group_project_latest_version

April 30, 2023

[1]:
```
!pip uninstall tensorflow
!pip install tensorflow==2.9.0
```

```
Found existing installation: tensorflow 2.12.0
Uninstalling tensorflow-2.12.0:
  Would remove:
    /usr/local/bin/estimator_ckpt_converter
    /usr/local/bin/import_pb_to_tensorboard
    /usr/local/bin/saved_model_cli
    /usr/local/bin/tensorboard
    /usr/local/bin/tf_upgrade_v2
    /usr/local/bin/tflite_convert
    /usr/local/bin/toco
    /usr/local/bin/toco_from_protos
    /usr/local/lib/python3.10/dist-packages/tensorflow-2.12.0.dist-info/*
    /usr/local/lib/python3.10/dist-packages/tensorflow/*
Proceed (Y/n)? y
  Successfully uninstalled tensorflow-2.12.0
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-
wheels/public/simple/
Collecting tensorflow==2.9.0
  Downloading
tensorflow-2.9.0-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl
(511.7 MB)
                           511.7/511.7
MB 2.4 MB/s eta 0:00:00
Requirement already satisfied: astunparse>=1.6.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (1.6.3)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (1.54.0)
Requirement already satisfied: setuptools in /usr/local/lib/python3.10/dist-
packages (from tensorflow==2.9.0) (67.7.2)
Requirement already satisfied: six>=1.12.0 in /usr/local/lib/python3.10/dist-
packages (from tensorflow==2.9.0) (1.16.0)
Requirement already satisfied: absl-py>=1.0.0 in /usr/local/lib/python3.10/dist-
packages (from tensorflow==2.9.0) (1.4.0)
Requirement already satisfied: termcolor>=1.1.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (2.3.0)
```

```
Collecting tensorflow-estimator<2.10.0,>=2.9.0rc0
  Downloading tensorflow_estimator-2.9.0-py2.py3-none-any.whl (438 kB)
                             438.7/438.7 kB
44.6 MB/s eta 0:00:00
Collecting tensorboard<2.10,>=2.9
  Downloading tensorboard-2.9.1-py3-none-any.whl (5.8 MB)
                               5.8/5.8 MB
104.7 MB/s eta 0:00:00
Requirement already satisfied: opt-einsum>=2.3.2 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (3.3.0)
Collecting flatbuffers<2,>=1.12
  Downloading flatbuffers-1.12-py2.py3-none-any.whl (15 kB)
Requirement already satisfied: wrapt>=1.11.0 in /usr/local/lib/python3.10/dist-
packages (from tensorflow==2.9.0) (1.14.1)
Requirement already satisfied: numpy>=1.20 in /usr/local/lib/python3.10/dist-
packages (from tensorflow==2.9.0) (1.22.4)
Requirement already satisfied: gast<=0.4.0,>=0.2.1 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (0.4.0)
Requirement already satisfied: libclang>=13.0.0 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (16.0.0)
Requirement already satisfied: typing-extensions>=3.6.6 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (4.5.0)
Requirement already satisfied: google-pasta>=0.1.1 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (0.2.0)
Collecting keras-preprocessing>=1.1.1
  Downloading Keras_Preprocessing-1.1.2-py2.py3-none-any.whl (42 kB)
                               42.6/42.6 kB
6.7 MB/s eta 0:00:00
Requirement already satisfied: protobuf>=3.9.2 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (3.20.3)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in
/usr/local/lib/python3.10/dist-packages (from tensorflow==2.9.0) (0.32.0)
Requirement already satisfied: h5py>=2.9.0 in /usr/local/lib/python3.10/dist-
packages (from tensorflow==2.9.0) (3.8.0)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-
packages (from tensorflow==2.9.0) (23.1)
Collecting keras<2.10.0,>=2.9.0rc0
  Downloading keras-2.9.0-py2.py3-none-any.whl (1.6 MB)
                               1.6/1.6 MB
91.7 MB/s eta 0:00:00
Requirement already satisfied: wheel<1.0,>=0.23.0 in
/usr/local/lib/python3.10/dist-packages (from
astunparse>=1.6.0->tensorflow==2.9.0) (0.40.0)
Requirement already satisfied: google-auth<3,>=1.6.3 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.10,>=2.9->tensorflow==2.9.0) (2.17.3)
Requirement already satisfied: tensorboard-plugin-wit>=1.6.0 in
/usr/local/lib/python3.10/dist-packages (from
```

```
tensorboard<2.10,>=2.9->tensorflow==2.9.0) (1.8.1)
Requirement already satisfied: requests<3,>=2.21.0 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.10,>=2.9->tensorflow==2.9.0) (2.27.1)
Collecting google-auth-oauthlib<0.5,>=0.4.1
  Downloading google_auth_oauthlib-0.4.6-py2.py3-none-any.whl (18 kB)
Requirement already satisfied: werkzeug>=1.0.1 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.10,>=2.9->tensorflow==2.9.0) (2.3.0)
Requirement already satisfied: markdown>=2.6.8 in
/usr/local/lib/python3.10/dist-packages (from
tensorboard<2.10,>=2.9->tensorflow==2.9.0) (3.4.3)
Collecting tensorboard-data-server<0.7.0,>=0.6.0
  Downloading tensorboard_data_server-0.6.1-py3-none-manylinux2010_x86_64.whl
(4.9 MB)
                              4.9/4.9 MB
112.7 MB/s eta 0:00:00
Collecting protobuf>=3.9.2
  Downloading
protobuf-3.19.6-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.1
MB)
                              1.1/1.1 MB
75.9 MB/s eta 0:00:00
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/usr/local/lib/python3.10/dist-packages (from google-
auth<3,>=1.6.3->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (0.3.0)
Requirement already satisfied: rsa<5,>=3.1.4 in /usr/local/lib/python3.10/dist-
packages (from google-auth<3,>=1.6.3->tensorboard<2.10,>=2.9->tensorflow==2.9.0)
(4.9)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in
/usr/local/lib/python3.10/dist-packages (from google-
auth<3,>=1.6.3->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (5.3.0)
Requirement already satisfied: requests-oauthlib>=0.7.0 in
/usr/local/lib/python3.10/dist-packages (from google-auth-
oauthlib<0.5,>=0.4.1->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (1.3.1)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.10/dist-packages (from
requests<3,>=2.21.0->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (2022.12.7)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-
packages (from requests<3,>=2.21.0->tensorboard<2.10,>=2.9->tensorflow==2.9.0)
(3.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in
/usr/local/lib/python3.10/dist-packages (from
requests<3,>=2.21.0->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (1.26.15)
Requirement already satisfied: charset-normalizer~=2.0.0 in
/usr/local/lib/python3.10/dist-packages (from
requests<3,>=2.21.0->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (2.0.12)
Requirement already satisfied: MarkupSafe>=2.1.1 in
```

```
/usr/local/lib/python3.10/dist-packages (from
werkzeug>=1.0.1->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (2.1.2)
Requirement already satisfied: pyasn1<0.6.0,>=0.4.6 in
/usr/local/lib/python3.10/dist-packages (from pyasn1-modules>=0.2.1->google-
auth<3,>=1.6.3->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (0.5.0)
Requirement already satisfied: oauthlib>=3.0.0 in
/usr/local/lib/python3.10/dist-packages (from requests-oauthlib>=0.7.0->google-
auth-oauthlib<0.5,>=0.4.1->tensorboard<2.10,>=2.9->tensorflow==2.9.0) (3.2.2)
Installing collected packages: keras, flatbuffers, tensorflow-estimator,
tensorboard-data-server, protobuf, keras-preprocessing, google-auth-oauthlib,
tensorboard, tensorflow
  Attempting uninstall: keras
    Found existing installation: keras 2.12.0
    Uninstalling keras-2.12.0:
      Successfully uninstalled keras-2.12.0
  Attempting uninstall: flatbuffers
    Found existing installation: flatbuffers 23.3.3
    Uninstalling flatbuffers-23.3.3:
      Successfully uninstalled flatbuffers-23.3.3
  Attempting uninstall: tensorflow-estimator
    Found existing installation: tensorflow-estimator 2.12.0
    Uninstalling tensorflow-estimator-2.12.0:
      Successfully uninstalled tensorflow-estimator-2.12.0
  Attempting uninstall: tensorboard-data-server
    Found existing installation: tensorboard-data-server 0.7.0
    Uninstalling tensorboard-data-server-0.7.0:
      Successfully uninstalled tensorboard-data-server-0.7.0
  Attempting uninstall: protobuf
    Found existing installation: protobuf 3.20.3
    Uninstalling protobuf-3.20.3:
      Successfully uninstalled protobuf-3.20.3
  Attempting uninstall: google-auth-oauthlib
    Found existing installation: google-auth-oauthlib 1.0.0
    Uninstalling google-auth-oauthlib-1.0.0:
      Successfully uninstalled google-auth-oauthlib-1.0.0
  Attempting uninstall: tensorboard
    Found existing installation: tensorboard 2.12.2
    Uninstalling tensorboard-2.12.2:
      Successfully uninstalled tensorboard-2.12.2
ERROR: pip's dependency resolver does not currently take into account all
the packages that are installed. This behaviour is the source of the following
dependency conflicts.
tensorflow-metadata 1.13.1 requires protobuf<5,>=3.20.3, but you have protobuf
3.19.6 which is incompatible.
Successfully installed flatbuffers-1.12 google-auth-oauthlib-0.4.6
```

```
keras-2.9.0 keras-preprocessing-1.1.2 protobuf-3.19.6 tensorboard-2.9.1
tensorboard-data-server-0.6.1 tensorflow-2.9.0 tensorflow-estimator-2.9.0
```

