TrainingDNNs2_pytorch_answer

December 20, 2021

1 Training Deep Neural Networks (Tiếp)

Trong buổi này, chúng ta tiếp tục làm quen với một số kỹ thuật huấn luyện mạng nơ-ron

[ ]:
```
!nvidia-smi
# from google.colab import drive
# drive.mount('/content/drive')

import torch
import torch.nn as nn
import torch.optim as optim
import numpy as np
import glob
import cv2
import torch.nn.functional as F
from torch.autograd import Variable

import torchvision
import torchvision.transforms as transforms

from torch.nn import CrossEntropyLoss, Dropout, Softmax, Linear, Conv2d,␣
↪LayerNorm
import matplotlib.pyplot as plt
from torchsummary import summary
```

```
Fri Sep 10 08:45:59 2021
+-----------------------------------------------------------------------------+
| NVIDIA-SMI 470.63.01    Driver Version: 460.32.03    CUDA Version: 11.2     |
|-------------------------------+----------------------+----------------------+
| GPU  Name        Persistence-M| Bus-Id        Disp.A | Volatile Uncorr. ECC |
| Fan  Temp  Perf  Pwr:Usage/Cap|         Memory-Usage | GPU-Util  Compute M. |
|                               |                      |               MIG M. |
|===============================+======================+======================|
|   0  Tesla K80           Off  | 00000000:00:04.0 Off |                    0 |
| N/A   69C    P8    33W / 149W |      0MiB / 11441MiB |      0%      Default |
|                               |                      |                  N/A |
+-------------------------------+----------------------+----------------------+
```

```
+-----------------------------------------------------------------------------+
| Processes:                                                                  |
|  GPU   GI   CI        PID   Type   Process name                  GPU Memory |
|        ID   ID                                                   Usage      |
|=============================================================================|
|  No running processes found                                                 |
+-----------------------------------------------------------------------------+
```

1.0.1 1. Cài đặt BatchNorm

[ ]:
```python
def compare_bn(bn1, bn2):
    err = False
    if not torch.allclose(bn1.running_mean, bn2.running_mean):
        print('Diff in running_mean: {} vs {}'.format(
            bn1.running_mean, bn2.running_mean))
        err = True

    if not torch.allclose(bn1.running_var, bn2.running_var):
        print('Diff in running_var: {} vs {}'.format(
            bn1.running_var, bn2.running_var))
        err = True

    if bn1.affine and bn2.affine:
        if not torch.allclose(bn1.weight, bn2.weight):
            print('Diff in weight: {} vs {}'.format(
                bn1.weight, bn2.weight))
            err = True

        if not torch.allclose(bn1.bias, bn2.bias):
            print('Diff in bias: {} vs {}'.format(
                bn1.bias, bn2.bias))
            err = True

    if not err:
        print('All parameters are equal!')


class MyBatchNorm2d(nn.BatchNorm2d):
    def __init__(self, num_features, eps=1e-5, momentum=0.1,
                 affine=True, track_running_stats=True):
        super(MyBatchNorm2d, self).__init__(
            num_features, eps, momentum, affine, track_running_stats)

    def forward(self, input):
        self._check_input_dim(input)

        exponential_average_factor = 0.0
```

```
        if self.training and self.track_running_stats:
            if self.num_batches_tracked is not None:
                self.num_batches_tracked += 1
                if self.momentum is None:  # use cumulative moving average
                    exponential_average_factor = 1.0 / float(self.
↪num_batches_tracked)
                else:  # use exponential moving average
                    exponential_average_factor = self.momentum

        # calculate running estimates
        if self.training:
            mean = input.mean([0, 2, 3])
            # use biased var in train
            var = input.var([0, 2, 3], unbiased=False)
            n = input.numel() / input.size(1)
            with torch.no_grad():
                self.running_mean = exponential_average_factor * mean\
                    + (1 - exponential_average_factor) * self.running_mean
                # update running_var with unbiased var
                self.running_var = exponential_average_factor * var * n / (n -␣
↪1)\
                    + (1 - exponential_average_factor) * self.running_var
        else:
            mean = self.running_mean
            var = self.running_var

        input = (input - mean[None, :, None, None]) / (torch.sqrt(var[None, :,␣
↪None, None] + self.eps))
        if self.affine:
            input = input * self.weight[None, :, None, None] + self.bias[None, :
↪, None, None]

        return input


# Init BatchNorm layers
my_bn = MyBatchNorm2d(3, affine=True)
bn = nn.BatchNorm2d(3, affine=True)

compare_bn(my_bn, bn)  # weight and bias should be different
# Load weight and bias
my_bn.load_state_dict(bn.state_dict())
compare_bn(my_bn, bn)

# Run train
for _ in range(10):
```

```python
    scale = torch.randint(1, 10, (1,)).float()
    bias = torch.randint(-10, 10, (1,)).float()
    x = torch.randn(10, 3, 100, 100) * scale + bias
    out1 = my_bn(x)
    out2 = bn(x)
    compare_bn(my_bn, bn)

    torch.allclose(out1, out2)
    print('Max diff: ', (out1 - out2).abs().max())

# Run eval
my_bn.eval()
bn.eval()
for _ in range(10):
    scale = torch.randint(1, 10, (1,)).float()
    bias = torch.randint(-10, 10, (1,)).float()
    x = torch.randn(10, 3, 100, 100) * scale + bias
    out1 = my_bn(x)
    out2 = bn(x)
    compare_bn(my_bn, bn)

    torch.allclose(out1, out2)
```

```
All parameters are equal!
All parameters are equal!
All parameters are equal!
Max diff:  tensor(4.7684e-07, grad_fn=<MaxBackward1>)
All parameters are equal!
Max diff:  tensor(4.7684e-07, grad_fn=<MaxBackward1>)
All parameters are equal!
Max diff:  tensor(4.7684e-07, grad_fn=<MaxBackward1>)
All parameters are equal!
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Max diff:  tensor(4.7684e-07, grad_fn=<MaxBackward1>)
All parameters are equal!
Max diff:  tensor(4.7684e-07, grad_fn=<MaxBackward1>)
All parameters are equal!
All parameters are equal!
All parameters are equal!
```

```
All parameters are equal!
All parameters are equal!
All parameters are equal!
All parameters are equal!
All parameters are equal!
All parameters are equal!
All parameters are equal!
```

