model_quantization_xillinx

March 26, 2021

1 Model quantization

To perform model quantization, we use the Xillinx DNNDK tool (https://www.xilinx.com/support/documentation/sw_manuals/ai_inference/v1_6/ug1327-dnndk-user-guide.pdf).

[1]:

```
import os
import sys
sys.path.append(os.path.dirname(os.getcwd()))
```

[4]:

```
import os
import subprocess

import tensorflow as tf

from scripts.quantization import evaluate_graph, freeze_model
from scripts import prepare_data, artifacts_reporter, train_model,␣
 ↪evaluate_model
from ml_intuition.data.utils import plot_training_curve, show_statistics
```

[5]:

```
DEST_PATH = 'xillinx_model_compilation_results'
DATA_FILE_PATH = os.path.join(os.path.dirname(os.getcwd()), 'datasets/pavia/
 ↪pavia.npy')
GT_FILE_PAT = os.path.join(os.path.dirname(os.getcwd()), 'datasets/pavia/
 ↪pavia_gt.npy')
experiment_dest_path = os.path.join(DEST_PATH, 'experiment_0')
data_path = os.path.join(experiment_dest_path, 'data.h5')
os.makedirs(experiment_dest_path, exist_ok=True)
```

2 Prepare the data

To fit into the the pipeline, the data has to be preprocessed. It is achieved by the `prepare_data.main` function. It accepts a path to a `.npy` file with the original cube as well as the corresponding ground truth. In this example, we randomly extract 250 samples from each class (balanced scenario), use 10% of them as validation set, and extract only spectral information of a pixel. The returned object is a dictionary with three keys: train, test and val. Each of them contains an additional dictionary with data and labels keys, holding corresponding numpy.ndarray objects with the data. For more details about the parameters, refer to the documentation of prepare_data.main function (located in scripts/prepare_data).

[6]:

```
prepare_data.main(data_file_path=DATA_FILE_PATH,
                            ground_truth_path=GT_FILE_PAT,
                            output_path=data_path,
                            train_size=250,
                            val_size=0.1,
                            stratified=True,
                            background_label=0,
                            channels_idx=2,
                            neighborhood_size=None,
                            save_data=True,
                            seed=0)
```

3 Train the model

The function trian_model.train executed the trainig procedure. Trained model will be stored under experiment_dest_path folder path.

[7]:

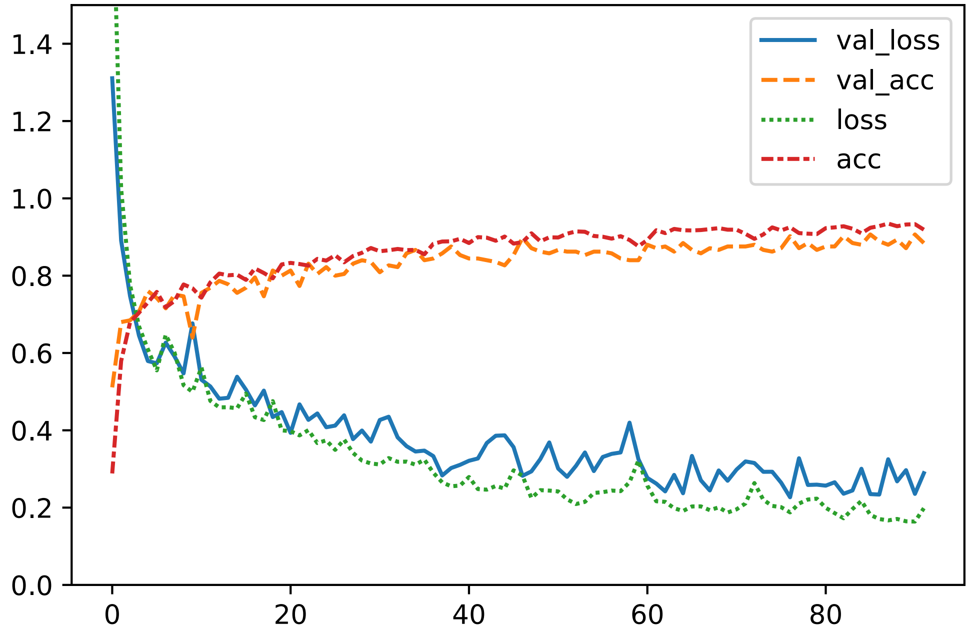
```
train_model.train(model_name='model_2d',
                    kernel_size=5,
                    n_kernels=200,
                    n_layers=1,
                    dest_path=experiment_dest_path,
                    data=data_path,
                    sample_size=103,
                    n_classes=9,
                    lr=0.001,
                    batch_size=128,
                    epochs=200,
                    verbose=0,
                    shuffle=True,
                    patience=15,
                    noise=[],
                    noise_sets=[])
```

```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 99, 1, 200)        1200
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 32, 1, 200)        200200
_________________________________________________________________
```

```
conv2d_2 (Conv2D)            (None, 14, 1, 200)        200200
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 5, 1, 200)         200200
_________________________________________________________________
flatten (Flatten)            (None, 1000)              0
_________________________________________________________________
dense (Dense)                (None, 200)               200200
_________________________________________________________________
dense_1 (Dense)              (None, 128)               25728
_________________________________________________________________
dense_2 (Dense)              (None, 9)                 1161
=================================================================
Total params: 828,889
Trainable params: 828,889
Non-trainable params: 0
_________________________________________________________________
```