[2]:
```
import os
import numpy as np
import pandas as pd
import tensorflow as tf
import torch
from tensorflow.keras.preprocessing import image
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Dense, GlobalAveragePooling2D
from tensorflow.keras.applications.efficientnet import EfficientNetB0,␣
 ↪preprocess_input as efficientnet_preprocess_input
from tensorflow.python.keras.models import Sequential
from tensorflow.keras.applications import EfficientNetB0
from tensorflow.keras.optimizers import Adam
from sklearn.metrics import f1_score
from sklearn.preprocessing import LabelBinarizer
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras import layers
from tensorflow.keras.layers.experimental import preprocessing
from sklearn.preprocessing import LabelBinarizer
from keras.utils import to_categorical
from google.colab import drive
drive.mount('/content/drive')

print(tf.__version__)
```

```
Mounted at /content/drive
2.9.0
```

[102]:
```
EPOCHS = 150
INIT_LR = 2e-4
batch_size = 16
input_shape=(224, 224, 3)
```

[4]:
```
cateList = []
marksList = []
labelList = []
def loadImageData():
    imageList = []
    data_path = "/content/drive/My Drive/data"
    listCategories = os.listdir(data_path) # categories
    for cate_name in listCategories:
        cate_path=os.path.join(data_path,cate_name)
        listLandmarks=os.listdir(cate_path)
        for marks_name in listLandmarks:
          marks_path = os.path.join(cate_path,marks_name)
```

```
        image_names=os.listdir(marks_path)
        for image_name in image_names:
          try:
            image_full_path = os.path.join(marks_path, image_name)
            image = tf.keras.utils.load_img(image_full_path)
            image_resized = tf.keras.layers.Resizing(height=224, width=224,
                                        crop_to_aspect_ratio=True)(image)
            image_preprocessed = efficientnet_preprocess_input(image_resized)
            imageList.append(image_preprocessed)
            cateList.append(cate_name)
            marksList.append(marks_name)
          except:
            print("error occurred at: " + image_name)

    print("image size: " + str(len(imageList)))
    print("cate size: " + str(len(cateList)))
    print("mark size: " + str(len(marksList)))
    return imageList
```

[5]:
```
imageArr = loadImageData()
```

```
error occurred at: Academy of Athens - 20.jpg
error occurred at: Buckingham Palace_19.jpg
error occurred at: Bibi Ka Maqbara - 14.jpg
image size: 417
cate size: 417
mark size: 417
```

[6]:
```
cateList = np.array(cateList)
marksList = np.array(marksList)
labelList = np.stack((cateList, marksList), axis=1)
```

[7]:
```
from sklearn.model_selection import train_test_split
from sklearn.model_selection import train_test_split

trainX, valX = train_test_split(imageArr, test_size=0.2, random_state=42)
# Splitting categories
trainCate, valCate = train_test_split(cateList, test_size=0.2, random_state=42)

# Splitting landmarks
trainMarks, valMarks = train_test_split(marksList, test_size=0.2,␣
 ↪random_state=42)

from sklearn.preprocessing import LabelEncoder
num_categories = 6
num_landmarks = 30
# Create a label encoder object
```

```
le_cate = LabelEncoder()
le_mark = LabelEncoder()

# Fit the encoder to the target categories and transform them to integer labels
trainCate = le_cate.fit_transform(trainCate)
valCate = le_cate.transform(valCate)
trainMarks = le_mark.fit_transform(trainMarks)
valMarks = le_mark.transform(valMarks)

# Convert the integer labels to one-hot encoded vectors
trainCate = to_categorical(trainCate, num_categories)
valCate = to_categorical(valCate, num_categories)

trainMarks = to_categorical(trainMarks, num_landmarks)
valMarks = to_categorical(valMarks, num_landmarks)
```

[103]:
```
def build_model():
    input_shape = (224, 224, 3)
    inputs = layers.Input(shape=input_shape)
    img_augmentation = Sequential([
        preprocessing.RandomRotation(factor=0.15),
        preprocessing.RandomTranslation(height_factor=0.1, width_factor=0.1),
        preprocessing.RandomFlip(),
        preprocessing.RandomContrast(factor=0.1),
    ])
    x = img_augmentation(inputs) # apply image augmentation
    base_model = EfficientNetB0(include_top=False, weights='imagenet',␣
 ↪input_tensor=x, input_shape=input_shape)
    for layer in base_model.layers[:127]:
      layer.trainable = False
    x = layers.GlobalAveragePooling2D()(base_model.output)
    x = layers.Dropout(0.1)(x)
    cate_output = layers.Dense(6, activation='softmax', name='cate_output')(x)
    marks_output = layers.Dense(30, activation='softmax',␣
 ↪name='marks_output')(x)
    outputs = [cate_output, marks_output]
    model = tf.keras.Model(inputs=inputs, outputs=outputs, name='model')
    model.compile(
        optimizer=tf.keras.optimizers.Adam(learning_rate=INIT_LR),
        loss='categorical_crossentropy',
        metrics=['accuracy']
    )
    return model
```

[9]:
```
trainX = tf.reshape(trainX,shape=(333,224,224,3))
valX = tf.reshape(valX,shape=(84,224,224,3))
```

[10]:
```
trainCate = tf.convert_to_tensor(trainCate)
valCate = tf.convert_to_tensor(valCate)
trainMarks = tf.convert_to_tensor(trainMarks)
valMarks = tf.convert_to_tensor(valMarks)
```

[104]:
```
model = build_model()
```

[12]:
```
print('traincate x:',trainX.shape)
print('traincate shape:',trainCate.shape)
print('trainmarks shape:',trainMarks.shape)
```

```
traincate x: (333, 224, 224, 3)
traincate shape: (333, 6)
trainmarks shape: (333, 30)
```

[105]:
```
history = model.fit(trainX, [trainCate, trainMarks],
                    epochs=EPOCHS,
                    validation_data=(valX, [valCate, valMarks]),
)
```

```
Epoch 1/150

WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2
WARNING:tensorflow:Using a while_loop for converting ImageProjectiveTransformV3
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting
StatelessRandomUniformFullIntV2
WARNING:tensorflow:Using a while_loop for converting
StatelessRandomGetKeyCounter
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2
WARNING:tensorflow:Using a while_loop for converting AdjustContrastv2
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2
WARNING:tensorflow:Using a while_loop for converting ImageProjectiveTransformV3
```

```
WARNING:tensorflow:Using a while_loop for converting RngReadAndSkip
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting Bitcast
WARNING:tensorflow:Using a while_loop for converting
StatelessRandomUniformFullIntV2
WARNING:tensorflow:Using a while_loop for converting
StatelessRandomGetKeyCounter
WARNING:tensorflow:Using a while_loop for converting StatelessRandomUniformV2
WARNING:tensorflow:Using a while_loop for converting AdjustContrastv2
11/11 [==============================] - 14s 362ms/step - loss: 5.1246 -
cate_output_loss: 1.7479 - marks_output_loss: 3.3767 - cate_output_accuracy:
0.2402 - marks_output_accuracy: 0.0541 - val_loss: 4.7038 -
val_cate_output_loss: 1.4582 - val_marks_output_loss: 3.2456 -
val_cate_output_accuracy: 0.5238 - val_marks_output_accuracy: 0.0833
Epoch 2/150
11/11 [==============================] - 2s 204ms/step - loss: 4.3054 -
cate_output_loss: 1.3202 - marks_output_loss: 2.9853 - cate_output_accuracy:
0.6036 - marks_output_accuracy: 0.2462 - val_loss: 4.2141 -
val_cate_output_loss: 1.1887 - val_marks_output_loss: 3.0255 -
val_cate_output_accuracy: 0.7143 - val_marks_output_accuracy: 0.1786
Epoch 3/150
11/11 [==============================] - 2s 204ms/step - loss: 3.5571 -
cate_output_loss: 0.9475 - marks_output_loss: 2.6096 - cate_output_accuracy:
0.8348 - marks_output_accuracy: 0.4685 - val_loss: 3.6506 -
val_cate_output_loss: 0.9036 - val_marks_output_loss: 2.7470 -
val_cate_output_accuracy: 0.8452 - val_marks_output_accuracy: 0.3571
Epoch 4/150
11/11 [==============================] - 2s 203ms/step - loss: 2.7672 -
cate_output_loss: 0.6294 - marks_output_loss: 2.1378 - cate_output_accuracy:
0.9129 - marks_output_accuracy: 0.7027 - val_loss: 2.9209 -
val_cate_output_loss: 0.5901 - val_marks_output_loss: 2.3308 -
val_cate_output_accuracy: 0.9405 - val_marks_output_accuracy: 0.4881
Epoch 5/150
11/11 [==============================] - 2s 204ms/step - loss: 2.0726 -
cate_output_loss: 0.4453 - marks_output_loss: 1.6273 - cate_output_accuracy:
0.9249 - marks_output_accuracy: 0.7958 - val_loss: 2.1892 -
val_cate_output_loss: 0.3562 - val_marks_output_loss: 1.8329 -
val_cate_output_accuracy: 0.9405 - val_marks_output_accuracy: 0.5952
Epoch 6/150
11/11 [==============================] - 2s 207ms/step - loss: 1.4603 -
cate_output_loss: 0.2923 - marks_output_loss: 1.1680 - cate_output_accuracy:
0.9489 - marks_output_accuracy: 0.8799 - val_loss: 1.6832 -
val_cate_output_loss: 0.2473 - val_marks_output_loss: 1.4360 -
val_cate_output_accuracy: 0.9762 - val_marks_output_accuracy: 0.6667
Epoch 7/150
11/11 [==============================] - 2s 210ms/step - loss: 1.0676 -
cate_output_loss: 0.2162 - marks_output_loss: 0.8514 - cate_output_accuracy:
```

```
0.9550 - marks_output_accuracy: 0.9069 - val_loss: 1.3104 -
val_cate_output_loss: 0.1843 - val_marks_output_loss: 1.1261 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.7024
Epoch 8/150
11/11 [==============================] - 2s 208ms/step - loss: 0.8096 -
cate_output_loss: 0.1691 - marks_output_loss: 0.6405 - cate_output_accuracy:
0.9760 - marks_output_accuracy: 0.9279 - val_loss: 1.0402 -
val_cate_output_loss: 0.1446 - val_marks_output_loss: 0.8955 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.7500
Epoch 9/150
11/11 [==============================] - 2s 203ms/step - loss: 0.6755 -
cate_output_loss: 0.1657 - marks_output_loss: 0.5098 - cate_output_accuracy:
0.9640 - marks_output_accuracy: 0.9399 - val_loss: 0.8215 -
val_cate_output_loss: 0.1077 - val_marks_output_loss: 0.7138 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.7857
Epoch 10/150
11/11 [==============================] - 2s 203ms/step - loss: 0.4826 -
cate_output_loss: 0.1132 - marks_output_loss: 0.3694 - cate_output_accuracy:
0.9730 - marks_output_accuracy: 0.9550 - val_loss: 0.6997 -
val_cate_output_loss: 0.0938 - val_marks_output_loss: 0.6059 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.8810
Epoch 11/150
11/11 [==============================] - 2s 202ms/step - loss: 0.3599 -
cate_output_loss: 0.0718 - marks_output_loss: 0.2881 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 0.9760 - val_loss: 0.5937 -
val_cate_output_loss: 0.0879 - val_marks_output_loss: 0.5058 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 12/150
11/11 [==============================] - 2s 204ms/step - loss: 0.2899 -
cate_output_loss: 0.0765 - marks_output_loss: 0.2135 - cate_output_accuracy:
0.9880 - marks_output_accuracy: 0.9790 - val_loss: 0.5306 -
val_cate_output_loss: 0.0787 - val_marks_output_loss: 0.4519 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 13/150
11/11 [==============================] - 2s 209ms/step - loss: 0.2395 -
cate_output_loss: 0.0531 - marks_output_loss: 0.1864 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9880 - val_loss: 0.4852 -
val_cate_output_loss: 0.0744 - val_marks_output_loss: 0.4107 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 14/150
11/11 [==============================] - 2s 213ms/step - loss: 0.2071 -
cate_output_loss: 0.0505 - marks_output_loss: 0.1566 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9910 - val_loss: 0.4560 -
val_cate_output_loss: 0.0739 - val_marks_output_loss: 0.3821 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 15/150
11/11 [==============================] - 2s 203ms/step - loss: 0.1868 -
cate_output_loss: 0.0545 - marks_output_loss: 0.1323 - cate_output_accuracy:
```

