```
import torch
import torchvision
import torchvision.transforms as transforms
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim

import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
import numpy as np
%matplotlib inline
import time
```

```
with np.load('/content/drive/MyDrive/Colab Notebooks/prediction-challenge-02-data.npz') as fh:
    x_train = fh['x_train']
    y_train = fh['y_train']
    x_test = fh['x_test']

# TRAINING DATA: INPUT (x) AND OUTPUT (y)
# 1. INDEX: IMAGE SERIAL NUMBER (6000)
# 2/3. INDEX: PIXEL VALUE (32 x 32)
# 4. INDEX: COLOR CHANNELS (3)
print(x_train.shape, x_train.dtype)
print(y_train.shape, y_train.dtype)

# TEST DATA: INPUT (x) ONLY
print(x_test.shape, x_test.dtype)
```

```
(3000, 32, 32, 3) float32
(3000,) float64
(300, 32, 32, 3) float32
```

```
x_train = np.transpose(x_train, axes=[0, 3, 1, 2])
x_test = np.transpose(x_test, axes=[0, 3, 1, 2])
print(x_train.shape, x_train.dtype)
print(y_train.shape, y_train.dtype)
print(x_test.shape, x_test.dtype)
```

```
(3000, 3, 32, 32) float32
(3000,) float64
(300, 3, 32, 32) float32
```

```
tf = transforms.Compose([transforms.ToTensor(), transforms.Normalize((0.5, 0.5, 0.5), (0.5, 0.5, 0.5))])
classes = ('plane', 'car', 'bird', 'cat', 'deer', 'dog', 'frog', 'horse', 'truck', 'ship')
```

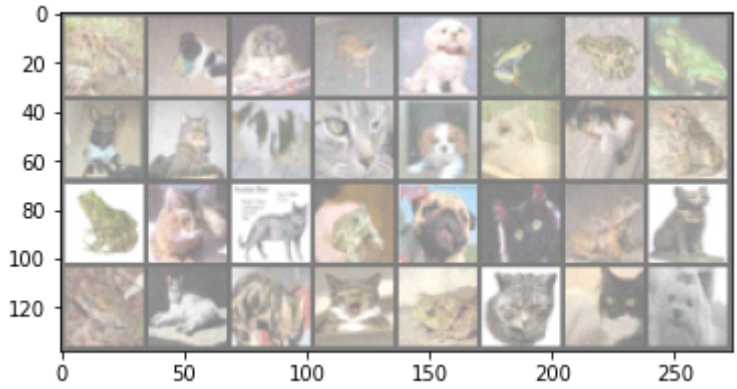
```
LR = 0.001
EPOCH = 30
BATCH_SIZE = 32
```

```
X_train, X_val, y_train, y_val = train_test_split(x_train, y_train,
test_size=0.1)
```

```
# Transform np to tensor
torch_X_train = torch.tensor(X_train)
torch_y_train = torch.tensor(y_train)

torch_X_val = torch.tensor(X_val)
torch_y_val = torch.tensor(y_val)

train = torch.utils.data.TensorDataset(torch_X_train,torch_y_train)
validate = torch.utils.data.TensorDataset(torch_X_val,torch_y_val)

train_loader = torch.utils.data.DataLoader(train, batch_size = BATCH_SIZE,
shuffle = True)
val_loader = torch.utils.data.DataLoader(validate, batch_size = BATCH_SIZE,
shuffle = False)
```

```
train_batch_size = 100
test_batch_size = 4

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

```
def imshow(img):
    img = img / 2 + 0.5     # unnormalize
    npimg = img.numpy()
    plt.imshow(np.transpose(npimg, (1, 2, 0)))
    plt.show()


# get some random training images
dataiter = iter(train_loader)
images, labels = dataiter.next()

# show images
imshow(torchvision.utils.make_grid(images))
# print labels
print(' '.join('%5s' % classes[labels[j].to(dtype=torch.long, device=device)]
for j in range(32)))
```




```
 bird   car   car   car   car  bird  bird  bird   car plane   car plane   car
plane plane  bird  bird plane plane  bird   car plane  bird plane  bird plane
plane plane  bird plane plane   car
```

