In [1]:
```
#!/usr/bin/env python3
# -*- coding: utf-8 -*-

"""
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Tune hyperparameters of VOC_net model.

"""

%matplotlib inline

import sys
import os
import matplotlib as mpl
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from scipy import signal
from ipywidgets import interactive
import seaborn as sns  #heat map
import glob # batch processing of images

if '../../' not in sys.path:
    sys.path.append('../../')

import math
from scipy import signal
from sklearn.metrics import confusion_matrix
from sklearn.preprocessing import LabelBinarizer
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
from sklearn.metrics import roc_auc_score

import itertools

from vocnet.misc.utils import classifier_internals
from vocnet.misc.utils import clf_post_processor


from vocnet.spectral_datasets.IR_datasets import IR_data
from vocnet.spectral_datasets.IR_datasets import spectra_to_img
from vocnet.spectral_datasets.THz_datasets import THz_data

from vocnet.misc.aperture import publication_fig
from vocnet.misc.voc_net_utils import multiclass_roc_auc_score
from vocnet.misc.voc_net_utils import plot_raw_scores
from vocnet.misc.voc_net_utils import simple_spectrum_fig
from vocnet.misc.voc_net_utils import simple_plot_raw_scores

from vocnet.misc.voc_net_utils import plot_sequential_group_prediction
```

```
import tensorflow as tf
from tensorflow.keras import datasets, layers, models

GPU_mem_limit=1.0
gpus = tf.config.experimental.list_physical_devices('GPU')
if gpus:
    try:
        tf.config.experimental.set_virtual_device_configuration(gpus[0]

    except RuntimeError as e:
        print(e)



# !pip install git+https://github.com/tensorflow/docs

import tensorflow_docs as tfdocs
import tensorflow_docs.modeling
import tensorflow_docs.plots
import tensorflow_docs.modeling
from tensorflow.keras import regularizers

from vocnet.models.voc_net_models import get_callbacks
from vocnet.models.voc_net_models import get_optimizer
from vocnet.models.voc_net_models import compile_and_fit


from vocnet.models.voc_net_models import C1f1k3_AP1_D12
from vocnet.models.voc_net_models import C1f1k3_MP1_D12

from vocnet.models.voc_net_models import C2f1k3_AP1_D12
from vocnet.models.voc_net_models import C2f1k3_AP1_D48_D12
from vocnet.models.voc_net_models import C2f1k3_AP2_D48_D12

from vocnet.models.voc_net_models import C2f3k3_AP1_D48_D12
from vocnet.models.voc_net_models import C2f3k3_AP1_D6_D12

from vocnet.models.voc_net_models import C1f1k3_AP1_RD50_D12
from vocnet.models.voc_net_models import C1f1k3_AP1_D48_RL1_D12
from vocnet.models.voc_net_models import C2f3k3_AP1_D48_RD50_D12
from vocnet.models.voc_net_models import C2f3k3_AP1_D48_RL1_D12
from vocnet.models.voc_net_models import C2f3k3_AP1_D48_RL1_RD50_D12



from tensorflow import keras
import keras_tuner as kt

#Set random seed
# os.environ['PYTHONHASHSEED'] = str(42)
tf.random.set_seed(42)
# np.random.seed(42)
```

```
2022-07-07 12:59:49.632684: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcudart.s
o.11.0
2022-07-07 12:59:50.496051: I tensorflow/stream_executor/platform/defa
```

```
ult/dso_loader.cc:53] Successfully opened dynamic library libcuda.so.1
2022-07-07 12:59:50.526016: I tensorflow/core/common_runtime/gpu/gpu_d
evice.cc:1733] Found device 0 with properties:
pciBusID: 0000:65:00.0 name: Quadro RTX 4000 computeCapability: 7.5
coreClock: 1.545GHz coreCount: 36 deviceMemorySize: 7.79GiB deviceMemo
ryBandwidth: 387.49GiB/s
2022-07-07 12:59:50.526078: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcudart.s
o.11.0
2022-07-07 12:59:50.532176: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcublas.s
o.11
2022-07-07 12:59:50.532277: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcublasLt.
so.11
2022-07-07 12:59:50.533524: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcufft.so.
10
2022-07-07 12:59:50.533807: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcurand.s
o.10
2022-07-07 12:59:50.534369: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcusolver.
so.11
2022-07-07 12:59:50.535278: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcusparse.
so.11
2022-07-07 12:59:50.535434: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcudnn.so.
8
2022-07-07 12:59:50.536294: I tensorflow/core/common_runtime/gpu/gpu_d
evice.cc:1871] Adding visible gpu devices: 0
```

In [2]:
```
s = THz_data(resolution=0.016, verbosity = False)
s.load_THz_data()
# s.dataset_info()
X = s.spectra
y = s.targets

X=np.expand_dims(X,-1)
```

In [3]:
```
#split intro train and test set

#seeds used 123,237, 786
from sklearn.model_selection import train_test_split

TRAIN_SIZE=0.70
TEST_SIZE=1-TRAIN_SIZE

x_train, x_test, y_train, y_test = train_test_split(X, y, train_size=TR
                                                    test_size=TEST_SIZE,
                                                    random_state=786,
                                                    stratify=y
                                                    )

print("All:", np.bincount(y) / float(len(y))*100  )
```

```
print("Training:", np.bincount(y_train) / float(len(y_train))*100  )
print("Testing:", np.bincount(y_test) / float(len(y_test))*100  )
```

```
All: [8.33333333 8.33333333 8.33333333 8.33333333 8.33333333 8.3333333
3
 8.33333333 8.33333333 8.33333333 8.33333333 8.33333333 8.33333333]
Training: [8.35148874 8.35148874 8.35148874 8.35148874 8.35148874 8.35
148874
 8.35148874 8.2788671  8.35148874 8.35148874 8.2788671  8.2788671 ]
Testing: [8.29103215 8.29103215 8.29103215 8.29103215 8.29103215 8.291
03215
 8.29103215 8.46023689 8.29103215 8.29103215 8.46023689 8.46023689]
```

In [4]:

```
def thz_model(hp):

    model = models.Sequential()

    hp_filters= hp.Int('filters', min_value=2, max_value=4, step=1)
#     hp_kernel_size= hp.Int('kernel_size', min_value=3, max_value=5, s
#     hp_pool_size=hp.Int('pool_size', min_value=2, max_value=3, step=1
#     hp_stride_size=hp.Int('stride_size', min_value=2, max_value=3, st
    hp_units= hp.Int('units', min_value=24, max_value=48, step=6)
#     hp_dropout = hp.Choice('dropout', values=[0.3, 0.5, 0.7])
    hp_learning_rate = hp.Choice('learning_rate', values=[1e-2, 1e-3, 1

    # C1 Convolutional Layer
    model.add(layers.Conv1D(filters = hp_filters , kernel_size=3, activ

    # S2 Subsampling Layer
    model.add(layers.AveragePooling1D(pool_size = 2, strides = 2, paddi

    # C3 Convolutional Layer
    model.add(layers.Conv1D(filters = hp_filters , kernel_size=3, activ

    # Flatten the CNN output to feed it with fully connected layers
    model.add(layers.Flatten())

    model.add(layers.Dense(hp_units, activation='relu'))
    model.add(layers.Dropout(0.5))
    model.add(layers.Dense(12))  # number of dense layer would be equal

    # Tune the learning rate for the optimizer
    # Choose an optimal value from 0.01, 0.001, or 0.0001


    model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=hp_l
            loss=tf.keras.losses.SparseCategoricalCrossentropy(from_log
                metrics=[
              tf.keras.losses.SparseCategoricalCrossentropy(
                  from_logits=True, name='SparseCatCrossentropy'),
              'accuracy'])

    model.summary()

    return model
```

