N1_best

December 23, 2021

1 MNIST handwritten digits

MLP - MNIST

[ ]:
```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
```

1.1 1. Load Dataset

MNIST dataset loading

[ ]:
```
(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()    #␣
↪load mnist data
x_train, x_test = x_train / 255.0, x_test / 255.0
```

1.2 2. Dataset split

train dataset 60000 , split 3

[ ]:
```
import random

rand_selected = random.sample([x for x in range(0, len(x_train))], 30000)
x_train = x_train[rand_selected]
y_train = y_train[rand_selected]

print(f"shape of x_train is {tf.shape(x_train)}")
print(f"shape of y_train is {tf.shape(y_train)}")
print(f"shape of x_test is {tf.shape(x_test)}")
print(f"shape of y_test is {tf.shape(y_test)}")
```

```
shape of x_train is [30000    28    28]
shape of y_train is [30000]
shape of x_test is [10000    28    28]
shape of y_test is [10000]
```

1.3 3. Training data preprocessing

1.3.1 3.1. Data Normalize

[ ]:
```
mean = np.mean(x_train)
std = np.std(x_train)

x_train = (x_train - mean)/std
x_test = (x_test - mean)/std
```

1.3.2 3.2. Data enhance - By shifting and rotating

[ ]:
```
from scipy.ndimage.interpolation import shift

x_enhanced = []
y_enhanced = []

shifting_list = [
    [0, 1],
    [1, 0],
    [-1, 0],
    [0, -1],
    [1, 1],
    [-1, 1],
    [1, -1],
    [-1, -1]
]

for x_shift, y_shift in shifting_list:
     for image, label in zip(x_train, y_train):
        shifted_image = shift(image, [y_shift, x_shift])
        shifted_image.reshape([-1])
        x_enhanced.append(shifted_image)
        y_enhanced.append(label)

shifted_x_train = np.array(x_enhanced)
shifted_y_train = np.array(y_enhanced)

print(f"shape of shifted_x_train is {np.shape(shifted_x_train)}")
print(f"shape of shifted_y_train is {np.shape(shifted_y_train)}")
```

```
shape of shifted_x_train is (240000, 28, 28)
shape of shifted_y_train is (240000,)
```

[ ]:
```
import imutils

x_enhanced = []
y_enhanced = []

rotating_list = [10, 20, 30]
```

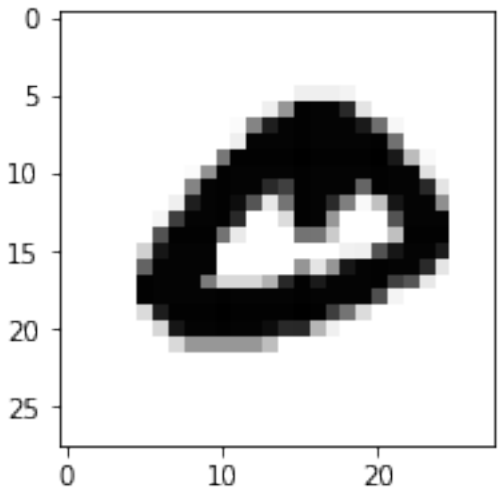
```
for rotate_angle in rotating_list:
    for image, label in zip(x_train, y_train):
        positive_rotated_image = imutils.rotate(image, rotate_angle)
        negative_rotated_image = imutils.rotate(image, -rotate_angle)
        x_enhanced.append(positive_rotated_image)
        y_enhanced.append(label)
        x_enhanced.append(negative_rotated_image)
        y_enhanced.append(label)

rotated_x_train = np.array(x_enhanced)
rotated_y_train = np.array(y_enhanced)

print(f"shape of rotated_x_train is {np.shape(rotated_x_train)}")
print(f"shape of rotated_y_train is {np.shape(rotated_y_train)}")
```

```
shape of rotated_x_train is (180000, 28, 28)
shape of rotated_y_train is (180000,)
```

[ ]:
```
x_train = np.append(x_train, shifted_x_train, 0)
x_train = np.append(x_train, rotated_x_train, 0)
shifted_x_train = []
rotated_x_train = []

y_train = np.append(y_train, shifted_y_train, 0)
y_train = np.append(y_train, rotated_y_train, 0)
shifted_y_train = []
rotated_y_train = []

rand_selected = random.sample([x for x in range(0, len(x_train))], len(x_train))
x_train = np.array(x_train)[rand_selected]
y_train = np.array(y_train)[rand_selected]

print(f"shape of x_train is {np.shape(x_train)}")
print(f"shape of y_train is {np.shape(y_train)}")
```

```
shape of x_train is (450000, 28, 28)
shape of y_train is (450000,)
```

