

```
In [ ]: import torch
import torch.nn as nn
import torch.nn.functional as F
import h5py
import numpy as np
import warnings
warnings.filterwarnings('ignore')
```

```
In [ ]: file_electron = "SingleElectronPt50_IMGCRPS_n249k_RHv1.hdf5"
file_photon = "SinglePhotonPt50_IMGCRPS_n249k_RHv1.hdf5"

with h5py.File(file_electron, "r") as f1:
    X_elec = np.array(f1['X'][:])
    y_elec = np.array(f1['y'][:])
with h5py.File(file_photon, "r") as f2:
    X_phot = np.array(f2['X'][:])
    y_phot = np.array(f2['y'][:])
```

```
In [ ]: print(X_elec.shape)
print(X_phot.shape)
```

```
(249000, 32, 32, 2)
(249000, 32, 32, 2)
```

```
In [ ]: X = np.append(X_elec, X_phot, axis=0)
y = np.append(y_elec, y_phot)
X.shape
```

```
Out[ ]: (498000, 32, 32, 2)
```

```
In [ ]: X = np.swapaxes(X, 3,1)
X.shape
```

```
Out[ ]: (498000, 2, 32, 32)
```

```
In [ ]: y = torch.as_tensor(y)
```

```
In [ ]: X = torch.from_numpy(X)
```

```
In [ ]: dataset = torch.utils.data.TensorDataset(X, y)
```

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In [ ]: train_data, val_data = torch.utils.data.random_split(dataset, [int(len(dataset)*0.9), int(len(dataset)*0.1)])
```

```
In [ ]: trainset = torch.utils.data.DataLoader(train_data, batch_size=256, shuffle=True, num_workers=4, pin_memory=True)
valset = torch.utils.data.DataLoader(val_data, batch_size=256, shuffle=True, num_workers=4, pin_memory=True)
```

```
In [ ]: class CNN(nn.Module):
    def __init__(self):
        super().__init__()
        self.conv1 = nn.Conv2d(in_channels=2, out_channels=16, kernel_size=2, padding='same')
        self.pool = nn.MaxPool2d(2, 2)
        self.fc1 = nn.Linear(16 * 16 * 16, 64)
        self.out = nn.Linear(64, 2)

    def forward(self, x):
        x = self.pool(F.relu(self.conv1(x)))
        x = torch.flatten(x, 1)
        x = F.relu(self.fc1(x))
        x = F.softmax(self.out(x))
        return x
```

```
In [ ]: model = CNN()
criterion = nn.CrossEntropyLoss()
optimizer = torch.optim.Adam(model.parameters(), lr=0.0001)
if torch.cuda.is_available():
    model = model.cuda()
    criterion = criterion.cuda()
```

```
In [ ]: from sklearn.metrics import roc_auc_score
for epoch in range(100):
    running_loss = 0.0
    val_loss = 0.0
    all_y_true = torch.zeros(0, dtype=torch.long, device='cuda')
    all_y_pred = torch.zeros(0, dtype=torch.long, device='cuda')
```

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all_y_true_val = torch.zeros(0, dtype=torch.long, device='cuda')
all_y_pred_val = torch.zeros(0, dtype=torch.long, device='cuda')

for i, data in enumerate(trainset, 0):
    X, y = data
    if torch.cuda.is_available():
        X = X.cuda()
        y = y.cuda()
    optimizer.zero_grad()
    outputs = model(X)
    preds = outputs
    preds = preds.detach()
    _, preds = torch.max(preds, 1)
    all_y_true = torch.cat((all_y_true, y.view(-1)))
    all_y_pred = torch.cat((all_y_pred, preds.view(-1)))
    loss = criterion(outputs, y.long())
    loss.backward()
    optimizer.step()

    running_loss += loss.item()
    if i%500 == 499:
        auc_score = roc_auc_score(all_y_true.cpu().numpy(), all_y_pred.cpu().numpy())
        print(f'[{epoch + 1}, {i + 1:5d}] loss: {running_loss / 500:.3f} auc_score_train: {auc_score}')
        running_loss = 0.0

with torch.no_grad():
    for j, data in enumerate(valset, 0):
        X_val, y_val = data
        if torch.cuda.is_available():
            X_val = X_val.cuda()
            y_val = y_val.cuda()
        val_outputs = model(X_val)
        loss_val = criterion(val_outputs, y_val.long())
        _, val_preds = torch.max(val_outputs, 1)
        all_y_true_val = torch.cat((all_y_true_val, y_val.view(-1)))
        all_y_pred_val = torch.cat((all_y_pred_val, val_preds.view(-1)))
        val_loss += loss_val.item()
    auc_score_val = roc_auc_score(all_y_true_val.cpu().numpy(), all_y_pred_val.cpu().numpy())
    print(f'val_loss: {val_loss/j:.3f} auc_score_val: {auc_score_val}')

```

```

[1, 500] loss: 0.689 auc_score_train: 0.5446973756680915
[1, 1000] loss: 0.677 auc_score_train: 0.5639866795837672
[1, 1500] loss: 0.668 auc_score_train: 0.5753346533364443
val_loss: 0.670 auc_score_val: 0.5964844172453844
[2, 500] loss: 0.665 auc_score_train: 0.6036049964386778
[2, 1000] loss: 0.663 auc_score_train: 0.6057784551359567
[2, 1500] loss: 0.661 auc_score_train: 0.6075812348264504
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[3, 1000] loss: 0.660 auc_score_train: 0.6123604498275471
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val_loss: 0.663 auc_score_val: 0.6149604132033533
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[13, 500] loss: 0.639 auc_score_train: 0.6435725326658266
[13, 1000] loss: 0.638 auc_score_train: 0.6446671153319643

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[13, 1500] loss: 0.638 auc\_score\_train: 0.6450390894406999  
val\_loss: 0.644 auc\_score\_val: 0.6411965074955892  
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val\_loss: 0.589 auc\_score\_val: 0.7128973615926952  
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```

As seen from the epoch metrics, we got:

Train AUC Score: 0.74

Validation AUC Score: 0.71