1.0.2 2. Cài đặt chiến lược thay đổi tốc độ học: Warm-up + Cosine Annealing LR

[ ]:
```python
def load_data(data_dir="./data"):
    transform = transforms.Compose([
        transforms.ToTensor(),
        transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5)),
    ])

    trainset = torchvision.datasets.CIFAR10(
        root=data_dir, train=True, download=True, transform=transform)

    testset = torchvision.datasets.CIFAR10(
        root=data_dir, train=False, download=True, transform=transform)

    return trainset, testset

class Net(nn.Module):
    def __init__(self, l1=120, l2=84):
        super(Net, self).__init__()
        self.conv1 = nn.Conv2d(3, 6, 5)
        self.pool = nn.MaxPool2d(2, 2)
        self.conv2 = nn.Conv2d(6, 16, 5)
        self.fc1 = nn.Linear(16 * 5 * 5, l1)
        self.fc2 = nn.Linear(l1, l2)
        self.fc3 = nn.Linear(l2, 10)
        self.softmax = nn.Softmax()

    def forward(self, x):
        x = self.pool(F.relu(self.conv1(x)))
        x = self.pool(F.relu(self.conv2(x)))
        x = x.view(-1, 16 * 5 * 5)
        x = F.relu(self.fc1(x))
        x = F.relu(self.fc2(x))
        x = self.fc3(x)
        x = self.softmax(x)

        return x
```

[ ]:
```
trainset, testset = load_data('./data')
trainloader = torch.utils.data.DataLoader(
    trainset,
    batch_size=128,
    shuffle=True,
)

epochs = 50
warm_epoch = 5
init_lr = 1e-1
last_lr = 1e-5
T_max = epochs
T_cur = 0
lr_list = [0]

net = Net()
device = "cpu"
if torch.cuda.is_available():
    device = "cuda:0"
    if torch.cuda.device_count() > 1:
        net = nn.DataParallel(net)
net.to(device)

criterion = nn.CrossEntropyLoss()
optimizer = optim.SGD(net.parameters(), lr=init_lr, momentum=0.9)
```

```
Downloading https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz to
./data/cifar-10-python.tar.gz
```

```
  0%|          | 0/170498071 [00:00<?, ?it/s]
```

```
Extracting ./data/cifar-10-python.tar.gz to ./data
Files already downloaded and verified
```