[ ]:
```
sel = random.randint(0, len(x_train))

plt.figure(figsize=(3, 3))
train_img = np.reshape(x_train[sel], [28, 28])
plt.imshow(train_img, cmap='Greys')
plt.show()

y_train[sel]
```



[ ]: 0

[ ]:
```
model = tf.keras.models.Sequential([
    tf.keras.layers.Flatten(input_shape=(28, 28)),
    tf.keras.layers.Dense(786, activation='relu'),
    tf.keras.layers.Dense(1024, activation='relu'),
    tf.keras.layers.Dense(2048, activation='relu'),
    tf.keras.layers.Dense(4096, activation='relu'),
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(4096, activation='relu'),
    tf.keras.layers.BatchNormalization(),
    tf.keras.layers.Dropout(0.2),
    tf.keras.layers.Dense(2048, activation='relu'),
    tf.keras.layers.Dense(1000, activation='relu'),
    tf.keras.layers.Dense(10, activation='softmax')
])

opt = tf.keras.optimizers.Adam(lr=0.0008)
los = tf.keras.losses.SparseCategoricalCrossentropy()
model.compile(optimizer=opt,
              loss=los,
              metrics=[tf.keras.metrics.SparseCategoricalAccuracy()])
```

```
C:\Users\s\anaconda3\envs\tf3\lib\site-
packages\tensorflow\python\keras\optimizer_v2\optimizer_v2.py:374: UserWarning:
The `lr` argument is deprecated, use `learning_rate` instead.
  warnings.warn(
```

