```
import torch
import matplotlib.pyplot as plt
import numpy as np
```

University of Toronto CIFAR-10 Dataset

60000 Images 3 channels. 10 classes

```
import torchvision
import torchvision.transforms as transform
```

```
trainsets = torchvision.datasets.CIFAR10(root = './data',train = True,download = T
```

```
Downloading https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz to ./data
                                  170500096/? [00:30<00:00, 17115319.01it/s]
Extracting ./data/cifar-10-python.tar.gz to ./data
```

```
classes = ('Airplane','Automobile','bird','cat','deer','dog','frog', 'horse','ship
```

```
trainloader = torch.utils.data.DataLoader(trainsets,batch_size=4,shuffle = True) #
```

```
dataiter = iter(trainloader)
images,labels = dataiter.next()
print(images.shape)
print(images[0].shape)
```

```
torch.Size([4, 3, 32, 32])
torch.Size([3, 32, 32])
```

Lets Visualize the Image

```
img = images[0]
```

```
npimg = img.numpy()
```

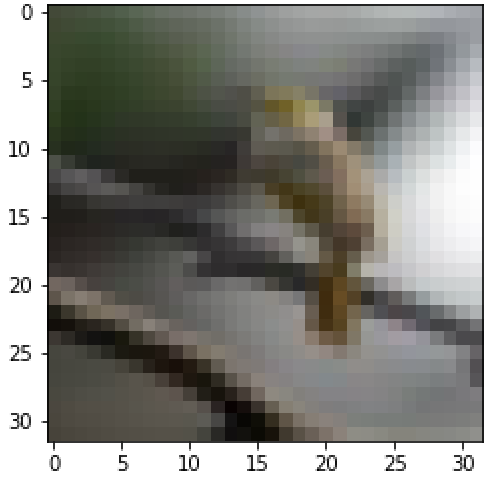
```
npimg.shape
```

```
(3, 32, 32)
```

```
npimg = np.transpose(npimg,(1,2,0))
```

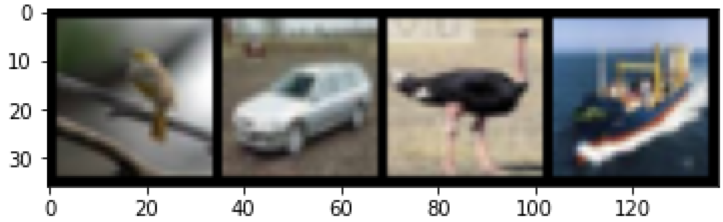
```
plt.figure()
plt.imshow(npimg)
```

```
<matplotlib.image.AxesImage at 0x7f4b300ea6a0>
```



```
def imshow(images):
  npimg1 = images.numpy()
  img = np.transpose(npimg1,(1,2,0))
  plt.imshow(img)
  plt.show()
```

```
imshow(torchvision.utils.make_grid(images))
print(' '.join(classes[labels[j]] for j in range(4)))
```



```
bird Automobile bird ship
```

Convolution

```
import torch.nn as nn

class CNN(nn.Module):
  def __init__(self):
    super(CNN,self).__init__()
    self.conv = nn.Conv2d(3,16,3,padding = (1,1),stride = (1,1)) #depth = channels
  def forward(self,X):
    return self.conv(X)
```

```
firstnet = CNN()
```

```
out = firstnet(images)
out.shape #Since we didn't use Padding the image dimensions have shrunk
```

```
torch.Size([4, 16, 32, 32])
```

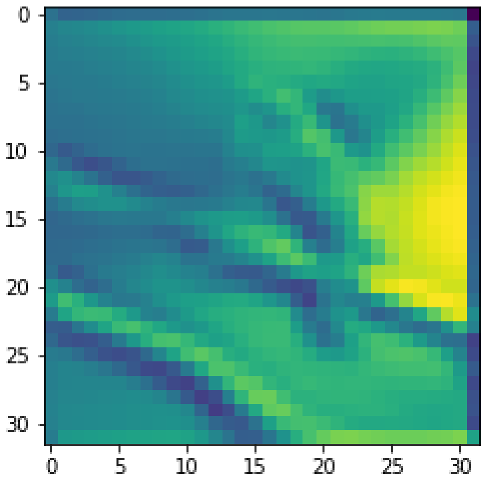
```
for param in firstnet.parameters():
  print(param.shape) #16 kernels 3channels 3X3 spatial filter
  #16 Bias terms
```

```
torch.Size([16, 3, 3, 3])
torch.Size([16])
```

```
out1 = out[0,0,:,:].detach().numpy()
out1.shape
```

```
(32, 32)
```

```
plt.imshow(out1)
plt.show() #preprocessed feature of the bird we are seeing
```