In [5]:
```
tuner = kt.Hyperband(thz_model,
                     objective='accuracy',
                     max_epochs=10,
                     factor=3,
                     directory='keras_hp_tuner',
                     project_name='thz-cnn')
```

```
INFO:tensorflow:Reloading Oracle from existing project keras_hp_tuner/
thz-cnn/oracle.json
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
C1 (Conv1D)                  (None, 227, 2)            8
_________________________________________________________________
S2 (AveragePooling1D)        (None, 113, 2)            0
_________________________________________________________________
C3 (Conv1D)                  (None, 111, 2)            14
_________________________________________________________________
flatten (Flatten)            (None, 222)               0
_________________________________________________________________
dense (Dense)                (None, 24)                5352
_________________________________________________________________
dropout (Dropout)            (None, 24)                0
_________________________________________________________________
dense_1 (Dense)              (None, 12)                300
=================================================================
Total params: 5,674
Trainable params: 5,674
Non-trainable params: 0
_________________________________________________________________
INFO:tensorflow:Reloading Tuner from keras_hp_tuner/thz-cnn/tuner0.jso
n

2022-07-07 12:59:52.679286: I tensorflow/core/platform/cpu_feature_gua
rd.cc:142] This TensorFlow binary is optimized with oneAPI Deep Neural
Network Library (oneDNN) to use the following CPU instructions in perf
ormance-critical operations:  AVX2 AVX512F FMA
To enable them in other operations, rebuild TensorFlow with the approp
riate compiler flags.
2022-07-07 12:59:52.680229: I tensorflow/core/common_runtime/gpu/gpu_d
evice.cc:1733] Found device 0 with properties:
pciBusID: 0000:65:00.0 name: Quadro RTX 4000 computeCapability: 7.5
coreClock: 1.545GHz coreCount: 36 deviceMemorySize: 7.79GiB deviceMemo
ryBandwidth: 387.49GiB/s
2022-07-07 12:59:52.681113: I tensorflow/core/common_runtime/gpu/gpu_d
evice.cc:1871] Adding visible gpu devices: 0
2022-07-07 12:59:52.681194: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcudart.s
o.11.0
2022-07-07 12:59:53.086049: I tensorflow/core/common_runtime/gpu/gpu_d
evice.cc:1258] Device interconnect StreamExecutor with strength 1 edge
matrix:
2022-07-07 12:59:53.086073: I tensorflow/core/common_runtime/gpu/gpu_d
evice.cc:1264]      0
2022-07-07 12:59:53.086078: I tensorflow/core/common_runtime/gpu/gpu_d
```

```
evice.cc:1277] 0:   N
2022-07-07 12:59:53.087017: I tensorflow/core/common_runtime/gpu/gpu_d
evice.cc:1418] Created TensorFlow device (/job:localhost/replica:0/tas
k:0/device:GPU:0 with 1000 MB memory) -> physical GPU (device: 0, nam
```

In [6]:
```
stop_early = tf.keras.callbacks.EarlyStopping(monitor='SparseCatCrossen
```

In [7]:
```
# tuner.search(X, y, epochs=200, validation_split=0.3, callbacks=[stop_
tuner.search(X, y, epochs=200, validation_data=(x_test, y_test), callba


# Get the optimal hyperparameters
best_hps=tuner.get_best_hyperparameters(num_trials=2)[0]
```

```
INFO:tensorflow:Oracle triggered exit
```

In [8]:
```
print("""The hyperparameter search is complete.""")
# print(f"""
# hp_filters_1= {best_hps.get('filters')}
# hp_kernel_size= {best_hps.get('kernel_size')}
# hp_pool_size= {best_hps.get('pool_size')}
# hp_stride_size={best_hps.get('stride_size')}
# hp_units= {best_hps.get('units')}
# hp_dropout = {best_hps.get('dropout')}
# hp_learning_rate =  {best_hps.get('learning_rate')}
# """)

print(f"""
hp_filters= {best_hps.get('filters')}


hp_units= {best_hps.get('units')}

hp_learning_rate =  {best_hps.get('learning_rate')}
""")
```

```
The hyperparameter search is complete.

hp_filters= 3


hp_units= 48

hp_learning_rate =  0.01
```

In [9]:
```
best_hps.space
```

Out[9]:

```
[Int(name: "filters", min_value: 2, max_value: 4, step: 1, sampling: N
one, default: 2)
```