[ ]:
```
tf.device('/device:GPU:0')
model.fit(x_train, y_train, epochs=200, batch_size=128,␣
 ↪validation_data=(x_test, y_test))

model.evaluate(x_test,  y_test)
```

```
Epoch 1/200
3516/3516 [==============================] - 155s 43ms/step - loss: 0.1639 -
sparse_categorical_accuracy: 0.9517 - val_loss: 0.1114 -
val_sparse_categorical_accuracy: 0.9716
Epoch 2/200
3516/3516 [==============================] - 150s 43ms/step - loss: 0.0816 -
sparse_categorical_accuracy: 0.9778 - val_loss: 0.0816 -
val_sparse_categorical_accuracy: 0.9769
Epoch 3/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0453 -
sparse_categorical_accuracy: 0.9866 - val_loss: 0.0595 -
val_sparse_categorical_accuracy: 0.9861
Epoch 4/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0409 -
sparse_categorical_accuracy: 0.9882 - val_loss: 0.0454 -
val_sparse_categorical_accuracy: 0.9870
Epoch 5/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0274 -
sparse_categorical_accuracy: 0.9918 - val_loss: 0.0786 -
val_sparse_categorical_accuracy: 0.9807
Epoch 6/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0220 -
sparse_categorical_accuracy: 0.9934 - val_loss: 33.4142 -
val_sparse_categorical_accuracy: 0.9736
Epoch 7/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0197 -
sparse_categorical_accuracy: 0.9941 - val_loss: 0.0668 -
val_sparse_categorical_accuracy: 0.9855
Epoch 8/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0161 -
sparse_categorical_accuracy: 0.9952 - val_loss: 0.9264 -
val_sparse_categorical_accuracy: 0.9865
Epoch 9/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0460 -
sparse_categorical_accuracy: 0.9889 - val_loss: 487.1641 -
val_sparse_categorical_accuracy: 0.9863
Epoch 10/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0148 -
sparse_categorical_accuracy: 0.9954 - val_loss: 0.0659 -
val_sparse_categorical_accuracy: 0.9864
Epoch 11/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0121 -
```

```
sparse_categorical_accuracy: 0.9963 - val_loss: 0.0641 -
val_sparse_categorical_accuracy: 0.9858
Epoch 12/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0119 -
sparse_categorical_accuracy: 0.9965 - val_loss: 402.8019 -
val_sparse_categorical_accuracy: 0.9890
Epoch 13/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0111 -
sparse_categorical_accuracy: 0.9968 - val_loss: 7.7001 -
val_sparse_categorical_accuracy: 0.9869
Epoch 14/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0092 -
sparse_categorical_accuracy: 0.9973 - val_loss: 152.8742 -
val_sparse_categorical_accuracy: 0.9882
Epoch 15/200
3516/3516 [==============================] - 153s 43ms/step - loss: 0.0087 -
sparse_categorical_accuracy: 0.9975 - val_loss: 0.5760 -
val_sparse_categorical_accuracy: 0.9865
Epoch 16/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0075 -
sparse_categorical_accuracy: 0.9978 - val_loss: 95.6817 -
val_sparse_categorical_accuracy: 0.9877
Epoch 17/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0072 -
sparse_categorical_accuracy: 0.9980 - val_loss: 2.4024 -
val_sparse_categorical_accuracy: 0.9873
Epoch 18/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0067 -
sparse_categorical_accuracy: 0.9980 - val_loss: 0.0763 -
val_sparse_categorical_accuracy: 0.9884
Epoch 19/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0061 -
sparse_categorical_accuracy: 0.9982 - val_loss: 15.9387 -
val_sparse_categorical_accuracy: 0.9870
Epoch 20/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0059 -
sparse_categorical_accuracy: 0.9983 - val_loss: 366.7099 -
val_sparse_categorical_accuracy: 0.9878
Epoch 21/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0055 -
sparse_categorical_accuracy: 0.9984 - val_loss: 5689.1011 -
val_sparse_categorical_accuracy: 0.9874
Epoch 22/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0050 -
sparse_categorical_accuracy: 0.9986 - val_loss: 5242.0806 -
val_sparse_categorical_accuracy: 0.9876
Epoch 23/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0046 -
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sparse_categorical_accuracy: 0.9986 - val_loss: 829.7619 -
val_sparse_categorical_accuracy: 0.9832
Epoch 24/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0048 -
sparse_categorical_accuracy: 0.9986 - val_loss: 1381.5134 -
val_sparse_categorical_accuracy: 0.9881
Epoch 25/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0048 -
sparse_categorical_accuracy: 0.9987 - val_loss: 331.2173 -
val_sparse_categorical_accuracy: 0.9894
Epoch 26/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0042 -
sparse_categorical_accuracy: 0.9988 - val_loss: 2062.0898 -
val_sparse_categorical_accuracy: 0.9873
Epoch 27/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0042 -
sparse_categorical_accuracy: 0.9988 - val_loss: 1367.2219 -
val_sparse_categorical_accuracy: 0.9884
Epoch 28/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0050 -
sparse_categorical_accuracy: 0.9987 - val_loss: 795.3657 -
val_sparse_categorical_accuracy: 0.9882
Epoch 29/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0042 -
sparse_categorical_accuracy: 0.9989 - val_loss: 9983.5146 -
val_sparse_categorical_accuracy: 0.9886
Epoch 30/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0040 -
sparse_categorical_accuracy: 0.9990 - val_loss: 842.8039 -
val_sparse_categorical_accuracy: 0.9894
Epoch 31/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0036 -
sparse_categorical_accuracy: 0.9991 - val_loss: 124.2607 -
val_sparse_categorical_accuracy: 0.9883
Epoch 32/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0104 -
sparse_categorical_accuracy: 0.9990 - val_loss: 31.6713 -
val_sparse_categorical_accuracy: 0.9894
Epoch 33/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0029 -
sparse_categorical_accuracy: 0.9992 - val_loss: 824.0040 -
val_sparse_categorical_accuracy: 0.9865
Epoch 34/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0037 -
sparse_categorical_accuracy: 0.9991 - val_loss: 729.6958 -