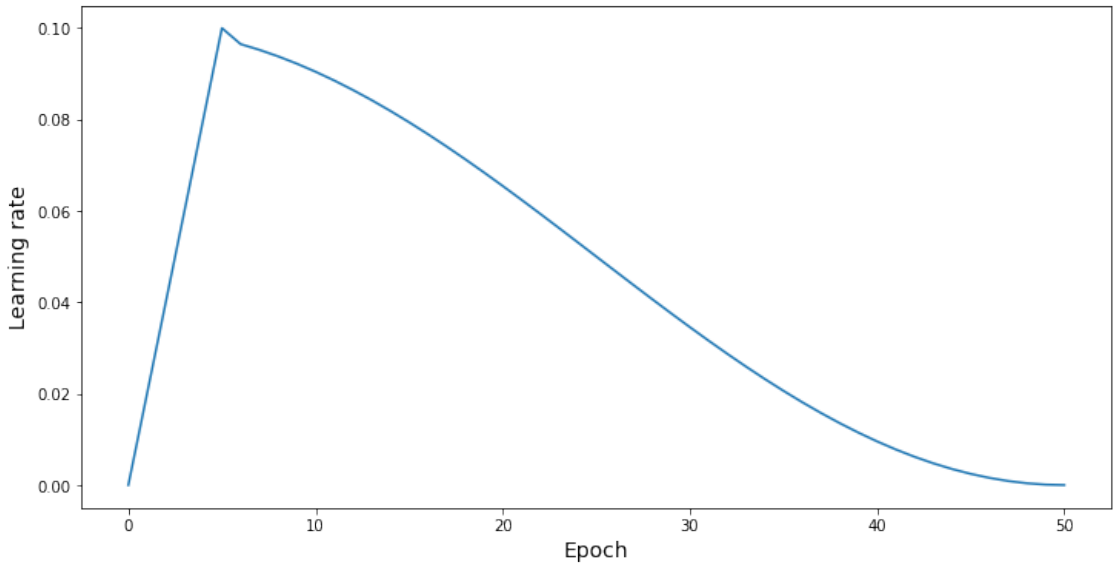
[ ]:
```
for epoch in range(1, epochs+1):  # loop over the dataset multiple times
    running_loss = 0.0
    epoch_steps = 0
    T_cur += 1

    # warm-up
    if epoch <= warm_epoch:
        optimizer.param_groups[0]['lr'] = (1.0 * epoch) / warm_epoch  * init_lr
    else:
        # cosine annealing lr
        optimizer.param_groups[0]['lr'] = last_lr + (init_lr - last_lr) * (1 +␣
 ↪np.cos(T_cur * np.pi / T_max)) / 2

    for i, data in enumerate(trainloader, 0):
```

```
        # get the inputs; data is a list of [inputs, labels]
        inputs, labels = data
        inputs, labels = inputs.to(device), labels.to(device)

        # zero the parameter gradients
        optimizer.zero_grad()

        # forward + backward + optimize
        outputs = net(inputs)
        loss = criterion(outputs, labels)
        loss.backward()
        optimizer.step()

        # print statistics
        running_loss += loss.item()
        epoch_steps += 1
        if i + 1 == len(trainloader):
            print("[Epoch %d] loss: %.3f" % (epoch, running_loss / epoch_steps))
            running_loss = 0.0

    lr_list.append(optimizer.param_groups[0]['lr'])

print("Finished Training")
```

```
/usr/local/lib/python3.7/dist-packages/torch/nn/functional.py:718: UserWarning:
Named tensors and all their associated APIs are an experimental feature and
subject to change. Please do not use them for anything important until they are
released as stable. (Triggered internally at
/pytorch/c10/core/TensorImpl.h:1156.)
  return torch.max_pool2d(input, kernel_size, stride, padding, dilation,
ceil_mode)
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:33: UserWarning:
Implicit dimension choice for softmax has been deprecated. Change the call to
include dim=X as an argument.

[Epoch 1] loss: 2.302
[Epoch 2] loss: 2.199
[Epoch 3] loss: 2.104
[Epoch 4] loss: 2.066
[Epoch 5] loss: 2.245
[Epoch 6] loss: 2.357
[Epoch 7] loss: 2.360
[Epoch 8] loss: 2.350
[Epoch 9] loss: 2.343
[Epoch 10] loss: 2.361
[Epoch 11] loss: 2.361
[Epoch 12] loss: 2.361
[Epoch 13] loss: 2.361
```

```
[Epoch 14] loss: 2.361
[Epoch 15] loss: 2.361
[Epoch 16] loss: 2.361
[Epoch 17] loss: 2.361
[Epoch 18] loss: 2.361
[Epoch 19] loss: 2.361
[Epoch 20] loss: 2.361
[Epoch 21] loss: 2.361
[Epoch 22] loss: 2.361
[Epoch 23] loss: 2.361
[Epoch 24] loss: 2.361
[Epoch 25] loss: 2.361
[Epoch 26] loss: 2.361
[Epoch 27] loss: 2.361
[Epoch 28] loss: 2.361
[Epoch 29] loss: 2.361
[Epoch 30] loss: 2.361
[Epoch 31] loss: 2.361
[Epoch 32] loss: 2.361
[Epoch 33] loss: 2.361
[Epoch 34] loss: 2.361
[Epoch 35] loss: 2.361
[Epoch 36] loss: 2.361
[Epoch 37] loss: 2.361
[Epoch 38] loss: 2.361
[Epoch 39] loss: 2.361
[Epoch 40] loss: 2.361
[Epoch 41] loss: 2.361
[Epoch 42] loss: 2.361
[Epoch 43] loss: 2.361
[Epoch 44] loss: 2.361
[Epoch 45] loss: 2.361
[Epoch 46] loss: 2.361
[Epoch 47] loss: 2.361
[Epoch 48] loss: 2.361
[Epoch 49] loss: 2.361
[Epoch 50] loss: 2.361
Finished Training
```

[ ]:
```python
plt.figure(figsize=(12, 6))
plt.plot(list(range(len(lr_list))), lr_list, label="lr")
plt.xlabel("Epoch", fontsize=14)
plt.ylabel("Learning rate", fontsize=14)
plt.show()
```



1.0.3 3. Tuning siêu tham số

Cài đặt thư viện ray

[ ]:
```
!pip install ray
```

```
Collecting ray
  Downloading ray-1.6.0-cp37-cp37m-manylinux2014_x86_64.whl (49.6 MB)
     |                 | 49.6 MB 6.2 kB/s
Requirement already satisfied: protobuf>=3.15.3 in
/usr/local/lib/python3.7/dist-packages (from ray) (3.17.3)
Requirement already satisfied: numpy>=1.16 in /usr/local/lib/python3.7/dist-
packages (from ray) (1.19.5)
Requirement already satisfied: filelock in /usr/local/lib/python3.7/dist-
packages (from ray) (3.0.12)
Requirement already satisfied: pyyaml in /usr/local/lib/python3.7/dist-packages
(from ray) (3.13)
Requirement already satisfied: msgpack<2.0.0,>=1.0.0 in
/usr/local/lib/python3.7/dist-packages (from ray) (1.0.2)
Requirement already satisfied: grpcio>=1.28.1 in /usr/local/lib/python3.7/dist-
packages (from ray) (1.39.0)
Requirement already satisfied: click>=7.0 in /usr/local/lib/python3.7/dist-
packages (from ray) (7.1.2)
Collecting redis>=3.5.0
  Downloading redis-3.5.3-py2.py3-none-any.whl (72 kB)
     |                 | 72 kB 565 kB/s
Requirement already satisfied: attrs in /usr/local/lib/python3.7/dist-
packages (from ray) (21.2.0)
Requirement already satisfied: six>=1.5.2 in /usr/local/lib/python3.7/dist-
```

```
packages (from grpcio>=1.28.1->ray) (1.15.0)
Installing collected packages: redis, ray
Successfully installed ray-1.6.0 redis-3.5.3
```

