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# Ravindra Bisram
# Deep Leaning Homework 5 - AG News
import numpy as np
import pandas as pd
import tensorflow as tf
from sklearn.model_selection import train_test_split
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
from sklearn.metrics import precision_recall_fscore_support as score
from tensorflow.python.keras.utils.np_utils import to_categorical
from tensorflow.keras.preprocessing.text import Tokenizer
from tensorflow.keras.preprocessing.sequence import pad_sequences
import re
from numpy import array, asarray, zeros
from tensorflow.keras.models import Sequential, Model
from tensorflow.keras.layers import Flatten, LSTM, Input,
GlobalMaxPooling1D, Activation, Dropout, Dense, Embedding,
TextVectorization
from tensorflow.keras import models, layers
from sklearn.model_selection import KFold, StratifiedKFold


# https://www.kaggle.com/code/keithcooper/multi-class-classification-
with-transformer-models
# https://stackabuse.com/python-for-nlp-multi-label-text-
classification-with-keras/

def import_data(csv_file):
    """
    in -> csv_file - string representing the location of the csv file
    out -> pandas dataframe
    """
    df = pd.read_csv(csv_file)
    df['text'] = df['Title'] + ' ' + df['Description']
    df.rename(columns = {'Class Index': 'label'}, inplace = True)
    # The models expects numerical catagories  starting from 0 Not 1
    df['label'].replace({4:0}, inplace = True)
    df.drop(['Title', 'Description'], axis = 1, inplace = True)

    return df

def preprocess_text(sen):
    # Remove punctuations and numbers
    sentence = re.sub('[^a-zA-Z]', ' ', sen)
    # Single character removal
    sentence = re.sub(r"\s+[a-zA-Z]\s+", ' ', sentence)
    # Removing multiple spaces
    sentence = re.sub(r'\s+', ' ', sentence)

    return sentence
```

```
train_val_df = import_data("../data/train.csv")
test_df = import_data("../data/test.csv")
print("Data has been imported. Starting")

x_train = []
y_train = train_val_df["label"].values

sentences = list(train_val_df["text"])

for sen in sentences:
    x_train.append(preprocess_text(sen))


# Tokenization
tokenizer = Tokenizer(num_words=5000)
tokenizer.fit_on_texts(x_train)

x_train = tokenizer.texts_to_sequences(x_train)

VOCAB_SIZE = len(tokenizer.word_index) + 1
MAX_LEN = 50

x_train = pad_sequences(x_train, padding='post', maxlen=MAX_LEN)
print(type(x_train))

x_test = []
test_sentences = list(test_df["text"])
for sen in test_sentences:
    x_test.append(preprocess_text(sen))

x_test = tokenizer.texts_to_sequences(x_test)
x_test = pad_sequences(x_test, padding='post', maxlen=MAX_LEN)

y_test = test_df["label"]
y_test = tf.keras.utils.to_categorical(y_test)


embeddings_dictionary = dict()

# Using the pretrained Glove word vectorization model
# https://stackoverflow.com/questions/50060241/how-to-use-glove-word-
embeddings-file-on-google-colaboratory
# https://nlp.stanford.edu/projects/glove/

glove_file = open('../data/glove.6B.100d.txt', encoding="utf8")

for line in glove_file:
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    records = line.split()
    word = records[0]
    vector_dimensions = asarray(records[1:], dtype='float32')
    embeddings_dictionary[word] = vector_dimensions
glove_file.close()

embedding_matrix = zeros((VOCAB_SIZE, 100))
for word, index in tokenizer.word_index.items():
    embedding_vector = embeddings_dictionary.get(word)
    if embedding_vector is not None:
        embedding_matrix[index] = embedding_vector


def main():
  # Perform proper cross validation by splitting the training set into
sections, where each iteration has a different section be the
validation set.
  # https://setscholars.net/how-to-use-kfold-cross-validation-in-
keras/
  # https://stackoverflow.com/questions/48508036/sklearn-
stratifiedkfold-valueerror-supported-target-types-are-binary-mul
  #
https://scikit-learn.org/stable/modules/generated/sklearn.model_select
ion.KFold.html

  kfold = StratifiedKFold(n_splits=5, shuffle=True, random_state=7)
  cvscores = []

  for index, (train_indices, val_indices) in
enumerate(kfold.split(x_train, y_train)):
    print ("Training on fold " + str(index+1) + "/5...")

    # Generate batches from indices
    xtrain, xval = x_train[train_indices], x_train[val_indices]
    ytrain, yval = y_train[train_indices], y_train[val_indices]

    # Build the model
    deep_inputs = Input(shape=(MAX_LEN,))
    embedding_layer = Embedding(VOCAB_SIZE, 100,
weights=[embedding_matrix], trainable=False)(deep_inputs)
    LSTM_Layer_1 = LSTM(128)(embedding_layer)
    dense_layer_1 = Dense(6, activation='relu')(LSTM_Layer_1)
    dense_layer_2 = Dense(128, activation='relu')(dense_layer_1)
    output = Dense(4, activation="softmax")(dense_layer_2)
    model = Model(inputs=deep_inputs, outputs=output)

    # model.summary()

    model.compile(loss=tf.keras.losses.categorical_crossentropy,
optimizer='adam', metrics=['accuracy'])
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    yval = to_categorical(yval)
    ytrain = to_categorical(ytrain)

    history=model.fit(xtrain, ytrain, batch_size=200, epochs=50,
validation_data=(xval, yval), verbose=2)

    scores = model.evaluate(x_test, y_test, verbose=0)
    print("%s: %.2f%%" % (model.metrics_names[1], scores[1]*100))
    cvscores.append(scores[1] * 100)

  print("%.2f%% (+/- %.2f%%)" % (np.mean(cvscores), np.std(cvscores)))