val_sparse_categorical_accuracy: 0.9866
Epoch 35/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0035 -
```

```
sparse_categorical_accuracy: 0.9991 - val_loss: 17056.6328 -
val_sparse_categorical_accuracy: 0.9871
Epoch 36/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0032 -
sparse_categorical_accuracy: 0.9992 - val_loss: 2136.6455 -
val_sparse_categorical_accuracy: 0.9883
Epoch 37/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0037 -
sparse_categorical_accuracy: 0.9991 - val_loss: 2485.1465 -
val_sparse_categorical_accuracy: 0.9889
Epoch 38/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0032 -
sparse_categorical_accuracy: 0.9992 - val_loss: 3397.7771 -
val_sparse_categorical_accuracy: 0.9885
Epoch 39/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0034 -
sparse_categorical_accuracy: 0.9993 - val_loss: 424.2791 -
val_sparse_categorical_accuracy: 0.9906
Epoch 40/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0030 -
sparse_categorical_accuracy: 0.9993 - val_loss: 1546.6687 -
val_sparse_categorical_accuracy: 0.9890
Epoch 41/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0031 -
sparse_categorical_accuracy: 0.9993 - val_loss: 0.3252 -
val_sparse_categorical_accuracy: 0.9888
Epoch 42/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0027 -
sparse_categorical_accuracy: 0.9993 - val_loss: 197.0490 -
val_sparse_categorical_accuracy: 0.9873
Epoch 43/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0029 -
sparse_categorical_accuracy: 0.9993 - val_loss: 0.0859 -
val_sparse_categorical_accuracy: 0.9876
Epoch 44/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0025 -
sparse_categorical_accuracy: 0.9994 - val_loss: 283.9232 -
val_sparse_categorical_accuracy: 0.9893
Epoch 45/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0022 -
sparse_categorical_accuracy: 0.9995 - val_loss: 0.1178 -
val_sparse_categorical_accuracy: 0.9891
Epoch 46/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0034 -
sparse_categorical_accuracy: 0.9993 - val_loss: 835.1567 -
val_sparse_categorical_accuracy: 0.9896
Epoch 47/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0024 -
```

```
sparse_categorical_accuracy: 0.9994 - val_loss: 1870.4091 -
val_sparse_categorical_accuracy: 0.9888
Epoch 48/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0027 -
sparse_categorical_accuracy: 0.9993 - val_loss: 1945.5258 -
val_sparse_categorical_accuracy: 0.9897
Epoch 49/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0023 -
sparse_categorical_accuracy: 0.9994 - val_loss: 463.7016 -
val_sparse_categorical_accuracy: 0.9883
Epoch 50/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0034 -
sparse_categorical_accuracy: 0.9993 - val_loss: 12.9880 -
val_sparse_categorical_accuracy: 0.9894
Epoch 51/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9995 - val_loss: 2531.2942 -
val_sparse_categorical_accuracy: 0.9883
Epoch 52/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0027 -
sparse_categorical_accuracy: 0.9994 - val_loss: 7.8626 -
val_sparse_categorical_accuracy: 0.9889
Epoch 53/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9995 - val_loss: 86.6578 -
val_sparse_categorical_accuracy: 0.9900
Epoch 54/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0023 -
sparse_categorical_accuracy: 0.9995 - val_loss: 6780.9487 -
val_sparse_categorical_accuracy: 0.9882
Epoch 55/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0030 -
sparse_categorical_accuracy: 0.9994 - val_loss: 0.0744 -
val_sparse_categorical_accuracy: 0.9886
Epoch 56/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.0987 -
val_sparse_categorical_accuracy: 0.9897
Epoch 57/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0024 -
sparse_categorical_accuracy: 0.9995 - val_loss: 14608.5332 -
val_sparse_categorical_accuracy: 0.9886
Epoch 58/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9996 - val_loss: 542.2712 -
val_sparse_categorical_accuracy: 0.9882
Epoch 59/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0025 -
```

```
sparse_categorical_accuracy: 0.9995 - val_loss: 0.1152 -
val_sparse_categorical_accuracy: 0.9889
Epoch 60/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0025 -
sparse_categorical_accuracy: 0.9995 - val_loss: 0.1345 -
val_sparse_categorical_accuracy: 0.9892
Epoch 61/200
3516/3516 [==============================] - 154s 44ms/step - loss: 0.0023 -
sparse_categorical_accuracy: 0.9995 - val_loss: 0.2236 -
val_sparse_categorical_accuracy: 0.9900
Epoch 62/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9995 - val_loss: 10717.2500 -
val_sparse_categorical_accuracy: 0.9907
Epoch 63/200
3516/3516 [==============================] - 154s 44ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9995 - val_loss: 0.1387 -
val_sparse_categorical_accuracy: 0.9888
Epoch 64/200
3516/3516 [==============================] - 154s 44ms/step - loss: 0.0022 -
sparse_categorical_accuracy: 0.9995 - val_loss: 7.3736 -
val_sparse_categorical_accuracy: 0.9892
Epoch 65/200
3516/3516 [==============================] - 154s 44ms/step - loss: 0.0028 -
sparse_categorical_accuracy: 0.9995 - val_loss: 690.6861 -
val_sparse_categorical_accuracy: 0.9900
Epoch 66/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.0875 -
val_sparse_categorical_accuracy: 0.9903
Epoch 67/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0023 -
sparse_categorical_accuracy: 0.9996 - val_loss: 906.5092 -
val_sparse_categorical_accuracy: 0.9890
Epoch 68/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9996 - val_loss: 3315.0220 -
val_sparse_categorical_accuracy: 0.9884
Epoch 69/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9996 - val_loss: 203.8761 -
val_sparse_categorical_accuracy: 0.9894
Epoch 70/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9996 - val_loss: 1.2443 -
val_sparse_categorical_accuracy: 0.9882
Epoch 71/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0017 -
```