[ ]:
```python
import os
from ray.tune import CLIReporter
from ray import tune
from torch.utils.data import random_split
from functools import partial
```

Viết hàm huấn luyện mô hình nơ-ron trên tập CIFAR10

[ ]:
```python
def train_cifar(config, checkpoint_dir=None, data_dir=None):
    net = Net(config["l1"], config["l2"])

    device = "cpu"
    if torch.cuda.is_available():
        device = "cuda:0"
        if torch.cuda.device_count() > 1:
            net = nn.DataParallel(net)
    net.to(device)

    criterion = nn.CrossEntropyLoss()
    optimizer = optim.SGD(net.parameters(), lr=config["lr"], momentum=0.9)

    if checkpoint_dir:
        model_state, optimizer_state = torch.load(
            os.path.join(checkpoint_dir, "checkpoint"))
        net.load_state_dict(model_state)
        optimizer.load_state_dict(optimizer_state)

    trainset, testset = load_data(data_dir)

    test_abs = int(len(trainset) * 0.8)
    train_subset, val_subset = random_split(
        trainset, [test_abs, len(trainset) - test_abs])

    trainloader = torch.utils.data.DataLoader(
        train_subset,
        batch_size=int(config["batch_size"]),
        shuffle=True,
        num_workers=8)
    valloader = torch.utils.data.DataLoader(
        val_subset,
        batch_size=int(config["batch_size"]),
        shuffle=True,
        num_workers=8)
```

```
    for epoch in range(5):  # loop over the dataset multiple times
        running_loss = 0.0
        epoch_steps = 0
        for i, data in enumerate(trainloader, 0):
            # get the inputs; data is a list of [inputs, labels]
            inputs, labels = data
            inputs, labels = inputs.to(device), labels.to(device)

            # zero the parameter gradients
            optimizer.zero_grad()

            # forward + backward + optimize
            outputs = net(inputs)
            loss = criterion(outputs, labels)
            loss.backward()
            optimizer.step()

            # print statistics
            running_loss += loss.item()
            epoch_steps += 1
            if i % 2000 == 1999:  # print every 2000 mini-batches
                print("[%d, %5d] loss: %.3f" % (epoch + 1, i + 1,
                                                running_loss / epoch_steps))
                running_loss = 0.0

        # Validation loss
        val_loss = 0.0
        val_steps = 0
        total = 0
        correct = 0
        for i, data in enumerate(valloader, 0):
            with torch.no_grad():
                inputs, labels = data
                inputs, labels = inputs.to(device), labels.to(device)

                outputs = net(inputs)
                _, predicted = torch.max(outputs.data, 1)
                total += labels.size(0)
                correct += (predicted == labels).sum().item()

                loss = criterion(outputs, labels)
                val_loss += loss.cpu().numpy()
                val_steps += 1

        with tune.checkpoint_dir(epoch) as checkpoint_dir:
            path = os.path.join(checkpoint_dir, "checkpoint")
            torch.save((net.state_dict(), optimizer.state_dict()), path)
```

```
            print("*"*10, path, "*"*10)

        tune.report(loss=(val_loss / val_steps), accuracy=correct / total)
    print("Finished Training")
```

Lựa chọn siêu tham số tốt (hyperparameter tuning)

