==============================] - 382s 7s/step - loss: 0.0202 - accuracy: 0.9983 - val_loss: 1.1700e-07 - val_accuracy: 1.0000
Epoch 466/500
54/54 [==============================] - 392s 7s/step - loss: 0.0088 - accuracy: 0.9965 - val_loss: 1.1210e-04 - val_accuracy: 1.0000
Epoch 467/500
54/54 [==============================] - 410s 8s/step - loss: 0.0072 - accuracy: 0.9977 - val_loss: 1.9316e-09 - val_accuracy: 1.0000
Epoch 468/500
```

```
54/54 [==============================] - 353s 7s/step - loss: 0.0106 - accuracy: 0.9965 - val_loss: 1.6557e-09 - val_accuracy: 1.0000
Epoch 469/500
54/54 [==============================] - 368s 7s/step - loss: 0.0242 - accuracy: 0.9965 - val_loss: 9.0521e-07 - val_accuracy: 1.0000
Epoch 470/500
54/54 [==============================] - 391s 7s/step - loss: 0.0065 - accuracy: 0.9983 - val_loss: 9.1265e-07 - val_accuracy: 1.0000
Epoch 471/500
54/54 [==============================] - 372s 7s/step - loss: 0.0139 - accuracy: 0.9971 - val_loss: 8.9130e-08 - val_accuracy: 1.0000
Epoch 472/500
54/54 [==============================] - 372s 7s/step - loss: 0.0082 - accuracy: 0.9971 - val_loss: 5.4637e-08 - val_accuracy: 1.0000
Epoch 473/500
54/54 [==============================] - 360s 7s/step - loss: 0.0174 - accuracy: 0.9965 - val_loss: 3.7253e-08 - val_accuracy: 1.0000
Epoch 474/500
54/54 [==============================] - 249s 5s/step - loss: 0.0094 - accuracy: 0.9977 - val_loss: 2.7871e-08 - val_accuracy: 1.0000
Epoch 475/500
54/54 [==============================] - 267s 5s/step - loss: 0.0097 - accuracy: 0.9965 - val_loss: 3.3389e-08 - val_accuracy: 1.0000
Epoch 476/500
54/54 [==============================] - 233s 4s/step - loss: 0.0095 - accuracy: 0.9965 - val_loss: 3.2899e-04 - val_accuracy: 1.0000
Epoch 477/500
54/54 [==============================] - 231s 4s/step - loss: 0.0064 - accuracy: 0.9971 - val_loss: 4.2621e-04 - val_accuracy: 1.0000
Epoch 478/500
54/54 [==============================] - 231s 4s/step - loss: 0.0175 - accuracy: 0.9953 - val_loss: 4.3429e-04 - val_accuracy: 1.0000
Epoch 479/500
54/54 [==============================] - 232s 4s/step - loss: 0.0168 - accuracy: 0.9959 - val_loss: 0.0381 - val_accuracy: 0.9977
Epoch 480/500
54/54 [==============================] - 229s 4s/step - loss: 0.0383 - accuracy: 0.9948 - val_loss: 0.0025 - val_accuracy: 0.9977
Epoch 481/500
54/54 [==============================] - 229s 4s/step - loss: 0.0065 - accuracy: 0.9971 - val_loss: 2.5496e-07 - val_accuracy: 1.0000
Epoch 482/500
54/54 [==============================] - 232s 4s/step - loss: 0.0032 - accuracy: 1.0000 - val_loss: 4.5444e-07 - val_accuracy: 1.0000
Epoch 483/500
54/54 [==============================] - 340s 6s/step - loss: 0.0079 - accuracy: 0.9977 - val_loss: 1.3245e-07 - val_accuracy: 1.0000
Epoch 484/500
54/54 [==============================] - 368s 7s/step - loss: 0.0055 - accuracy: 0.9983 - val_loss: 1.0707e-07 - val_accuracy: 1.0000
Epoch 485/500
54/54 [==============================] - 408s 8s/step - loss: 0.0065 - accuracy: 0.9977 - val_loss: 9.7407e-08 - val_accuracy: 1.0000
Epoch 486/500
54/54 [==============================] - 424s 8s/step - loss: 0.0030 - accuracy: 0.9994 - val_loss: 9.6028e-08 - val_accuracy: 1.0000
Epoch 487/500
54/54 [==============================] - 410s 8s/step - loss: 0.0093 - accuracy: 0.9959 - val_loss: 8.9681e-08 - val_accuracy: 1.0000
Epoch 488/500
54/54 [==============================] - 417s 8s/step - loss: 0.0077 - accuracy: 0.9971 - val_loss: 9.1337e-08 - val_accuracy: 1.0000
Epoch 489/500
54/54 [==============================] - 403s 7s/step - loss: 0.0042 - accuracy: 0.9983 - val_loss: 9.1062e-09 - val_accuracy: 1.0000
Epoch 490/500
54/54 [==============================] - 240s 4s/step - loss: 0.0039 - accuracy: 0.9994 - val_loss: 2.4835e-09 - val_accuracy: 1.0000
Epoch 491/500
54/54 [==============================] - 282s 5s/step - loss: 0.0074 - accuracy: 0.9977 - val_loss: 2.7595e-10 - val_accuracy: 1.0000
Epoch 492/500
54/54 [==============================] - 395s 7s/step - loss: 0.0057 - accuracy: 0.9983 - val_loss: 0.0000e+00 - val_accuracy: 1.0000
Epoch 493/500
54/54 [==============================] - 362s 7s/step - loss: 0.0129 - accuracy: 0.9971 - val_loss: 0.0370 - val_accuracy: 0.9954
Epoch 494/500
54/54 [==============================] - 356s 7s/step - loss: 0.0063 - accuracy: 0.9977 - val_loss: 0.0423 - val_accuracy: 0.9977
Epoch 495/500
54/54 [==============================] - 239s 4s/step - loss: 0.0084 - accuracy: 0.9959 - val_loss: 0.0300 - val_accuracy: 0.9977
```