main()
```

```
Starting
<class 'numpy.ndarray'>
Training on fold 1/5...
[     1      2      3 ... 119996 119998 119999] [     0      4
7 ... 119988 119990 119997]
Epoch 1/50
480/480 - 5s - loss: 0.4777 - accuracy: 0.8418 - val_loss: 0.3398 -
val_accuracy: 0.8858 - 5s/epoch - 10ms/step
Epoch 2/50
480/480 - 3s - loss: 0.3228 - accuracy: 0.8910 - val_loss: 0.3039 -
val_accuracy: 0.8978 - 3s/epoch - 7ms/step
Epoch 3/50
480/480 - 3s - loss: 0.2937 - accuracy: 0.8999 - val_loss: 0.2865 -
val_accuracy: 0.9013 - 3s/epoch - 6ms/step
Epoch 4/50
480/480 - 3s - loss: 0.2749 - accuracy: 0.9053 - val_loss: 0.2751 -
val_accuracy: 0.9062 - 3s/epoch - 7ms/step
Epoch 5/50
480/480 - 3s - loss: 0.2580 - accuracy: 0.9097 - val_loss: 0.2755 -
val_accuracy: 0.9045 - 3s/epoch - 7ms/step
Epoch 6/50
480/480 - 3s - loss: 0.2473 - accuracy: 0.9131 - val_loss: 0.2616 -
val_accuracy: 0.9089 - 3s/epoch - 6ms/step
Epoch 7/50
480/480 - 3s - loss: 0.2354 - accuracy: 0.9177 - val_loss: 0.2520 -
val_accuracy: 0.9142 - 3s/epoch - 6ms/step
Epoch 8/50
480/480 - 3s - loss: 0.2234 - accuracy: 0.9214 - val_loss: 0.2460 -
val_accuracy: 0.9143 - 3s/epoch - 6ms/step
Epoch 9/50
480/480 - 3s - loss: 0.2147 - accuracy: 0.9249 - val_loss: 0.2510 -
val_accuracy: 0.9141 - 3s/epoch - 7ms/step
Epoch 10/50
480/480 - 3s - loss: 0.2032 - accuracy: 0.9286 - val_loss: 0.2432 -
val_accuracy: 0.9168 - 3s/epoch - 7ms/step
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Epoch 11/50
480/480 - 3s - loss: 0.1950 - accuracy: 0.9317 - val_loss: 0.2427 -
val_accuracy: 0.9171 - 3s/epoch - 6ms/step
Epoch 12/50
480/480 - 3s - loss: 0.1853 - accuracy: 0.9338 - val_loss: 0.2542 -
val_accuracy: 0.9175 - 3s/epoch - 6ms/step
Epoch 13/50
480/480 - 3s - loss: 0.1770 - accuracy: 0.9378 - val_loss: 0.2485 -
val_accuracy: 0.9177 - 3s/epoch - 6ms/step
Epoch 14/50
480/480 - 3s - loss: 0.1681 - accuracy: 0.9406 - val_loss: 0.2471 -
val_accuracy: 0.9187 - 3s/epoch - 6ms/step
Epoch 15/50
480/480 - 3s - loss: 0.1592 - accuracy: 0.9443 - val_loss: 0.2481 -
val_accuracy: 0.9183 - 3s/epoch - 6ms/step
Epoch 16/50
480/480 - 3s - loss: 0.1505 - accuracy: 0.9472 - val_loss: 0.2661 -
val_accuracy: 0.9130 - 3s/epoch - 6ms/step
Epoch 17/50
480/480 - 3s - loss: 0.1412 - accuracy: 0.9500 - val_loss: 0.2600 -
val_accuracy: 0.9145 - 3s/epoch - 6ms/step
Epoch 18/50
480/480 - 3s - loss: 0.1341 - accuracy: 0.9532 - val_loss: 0.2690 -
val_accuracy: 0.9152 - 3s/epoch - 6ms/step
Epoch 19/50
480/480 - 3s - loss: 0.1244 - accuracy: 0.9566 - val_loss: 0.2742 -
val_accuracy: 0.9165 - 3s/epoch - 7ms/step
Epoch 20/50
480/480 - 3s - loss: 0.1182 - accuracy: 0.9587 - val_loss: 0.2806 -
val_accuracy: 0.9155 - 3s/epoch - 6ms/step
Epoch 21/50
480/480 - 3s - loss: 0.1083 - accuracy: 0.9625 - val_loss: 0.2957 -
val_accuracy: 0.9145 - 3s/epoch - 6ms/step
Epoch 22/50
480/480 - 3s - loss: 0.1034 - accuracy: 0.9641 - val_loss: 0.3187 -
val_accuracy: 0.9135 - 3s/epoch - 7ms/step
Epoch 23/50
480/480 - 3s - loss: 0.1002 - accuracy: 0.9649 - val_loss: 0.3125 -
val_accuracy: 0.9146 - 3s/epoch - 6ms/step
Epoch 24/50
480/480 - 4s - loss: 0.0901 - accuracy: 0.9685 - val_loss: 0.3157 -
val_accuracy: 0.9125 - 4s/epoch - 8ms/step
Epoch 25/50
480/480 - 3s - loss: 0.0832 - accuracy: 0.9709 - val_loss: 0.3317 -
val_accuracy: 0.9135 - 3s/epoch - 6ms/step
Epoch 26/50
480/480 - 3s - loss: 0.0808 - accuracy: 0.9720 - val_loss: 0.3616 -
val_accuracy: 0.9116 - 3s/epoch - 6ms/step
Epoch 27/50
480/480 - 3s - loss: 0.0734 - accuracy: 0.9750 - val_loss: 0.3826 -
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val_accuracy: 0.9102 - 3s/epoch - 7ms/step
Epoch 28/50
480/480 - 3s - loss: 0.0717 - accuracy: 0.9753 - val_loss: 0.3475 -
val_accuracy: 0.9130 - 3s/epoch - 6ms/step
Epoch 29/50
480/480 - 3s - loss: 0.0644 - accuracy: 0.9779 - val_loss: 0.3789 -
val_accuracy: 0.9117 - 3s/epoch - 6ms/step
Epoch 30/50
480/480 - 3s - loss: 0.0613 - accuracy: 0.9793 - val_loss: 0.3801 -
val_accuracy: 0.9119 - 3s/epoch - 6ms/step
Epoch 31/50
480/480 - 3s - loss: 0.0556 - accuracy: 0.9817 - val_loss: 0.4309 -
val_accuracy: 0.9110 - 3s/epoch - 6ms/step
Epoch 32/50
480/480 - 3s - loss: 0.0578 - accuracy: 0.9805 - val_loss: 0.4021 -
val_accuracy: 0.9088 - 3s/epoch - 7ms/step
Epoch 33/50
480/480 - 3s - loss: 0.0501 - accuracy: 0.9830 - val_loss: 0.4270 -
val_accuracy: 0.9092 - 3s/epoch - 6ms/step
Epoch 34/50
480/480 - 3s - loss: 0.0490 - accuracy: 0.9836 - val_loss: 0.4535 -
val_accuracy: 0.9081 - 3s/epoch - 7ms/step
Epoch 35/50
480/480 - 3s - loss: 0.0457 - accuracy: 0.9849 - val_loss: 0.4846 -
val_accuracy: 0.9102 - 3s/epoch - 7ms/step
Epoch 36/50
480/480 - 3s - loss: 0.0438 - accuracy: 0.9853 - val_loss: 0.4597 -
val_accuracy: 0.9041 - 3s/epoch - 6ms/step
Epoch 37/50
480/480 - 3s - loss: 0.0441 - accuracy: 0.9852 - val_loss: 0.4634 -
val_accuracy: 0.9088 - 3s/epoch - 6ms/step
Epoch 38/50
480/480 - 3s - loss: 0.0367 - accuracy: 0.9874 - val_loss: 0.4755 -
val_accuracy: 0.9118 - 3s/epoch - 6ms/step
Epoch 39/50
480/480 - 3s - loss: 0.0357 - accuracy: 0.9881 - val_loss: 0.4773 -
val_accuracy: 0.9087 - 3s/epoch - 7ms/step
Epoch 40/50
480/480 - 3s - loss: 0.0354 - accuracy: 0.9878 - val_loss: 0.5116 -
val_accuracy: 0.9096 - 3s/epoch - 6ms/step
Epoch 41/50
480/480 - 3s - loss: 0.0307 - accuracy: 0.9898 - val_loss: 0.5204 -
val_accuracy: 0.9101 - 3s/epoch - 6ms/step
Epoch 42/50
480/480 - 3s - loss: 0.0320 - accuracy: 0.9891 - val_loss: 0.5217 -
val_accuracy: 0.9081 - 3s/epoch - 7ms/step
Epoch 43/50
480/480 - 3s - loss: 0.0297 - accuracy: 0.9902 - val_loss: 0.5543 -
val_accuracy: 0.9081 - 3s/epoch - 6ms/step
Epoch 44/50
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480/480 - 3s - loss: 0.0305 - accuracy: 0.9899 - val_loss: 0.5206 -
val_accuracy: 0.9057 - 3s/epoch - 6ms/step
Epoch 45/50
480/480 - 3s - loss: 0.0288 - accuracy: 0.9906 - val_loss: 0.5373 -
val_accuracy: 0.9069 - 3s/epoch - 6ms/step
Epoch 46/50
480/480 - 3s - loss: 0.0255 - accuracy: 0.9917 - val_loss: 0.5627 -
val_accuracy: 0.9097 - 3s/epoch - 6ms/step
Epoch 47/50
480/480 - 3s - loss: 0.0249 - accuracy: 0.9918 - val_loss: 0.5592 -
val_accuracy: 0.9080 - 3s/epoch - 6ms/step
Epoch 48/50
480/480 - 3s - loss: 0.0236 - accuracy: 0.9923 - val_loss: 0.5634 -
val_accuracy: 0.9094 - 3s/epoch - 7ms/step
Epoch 49/50
480/480 - 3s - loss: 0.0233 - accuracy: 0.9921 - val_loss: 0.5946 -
val_accuracy: 0.9073 - 3s/epoch - 6ms/step
Epoch 50/50
480/480 - 3s - loss: 0.0217 - accuracy: 0.9929 - val_loss: 0.5877 -
val_accuracy: 0.9049 - 3s/epoch - 6ms/step
accuracy: 90.51%
Training on fold 2/5...
[     0      4      5 ... 119997 119998 119999] [     1      2
3 ... 119994 119995 119996]
Epoch 1/50
480/480 - 5s - loss: 0.4517 - accuracy: 0.8396 - val_loss: 0.3214 -
val_accuracy: 0.8855 - 5s/epoch - 10ms/step
Epoch 2/50
480/480 - 3s - loss: 0.3081 - accuracy: 0.8925 - val_loss: 0.2950 -
val_accuracy: 0.8955 - 3s/epoch - 6ms/step
Epoch 3/50
480/480 - 3s - loss: 0.2801 - accuracy: 0.9019 - val_loss: 0.2740 -
val_accuracy: 0.9044 - 3s/epoch - 7ms/step