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0.9910 - marks_output_accuracy: 0.9910 - val_loss: 0.4224 -
val_cate_output_loss: 0.0658 - val_marks_output_loss: 0.3566 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 16/150
11/11 [==============================] - 2s 204ms/step - loss: 0.1323 -
cate_output_loss: 0.0310 - marks_output_loss: 0.1013 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 0.9940 - val_loss: 0.3879 -
val_cate_output_loss: 0.0615 - val_marks_output_loss: 0.3264 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9643
Epoch 17/150
11/11 [==============================] - 2s 204ms/step - loss: 0.1245 -
cate_output_loss: 0.0322 - marks_output_loss: 0.0923 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.3789 -
val_cate_output_loss: 0.0610 - val_marks_output_loss: 0.3179 -
val_cate_output_accuracy: 0.9762 - val_marks_output_accuracy: 0.9405
Epoch 18/150
11/11 [==============================] - 2s 204ms/step - loss: 0.1113 -
cate_output_loss: 0.0254 - marks_output_loss: 0.0859 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 0.9970 - val_loss: 0.3822 -
val_cate_output_loss: 0.0662 - val_marks_output_loss: 0.3160 -
val_cate_output_accuracy: 0.9762 - val_marks_output_accuracy: 0.9286
Epoch 19/150
11/11 [==============================] - 2s 208ms/step - loss: 0.1135 -
cate_output_loss: 0.0373 - marks_output_loss: 0.0762 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 0.9940 - val_loss: 0.3769 -
val_cate_output_loss: 0.0660 - val_marks_output_loss: 0.3109 -
val_cate_output_accuracy: 0.9762 - val_marks_output_accuracy: 0.9167
Epoch 20/150
11/11 [==============================] - 2s 212ms/step - loss: 0.1127 -
cate_output_loss: 0.0401 - marks_output_loss: 0.0726 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 0.9970 - val_loss: 0.3984 -
val_cate_output_loss: 0.0790 - val_marks_output_loss: 0.3194 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 21/150
11/11 [==============================] - 2s 208ms/step - loss: 0.0894 -
cate_output_loss: 0.0238 - marks_output_loss: 0.0656 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.3979 -
val_cate_output_loss: 0.0829 - val_marks_output_loss: 0.3150 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 22/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0713 -
cate_output_loss: 0.0233 - marks_output_loss: 0.0481 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.3689 -
val_cate_output_loss: 0.0675 - val_marks_output_loss: 0.3014 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 23/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0863 -
cate_output_loss: 0.0286 - marks_output_loss: 0.0577 - cate_output_accuracy:
```

```
0.9940 - marks_output_accuracy: 0.9970 - val_loss: 0.3387 -
val_cate_output_loss: 0.0518 - val_marks_output_loss: 0.2869 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 24/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0850 -
cate_output_loss: 0.0413 - marks_output_loss: 0.0437 - cate_output_accuracy:
0.9880 - marks_output_accuracy: 1.0000 - val_loss: 0.3259 -
val_cate_output_loss: 0.0585 - val_marks_output_loss: 0.2674 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 25/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0771 -
cate_output_loss: 0.0271 - marks_output_loss: 0.0500 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 1.0000 - val_loss: 0.3045 -
val_cate_output_loss: 0.0617 - val_marks_output_loss: 0.2428 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 26/150
11/11 [==============================] - 2s 209ms/step - loss: 0.0494 -
cate_output_loss: 0.0143 - marks_output_loss: 0.0351 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.2839 -
val_cate_output_loss: 0.0562 - val_marks_output_loss: 0.2277 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 27/150
11/11 [==============================] - 2s 212ms/step - loss: 0.0396 -
cate_output_loss: 0.0094 - marks_output_loss: 0.0302 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2806 -
val_cate_output_loss: 0.0510 - val_marks_output_loss: 0.2297 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 28/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0467 -
cate_output_loss: 0.0176 - marks_output_loss: 0.0291 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2739 -
val_cate_output_loss: 0.0458 - val_marks_output_loss: 0.2281 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 29/150
11/11 [==============================] - 2s 201ms/step - loss: 0.0593 -
cate_output_loss: 0.0235 - marks_output_loss: 0.0358 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 1.0000 - val_loss: 0.2879 -
val_cate_output_loss: 0.0461 - val_marks_output_loss: 0.2418 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 30/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0296 -
cate_output_loss: 0.0076 - marks_output_loss: 0.0219 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2699 -
val_cate_output_loss: 0.0388 - val_marks_output_loss: 0.2311 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 31/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0335 -
cate_output_loss: 0.0078 - marks_output_loss: 0.0257 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2520 -
val_cate_output_loss: 0.0343 - val_marks_output_loss: 0.2178 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 32/150
11/11 [==============================] - 2s 209ms/step - loss: 0.0328 -
cate_output_loss: 0.0108 - marks_output_loss: 0.0220 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2411 -
val_cate_output_loss: 0.0301 - val_marks_output_loss: 0.2111 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 33/150
11/11 [==============================] - 2s 213ms/step - loss: 0.0490 -
cate_output_loss: 0.0203 - marks_output_loss: 0.0287 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2362 -
val_cate_output_loss: 0.0293 - val_marks_output_loss: 0.2070 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 34/150
11/11 [==============================] - 2s 206ms/step - loss: 0.0428 -
cate_output_loss: 0.0192 - marks_output_loss: 0.0236 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 0.9970 - val_loss: 0.2672 -
val_cate_output_loss: 0.0450 - val_marks_output_loss: 0.2221 -
val_cate_output_accuracy: 0.9762 - val_marks_output_accuracy: 0.9167
Epoch 35/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0342 -
cate_output_loss: 0.0106 - marks_output_loss: 0.0236 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2896 -
val_cate_output_loss: 0.0474 - val_marks_output_loss: 0.2422 -
val_cate_output_accuracy: 0.9762 - val_marks_output_accuracy: 0.9167
Epoch 36/150
11/11 [==============================] - 2s 201ms/step - loss: 0.0324 -
cate_output_loss: 0.0101 - marks_output_loss: 0.0223 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.2921 -
val_cate_output_loss: 0.0408 - val_marks_output_loss: 0.2513 -
val_cate_output_accuracy: 0.9762 - val_marks_output_accuracy: 0.9167
Epoch 37/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0307 -
cate_output_loss: 0.0122 - marks_output_loss: 0.0186 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2746 -
val_cate_output_loss: 0.0365 - val_marks_output_loss: 0.2381 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 38/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0225 -
cate_output_loss: 0.0092 - marks_output_loss: 0.0133 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2955 -
val_cate_output_loss: 0.0588 - val_marks_output_loss: 0.2366 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 39/150
11/11 [==============================] - 2s 211ms/step - loss: 0.0359 -
cate_output_loss: 0.0159 - marks_output_loss: 0.0199 - cate_output_accuracy:
```