[8]:

```
plot_training_curve(os.path.join(experiment_dest_path, "training_metrics.csv"),␣
 ↪['val_loss', 'val_acc', 'loss', 'acc'])
```



4 Evaluate full precision model

Evaluate performance of the model in full precision to later compare to the quantized one.

[ ]:

```
evaluate_model.evaluate(
    model_path=os.path.join(experiment_dest_path, 'model_2d'),
    data=data_path,
    dest_path=experiment_dest_path,
    n_classes=9,
    batch_size=1024,
    noise=[],
    noise_sets=[])
tf.keras.backend.clear_session()
```

[10]:

```
show_statistics(os.path.join(experiment_dest_path, "inference_metrics.csv"))
```

[10]:

```
   accuracy_score  balanced_accuracy_score  cohen_kappa_score   Class_0  \
0        0.842077                 0.903612           0.795369  0.843755

    Class_1   Class_2   Class_3  Class_4   Class_5   Class_6   Class_7  \
0  0.783575  0.831801  0.964463  0.99726  0.903327  0.953704  0.856061

    Class_8  inference_time
0  0.998565        7.275701
```

5 Freeze model

Freeze the tensorflow model into the `.pb` format.

[11]:

```
freeze_model.main(model_path=os.path.join(experiment_dest_path, 'model_2d'),
                  output_dir=experiment_dest_path)
```

```
INFO:tensorflow:Froze 61 variables.
INFO:tensorflow:Converted 61 variables to const ops.
Frozen model saved at xillinx_model_compilation_results/experiment_0
```

6 Quantize the model

Perform the quantization by running the `quantize.sh` bash script with appropriate parameters. It executes the `decent_q` command from the Xillinx DNNDK library. The output is the `quantize_eval_model.pb` file and a `deploy_model.pb` file, which should be used for compilation for a specific DPU.

[12]:

```
node_names_file = os.path.join(experiment_dest_path,␣
 ↪'freeze_input_output_node_name.json')
frozen_graph_path = os.path.join(experiment_dest_path, 'frozen_graph.pb')
cmd = '../scripts/quantize.sh ' + node_names_file + ' ' \
        + frozen_graph_path + ' ' + data_path + ' ' + \
        '?,103,1,1' + ' ' + \
        'ml_intuition.data.input_fn.calibrate_2d_input' + ' ' + \
        '128' + ' ' + experiment_dest_path + \
        ' ' + str(0)
f = open(os.path.join(experiment_dest_path, 'call_output.txt'),'w')
env = os.environ.copy()
env['PYTHONPATH'] = os.path.dirname(os.getcwd())
subprocess.call(cmd, shell=True, env=env, stderr=f)
f.close()
```

7 Evaluate the quantized model (graph)

Evaluate the performance of the quantized model to check whether there was any loss in performance. Results for the graph are stored in `inference_graph_metrics.csv`.

```
[ ]: graph_path = os.path.join(experiment_dest_path, 'quantize_eval_model.pb')
     evaluate_graph.main(graph_path=graph_path,
                         node_names_path=node_names_file,
                         dataset_path=data_path,
                         batch_size=1024)
     tf.keras.backend.clear_session()
```

```
[14]: show_statistics(os.path.join(experiment_dest_path, "inference_graph_metrics.
      ↪csv"))
```

```
[14]:    accuracy_score  balanced_accuracy_score  cohen_kappa_score   Class_0  \
      0        0.874402                 0.888489           0.832185  0.908322

         Class_1   Class_2   Class_3   Class_4   Class_5   Class_6   Class_7  \
      0  0.89119  0.868037  0.933547  0.998174  0.799121  0.887037  0.712413

          Class_8  inference_time
      0  0.998565       21.373184
```

```
[ ]:
```