[ ]:
```
def main(num_samples=10, gpus_per_trial=2):
    data_dir = os.path.abspath("./data")
    config = {
        "l1": tune.grid_search([32, 64]),
        "l2": tune.grid_search([16, 32]),
        "lr": tune.grid_search([1e-4, 1e-2]),
        "batch_size": tune.grid_search([16])
    }
    reporter = CLIReporter(
        metric_columns=["loss", "accuracy", "training_iteration"])
    result = tune.run(
        partial(train_cifar, data_dir=data_dir),
        resources_per_trial={"cpu": 2, "gpu": gpus_per_trial},
        config=config,
        num_samples=num_samples,
        progress_reporter=reporter)

main(num_samples=10, gpus_per_trial=1)
```

```
/usr/local/lib/python3.7/dist-packages/ray/_private/services.py:238:
UserWarning: Not all Ray Dashboard dependencies were found. To use the dashboard
please install Ray using `pip install ray[default]`. To disable this message,
set RAY_DISABLE_IMPORT_WARNING env var to '1'.
  warnings.warn(warning_message)
2021-09-10 08:58:41,056 WARNING experiment.py:296 -- No name detected on
trainable. Using DEFAULT.
2021-09-10 08:58:41,058 INFO registry.py:67 -- Detected unknown callable for
trainable. Converting to class.
2021-09-10 08:58:41,115 INFO logger.py:597 -- pip install 'ray[tune]' to see
TensorBoard files.
2021-09-10 08:58:41,117 WARNING callback.py:117 -- The TensorboardX logger
cannot be instantiated because either TensorboardX or one of it's dependencies
is not installed. Please make sure you have the latest version of TensorboardX
installed: `pip install -U tensorboardx`

== Status ==
Memory usage on this node: 2.1/12.7 GiB
Using FIFO scheduling algorithm.
Resources requested: 2.0/2 CPUs, 1.0/1 GPUs, 0.0/7.32 GiB heap, 0.0/3.66 GiB
objects (0.0/1.0 accelerator_type:K80)
Result logdir: /root/ray_results/DEFAULT_2021-09-10_08-58-41
Number of trials: 16/80 (15 PENDING, 1 RUNNING)
```

```
+---------------------+----------+-------+--------------+------+------+--------+
| Trial name          | status   | loc   |   batch_size |   l1 |   l2 |     lr |
|---------------------+----------+-------+--------------+------+------+--------|
| DEFAULT_4b73f_00000 | RUNNING  |       |           16 |   32 |   16 | 0.0001 |
| DEFAULT_4b73f_00001 | PENDING  |       |           16 |   64 |   16 | 0.0001 |
| DEFAULT_4b73f_00002 | PENDING  |       |           16 |   32 |   32 | 0.0001 |
| DEFAULT_4b73f_00003 | PENDING  |       |           16 |   64 |   32 | 0.0001 |
| DEFAULT_4b73f_00004 | PENDING  |       |           16 |   32 |   16 | 0.01   |
| DEFAULT_4b73f_00005 | PENDING  |       |           16 |   64 |   16 | 0.01   |
| DEFAULT_4b73f_00006 | PENDING  |       |           16 |   32 |   32 | 0.01   |
| DEFAULT_4b73f_00007 | PENDING  |       |           16 |   64 |   32 | 0.01   |
| DEFAULT_4b73f_00008 | PENDING  |       |           16 |   32 |   16 | 0.0001 |
| DEFAULT_4b73f_00009 | PENDING  |       |           16 |   64 |   16 | 0.0001 |
| DEFAULT_4b73f_00010 | PENDING  |       |           16 |   32 |   32 | 0.0001 |
| DEFAULT_4b73f_00011 | PENDING  |       |           16 |   64 |   32 | 0.0001 |
| DEFAULT_4b73f_00012 | PENDING  |       |           16 |   32 |   16 | 0.01   |
| DEFAULT_4b73f_00013 | PENDING  |       |           16 |   64 |   16 | 0.01   |
| DEFAULT_4b73f_00014 | PENDING  |       |           16 |   32 |   32 | 0.01   |
| DEFAULT_4b73f_00015 | PENDING  |       |           16 |   64 |   32 | 0.01   |
+---------------------+----------+-------+--------------+------+------+--------+


(pid=351) Files already downloaded and verified
(pid=351) Files already downloaded and verified
== Status ==
Memory usage on this node: 3.1/12.7 GiB
Using FIFO scheduling algorithm.
Resources requested: 2.0/2 CPUs, 1.0/1 GPUs, 0.0/7.32 GiB heap, 0.0/3.66 GiB
objects (0.0/1.0 accelerator_type:K80)
Result logdir: /root/ray_results/DEFAULT_2021-09-10_08-58-41
Number of trials: 17/80 (16 PENDING, 1 RUNNING)
+---------------------+----------+-------+--------------+------+------+--------+
| Trial name          | status   | loc   |   batch_size |   l1 |   l2 |     lr |
|---------------------+----------+-------+--------------+------+------+--------|
| DEFAULT_4b73f_00000 | RUNNING  |       |           16 |   32 |   16 | 0.0001 |
| DEFAULT_4b73f_00001 | PENDING  |       |           16 |   64 |   16 | 0.0001 |
| DEFAULT_4b73f_00002 | PENDING  |       |           16 |   32 |   32 | 0.0001 |
| DEFAULT_4b73f_00003 | PENDING  |       |           16 |   64 |   32 | 0.0001 |
| DEFAULT_4b73f_00004 | PENDING  |       |           16 |   32 |   16 | 0.01   |
| DEFAULT_4b73f_00005 | PENDING  |       |           16 |   64 |   16 | 0.01   |
| DEFAULT_4b73f_00006 | PENDING  |       |           16 |   32 |   32 | 0.01   |
| DEFAULT_4b73f_00007 | PENDING  |       |           16 |   64 |   32 | 0.01   |
| DEFAULT_4b73f_00008 | PENDING  |       |           16 |   32 |   16 | 0.0001 |
| DEFAULT_4b73f_00009 | PENDING  |       |           16 |   64 |   16 | 0.0001 |
| DEFAULT_4b73f_00010 | PENDING  |       |           16 |   32 |   32 | 0.0001 |
| DEFAULT_4b73f_00011 | PENDING  |       |           16 |   64 |   32 | 0.0001 |
| DEFAULT_4b73f_00012 | PENDING  |       |           16 |   32 |   16 | 0.01   |
| DEFAULT_4b73f_00013 | PENDING  |       |           16 |   64 |   16 | 0.01   |
```

```
| DEFAULT_4b73f_00014 | PENDING  |       |           16 |   32 |   32 | 0.01   |
| DEFAULT_4b73f_00015 | PENDING  |       |           16 |   64 |   32 | 0.01   |
| DEFAULT_4b73f_00016 | PENDING  |       |           16 |   32 |   16 | 0.0001 |
+---------------------+----------+-------+--------------+------+------+--------+


(pid=351) /usr/local/lib/python3.7/dist-
packages/torch/utils/data/dataloader.py:481: UserWarning: This DataLoader will
create 8 worker processes in total. Our suggested max number of worker in
current system is 2, which is smaller than what this DataLoader is going to
create. Please be aware that excessive worker creation might get DataLoader
running slow or even freeze, lower the worker number to avoid potential
slowness/freeze if necessary.
(pid=351)   cpuset_checked))
(pid=351) /usr/local/lib/python3.7/dist-
packages/torch/nn/functional.py:718: UserWarning: Named tensors and all their
associated APIs are an experimental feature and subject to change. Please do not
use them for anything important until they are released as stable. (Triggered
internally at  /pytorch/c10/core/TensorImpl.h:1156.)
(pid=351)   return torch.max_pool2d(input, kernel_size, stride,
padding, dilation, ceil_mode)
(pid=351) /usr/local/lib/python3.7/dist-
packages/ray/workers/default_worker.py:33: UserWarning: Implicit dimension
choice for softmax has been deprecated. Change the call to include dim=X as an
argument.
(pid=351)   type=str,
(pid=351) [1,  2000] loss: 2.303
Result for DEFAULT_4b73f_00000:
  accuracy: 0.0999
  date: 2021-09-10_08-59-13
  done: false
  experiment_id: a590202bec2f4c1ea826538c56035a9f
  hostname: f7aececd2bb3
  iterations_since_restore: 1
  loss: 2.3026386421203613
  node_ip: 172.28.0.2
  pid: 351
  should_checkpoint: true
  time_since_restore: 30.793678045272827