Epoch 4/50
480/480 - 3s - loss: 0.2621 - accuracy: 0.9081 - val_loss: 0.2629 -
val_accuracy: 0.9090 - 3s/epoch - 6ms/step
Epoch 5/50
480/480 - 3s - loss: 0.2459 - accuracy: 0.9142 - val_loss: 0.2529 -
val_accuracy: 0.9106 - 3s/epoch - 6ms/step
Epoch 6/50
480/480 - 3s - loss: 0.2335 - accuracy: 0.9179 - val_loss: 0.2464 -
val_accuracy: 0.9132 - 3s/epoch - 6ms/step
Epoch 7/50
480/480 - 3s - loss: 0.2256 - accuracy: 0.9200 - val_loss: 0.2507 -
val_accuracy: 0.9111 - 3s/epoch - 6ms/step
Epoch 8/50
480/480 - 3s - loss: 0.2133 - accuracy: 0.9245 - val_loss: 0.2363 -
val_accuracy: 0.9167 - 3s/epoch - 6ms/step
Epoch 9/50
480/480 - 3s - loss: 0.2051 - accuracy: 0.9270 - val_loss: 0.2371 -
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val_accuracy: 0.9162 - 3s/epoch - 6ms/step
Epoch 10/50
480/480 - 3s - loss: 0.1949 - accuracy: 0.9313 - val_loss: 0.2367 -
val_accuracy: 0.9193 - 3s/epoch - 7ms/step
Epoch 11/50
480/480 - 3s - loss: 0.1868 - accuracy: 0.9339 - val_loss: 0.2346 -
val_accuracy: 0.9193 - 3s/epoch - 7ms/step
Epoch 12/50
480/480 - 3s - loss: 0.1770 - accuracy: 0.9378 - val_loss: 0.2436 -
val_accuracy: 0.9193 - 3s/epoch - 6ms/step
Epoch 13/50
480/480 - 3s - loss: 0.1726 - accuracy: 0.9391 - val_loss: 0.2464 -
val_accuracy: 0.9162 - 3s/epoch - 6ms/step
Epoch 14/50
480/480 - 3s - loss: 0.1606 - accuracy: 0.9432 - val_loss: 0.2464 -
val_accuracy: 0.9190 - 3s/epoch - 6ms/step
Epoch 15/50
480/480 - 3s - loss: 0.1508 - accuracy: 0.9466 - val_loss: 0.2523 -
val_accuracy: 0.9188 - 3s/epoch - 6ms/step
Epoch 16/50
480/480 - 3s - loss: 0.1429 - accuracy: 0.9502 - val_loss: 0.2501 -
val_accuracy: 0.9166 - 3s/epoch - 6ms/step
Epoch 17/50
480/480 - 3s - loss: 0.1341 - accuracy: 0.9531 - val_loss: 0.2560 -
val_accuracy: 0.9174 - 3s/epoch - 6ms/step
Epoch 18/50
480/480 - 3s - loss: 0.1265 - accuracy: 0.9556 - val_loss: 0.2658 -
val_accuracy: 0.9155 - 3s/epoch - 6ms/step
Epoch 19/50
480/480 - 3s - loss: 0.1182 - accuracy: 0.9590 - val_loss: 0.2691 -
val_accuracy: 0.9163 - 3s/epoch - 6ms/step
Epoch 20/50
480/480 - 3s - loss: 0.1092 - accuracy: 0.9612 - val_loss: 0.2876 -
val_accuracy: 0.9161 - 3s/epoch - 6ms/step
Epoch 21/50
480/480 - 3s - loss: 0.1027 - accuracy: 0.9639 - val_loss: 0.3061 -
val_accuracy: 0.9121 - 3s/epoch - 6ms/step
Epoch 22/50
480/480 - 3s - loss: 0.0935 - accuracy: 0.9681 - val_loss: 0.3012 -
val_accuracy: 0.9137 - 3s/epoch - 7ms/step
Epoch 23/50
480/480 - 3s - loss: 0.0861 - accuracy: 0.9704 - val_loss: 0.3165 -
val_accuracy: 0.9121 - 3s/epoch - 6ms/step
Epoch 24/50
480/480 - 3s - loss: 0.0795 - accuracy: 0.9721 - val_loss: 0.3489 -
val_accuracy: 0.9121 - 3s/epoch - 6ms/step
Epoch 25/50
480/480 - 3s - loss: 0.0771 - accuracy: 0.9736 - val_loss: 0.3328 -
val_accuracy: 0.9141 - 3s/epoch - 6ms/step
Epoch 26/50
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480/480 - 3s - loss: 0.0681 - accuracy: 0.9767 - val_loss: 0.3685 -
val_accuracy: 0.9115 - 3s/epoch - 7ms/step
Epoch 27/50
480/480 - 3s - loss: 0.0609 - accuracy: 0.9794 - val_loss: 0.3707 -
val_accuracy: 0.9124 - 3s/epoch - 6ms/step
Epoch 28/50
480/480 - 3s - loss: 0.0605 - accuracy: 0.9797 - val_loss: 0.3719 -
val_accuracy: 0.9120 - 3s/epoch - 7ms/step
Epoch 29/50
480/480 - 4s - loss: 0.0542 - accuracy: 0.9817 - val_loss: 0.3888 -
val_accuracy: 0.9135 - 4s/epoch - 8ms/step
Epoch 30/50
480/480 - 3s - loss: 0.0483 - accuracy: 0.9838 - val_loss: 0.4145 -
val_accuracy: 0.9102 - 3s/epoch - 7ms/step
Epoch 31/50
480/480 - 3s - loss: 0.0484 - accuracy: 0.9835 - val_loss: 0.4125 -
val_accuracy: 0.9113 - 3s/epoch - 6ms/step
Epoch 32/50
480/480 - 3s - loss: 0.0445 - accuracy: 0.9853 - val_loss: 0.4287 -
val_accuracy: 0.9104 - 3s/epoch - 7ms/step
Epoch 33/50
480/480 - 3s - loss: 0.0405 - accuracy: 0.9869 - val_loss: 0.4317 -
val_accuracy: 0.9096 - 3s/epoch - 6ms/step
Epoch 34/50
480/480 - 3s - loss: 0.0411 - accuracy: 0.9866 - val_loss: 0.4650 -
val_accuracy: 0.9115 - 3s/epoch - 6ms/step
Epoch 35/50
480/480 - 3s - loss: 0.0370 - accuracy: 0.9879 - val_loss: 0.4637 -
val_accuracy: 0.9085 - 3s/epoch - 6ms/step
Epoch 36/50
480/480 - 3s - loss: 0.0360 - accuracy: 0.9886 - val_loss: 0.4755 -
val_accuracy: 0.9125 - 3s/epoch - 6ms/step
Epoch 37/50
480/480 - 3s - loss: 0.0307 - accuracy: 0.9901 - val_loss: 0.4996 -
val_accuracy: 0.9078 - 3s/epoch - 6ms/step
Epoch 38/50
480/480 - 3s - loss: 0.0365 - accuracy: 0.9881 - val_loss: 0.4852 -
val_accuracy: 0.9114 - 3s/epoch - 6ms/step
Epoch 39/50
480/480 - 3s - loss: 0.0297 - accuracy: 0.9903 - val_loss: 0.4930 -
val_accuracy: 0.9101 - 3s/epoch - 6ms/step
Epoch 40/50
480/480 - 3s - loss: 0.0263 - accuracy: 0.9913 - val_loss: 0.5326 -
val_accuracy: 0.9110 - 3s/epoch - 6ms/step
Epoch 41/50
480/480 - 3s - loss: 0.0298 - accuracy: 0.9905 - val_loss: 0.4883 -
val_accuracy: 0.9081 - 3s/epoch - 6ms/step
Epoch 42/50
480/480 - 3s - loss: 0.0267 - accuracy: 0.9916 - val_loss: 0.5172 -
val_accuracy: 0.9083 - 3s/epoch - 6ms/step
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Epoch 43/50
480/480 - 3s - loss: 0.0254 - accuracy: 0.9917 - val_loss: 0.5126 -
val_accuracy: 0.9080 - 3s/epoch - 7ms/step
Epoch 44/50
480/480 - 3s - loss: 0.0252 - accuracy: 0.9918 - val_loss: 0.5314 -
val_accuracy: 0.9105 - 3s/epoch - 7ms/step
Epoch 45/50
480/480 - 3s - loss: 0.0248 - accuracy: 0.9914 - val_loss: 0.5376 -
val_accuracy: 0.9087 - 3s/epoch - 6ms/step
Epoch 46/50
480/480 - 4s - loss: 0.0186 - accuracy: 0.9940 - val_loss: 0.5821 -
val_accuracy: 0.9079 - 4s/epoch - 8ms/step
Epoch 47/50
480/480 - 3s - loss: 0.0198 - accuracy: 0.9936 - val_loss: 0.5812 -
val_accuracy: 0.9056 - 3s/epoch - 7ms/step
Epoch 48/50
480/480 - 3s - loss: 0.0207 - accuracy: 0.9933 - val_loss: 0.5886 -
val_accuracy: 0.9068 - 3s/epoch - 6ms/step
Epoch 49/50
480/480 - 3s - loss: 0.0188 - accuracy: 0.9938 - val_loss: 0.5684 -
val_accuracy: 0.9108 - 3s/epoch - 7ms/step
Epoch 50/50
480/480 - 4s - loss: 0.0213 - accuracy: 0.9933 - val_loss: 0.5737 -
val_accuracy: 0.9077 - 4s/epoch - 7ms/step
accuracy: 90.17%
Training on fold 3/5...
[     0      1      2 ... 119996 119997 119999] [    26     34
39 ... 119991 119992 119998]
Epoch 1/50
480/480 - 6s - loss: 0.5734 - accuracy: 0.7776 - val_loss: 0.3591 -
val_accuracy: 0.8825 - 6s/epoch - 12ms/step
Epoch 2/50
480/480 - 3s - loss: 0.3303 - accuracy: 0.8894 - val_loss: 0.3279 -
val_accuracy: 0.8883 - 3s/epoch - 7ms/step
Epoch 3/50
480/480 - 3s - loss: 0.2967 - accuracy: 0.8985 - val_loss: 0.3039 -
val_accuracy: 0.8959 - 3s/epoch - 7ms/step
Epoch 4/50
480/480 - 3s - loss: 0.2744 - accuracy: 0.9059 - val_loss: 0.2816 -
val_accuracy: 0.9023 - 3s/epoch - 7ms/step
Epoch 5/50
480/480 - 3s - loss: 0.2602 - accuracy: 0.9100 - val_loss: 0.2729 -
val_accuracy: 0.9072 - 3s/epoch - 7ms/step
Epoch 6/50
480/480 - 3s - loss: 0.2455 - accuracy: 0.9156 - val_loss: 0.2603 -
val_accuracy: 0.9127 - 3s/epoch - 7ms/step
Epoch 7/50
480/480 - 3s - loss: 0.2361 - accuracy: 0.9175 - val_loss: 0.2569 -
val_accuracy: 0.9122 - 3s/epoch - 7ms/step
Epoch 8/50
```

