TP1 - UnsharpMask-AlexNet

October 30, 2022

TP 01

3. (40 puntos) Redes convolucionales para detección de glaucoma en imágenes de fondo de ojo.

[ ]:
```
from __future__ import print_function
import argparse
import torch
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim
from torchvision import datasets, transforms
from torch.optim.lr_scheduler import StepLR
import numpy as np
import torch
import torchvision
import matplotlib.pyplot as plt
from time import time
from torchvision import datasets, transforms
from torchvision.io import read_image
from torch import nn, optim
from matplotlib import cm
from matplotlib import style
from matplotlib.pyplot import imshow
#%matplotlib widget
%matplotlib inline
style.use('default')
```

3.1. (20 puntos) Implemente el filtro de «Unsharp masking» para la mejora de las imágenes, según lo especificado en el material del curso.

Una explicación más amplia puede ser encontrada en el documento TP-01.pdf

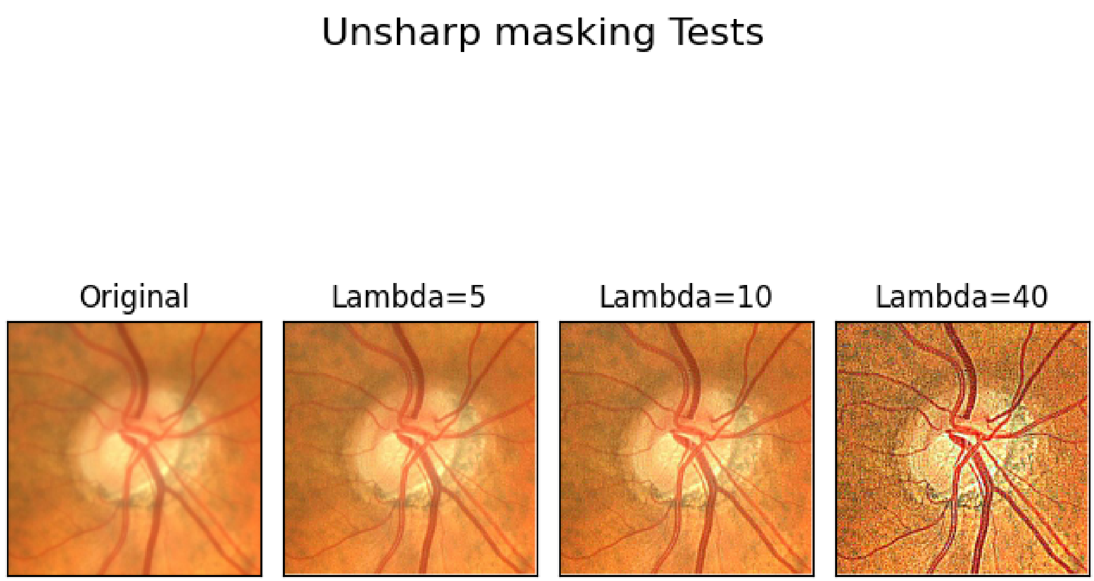
[ ]:
```
#Gaussian blur filter
def gaussian_blur():
    #Gaussian blur filter
```

```python
    F = torch.tensor([[0.0625,0.125,0.0625],[0.125,0.25,0.125],[0.0625,0.125,0.
↪0625]]).float()
    return F

# Determine the new image size after the filter is applied.
def calculate_target_size(img_size: int, kernel_size: int) -> int:
    num_pixels = 0

    # From 0 up to img size (if img size = 224, then up to 223)
    for i in range(img_size):
        # Add the kernel size (let's say 3) to the current i
        added = i + kernel_size
        # It must be lower than the image size
        if added <= img_size:
            # Increment if so
            num_pixels += 1

    return num_pixels

#Manual convlution method for 3 channel images.
def convolution(U,F):

    new_size = calculate_target_size(img_size=U.shape[1],kernel_size=U.shape[0])

    kernel=F

    kernel_shape = kernel.shape[0]

    conv_img = torch.zeros(3,new_size,new_size)

    for g in range(3):
        for i in range(new_size):
            for j in range(new_size):
                mat = U[g,i:i+kernel_shape,j:j+kernel_shape]
                conv_img[g, i, j] = torch.sum(torch.multiply(mat,kernel))

    #Add padding to the convuluted image so the size is the same for original␣
↪and convoluted image.
    conv_img=torchvision.transforms.Pad(1)(conv_img)

    return conv_img

def unsharp_masking(U,amount):
    return U + (U-convolution(U,gaussian_blur())) * amount

#Test with one of the images of the dataset.
```

```python
U = read_image(r'.\dataset_train_test\dataset_train_test\train\0\Im107_ACRIMA.
  ↪jpg') / 255
U=torchvision.transforms.Resize(227)(U)
print(U.shape)

#To normalize the values for each pixel.
def disp(x): return (x.clamp(0,1) * 255).byte().permute(1,2,0).cpu()

#Plot the images with the unsharp masking filter applied.
fig, (ax, bx, cx, dx) = plt.subplots(1,4,constrained_layout=True)
fig.suptitle('Unsharp masking Tests', fontsize=16)
ax.set_title("Original")
ax.set_yticklabels([])
ax.set_xticklabels([])
ax.set_xticks([])
ax.set_yticks([])
ax.imshow(disp(U))

bx.set_title("Lambda=5")
bx.set_yticklabels([])
bx.set_xticklabels([])
bx.set_xticks([])
bx.set_yticks([])
bx.imshow(disp(unsharp_masking(U,5)))

cx.set_title("Lambda=10")
cx.set_yticklabels([])
cx.set_xticklabels([])
cx.set_xticks([])
cx.set_yticks([])
cx.imshow(disp(unsharp_masking(U,10)))

dx.set_title("Lambda=40")
dx.set_yticklabels([])
dx.set_xticklabels([])
dx.set_xticks([])
dx.set_yticks([])
dx.imshow(disp(unsharp_masking(U,40)))

#plt.tight_layout(pad=0.4, w_pad=0.5, h_pad=1.0)
```

```
torch.Size([3, 227, 227])
```

[ ]:
```
<matplotlib.image.AxesImage at 0x27f079e1f30>
```



Inicio de sección para definir el modelo AlexNet.