```
0.9970 - marks_output_accuracy: 0.9970 - val_loss: 0.2948 -
val_cate_output_loss: 0.0609 - val_marks_output_loss: 0.2339 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 40/150
11/11 [==============================] - 2s 211ms/step - loss: 0.0236 -
cate_output_loss: 0.0095 - marks_output_loss: 0.0141 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2938 -
val_cate_output_loss: 0.0538 - val_marks_output_loss: 0.2400 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 41/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0413 -
cate_output_loss: 0.0138 - marks_output_loss: 0.0275 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 0.9940 - val_loss: 0.2856 -
val_cate_output_loss: 0.0484 - val_marks_output_loss: 0.2372 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 42/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0256 -
cate_output_loss: 0.0127 - marks_output_loss: 0.0128 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.3136 -
val_cate_output_loss: 0.0579 - val_marks_output_loss: 0.2557 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 43/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0367 -
cate_output_loss: 0.0181 - marks_output_loss: 0.0186 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.3233 -
val_cate_output_loss: 0.0642 - val_marks_output_loss: 0.2591 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 44/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0222 -
cate_output_loss: 0.0061 - marks_output_loss: 0.0161 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.3192 -
val_cate_output_loss: 0.0681 - val_marks_output_loss: 0.2511 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 45/150
11/11 [==============================] - 2s 211ms/step - loss: 0.0258 -
cate_output_loss: 0.0074 - marks_output_loss: 0.0184 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.3152 -
val_cate_output_loss: 0.0702 - val_marks_output_loss: 0.2450 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 46/150
11/11 [==============================] - 2s 213ms/step - loss: 0.0269 -
cate_output_loss: 0.0120 - marks_output_loss: 0.0149 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.3066 -
val_cate_output_loss: 0.0666 - val_marks_output_loss: 0.2400 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 47/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0229 -
cate_output_loss: 0.0105 - marks_output_loss: 0.0125 - cate_output_accuracy:
```

```
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2782 -
val_cate_output_loss: 0.0545 - val_marks_output_loss: 0.2237 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 48/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0160 -
cate_output_loss: 0.0063 - marks_output_loss: 0.0098 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2663 -
val_cate_output_loss: 0.0502 - val_marks_output_loss: 0.2161 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 49/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0422 -
cate_output_loss: 0.0211 - marks_output_loss: 0.0211 - cate_output_accuracy:
0.9910 - marks_output_accuracy: 1.0000 - val_loss: 0.2591 -
val_cate_output_loss: 0.0475 - val_marks_output_loss: 0.2116 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 50/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0214 -
cate_output_loss: 0.0076 - marks_output_loss: 0.0138 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2896 -
val_cate_output_loss: 0.0558 - val_marks_output_loss: 0.2338 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 51/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0517 -
cate_output_loss: 0.0380 - marks_output_loss: 0.0138 - cate_output_accuracy:
0.9850 - marks_output_accuracy: 1.0000 - val_loss: 0.2705 -
val_cate_output_loss: 0.0431 - val_marks_output_loss: 0.2274 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 52/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0210 -
cate_output_loss: 0.0080 - marks_output_loss: 0.0131 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2463 -
val_cate_output_loss: 0.0323 - val_marks_output_loss: 0.2139 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 53/150
11/11 [==============================] - 2s 212ms/step - loss: 0.0286 -
cate_output_loss: 0.0139 - marks_output_loss: 0.0147 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2338 -
val_cate_output_loss: 0.0260 - val_marks_output_loss: 0.2078 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 54/150
11/11 [==============================] - 2s 206ms/step - loss: 0.0209 -
cate_output_loss: 0.0079 - marks_output_loss: 0.0130 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2215 -
val_cate_output_loss: 0.0235 - val_marks_output_loss: 0.1980 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 55/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0176 -
cate_output_loss: 0.0078 - marks_output_loss: 0.0099 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2183 -
val_cate_output_loss: 0.0233 - val_marks_output_loss: 0.1950 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 56/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0303 -
cate_output_loss: 0.0149 - marks_output_loss: 0.0154 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 0.9970 - val_loss: 0.2264 -
val_cate_output_loss: 0.0247 - val_marks_output_loss: 0.2017 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9286
Epoch 57/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0114 -
cate_output_loss: 0.0050 - marks_output_loss: 0.0064 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2407 -
val_cate_output_loss: 0.0348 - val_marks_output_loss: 0.2059 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 58/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0153 -
cate_output_loss: 0.0050 - marks_output_loss: 0.0103 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2246 -
val_cate_output_loss: 0.0305 - val_marks_output_loss: 0.1941 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 59/150
11/11 [==============================] - 2s 213ms/step - loss: 0.0096 -
cate_output_loss: 0.0028 - marks_output_loss: 0.0068 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2056 -
val_cate_output_loss: 0.0234 - val_marks_output_loss: 0.1822 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 60/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0130 -
cate_output_loss: 0.0054 - marks_output_loss: 0.0076 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2002 -
val_cate_output_loss: 0.0228 - val_marks_output_loss: 0.1774 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 61/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0108 -
cate_output_loss: 0.0036 - marks_output_loss: 0.0072 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2041 -
val_cate_output_loss: 0.0247 - val_marks_output_loss: 0.1795 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 62/150
11/11 [==============================] - 2s 201ms/step - loss: 0.0232 -
cate_output_loss: 0.0137 - marks_output_loss: 0.0095 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 1.0000 - val_loss: 0.2089 -
val_cate_output_loss: 0.0269 - val_marks_output_loss: 0.1820 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 63/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0134 -
cate_output_loss: 0.0039 - marks_output_loss: 0.0094 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.2020 -
val_cate_output_loss: 0.0215 - val_marks_output_loss: 0.1805 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 64/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0236 -
cate_output_loss: 0.0104 - marks_output_loss: 0.0132 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 0.9970 - val_loss: 0.2078 -
val_cate_output_loss: 0.0185 - val_marks_output_loss: 0.1892 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 65/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0189 -
cate_output_loss: 0.0115 - marks_output_loss: 0.0074 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2066 -
val_cate_output_loss: 0.0175 - val_marks_output_loss: 0.1891 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 66/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0274 -
cate_output_loss: 0.0147 - marks_output_loss: 0.0127 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 0.9940 - val_loss: 0.2088 -
val_cate_output_loss: 0.0182 - val_marks_output_loss: 0.1906 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 67/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0099 -
cate_output_loss: 0.0044 - marks_output_loss: 0.0055 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2126 -
val_cate_output_loss: 0.0205 - val_marks_output_loss: 0.1920 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 68/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0133 -
cate_output_loss: 0.0057 - marks_output_loss: 0.0076 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2161 -
val_cate_output_loss: 0.0216 - val_marks_output_loss: 0.1945 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 69/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0160 -
cate_output_loss: 0.0068 - marks_output_loss: 0.0092 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2143 -
val_cate_output_loss: 0.0205 - val_marks_output_loss: 0.1938 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 70/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0113 -
cate_output_loss: 0.0063 - marks_output_loss: 0.0050 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2109 -
val_cate_output_loss: 0.0210 - val_marks_output_loss: 0.1899 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 71/150
11/11 [==============================] - 2s 215ms/step - loss: 0.0110 -
cate_output_loss: 0.0042 - marks_output_loss: 0.0068 - cate_output_accuracy:
```

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1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2123 -
val_cate_output_loss: 0.0213 - val_marks_output_loss: 0.1910 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 72/150
11/11 [==============================] - 2s 218ms/step - loss: 0.0090 -
cate_output_loss: 0.0035 - marks_output_loss: 0.0055 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2090 -
val_cate_output_loss: 0.0207 - val_marks_output_loss: 0.1883 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 73/150
11/11 [==============================] - 2s 208ms/step - loss: 0.0179 -
cate_output_loss: 0.0117 - marks_output_loss: 0.0063 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2018 -
val_cate_output_loss: 0.0171 - val_marks_output_loss: 0.1846 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 74/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0079 -
cate_output_loss: 0.0030 - marks_output_loss: 0.0050 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2014 -
val_cate_output_loss: 0.0159 - val_marks_output_loss: 0.1855 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 75/150
11/11 [==============================] - 2s 206ms/step - loss: 0.0127 -
cate_output_loss: 0.0057 - marks_output_loss: 0.0069 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2117 -
val_cate_output_loss: 0.0142 - val_marks_output_loss: 0.1976 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 76/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0144 -
cate_output_loss: 0.0108 - marks_output_loss: 0.0037 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2091 -
val_cate_output_loss: 0.0134 - val_marks_output_loss: 0.1957 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 77/150
11/11 [==============================] - 2s 209ms/step - loss: 0.0072 -
cate_output_loss: 0.0024 - marks_output_loss: 0.0049 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2079 -
val_cate_output_loss: 0.0140 - val_marks_output_loss: 0.1939 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 78/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0143 -
cate_output_loss: 0.0087 - marks_output_loss: 0.0055 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2119 -
val_cate_output_loss: 0.0146 - val_marks_output_loss: 0.1973 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 79/150
11/11 [==============================] - 2s 208ms/step - loss: 0.0118 -
cate_output_loss: 0.0047 - marks_output_loss: 0.0072 - cate_output_accuracy:
```