```
480/480 - 3s - loss: 0.2262 - accuracy: 0.9223 - val_loss: 0.2567 -
val_accuracy: 0.9132 - 3s/epoch - 6ms/step
Epoch 9/50
480/480 - 3s - loss: 0.2171 - accuracy: 0.9247 - val_loss: 0.2479 -
val_accuracy: 0.9153 - 3s/epoch - 7ms/step
Epoch 10/50
480/480 - 3s - loss: 0.2039 - accuracy: 0.9294 - val_loss: 0.2491 -
val_accuracy: 0.9164 - 3s/epoch - 6ms/step
Epoch 11/50
480/480 - 3s - loss: 0.1984 - accuracy: 0.9308 - val_loss: 0.2486 -
val_accuracy: 0.9125 - 3s/epoch - 7ms/step
Epoch 12/50
480/480 - 3s - loss: 0.1870 - accuracy: 0.9348 - val_loss: 0.2468 -
val_accuracy: 0.9160 - 3s/epoch - 6ms/step
Epoch 13/50
480/480 - 3s - loss: 0.1784 - accuracy: 0.9383 - val_loss: 0.2472 -
val_accuracy: 0.9150 - 3s/epoch - 7ms/step
Epoch 14/50
480/480 - 3s - loss: 0.1703 - accuracy: 0.9408 - val_loss: 0.2606 -
val_accuracy: 0.9120 - 3s/epoch - 6ms/step
Epoch 15/50
480/480 - 3s - loss: 0.1601 - accuracy: 0.9444 - val_loss: 0.2587 -
val_accuracy: 0.9167 - 3s/epoch - 6ms/step
Epoch 16/50
480/480 - 3s - loss: 0.1527 - accuracy: 0.9465 - val_loss: 0.2614 -
val_accuracy: 0.9166 - 3s/epoch - 7ms/step
Epoch 17/50
480/480 - 4s - loss: 0.1439 - accuracy: 0.9497 - val_loss: 0.2903 -
val_accuracy: 0.9146 - 4s/epoch - 8ms/step
Epoch 18/50
480/480 - 3s - loss: 0.1377 - accuracy: 0.9519 - val_loss: 0.2774 -
val_accuracy: 0.9160 - 3s/epoch - 6ms/step
Epoch 19/50
480/480 - 3s - loss: 0.1292 - accuracy: 0.9555 - val_loss: 0.2813 -
val_accuracy: 0.9126 - 3s/epoch - 7ms/step
Epoch 20/50
480/480 - 3s - loss: 0.1208 - accuracy: 0.9580 - val_loss: 0.2820 -
val_accuracy: 0.9138 - 3s/epoch - 6ms/step
Epoch 21/50
480/480 - 3s - loss: 0.1164 - accuracy: 0.9602 - val_loss: 0.2932 -
val_accuracy: 0.9128 - 3s/epoch - 6ms/step
Epoch 22/50
480/480 - 3s - loss: 0.1099 - accuracy: 0.9624 - val_loss: 0.2815 -
val_accuracy: 0.9175 - 3s/epoch - 7ms/step
Epoch 23/50
480/480 - 3s - loss: 0.1005 - accuracy: 0.9651 - val_loss: 0.3120 -
val_accuracy: 0.9165 - 3s/epoch - 6ms/step
Epoch 24/50
480/480 - 3s - loss: 0.0943 - accuracy: 0.9682 - val_loss: 0.3272 -
val_accuracy: 0.9149 - 3s/epoch - 6ms/step
```