DeepCNN

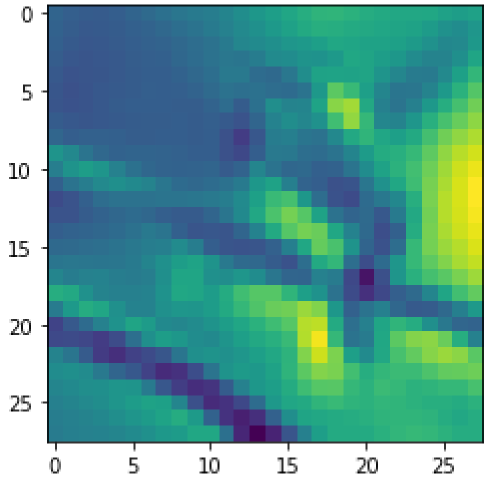
```
class deepCNN(nn.Module):
  def __init__(self):
    super(deepCNN, self).__init__()
    self.model = nn.Sequential(
        nn.Conv2d(3,8,3),  #input (4-batch size,3,32,32) -> #3 Channels, 8 No. of
        nn.Conv2d(8,16,3) #8 Channels, 16 No. of Kernels, 3 F Spatial Extent - > (
    )
  def forward(self,X):
    return self.model(X)
```

```
Deepcnn = deepCNN()
```

```
out = Deepcnn.forward(images)
out.shape
```

```
torch.Size([4, 16, 28, 28])
```

```
npout = out[0,0,:,:].detach().numpy()
plt.imshow(npout)
plt.show()
```

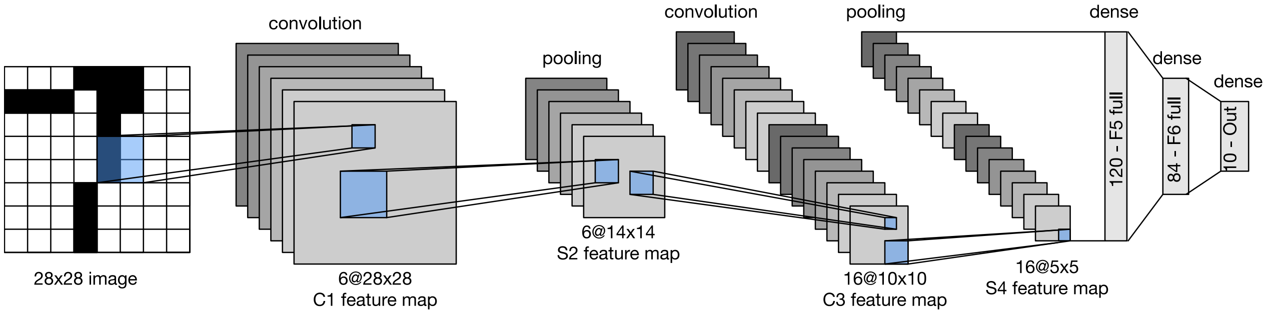


```
class deepCNN_v2(nn.Module):
  def __init__(self):
    super(deepCNN_v2,self).__init__()
    self.model = nn.Sequential(
        nn.Conv2d(3,6,5), #output -> (4,6,28,28)
        nn.AvgPool2d(2,stride = 2), #2X2 patch size and stride = 2,2 - >  (4,6,14,
        nn.Conv2d(6,16,5), # (4,16,10,10)
        nn.AvgPool2d(2,stride = 2) #(4,16,5,5)
    )
  def forward(self,X):
    return self.model(X)


deepcnn = deepCNN_v2()


out = deepcnn.forward(images)
print(out.shape)
npout = out[0,0,:,:].detach().numpy()
```

```
torch.Size([4, 16, 5, 5])
```

```
plt.imshow(npout)
plt.show()
```

Lenet Architecture



```
class Lenet(nn.Module):
  def __init__(self):
    super(Lenet,self).__init__()
    self.convol = nn.Sequential(
        nn.Conv2d(3,6,5), #(4,3,32,32) -> (4,6,28,28)
        nn.LeakyReLU(),
        nn.AvgPool2d(2,stride=2), #(4,6,14,14)
        nn.Conv2d(6,16,5),# (4,16,10,10)
        nn.LeakyReLU(),
        nn.AvgPool2d(2,stride = 2) #(4,16,5,5)
        #after this we need to flatten the structure into a 1d vector    16*5*5 = 
    )
    self.FCNN = nn.Sequential(
        nn.Linear(400,120),
        nn.LeakyReLU(),
        nn.Linear(120,84),
        nn.LeakyReLU(),
        nn.Linear(84,10) #Softmax will be available in training
    )
  def forward(self,X):
    # print("The shape right now is:",X.shape)
    X = self.convol(X)
    # print("The shape right now is:",X.shape)
    X = X.view(X.shape[0],-1)
    # print("The shape right now is:",X.shape) #Flattening to N,400
    X = self.FCNN(X)
    # print("The shape right now is:",X.shape)
    return X
```

```
lenet = Lenet()
```

```
out = lenet.forward(images)
```

```
The shape right now is: torch.Size([4, 3, 32, 32])
The shape right now is: torch.Size([4, 16, 5, 5])
The shape right now is: torch.Size([4, 400])
The shape right now is: torch.Size([4, 10])
```

```
max_vals,class_pred =torch.max(out.data,1) # 1 corresponds to column
```

```
class_pred
```

```
tensor([1, 1, 1, 1])
```