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1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2153 -
val_cate_output_loss: 0.0141 - val_marks_output_loss: 0.2013 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 80/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0066 -
cate_output_loss: 0.0026 - marks_output_loss: 0.0041 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2174 -
val_cate_output_loss: 0.0139 - val_marks_output_loss: 0.2035 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 81/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0054 -
cate_output_loss: 0.0015 - marks_output_loss: 0.0038 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2161 -
val_cate_output_loss: 0.0141 - val_marks_output_loss: 0.2020 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 82/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0059 -
cate_output_loss: 0.0016 - marks_output_loss: 0.0043 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2136 -
val_cate_output_loss: 0.0145 - val_marks_output_loss: 0.1990 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 83/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0065 -
cate_output_loss: 0.0026 - marks_output_loss: 0.0039 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2104 -
val_cate_output_loss: 0.0153 - val_marks_output_loss: 0.1951 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 84/150
11/11 [==============================] - 2s 208ms/step - loss: 0.0114 -
cate_output_loss: 0.0067 - marks_output_loss: 0.0047 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2059 -
val_cate_output_loss: 0.0143 - val_marks_output_loss: 0.1916 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 85/150
11/11 [==============================] - 2s 214ms/step - loss: 0.0059 -
cate_output_loss: 0.0022 - marks_output_loss: 0.0037 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2006 -
val_cate_output_loss: 0.0118 - val_marks_output_loss: 0.1888 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9286
Epoch 86/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0069 -
cate_output_loss: 0.0021 - marks_output_loss: 0.0048 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2118 -
val_cate_output_loss: 0.0119 - val_marks_output_loss: 0.1999 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9286
Epoch 87/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0091 -
cate_output_loss: 0.0018 - marks_output_loss: 0.0073 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.2209 -
val_cate_output_loss: 0.0121 - val_marks_output_loss: 0.2088 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9286
Epoch 88/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0054 -
cate_output_loss: 0.0024 - marks_output_loss: 0.0030 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2389 -
val_cate_output_loss: 0.0133 - val_marks_output_loss: 0.2256 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 89/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0063 -
cate_output_loss: 0.0029 - marks_output_loss: 0.0034 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2450 -
val_cate_output_loss: 0.0158 - val_marks_output_loss: 0.2291 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 90/150
11/11 [==============================] - 2s 209ms/step - loss: 0.0063 -
cate_output_loss: 0.0021 - marks_output_loss: 0.0041 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2391 -
val_cate_output_loss: 0.0175 - val_marks_output_loss: 0.2216 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9167
Epoch 91/150
11/11 [==============================] - 2s 211ms/step - loss: 0.0046 -
cate_output_loss: 9.4454e-04 - marks_output_loss: 0.0036 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2297 -
val_cate_output_loss: 0.0186 - val_marks_output_loss: 0.2111 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 92/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0056 -
cate_output_loss: 0.0019 - marks_output_loss: 0.0037 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2259 -
val_cate_output_loss: 0.0197 - val_marks_output_loss: 0.2062 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 93/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0139 -
cate_output_loss: 0.0076 - marks_output_loss: 0.0063 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.2139 -
val_cate_output_loss: 0.0166 - val_marks_output_loss: 0.1973 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 94/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0165 -
cate_output_loss: 0.0133 - marks_output_loss: 0.0032 - cate_output_accuracy:
0.9940 - marks_output_accuracy: 1.0000 - val_loss: 0.2092 -
val_cate_output_loss: 0.0162 - val_marks_output_loss: 0.1930 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 95/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0155 -
cate_output_loss: 0.0028 - marks_output_loss: 0.0127 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.2034 -
val_cate_output_loss: 0.0322 - val_marks_output_loss: 0.1712 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 96/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0069 -
cate_output_loss: 0.0030 - marks_output_loss: 0.0039 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2003 -
val_cate_output_loss: 0.0383 - val_marks_output_loss: 0.1620 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 97/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0098 -
cate_output_loss: 0.0044 - marks_output_loss: 0.0055 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9970 - val_loss: 0.1967 -
val_cate_output_loss: 0.0319 - val_marks_output_loss: 0.1648 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 98/150
11/11 [==============================] - 2s 213ms/step - loss: 0.0099 -
cate_output_loss: 0.0067 - marks_output_loss: 0.0032 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2079 -
val_cate_output_loss: 0.0340 - val_marks_output_loss: 0.1739 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 99/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0074 -
cate_output_loss: 0.0034 - marks_output_loss: 0.0040 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2169 -
val_cate_output_loss: 0.0329 - val_marks_output_loss: 0.1840 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9286
Epoch 100/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0076 -
cate_output_loss: 0.0039 - marks_output_loss: 0.0037 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2106 -
val_cate_output_loss: 0.0297 - val_marks_output_loss: 0.1809 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 101/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0124 -
cate_output_loss: 0.0012 - marks_output_loss: 0.0111 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 0.9940 - val_loss: 0.2086 -
val_cate_output_loss: 0.0265 - val_marks_output_loss: 0.1821 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 102/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0075 -
cate_output_loss: 0.0024 - marks_output_loss: 0.0051 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.2041 -
val_cate_output_loss: 0.0250 - val_marks_output_loss: 0.1791 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 103/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0080 -
cate_output_loss: 0.0022 - marks_output_loss: 0.0058 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1974 -
val_cate_output_loss: 0.0221 - val_marks_output_loss: 0.1754 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 104/150
11/11 [==============================] - 2s 213ms/step - loss: 0.0049 -
cate_output_loss: 0.0020 - marks_output_loss: 0.0029 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1930 -
val_cate_output_loss: 0.0223 - val_marks_output_loss: 0.1707 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 105/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0074 -
cate_output_loss: 0.0046 - marks_output_loss: 0.0029 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1874 -
val_cate_output_loss: 0.0198 - val_marks_output_loss: 0.1676 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 106/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0045 -
cate_output_loss: 0.0022 - marks_output_loss: 0.0023 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1880 -
val_cate_output_loss: 0.0195 - val_marks_output_loss: 0.1685 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 107/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0040 -
cate_output_loss: 0.0020 - marks_output_loss: 0.0020 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1874 -
val_cate_output_loss: 0.0181 - val_marks_output_loss: 0.1694 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 108/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0054 -
cate_output_loss: 0.0019 - marks_output_loss: 0.0034 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1869 -
val_cate_output_loss: 0.0179 - val_marks_output_loss: 0.1690 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 109/150
11/11 [==============================] - 2s 206ms/step - loss: 0.0092 -
cate_output_loss: 0.0046 - marks_output_loss: 0.0046 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1846 -
val_cate_output_loss: 0.0162 - val_marks_output_loss: 0.1684 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 110/150
11/11 [==============================] - 2s 211ms/step - loss: 0.0049 -
cate_output_loss: 0.0029 - marks_output_loss: 0.0021 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1926 -
val_cate_output_loss: 0.0149 - val_marks_output_loss: 0.1778 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9405
Epoch 111/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0066 -
cate_output_loss: 0.0043 - marks_output_loss: 0.0023 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1921 -
val_cate_output_loss: 0.0114 - val_marks_output_loss: 0.1806 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 112/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0040 -
cate_output_loss: 0.0011 - marks_output_loss: 0.0029 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1869 -
val_cate_output_loss: 0.0097 - val_marks_output_loss: 0.1772 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 113/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0038 -
cate_output_loss: 0.0016 - marks_output_loss: 0.0023 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1834 -
val_cate_output_loss: 0.0104 - val_marks_output_loss: 0.1731 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 114/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0060 -
cate_output_loss: 0.0030 - marks_output_loss: 0.0030 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1729 -
val_cate_output_loss: 0.0076 - val_marks_output_loss: 0.1653 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 115/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0104 -
cate_output_loss: 0.0081 - marks_output_loss: 0.0022 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1659 -
val_cate_output_loss: 0.0035 - val_marks_output_loss: 0.1624 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 116/150
11/11 [==============================] - 2s 208ms/step - loss: 0.0023 -
cate_output_loss: 8.2153e-04 - marks_output_loss: 0.0015 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1657 -
val_cate_output_loss: 0.0033 - val_marks_output_loss: 0.1625 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 117/150
11/11 [==============================] - 2s 213ms/step - loss: 0.0121 -
cate_output_loss: 0.0072 - marks_output_loss: 0.0049 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1601 -
val_cate_output_loss: 0.0041 - val_marks_output_loss: 0.1560 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 118/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0104 -
cate_output_loss: 0.0058 - marks_output_loss: 0.0046 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1590 -
val_cate_output_loss: 0.0052 - val_marks_output_loss: 0.1538 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 119/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0051 -
cate_output_loss: 0.0024 - marks_output_loss: 0.0027 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1618 -
val_cate_output_loss: 0.0059 - val_marks_output_loss: 0.1559 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 120/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0140 -
cate_output_loss: 0.0104 - marks_output_loss: 0.0036 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1645 -
val_cate_output_loss: 0.0059 - val_marks_output_loss: 0.1586 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 121/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0088 -
cate_output_loss: 0.0046 - marks_output_loss: 0.0042 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1702 -
val_cate_output_loss: 0.0064 - val_marks_output_loss: 0.1639 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 122/150
11/11 [==============================] - 2s 206ms/step - loss: 0.0031 -
cate_output_loss: 0.0016 - marks_output_loss: 0.0015 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1792 -
val_cate_output_loss: 0.0091 - val_marks_output_loss: 0.1702 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 123/150
11/11 [==============================] - 2s 214ms/step - loss: 0.0069 -
cate_output_loss: 0.0036 - marks_output_loss: 0.0033 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1774 -
val_cate_output_loss: 0.0096 - val_marks_output_loss: 0.1678 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 124/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0052 -
cate_output_loss: 0.0022 - marks_output_loss: 0.0030 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1794 -
val_cate_output_loss: 0.0096 - val_marks_output_loss: 0.1698 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 125/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0059 -
cate_output_loss: 0.0034 - marks_output_loss: 0.0025 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1762 -
val_cate_output_loss: 0.0082 - val_marks_output_loss: 0.1681 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 126/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0035 -
cate_output_loss: 0.0015 - marks_output_loss: 0.0019 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1742 -
val_cate_output_loss: 0.0078 - val_marks_output_loss: 0.1665 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 127/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0037 -
cate_output_loss: 9.1425e-04 - marks_output_loss: 0.0028 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1711 -
val_cate_output_loss: 0.0068 - val_marks_output_loss: 0.1642 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9405
Epoch 128/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0066 -
cate_output_loss: 0.0040 - marks_output_loss: 0.0026 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1608 -
val_cate_output_loss: 0.0059 - val_marks_output_loss: 0.1549 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 129/150
11/11 [==============================] - 2s 212ms/step - loss: 0.0042 -
cate_output_loss: 0.0027 - marks_output_loss: 0.0016 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1637 -
val_cate_output_loss: 0.0076 - val_marks_output_loss: 0.1561 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 130/150
11/11 [==============================] - 2s 219ms/step - loss: 0.0198 -
cate_output_loss: 0.0172 - marks_output_loss: 0.0026 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1640 -
val_cate_output_loss: 0.0077 - val_marks_output_loss: 0.1563 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 131/150
11/11 [==============================] - 2s 220ms/step - loss: 0.0061 -
cate_output_loss: 0.0040 - marks_output_loss: 0.0021 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1670 -
val_cate_output_loss: 0.0067 - val_marks_output_loss: 0.1603 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 132/150
11/11 [==============================] - 2s 206ms/step - loss: 0.0048 -
cate_output_loss: 0.0015 - marks_output_loss: 0.0033 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1627 -
val_cate_output_loss: 0.0064 - val_marks_output_loss: 0.1563 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 133/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0033 -
cate_output_loss: 0.0018 - marks_output_loss: 0.0015 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1599 -
val_cate_output_loss: 0.0065 - val_marks_output_loss: 0.1534 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 134/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0034 -
cate_output_loss: 0.0016 - marks_output_loss: 0.0018 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1593 -
val_cate_output_loss: 0.0067 - val_marks_output_loss: 0.1525 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 135/150
11/11 [==============================] - 2s 210ms/step - loss: 0.0038 -
cate_output_loss: 0.0020 - marks_output_loss: 0.0018 - cate_output_accuracy:
```