```
Epoch 25/50
480/480 - 3s - loss: 0.0909 - accuracy: 0.9686 - val_loss: 0.3246 -
val_accuracy: 0.9153 - 3s/epoch - 6ms/step
Epoch 26/50
480/480 - 3s - loss: 0.0858 - accuracy: 0.9711 - val_loss: 0.3459 -
val_accuracy: 0.9157 - 3s/epoch - 6ms/step
Epoch 27/50
480/480 - 3s - loss: 0.0819 - accuracy: 0.9726 - val_loss: 0.3582 -
val_accuracy: 0.9104 - 3s/epoch - 6ms/step
Epoch 28/50
480/480 - 3s - loss: 0.0798 - accuracy: 0.9730 - val_loss: 0.3625 -
val_accuracy: 0.9122 - 3s/epoch - 6ms/step
Epoch 29/50
480/480 - 3s - loss: 0.0727 - accuracy: 0.9760 - val_loss: 0.3892 -
val_accuracy: 0.9062 - 3s/epoch - 7ms/step
Epoch 30/50
480/480 - 3s - loss: 0.0687 - accuracy: 0.9772 - val_loss: 0.3735 -
val_accuracy: 0.9107 - 3s/epoch - 6ms/step
Epoch 31/50
480/480 - 3s - loss: 0.0648 - accuracy: 0.9784 - val_loss: 0.3906 -
val_accuracy: 0.9130 - 3s/epoch - 6ms/step
Epoch 32/50
480/480 - 4s - loss: 0.0581 - accuracy: 0.9806 - val_loss: 0.4013 -
val_accuracy: 0.9122 - 4s/epoch - 8ms/step
Epoch 33/50
480/480 - 3s - loss: 0.0553 - accuracy: 0.9816 - val_loss: 0.4291 -
val_accuracy: 0.9082 - 3s/epoch - 6ms/step
Epoch 34/50
480/480 - 3s - loss: 0.0559 - accuracy: 0.9813 - val_loss: 0.3939 -
val_accuracy: 0.9121 - 3s/epoch - 6ms/step
Epoch 35/50
480/480 - 3s - loss: 0.0538 - accuracy: 0.9821 - val_loss: 0.4337 -
val_accuracy: 0.9120 - 3s/epoch - 6ms/step
Epoch 36/50
480/480 - 3s - loss: 0.0486 - accuracy: 0.9837 - val_loss: 0.4341 -
val_accuracy: 0.9098 - 3s/epoch - 6ms/step
Epoch 37/50
480/480 - 3s - loss: 0.0457 - accuracy: 0.9849 - val_loss: 0.4457 -
val_accuracy: 0.9041 - 3s/epoch - 6ms/step
Epoch 38/50
480/480 - 3s - loss: 0.0425 - accuracy: 0.9862 - val_loss: 0.4558 -
val_accuracy: 0.9074 - 3s/epoch - 7ms/step
Epoch 39/50
480/480 - 3s - loss: 0.0415 - accuracy: 0.9863 - val_loss: 0.4702 -
val_accuracy: 0.9097 - 3s/epoch - 6ms/step
Epoch 40/50
480/480 - 3s - loss: 0.0394 - accuracy: 0.9868 - val_loss: 0.4850 -
val_accuracy: 0.9105 - 3s/epoch - 7ms/step
Epoch 41/50
480/480 - 3s - loss: 0.0394 - accuracy: 0.9874 - val_loss: 0.4648 -
```