LeNet Training

```
device = torch.device('cuda:0' if torch.cuda.is_available() else 'cpu')
device
```

```
device(type='cuda', index=0)
```

```
import torch.optim as optim
```

```
batch_size = 128
train = torchvision.datasets.CIFAR10(root='./data',train = True, download = True,t
trainset = torch.utils.data.DataLoader(train,batch_size=batch_size, shuffle = True
test = torchvision.datasets.CIFAR10(root='./data',train = False, download = True,t
testset = torch.utils.data.DataLoader(test,batch_size=batch_size, shuffle = False)
```

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

```
def accuracy(dataloader,model):
  total, correct = 0,0
  for data in dataloader:
    input,labels= data
    input,labels = input.to(device),labels.to(device)
    output = model(input)
    max_Val,pred_class = torch.max(output.data,1)
    total += labels.size(0)
    correct += (pred_class == labels).sum()
  return torch.true_divide(correct*100,total)
```

```
lenet = Lenet().to(device)
lossfn = nn.CrossEntropyLoss()
opt = optim.Adam(lenet.parameters())
```

```
%%time
max_epoch = 32
for epoch in range(max_epoch):
  for i,data in enumerate(trainset,0):
    inps, labels = data
    inps, labels = inps.to(device),labels.to(device)
    opt.zero_grad()
    loss = lossfn(lenet(inps),labels)
    loss.backward()
    opt.step()
  print('Epoch :',epoch,'/',max_epoch,'Loss is:',loss.item())
```

```
Epoch : 0 / 32 Loss is: 1.538364052772522
Epoch : 1 / 32 Loss is: 1.7239067554473877
Epoch : 2 / 32 Loss is: 1.23875892162323
Epoch : 3 / 32 Loss is: 1.424127459526062
Epoch : 4 / 32 Loss is: 1.251449704170227
Epoch : 5 / 32 Loss is: 1.192341923713684
Epoch : 6 / 32 Loss is: 1.157594919204712
Epoch : 7 / 32 Loss is: 1.2191708087921143
Epoch : 8 / 32 Loss is: 1.1265733242034912
Epoch : 9 / 32 Loss is: 1.522506833076477
Epoch : 10 / 32 Loss is: 1.0725568532943726
Epoch : 11 / 32 Loss is: 1.0506104230880737
Epoch : 12 / 32 Loss is: 0.9163331985473633
Epoch : 13 / 32 Loss is: 0.8944609761238098
Epoch : 14 / 32 Loss is: 1.1217654943466187
Epoch : 15 / 32 Loss is: 0.8239011764526367
Epoch : 16 / 32 Loss is: 0.8525492548942566
Epoch : 17 / 32 Loss is: 0.9200846552848816
Epoch : 18 / 32 Loss is: 0.7832186818122864
Epoch : 19 / 32 Loss is: 0.8203381299972534
Epoch : 20 / 32 Loss is: 0.777091920375824
Epoch : 21 / 32 Loss is: 0.804993748664856
Epoch : 22 / 32 Loss is: 0.5650824904441833
Epoch : 23 / 32 Loss is: 0.7677661180496216
Epoch : 24 / 32 Loss is: 0.8037186861038208
Epoch : 25 / 32 Loss is: 0.8482853174209595
Epoch : 26 / 32 Loss is: 0.7466887831687927
Epoch : 27 / 32 Loss is: 0.60906982421875
Epoch : 28 / 32 Loss is: 0.6150197386741638
Epoch : 29 / 32 Loss is: 0.5859740972518921
Epoch : 30 / 32 Loss is: 0.7235674858093262
Epoch : 31 / 32 Loss is: 0.6441265344619751
CPU times: user 2min 43s, sys: 1.32 s, total: 2min 44s
Wall time: 2min 45s
```

```
%%time
print('Train Accuracy :{} Test Accuracy :{}'.format(accuracy(trainset,lenet),accura
```

```
Train Accuracy :78.05599975585938 Test Accuracy :62.37999725341797
CPU times: user 5.31 s, sys: 26.8 ms, total: 5.33 s
Wall time: 5.33 s
```