Resize images

```
[ ]: #AlexNet model uses images 227x227.
img_size = 227

#No normalization as document says.
transform = transforms.Compose([transforms.ToTensor(),
                                transforms.Resize((img_size, img_size))])
```

```
[ ]: #Code just to ease the load from local folder
import os
print(os.listdir("."))

from os import walk
for (dirpath, dirnames, filenames) in walk("."):
    print("Directory path: ", dirpath)
    print("Folder name: ", dirnames)
#     print("File name: ", filenames)
```

```
['#TP_1_Optimizacion_Redes_Neuronales.lyx#', 'dataset_train_test',
'dataset_train_test.zip', 'PAPILA_dataset.pdf', 'Punto 3.lyx', 'Readme.txt',
'Results.md', 'Results.txt', 'Results_Selected_LR.md', 'Results_v2.md',
'Tests.docx', 'TP1 - Newton-Rhapson.ipynb', 'TP1 - Optimizacion de
Funciones.ipynb', 'TP1 - Perceptron multi-capa - propEntregable-Juan-PC.ipynb',
'TP1 - Perceptron multi-capa - propEntregable.ipynb', 'TP1 - Perceptron multi-
capa - propEntregablev2.pdf', 'TP1 - Perceptron multi-capa.ipynb', 'TP1 -
```

```
UnsharpMask-AlexNet.ipynb', 'TP1 - UnsharpMask-AlexNet.pdf', 'TP_01.pdf',
'TP_1_Optimizacion_Redes_Neuronales.lyx',
'TP_1_Optimizacion_Redes_Neuronales.lyx~',
'TP_1_Optimizacion_Redes_Neuronales.pdf']
Directory path:  .
Folder name:  ['dataset_train_test']
Directory path:  .\dataset_train_test
Folder name:  ['dataset_train_test']
Directory path:  .\dataset_train_test\dataset_train_test
Folder name:  ['test', 'train']
Directory path:  .\dataset_train_test\dataset_train_test\test
Folder name:  ['0', '1']
Directory path:  .\dataset_train_test\dataset_train_test\test\0
Folder name:  []
Directory path:  .\dataset_train_test\dataset_train_test\test\1
Folder name:  []
Directory path:  .\dataset_train_test\dataset_train_test\train
Folder name:  ['0', '1']
Directory path:  .\dataset_train_test\dataset_train_test\train\0
Folder name:  []
Directory path:  .\dataset_train_test\dataset_train_test\train\1
Folder name:  []
```

Load the dataset

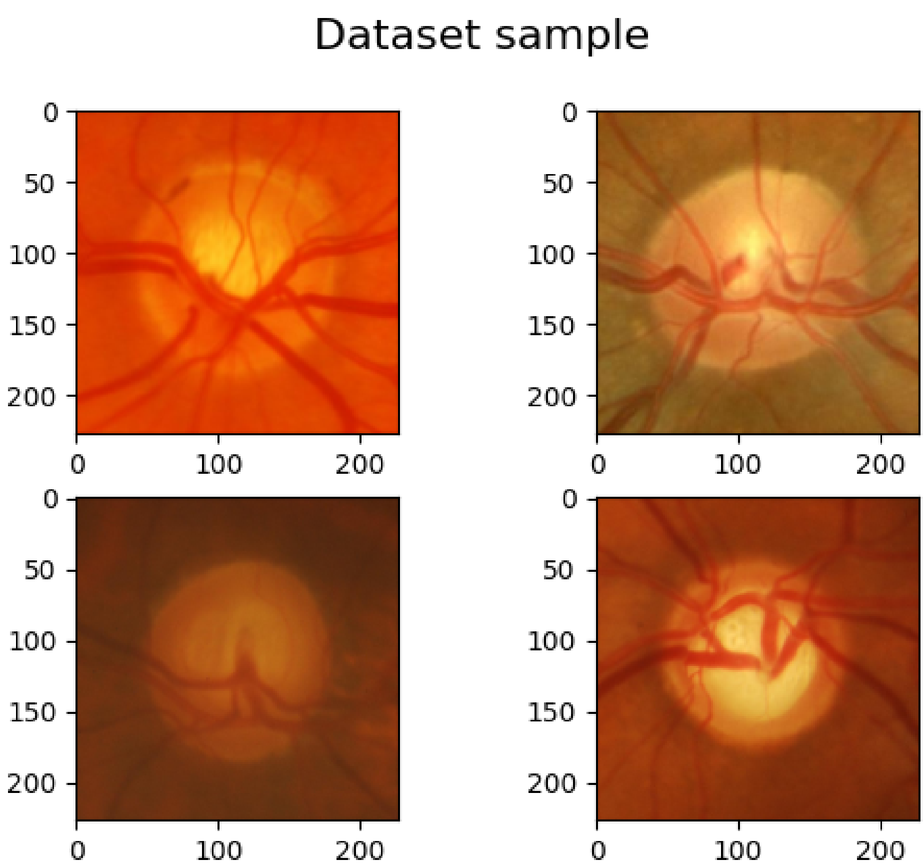
[ ]:
```
def load_test_train_data_tp1():
    trainset = torchvision.datasets.ImageFolder(r'.
↪\dataset_train_test\dataset_train_test\train',transform = transform)
    trainloader = torch.utils.data.DataLoader(trainset, batch_size=32,␣
↪shuffle=True)

    testset = torchvision.datasets.ImageFolder(r'.
↪\dataset_train_test\dataset_train_test\test',transform = transform)
    testloader = torch.utils.data.DataLoader(testset, batch_size=32,␣
↪shuffle=True)
    return trainloader, testloader

trainloader, testloader = load_test_train_data_tp1()
dataiter = iter(trainloader) # creating a iterator
images, labels = dataiter.next() # creating images for image and lables for␣
↪image number (0 to 9)

print(images.mT.shape)

fig, axs = plt.subplots(2,2)
fig.suptitle("Dataset sample", fontsize=16)
axs[0,0].imshow(images[0].T.numpy().squeeze(), cmap='gray_r')
```

```
axs[0,1].imshow(images[1].T.numpy().squeeze(), cmap='gray_r')
axs[1,0].imshow(images[2].T.numpy().squeeze(), cmap='gray_r')
axs[1,1].imshow(images[3].T.numpy().squeeze(), cmap='gray_r')
```

```
torch.Size([32, 3, 227, 227])
```

```
C:\Users\jcord\AppData\Local\Temp\ipykernel_41920\629819469.py:17: UserWarning:
The use of `x.T` on tensors of dimension other than 2 to reverse their shape is
deprecated and it will throw an error in a future release. Consider `x.mT` to
transpose batches of matricesor `x.permute(*torch.arange(x.ndim - 1, -1, -1))`
to reverse the dimensions of a tensor. (Triggered internally at
..\aten\src\ATen\native\TensorShape.cpp:2985.)
  axs[0,0].imshow(images[0].T.numpy().squeeze(), cmap='gray_r')
```

```
[ ]: <matplotlib.image.AxesImage at 0x27f09f96170>
```