  time_this_iter_s: 30.793678045272827
  time_total_s: 30.793678045272827
  timestamp: 1631264353
  timesteps_since_restore: 0
  training_iteration: 1
  trial_id: 4b73f_00000

== Status ==
```

```
Memory usage on this node: 3.1/12.7 GiB
Using FIFO scheduling algorithm.
Resources requested: 2.0/2 CPUs, 1.0/1 GPUs, 0.0/7.32 GiB heap, 0.0/3.66 GiB
objects (0.0/1.0 accelerator_type:K80)
Result logdir: /root/ray_results/DEFAULT_2021-09-10_08-58-41
Number of trials: 17/80 (16 PENDING, 1 RUNNING)
+--------------------+----------+----------------+--------------+------+------+
--------+---------+------------+----------------------+
| Trial name         | status   | loc            |   batch_size |   l1 |   l2 |
lr |    loss |   accuracy |   training_iteration |
|--------------------+----------+----------------+--------------+------+------+
--------+---------+------------+----------------------|
| DEFAULT_4b73f_00000 | RUNNING  | 172.28.0.2:351 |           16 |   32 |   16 |
0.0001 | 2.30264 |     0.0999 |                    1 |
| DEFAULT_4b73f_00001 | PENDING  |                |           16 |   64 |   16 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00002 | PENDING  |                |           16 |   32 |   32 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00003 | PENDING  |                |           16 |   64 |   32 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00004 | PENDING  |                |           16 |   32 |   16 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00005 | PENDING  |                |           16 |   64 |   16 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00006 | PENDING  |                |           16 |   32 |   32 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00007 | PENDING  |                |           16 |   64 |   32 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00008 | PENDING  |                |           16 |   32 |   16 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00009 | PENDING  |                |           16 |   64 |   16 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00010 | PENDING  |                |           16 |   32 |   32 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00011 | PENDING  |                |           16 |   64 |   32 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00012 | PENDING  |                |           16 |   32 |   16 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00013 | PENDING  |                |           16 |   64 |   16 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00014 | PENDING  |                |           16 |   32 |   32 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00015 | PENDING  |                |           16 |   64 |   32 |
0.01   |         |            |                      |
| DEFAULT_4b73f_00016 | PENDING  |                |           16 |   32 |   16 |
0.0001 |         |            |                      |
+--------------------+----------+----------------+--------------+------+------+
--------+---------+------------+----------------------+
```

```
(pid=351) ********** /root/ray_results/DEFAULT_2021-09-10_08-58-41/
DEFAULT_4b73f_00000_0_batch_size=16,l1=32,l2=16,lr=0.0001_2021-09-10_08-58-41/ch
eckpoint_000000/checkpoint **********
(pid=351) [2,  2000] loss: 2.303
Result for DEFAULT_4b73f_00000:
  accuracy: 0.0999
  date: 2021-09-10_08-59-39
  done: false
  experiment_id: a590202bec2f4c1ea826538c56035a9f
  hostname: f7aececd2bb3
  iterations_since_restore: 2
  loss: 2.3026155532836916
  node_ip: 172.28.0.2
  pid: 351
  should_checkpoint: true
  time_since_restore: 57.259856939315796
  time_this_iter_s: 26.46617889404297
  time_total_s: 57.259856939315796
  timestamp: 1631264379
  timesteps_since_restore: 0
  training_iteration: 2
  trial_id: 4b73f_00000

== Status ==
Memory usage on this node: 3.1/12.7 GiB
Using FIFO scheduling algorithm.
Resources requested: 2.0/2 CPUs, 1.0/1 GPUs, 0.0/7.32 GiB heap, 0.0/3.66 GiB
objects (0.0/1.0 accelerator_type:K80)
Result logdir: /root/ray_results/DEFAULT_2021-09-10_08-58-41
Number of trials: 17/80 (16 PENDING, 1 RUNNING)
+---------------------+----------+---------------+--------------+------+------+
--------+---------+------------+----------------------+
| Trial name          | status   | loc           |   batch_size |   l1 |   l2 |
lr |    loss |   accuracy |   training_iteration |
|---------------------+----------+---------------+--------------+------+------+
--------+---------+------------+----------------------|
| DEFAULT_4b73f_00000 | RUNNING  | 172.28.0.2:351 |           16 |   32 |   16 |
0.0001 | 2.30262 |     0.0999 |                    2 |
| DEFAULT_4b73f_00001 | PENDING  |               |           16 |   64 |   16 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00002 | PENDING  |               |           16 |   32 |   32 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00003 | PENDING  |               |           16 |   64 |   32 |
0.0001 |         |            |                      |
| DEFAULT_4b73f_00004 | PENDING  |               |           16 |   32 |   16 |
0.01   |         |            |                      |
```

```
| DEFAULT_4b73f_00005 | PENDING  |                |          16 |   64 |   16 |
0.01   |         |            |                     |
| DEFAULT_4b73f_00006 | PENDING  |                |          16 |   32 |   32 |
0.01   |         |            |                     |
| DEFAULT_4b73f_00007 | PENDING  |                |          16 |   64 |   32 |
0.01   |         |            |                     |
| DEFAULT_4b73f_00008 | PENDING  |                |          16 |   32 |   16 |
0.0001 |         |            |                     |
| DEFAULT_4b73f_00009 | PENDING  |                |          16 |   64 |   16 |
0.0001 |         |            |                     |
| DEFAULT_4b73f_00010 | PENDING  |                |          16 |   32 |   32 |
0.0001 |         |            |                     |
| DEFAULT_4b73f_00011 | PENDING  |                |          16 |   64 |   32 |
0.0001 |         |            |                     |
| DEFAULT_4b73f_00012 | PENDING  |                |          16 |   32 |   16 |
0.01   |         |            |                     |
| DEFAULT_4b73f_00013 | PENDING  |                |          16 |   64 |   16 |
0.01   |         |            |                     |
| DEFAULT_4b73f_00014 | PENDING  |                |          16 |   32 |   32 |
0.01   |         |            |                     |
| DEFAULT_4b73f_00015 | PENDING  |                |          16 |   64 |   32 |
0.01   |         |            |                     |
| DEFAULT_4b73f_00016 | PENDING  |                |          16 |   32 |   16 |
0.0001 |         |            |                     |
+---------------------+----------+----------------+-------------+------+------+
--------+---------+------------+----------------------+
```

```
(pid=351) ********** /root/ray_results/DEFAULT_2021-09-10_08-58-41/
DEFAULT_4b73f_00000_0_batch_size=16,l1=32,l2=16,lr=0.0001_2021-09-10_08-58-41/ch
eckpoint_000001/checkpoint **********
```