```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1571 -
val_cate_output_loss: 0.0065 - val_marks_output_loss: 0.1507 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9762
Epoch 136/150
11/11 [==============================] - 2s 213ms/step - loss: 0.0053 -
cate_output_loss: 0.0034 - marks_output_loss: 0.0019 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1581 -
val_cate_output_loss: 0.0061 - val_marks_output_loss: 0.1521 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 137/150
11/11 [==============================] - 2s 209ms/step - loss: 0.0094 -
cate_output_loss: 0.0063 - marks_output_loss: 0.0030 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1647 -
val_cate_output_loss: 0.0053 - val_marks_output_loss: 0.1594 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 138/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0064 -
cate_output_loss: 0.0040 - marks_output_loss: 0.0024 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1711 -
val_cate_output_loss: 0.0052 - val_marks_output_loss: 0.1659 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 139/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0075 -
cate_output_loss: 0.0040 - marks_output_loss: 0.0035 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1929 -
val_cate_output_loss: 0.0194 - val_marks_output_loss: 0.1735 -
val_cate_output_accuracy: 0.9881 - val_marks_output_accuracy: 0.9524
Epoch 140/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0030 -
cate_output_loss: 0.0014 - marks_output_loss: 0.0016 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1818 -
val_cate_output_loss: 0.0140 - val_marks_output_loss: 0.1678 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 141/150
11/11 [==============================] - 2s 202ms/step - loss: 0.0025 -
cate_output_loss: 0.0011 - marks_output_loss: 0.0014 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1774 -
val_cate_output_loss: 0.0124 - val_marks_output_loss: 0.1650 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 142/150
11/11 [==============================] - 2s 215ms/step - loss: 0.0046 -
cate_output_loss: 0.0036 - marks_output_loss: 0.0010 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1698 -
val_cate_output_loss: 0.0124 - val_marks_output_loss: 0.1574 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 143/150
11/11 [==============================] - 2s 214ms/step - loss: 0.0048 -
cate_output_loss: 0.0018 - marks_output_loss: 0.0030 - cate_output_accuracy:
```

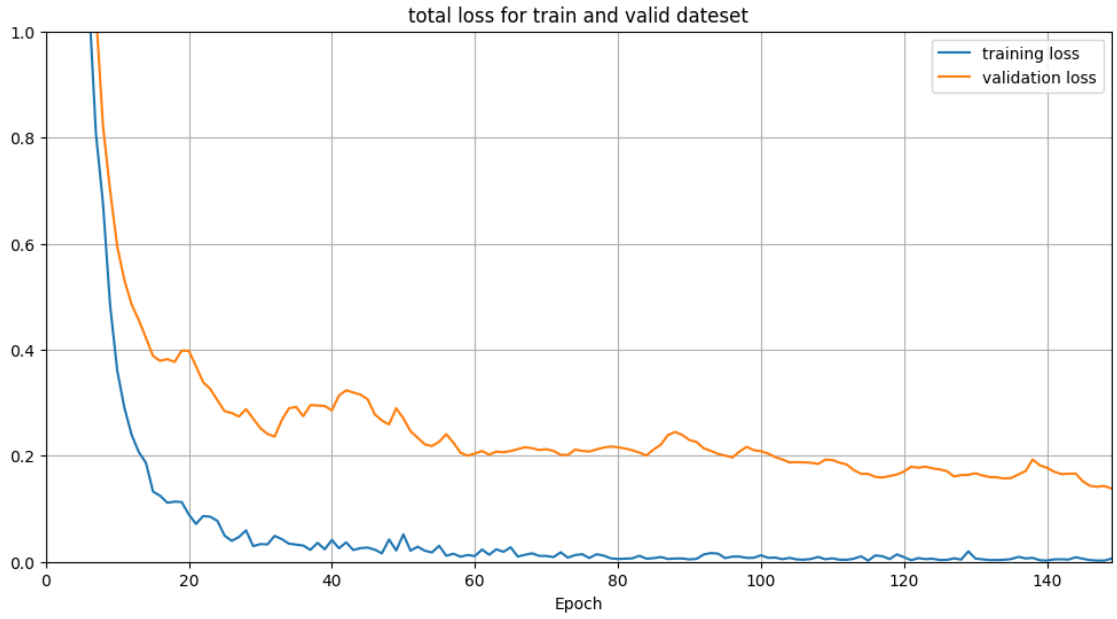
```
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1655 -
val_cate_output_loss: 0.0110 - val_marks_output_loss: 0.1544 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 144/150
11/11 [==============================] - 2s 205ms/step - loss: 0.0042 -
cate_output_loss: 0.0022 - marks_output_loss: 0.0021 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1661 -
val_cate_output_loss: 0.0111 - val_marks_output_loss: 0.1550 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 145/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0087 -
cate_output_loss: 0.0051 - marks_output_loss: 0.0035 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1665 -
val_cate_output_loss: 0.0111 - val_marks_output_loss: 0.1554 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 146/150
11/11 [==============================] - 2s 204ms/step - loss: 0.0058 -
cate_output_loss: 0.0039 - marks_output_loss: 0.0019 - cate_output_accuracy:
0.9970 - marks_output_accuracy: 1.0000 - val_loss: 0.1519 -
val_cate_output_loss: 0.0101 - val_marks_output_loss: 0.1418 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9524
Epoch 147/150
11/11 [==============================] - 2s 203ms/step - loss: 0.0033 -
cate_output_loss: 0.0018 - marks_output_loss: 0.0015 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1434 -
val_cate_output_loss: 0.0088 - val_marks_output_loss: 0.1346 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 148/150
11/11 [==============================] - 2s 207ms/step - loss: 0.0025 -
cate_output_loss: 7.5121e-04 - marks_output_loss: 0.0017 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1415 -
val_cate_output_loss: 0.0085 - val_marks_output_loss: 0.1330 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 149/150
11/11 [==============================] - 2s 214ms/step - loss: 0.0023 -
cate_output_loss: 7.9246e-04 - marks_output_loss: 0.0015 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1430 -
val_cate_output_loss: 0.0084 - val_marks_output_loss: 0.1346 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
Epoch 150/150
11/11 [==============================] - 2s 206ms/step - loss: 0.0060 -
cate_output_loss: 0.0014 - marks_output_loss: 0.0045 - cate_output_accuracy:
1.0000 - marks_output_accuracy: 1.0000 - val_loss: 0.1383 -
val_cate_output_loss: 0.0075 - val_marks_output_loss: 0.1309 -
val_cate_output_accuracy: 1.0000 - val_marks_output_accuracy: 0.9643
```

[105]:

[106]:
```
result= pd.DataFrame(history.history)
```

[107]:
```
import matplotlib.pyplot as plt