3.2. (20 puntos) Implemente manualmente (especificando las capas) en pytorch la arquitectura de AlexNet. Entrene la red usando el conjunto de datos de imágenes de fondo de ojo. Calibre los hiper-parámetros necesarios para obtener los mejores resultados posibles y reportelos. Ejecute el entrenamiento 10 veces por 15 épocas por corrida, y reporte la tasa de aciertos, falsos positivos y falsos negativos promedio y su desviación estándar para esas 10 corridas.

[ ]:
```
#AlexNet model definition, we use as reference the published paper "ImageNet␣
↪Classification with Deep Convolutional Neural Networks" and the provided␣
↪documentation from previous classes.
def create_AlexNet_model():
    class AlexNet(nn.Module):
        def __init__(self):
            super(AlexNet, self).__init__()

            self.layer1 = nn.Sequential(
                nn.Conv2d(3, 96, kernel_size=11, stride=4, padding=0),
                nn.BatchNorm2d(96),
                nn.ReLU(),
                nn.MaxPool2d(kernel_size = 3, stride = 2))
            self.layer2 = nn.Sequential(
                nn.Conv2d(96, 256, kernel_size=5, stride=1, padding=2),
                nn.BatchNorm2d(256),
                nn.ReLU(),
                nn.MaxPool2d(kernel_size = 3, stride = 2))
            self.layer3 = nn.Sequential(
                nn.Conv2d(256, 384, kernel_size=3, stride=1, padding=1),
                nn.BatchNorm2d(384),
                nn.ReLU())
            self.layer4 = nn.Sequential(
                nn.Conv2d(384, 384, kernel_size=3, stride=1, padding=1),
                nn.BatchNorm2d(384),
                nn.ReLU())
            self.layer5 = nn.Sequential(
                nn.Conv2d(384, 256, kernel_size=3, stride=1, padding=1),
                nn.BatchNorm2d(256),
                nn.ReLU(),
                nn.MaxPool2d(kernel_size = 3, stride = 2))
            self.fc = nn.Sequential(
                nn.Dropout(0.5),
                nn.Linear(9216, 4096),
                nn.ReLU())
            self.fc1 = nn.Sequential(
                nn.Dropout(0.5),
                nn.Linear(4096, 4096),
                nn.ReLU())
            self.fc2= nn.Sequential(
```

```python
                nn.Linear(4096, 2),nn.LogSoftmax(dim=1))
                #nn.Linear(4096, 2),nn.Softmax(dim=1))

        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 = out.reshape(out.size(0), -1)
            out = self.fc(out)
            out = self.fc1(out)
            out = self.fc2(out)
            return out

    cnn = AlexNet()
    return cnn


device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')
cnn_model = create_AlexNet_model()
cnn_model.to(device)
#Error function
criterion = nn.NLLLoss()

print("AlexNet model: ")
print(cnn_model)
```

```
AlexNet model:
AlexNet(
  (layer1): Sequential(
    (0): Conv2d(3, 96, kernel_size=(11, 11), stride=(4, 4))
    (1): BatchNorm2d(96, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): ReLU()
    (3): MaxPool2d(kernel_size=3, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (layer2): Sequential(
    (0): Conv2d(96, 256, kernel_size=(5, 5), stride=(1, 1), padding=(2, 2))
    (1): BatchNorm2d(256, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): ReLU()
    (3): MaxPool2d(kernel_size=3, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (layer3): Sequential(
    (0): Conv2d(256, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
```

```
    (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): ReLU()
  )
  (layer4): Sequential(
    (0): Conv2d(384, 384, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): BatchNorm2d(384, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
    (2): ReLU()
  )
  (layer5): Sequential(
    (0): Conv2d(384, 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): ReLU()
    (3): MaxPool2d(kernel_size=3, stride=2, padding=0, dilation=1,
ceil_mode=False)
  )
  (fc): Sequential(
    (0): Dropout(p=0.5, inplace=False)
    (1): Linear(in_features=9216, out_features=4096, bias=True)
    (2): ReLU()
  )
  (fc1): Sequential(
    (0): Dropout(p=0.5, inplace=False)
    (1): Linear(in_features=4096, out_features=4096, bias=True)
    (2): ReLU()
  )
  (fc2): Sequential(
    (0): Linear(in_features=4096, out_features=2, bias=True)
    (1): LogSoftmax(dim=1)
  )
)
```