Cài đặt thử viện skorch

[ ]:
```
!pip install skorch
import numpy as np
from sklearn.datasets import make_classification
from torch import nn

from skorch import NeuralNetClassifier
from sklearn.model_selection import GridSearchCV
```

```
Collecting skorch
  Downloading skorch-0.10.0-py3-none-any.whl (128 kB)
     |                | 128 kB 5.3 MB/s
Requirement already satisfied: numpy>=1.13.3 in
/usr/local/lib/python3.7/dist-packages (from skorch) (1.19.5)
Requirement already satisfied: scipy>=1.1.0 in /usr/local/lib/python3.7/dist-
packages (from skorch) (1.4.1)
```

```
Requirement already satisfied: tqdm>=4.14.0 in /usr/local/lib/python3.7/dist-
packages (from skorch) (4.62.0)
Requirement already satisfied: tabulate>=0.7.7 in /usr/local/lib/python3.7/dist-
packages (from skorch) (0.8.9)
Requirement already satisfied: scikit-learn>=0.19.1 in
/usr/local/lib/python3.7/dist-packages (from skorch) (0.22.2.post1)
Requirement already satisfied: joblib>=0.11 in /usr/local/lib/python3.7/dist-
packages (from scikit-learn>=0.19.1->skorch) (1.0.1)
Installing collected packages: skorch
Successfully installed skorch-0.10.0
```

Sử dụng thư viện skorch để huấn luyện

[ ]:
```
trainset, testset = load_data('./data')
(X, y) = np.asarray(trainset.data[:]), np.asarray(trainset.targets[:])
X = X.reshape((-1, 3, 32, 32))
X = X.astype(np.float32)
y = y.astype(np.int64)

net = NeuralNetClassifier(
    Net,
    max_epochs=5,
    lr=0.01,
    # Shuffle training data on each epoch
    iterator_train__shuffle=True,
)

# training with default config
net.fit(X, y)
y_proba = net.predict_proba(X)
```

```
Files already downloaded and verified
Files already downloaded and verified

/usr/local/lib/python3.7/dist-packages/torch/nn/functional.py:718: UserWarning:
Named tensors and all their associated APIs are an experimental feature and
subject to change. Please do not use them for anything important until they are
released as stable. (Triggered internally at
/pytorch/c10/core/TensorImpl.h:1156.)
  return torch.max_pool2d(input, kernel_size, stride, padding, dilation,
ceil_mode)
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:33: UserWarning:
Implicit dimension choice for softmax has been deprecated. Change the call to
include dim=X as an argument.

  epoch    train_loss    valid_acc    valid_loss      dur
-------  ------------  -----------  ------------  -------
      1        2.1907       0.2514        2.0782
10.1372
      2        2.0612       0.2378        2.0725  9.8438
```

```
      3        2.0083       0.2707        1.9760
9.8169
      4        1.9511       0.3011        1.9104
9.8356
      5        1.8987       0.3052        1.9103
9.8972
```