```
class CNN(nn.Module):
  def __init__(self):
    super(CNN, self).__init__()
    self.conv_layer = nn.Sequential(

      # Conv Layer block 1
      nn.Conv2d(in_channels=3, out_channels=32, kernel_size=3, padding=1),
      nn.BatchNorm2d(32),
      nn.ReLU(inplace=True),
      nn.Conv2d(in_channels=32, out_channels=64, kernel_size=3, padding=1),
      nn.ReLU(inplace=True),
      nn.MaxPool2d(kernel_size=2, stride=2),

      # Conv Layer block 2
      nn.Conv2d(in_channels=64, out_channels=128, kernel_size=3, padding=1),
      nn.BatchNorm2d(128),
      nn.ReLU(inplace=True),
      nn.Conv2d(in_channels=128, out_channels=128, kernel_size=3, padding=1),
      nn.ReLU(inplace=True),
      nn.MaxPool2d(kernel_size=2, stride=2),
      nn.Dropout2d(p=0.05),

      # Conv Layer block 3
      nn.Conv2d(in_channels=128, out_channels=256, kernel_size=3, padding=1),
      nn.BatchNorm2d(256),
      nn.ReLU(inplace=True),
      nn.Conv2d(in_channels=256, out_channels=256, kernel_size=3, padding=1),
      nn.ReLU(inplace=True),
      nn.MaxPool2d(kernel_size=2, stride=2),
    )


    self.fc_layer = nn.Sequential(
      nn.Dropout(p=0.1),
      nn.Linear(4096, 1024),
      nn.ReLU(inplace=True),
      nn.Linear(1024, 512),
      nn.ReLU(inplace=True),
```

```
      nn.Dropout(p=0.1),
      nn.Linear(512, 10)
    )

  def forward(self, x):
    # conv layers
    x = self.conv_layer(x)

    # flatten
    x = x.view(x.size(0), -1)

    # fc layer
    x = self.fc_layer(x)
    return x
```

```
cnn = CNN()
```

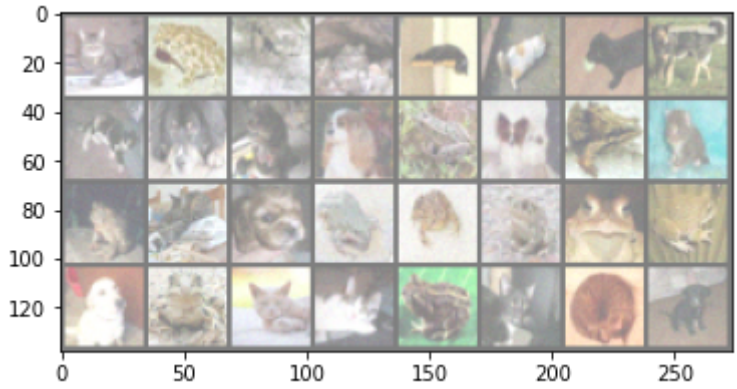
```
cnn.to(device)

loss_func = torch.nn.CrossEntropyLoss()
optimizer = optim.Adam(cnn.parameters(), lr=LR)
```

```
cnn.train()
state_dicts = {}

train_loss = np.zeros(EPOCH)
val_loss = np.zeros(EPOCH)

for epoch in range(EPOCH):
  for data in train_loader:
    X, y = data
    cnn.zero_grad()
    output = cnn(X.to(device))
    y = torch.tensor(y, dtype=torch.int64).cuda()
    loss = loss_func(output, y)
    loss.backward()
    optimizer.step()
    train_loss[epoch] += loss
  # normalizing the loss by the total number of train batches
  train_loss[epoch] /= len(train_loader)

  with torch.no_grad():
    for X, y in val_loader:
      output = cnn(X.to(device))
      y = torch.tensor(y, dtype=torch.int64).cuda()

      loss = loss_func(output, y)
      val_loss[epoch] += loss
    val_loss[epoch] /= len(val_loader)

  state_dicts[epoch] = cnn.state_dict()