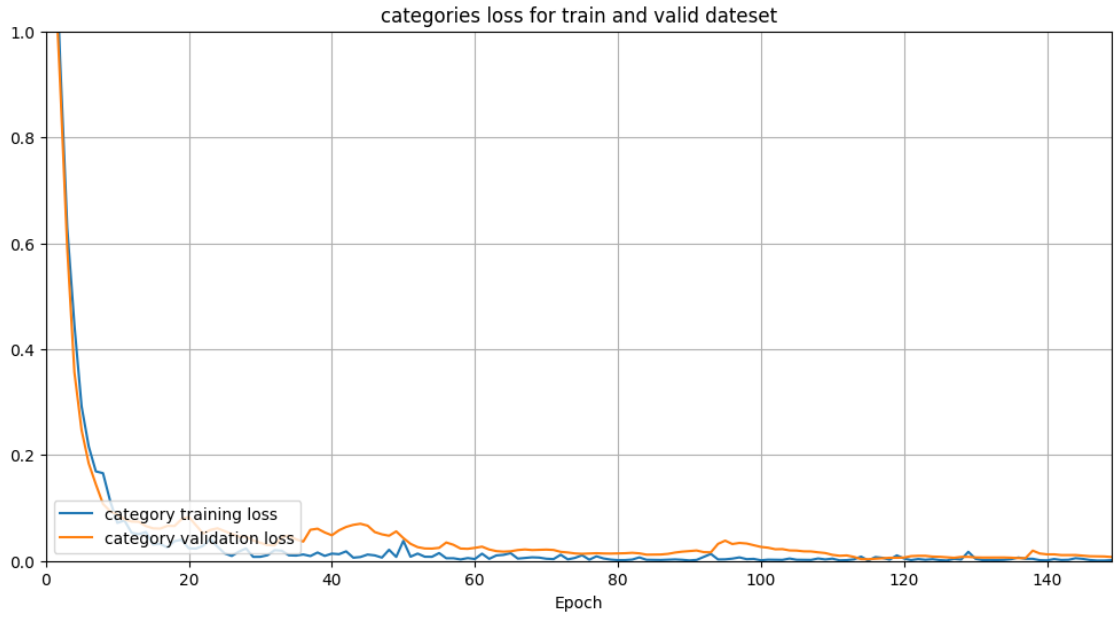
plt.figure(figsize=(12, 6))
plt.plot(result["loss"],label = "training loss")
plt.plot(result["val_loss"],label = "validation loss")
plt.xlim([0,EPOCHS-1])
plt.ylim([0, 1])
plt.title("total loss for train and valid dateset")
plt.grid(True)
plt.xlabel("Epoch")
plt.legend()
plt.show()
```



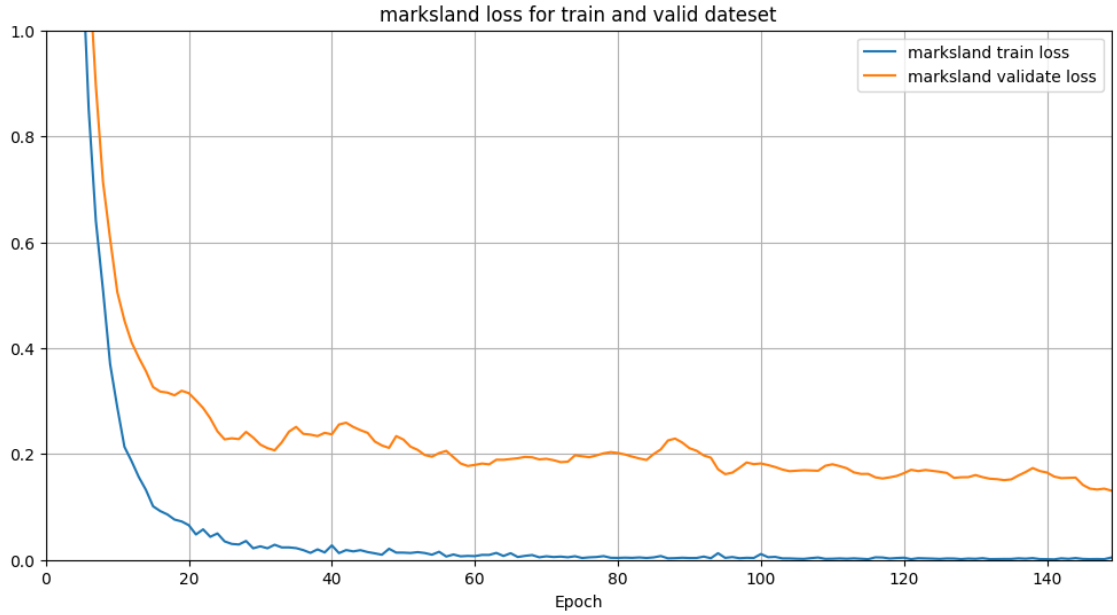
[108]:
```
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 6))
plt.plot(result["cate_output_loss"],label ="category training loss")
plt.plot(result["val_cate_output_loss"],label = "category validation loss")
plt.xlim([0,EPOCHS-1])
plt.ylim([0, 1])
plt.title("categories loss for train and valid dateset")
plt.grid(True)
plt.xlabel("Epoch")
plt.legend(loc=3)
```

```
plt.show()
```

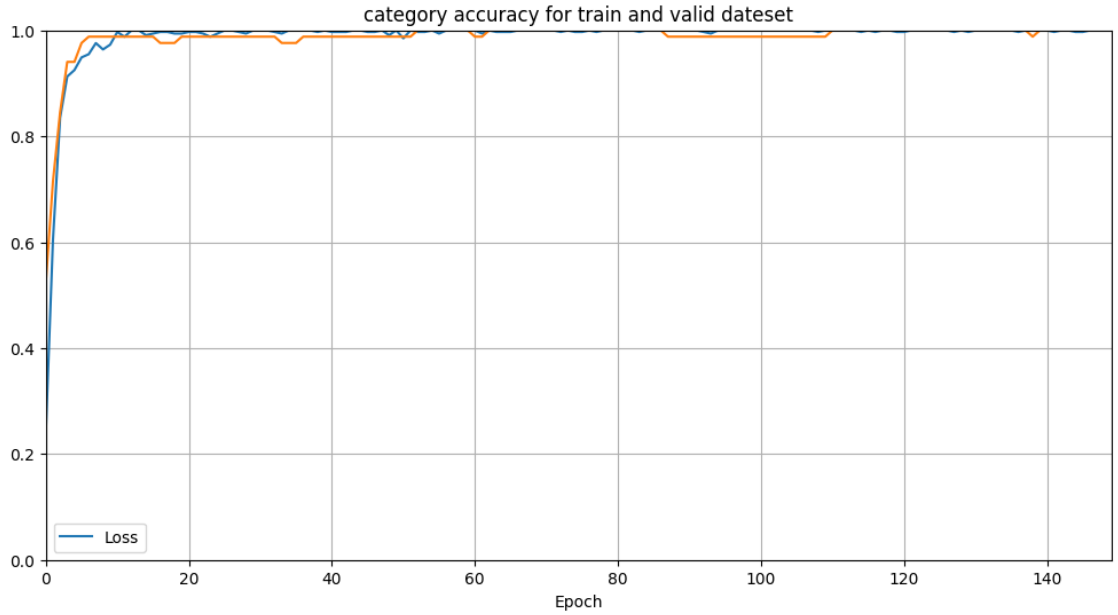


[109]:
```
plt.figure(figsize=(12, 6))
plt.plot(result["marks_output_loss"],label = "marksland train loss")
plt.plot(result["val_marks_output_loss"], label = "marksland validate loss")
plt.xlim([0,EPOCHS-1])
plt.ylim([0, 1])
plt.title("marksland loss for train and valid dateset")
plt.grid(True)
plt.xlabel("Epoch")
plt.legend()
plt.show()
```



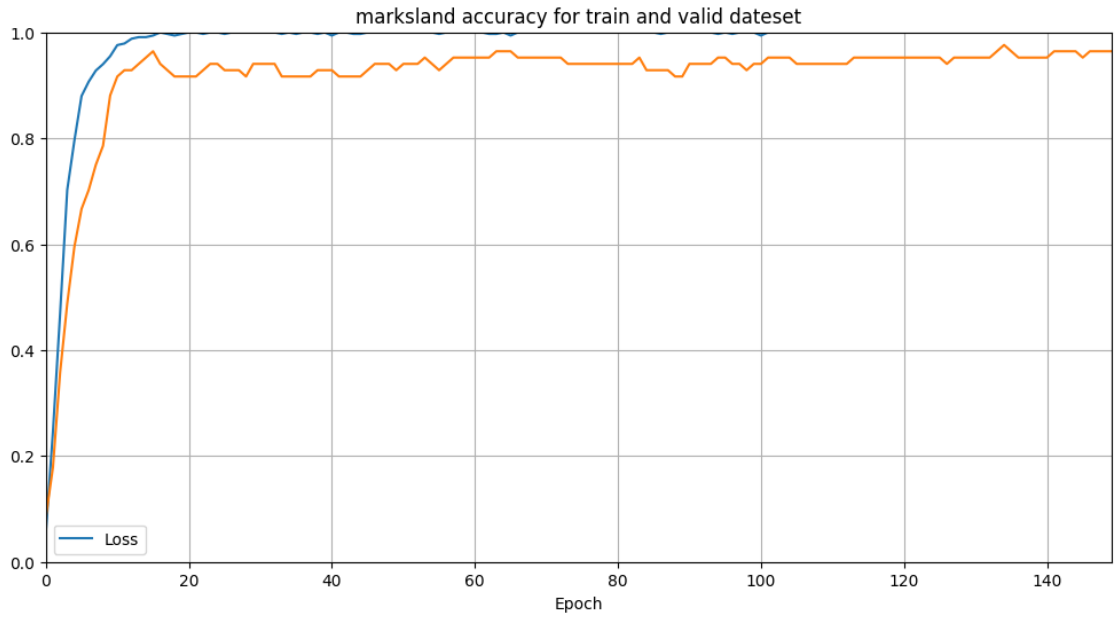
[110]:
```
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 6))
plt.plot(result["cate_output_accuracy"],label = "category train accuracy")
plt.plot(result["val_cate_output_accuracy"], label = " category validate␣
 ↪accuracy")
plt.xlim([0,EPOCHS-1])
plt.ylim([0, 1])
plt.grid(True)
plt.title("category accuracy for train and valid dateset")
plt.xlabel("Epoch")
plt.legend(["Loss"], loc=3)
plt.show()
```



[111]:
```
import matplotlib.pyplot as plt