```
val_accuracy: 0.9097 - 3s/epoch - 7ms/step
Epoch 42/50
480/480 - 3s - loss: 0.0354 - accuracy: 0.9886 - val_loss: 0.4941 -
val_accuracy: 0.9079 - 3s/epoch - 6ms/step
Epoch 43/50
480/480 - 3s - loss: 0.0346 - accuracy: 0.9887 - val_loss: 0.5064 -
val_accuracy: 0.9097 - 3s/epoch - 6ms/step
Epoch 44/50
480/480 - 3s - loss: 0.0352 - accuracy: 0.9889 - val_loss: 0.5059 -
val_accuracy: 0.9073 - 3s/epoch - 7ms/step
Epoch 45/50
480/480 - 3s - loss: 0.0341 - accuracy: 0.9894 - val_loss: 0.5025 -
val_accuracy: 0.9073 - 3s/epoch - 7ms/step
Epoch 46/50
480/480 - 3s - loss: 0.0337 - accuracy: 0.9891 - val_loss: 0.4990 -
val_accuracy: 0.9043 - 3s/epoch - 6ms/step
Epoch 47/50
480/480 - 4s - loss: 0.0348 - accuracy: 0.9885 - val_loss: 0.5297 -
val_accuracy: 0.9050 - 4s/epoch - 8ms/step
Epoch 48/50
480/480 - 3s - loss: 0.0258 - accuracy: 0.9915 - val_loss: 0.5389 -
val_accuracy: 0.9099 - 3s/epoch - 7ms/step
Epoch 49/50
480/480 - 4s - loss: 0.0272 - accuracy: 0.9911 - val_loss: 0.5296 -
val_accuracy: 0.9035 - 4s/epoch - 8ms/step
Epoch 50/50
480/480 - 3s - loss: 0.0258 - accuracy: 0.9918 - val_loss: 0.5410 -
val_accuracy: 0.9056 - 3s/epoch - 7ms/step
accuracy: 90.80%
Training on fold 4/5...
[     0      1      2 ... 119997 119998 119999] [     5     10
11 ... 119982 119985 119989]
Epoch 1/50
480/480 - 7s - loss: 0.5562 - accuracy: 0.8180 - val_loss: 0.3549 -
val_accuracy: 0.8815 - 7s/epoch - 14ms/step
Epoch 2/50
480/480 - 4s - loss: 0.3226 - accuracy: 0.8918 - val_loss: 0.3173 -
val_accuracy: 0.8915 - 4s/epoch - 7ms/step
Epoch 3/50
480/480 - 3s - loss: 0.2977 - accuracy: 0.8991 - val_loss: 0.2892 -
val_accuracy: 0.9003 - 3s/epoch - 7ms/step
Epoch 4/50
480/480 - 4s - loss: 0.2760 - accuracy: 0.9059 - val_loss: 0.2811 -
val_accuracy: 0.9015 - 4s/epoch - 9ms/step
Epoch 5/50
480/480 - 4s - loss: 0.2594 - accuracy: 0.9102 - val_loss: 0.2801 -
val_accuracy: 0.9007 - 4s/epoch - 8ms/step
Epoch 6/50
480/480 - 3s - loss: 0.2464 - accuracy: 0.9149 - val_loss: 0.2567 -
val_accuracy: 0.9106 - 3s/epoch - 6ms/step
```

```
Epoch 7/50
480/480 - 3s - loss: 0.2340 - accuracy: 0.9187 - val_loss: 0.2548 -
val_accuracy: 0.9120 - 3s/epoch - 7ms/step
Epoch 8/50
480/480 - 3s - loss: 0.2239 - accuracy: 0.9234 - val_loss: 0.2484 -
val_accuracy: 0.9119 - 3s/epoch - 7ms/step
Epoch 9/50
480/480 - 4s - loss: 0.2132 - accuracy: 0.9262 - val_loss: 0.2431 -
val_accuracy: 0.9155 - 4s/epoch - 8ms/step
Epoch 10/50
480/480 - 4s - loss: 0.2040 - accuracy: 0.9289 - val_loss: 0.2500 -
val_accuracy: 0.9143 - 4s/epoch - 7ms/step
Epoch 11/50
480/480 - 3s - loss: 0.1926 - accuracy: 0.9324 - val_loss: 0.2442 -
val_accuracy: 0.9169 - 3s/epoch - 7ms/step
Epoch 12/50
480/480 - 3s - loss: 0.1848 - accuracy: 0.9349 - val_loss: 0.2511 -
val_accuracy: 0.9160 - 3s/epoch - 7ms/step
Epoch 13/50
480/480 - 3s - loss: 0.1748 - accuracy: 0.9390 - val_loss: 0.2518 -
val_accuracy: 0.9147 - 3s/epoch - 6ms/step
Epoch 14/50
480/480 - 3s - loss: 0.1656 - accuracy: 0.9422 - val_loss: 0.2466 -
val_accuracy: 0.9169 - 3s/epoch - 7ms/step
Epoch 15/50
480/480 - 3s - loss: 0.1571 - accuracy: 0.9451 - val_loss: 0.2524 -
val_accuracy: 0.9153 - 3s/epoch - 6ms/step
Epoch 16/50
480/480 - 3s - loss: 0.1481 - accuracy: 0.9484 - val_loss: 0.2677 -
val_accuracy: 0.9140 - 3s/epoch - 7ms/step
Epoch 17/50
480/480 - 3s - loss: 0.1392 - accuracy: 0.9515 - val_loss: 0.2683 -
val_accuracy: 0.9134 - 3s/epoch - 7ms/step
Epoch 18/50
480/480 - 3s - loss: 0.1308 - accuracy: 0.9543 - val_loss: 0.2767 -
val_accuracy: 0.9134 - 3s/epoch - 7ms/step
Epoch 19/50
480/480 - 3s - loss: 0.1249 - accuracy: 0.9566 - val_loss: 0.2832 -
val_accuracy: 0.9143 - 3s/epoch - 6ms/step
Epoch 20/50
480/480 - 3s - loss: 0.1172 - accuracy: 0.9591 - val_loss: 0.2904 -
val_accuracy: 0.9146 - 3s/epoch - 7ms/step
Epoch 21/50
480/480 - 3s - loss: 0.1094 - accuracy: 0.9628 - val_loss: 0.3038 -
val_accuracy: 0.9123 - 3s/epoch - 6ms/step
Epoch 22/50
480/480 - 3s - loss: 0.1020 - accuracy: 0.9652 - val_loss: 0.3226 -
val_accuracy: 0.9075 - 3s/epoch - 6ms/step
Epoch 23/50
480/480 - 4s - loss: 0.0951 - accuracy: 0.9675 - val_loss: 0.3151 -
```