In [10]:
```
# Build the model with the optimal hyperparameters and train it on the
model = tuner.hypermodel.build(best_hps)
history = model.fit(x_train, y_train, epochs=200, validation_data=(x_te

val_acc_per_epoch = history.history['val_accuracy']
best_epoch = val_acc_per_epoch.index(max(val_acc_per_epoch)) + 1
print('Best epoch: %d' % (best_epoch,))
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
C1 (Conv1D)                  (None, 227, 3)            12
_________________________________________________________________
S2 (AveragePooling1D)        (None, 113, 3)            0
_________________________________________________________________
C3 (Conv1D)                  (None, 111, 3)            30
_________________________________________________________________
flatten_1 (Flatten)          (None, 333)               0
_________________________________________________________________
dense_2 (Dense)              (None, 48)                16032
_________________________________________________________________
dropout_1 (Dropout)          (None, 48)                0
_________________________________________________________________
dense_3 (Dense)              (None, 12)                588
=================================================================
Total params: 16,662
Trainable params: 16,662
Non-trainable params: 0
_________________________________________________________________
Epoch 1/200

2022-07-07 13:00:03.476771: I tensorflow/compiler/mlir/mlir_graph_opti
mization_pass.cc:176] None of the MLIR Optimization Passes are enabled
(registered 2)
2022-07-07 13:00:03.497642: I tensorflow/core/platform/profile_utils/c
pu_utils.cc:114] CPU Frequency: 3600000000 Hz
2022-07-07 13:00:03.988891: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcudnn.so.
8
2022-07-07 13:00:04.233095: I tensorflow/stream_executor/cuda/cuda_dn
n.cc:359] Loaded cuDNN version 8204
2022-07-07 13:00:04.689231: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcublas.s
o.11

 1/44 [..............................] - ETA: 1:18 - loss: 2.4642 - Sp
arseCatCrossentropy: 2.4642 - accuracy: 0.0312

2022-07-07 13:00:05.156000: I tensorflow/stream_executor/platform/defa
ult/dso_loader.cc:53] Successfully opened dynamic library libcublasLt.
so.11
```

```
44/44 [==============================] - 2s 12ms/step - loss: 1.0290 -
SparseCatCrossentropy: 1.0064 - accuracy: 0.7248 - val_loss: 0.1309 -
val_SparseCatCrossentropy: 0.1310 - val_accuracy: 0.9831
Epoch 2/200
44/44 [==============================] - 0s 7ms/step - loss: 0.1921 -
SparseCatCrossentropy: 0.1880 - accuracy: 0.9506 - val_loss: 0.0470 -
val_SparseCatCrossentropy: 0.0473 - val_accuracy: 0.9949
Epoch 3/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0980 -
SparseCatCrossentropy: 0.0995 - accuracy: 0.9826 - val_loss: 0.0304 -
val_SparseCatCrossentropy: 0.0304 - val_accuracy: 0.9966
Epoch 4/200
44/44 [==============================] - 0s 7ms/step - loss: 0.1575 -
SparseCatCrossentropy: 0.1541 - accuracy: 0.9731 - val_loss: 0.0179 -
val_SparseCatCrossentropy: 0.0183 - val_accuracy: 1.0000
Epoch 5/200
44/44 [==============================] - 0s 7ms/step - loss: 0.1309 -
SparseCatCrossentropy: 0.1280 - accuracy: 0.9739 - val_loss: 0.0190 -
val_SparseCatCrossentropy: 0.0196 - val_accuracy: 1.0000
Epoch 6/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0694 -
SparseCatCrossentropy: 0.0783 - accuracy: 0.9804 - val_loss: 0.0175 -
val_SparseCatCrossentropy: 0.0175 - val_accuracy: 1.0000
Epoch 7/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0744 -
SparseCatCrossentropy: 0.0728 - accuracy: 0.9811 - val_loss: 0.0101 -
val_SparseCatCrossentropy: 0.0100 - val_accuracy: 1.0000
Epoch 8/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0796 -
SparseCatCrossentropy: 0.0779 - accuracy: 0.9811 - val_loss: 0.0131 -
val_SparseCatCrossentropy: 0.0133 - val_accuracy: 0.9983
Epoch 9/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0610 -
SparseCatCrossentropy: 0.0596 - accuracy: 0.9833 - val_loss: 0.0088 -
val_SparseCatCrossentropy: 0.0087 - val_accuracy: 1.0000
Epoch 10/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0765 -
SparseCatCrossentropy: 0.0748 - accuracy: 0.9855 - val_loss: 0.0132 -
val_SparseCatCrossentropy: 0.0130 - val_accuracy: 0.9949
Epoch 11/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0772 -
SparseCatCrossentropy: 0.0755 - accuracy: 0.9818 - val_loss: 0.0059 -
val_SparseCatCrossentropy: 0.0059 - val_accuracy: 1.0000
Epoch 12/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0853 -
SparseCatCrossentropy: 0.0834 - accuracy: 0.9775 - val_loss: 0.0198 -
val_SparseCatCrossentropy: 0.0197 - val_accuracy: 0.9932
Epoch 13/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0578 -
SparseCatCrossentropy: 0.0565 - accuracy: 0.9855 - val_loss: 0.0049 -
val_SparseCatCrossentropy: 0.0048 - val_accuracy: 1.0000
Epoch 14/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0553 -
SparseCatCrossentropy: 0.0541 - accuracy: 0.9789 - val_loss: 0.0068 -
val_SparseCatCrossentropy: 0.0068 - val_accuracy: 1.0000
Epoch 15/200
```

```
44/44 [==============================] - 0s 7ms/step - loss: 0.0363 -
SparseCatCrossentropy: 0.0355 - accuracy: 0.9891 - val_loss: 0.0033 -
val_SparseCatCrossentropy: 0.0032 - val_accuracy: 1.0000
Epoch 16/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0199 -
SparseCatCrossentropy: 0.0195 - accuracy: 0.9927 - val_loss: 0.0025 -
val_SparseCatCrossentropy: 0.0025 - val_accuracy: 1.0000
Epoch 17/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0371 -
SparseCatCrossentropy: 0.0363 - accuracy: 0.9898 - val_loss: 0.0023 -
val_SparseCatCrossentropy: 0.0023 - val_accuracy: 1.0000
Epoch 18/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0445 -
SparseCatCrossentropy: 0.0436 - accuracy: 0.9847 - val_loss: 0.0087 -
val_SparseCatCrossentropy: 0.0087 - val_accuracy: 1.0000
Epoch 19/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0254 -
SparseCatCrossentropy: 0.0249 - accuracy: 0.9935 - val_loss: 0.0030 -
val_SparseCatCrossentropy: 0.0030 - val_accuracy: 1.0000
Epoch 20/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0473 -
SparseCatCrossentropy: 0.0463 - accuracy: 0.9898 - val_loss: 0.0022 -
val_SparseCatCrossentropy: 0.0021 - val_accuracy: 1.0000
Epoch 21/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0569 -
SparseCatCrossentropy: 0.0557 - accuracy: 0.9877 - val_loss: 0.0022 -
val_SparseCatCrossentropy: 0.0021 - val_accuracy: 1.0000
Epoch 22/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0342 -
SparseCatCrossentropy: 0.0481 - accuracy: 0.9920 - val_loss: 0.0086 -
val_SparseCatCrossentropy: 0.0086 - val_accuracy: 1.0000
Epoch 23/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0529 -
SparseCatCrossentropy: 0.0517 - accuracy: 0.9847 - val_loss: 0.0071 -
val_SparseCatCrossentropy: 0.0070 - val_accuracy: 1.0000
Epoch 24/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0494 -
SparseCatCrossentropy: 0.0484 - accuracy: 0.9898 - val_loss: 0.0051 -
val_SparseCatCrossentropy: 0.0050 - val_accuracy: 1.0000
Epoch 25/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0422 -
SparseCatCrossentropy: 0.0413 - accuracy: 0.9898 - val_loss: 0.0052 -
val_SparseCatCrossentropy: 0.0051 - val_accuracy: 1.0000
Epoch 26/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0246 -
SparseCatCrossentropy: 0.0241 - accuracy: 0.9942 - val_loss: 0.0040 -
val_SparseCatCrossentropy: 0.0039 - val_accuracy: 1.0000
Epoch 27/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0287 -
SparseCatCrossentropy: 0.0281 - accuracy: 0.9927 - val_loss: 0.0038 -
val_SparseCatCrossentropy: 0.0038 - val_accuracy: 1.0000
Epoch 28/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0495 -
SparseCatCrossentropy: 0.0484 - accuracy: 0.9891 - val_loss: 0.0025 -
val_SparseCatCrossentropy: 0.0024 - val_accuracy: 1.0000
Epoch 29/200
```

```
44/44 [==============================] - 0s 7ms/step - loss: 0.0671 -
SparseCatCrossentropy: 0.0657 - accuracy: 0.9862 - val_loss: 0.0091 -
val_SparseCatCrossentropy: 0.0089 - val_accuracy: 0.9983
Epoch 30/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0323 -
SparseCatCrossentropy: 0.0316 - accuracy: 0.9920 - val_loss: 0.0020 -
val_SparseCatCrossentropy: 0.0020 - val_accuracy: 1.0000
Epoch 31/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0229 -
SparseCatCrossentropy: 0.0224 - accuracy: 0.9927 - val_loss: 0.0016 -
val_SparseCatCrossentropy: 0.0015 - val_accuracy: 1.0000
Epoch 32/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0277 -
SparseCatCrossentropy: 0.0271 - accuracy: 0.9949 - val_loss: 9.1887e-0
4 - val_SparseCatCrossentropy: 9.0230e-04 - val_accuracy: 1.0000
Epoch 33/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0597 -
SparseCatCrossentropy: 0.0583 - accuracy: 0.9869 - val_loss: 0.0034 -
val_SparseCatCrossentropy: 0.0033 - val_accuracy: 1.0000
Epoch 34/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0627 -
SparseCatCrossentropy: 0.0613 - accuracy: 0.9855 - val_loss: 0.0020 -
val_SparseCatCrossentropy: 0.0019 - val_accuracy: 1.0000
Epoch 35/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0232 -
SparseCatCrossentropy: 0.0227 - accuracy: 0.9920 - val_loss: 0.0065 -
val_SparseCatCrossentropy: 0.0064 - val_accuracy: 0.9983
Epoch 36/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0299 -
SparseCatCrossentropy: 0.0292 - accuracy: 0.9935 - val_loss: 0.0012 -
val_SparseCatCrossentropy: 0.0012 - val_accuracy: 1.0000
Epoch 37/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0256 -
SparseCatCrossentropy: 0.0251 - accuracy: 0.9920 - val_loss: 0.0011 -
val_SparseCatCrossentropy: 0.0011 - val_accuracy: 1.0000
Epoch 38/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0241 -
SparseCatCrossentropy: 0.0239 - accuracy: 0.9920 - val_loss: 8.8106e-0
4 - val_SparseCatCrossentropy: 8.5953e-04 - val_accuracy: 1.0000
Epoch 39/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0319 -
44/44 [==============================] - 0s 7ms/step - loss: 0.0203 -
SparseCatCrossentropy: 0.0198 - accuracy: 0.9964 - val_loss: 0.0022 -
val_SparseCatCrossentropy: 0.0021 - val_accuracy: 1.0000
Epoch 41/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0177 -
SparseCatCrossentropy: 0.0173 - accuracy: 0.9942 - val_loss: 7.7580e-0
4 - val_SparseCatCrossentropy: 7.5815e-04 - val_accuracy: 1.0000
Epoch 42/200
44/44 [==============================] - 0s 8ms/step - loss: 0.0153 -
SparseCatCrossentropy: 0.0150 - accuracy: 0.9971 - val_loss: 5.8284e-0
4 - val_SparseCatCrossentropy: 5.6970e-04 - val_accuracy: 1.0000
Epoch 43/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0175 -
SparseCatCrossentropy: 0.0171 - accuracy: 0.9927 - val_loss: 9.4120e-0
4 - val_SparseCatCrossentropy: 9.2694e-04 - val_accuracy: 1.0000
```