plt.figure(figsize=(12, 6))
plt.plot(result["marks_output_accuracy"],label = "marksland train accuracy")
plt.plot(result["val_marks_output_accuracy"], label = "marksland validate␣
 ↪accuracy")
plt.title("marksland accuracy for train and valid dateset")
plt.xlim([0,EPOCHS-1])
plt.ylim([0, 1])
plt.grid(True)
plt.xlabel("Epoch")
plt.legend(["Loss"], loc=3)
plt.show()
```



[119]:
```
model.save("/content/drive/My Drive/final_model123.h5")
```

[120]:
```
import os
import pandas as pd
import tensorflow as tf
from tensorflow.keras.models import load_model

categories = ['Gothic', 'Modern', 'Mughal', 'Neoclassical', 'Pagodas',␣
 ↪'Pyramids']
landmarks = ['Academy of Athens', 'Bibi Ka Maqbara', 'Buckingham Palace',
 'CCTV Headquarters', 'Cathedral of Bras\ue4f2ia', 'ChartresCathedral',
 'Chrysler Building', 'CologneCathedral', 'Concertgebouw',
 'El Castillo, Chichen Itza', 'FogongTemplePagoda', 'GiantWildGoosePagoda',
 'Hallgr\ue4f3skirkja', 'Jama Masjid', 'Louvre Pyramid', 'MilanCathedral',
 'Notre-DameCathedral', 'Panthéon', 'Pyramid of Djoser', 'Pyramid of Giza',
 'Ripon Building', 'Santa Cecilia Acatitlan Pyramid', 'ShwedagonPagoda',
 'St.VitusCathedral', 'Taj Mahal', 'ThienMuPagoda', 'TianningTemplePagoda',
 'Tomb of Akbar', 'Tomb of I_timad-ud-Daulah', 'eiffel','other']

model = load_model("/content/drive/My Drive/final_model123.h5")

def model_prediction(directory):
    predictions = []
    cate_list = os.listdir(directory)
    for each_cate in cate_list:
      cate_path = os.path.join(directory, each_cate)
```

```
    mark_list = os.listdir(cate_path)
    for each_mark in mark_list:
      mark_path = os.path.join(cate_path, each_mark)
      file_list = os.listdir(mark_path)
      for file in file_list:
        try:
          img_path = os.path.join(mark_path, file)
          img = tf.keras.preprocessing.image.load_img(img_path,␣
↪target_size=input_shape)
          img_array = tf.keras.preprocessing.image.img_to_array(img)
          img_array = tf.expand_dims(img_array, 0) # Create batch axis

          # Make prediction
          cat_pred, landmark_pred = model.predict(img_array)


          # Get category and landmark with highest confidence
          cat_index = np.argmax(cat_pred)
          landmark_index = np.argmax(landmark_pred)


          # Calculate confidence scores
          cat_confidence = cat_pred[0][cat_index]
          landmark_confidence = landmark_pred[0][landmark_index]

          # Set landmark to "others" if confidence is too low
          if landmark_confidence < 0.5:
              landmark_index = 30
              landmark_confidence = 1 - landmark_confidence

          # Add prediction to list
          predictions.append({
              'image': file,
              'category': categories[cat_index],
              'category_confidence': cat_confidence,
              'landmark': landmarks[landmark_index],
              'landmark_confidence': landmark_confidence
          })
        except:
          print("load img failed: " + mark_path + "/" + file)


  # file_list = [f for f in file_list]
  # predictions = []
  # for file in file_list:
  #     img_path = os.path.join(directory, file)
```

```
    #     img = tf.keras.preprocessing.image.load_img(img_path,␣
 ↪target_size=input_shape)
    #     img_array = tf.keras.preprocessing.image.img_to_array(img)
    #     img_array = tf.expand_dims(img_array, 0) # Create batch axis

    #     # Make prediction
    #     cat_pred, landmark_pred = model.predict(img_array)


    #     # Get category and landmark with highest confidence
    #     cat_index = np.argmax(cat_pred)
    #     landmark_index = np.argmax(landmark_pred)


    #     # Calculate confidence scores
    #     cat_confidence = cat_pred[0][cat_index]
    #     landmark_confidence = landmark_pred[0][landmark_index]

    #     # Set landmark to "others" if confidence is too low
    #     if landmark_confidence < 0.5:
    #         landmark_index = 30
    #         landmark_confidence = 1 - landmark_confidence

    #     # Add prediction to list
    #     predictions.append({
    #         'image': file,
    #         'category': categories[cat_index],
    #         'category_confidence': cat_confidence,
    #         'landmark': landmarks[landmark_index],
    #         'landmark_confidence': landmark_confidence
    #     })

    # Create DataFrame from list of predictions
    prediction_df = pd.DataFrame(predictions)
    print(prediction_df)

    return prediction_df

pred = model_prediction("/content/drive/My Drive/data")
```

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Maqbara - 14.jpg
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	image	category	category_confidence	\
0	St.VitusCathedral0.jpeg	Gothic	0.999863	
1	St.VitusCathedral1.jpeg	Gothic	0.999982	
2	St.VitusCathedral4.jpeg	Gothic	0.999829	
3	St.VitusCathedral5.jpeg	Gothic	0.999995	
4	St.VitusCathedral8.jpeg	Gothic	0.999873	
..	…	…	…	
412	El Castillo, Chichen Itza-14.jpg	Pyramids	0.645178	
413	El Castillo, Chichen Itza-15.jpg	Pyramids	0.995754	
414	El Castillo, Chichen Itza-16.jpg	Pyramids	0.997008	
415	El Castillo, Chichen Itza-18.jpg	Pyramids	0.999468	
416	El Castillo, Chichen Itza-20.jpg	Pyramids	0.999827	

	landmark	landmark_confidence
0	St.VitusCathedral	0.953727
1	St.VitusCathedral	0.999773
2	St.VitusCathedral	0.996476

```
3                  St.VitusCathedral             0.997651
4                  St.VitusCathedral             0.985468
..                               …                  …
412  Santa Cecilia Acatitlan Pyramid             0.815378
413        El Castillo, Chichen Itza             0.998175
414        El Castillo, Chichen Itza             0.999843
415        El Castillo, Chichen Itza             0.906479
416        El Castillo, Chichen Itza             0.999899

[417 rows x 5 columns]
```

[121]:
```
pred
```

[121]:
```
                               image  category  category_confidence  \
0             St.VitusCathedral0.jpeg    Gothic             0.999863
1             St.VitusCathedral1.jpeg    Gothic             0.999982
2             St.VitusCathedral4.jpeg    Gothic             0.999829
3             St.VitusCathedral5.jpeg    Gothic             0.999995
4             St.VitusCathedral8.jpeg    Gothic             0.999873
..                                 …       …                  …
412  El Castillo, Chichen Itza-14.jpg  Pyramids             0.645178
413  El Castillo, Chichen Itza-15.jpg  Pyramids             0.995754
414  El Castillo, Chichen Itza-16.jpg  Pyramids             0.997008
415  El Castillo, Chichen Itza-18.jpg  Pyramids             0.999468
416  El Castillo, Chichen Itza-20.jpg  Pyramids             0.999827

                          landmark  landmark_confidence
0                St.VitusCathedral             0.953727
1                St.VitusCathedral             0.999773
2                St.VitusCathedral             0.996476
3                St.VitusCathedral             0.997651
4                St.VitusCathedral             0.985468
..                               …                  …
412  Santa Cecilia Acatitlan Pyramid             0.815378
413        El Castillo, Chichen Itza             0.998175
414        El Castillo, Chichen Itza             0.999843
415        El Castillo, Chichen Itza             0.906479
416        El Castillo, Chichen Itza             0.999899

[417 rows x 5 columns]
```

[122]:
```
from sklearn.metrics import f1_score

# assuming y_true and y_pred are the true and predicted labels, respectively
f1_cate = f1_score(cateList, pred["category"], average='weighted')
f1_mark = f1_score(marksList, pred["landmark"], average='weighted')
print('F1 score:', f1_cate)
print('F1 score:', f1_mark)
```

```
F1 score: 1.0
F1 score: 0.9866501675812848
```

[115]:

[116]:
```
# Run the function of model prediction
###
### AUTOGRADER TEST - DO NOT REMOVE
###
```

[117]:
```
###
### AUTOGRADER TEST - DO NOT REMOVE
###
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[118]:
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###
### AUTOGRADER TEST - DO NOT REMOVE
###
```