```
val_accuracy: 0.9121 - 4s/epoch - 9ms/step
Epoch 24/50
480/480 - 3s - loss: 0.0899 - accuracy: 0.9697 - val_loss: 0.3220 -
val_accuracy: 0.9128 - 3s/epoch - 7ms/step
Epoch 25/50
480/480 - 3s - loss: 0.0835 - accuracy: 0.9716 - val_loss: 0.3480 -
val_accuracy: 0.9097 - 3s/epoch - 6ms/step
Epoch 26/50
480/480 - 3s - loss: 0.0832 - accuracy: 0.9721 - val_loss: 0.3508 -
val_accuracy: 0.9110 - 3s/epoch - 6ms/step
Epoch 27/50
480/480 - 3s - loss: 0.0746 - accuracy: 0.9749 - val_loss: 0.3539 -
val_accuracy: 0.9126 - 3s/epoch - 6ms/step
Epoch 28/50
480/480 - 3s - loss: 0.0696 - accuracy: 0.9773 - val_loss: 0.3552 -
val_accuracy: 0.9115 - 3s/epoch - 7ms/step
Epoch 29/50
480/480 - 3s - loss: 0.0632 - accuracy: 0.9798 - val_loss: 0.3753 -
val_accuracy: 0.9089 - 3s/epoch - 6ms/step
Epoch 30/50
480/480 - 3s - loss: 0.0665 - accuracy: 0.9780 - val_loss: 0.3816 -
val_accuracy: 0.9093 - 3s/epoch - 6ms/step
Epoch 31/50
480/480 - 3s - loss: 0.0567 - accuracy: 0.9813 - val_loss: 0.4148 -
val_accuracy: 0.9096 - 3s/epoch - 6ms/step
Epoch 32/50
480/480 - 3s - loss: 0.0508 - accuracy: 0.9835 - val_loss: 0.4283 -
val_accuracy: 0.9108 - 3s/epoch - 6ms/step
Epoch 33/50
480/480 - 3s - loss: 0.0565 - accuracy: 0.9816 - val_loss: 0.4174 -
val_accuracy: 0.9094 - 3s/epoch - 6ms/step
Epoch 34/50
480/480 - 3s - loss: 0.0483 - accuracy: 0.9838 - val_loss: 0.4425 -
val_accuracy: 0.9058 - 3s/epoch - 6ms/step
Epoch 35/50
480/480 - 3s - loss: 0.0442 - accuracy: 0.9857 - val_loss: 0.4665 -
val_accuracy: 0.9084 - 3s/epoch - 6ms/step
Epoch 36/50
480/480 - 3s - loss: 0.0432 - accuracy: 0.9858 - val_loss: 0.4788 -
val_accuracy: 0.9063 - 3s/epoch - 6ms/step
Epoch 37/50
480/480 - 3s - loss: 0.0431 - accuracy: 0.9861 - val_loss: 0.4399 -
val_accuracy: 0.9083 - 3s/epoch - 6ms/step
Epoch 38/50
480/480 - 3s - loss: 0.0394 - accuracy: 0.9873 - val_loss: 0.4725 -
val_accuracy: 0.9078 - 3s/epoch - 6ms/step
Epoch 39/50
480/480 - 3s - loss: 0.0407 - accuracy: 0.9868 - val_loss: 0.4890 -
val_accuracy: 0.9045 - 3s/epoch - 7ms/step
Epoch 40/50
```

```
480/480 - 4s - loss: 0.0349 - accuracy: 0.9885 - val_loss: 0.4946 -
val_accuracy: 0.9106 - 4s/epoch - 8ms/step
Epoch 41/50
480/480 - 3s - loss: 0.0352 - accuracy: 0.9887 - val_loss: 0.4947 -
val_accuracy: 0.9060 - 3s/epoch - 6ms/step
Epoch 42/50
480/480 - 3s - loss: 0.0340 - accuracy: 0.9890 - val_loss: 0.5077 -
val_accuracy: 0.9053 - 3s/epoch - 7ms/step
Epoch 43/50
480/480 - 3s - loss: 0.0285 - accuracy: 0.9907 - val_loss: 0.5344 -
val_accuracy: 0.9036 - 3s/epoch - 7ms/step
Epoch 44/50
480/480 - 3s - loss: 0.0288 - accuracy: 0.9911 - val_loss: 0.5091 -
val_accuracy: 0.9038 - 3s/epoch - 7ms/step
Epoch 45/50
480/480 - 4s - loss: 0.0298 - accuracy: 0.9904 - val_loss: 0.5537 -
val_accuracy: 0.9076 - 4s/epoch - 8ms/step
Epoch 46/50
480/480 - 4s - loss: 0.0287 - accuracy: 0.9908 - val_loss: 0.5589 -
val_accuracy: 0.9072 - 4s/epoch - 7ms/step
Epoch 47/50
480/480 - 3s - loss: 0.0267 - accuracy: 0.9914 - val_loss: 0.5792 -
val_accuracy: 0.9035 - 3s/epoch - 7ms/step
Epoch 48/50
480/480 - 4s - loss: 0.0340 - accuracy: 0.9894 - val_loss: 0.5307 -
val_accuracy: 0.9090 - 4s/epoch - 7ms/step
Epoch 49/50
480/480 - 3s - loss: 0.0211 - accuracy: 0.9934 - val_loss: 0.5878 -
val_accuracy: 0.9029 - 3s/epoch - 6ms/step
Epoch 50/50
480/480 - 3s - loss: 0.0259 - accuracy: 0.9914 - val_loss: 0.5727 -
val_accuracy: 0.9080 - 3s/epoch - 7ms/step
accuracy: 90.75%
Training on fold 5/5...
[     0      1      2 ... 119996 119997 119998] [    18     25
28 ... 119984 119993 119999]
Epoch 1/50
480/480 - 5s - loss: 0.6126 - accuracy: 0.8071 - val_loss: 0.3744 -
val_accuracy: 0.8827 - 5s/epoch - 11ms/step
Epoch 2/50
480/480 - 4s - loss: 0.3296 - accuracy: 0.8922 - val_loss: 0.3171 -
val_accuracy: 0.8980 - 4s/epoch - 8ms/step
Epoch 3/50
480/480 - 4s - loss: 0.2952 - accuracy: 0.9007 - val_loss: 0.2888 -
val_accuracy: 0.9012 - 4s/epoch - 8ms/step
Epoch 4/50
480/480 - 3s - loss: 0.2721 - accuracy: 0.9064 - val_loss: 0.2832 -
val_accuracy: 0.9053 - 3s/epoch - 7ms/step
Epoch 5/50
480/480 - 4s - loss: 0.2539 - accuracy: 0.9120 - val_loss: 0.2571 -
```

```
val_accuracy: 0.9119 - 4s/epoch - 9ms/step
Epoch 6/50
480/480 - 3s - loss: 0.2428 - accuracy: 0.9158 - val_loss: 0.2523 -
val_accuracy: 0.9137 - 3s/epoch - 7ms/step
Epoch 7/50
480/480 - 3s - loss: 0.2316 - accuracy: 0.9182 - val_loss: 0.2486 -
val_accuracy: 0.9150 - 3s/epoch - 7ms/step
Epoch 8/50
480/480 - 3s - loss: 0.2197 - accuracy: 0.9230 - val_loss: 0.2480 -
val_accuracy: 0.9165 - 3s/epoch - 7ms/step
Epoch 9/50
480/480 - 3s - loss: 0.2086 - accuracy: 0.9269 - val_loss: 0.2545 -
val_accuracy: 0.9135 - 3s/epoch - 6ms/step
Epoch 10/50
480/480 - 3s - loss: 0.1995 - accuracy: 0.9296 - val_loss: 0.2459 -
val_accuracy: 0.9187 - 3s/epoch - 6ms/step
Epoch 11/50
480/480 - 3s - loss: 0.1900 - accuracy: 0.9333 - val_loss: 0.2502 -
val_accuracy: 0.9165 - 3s/epoch - 7ms/step
Epoch 12/50
480/480 - 3s - loss: 0.1819 - accuracy: 0.9370 - val_loss: 0.2483 -
val_accuracy: 0.9174 - 3s/epoch - 7ms/step
Epoch 13/50
480/480 - 3s - loss: 0.1716 - accuracy: 0.9399 - val_loss: 0.2543 -
val_accuracy: 0.9183 - 3s/epoch - 6ms/step
Epoch 14/50
480/480 - 3s - loss: 0.1623 - accuracy: 0.9429 - val_loss: 0.2663 -
val_accuracy: 0.9156 - 3s/epoch - 6ms/step
Epoch 15/50
480/480 - 3s - loss: 0.1540 - accuracy: 0.9463 - val_loss: 0.2568 -
val_accuracy: 0.9166 - 3s/epoch - 6ms/step
Epoch 16/50
480/480 - 3s - loss: 0.1433 - accuracy: 0.9501 - val_loss: 0.2582 -
val_accuracy: 0.9195 - 3s/epoch - 6ms/step
Epoch 17/50
480/480 - 3s - loss: 0.1369 - accuracy: 0.9524 - val_loss: 0.2648 -
val_accuracy: 0.9178 - 3s/epoch - 6ms/step
Epoch 18/50
480/480 - 3s - loss: 0.1311 - accuracy: 0.9542 - val_loss: 0.2684 -
val_accuracy: 0.9171 - 3s/epoch - 7ms/step
Epoch 19/50
480/480 - 3s - loss: 0.1222 - accuracy: 0.9573 - val_loss: 0.2893 -
val_accuracy: 0.9176 - 3s/epoch - 6ms/step
Epoch 20/50
480/480 - 3s - loss: 0.1121 - accuracy: 0.9609 - val_loss: 0.3061 -
val_accuracy: 0.9158 - 3s/epoch - 6ms/step
Epoch 21/50
480/480 - 3s - loss: 0.1052 - accuracy: 0.9632 - val_loss: 0.2921 -
val_accuracy: 0.9165 - 3s/epoch - 6ms/step
Epoch 22/50
```