Dùng skorch để lựa chọn siêu tham số

[ ]:
```
# hyperparameter tuning
net.set_params(train_split=False, verbose=0)
params = {
    'lr': [1e-4, 1e-2],
    'module__l1': [32, 64],
    'module__l2': [16, 32],
}

gs = GridSearchCV(net, params, refit=False, cv=3, scoring='accuracy', verbose=2)

gs.fit(X, y)
print("best score: {:.3f}, best params: {}".format(gs.best_score_, gs.
 ↪best_params_))
```

```
Fitting 3 folds for each of 8 candidates, totalling 24 fits
[CV] lr=0.0001, module__l1=32, module__l2=16 …

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:33: UserWarning:
Implicit dimension choice for softmax has been deprecated. Change the call to
include dim=X as an argument.

[CV] … lr=0.0001, module__l1=32, module__l2=16, total=  38.0s
[CV] lr=0.0001, module__l1=32, module__l2=16 …

[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:   38.0s remaining:    0.0s

[CV] … lr=0.0001, module__l1=32, module__l2=16, total=  37.9s
[CV] lr=0.0001, module__l1=32, module__l2=16 …
[CV] … lr=0.0001, module__l1=32, module__l2=16, total=  37.8s
[CV] lr=0.0001, module__l1=32, module__l2=32 …
[CV] … lr=0.0001, module__l1=32, module__l2=32, total=  37.5s
[CV] lr=0.0001, module__l1=32, module__l2=32 …
[CV] … lr=0.0001, module__l1=32, module__l2=32, total=  37.6s
[CV] lr=0.0001, module__l1=32, module__l2=32 …
[CV] … lr=0.0001, module__l1=32, module__l2=32, total=  37.6s
[CV] lr=0.0001, module__l1=64, module__l2=16 …
[CV] … lr=0.0001, module__l1=64, module__l2=16, total=  37.4s
[CV] lr=0.0001, module__l1=64, module__l2=16 …
[CV] … lr=0.0001, module__l1=64, module__l2=16, total=  37.9s
[CV] lr=0.0001, module__l1=64, module__l2=16 …
[CV] … lr=0.0001, module__l1=64, module__l2=16, total=  38.1s
```

```
[CV] lr=0.0001, module__l1=64, module__l2=32 …
[CV] … lr=0.0001, module__l1=64, module__l2=32, total=  39.0s
[CV] lr=0.0001, module__l1=64, module__l2=32 …
[CV] … lr=0.0001, module__l1=64, module__l2=32, total=  38.5s
[CV] lr=0.0001, module__l1=64, module__l2=32 …
[CV] … lr=0.0001, module__l1=64, module__l2=32, total=  37.5s
[CV] lr=0.01, module__l1=32, module__l2=16 …
[CV] … lr=0.01, module__l1=32, module__l2=16, total=  36.1s
[CV] lr=0.01, module__l1=32, module__l2=16 …
[CV] … lr=0.01, module__l1=32, module__l2=16, total=  36.3s
[CV] lr=0.01, module__l1=32, module__l2=16 …
[CV] … lr=0.01, module__l1=32, module__l2=16, total=  36.3s
[CV] lr=0.01, module__l1=32, module__l2=32 …
[CV] … lr=0.01, module__l1=32, module__l2=32, total=  36.8s
[CV] lr=0.01, module__l1=32, module__l2=32 …
[CV] … lr=0.01, module__l1=32, module__l2=32, total=  37.0s
[CV] lr=0.01, module__l1=32, module__l2=32 …
[CV] … lr=0.01, module__l1=32, module__l2=32, total=  36.6s
[CV] lr=0.01, module__l1=64, module__l2=16 …
[CV] … lr=0.01, module__l1=64, module__l2=16, total=  36.9s
[CV] lr=0.01, module__l1=64, module__l2=16 …
[CV] … lr=0.01, module__l1=64, module__l2=16, total=  37.7s
[CV] lr=0.01, module__l1=64, module__l2=16 …
[CV] … lr=0.01, module__l1=64, module__l2=16, total=  38.1s
[CV] lr=0.01, module__l1=64, module__l2=32 …
[CV] … lr=0.01, module__l1=64, module__l2=32, total=  37.5s
[CV] lr=0.01, module__l1=64, module__l2=32 …
[CV] … lr=0.01, module__l1=64, module__l2=32, total=  36.9s
[CV] lr=0.01, module__l1=64, module__l2=32 …
[CV] … lr=0.01, module__l1=64, module__l2=32, total=  37.0s
best score: 0.287, best params: {'lr': 0.01, 'module__l1': 32, 'module__l2': 32}

[Parallel(n_jobs=1)]: Done  24 out of  24 | elapsed: 15.0min finished
```