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sparse_categorical_accuracy: 0.9996 - val_loss: 0.1553 -
val_sparse_categorical_accuracy: 0.9891
Epoch 72/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0022 -
sparse_categorical_accuracy: 0.9996 - val_loss: 4877.5967 -
val_sparse_categorical_accuracy: 0.9888
Epoch 73/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1408 -
val_sparse_categorical_accuracy: 0.9884
Epoch 74/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9996 - val_loss: 1.9329 -
val_sparse_categorical_accuracy: 0.9884
Epoch 75/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9996 - val_loss: 262.3875 -
val_sparse_categorical_accuracy: 0.9890
Epoch 76/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9996 - val_loss: 56.5535 -
val_sparse_categorical_accuracy: 0.9883
Epoch 77/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0024 -
sparse_categorical_accuracy: 0.9995 - val_loss: 0.1173 -
val_sparse_categorical_accuracy: 0.9894
Epoch 78/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 1.0001 -
val_sparse_categorical_accuracy: 0.9886
Epoch 79/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1112 -
val_sparse_categorical_accuracy: 0.9882
Epoch 80/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1545 -
val_sparse_categorical_accuracy: 0.9886
Epoch 81/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9996 - val_loss: 6.7095 -
val_sparse_categorical_accuracy: 0.9890
Epoch 82/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1142 -
val_sparse_categorical_accuracy: 0.9885
Epoch 83/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0020 -
```

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sparse_categorical_accuracy: 0.9996 - val_loss: 0.0992 -
val_sparse_categorical_accuracy: 0.9900
Epoch 84/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.5133 -
val_sparse_categorical_accuracy: 0.9883
Epoch 85/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1100 -
val_sparse_categorical_accuracy: 0.9905
Epoch 86/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1754 -
val_sparse_categorical_accuracy: 0.9883
Epoch 87/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 427.0164 -
val_sparse_categorical_accuracy: 0.9889
Epoch 88/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9997 - val_loss: 2661.8154 -
val_sparse_categorical_accuracy: 0.9894
Epoch 89/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1719 -
val_sparse_categorical_accuracy: 0.9896
Epoch 90/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9997 - val_loss: 5.8366 -
val_sparse_categorical_accuracy: 0.9875
Epoch 91/200
3516/3516 [==============================] - 154s 44ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9996 - val_loss: 24.3505 -
val_sparse_categorical_accuracy: 0.9900
Epoch 92/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9996 - val_loss: 8246.3281 -
val_sparse_categorical_accuracy: 0.9890
Epoch 93/200
3516/3516 [==============================] - 160s 46ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.4016 -
val_sparse_categorical_accuracy: 0.9885
Epoch 94/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.9143 -
val_sparse_categorical_accuracy: 0.9891
Epoch 95/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0018 -
```