```
480/480 - 3s - loss: 0.1007 - accuracy: 0.9644 - val_loss: 0.3150 -
val_accuracy: 0.9142 - 3s/epoch - 6ms/step
Epoch 23/50
480/480 - 3s - loss: 0.0962 - accuracy: 0.9664 - val_loss: 0.3176 -
val_accuracy: 0.9137 - 3s/epoch - 7ms/step
Epoch 24/50
480/480 - 3s - loss: 0.0869 - accuracy: 0.9696 - val_loss: 0.3350 -
val_accuracy: 0.9140 - 3s/epoch - 6ms/step
Epoch 25/50
480/480 - 3s - loss: 0.0827 - accuracy: 0.9712 - val_loss: 0.3202 -
val_accuracy: 0.9138 - 3s/epoch - 6ms/step
Epoch 26/50
480/480 - 3s - loss: 0.0794 - accuracy: 0.9726 - val_loss: 0.3423 -
val_accuracy: 0.9136 - 3s/epoch - 7ms/step
Epoch 27/50
480/480 - 3s - loss: 0.0741 - accuracy: 0.9746 - val_loss: 0.3655 -
val_accuracy: 0.9123 - 3s/epoch - 7ms/step
Epoch 28/50
480/480 - 3s - loss: 0.0683 - accuracy: 0.9763 - val_loss: 0.3781 -
val_accuracy: 0.9085 - 3s/epoch - 6ms/step
Epoch 29/50
480/480 - 3s - loss: 0.0645 - accuracy: 0.9779 - val_loss: 0.3837 -
val_accuracy: 0.9137 - 3s/epoch - 6ms/step
Epoch 30/50
480/480 - 3s - loss: 0.0579 - accuracy: 0.9803 - val_loss: 0.3957 -
val_accuracy: 0.9108 - 3s/epoch - 6ms/step
Epoch 31/50
480/480 - 3s - loss: 0.0585 - accuracy: 0.9801 - val_loss: 0.3987 -
val_accuracy: 0.9134 - 3s/epoch - 6ms/step
Epoch 32/50
480/480 - 3s - loss: 0.0542 - accuracy: 0.9813 - val_loss: 0.4005 -
val_accuracy: 0.9116 - 3s/epoch - 6ms/step
Epoch 33/50
480/480 - 3s - loss: 0.0496 - accuracy: 0.9829 - val_loss: 0.4296 -
val_accuracy: 0.9105 - 3s/epoch - 7ms/step
Epoch 34/50
480/480 - 3s - loss: 0.0481 - accuracy: 0.9837 - val_loss: 0.4409 -
val_accuracy: 0.9112 - 3s/epoch - 7ms/step
Epoch 35/50
480/480 - 3s - loss: 0.0437 - accuracy: 0.9856 - val_loss: 0.4670 -
val_accuracy: 0.9093 - 3s/epoch - 6ms/step
Epoch 36/50
480/480 - 3s - loss: 0.0422 - accuracy: 0.9857 - val_loss: 0.4660 -
val_accuracy: 0.9056 - 3s/epoch - 6ms/step
Epoch 37/50
480/480 - 3s - loss: 0.0430 - accuracy: 0.9857 - val_loss: 0.4699 -
val_accuracy: 0.9095 - 3s/epoch - 6ms/step
Epoch 38/50
480/480 - 3s - loss: 0.0358 - accuracy: 0.9881 - val_loss: 0.4851 -
val_accuracy: 0.9078 - 3s/epoch - 6ms/step
```

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Epoch 39/50
480/480 - 3s - loss: 0.0359 - accuracy: 0.9879 - val_loss: 0.4621 -
val_accuracy: 0.9094 - 3s/epoch - 6ms/step
Epoch 40/50
480/480 - 3s - loss: 0.0363 - accuracy: 0.9878 - val_loss: 0.4975 -
val_accuracy: 0.9105 - 3s/epoch - 6ms/step
Epoch 41/50
480/480 - 3s - loss: 0.0310 - accuracy: 0.9896 - val_loss: 0.4996 -
val_accuracy: 0.9097 - 3s/epoch - 6ms/step
Epoch 42/50
480/480 - 3s - loss: 0.0298 - accuracy: 0.9905 - val_loss: 0.5085 -
val_accuracy: 0.9036 - 3s/epoch - 7ms/step
Epoch 43/50
480/480 - 3s - loss: 0.0275 - accuracy: 0.9908 - val_loss: 0.5352 -
val_accuracy: 0.9117 - 3s/epoch - 7ms/step
Epoch 44/50
480/480 - 3s - loss: 0.0290 - accuracy: 0.9903 - val_loss: 0.5248 -
val_accuracy: 0.9055 - 3s/epoch - 6ms/step
Epoch 45/50
480/480 - 3s - loss: 0.0306 - accuracy: 0.9898 - val_loss: 0.5050 -
val_accuracy: 0.9076 - 3s/epoch - 6ms/step
Epoch 46/50
480/480 - 3s - loss: 0.0298 - accuracy: 0.9899 - val_loss: 0.4951 -
val_accuracy: 0.9081 - 3s/epoch - 6ms/step
Epoch 47/50
480/480 - 3s - loss: 0.0290 - accuracy: 0.9905 - val_loss: 0.5337 -
val_accuracy: 0.9082 - 3s/epoch - 6ms/step
Epoch 48/50
480/480 - 3s - loss: 0.0192 - accuracy: 0.9936 - val_loss: 0.5708 -
val_accuracy: 0.9076 - 3s/epoch - 6ms/step
Epoch 49/50
480/480 - 3s - loss: 0.0186 - accuracy: 0.9941 - val_loss: 0.5915 -
val_accuracy: 0.9074 - 3s/epoch - 6ms/step
Epoch 50/50
480/480 - 3s - loss: 0.0239 - accuracy: 0.9921 - val_loss: 0.5731 -
val_accuracy: 0.9060 - 3s/epoch - 7ms/step
accuracy: 90.21%
90.49% (+/- 0.26%)
```