```
Epoch 496/500
54/54 [==============================] - 239s 4s/step - loss: 0.0101 - accuracy: 0.9959 - val_loss: 0.0205 - val_accuracy: 0.9977
Epoch 497/500
54/54 [==============================] - 296s 6s/step - loss: 0.0064 - accuracy: 0.9983 - val_loss: 0.0204 - val_accuracy: 0.9977
Epoch 498/500
54/54 [==============================] - 426s 8s/step - loss: 0.0117 - accuracy: 0.9953 - val_loss: 0.0232 - val_accuracy: 0.9977
Epoch 499/500
54/54 [==============================] - 412s 8s/step - loss: 0.0025 - accuracy: 0.9994 - val_loss: 0.0298 - val_accuracy: 0.9977
Epoch 500/500
54/54 [==============================] - 424s 8s/step - loss: 0.0057 - accuracy: 0.9983 - val_loss: 0.0298 - val_accuracy: 0.9977
```

APRESENTANDO OS RESULTADOS

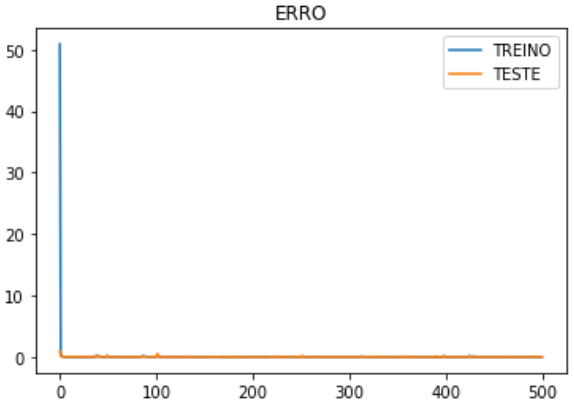
In [35]:
```
results = model.evaluate_generator(test_generator, 437)
print('Acc: %.3f, Loss: %.3f' % (results[1], results[0]))
```