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sparse_categorical_accuracy: 0.9997 - val_loss: 4.2574 -
val_sparse_categorical_accuracy: 0.9887
Epoch 96/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 1193.6361 -
val_sparse_categorical_accuracy: 0.9902
Epoch 97/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 1.3925 -
val_sparse_categorical_accuracy: 0.9897
Epoch 98/200
3516/3516 [==============================] - 160s 45ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.4177 -
val_sparse_categorical_accuracy: 0.9879
Epoch 99/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9997 - val_loss: 20762.6523 -
val_sparse_categorical_accuracy: 0.9897
Epoch 100/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 1681.7190 -
val_sparse_categorical_accuracy: 0.9888
Epoch 101/200
3516/3516 [==============================] - 160s 46ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 38414.5391 -
val_sparse_categorical_accuracy: 0.9889
Epoch 102/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 91.9181 -
val_sparse_categorical_accuracy: 0.9906
Epoch 103/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9997 - val_loss: 125.6030 -
val_sparse_categorical_accuracy: 0.9880
Epoch 104/200
3516/3516 [==============================] - 160s 46ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 11142.0859 -
val_sparse_categorical_accuracy: 0.9905
Epoch 105/200
3516/3516 [==============================] - 160s 46ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1405 -
val_sparse_categorical_accuracy: 0.9892
Epoch 106/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1585 -
val_sparse_categorical_accuracy: 0.9899
Epoch 107/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0023 -
```

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sparse_categorical_accuracy: 0.9996 - val_loss: 0.1372 -
val_sparse_categorical_accuracy: 0.9891
Epoch 108/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1450 -
val_sparse_categorical_accuracy: 0.9896
Epoch 109/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1418 -
val_sparse_categorical_accuracy: 0.9896
Epoch 110/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9997 - val_loss: 2568.9580 -
val_sparse_categorical_accuracy: 0.9893
Epoch 111/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9998 - val_loss: 16227.6445 -
val_sparse_categorical_accuracy: 0.9890
Epoch 112/200
3516/3516 [==============================] - 153s 44ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1478 -
val_sparse_categorical_accuracy: 0.9899
Epoch 113/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1532 -
val_sparse_categorical_accuracy: 0.9884
Epoch 114/200
3516/3516 [==============================] - 159s 45ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 18708.3770 -
val_sparse_categorical_accuracy: 0.9882
Epoch 115/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0081 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1122 -
val_sparse_categorical_accuracy: 0.9894
Epoch 116/200
3516/3516 [==============================] - 161s 46ms/step - loss: 8.8311e-04 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1505 -
val_sparse_categorical_accuracy: 0.9883
Epoch 117/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0022 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1902 -
val_sparse_categorical_accuracy: 0.9894
Epoch 118/200
3516/3516 [==============================] - 159s 45ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1896 -
val_sparse_categorical_accuracy: 0.9881
Epoch 119/200
3516/3516 [==============================] - 153s 44ms/step - loss: 0.0019 -
```