  print('epoch %d:\ttrain loss: %.5f\tvalidation loss: %.5f'%(epoch,
train_loss[epoch], val_loss[epoch]))
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:13: UserWarning: To
copy construct from a tensor, it is recommended to use
sourceTensor.clone().detach() or
sourceTensor.clone().detach().requires_grad_(True), rather than
torch.tensor(sourceTensor).
  del sys.path[0]
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:25: UserWarning: To
copy construct from a tensor, it is recommended to use
sourceTensor.clone().detach() or
sourceTensor.clone().detach().requires_grad_(True), rather than
torch.tensor(sourceTensor).
```

```
epoch 0:    train loss: 1.11193 validation loss: 0.89427
epoch 1:    train loss: 0.85057 validation loss: 0.80022
epoch 2:    train loss: 0.79533 validation loss: 0.74824
epoch 3:    train loss: 0.77807 validation loss: 0.74779
epoch 4:    train loss: 0.73314 validation loss: 0.75517
epoch 5:    train loss: 0.70341 validation loss: 0.74348
epoch 6:    train loss: 0.66522 validation loss: 0.71027
epoch 7:    train loss: 0.63123 validation loss: 0.66764
epoch 8:    train loss: 0.58960 validation loss: 0.69164
epoch 9:    train loss: 0.60050 validation loss: 0.72256
epoch 10:   train loss: 0.51912 validation loss: 0.77681
epoch 11:   train loss: 0.48815 validation loss: 0.77865
epoch 12:   train loss: 0.46890 validation loss: 0.82598
epoch 13:   train loss: 0.41462 validation loss: 0.76422
epoch 14:   train loss: 0.39843 validation loss: 0.84519
epoch 15:   train loss: 0.33344 validation loss: 0.81488
epoch 16:   train loss: 0.28483 validation loss: 0.96957
epoch 17:   train loss: 0.29094 validation loss: 0.90185
epoch 18:   train loss: 0.23084 validation loss: 1.03750
epoch 19:   train loss: 0.22168 validation loss: 0.95951
epoch 20:   train loss: 0.19030 validation loss: 1.09441
epoch 21:   train loss: 0.18581 validation loss: 1.32390
epoch 22:   train loss: 0.17048 validation loss: 0.94882
epoch 23:   train loss: 0.12655 validation loss: 1.13644
epoch 24:   train loss: 0.10289 validation loss: 1.50791
epoch 25:   train loss: 0.10550 validation loss: 1.32950
epoch 26:   train loss: 0.08481 validation loss: 1.21565
epoch 27:   train loss: 0.09766 validation loss: 1.52231
epoch 28:   train loss: 0.09045 validation loss: 1.39336
epoch 29:   train loss: 0.08925 validation loss: 1.36211
```

```
dataiter = iter(val_loader)
images, labels = dataiter.next()

# print images
imshow(torchvision.utils.make_grid(images))
print('GroundTruth: ', ' '.join('%5s' % classes[labels[j].to(dtype=torch.long,
device=device)] for j in range(32)))
```




```
GroundTruth:  plane  bird plane  bird plane plane   car   car plane   car plane
car  bird   car  bird plane  bird plane   car  bird  bird  bird  bird  bird   car
bird plane plane  bird plane plane   car
```

```
cnn.cpu().eval()

output_train = cnn(torch_X_train.cpu()).cpu().detach().numpy().argmax(axis=1)
output_val = cnn(torch_X_val.cpu()).cpu().detach().numpy().argmax(axis=1)

print('Training accuracy:\t%.3f'%(sum(output_train == y_train)/len(y_train)))
print('Validation accuracy:\t%.3f'%(sum(output_val == y_val)/len(y_val)))
```

```
Training accuracy:  0.991
Validation accuracy:    0.710
```

```
prediction = cnn(torch.from_numpy(x_test)).cpu().detach().numpy().argmax(axis=1)
```

```
print(prediction[19])
```

```
0
```

```
assert prediction.ndim == 1
assert prediction.shape[0] == 300
```

```
np.save('prediction.npy', prediction.astype(int))
```