[ ]:
```
#This code trains the model previously constructed with the loaded dataset from
 ↪previous steps.
def train_model(model, criterion, epochs = 15, lr = 0.01, is_MLP = False):

    time0 = time()
    running_loss_list= []
    epochs_list = []
    optimizer = optim.SGD(model.parameters(), lr= lr, momentum=0.9)
    for e in range(epochs):
        running_loss = 0

        #go for every batch
        for images, labels in trainloader:
```

```python
            #move data to specific device
            images = images.to(device)
            labels = labels.to(device)
            # Flatenning MNIST images with size [64,784] (for MLP)
            if(is_MLP):
              images = images.view(images.shape[0], -1)

            # defining gradient in each epoch as 0
            optimizer.zero_grad()
            # modeling for each image batch
            output = model(images)

            # calculating the loss
            loss = criterion(output, labels)

            # This is where the model learns by backpropagating
            loss.backward()

            # And optimizes its weights here
            optimizer.step()

            # calculating the loss
            running_loss += loss.item()

        else:
            print("- Epoch {} - Training loss: {}".format(e, running_loss/
 ↪len(trainloader)))
    print("\nTraining Time (in minutes) =",(time()-time0)/60)
    return model

print("### Training AlexNet model")
cnn_model = train_model(cnn_model, criterion, epochs = 15, lr = 0.01, is_MLP =␣
 ↪False)
```

```
### Training AlexNet model
- Epoch 0 - Training loss: 0.5225886087864637
- Epoch 1 - Training loss: 0.3469889238476753
- Epoch 2 - Training loss: 0.28907499369233847
- Epoch 3 - Training loss: 0.2131674624979496
- Epoch 4 - Training loss: 0.19003896368667483
- Epoch 5 - Training loss: 0.20702171605080366
- Epoch 6 - Training loss: 0.15682306489907205
- Epoch 7 - Training loss: 0.1703691139118746
- Epoch 8 - Training loss: 0.13560482603497803
- Epoch 9 - Training loss: 0.13303680554963648
- Epoch 10 - Training loss: 0.14810354763176292
- Epoch 11 - Training loss: 0.09577572834677994
- Epoch 12 - Training loss: 0.12820055824704468
```

```
- Epoch 13 - Training loss: 0.11982646654359996
- Epoch 14 - Training loss: 0.08340773831878323

Training Time (in minutes) = 0.6707083900769552
```

[ ]:
```python
#Test the model.
def test_model_cnn(testloader, model):
  correct_count, all_count, false_positive = 0, 0, 0
  for images,labels in testloader:
    #move data to specific device
    images = images.to(device)
    labels = labels.to(device)
    #get model output
    with torch.no_grad():
      outputs = model(images)
    for i in range(len(labels)):
      #apply exp as the activation function has the log
      output_observation = torch.exp(outputs[i, :])
      #get predicted label
      output_observation_np = list(output_observation.cpu().numpy())
      pred_label = output_observation_np.index(max(output_observation_np))
      #get the label
      true_label = labels.cpu().numpy()[i]
      if(true_label == pred_label):
        correct_count += 1
      else:
        if(true_label==0):
            false_positive += 1
      all_count += 1

  print("")
  print("- Number Of Images Tested =", all_count)
  print("- Number Of Correct Tests =", correct_count)
  print("- Number Of Incorrect Tests =", all_count - correct_count)
  print("- Number Of False Positive Tests =", false_positive)
  print("- Number Of False Negative Tests =", (all_count - correct_count) -␣
 ↪false_positive)
  print("\nModel Accuracy (Average) =", np.round((correct_count/
 ↪all_count)*100,4),"%")

print("### Testing AlexNet model")
test_model_cnn(testloader, cnn_model)
```

```
### Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 197
- Number Of Incorrect Tests = 13
```

```
- Number Of False Positive Tests = 10
- Number Of False Negative Tests = 3

Model Accuracy (Average) = 93.8095 %
```

```
[ ]: #Calculate the Standard deviation for the different runs with learning rates.
results=[178,169,204,196,192,187,197,200,199,201]
results2=[201,200,200,199,199,189,194,202,197,202]

print("Stadard deviation:",np.std(results))
print("Stadard deviation:",np.std(results2))
```

```
Stadard deviation: 10.621205204683694
Stadard deviation: 3.848376280978771
```

1 Iterations to find the best LR for the model.

1.1 Iteration 1

1.1.1 Training AlexNet model

- Epoch 0 - Training loss: 3.466971807181835
- Epoch 1 - Training loss: 0.9399996288120747
- Epoch 2 - Training loss: 0.952039822936058
- Epoch 3 - Training loss: 0.6585316099226475
- Epoch 4 - Training loss: 0.4611892681568861
- Epoch 5 - Training loss: 0.4217939144000411
- Epoch 6 - Training loss: 0.42551492247730494
- Epoch 7 - Training loss: 0.3356456020846963
- Epoch 8 - Training loss: 0.33745836978778243
- Epoch 9 - Training loss: 0.31369887571781874
- Epoch 10 - Training loss: 0.276780785061419
- Epoch 11 - Training loss: 0.293039171025157
- Epoch 12 - Training loss: 0.27116969507187605
- Epoch 13 - Training loss: 0.2118628853932023
- Epoch 14 - Training loss: 0.21507969964295626

