FusionDeepCNN

February 26, 2023

[15]:

```
import math
import time
import sys
import os
import random
import glob
import cv2
from glob import glob
import numpy as np
import matplotlib.pyplot as plt
from tqdm import tqdm
from PIL import Image
import PIL.ImageOps
from sklearn.metrics import confusion_matrix
import torch
import torch.nn as nn
import torch.optim as optim
import torch.nn.functional as F
from torch.autograd import Variable
import torchvision
import torchvision.datasets as datasets
import torchvision.models as models
import torchvision.transforms as transforms
import torchvision.utils
from torch.utils.data import DataLoader, Dataset

use_gpu = torch.cuda.is_available()
```

[16]:

```
DATA_DIR = "data/"
trn_dir = f'{DATA_DIR}/train'
tst_dir = f'{DATA_DIR}/test'

sz = 64
batch_size = 64
```

[17]:

```
os.listdir(DATA_DIR)
```

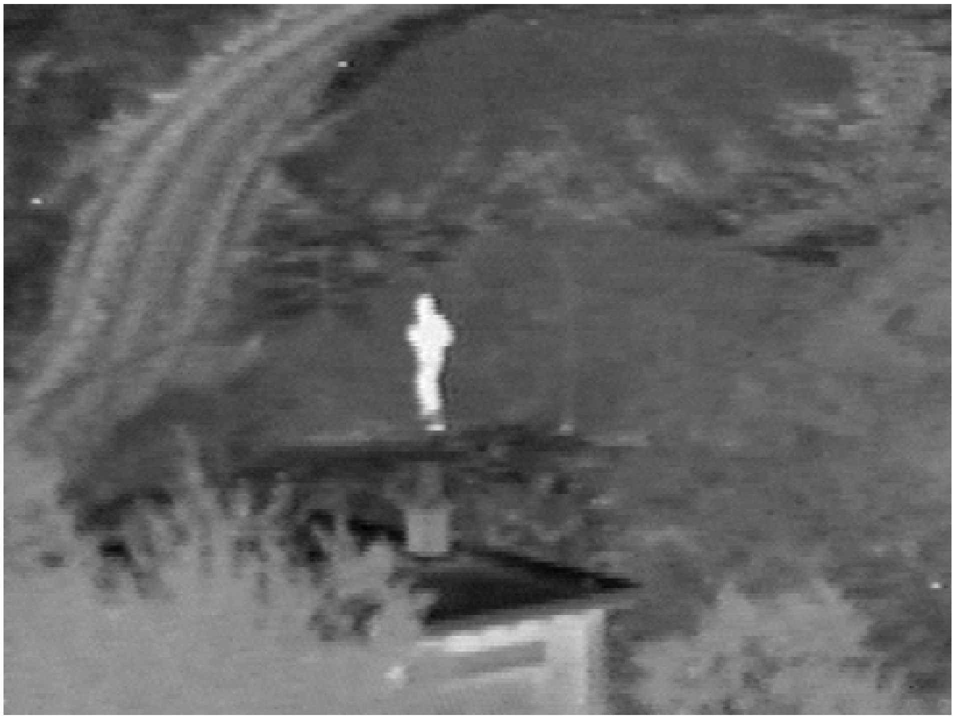
```
[17]: ['train', 'test']
```

```
[18]: trn_fnames = glob(f'{trn_dir}/*/*.bmp')
      trn_fnames[:3]
```

```
[18]: ['data//train/thermal/1821i.bmp',
       'data//train/thermal/1823i.bmp',
       'data//train/thermal/1802i.bmp']
```

```
[19]: img = plt.imread(trn_fnames[1])
      plt.imshow(img,cmap='gray');
      plt.axis('off')
```

```
[19]: (-0.5, 359.5, 269.5, -0.5)
```



```
[20]: train_ds = datasets.ImageFolder(trn_dir)

      tfms = transforms.Compose([
          transforms.Resize((sz, sz//2)),  # PIL Image
      #     transforms.Grayscale(),
          transforms.ToTensor(),        # Tensor
          transforms.Normalize([0.44 , 0.053, 0.062], [0.076, 0.079, 0.085])
      ])
```

```python
train_ds = datasets.ImageFolder(trn_dir, transform=tfms)
test_ds = datasets.ImageFolder(tst_dir, transform=tfms)

len(train_ds), len(test_ds)
```

[20]:

```
(64, 64)
```

[21]:

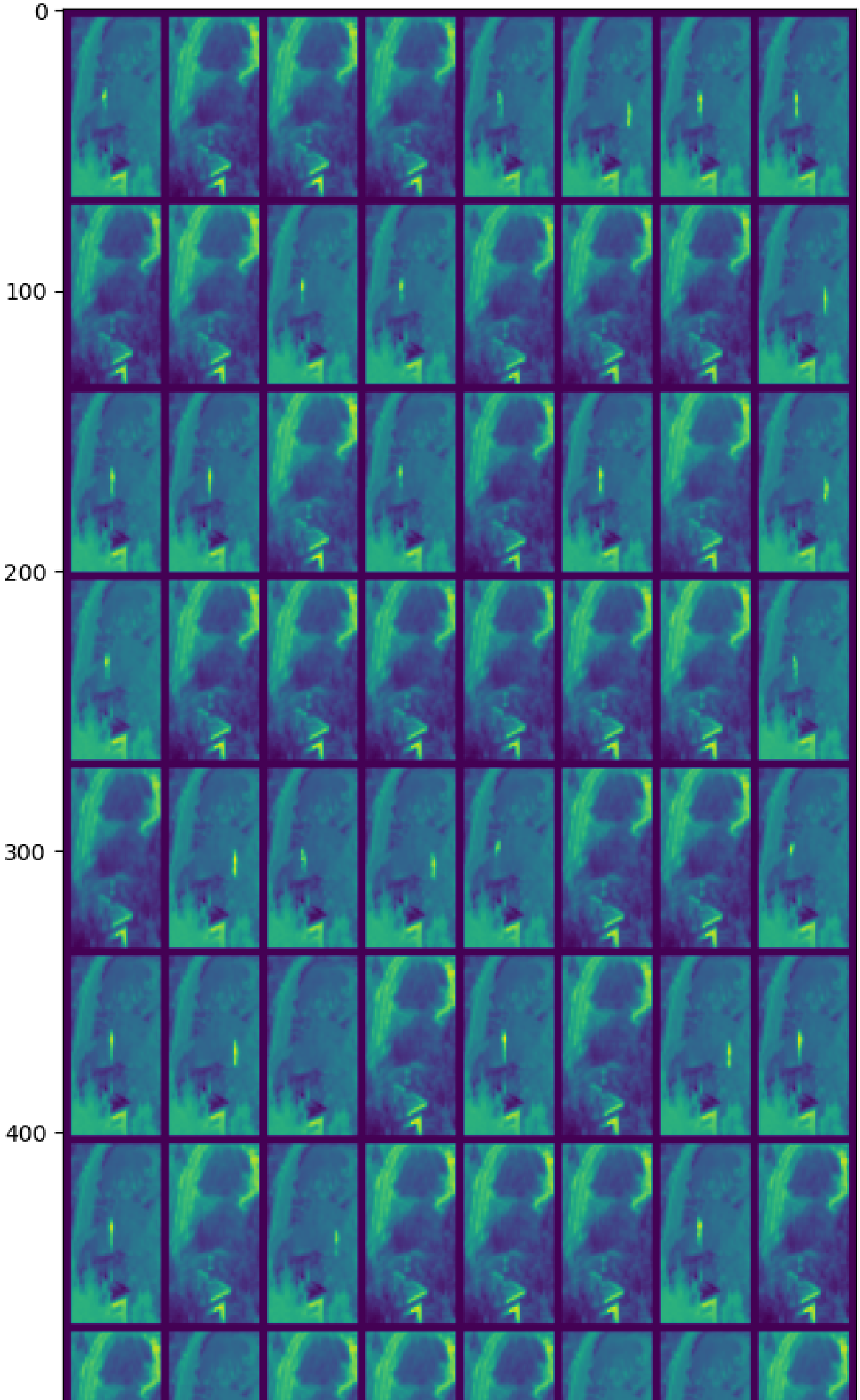
```python
train_dl = torch.utils.data.DataLoader(train_ds, batch_size=batch_size, shuffle=True, num_workers=8)
test_dl = torch.utils.data.DataLoader(test_ds, batch_size=batch_size, shuffle=True, num_workers=8)
```

[26]:

```python
inputs, targets = next(iter(train_dl))
out = torchvision.utils.make_grid(inputs, padding=3)
plt.figure(figsize=(16, 12))
plt.imshow(out[-1])
```

[26]:

```
<matplotlib.image.AxesImage at 0x7fce66a19910>
```


0
100
200
300
400
500
0
50
100
150
200
250

[28]:

```
class CNN(nn.Module):

    def __init__(self):
        super(CNN, self).__init__()

        self.conv1_1 = nn.Sequential(
            nn.Conv2d(1, 64, kernel_size=3, padding=1),
            nn.BatchNorm2d(64),

            nn.LeakyReLU(0.1, inplace=True),

        )
        self.conv1_2 = nn.Sequential(
            nn.Conv2d(1, 64, kernel_size=3, padding=1),
            nn.BatchNorm2d(64),

            nn.LeakyReLU(0.1, inplace=True),

        )
        self.conv1_3 = nn.Sequential(
            nn.Conv2d(1, 64, kernel_size=3, padding=1),
            nn.BatchNorm2d(64),

            nn.LeakyReLU(0.1, inplace=True),

        )

        self.conv2_1 = nn.Sequential(
            nn.Conv2d(64, 128, kernel_size=3, padding=1),
            nn.BatchNorm2d(128),
            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)
        )
        self.conv2_2 = nn.Sequential(
            nn.Conv2d(64, 128, kernel_size=3, padding=1),
            nn.BatchNorm2d(128),
            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)
        )
        self.conv2_3 = nn.Sequential(
            nn.Conv2d(64, 128, kernel_size=3, padding=1),
            nn.BatchNorm2d(128),
            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)
        )
        self.conv3_1 = nn.Sequential(
            nn.Conv2d(128, 128, kernel_size=3, padding=1),
            nn.BatchNorm2d(128),
            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)

        )
        self.conv3_2 = nn.Sequential(
            nn.Conv2d(128, 128, kernel_size=3, padding=1),
            nn.BatchNorm2d(128),
            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)

        )

        self.conv3_3 = nn.Sequential(
            nn.Conv2d(128, 128, kernel_size=3, padding=1),
            nn.BatchNorm2d(128),
            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)

        )


        self.conv4 = nn.Sequential(
            nn.Conv2d(128, 256, kernel_size=3, padding=1),
            nn.BatchNorm2d(256),

            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)
        )


        self.conv5 = nn.Sequential(
            nn.Conv2d(128*2, 256, kernel_size=3, padding=1),
            nn.BatchNorm2d(256),

            nn.LeakyReLU(0.1, inplace=True),
            nn.MaxPool2d(2)
        )

        self.fc1 = nn.Linear(256*8*4*2, 2)



    def forward(self, x, y, z):
        outx = self.conv1_1(x)
        outx = self.conv2_1(outx)
        outx = self.conv3_1(outx)
        outx = self.conv4(outx)
        outx = outx.view(outx.size(0), -1)

        outy = self.conv1_2(y)
        outy = self.conv2_2(outy)
        outy = self.conv3_2(outy)


        outz = self.conv1_3(z)
        outz = self.conv2_3(outz)
        outz = self.conv3_3(outz)

        oyz=torch.cat([outy,outz],1)

        oyz = self.conv5(oyz)
        oyz = oyz.view(oyz.size(0), -1)

        oo=torch.cat([outx,oyz],1)

        out = self.fc1(oo)

        return out
```

[31]:

```
model = CNN()

if use_gpu:

    model = model.cuda()
    model.cuda()
    model = torch.nn.DataParallel(model, device_ids=range(torch.cuda.
 ↪device_count()))

model
```

[31]:

```
CNN(
  (conv1_1): Sequential(
    (0): Conv2d(1, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
  )
  (conv1_2): Sequential(
    (0): Conv2d(1, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
  )
  (conv1_3): Sequential(
    (0): Conv2d(1, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
  )
  (conv2_1): Sequential(
    (0): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (conv2_2): Sequential(
    (0): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (conv2_3): Sequential(
    (0): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (conv3_1): Sequential(
    (0): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (conv3_2): Sequential(
    (0): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (conv3_3): Sequential(
    (0): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (conv4): Sequential(
    (0): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (conv5): Sequential(
    (0): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): LeakyReLU(negative_slope=0.1, inplace=True)
    (3): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (fc1): Linear(in_features=16384, out_features=2, bias=True)
)
```

[30]:

```
criterion = nn.CrossEntropyLoss()

optimizer = optim.SGD(model.parameters(), lr=0.0002, momentum=0.9)
scheduler = optim.lr_scheduler.StepLR(optimizer, step_size=1, gamma=0.9)
```

[32]:

```
def to_var(x, volatile=False):
    if torch.cuda.is_available():
        x = x.cuda()
    return Variable(x, volatile=volatile)
```

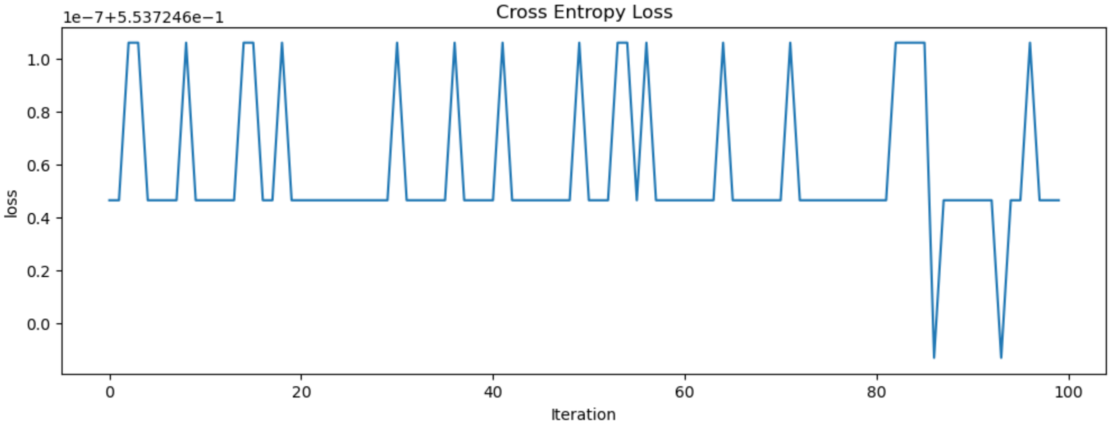
[34]:

```
a = time.time()
num_epochs = 100
losses = []
for epoch in range(num_epochs):
    for i, (inputs, targets) in enumerate(train_dl):
        inputs = to_var(inputs)
#         inputs2 = to_var(inputs2)
#         inputs3 = to_var(inputs3)
        targets = to_var(targets)

        inputs1=inputs[:,0,:,:]
        inputs1=inputs1.resize(inputs1.shape[0],1,64,32)
        inputs2=inputs[:,1,:,:]
        inputs2=inputs1.resize(inputs2.shape[0],1,64,32)
        inputs3=inputs[:,2,:,:]
        inputs3=inputs1.resize(inputs3.shape[0],1,64,32)

        # forwad pass
        optimizer.zero_grad()
        outputs = model(inputs1,inputs2,inputs3)

        # loss
        loss = criterion(outputs, targets)
        losses += [loss.item()]


        # backward pass
        loss.backward()


        # update parameters
        optimizer.step()


        # report
        if (i + 1) % 50 == 0:
            print('Epoch [%2d/%2d], Step [%3d/%3d], Loss: %.4f'
                  % (epoch + 1, num_epochs, i + 1, len(train_ds) // batch_size,␣
 ↪loss.data[0]))

b = time.time()
print('Total Time of Training {:.1000}s'.format(b - a))
```

```
Total Time of Training 377.82075214385986328125s
```

[35]:

```
plt.figure(figsize=(12, 4))
plt.plot(losses)
plt.xlabel('Iteration')
plt.ylabel('loss')
plt.title('Cross Entropy Loss');
```



[36]:

```
def evaluate_model(model, dataloader):
    model.eval()  # for batch normalization layers
    corrects = 0
    for inputs, targets in dataloader:
        inputs, targets = to_var(inputs, True), to_var(targets, True)
#          targets = to_var(targets)

        inputs1=inputs[:,0,:,:]
        inputs1=inputs1.resize(inputs1.shape[0],1,64,32)
        inputs2=inputs[:,1,:,:]
        inputs2=inputs1.resize(inputs2.shape[0],1,64,32)
        inputs3=inputs[:,2,:,:]
        inputs3=inputs1.resize(inputs3.shape[0],1,64,32)

        outputs = model(inputs1,inputs2,inputs3)
        _, preds = torch.max(outputs.data, 1)
        corrects += (preds == targets.data).sum()

    zz=len(dataloader.dataset)

    print('accuracy: {:.2f}'.format(100. * corrects / len(dataloader.dataset)))
    print('corrects: {:.2f}'.format(corrects))
    print('Toatal: {:.2f}'.format(zz))
```

[38]:

```
evaluate_model(model, train_dl)
evaluate_model(model, test_dl)
torch.save(model.state_dict(), 'ECNN_network_wights_1.pth')
```

```
/tmp/ipykernel_218878/2255835562.py:4: UserWarning: volatile was removed and now
has no effect. Use `with torch.no_grad():` instead.
  return Variable(x, volatile=volatile)
```

```
accuracy: 84.38
corrects: 54.00
Toatal: 64.00
accuracy: 84.38
corrects: 54.00
Toatal: 64.00
```

[ ]:

```

```