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Epoch 44/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0190 -
SparseCatCrossentropy: 0.0185 - accuracy: 0.9949 - val_loss: 8.0197e-0
4 - val_SparseCatCrossentropy: 7.9714e-04 - val_accuracy: 1.0000
Epoch 45/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0232 -
SparseCatCrossentropy: 0.0227 - accuracy: 0.9935 - val_loss: 4.6704e-0
4 - val_SparseCatCrossentropy: 4.6424e-04 - val_accuracy: 1.0000
Epoch 46/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0356 -
SparseCatCrossentropy: 0.0348 - accuracy: 0.9935 - val_loss: 0.0010 -
val_SparseCatCrossentropy: 9.9114e-04 - val_accuracy: 1.0000
Epoch 47/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0107 -
SparseCatCrossentropy: 0.0104 - accuracy: 0.9964 - val_loss: 7.9604e-0
4 - val_SparseCatCrossentropy: 7.7504e-04 - val_accuracy: 1.0000
Epoch 48/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0160 -
SparseCatCrossentropy: 0.0157 - accuracy: 0.9985 - val_loss: 4.0670e-0
4 - val_SparseCatCrossentropy: 3.9696e-04 - val_accuracy: 1.0000
Epoch 49/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0162 -
SparseCatCrossentropy: 0.0158 - accuracy: 0.9956 - val_loss: 0.0047 -
val_SparseCatCrossentropy: 0.0046 - val_accuracy: 0.9983
Epoch 50/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0183 -
SparseCatCrossentropy: 0.0179 - accuracy: 0.9942 - val_loss: 5.9630e-0
4 - val_SparseCatCrossentropy: 5.8517e-04 - val_accuracy: 1.0000
Epoch 51/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0086 -
SparseCatCrossentropy: 0.0084 - accuracy: 0.9971 - val_loss: 0.0015 -
val_SparseCatCrossentropy: 0.0014 - val_accuracy: 1.0000
Epoch 52/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0147 -
SparseCatCrossentropy: 0.0144 - accuracy: 0.9956 - val_loss: 5.1408e-0
4 - val_SparseCatCrossentropy: 5.0617e-04 - val_accuracy: 1.0000
Epoch 53/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0214 -
SparseCatCrossentropy: 0.0209 - accuracy: 0.9920 - val_loss: 8.1163e-0
4 - val_SparseCatCrossentropy: 7.9484e-04 - val_accuracy: 1.0000
Epoch 54/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0112 -
SparseCatCrossentropy: 0.0109 - accuracy: 0.9971 - val_loss: 0.0014 -
val_SparseCatCrossentropy: 0.0013 - val_accuracy: 1.0000
Epoch 55/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0218 -
SparseCatCrossentropy: 0.0213 - accuracy: 0.9956 - val_loss: 5.1348e-0
4 - val_SparseCatCrossentropy: 5.0079e-04 - val_accuracy: 1.0000
Epoch 56/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0049 -
SparseCatCrossentropy: 0.0048 - accuracy: 0.9985 - val_loss: 1.3071e-0
4 - val_SparseCatCrossentropy: 1.2739e-04 - val_accuracy: 1.0000
Epoch 57/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0154 -
SparseCatCrossentropy: 0.0151 - accuracy: 0.9964 - val_loss: 0.0012 -
val_SparseCatCrossentropy: 0.0011 - val_accuracy: 1.0000
```

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Epoch 58/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0352 -
SparseCatCrossentropy: 0.0346 - accuracy: 0.9906 - val_loss: 0.0011 -
val_SparseCatCrossentropy: 0.0010 - val_accuracy: 1.0000
Epoch 59/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0524 -
SparseCatCrossentropy: 0.0513 - accuracy: 0.9927 - val_loss: 0.0013 -
val_SparseCatCrossentropy: 0.0013 - val_accuracy: 1.0000
Epoch 60/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0093 -
SparseCatCrossentropy: 0.0091 - accuracy: 0.9985 - val_loss: 2.8741e-0
4 - val_SparseCatCrossentropy: 2.8030e-04 - val_accuracy: 1.0000
Epoch 61/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0168 -
SparseCatCrossentropy: 0.0164 - accuracy: 0.9964 - val_loss: 3.6585e-0
4 - val_SparseCatCrossentropy: 3.5815e-04 - val_accuracy: 1.0000
Epoch 62/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0117 -
SparseCatCrossentropy: 0.0114 - accuracy: 0.9978 - val_loss: 1.5240e-0
4 - val_SparseCatCrossentropy: 1.4924e-04 - val_accuracy: 1.0000
Epoch 63/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0062 -
SparseCatCrossentropy: 0.0060 - accuracy: 0.9985 - val_loss: 1.2638e-0
4 - val_SparseCatCrossentropy: 1.2355e-04 - val_accuracy: 1.0000
Epoch 64/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0101 -
SparseCatCrossentropy: 0.0099 - accuracy: 0.9964 - val_loss: 7.0945e-0
5 - val_SparseCatCrossentropy: 6.9211e-05 - val_accuracy: 1.0000
Epoch 65/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0137 -
SparseCatCrossentropy: 0.0134 - accuracy: 0.9971 - val_loss: 7.2444e-0
5 - val_SparseCatCrossentropy: 7.0598e-05 - val_accuracy: 1.0000
Epoch 66/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0200 -
SparseCatCrossentropy: 0.0196 - accuracy: 0.9956 - val_loss: 1.3249e-0
4 - val_SparseCatCrossentropy: 1.2903e-04 - val_accuracy: 1.0000
Epoch 67/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0212 -
SparseCatCrossentropy: 0.0207 - accuracy: 0.9956 - val_loss: 1.6195e-0
4 - val_SparseCatCrossentropy: 1.5819e-04 - val_accuracy: 1.0000
Epoch 68/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0044 -
SparseCatCrossentropy: 0.0043 - accuracy: 0.9985 - val_loss: 1.0475e-0
4 - val_SparseCatCrossentropy: 1.0191e-04 - val_accuracy: 1.0000
Epoch 69/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0134 -
SparseCatCrossentropy: 0.0131 - accuracy: 0.9949 - val_loss: 8.8742e-0
5 - val_SparseCatCrossentropy: 8.6347e-05 - val_accuracy: 1.0000
Epoch 70/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0167 -
SparseCatCrossentropy: 0.0163 - accuracy: 0.9949 - val_loss: 7.4353e-0
5 - val_SparseCatCrossentropy: 7.2343e-05 - val_accuracy: 1.0000
Epoch 71/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0184 -
SparseCatCrossentropy: 0.0180 - accuracy: 0.9971 - val_loss: 7.9321e-0
5 - val_SparseCatCrossentropy: 7.7259e-05 - val_accuracy: 1.0000
```