Training Time (in minutes) = 0.6591819167137146

1.1.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 178
- Number Of Incorrect Tests = 32
- Number Of False Positive Tests = 29
- Number Of False Negative Tests = 3

Model Accuracy (Average) = 84.7619 %

1.2 Iteration 2

1.2.1 Training AlexNet model

- Epoch 0 - Training loss: 3.2027845717966557
- Epoch 1 - Training loss: 0.9780878517776728
- Epoch 2 - Training loss: 1.1219577118754387
- Epoch 3 - Training loss: 0.795509222894907
- Epoch 4 - Training loss: 0.6494000591337681
- Epoch 5 - Training loss: 0.4571275878697634
- Epoch 6 - Training loss: 0.5303807053714991
- Epoch 7 - Training loss: 0.5396288810297847
- Epoch 8 - Training loss: 0.386084558442235
- Epoch 9 - Training loss: 0.30447541922330856
- Epoch 10 - Training loss: 0.4157729558646679
- Epoch 11 - Training loss: 0.45481853000819683
- Epoch 12 - Training loss: 0.4249056512489915
- Epoch 13 - Training loss: 0.6059059808030725
- Epoch 14 - Training loss: 0.6093654371798038

Training Time (in minutes) = 0.607205065091451

1.2.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 169
- Number Of Incorrect Tests = 41
- Number Of False Positive Tests = 11
- Number Of False Negative Tests = 30

Model Accuracy (Average) = 80.4762 %

2 LR 0.01

2.1 Iteration 1

2.1.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5268608136102557
- Epoch 1 - Training loss: 0.36485178279690444
- Epoch 2 - Training loss: 0.32854316430166364
- Epoch 3 - Training loss: 0.2671946748159826
- Epoch 4 - Training loss: 0.28669610945507884
- Epoch 5 - Training loss: 0.21644524508155882
- Epoch 6 - Training loss: 0.16123293130658567
- Epoch 7 - Training loss: 0.14714646944776177
- Epoch 8 - Training loss: 0.12932269531302154
- Epoch 9 - Training loss: 0.09250835710554384
- Epoch 10 - Training loss: 0.06334813521243632
- Epoch 11 - Training loss: 0.11503208964131773
- Epoch 12 - Training loss: 0.08692139474442229

- Epoch 13 - Training loss: 0.07841975153132807
- Epoch 14 - Training loss: 0.054170610499568284

Training Time (in minutes) = 0.6602014263470968

2.1.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 204
- Number Of Incorrect Tests = 6
- Number Of False Positive Tests = 5
- Number Of False Negative Tests = 1

Model Accuracy (Average) = 97.1429 %

2.2 Iteration 2

2.2.1 Training AlexNet model

- Epoch 0 - Training loss: 0.6366985570639372
- Epoch 1 - Training loss: 0.3185109249316156
- Epoch 2 - Training loss: 0.28442566376179457
- Epoch 3 - Training loss: 0.26357863703742623
- Epoch 4 - Training loss: 0.2341797649860382
- Epoch 5 - Training loss: 0.16988179099280387
- Epoch 6 - Training loss: 0.21602441067807376
- Epoch 7 - Training loss: 0.17573917703703046
- Epoch 8 - Training loss: 0.14310844847932458
- Epoch 9 - Training loss: 0.1454107970930636
- Epoch 10 - Training loss: 0.2047864175401628
- Epoch 11 - Training loss: 0.14335097861476243
- Epoch 12 - Training loss: 0.09782545431517065
- Epoch 13 - Training loss: 0.06703998637385666
- Epoch 14 - Training loss: 0.11145321454387158

Training Time (in minutes) = 0.6667162219683329

2.2.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 196
- Number Of Incorrect Tests = 14
- Number Of False Positive Tests = 13
- Number Of False Negative Tests = 1

Model Accuracy (Average) = 93.3333 %

3 LR 0.03

3.1 Iteration 1

3.1.1 Training AlexNet model

- Epoch 0 - Training loss: 1.0302603468298912
- Epoch 1 - Training loss: 0.45345357339829206
- Epoch 2 - Training loss: 0.3365689655765891
- Epoch 3 - Training loss: 0.26739984890446067
- Epoch 4 - Training loss: 0.3605161104351282
- Epoch 5 - Training loss: 0.47764685400761664
- Epoch 6 - Training loss: 0.4796533677726984
- Epoch 7 - Training loss: 0.4083690168336034
- Epoch 8 - Training loss: 0.33933584252372384
- Epoch 9 - Training loss: 0.2630862295627594
- Epoch 10 - Training loss: 0.21916685719043016
- Epoch 11 - Training loss: 0.21095802541822195
- Epoch 12 - Training loss: 0.20188841805793345
- Epoch 13 - Training loss: 0.1648359466344118
- Epoch 14 - Training loss: 0.21207927912473679

Training Time (in minutes) = 0.6647823890050252

3.1.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 192
- Number Of Incorrect Tests = 18
- Number Of False Positive Tests = 11
- Number Of False Negative Tests = 7

Model Accuracy (Average) = 91.4286 %

3.2 Iteration 2

3.2.1 Training AlexNet model

- Epoch 0 - Training loss: 0.9282141793519258
- Epoch 1 - Training loss: 0.5215244069695473
- Epoch 2 - Training loss: 0.37275474704802036
- Epoch 3 - Training loss: 0.34664025204256177
- Epoch 4 - Training loss: 0.2715222854167223
- Epoch 5 - Training loss: 0.2910944181494415
- Epoch 6 - Training loss: 0.2167084941174835
- Epoch 7 - Training loss: 0.2808607262559235
- Epoch 8 - Training loss: 0.18767674174159765
- Epoch 9 - Training loss: 0.1599291751626879
- Epoch 10 - Training loss: 0.14636856876313686
- Epoch 11 - Training loss: 0.27479725051671267
- Epoch 12 - Training loss: 0.2056130883283913

- Epoch 13 - Training loss: 0.12557432753965259
- Epoch 14 - Training loss: 0.16885096044279635

Training Time (in minutes) = 0.662312551339467

3.2.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 187
- Number Of Incorrect Tests = 23
- Number Of False Positive Tests = 13
- Number Of False Negative Tests = 10

Model Accuracy (Average) = 89.0476 %

4 LR 0.001

4.1 Iteration 1

4.1.1 Training AlexNet model

- Epoch 0 - Training loss: 0.6168640349060297
- Epoch 1 - Training loss: 0.37503026332706213
- Epoch 2 - Training loss: 0.254258350469172
- Epoch 3 - Training loss: 0.197203631978482
- Epoch 4 - Training loss: 0.16206020605750382
- Epoch 5 - Training loss: 0.10539843933656812
- Epoch 6 - Training loss: 0.10225343646015972
- Epoch 7 - Training loss: 0.10801735194399953
- Epoch 8 - Training loss: 0.0743315308354795
- Epoch 9 - Training loss: 0.06271188193932176
- Epoch 10 - Training loss: 0.09256057703169063
- Epoch 11 - Training loss: 0.08587920889840461
- Epoch 12 - Training loss: 0.07660054255393334
- Epoch 13 - Training loss: 0.06289002274570521
- Epoch 14 - Training loss: 0.057205728779081255

Training Time (in minutes) = 0.6677144169807434

4.1.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 197
- Number Of Incorrect Tests = 13
- Number Of False Positive Tests = 10
- Number Of False Negative Tests = 3

Model Accuracy (Average) = 93.8095 %

4.2 Iteration 2

4.2.1 Training AlexNet model

- Epoch 0 - Training loss: 0.6078770775347948
- Epoch 1 - Training loss: 0.39860402047634125
- Epoch 2 - Training loss: 0.24782513547688723
- Epoch 3 - Training loss: 0.16746533662080765
- Epoch 4 - Training loss: 0.146248915232718
- Epoch 5 - Training loss: 0.1514138780767098
- Epoch 6 - Training loss: 0.16407515364699066
- Epoch 7 - Training loss: 0.11562630801927298
- Epoch 8 - Training loss: 0.14460704755038023
- Epoch 9 - Training loss: 0.10818295297212899
- Epoch 10 - Training loss: 0.14389787235995755
- Epoch 11 - Training loss: 0.10175285791046917
- Epoch 12 - Training loss: 0.060109812300652266
- Epoch 13 - Training loss: 0.07298974407603964
- Epoch 14 - Training loss: 0.05707933095982298

Training Time (in minutes) = 0.6617880225181579

4.2.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 200
- Number Of Incorrect Tests = 10
- Number Of False Positive Tests = 6
- Number Of False Negative Tests = 4

Model Accuracy (Average) = 95.2381 %

5 LR 0.003

5.1 Iteration 1

5.1.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5228672819212079
- Epoch 1 - Training loss: 0.269591985270381
- Epoch 2 - Training loss: 0.2607145691290498
- Epoch 3 - Training loss: 0.27450465923175216
- Epoch 4 - Training loss: 0.21667040698230267
- Epoch 5 - Training loss: 0.12245651171542704
- Epoch 6 - Training loss: 0.10470462404191494
- Epoch 7 - Training loss: 0.10666289302753285
- Epoch 8 - Training loss: 0.15507071488536894
- Epoch 9 - Training loss: 0.09623848146293312
- Epoch 10 - Training loss: 0.14152563572861254
- Epoch 11 - Training loss: 0.06552151427604258
- Epoch 12 - Training loss: 0.0856551329488866

- Epoch 13 - Training loss: 0.14494903443846852
- Epoch 14 - Training loss: 0.08557249215664342

Training Time (in minutes) = 0.6544925491015117

5.1.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 199
- Number Of Incorrect Tests = 11
- Number Of False Positive Tests = 8
- Number Of False Negative Tests = 3

Model Accuracy (Average) = 94.7619 %

5.2 Iteration 2

5.2.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5628637429326773
- Epoch 1 - Training loss: 0.3033822262659669
- Epoch 2 - Training loss: 0.3228445006534457
- Epoch 3 - Training loss: 0.22633983753621578
- Epoch 4 - Training loss: 0.1398478897754103
- Epoch 5 - Training loss: 0.14360721892444417
- Epoch 6 - Training loss: 0.09442094946280122
- Epoch 7 - Training loss: 0.1280532939126715
- Epoch 8 - Training loss: 0.14722494152374566
- Epoch 9 - Training loss: 0.11674903135281056
- Epoch 10 - Training loss: 0.1385550900013186
- Epoch 11 - Training loss: 0.1921572414576076
- Epoch 12 - Training loss: 0.08083704556338489
- Epoch 13 - Training loss: 0.0674521844193805
- Epoch 14 - Training loss: 0.04642577370395884

Training Time (in minutes) = 0.6493113875389099

5.2.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 201
- Number Of Incorrect Tests = 9
- Number Of False Positive Tests = 5
- Number Of False Negative Tests = 4

Model Accuracy (Average) = 95.7143 %

6 Iterations with the most effective LR from previous results.

6.1 Iteration 1

6.1.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5308702872134745
- Epoch 1 - Training loss: 0.34413944836705923
- Epoch 2 - Training loss: 0.2154903169721365
- Epoch 3 - Training loss: 0.2519296268001199
- Epoch 4 - Training loss: 0.19924818631261587
- Epoch 5 - Training loss: 0.15996037819422781
- Epoch 6 - Training loss: 0.19673094467725605
- Epoch 7 - Training loss: 0.23595069209113717
- Epoch 8 - Training loss: 0.2189934141933918
- Epoch 9 - Training loss: 0.14924236747901887
- Epoch 10 - Training loss: 0.09013659821357578
- Epoch 11 - Training loss: 0.12533322736635455
- Epoch 12 - Training loss: 0.1657326394924894
- Epoch 13 - Training loss: 0.2884815914439969
- Epoch 14 - Training loss: 0.1533323919866234

Training Time (in minutes) = 0.6589006265004476

6.1.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 201
- Number Of Incorrect Tests = 9
- Number Of False Positive Tests = 9
- Number Of False Negative Tests = 0

Model Accuracy (Average) = 95.7143 %

6.2 Iteración 2

6.2.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5838161334395409
- Epoch 1 - Training loss: 0.26516671385616064
- Epoch 2 - Training loss: 0.25891397055238485
- Epoch 3 - Training loss: 0.3431774126365781
- Epoch 4 - Training loss: 0.17082885233685374
- Epoch 5 - Training loss: 0.1864396990276873
- Epoch 6 - Training loss: 0.180886602262035
- Epoch 7 - Training loss: 0.09420285071246326
- Epoch 8 - Training loss: 0.1333982462529093
- Epoch 9 - Training loss: 0.1327831633388996
- Epoch 10 - Training loss: 0.11631085001863539
- Epoch 11 - Training loss: 0.3085051323287189
- Epoch 12 - Training loss: 0.1480462634935975

- Epoch 13 - Training loss: 0.11217899667099118
- Epoch 14 - Training loss: 0.12088108214084059

Training Time (in minutes) = 0.6482124169667561

6.2.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 200
- Number Of Incorrect Tests = 10
- Number Of False Positive Tests = 8
- Number Of False Negative Tests = 2

Model Accuracy (Average) = 95.2381 %

6.3 Iteración 3

6.3.1 Training AlexNet model

- Epoch 0 - Training loss: 0.7509719282388687
- Epoch 1 - Training loss: 0.2958024418912828
- Epoch 2 - Training loss: 0.22924863640218973
- Epoch 3 - Training loss: 0.2566783418878913
- Epoch 4 - Training loss: 0.2210758300498128
- Epoch 5 - Training loss: 0.19292264338582754
- Epoch 6 - Training loss: 0.1234274567104876
- Epoch 7 - Training loss: 0.1693486931035295
- Epoch 8 - Training loss: 0.1386352542322129
- Epoch 9 - Training loss: 0.1979184893425554
- Epoch 10 - Training loss: 0.2827359460061416
- Epoch 11 - Training loss: 0.14630640065297484
- Epoch 12 - Training loss: 0.12799807777628303
- Epoch 13 - Training loss: 0.12139281915733591
- Epoch 14 - Training loss: 0.07890019522164948

Training Time (in minutes) = 0.6458194335301717

6.3.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 200
- Number Of Incorrect Tests = 10
- Number Of False Positive Tests = 8
- Number Of False Negative Tests = 2

Model Accuracy (Average) = 95.2381 %

6.4 Iteración 4

6.4.1 Training AlexNet model

- Epoch 0 - Training loss: 0.543658141978085

- Epoch 1 - Training loss: 0.34045443776994944
- Epoch 2 - Training loss: 0.330774066504091
- Epoch 3 - Training loss: 0.1981811875011772
- Epoch 4 - Training loss: 0.1547465065959841
- Epoch 5 - Training loss: 0.1549253291450441
- Epoch 6 - Training loss: 0.19524431275203824
- Epoch 7 - Training loss: 0.1687006156425923
- Epoch 8 - Training loss: 0.11686989292502403
- Epoch 9 - Training loss: 0.11533798687742092
- Epoch 10 - Training loss: 0.09199532237835228
- Epoch 11 - Training loss: 0.0928747346624732
- Epoch 12 - Training loss: 0.1250686552375555
- Epoch 13 - Training loss: 0.07316915702540427
- Epoch 14 - Training loss: 0.06854432070394978

Training Time (in minutes) = 0.6535166343053181

6.4.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 199
- Number Of Incorrect Tests = 11
- Number Of False Positive Tests = 6
- Number Of False Negative Tests = 5

Model Accuracy (Average) = 94.7619 %

6.5 Iteración 5

6.5.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5710061891004443
- Epoch 1 - Training loss: 0.4020601874217391
- Epoch 2 - Training loss: 0.28762456262484193
- Epoch 3 - Training loss: 0.23016119142994285
- Epoch 4 - Training loss: 0.2277387590147555
- Epoch 5 - Training loss: 0.19834735454060137
- Epoch 6 - Training loss: 0.228271946310997
- Epoch 7 - Training loss: 0.17112461850047112
- Epoch 8 - Training loss: 0.15008161449804902
- Epoch 9 - Training loss: 0.15071341372095048
- Epoch 10 - Training loss: 0.18041065149009228
- Epoch 11 - Training loss: 0.12974811671301723
- Epoch 12 - Training loss: 0.17385044135153294
- Epoch 13 - Training loss: 0.21264251112006605
- Epoch 14 - Training loss: 0.1661136207403615

Training Time (in minutes) = 0.6414668917655945

6.5.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 199
- Number Of Incorrect Tests = 11
- Number Of False Positive Tests = 10
- Number Of False Negative Tests = 1

Model Accuracy (Average) = 94.7619 %

6.6 Iteración 6

6.6.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5429478716105223
- Epoch 1 - Training loss: 0.3992093740962446
- Epoch 2 - Training loss: 0.265152620151639
- Epoch 3 - Training loss: 0.2643177786376327
- Epoch 4 - Training loss: 0.17137902416288853
- Epoch 5 - Training loss: 0.19788075401447713
- Epoch 6 - Training loss: 0.13462823093868792
- Epoch 7 - Training loss: 0.14164923666976392
- Epoch 8 - Training loss: 0.1728191734291613
- Epoch 9 - Training loss: 0.12383430707268417
- Epoch 10 - Training loss: 0.15252250665798783
- Epoch 11 - Training loss: 0.06717505818232894
- Epoch 12 - Training loss: 0.09659433740307577
- Epoch 13 - Training loss: 0.08396052313037217
- Epoch 14 - Training loss: 0.08706771291326731

Training Time (in minutes) = 0.6404974540074666

6.6.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 189
- Number Of Incorrect Tests = 21
- Number Of False Positive Tests = 20
- Number Of False Negative Tests = 1

Model Accuracy (Average) = 90.0 %

6.7 Iteración 7

6.7.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5508130881935358
- Epoch 1 - Training loss: 0.43374490085989237
- Epoch 2 - Training loss: 0.30802471237257123
- Epoch 3 - Training loss: 0.21344820922240615
- Epoch 4 - Training loss: 0.2562421401962638
- Epoch 5 - Training loss: 0.20496608037501574

- Epoch 6 - Training loss: 0.13906250661239028
- Epoch 7 - Training loss: 0.10709669045172632
- Epoch 8 - Training loss: 0.0980377194355242
- Epoch 9 - Training loss: 0.14105192315764725
- Epoch 10 - Training loss: 0.1824238693807274
- Epoch 11 - Training loss: 0.12677825603168458
- Epoch 12 - Training loss: 0.11795433319639415
- Epoch 13 - Training loss: 0.11304829735308886
- Epoch 14 - Training loss: 0.11300306138582528

Training Time (in minutes) = 0.6360796133677165

6.7.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 194
- Number Of Incorrect Tests = 16
- Number Of False Positive Tests = 3
- Number Of False Negative Tests = 13

Model Accuracy (Average) = 92.381 %

6.8 Iteración 8

6.8.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5044696857221425
- Epoch 1 - Training loss: 0.5214830981567502
- Epoch 2 - Training loss: 0.2562340432778001
- Epoch 3 - Training loss: 0.1868773817550391
- Epoch 4 - Training loss: 0.15367462928406894
- Epoch 5 - Training loss: 0.17081606178544462
- Epoch 6 - Training loss: 0.23135042982175946
- Epoch 7 - Training loss: 0.14121357910335064
- Epoch 8 - Training loss: 0.11537640454480425
- Epoch 9 - Training loss: 0.1061520732473582
- Epoch 10 - Training loss: 0.09583169291727245
- Epoch 11 - Training loss: 0.0681147099348891
- Epoch 12 - Training loss: 0.08792659733444452
- Epoch 13 - Training loss: 0.06715468943002634
- Epoch 14 - Training loss: 0.11969034047797322

Training Time (in minutes) = 0.6425204515457154

6.8.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 202
- Number Of Incorrect Tests = 8
- Number Of False Positive Tests = 5
- Number Of False Negative Tests = 3

Model Accuracy (Average) = 96.1905 %

6.9 Iteración 9

6.9.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5458410140126944
- Epoch 1 - Training loss: 0.4533605817705393
- Epoch 2 - Training loss: 0.2761701187118888
- Epoch 3 - Training loss: 0.2040226743556559
- Epoch 4 - Training loss: 0.2476488770917058
- Epoch 5 - Training loss: 0.18593263323418796
- Epoch 6 - Training loss: 0.20424057496711612
- Epoch 7 - Training loss: 0.21662758570164442
- Epoch 8 - Training loss: 0.15156784327700734
- Epoch 9 - Training loss: 0.13617998827248812
- Epoch 10 - Training loss: 0.11377573921345174
- Epoch 11 - Training loss: 0.11147700063884258
- Epoch 12 - Training loss: 0.12318700616015121
- Epoch 13 - Training loss: 0.1377002474036999
- Epoch 14 - Training loss: 0.119209153810516

Training Time (in minutes) = 0.6379011154174805

6.9.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 197
- Number Of Incorrect Tests = 13
- Number Of False Positive Tests = 3
- Number Of False Negative Tests = 10

Model Accuracy (Average) = 93.8095 %

6.10 Iteración 10

6.10.1 Training AlexNet model

- Epoch 0 - Training loss: 0.5502356281504035
- Epoch 1 - Training loss: 0.31452066358178854
- Epoch 2 - Training loss: 0.318940123077482
- Epoch 3 - Training loss: 0.2659252444282174
- Epoch 4 - Training loss: 0.2817392263095826
- Epoch 5 - Training loss: 0.23590534878894687
- Epoch 6 - Training loss: 0.1462446820223704
- Epoch 7 - Training loss: 0.18059788132086396
- Epoch 8 - Training loss: 0.1351960605243221
- Epoch 9 - Training loss: 0.16648517386056483
- Epoch 10 - Training loss: 0.13759089214727283
- Epoch 11 - Training loss: 0.11946472385898232
- Epoch 12 - Training loss: 0.14736289880238473

- Epoch 13 - Training loss: 0.10291229834547266
- Epoch 14 - Training loss: 0.06749143870547414

Training Time (in minutes) = 0.644016170501709

6.10.2 Testing AlexNet model

- Number Of Images Tested = 210
- Number Of Correct Tests = 202
- Number Of Incorrect Tests = 8
- Number Of False Positive Tests = 8
- Number Of False Negative Tests = 0

Model Accuracy (Average) = 96.1905 %