```
C:\Users\gui_r\AppData\Local\Temp\ipykernel_16068\2082521232.py:1: UserWarning: `Model.evaluate_generator` is deprecated and will be removed in a future version. Pleas
e use `Model.evaluate`, which supports generators.
  results = model.evaluate_generator(test_generator, 437)
WARNING:tensorflow:Your input ran out of data; interrupting training. Make sure that your dataset or generator can generate at least `steps_per_epoch * epochs` batches
(in this case, 437 batches). You may need to use the repeat() function when building your dataset.
Acc: 0.998, Loss: 0.029
```

11. APRESENTANDO OS GRÁFICOS DE LINHA

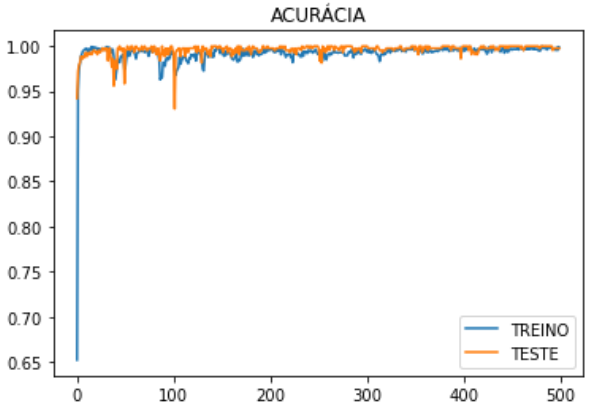
- ERRO DO TESTE E TREINO

In [36]:
```
plt.title('ERRO')
plt.plot(history.history['loss'], label='TREINO')
plt.plot(history.history['val_loss'], label='TESTE')
plt.legend()
plt.show()
```



- ACURÁCIA DO TESTE E TREINO

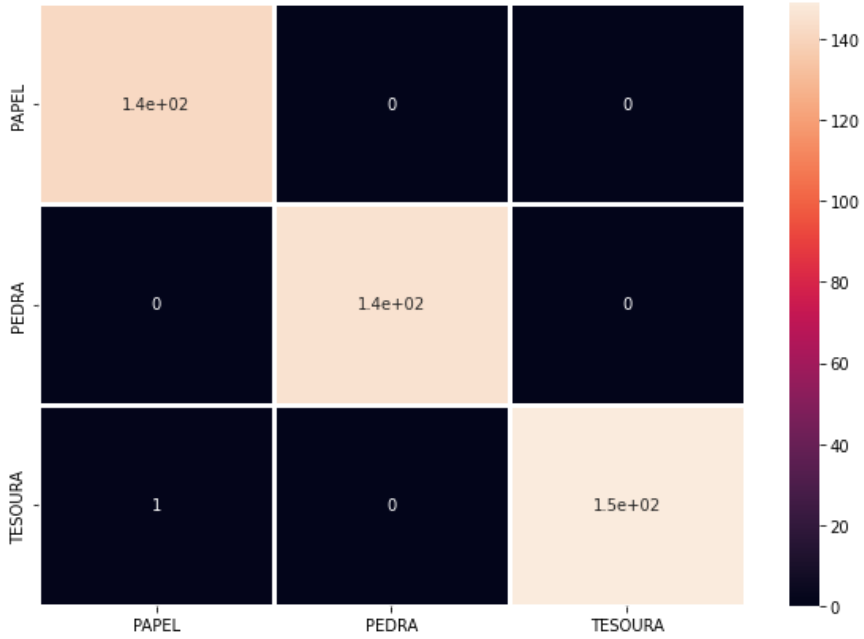
In [37]:
```
plt.title('ACURÁCIA')
plt.plot(history.history['accuracy'], label='TREINO')
plt.plot(history.history['val_accuracy'], label='TESTE')
plt.legend()
plt.show()
```



12. APRESENTANDO A MATRIZ DE CONFUSÃO

In [38]:
```
Y_pred = model.predict(test_generator)
y_pred = np.argmax(Y_pred, axis=1)
matrix = confusion_matrix(test_generator.classes, y_pred)
df_cm = pd.DataFrame(matrix, index = ['PAPEL', 'PEDRA', 'TESOURA'],
                     columns = ['PAPEL', 'PEDRA', 'TESOURA'])
plt.figure(figsize = (10,7))
sn.heatmap(df_cm, annot=True, linewidths=2.5)
plt.show()
```

```
28/28 [==============================] - 45s 2s/step
```



13. APRESENTANDO OS DADOS DO CONJUNTO DE TESTES

ACURÁCIA, PRECISÃO, REVOCAÇÃO E F1-SCORE

In [39]:
```
print(classification_report(test_generator.classes, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.99      1.00      1.00       142
           1       1.00      1.00      1.00       145
           2       1.00      0.99      1.00       150

    accuracy                           1.00       437
   macro avg       1.00      1.00      1.00       437
weighted avg       1.00      1.00      1.00       437
```

In [ ]:
```

```