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Epoch 72/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0182 -
SparseCatCrossentropy: 0.0178 - accuracy: 0.9949 - val_loss: 3.5428e-0
5 - val_SparseCatCrossentropy: 3.4560e-05 - val_accuracy: 1.0000
Epoch 73/200
44/44 [==============================] - 0s 10ms/step - loss: 0.0103 -
SparseCatCrossentropy: 0.0101 - accuracy: 0.9971 - val_loss: 3.6066e-0
5 - val_SparseCatCrossentropy: 3.5118e-05 - val_accuracy: 1.0000
Epoch 74/200
44/44 [==============================] - 0s 4ms/step - loss: 0.0060 -
SparseCatCrossentropy: 0.0059 - accuracy: 0.9985 - val_loss: 5.8322e-0
5 - val_SparseCatCrossentropy: 5.6772e-05 - val_accuracy: 1.0000
Epoch 75/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0077 -
SparseCatCrossentropy: 0.0076 - accuracy: 0.9971 - val_loss: 2.5710e-0
5 - val_SparseCatCrossentropy: 2.5018e-05 - val_accuracy: 1.0000
Epoch 76/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0124 -
SparseCatCrossentropy: 0.0121 - accuracy: 0.9964 - val_loss: 4.1023e-0
5 - val_SparseCatCrossentropy: 3.9919e-05 - val_accuracy: 1.0000
Epoch 77/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0086 -
SparseCatCrossentropy: 0.0084 - accuracy: 0.9971 - val_loss: 3.2143e-0
Epoch 78/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0223 -
SparseCatCrossentropy: 0.0218 - accuracy: 0.9949 - val_loss: 3.4710e-0
5 - val_SparseCatCrossentropy: 3.3842e-05 - val_accuracy: 1.0000
Epoch 79/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0236 -
SparseCatCrossentropy: 0.0231 - accuracy: 0.9942 - val_loss: 8.1616e-0
5 - val_SparseCatCrossentropy: 7.9573e-05 - val_accuracy: 1.0000
Epoch 80/200
44/44 [==============================] - 0s 8ms/step - loss: 0.0116 -
SparseCatCrossentropy: 0.0113 - accuracy: 0.9971 - val_loss: 8.3661e-0
5 - val_SparseCatCrossentropy: 8.1448e-05 - val_accuracy: 1.0000
Epoch 81/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0046 -
SparseCatCrossentropy: 0.0045 - accuracy: 0.9978 - val_loss: 5.4689e-0
5 - val_SparseCatCrossentropy: 5.3328e-05 - val_accuracy: 1.0000
Epoch 82/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0087 -
SparseCatCrossentropy: 0.0195 - accuracy: 0.9985 - val_loss: 3.6450e-0
5 - val_SparseCatCrossentropy: 3.5531e-05 - val_accuracy: 1.0000
Epoch 83/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0089 -
SparseCatCrossentropy: 0.0087 - accuracy: 0.9964 - val_loss: 4.7772e-0
5 - val_SparseCatCrossentropy: 4.6563e-05 - val_accuracy: 1.0000
Epoch 84/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0089 -
SparseCatCrossentropy: 0.0087 - accuracy: 0.9964 - val_loss: 2.6261e-0
5 - val_SparseCatCrossentropy: 2.5574e-05 - val_accuracy: 1.0000
Epoch 85/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0120 -
SparseCatCrossentropy: 0.0117 - accuracy: 0.9971 - val_loss: 8.6612e-0
4 - val_SparseCatCrossentropy: 8.4242e-04 - val_accuracy: 1.0000
Epoch 86/200
```

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44/44 [==============================] - 0s 7ms/step - loss: 0.0095 -
SparseCatCrossentropy: 0.0093 - accuracy: 0.9978 - val_loss: 5.7765e-0
5 - val_SparseCatCrossentropy: 5.6263e-05 - val_accuracy: 1.0000
Epoch 87/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0110 -
SparseCatCrossentropy: 0.0108 - accuracy: 0.9985 - val_loss: 0.0013 -
val_SparseCatCrossentropy: 0.0012 - val_accuracy: 1.0000
Epoch 88/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0079 -
SparseCatCrossentropy: 0.0077 - accuracy: 0.9971 - val_loss: 2.4174e-0
5 - val_SparseCatCrossentropy: 2.3543e-05 - val_accuracy: 1.0000
Epoch 89/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0066 -
SparseCatCrossentropy: 0.0065 - accuracy: 0.9978 - val_loss: 7.9308e-0
5 - val_SparseCatCrossentropy: 7.7202e-05 - val_accuracy: 1.0000
Epoch 90/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0115 -
SparseCatCrossentropy: 0.0113 - accuracy: 0.9978 - val_loss: 8.9024e-0
6 - val_SparseCatCrossentropy: 8.6704e-06 - val_accuracy: 1.0000
Epoch 91/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0041 -
SparseCatCrossentropy: 0.0041 - accuracy: 0.9993 - val_loss: 0.0021 -
val_SparseCatCrossentropy: 0.0021 - val_accuracy: 1.0000
Epoch 92/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0168 -
SparseCatCrossentropy: 0.0165 - accuracy: 0.9949 - val_loss: 4.1867e-0
5 - val_SparseCatCrossentropy: 4.0866e-05 - val_accuracy: 1.0000
Epoch 93/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0063 -
SparseCatCrossentropy: 0.0062 - accuracy: 0.9978 - val_loss: 1.9747e-0
5 - val_SparseCatCrossentropy: 1.9210e-05 - val_accuracy: 1.0000
Epoch 94/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0069 -
SparseCatCrossentropy: 0.0067 - accuracy: 0.9978 - val_loss: 4.9458e-0
5 - val_SparseCatCrossentropy: 4.8092e-05 - val_accuracy: 1.0000
Epoch 95/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0145 -
SparseCatCrossentropy: 0.0142 - accuracy: 0.9949 - val_loss: 7.3281e-0
5 - val_SparseCatCrossentropy: 7.1252e-05 - val_accuracy: 1.0000
Epoch 96/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0226 -
SparseCatCrossentropy: 0.0221 - accuracy: 0.9949 - val_loss: 1.6133e-0
5 - val_SparseCatCrossentropy: 1.5704e-05 - val_accuracy: 1.0000
Epoch 97/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0142 -
SparseCatCrossentropy: 0.0139 - accuracy: 0.9956 - val_loss: 2.6409e-0
5 - val_SparseCatCrossentropy: 2.5678e-05 - val_accuracy: 1.0000
Epoch 98/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0113 -
SparseCatCrossentropy: 0.0111 - accuracy: 0.9956 - val_loss: 8.3983e-0
5 - val_SparseCatCrossentropy: 8.1694e-05 - val_accuracy: 1.0000
Epoch 99/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0220 -
SparseCatCrossentropy: 0.0215 - accuracy: 0.9964 - val_loss: 1.8699e-0
5 - val_SparseCatCrossentropy: 1.8180e-05 - val_accuracy: 1.0000
Epoch 100/200
```