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sparse_categorical_accuracy: 0.9997 - val_loss: 0.1404 -
val_sparse_categorical_accuracy: 0.9895
Epoch 120/200
3516/3516 [==============================] - 153s 43ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.3695 -
val_sparse_categorical_accuracy: 0.9909
Epoch 121/200
3516/3516 [==============================] - 153s 43ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 2.9952 -
val_sparse_categorical_accuracy: 0.9887
Epoch 122/200
3516/3516 [==============================] - 153s 44ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1448 -
val_sparse_categorical_accuracy: 0.9880
Epoch 123/200
3516/3516 [==============================] - 153s 43ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.2591 -
val_sparse_categorical_accuracy: 0.9885
Epoch 124/200
3516/3516 [==============================] - 153s 43ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1552 -
val_sparse_categorical_accuracy: 0.9893
Epoch 125/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0011 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2178 -
val_sparse_categorical_accuracy: 0.9905
Epoch 126/200
3516/3516 [==============================] - 168s 48ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.2516 -
val_sparse_categorical_accuracy: 0.9893
Epoch 127/200
3516/3516 [==============================] - 171s 49ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1459 -
val_sparse_categorical_accuracy: 0.9899
Epoch 128/200
3516/3516 [==============================] - 162s 46ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 23.1394 -
val_sparse_categorical_accuracy: 0.9878
Epoch 129/200
3516/3516 [==============================] - 153s 44ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1298 -
val_sparse_categorical_accuracy: 0.9892
Epoch 130/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1404 -
val_sparse_categorical_accuracy: 0.9902
Epoch 131/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0015 -
```

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sparse_categorical_accuracy: 0.9997 - val_loss: 0.1437 -
val_sparse_categorical_accuracy: 0.9881
Epoch 132/200
3516/3516 [==============================] - 163s 46ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1157 -
val_sparse_categorical_accuracy: 0.9888
Epoch 133/200
3516/3516 [==============================] - 160s 45ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 13014.4092 -
val_sparse_categorical_accuracy: 0.9897
Epoch 134/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1818 -
val_sparse_categorical_accuracy: 0.9890
Epoch 135/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1653 -
val_sparse_categorical_accuracy: 0.9886
Epoch 136/200
3516/3516 [==============================] - 150s 43ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.2971 -
val_sparse_categorical_accuracy: 0.9890
Epoch 137/200
3516/3516 [==============================] - 151s 43ms/step - loss: 0.0011 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.3495 -
val_sparse_categorical_accuracy: 0.9901
Epoch 138/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0024 -
sparse_categorical_accuracy: 0.9996 - val_loss: 0.1263 -
val_sparse_categorical_accuracy: 0.9898
Epoch 139/200
3516/3516 [==============================] - 156s 44ms/step - loss: 9.9943e-04 -
sparse_categorical_accuracy: 0.9998 - val_loss: 17.7183 -
val_sparse_categorical_accuracy: 0.9887
Epoch 140/200
3516/3516 [==============================] - 153s 44ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.7339 -
val_sparse_categorical_accuracy: 0.9908
Epoch 141/200
3516/3516 [==============================] - 153s 44ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1457 -
val_sparse_categorical_accuracy: 0.9877
Epoch 142/200
3516/3516 [==============================] - 150s 43ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 17.4736 -
val_sparse_categorical_accuracy: 0.9894
Epoch 143/200
3516/3516 [==============================] - 151s 43ms/step - loss: 0.0018 -
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sparse_categorical_accuracy: 0.9997 - val_loss: 0.1823 -
val_sparse_categorical_accuracy: 0.9889
Epoch 144/200
3516/3516 [==============================] - 155s 44ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1732 -
val_sparse_categorical_accuracy: 0.9900
Epoch 145/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1731 -
val_sparse_categorical_accuracy: 0.9890
Epoch 146/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1135 -
val_sparse_categorical_accuracy: 0.9908
Epoch 147/200
3516/3516 [==============================] - 154s 44ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1773 -
val_sparse_categorical_accuracy: 0.9896
Epoch 148/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1487 -
val_sparse_categorical_accuracy: 0.9903
Epoch 149/200
3516/3516 [==============================] - 162s 46ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1247 -
val_sparse_categorical_accuracy: 0.9901
Epoch 150/200
3516/3516 [==============================] - 154s 44ms/step - loss: 0.0010 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1437 -
val_sparse_categorical_accuracy: 0.9894
Epoch 151/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0018 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1339 -
val_sparse_categorical_accuracy: 0.9895
Epoch 152/200
3516/3516 [==============================] - 156s 44ms/step - loss: 8.8194e-04 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1687 -
val_sparse_categorical_accuracy: 0.9894
Epoch 153/200
3516/3516 [==============================] - 160s 45ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9997 - val_loss: 1.3412 -
val_sparse_categorical_accuracy: 0.9895
Epoch 154/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1039 -
val_sparse_categorical_accuracy: 0.9902
Epoch 155/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0016 -
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sparse_categorical_accuracy: 0.9998 - val_loss: 42.0488 -
val_sparse_categorical_accuracy: 0.9895
Epoch 156/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.1762 -
val_sparse_categorical_accuracy: 0.9898
Epoch 157/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0011 -
sparse_categorical_accuracy: 0.9998 - val_loss: 5.6772 -
val_sparse_categorical_accuracy: 0.9901
Epoch 158/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9997 - val_loss: 2004.5176 -
val_sparse_categorical_accuracy: 0.9903
Epoch 159/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9998 - val_loss: 15290.8945 -
val_sparse_categorical_accuracy: 0.9894
Epoch 160/200
3516/3516 [==============================] - 158s 45ms/step - loss: 5.3244e-04 -
sparse_categorical_accuracy: 0.9999 - val_loss: 8920.5752 -
val_sparse_categorical_accuracy: 0.9897
Epoch 161/200
3516/3516 [==============================] - 160s 45ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9997 - val_loss: 4918.4126 -
val_sparse_categorical_accuracy: 0.9903
Epoch 162/200
3516/3516 [==============================] - 151s 43ms/step - loss: 9.3921e-04 -
sparse_categorical_accuracy: 0.9998 - val_loss: 6.1484 -
val_sparse_categorical_accuracy: 0.9898
Epoch 163/200
3516/3516 [==============================] - 163s 46ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9997 - val_loss: 869.4488 -
val_sparse_categorical_accuracy: 0.9899
Epoch 164/200
3516/3516 [==============================] - 162s 46ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9998 - val_loss: 6.7427 -
val_sparse_categorical_accuracy: 0.9896
Epoch 165/200
3516/3516 [==============================] - 164s 47ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 544.3418 -
val_sparse_categorical_accuracy: 0.9891
Epoch 166/200
3516/3516 [==============================] - 160s 46ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.2871 -
val_sparse_categorical_accuracy: 0.9888
Epoch 167/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0015 -
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sparse_categorical_accuracy: 0.9998 - val_loss: 4202.4502 -
val_sparse_categorical_accuracy: 0.9892
Epoch 168/200
3516/3516 [==============================] - 167s 47ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9998 - val_loss: 12825.3701 -
val_sparse_categorical_accuracy: 0.9902
Epoch 169/200
3516/3516 [==============================] - 164s 47ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.5625 -
val_sparse_categorical_accuracy: 0.9903
Epoch 170/200
3516/3516 [==============================] - 167s 47ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9998 - val_loss: 2621.2673 -
val_sparse_categorical_accuracy: 0.9893
Epoch 171/200
3516/3516 [==============================] - 166s 47ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 5.7971 -
val_sparse_categorical_accuracy: 0.9892
Epoch 172/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 19.7114 -
val_sparse_categorical_accuracy: 0.9898
Epoch 173/200
3516/3516 [==============================] - 160s 45ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 19.8529 -
val_sparse_categorical_accuracy: 0.9885
Epoch 174/200
3516/3516 [==============================] - 159s 45ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2009 -
val_sparse_categorical_accuracy: 0.9905
Epoch 175/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2121 -
val_sparse_categorical_accuracy: 0.9890
Epoch 176/200
3516/3516 [==============================] - 153s 44ms/step - loss: 0.0017 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.3163 -
val_sparse_categorical_accuracy: 0.9886
Epoch 177/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0013 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2672 -
val_sparse_categorical_accuracy: 0.9899
Epoch 178/200
3516/3516 [==============================] - 160s 46ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9997 - val_loss: 5309.5259 -
val_sparse_categorical_accuracy: 0.9896
Epoch 179/200
3516/3516 [==============================] - 159s 45ms/step - loss: 0.0012 -
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sparse_categorical_accuracy: 0.9998 - val_loss: 33619.4023 -
val_sparse_categorical_accuracy: 0.9893
Epoch 180/200
3516/3516 [==============================] - 161s 46ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.3643 -
val_sparse_categorical_accuracy: 0.9899
Epoch 181/200
3516/3516 [==============================] - 157s 45ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.3131 -
val_sparse_categorical_accuracy: 0.9903
Epoch 182/200
3516/3516 [==============================] - 160s 45ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2585 -
val_sparse_categorical_accuracy: 0.9901
Epoch 183/200
3516/3516 [==============================] - 160s 46ms/step - loss: 0.0022 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.6802 -
val_sparse_categorical_accuracy: 0.9906
Epoch 184/200
3516/3516 [==============================] - 162s 46ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9997 - val_loss: 0.2816 -
val_sparse_categorical_accuracy: 0.9897
Epoch 185/200
3516/3516 [==============================] - 163s 46ms/step - loss: 0.0016 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2208 -
val_sparse_categorical_accuracy: 0.9899
Epoch 186/200
3516/3516 [==============================] - 168s 48ms/step - loss: 9.5316e-04 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2654 -
val_sparse_categorical_accuracy: 0.9897
Epoch 187/200
3516/3516 [==============================] - 164s 47ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.4231 -
val_sparse_categorical_accuracy: 0.9893
Epoch 188/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2888 -
val_sparse_categorical_accuracy: 0.9884
Epoch 189/200
3516/3516 [==============================] - 159s 45ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9998 - val_loss: 39.2707 -
val_sparse_categorical_accuracy: 0.9900
Epoch 190/200
3516/3516 [==============================] - 159s 45ms/step - loss: 0.0012 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2374 -
val_sparse_categorical_accuracy: 0.9901
Epoch 191/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0020 -
```

```
sparse_categorical_accuracy: 0.9998 - val_loss: 0.2250 -
val_sparse_categorical_accuracy: 0.9891
Epoch 192/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0010 -
sparse_categorical_accuracy: 0.9998 - val_loss: 542.1512 -
val_sparse_categorical_accuracy: 0.9890
3516/3516 [==============================] - 158s 45ms/step - loss: 9.1281e-04 -
sparse_categorical_accuracy: 0.9998 - val_loss: 22536.8047 -
val_sparse_categorical_accuracy: 0.9898
Epoch 194/200
3516/3516 [==============================] - 159s 45ms/step - loss: 0.0014 -
sparse_categorical_accuracy: 0.9998 - val_loss: 1554.7810 -
val_sparse_categorical_accuracy: 0.9896
Epoch 195/200
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0020 -
sparse_categorical_accuracy: 0.9998 - val_loss: 3.0466 -
val_sparse_categorical_accuracy: 0.9897
Epoch 196/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0019 -
sparse_categorical_accuracy: 0.9998 - val_loss: 71.2805 -
val_sparse_categorical_accuracy: 0.9895
Epoch 197/200
3516/3516 [==============================] - 156s 44ms/step - loss: 0.0015 -
sparse_categorical_accuracy: 0.9998 - val_loss: 0.1560 -
val_sparse_categorical_accuracy: 0.9902
3516/3516 [==============================] - 158s 45ms/step - loss: 0.0021 -
sparse_categorical_accuracy: 0.9997 - val_loss: 12185.9131 -
val_sparse_categorical_accuracy: 0.9908n
Epoch 199/200
3516/3516 [==============================] - 152s 43ms/step - loss: 0.0090 -
sparse_categorical_accuracy: 0.9997 - val_loss: 7387.3657 -
val_sparse_categorical_accuracy: 0.9888
Epoch 200/200
3516/3516 [==============================] - 150s 43ms/step - loss: 9.6642e-04 -
sparse_categorical_accuracy: 0.9999 - val_loss: 16.3740 -
val_sparse_categorical_accuracy: 0.9900
313/313 [==============================] - 2s 6ms/step - loss: 16.3739 -
sparse_categorical_accuracy: 0.9900
```

[ ]:
```
[16.373878479003906, 0.9900000095367432]
```

[ ]: