پروژه پایانی

افزودن کتابخانه‌ها

In [1]:
```
import numpy as np
import torch
import torch.nn as nn # برای پیاده‌سازی معماری شبکه
from torchvision import datasets # وجود بودن دیتاست مورد نظر در این کتابخانه
from torchvision import transforms # برای کارهای پیش‌پردازش تصویر
from torch.utils.data.sampler import SubsetRandomSampler # نمونه‌برداری تصادفی


# انتخاب نوع پردازنده
device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')
print(device)
```

```
cuda
```

Loading the Data

In [2]:
```
def data_loader(data_dir, batch_size, random_seed=123, valid_size=0.1, shuff

    normalize = transforms.Normalize(
        mean=[0.4914, 0.4822, 0.4465], std=[0.2023, 0.1994, 0.2010],
    )

    # پیش‌پردازش تصویر
    transform = transforms.Compose([
            transforms.Resize((227,227)),
            transforms.ToTensor(), # تبدیل به تنسور برای استفاده از جی‌پی‌یو
            normalize,
    ])

    if test:
        dataset = datasets.CIFAR100(
          root=data_dir, train=False,
          download=True, transform=transform,
        )

        data_loader = torch.utils.data.DataLoader(
            dataset, batch_size=batch_size, shuffle=shuffle
        )

        return data_loader

    # load the dataset
    train_dataset = datasets.CIFAR100(
        root=data_dir, train=True,
        download=True, transform=transform,
    )

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

    num_train = len(train_dataset)
    indices = list(range(num_train))
    split = int(np.floor(valid_size * num_train))

    if shuffle:
        np.random.seed(random_seed)
        np.random.shuffle(indices)

    train_idx, valid_idx = indices[split:], indices[:split]
    train_sampler = SubsetRandomSampler(train_idx)
    valid_sampler = SubsetRandomSampler(valid_idx)

    train_loader = torch.utils.data.DataLoader(
        train_dataset, batch_size=batch_size, sampler=train_sampler)

    valid_loader = torch.utils.data.DataLoader(
```

```
        valid_dataset, batch_size=batch_size, sampler=valid_sampler)

    return (train_loader, valid_loader)
```

In [3]:
```
# CIFAR100 دیتاست
train_loader, valid_loader = data_loader(data_dir='./data', batch_size=64)

test_loader = data_loader(data_dir='./data', batch_size=64, test=True)
```

```
Files already downloaded and verified
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```

VGG Network

In [4]:
```
class VGG16(nn.Module):
    def __init__(self, num_classes=10):
        super(VGG16, self).__init__()
        self.layer1 = nn.Sequential(
            nn.Conv2d(3, 64, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(64),
            nn.ReLU())
        self.layer2 = nn.Sequential(
            nn.Conv2d(64, 64, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(64),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size = 2, stride = 2))
        self.layer3 = nn.Sequential(
            nn.Conv2d(64, 128, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(128),
            nn.ReLU())
        self.layer4 = nn.Sequential(
            nn.Conv2d(128, 128, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(128),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size = 2, stride = 2))
        self.layer5 = nn.Sequential(
            nn.Conv2d(128, 256, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(256),
            nn.ReLU())
        self.layer6 = nn.Sequential(
            nn.Conv2d(256, 256, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(256),
            nn.ReLU())
        self.layer7 = nn.Sequential(
            nn.Conv2d(256, 256, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(256),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size = 2, stride = 2))
        self.layer8 = nn.Sequential(
            nn.Conv2d(256, 512, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(512),
            nn.ReLU())
        self.layer9 = nn.Sequential(
            nn.Conv2d(512, 512, kernel_size=3, stride=1, padding=1),
```

```
            nn.BatchNorm2d(512),
            nn.ReLU())
        self.layer10 = nn.Sequential(
            nn.Conv2d(512, 512, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size = 2, stride = 2))
        self.layer11 = nn.Sequential(
            nn.Conv2d(512, 512, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(512),
            nn.ReLU())
        self.layer12 = nn.Sequential(
            nn.Conv2d(512, 512, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(512),
            nn.ReLU())
        self.layer13 = nn.Sequential(
            nn.Conv2d(512, 512, kernel_size=3, stride=1, padding=1),
            nn.BatchNorm2d(512),
            nn.ReLU(),
            nn.MaxPool2d(kernel_size = 2, stride = 2))
        self.fc = nn.Sequential(
            nn.Dropout(0.5),
            nn.Linear(7*7*512, 4096),
            nn.ReLU())
        self.fc1 = nn.Sequential(
            nn.Dropout(0.5),
            nn.Linear(4096, 4096),
            nn.ReLU())
        self.fc2= nn.Sequential(
            nn.Linear(4096, num_classes))

    def forward(self, x):
        out = self.layer1(x)
        out = self.layer2(out)
        out = self.layer3(out)
        out = self.layer4(out)
        out = self.layer5(out)
        out = self.layer6(out)
        out = self.layer7(out)
        out = self.layer8(out)
        out = self.layer9(out)
        out = self.layer10(out)
        out = self.layer11(out)
        out = self.layer12(out)
        out = self.layer13(out)
        out = out.reshape(out.size(0), -1)
        out = self.fc(out)
        out = self.fc1(out)
        out = self.fc2(out)
        return out
```

Hyperparameters

In [5]:
```
num_classes = 100
```

```
num_epochs = 20
batch_size = 16
learning_rate = 0.005

model = VGG16(num_classes).to(device)


# Loss and optimizer
criterion = nn.CrossEntropyLoss()
optimizer = torch.optim.SGD(model.parameters(), lr=learning_rate, weight_dec


# Train the model
total_step = len(train_loader)
```

آموزش - Train

> به دلیل حجیم بودن این معماری، نزدیک به چهارده میلیون پارامتر، این که مدل را از صفر آموزش دهیم باعث صرف زمان خیلی خیلی زیادی میشود. به همین دلیل تا اندکی از را اجرا کرده‌ام

In [6]:
```
total_step = len(train_loader)

for epoch in range(num_epochs):
    for i, (images, labels) in enumerate(train_loader):
        # Move tensors to the configured device
        images = images.to(device)
        labels = labels.to(device)

        # Forward pass
        outputs = model(images)
        loss = criterion(outputs, labels)

        # Backward and optimize
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()

        print (f"Epoch [{epoch+1}/{num_epochs}], Step [{i+1}/{total_step}],

    # Validation
    with torch.no_grad():
        correct = 0
        total = 0
        for images, labels in valid_loader:
            images = images.to(device)
            labels = labels.to(device)
            outputs = model(images)
            _, predicted = torch.max(outputs.data, 1)
            total += labels.size(0)
            correct += (predicted == labels).sum().item()
            del images, labels, outputs
```

```
        print(f"Accuracy of the network on the [{5000}] validation images: [
```

```
Epoch [1/20], Step [1/704], Loss: 4.6159
Epoch [1/20], Step [2/704], Loss: 4.6327
Epoch [1/20], Step [3/704], Loss: 4.6542
Epoch [1/20], Step [4/704], Loss: 4.6874
Epoch [1/20], Step [5/704], Loss: 4.6634
Epoch [1/20], Step [6/704], Loss: 4.6515
Epoch [1/20], Step [7/704], Loss: 4.6271
Epoch [1/20], Step [8/704], Loss: 4.6674
Epoch [1/20], Step [9/704], Loss: 4.6177
Epoch [1/20], Step [10/704], Loss: 4.6153
Epoch [1/20], Step [11/704], Loss: 4.6632
Epoch [1/20], Step [12/704], Loss: 4.6545
Epoch [1/20], Step [13/704], Loss: 4.6506
Epoch [1/20], Step [14/704], Loss: 4.6200
Epoch [1/20], Step [15/704], Loss: 4.6399
Epoch [1/20], Step [16/704], Loss: 4.5816
Epoch [1/20], Step [17/704], Loss: 4.5591
Epoch [1/20], Step [18/704], Loss: 4.5742
Epoch [1/20], Step [19/704], Loss: 4.6781
Epoch [1/20], Step [20/704], Loss: 4.6258
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Epoch [1/20], Step [26/704], Loss: 4.5637
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Epoch [1/20], Step [28/704], Loss: 4.6050
Epoch [1/20], Step [29/704], Loss: 4.4990
Epoch [1/20], Step [30/704], Loss: 4.6239
Epoch [1/20], Step [31/704], Loss: 4.6191
Epoch [1/20], Step [32/704], Loss: 4.5383
Epoch [1/20], Step [33/704], Loss: 4.6316
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Epoch [1/20], Step [35/704], Loss: 4.4912
Epoch [1/20], Step [36/704], Loss: 4.5065
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Epoch [1/20], Step [39/704], Loss: 4.4413
Epoch [1/20], Step [40/704], Loss: 4.6129
Epoch [1/20], Step [41/704], Loss: 4.6675
Epoch [1/20], Step [42/704], Loss: 4.5434
Epoch [1/20], Step [43/704], Loss: 4.5112
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Epoch [1/20], Step [45/704], Loss: 4.5346
Epoch [1/20], Step [46/704], Loss: 4.5080
Epoch [1/20], Step [47/704], Loss: 4.5608
Epoch [1/20], Step [48/704], Loss: 4.5121
Epoch [1/20], Step [49/704], Loss: 4.4818
Epoch [1/20], Step [50/704], Loss: 4.3848
Epoch [1/20], Step [51/704], Loss: 4.7066
Epoch [1/20], Step [52/704], Loss: 4.6048
Epoch [1/20], Step [53/704], Loss: 4.5752
Epoch [1/20], Step [54/704], Loss: 4.6469
Epoch [1/20], Step [55/704], Loss: 4.7023
Epoch [1/20], Step [56/704], Loss: 4.4691
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Epoch [1/20], Step [57/704], Loss: 4.5268
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Epoch [1/20], Step [61/704], Loss: 4.4889
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Epoch [1/20], Step [63/704], Loss: 4.4375
Epoch [1/20], Step [64/704], Loss: 4.4940
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Epoch [1/20], Step [96/704], Loss: 4.4219
Epoch [1/20], Step [97/704], Loss: 4.5613
Epoch [1/20], Step [98/704], Loss: 4.4705
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Epoch [1/20], Step [121/704], Loss: 4.3900
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Epoch [1/20], Step [165/704], Loss: 4.0413
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Epoch [1/20], Step [205/704], Loss: 4.1174
Epoch [1/20], Step [206/704], Loss: 4.3446
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Epoch [1/20], Step [241/704], Loss: 4.0931
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Epoch [1/20], Step [251/704], Loss: 3.9735
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Epoch [1/20], Step [639/704], Loss: 3.3864
Epoch [1/20], Step [640/704], Loss: 3.7345
Epoch [1/20], Step [641/704], Loss: 3.8257
Epoch [1/20], Step [642/704], Loss: 3.6024
Epoch [1/20], Step [643/704], Loss: 3.6010
Epoch [1/20], Step [644/704], Loss: 3.8394
Epoch [1/20], Step [645/704], Loss: 3.4445
Epoch [1/20], Step [646/704], Loss: 3.6733
Epoch [1/20], Step [647/704], Loss: 3.6470
Epoch [1/20], Step [648/704], Loss: 3.6029
Epoch [1/20], Step [649/704], Loss: 3.5786
Epoch [1/20], Step [650/704], Loss: 3.5392
Epoch [1/20], Step [651/704], Loss: 3.8332
Epoch [1/20], Step [652/704], Loss: 3.3525
Epoch [1/20], Step [653/704], Loss: 3.4788
Epoch [1/20], Step [654/704], Loss: 3.6342
Epoch [1/20], Step [655/704], Loss: 3.4271
Epoch [1/20], Step [656/704], Loss: 3.4895
Epoch [1/20], Step [657/704], Loss: 3.6209
Epoch [1/20], Step [658/704], Loss: 3.9248
Epoch [1/20], Step [659/704], Loss: 3.4894
Epoch [1/20], Step [660/704], Loss: 3.2977
Epoch [1/20], Step [661/704], Loss: 3.5087
Epoch [1/20], Step [662/704], Loss: 3.6203
Epoch [1/20], Step [663/704], Loss: 3.1481
Epoch [1/20], Step [664/704], Loss: 3.5422
Epoch [1/20], Step [665/704], Loss: 3.6924
Epoch [1/20], Step [666/704], Loss: 3.6799
Epoch [1/20], Step [667/704], Loss: 3.8726
Epoch [1/20], Step [668/704], Loss: 3.5316
Epoch [1/20], Step [669/704], Loss: 3.5299
Epoch [1/20], Step [670/704], Loss: 3.5231
Epoch [1/20], Step [671/704], Loss: 3.4494
Epoch [1/20], Step [672/704], Loss: 3.6195
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Epoch [1/20], Step [673/704], Loss: 3.5018
Epoch [1/20], Step [674/704], Loss: 3.6060
Epoch [1/20], Step [675/704], Loss: 3.2628
Epoch [1/20], Step [676/704], Loss: 3.5435
Epoch [1/20], Step [677/704], Loss: 3.7050
Epoch [1/20], Step [678/704], Loss: 3.6837
Epoch [1/20], Step [679/704], Loss: 3.5100
Epoch [1/20], Step [680/704], Loss: 3.4816
Epoch [1/20], Step [681/704], Loss: 3.3876
Epoch [1/20], Step [682/704], Loss: 3.4601
Epoch [1/20], Step [683/704], Loss: 3.4895
Epoch [1/20], Step [684/704], Loss: 3.5164
Epoch [1/20], Step [685/704], Loss: 3.5236
Epoch [1/20], Step [686/704], Loss: 3.5223
Epoch [1/20], Step [687/704], Loss: 3.4783
Epoch [1/20], Step [688/704], Loss: 3.8543
Epoch [1/20], Step [689/704], Loss: 3.4441
Epoch [1/20], Step [690/704], Loss: 3.6542
Epoch [1/20], Step [691/704], Loss: 3.3030
Epoch [1/20], Step [692/704], Loss: 3.7553
Epoch [1/20], Step [693/704], Loss: 3.7104
Epoch [1/20], Step [694/704], Loss: 3.4576
Epoch [1/20], Step [695/704], Loss: 3.4843
Epoch [1/20], Step [696/704], Loss: 3.7161
Epoch [1/20], Step [697/704], Loss: 3.8659
Epoch [1/20], Step [698/704], Loss: 3.5420
Epoch [1/20], Step [699/704], Loss: 3.4252
Epoch [1/20], Step [700/704], Loss: 3.4252
Epoch [1/20], Step [701/704], Loss: 3.8073
Epoch [1/20], Step [702/704], Loss: 3.5470
Epoch [1/20], Step [703/704], Loss: 3.3843
Epoch [1/20], Step [704/704], Loss: 4.1979
Accuracy of the network on the [5000] validation images: [1.14 %]
Epoch [2/20], Step [1/704], Loss: 3.2683
Epoch [2/20], Step [2/704], Loss: 3.6010
Epoch [2/20], Step [3/704], Loss: 3.7209
Epoch [2/20], Step [4/704], Loss: 3.4442
Epoch [2/20], Step [5/704], Loss: 3.9129
Epoch [2/20], Step [6/704], Loss: 3.5727
Epoch [2/20], Step [7/704], Loss: 3.6732
Epoch [2/20], Step [8/704], Loss: 3.5934
Epoch [2/20], Step [9/704], Loss: 3.8208
Epoch [2/20], Step [10/704], Loss: 3.4302
Epoch [2/20], Step [11/704], Loss: 3.3899
Epoch [2/20], Step [12/704], Loss: 3.4420
Epoch [2/20], Step [13/704], Loss: 3.1811
Epoch [2/20], Step [14/704], Loss: 3.7555
Epoch [2/20], Step [15/704], Loss: 3.2909
Epoch [2/20], Step [16/704], Loss: 3.4527
Epoch [2/20], Step [17/704], Loss: 3.6484
Epoch [2/20], Step [18/704], Loss: 3.4986
Epoch [2/20], Step [19/704], Loss: 3.5834
Epoch [2/20], Step [20/704], Loss: 3.3719
Epoch [2/20], Step [21/704], Loss: 3.4572
Epoch [2/20], Step [22/704], Loss: 3.6332
Epoch [2/20], Step [23/704], Loss: 3.5263
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Epoch [2/20], Step [24/704], Loss: 3.9321
Epoch [2/20], Step [25/704], Loss: 3.4153
Epoch [2/20], Step [26/704], Loss: 3.8731
Epoch [2/20], Step [27/704], Loss: 3.6120
Epoch [2/20], Step [28/704], Loss: 3.2469
Epoch [2/20], Step [29/704], Loss: 3.5769
Epoch [2/20], Step [30/704], Loss: 3.5409
Epoch [2/20], Step [31/704], Loss: 3.4584
Epoch [2/20], Step [32/704], Loss: 3.4943
Epoch [2/20], Step [33/704], Loss: 3.3514
Epoch [2/20], Step [34/704], Loss: 3.4571
Epoch [2/20], Step [35/704], Loss: 3.4781
Epoch [2/20], Step [36/704], Loss: 3.3400
Epoch [2/20], Step [37/704], Loss: 3.2766
Epoch [2/20], Step [38/704], Loss: 3.2938
Epoch [2/20], Step [39/704], Loss: 3.1552
Epoch [2/20], Step [40/704], Loss: 3.3639
Epoch [2/20], Step [41/704], Loss: 3.6088
Epoch [2/20], Step [42/704], Loss: 3.3205
Epoch [2/20], Step [43/704], Loss: 3.0035
Epoch [2/20], Step [44/704], Loss: 3.5144
Epoch [2/20], Step [45/704], Loss: 3.4193
Epoch [2/20], Step [46/704], Loss: 3.4833
Epoch [2/20], Step [47/704], Loss: 3.2816
Epoch [2/20], Step [48/704], Loss: 2.9913
Epoch [2/20], Step [49/704], Loss: 3.4110
Epoch [2/20], Step [50/704], Loss: 3.4490
Epoch [2/20], Step [51/704], Loss: 3.8314
Epoch [2/20], Step [52/704], Loss: 3.2386
Epoch [2/20], Step [53/704], Loss: 3.2829
Epoch [2/20], Step [54/704], Loss: 3.3576
Epoch [2/20], Step [55/704], Loss: 3.8709
Epoch [2/20], Step [56/704], Loss: 3.6293
Epoch [2/20], Step [57/704], Loss: 3.4735
Epoch [2/20], Step [58/704], Loss: 3.7656
Epoch [2/20], Step [59/704], Loss: 3.2644
Epoch [2/20], Step [60/704], Loss: 3.5913
Epoch [2/20], Step [61/704], Loss: 3.4287
Epoch [2/20], Step [62/704], Loss: 3.4539
Epoch [2/20], Step [63/704], Loss: 3.4327
Epoch [2/20], Step [64/704], Loss: 3.4952
Epoch [2/20], Step [65/704], Loss: 3.2205
Epoch [2/20], Step [66/704], Loss: 3.5162
Epoch [2/20], Step [67/704], Loss: 3.2898
Epoch [2/20], Step [68/704], Loss: 3.1895
Epoch [2/20], Step [69/704], Loss: 3.1754
Epoch [2/20], Step [70/704], Loss: 3.5160
Epoch [2/20], Step [71/704], Loss: 3.5202
Epoch [2/20], Step [72/704], Loss: 3.3930
Epoch [2/20], Step [73/704], Loss: 3.3683
Epoch [2/20], Step [74/704], Loss: 3.1204
Epoch [2/20], Step [75/704], Loss: 3.5181
Epoch [2/20], Step [76/704], Loss: 3.2515
Epoch [2/20], Step [77/704], Loss: 3.5671
Epoch [2/20], Step [78/704], Loss: 3.3946
Epoch [2/20], Step [79/704], Loss: 3.2500
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Epoch [2/20], Step [80/704], Loss: 3.4346
Epoch [2/20], Step [81/704], Loss: 3.3043
Epoch [2/20], Step [82/704], Loss: 3.6814
Epoch [2/20], Step [83/704], Loss: 3.1299
Epoch [2/20], Step [84/704], Loss: 3.3028
Epoch [2/20], Step [85/704], Loss: 3.4805
Epoch [2/20], Step [86/704], Loss: 3.6497
Epoch [2/20], Step [87/704], Loss: 3.3662
Epoch [2/20], Step [88/704], Loss: 3.7947
```

```
---------------------------------------------------------------------------
KeyboardInterrupt                         Traceback (most recent call last)
<ipython-input-6-a8cd1768a748> in <cell line: 3>()
     16         optimizer.step()
     17
---> 18         print (f"Epoch [{epoch+1}/{num_epochs}], Step [{i+1}/{total_
step}], Loss: {loss.item():.4f}")
     19
     20     # Validation

KeyboardInterrupt:
```

آزمایش - Test

In [ ]:
```
with torch.no_grad():
    correct = 0
    total = 0
    for images, labels in test_loader:
        images = images.to(device)
        labels = labels.to(device)
        outputs = model(images)
        _, predicted = torch.max(outputs.data, 1)
        total += labels.size(0)
        correct += (predicted == labels).sum().item()
        del images, labels, outputs

    print(f"Accuracy of the network on the [{10000}] test images: [{100 * co
```