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44/44 [==============================] - 0s 7ms/step - loss: 0.0124 -
SparseCatCrossentropy: 0.0121 - accuracy: 0.9964 - val_loss: 1.5941e-0
5 - val_SparseCatCrossentropy: 1.5503e-05 - val_accuracy: 1.0000
Epoch 101/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0069 -
SparseCatCrossentropy: 0.0068 - accuracy: 0.9971 - val_loss: 1.8244e-0
5 - val_SparseCatCrossentropy: 1.7739e-05 - val_accuracy: 1.0000
Epoch 102/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0132 -
SparseCatCrossentropy: 0.0129 - accuracy: 0.9956 - val_loss: 1.4686e-0
5 - val_SparseCatCrossentropy: 1.4283e-05 - val_accuracy: 1.0000
Epoch 103/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0025 -
SparseCatCrossentropy: 0.0024 - accuracy: 0.9993 - val_loss: 9.2218e-0
6 - val_SparseCatCrossentropy: 8.9670e-06 - val_accuracy: 1.0000
Epoch 104/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0163 -
SparseCatCrossentropy: 0.0159 - accuracy: 0.9956 - val_loss: 2.4101e-0
5 - val_SparseCatCrossentropy: 2.3437e-05 - val_accuracy: 1.0000
Epoch 105/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0165 -
SparseCatCrossentropy: 0.0162 - accuracy: 0.9964 - val_loss: 4.5554e-0
5 - val_SparseCatCrossentropy: 4.4281e-05 - val_accuracy: 1.0000
Epoch 106/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0135 -
SparseCatCrossentropy: 0.0132 - accuracy: 0.9942 - val_loss: 7.0697e-0
5 - val_SparseCatCrossentropy: 6.8722e-05 - val_accuracy: 1.0000
Epoch 107/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0189 -
SparseCatCrossentropy: 0.0185 - accuracy: 0.9935 - val_loss: 3.2818e-0
4 - val_SparseCatCrossentropy: 3.1901e-04 - val_accuracy: 1.0000
Epoch 108/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0138 -
SparseCatCrossentropy: 0.0135 - accuracy: 0.9956 - val_loss: 2.6052e-0
5 - val_SparseCatCrossentropy: 2.5326e-05 - val_accuracy: 1.0000
Epoch 109/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0187 -
SparseCatCrossentropy: 0.0183 - accuracy: 0.9964 - val_loss: 0.0019 -
val_SparseCatCrossentropy: 0.0018 - val_accuracy: 0.9983
Epoch 110/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0185 -
SparseCatCrossentropy: 0.0181 - accuracy: 0.9985 - val_loss: 9.1615e-0
6 - val_SparseCatCrossentropy: 8.9062e-06 - val_accuracy: 1.0000
Epoch 111/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0151 -
SparseCatCrossentropy: 0.0148 - accuracy: 0.9956 - val_loss: 1.6466e-0
4 - val_SparseCatCrossentropy: 1.6005e-04 - val_accuracy: 1.0000
Epoch 112/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0188 -
SparseCatCrossentropy: 0.0183 - accuracy: 0.9942 - val_loss: 9.9832e-0
6 - val_SparseCatCrossentropy: 9.7045e-06 - val_accuracy: 1.0000
Epoch 113/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0121 -
SparseCatCrossentropy: 0.0118 - accuracy: 0.9956 - val_loss: 4.8969e-0
5 - val_SparseCatCrossentropy: 4.7603e-05 - val_accuracy: 1.0000
Epoch 114/200
```

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44/44 [==============================] - 0s 7ms/step - loss: 0.0175 -
SparseCatCrossentropy: 0.0171 - accuracy: 0.9949 - val_loss: 1.0598e-0
5 - val_SparseCatCrossentropy: 1.0303e-05 - val_accuracy: 1.0000
Epoch 115/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0435 -
SparseCatCrossentropy: 0.0425 - accuracy: 0.9956 - val_loss: 2.1186e-0
4 - val_SparseCatCrossentropy: 2.0601e-04 - val_accuracy: 1.0000
Epoch 116/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0205 -
SparseCatCrossentropy: 0.0200 - accuracy: 0.9935 - val_loss: 5.2909e-0
4 - val_SparseCatCrossentropy: 5.1438e-04 - val_accuracy: 1.0000
Epoch 117/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0119 -
SparseCatCrossentropy: 0.0116 - accuracy: 0.9956 - val_loss: 8.1268e-0
5 - val_SparseCatCrossentropy: 7.9040e-05 - val_accuracy: 1.0000
Epoch 118/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0016 -
SparseCatCrossentropy: 0.0015 - accuracy: 1.0000 - val_loss: 1.9915e-0
4 - val_SparseCatCrossentropy: 1.9360e-04 - val_accuracy: 1.0000
Epoch 119/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0111 -
SparseCatCrossentropy: 0.0109 - accuracy: 0.9971 - val_loss: 2.0797e-0
4 - val_SparseCatCrossentropy: 2.0221e-04 - val_accuracy: 1.0000
Epoch 120/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0112 -
SparseCatCrossentropy: 0.0109 - accuracy: 0.9964 - val_loss: 1.1183e-0
5 - val_SparseCatCrossentropy: 1.0875e-05 - val_accuracy: 1.0000
Epoch 121/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0109 -
SparseCatCrossentropy: 0.0107 - accuracy: 0.9964 - val_loss: 3.6907e-0
5 - val_SparseCatCrossentropy: 3.5884e-05 - val_accuracy: 1.0000
Epoch 122/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0119 -
SparseCatCrossentropy: 0.0117 - accuracy: 0.9971 - val_loss: 2.0194e-0
4 - val_SparseCatCrossentropy: 1.9632e-04 - val_accuracy: 1.0000
Epoch 123/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0071 -
SparseCatCrossentropy: 0.0070 - accuracy: 0.9971 - val_loss: 8.4368e-0
6 - val_SparseCatCrossentropy: 8.2035e-06 - val_accuracy: 1.0000
Epoch 124/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0075 -
SparseCatCrossentropy: 0.0073 - accuracy: 0.9978 - val_loss: 9.3013e-0
6 - val_SparseCatCrossentropy: 9.0455e-06 - val_accuracy: 1.0000
Epoch 125/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0181 -
SparseCatCrossentropy: 0.0177 - accuracy: 0.9956 - val_loss: 1.8008e-0
5 - val_SparseCatCrossentropy: 1.7519e-05 - val_accuracy: 1.0000
Epoch 126/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0041 -
SparseCatCrossentropy: 0.0040 - accuracy: 0.9978 - val_loss: 3.0792e-0
5 - val_SparseCatCrossentropy: 2.9956e-05 - val_accuracy: 1.0000
Epoch 127/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0044 -
SparseCatCrossentropy: 0.0043 - accuracy: 0.9985 - val_loss: 9.1283e-0
6 - val_SparseCatCrossentropy: 8.8926e-06 - val_accuracy: 1.0000
Epoch 128/200
```

```
44/44 [==============================] - 0s 7ms/step - loss: 0.0087 -
SparseCatCrossentropy: 0.0085 - accuracy: 0.9971 - val_loss: 5.1214e-0
6 - val_SparseCatCrossentropy: 4.9822e-06 - val_accuracy: 1.0000
Epoch 129/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0143 -
SparseCatCrossentropy: 0.0139 - accuracy: 0.9978 - val_loss: 1.6892e-0
5 - val_SparseCatCrossentropy: 1.6432e-05 - val_accuracy: 1.0000
Epoch 130/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0105 -
SparseCatCrossentropy: 0.0102 - accuracy: 0.9964 - val_loss: 8.0430e-0
6 - val_SparseCatCrossentropy: 7.8197e-06 - val_accuracy: 1.0000
Epoch 131/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0045 -
SparseCatCrossentropy: 0.0044 - accuracy: 0.9978 - val_loss: 4.9687e-0
6 - val_SparseCatCrossentropy: 4.8482e-06 - val_accuracy: 1.0000
Epoch 132/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0089 -
SparseCatCrossentropy: 0.0087 - accuracy: 0.9971 - val_loss: 5.7621e-0
6 - val_SparseCatCrossentropy: 5.6117e-06 - val_accuracy: 1.0000
Epoch 133/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0131 -
SparseCatCrossentropy: 0.0128 - accuracy: 0.9964 - val_loss: 4.9310e-0
6 - val_SparseCatCrossentropy: 4.7951e-06 - val_accuracy: 1.0000
Epoch 134/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0072 -
SparseCatCrossentropy: 0.0071 - accuracy: 0.9971 - val_loss: 3.1857e-0
6 - val_SparseCatCrossentropy: 3.0977e-06 - val_accuracy: 1.0000
Epoch 135/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0058 -
SparseCatCrossentropy: 0.0057 - accuracy: 0.9985 - val_loss: 6.0280e-0
6 - val_SparseCatCrossentropy: 5.8601e-06 - val_accuracy: 1.0000
Epoch 136/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0124 -
SparseCatCrossentropy: 0.0121 - accuracy: 0.9964 - val_loss: 2.1277e-0
6 - val_SparseCatCrossentropy: 2.0684e-06 - val_accuracy: 1.0000
Epoch 137/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0196 -
SparseCatCrossentropy: 0.0192 - accuracy: 0.9971 - val_loss: 2.4114e-0
6 - val_SparseCatCrossentropy: 2.3444e-06 - val_accuracy: 1.0000
Epoch 138/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0131 -
SparseCatCrossentropy: 0.0129 - accuracy: 0.9971 - val_loss: 5.3710e-0
6 - val_SparseCatCrossentropy: 5.2228e-06 - val_accuracy: 1.0000
Epoch 139/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0033 -
SparseCatCrossentropy: 0.0033 - accuracy: 0.9985 - val_loss: 9.3615e-0
6 - val_SparseCatCrossentropy: 9.1009e-06 - val_accuracy: 1.0000
Epoch 140/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0062 -
SparseCatCrossentropy: 0.0060 - accuracy: 0.9985 - val_loss: 1.8570e-0
5 - val_SparseCatCrossentropy: 1.8053e-05 - val_accuracy: 1.0000
Epoch 141/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0126 -
SparseCatCrossentropy: 0.0123 - accuracy: 0.9971 - val_loss: 3.8701e-0
4 - val_SparseCatCrossentropy: 3.7620e-04 - val_accuracy: 1.0000
Epoch 142/200
```

```
44/44 [==============================] - 0s 7ms/step - loss: 0.0067 -
SparseCatCrossentropy: 0.0065 - accuracy: 0.9985 - val_loss: 7.3410e-0
5 - val_SparseCatCrossentropy: 7.1365e-05 - val_accuracy: 1.0000
Epoch 143/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0091 -
SparseCatCrossentropy: 0.0089 - accuracy: 0.9971 - val_loss: 3.7300e-0
6 - val_SparseCatCrossentropy: 3.6262e-06 - val_accuracy: 1.0000
Epoch 144/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0100 -
SparseCatCrossentropy: 0.0098 - accuracy: 0.9971 - val_loss: 4.6542e-0
6 - val_SparseCatCrossentropy: 4.5263e-06 - val_accuracy: 1.0000
Epoch 145/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0200 -
SparseCatCrossentropy: 0.0196 - accuracy: 0.9956 - val_loss: 6.2278e-0
6 - val_SparseCatCrossentropy: 6.0550e-06 - val_accuracy: 1.0000
Epoch 146/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0108 -
SparseCatCrossentropy: 0.0106 - accuracy: 0.9971 - val_loss: 1.6230e-0
5 - val_SparseCatCrossentropy: 1.5778e-05 - val_accuracy: 1.0000
Epoch 147/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0052 -
SparseCatCrossentropy: 0.0050 - accuracy: 0.9993 - val_loss: 2.3341e-0
4 - val_SparseCatCrossentropy: 2.2689e-04 - val_accuracy: 1.0000
Epoch 148/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0232 -
SparseCatCrossentropy: 0.0227 - accuracy: 0.9935 - val_loss: 5.8760e-0
6 - val_SparseCatCrossentropy: 5.7184e-06 - val_accuracy: 1.0000
Epoch 149/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0165 -
SparseCatCrossentropy: 0.0161 - accuracy: 0.9971 - val_loss: 3.9228e-0
6 - val_SparseCatCrossentropy: 3.8178e-06 - val_accuracy: 1.0000
Epoch 150/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0130 -
SparseCatCrossentropy: 0.0127 - accuracy: 0.9956 - val_loss: 4.2908e-0
6 - val_SparseCatCrossentropy: 4.1735e-06 - val_accuracy: 1.0000
Epoch 151/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0116 -
SparseCatCrossentropy: 0.0113 - accuracy: 0.9971 - val_loss: 9.3801e-0
6 - val_SparseCatCrossentropy: 9.1267e-06 - val_accuracy: 1.0000
44/44 [==============================] - 0s 7ms/step - loss: 0.0276 -
SparseCatCrossentropy: 0.0270 - accuracy: 0.9949 - val_loss: 2.8633e-0
5 - val_SparseCatCrossentropy: 2.7839e-05 - val_accuracy: 1.0000
Epoch 153/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0084 -
SparseCatCrossentropy: 0.0082 - accuracy: 0.9971 - val_loss: 4.4414e-0
5 - val_SparseCatCrossentropy: 4.3175e-05 - val_accuracy: 1.0000
Epoch 154/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0206 -
SparseCatCrossentropy: 0.0202 - accuracy: 0.9942 - val_loss: 1.7203e-0
4 - val_SparseCatCrossentropy: 1.6722e-04 - val_accuracy: 1.0000
Epoch 155/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0087 -
SparseCatCrossentropy: 0.0085 - accuracy: 0.9985 - val_loss: 4.7008e-0
5 - val_SparseCatCrossentropy: 4.5695e-05 - val_accuracy: 1.0000
Epoch 156/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0077 -
```

```
SparseCatCrossentropy: 0.0075 - accuracy: 0.9956 - val_loss: 6.6665e-0
6 - val_SparseCatCrossentropy: 6.4807e-06 - val_accuracy: 1.0000
Epoch 157/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0256 -
SparseCatCrossentropy: 0.0250 - accuracy: 0.9964 - val_loss: 4.2852e-0
6 - val_SparseCatCrossentropy: 4.1658e-06 - val_accuracy: 1.0000
Epoch 158/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0113 -
SparseCatCrossentropy: 0.0110 - accuracy: 0.9949 - val_loss: 2.4410e-0
5 - val_SparseCatCrossentropy: 2.3728e-05 - val_accuracy: 1.0000
Epoch 159/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0115 -
SparseCatCrossentropy: 0.0112 - accuracy: 0.9971 - val_loss: 1.2828e-0
4 - val_SparseCatCrossentropy: 1.2470e-04 - val_accuracy: 1.0000
Epoch 160/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0233 -
SparseCatCrossentropy: 0.0228 - accuracy: 0.9935 - val_loss: 0.0011 -
val_SparseCatCrossentropy: 0.0011 - val_accuracy: 1.0000
Epoch 161/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0129 -
SparseCatCrossentropy: 0.0126 - accuracy: 0.9942 - val_loss: 4.4762e-0
6 - val_SparseCatCrossentropy: 4.3510e-06 - val_accuracy: 1.0000
Epoch 162/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0146 -
SparseCatCrossentropy: 0.0143 - accuracy: 0.9964 - val_loss: 9.5743e-0
5 - val_SparseCatCrossentropy: 9.3066e-05 - val_accuracy: 1.0000
Epoch 163/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0063 -
SparseCatCrossentropy: 0.0062 - accuracy: 0.9985 - val_loss: 1.2002e-0
5 - val_SparseCatCrossentropy: 1.1667e-05 - val_accuracy: 1.0000
Epoch 164/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0186 -
SparseCatCrossentropy: 0.0182 - accuracy: 0.9971 - val_loss: 5.0259e-0
6 - val_SparseCatCrossentropy: 4.8854e-06 - val_accuracy: 1.0000
Epoch 165/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0073 -
SparseCatCrossentropy: 0.0072 - accuracy: 0.9971 - val_loss: 1.2902e-0
5 - val_SparseCatCrossentropy: 1.2541e-05 - val_accuracy: 1.0000
Epoch 166/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0130 -
SparseCatCrossentropy: 0.0127 - accuracy: 0.9949 - val_loss: 7.1959e-0
4 - val_SparseCatCrossentropy: 6.9966e-04 - val_accuracy: 1.0000
Epoch 167/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0267 -
SparseCatCrossentropy: 0.0261 - accuracy: 0.9913 - val_loss: 0.0013 -
val_SparseCatCrossentropy: 0.0012 - val_accuracy: 1.0000
Epoch 168/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0161 -
SparseCatCrossentropy: 0.0157 - accuracy: 0.9935 - val_loss: 1.3444e-0
5 - val_SparseCatCrossentropy: 1.3068e-05 - val_accuracy: 1.0000
Epoch 169/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0066 -
SparseCatCrossentropy: 0.0065 - accuracy: 0.9985 - val_loss: 3.7001e-0
5 - val_SparseCatCrossentropy: 3.5967e-05 - val_accuracy: 1.0000
Epoch 170/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0261 -
```

```
SparseCatCrossentropy: 0.0257 - accuracy: 0.9942 - val_loss: 1.9539e-0
4 - val_SparseCatCrossentropy: 1.8993e-04 - val_accuracy: 1.0000
Epoch 171/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0079 -
SparseCatCrossentropy: 0.0077 - accuracy: 0.9964 - val_loss: 2.5729e-0
5 - val_SparseCatCrossentropy: 2.5010e-05 - val_accuracy: 1.0000
Epoch 172/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0190 -
SparseCatCrossentropy: 0.0186 - accuracy: 0.9964 - val_loss: 2.3541e-0
4 - val_SparseCatCrossentropy: 2.2883e-04 - val_accuracy: 1.0000
Epoch 173/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0096 -
SparseCatCrossentropy: 0.0094 - accuracy: 0.9956 - val_loss: 2.9758e-0
6 - val_SparseCatCrossentropy: 2.8926e-06 - val_accuracy: 1.0000
Epoch 174/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0068 -
SparseCatCrossentropy: 0.0067 - accuracy: 0.9971 - val_loss: 2.1307e-0
6 - val_SparseCatCrossentropy: 2.0711e-06 - val_accuracy: 1.0000
Epoch 175/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0076 -
SparseCatCrossentropy: 0.0074 - accuracy: 0.9971 - val_loss: 1.8635e-0
6 - val_SparseCatCrossentropy: 1.8114e-06 - val_accuracy: 1.0000
Epoch 176/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0127 -
SparseCatCrossentropy: 0.0124 - accuracy: 0.9971 - val_loss: 2.8075e-0
6 - val_SparseCatCrossentropy: 2.7290e-06 - val_accuracy: 1.0000
Epoch 177/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0150 -
SparseCatCrossentropy: 0.0147 - accuracy: 0.9971 - val_loss: 1.1073e-0
5 - val_SparseCatCrossentropy: 1.0764e-05 - val_accuracy: 1.0000
Epoch 178/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0168 -
SparseCatCrossentropy: 0.0165 - accuracy: 0.9964 - val_loss: 0.0027 -
val_SparseCatCrossentropy: 0.0027 - val_accuracy: 0.9983
Epoch 179/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0088 -
SparseCatCrossentropy: 0.0086 - accuracy: 0.9971 - val_loss: 0.0152 -
val_SparseCatCrossentropy: 0.0147 - val_accuracy: 0.9949
Epoch 180/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0073 -
SparseCatCrossentropy: 0.0071 - accuracy: 0.9971 - val_loss: 2.8230e-0
6 - val_SparseCatCrossentropy: 2.7441e-06 - val_accuracy: 1.0000
Epoch 181/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0139 -
SparseCatCrossentropy: 0.0136 - accuracy: 0.9956 - val_loss: 2.6307e-0
6 - val_SparseCatCrossentropy: 2.5571e-06 - val_accuracy: 1.0000
Epoch 182/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0173 -
SparseCatCrossentropy: 0.0169 - accuracy: 0.9964 - val_loss: 4.3489e-0
6 - val_SparseCatCrossentropy: 4.2273e-06 - val_accuracy: 1.0000
Epoch 183/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0105 -
SparseCatCrossentropy: 0.0103 - accuracy: 0.9978 - val_loss: 1.9514e-0
5 - val_SparseCatCrossentropy: 1.8968e-05 - val_accuracy: 1.0000
Epoch 184/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0067 -
```

```
SparseCatCrossentropy: 0.0066 - accuracy: 0.9964 - val_loss: 4.7264e-0
6 - val_SparseCatCrossentropy: 4.5943e-06 - val_accuracy: 1.0000
Epoch 185/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0059 -
SparseCatCrossentropy: 0.0057 - accuracy: 0.9978 - val_loss: 3.4760e-0
6 - val_SparseCatCrossentropy: 3.3788e-06 - val_accuracy: 1.0000
Epoch 186/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0391 -
SparseCatCrossentropy: 0.0382 - accuracy: 0.9891 - val_loss: 2.3416e-0
4 - val_SparseCatCrossentropy: 2.2762e-04 - val_accuracy: 1.0000
Epoch 187/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0137 -
SparseCatCrossentropy: 0.0134 - accuracy: 0.9964 - val_loss: 1.2486e-0
5 - val_SparseCatCrossentropy: 1.2137e-05 - val_accuracy: 1.0000
Epoch 188/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0092 -
SparseCatCrossentropy: 0.0105 - accuracy: 0.9985 - val_loss: 4.0201e-0
5 - val_SparseCatCrossentropy: 3.9077e-05 - val_accuracy: 1.0000
Epoch 189/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0210 -
SparseCatCrossentropy: 0.0205 - accuracy: 0.9949 - val_loss: 1.0923e-0
Epoch 190/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0112 -
SparseCatCrossentropy: 0.0110 - accuracy: 0.9978 - val_loss: 1.0344e-0
5 - val_SparseCatCrossentropy: 1.0055e-05 - val_accuracy: 1.0000
Epoch 191/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0474 -
SparseCatCrossentropy: 0.0463 - accuracy: 0.9906 - val_loss: 1.8850e-0
4 - val_SparseCatCrossentropy: 1.8323e-04 - val_accuracy: 1.0000
Epoch 192/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0405 -
SparseCatCrossentropy: 0.0396 - accuracy: 0.9891 - val_loss: 3.6662e-0
5 - val_SparseCatCrossentropy: 3.5637e-05 - val_accuracy: 1.0000
Epoch 193/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0073 -
SparseCatCrossentropy: 0.0071 - accuracy: 0.9971 - val_loss: 4.6879e-0
6 - val_SparseCatCrossentropy: 4.5568e-06 - val_accuracy: 1.0000
Epoch 194/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0122 -
SparseCatCrossentropy: 0.0119 - accuracy: 0.9956 - val_loss: 3.5762e-0
6 - val_SparseCatCrossentropy: 3.4762e-06 - val_accuracy: 1.0000
Epoch 195/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0191 -
SparseCatCrossentropy: 0.0187 - accuracy: 0.9949 - val_loss: 9.9199e-0
6 - val_SparseCatCrossentropy: 9.6425e-06 - val_accuracy: 1.0000
Epoch 196/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0238 -
SparseCatCrossentropy: 0.0233 - accuracy: 0.9956 - val_loss: 3.3333e-0
5 - val_SparseCatCrossentropy: 3.2402e-05 - val_accuracy: 1.0000
Epoch 197/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0267 -
SparseCatCrossentropy: 0.0630 - accuracy: 0.9949 - val_loss: 6.2759e-0
6 - val_SparseCatCrossentropy: 6.1007e-06 - val_accuracy: 1.0000
Epoch 198/200
44/44 [==============================] - 0s 7ms/step - loss: 0.0579 -
SparseCatCrossentropy: 0.0566 - accuracy: 0.9855 - val_loss: 0.0058 -
```

```
val_SparseCatCrossentropy: 0.0056 - val_accuracy: 0.9966
Epoch 199/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0280 -
SparseCatCrossentropy: 0.0274 - accuracy: 0.9920 - val_loss: 9.3566e-0
5 - val_SparseCatCrossentropy: 9.0950e-05 - val_accuracy: 1.0000
Epoch 200/200
44/44 [==============================] - 0s 6ms/step - loss: 0.0145 -
SparseCatCrossentropy: 0.0142 - accuracy: 0.9949 - val_loss: 6.8940e-0
4 - val_SparseCatCrossentropy: 6.7012e-04 - val_accuracy: 1.0000
Best epoch: 4
```

notebook ends

In [ ]:

```
def voc_net():

    model = models.Sequential()

    # C1 Convolutional Layer
    model.add(layers.Conv1D(filters = 3 , kernel_size=3, activation='re

    # S2 Subsampling Layer
    model.add(layers.AveragePooling1D(pool_size = 2, strides = 2, paddi

    # C3 Convolutional Layer
    model.add(layers.Conv1D(filters = 3 , kernel_size=3, activation='re

    # Flatten the CNN output to feed it with fully connected layers
    model.add(layers.Flatten())

    model.add(layers.Dense(48, activation='relu'))
    model.add(layers.Dropout(0.5))
    model.add(layers.Dense(12))  # number of dense layer would be equal



    model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=0.01
            loss=tf.keras.losses.SparseCategoricalCrossentropy(from_log
                 metrics=[
              tf.keras.losses.SparseCategoricalCrossentropy(
                  from_logits=True, name='SparseCatCrossentropy'),
              'accuracy'])

    model.summary()

    return model
```

In [ ]: