In [2]:
```
from pathlib import Path
from tqdm import tqdm
import torchvision
import cv2
import numpy as np
import torch
import os
import torch.nn as nn
from torch import long, tensor
from torch.utils.data.dataset import Dataset
from torchvision.transforms import Compose, ToTensor
from torch.utils.data.dataloader import DataLoader
from torchvision.utils import make_grid
import matplotlib.pyplot as plt
import torch.nn.functional as F
from torch.utils.tensorboard import SummaryWriter
batch_size = 16
classes = ['Non-Masked', 'Masked']
```

In [3]:
```
torch.cuda.empty_cache()
```

In [4]:
```
data_path = Path(r'C:/Users/world/Desktop/511Finalpjt/data_set')
maskPath = data_path/'with_mask'
nonMaskPath = data_path/'without_mask'
path_dirs = [ [maskPath,1],[nonMaskPath,0] ] #path and label
```

In [5]:
```
class MaskvNoMask():
    LABELS = {'NON_MASKED': 0, 'MASKED': 0}
    training_data = []
    def make_training_data(self):
        for data_dir,label in path_dirs:
            for folder in tqdm(list(data_dir.iterdir())):
                folder_path = os.path.join(data_dir,folder)
                #try:
                #print(folder_path)
                img = cv2.imread(folder_path)
                img = cv2.resize(img, (100,100))
                self.training_data.append([np.array(img), label])
                #except :
                        #print(folder_path)

                if label == 0:
                    self.LABELS['NON_MASKED'] +=1
                if label == 1:
                    self.LABELS['MASKED'] += 1

        print(self.LABELS)
        np.random.shuffle(self.training_data)
```

In [6]:
```
maskvnomask = MaskvNoMask()
maskvnomask.make_training_data()
training_data = maskvnomask.training_data
```

```
100%|██████████| 3769/3769 [00:20<00:00, 179.74it/s]
100%|██████████| 3801/3801 [00:32<00:00, 118.02it/s]
```

```
{'NON_MASKED': 3801, 'MASKED': 3769}
```

In [7]:
```
class MaskDataset(Dataset):
        """ Masked faces dataset        0 = 'no mask'     1 = 'mask'        """
        def __init__(self, train_data):
            self.train_data = train_data
            self.transformations = Compose([
                ToTensor()        ])

        def __getitem__(self, key):
            if isinstance(key, slice):
                raise NotImplementedError('slicing is not supported')
            return [
                self.transformations(self.train_data[key][0]),
                torch.tensor(self.train_data[key][1]) # pylint: disable=not-callable
            ]

        def __len__(self):
            return len(self.train_data)
```

In [8]:
```
myDataset = MaskDataset(training_data)
myDataset[5]
```

Out[8]:
```
[tensor([[[0.0118, 0.0078, 0.0078,  ..., 0.0353, 0.0078, 0.0000],
          [0.0078, 0.0078, 0.0078,  ..., 0.0392, 0.0078, 0.0000],
          [0.0039, 0.0000, 0.0000,  ..., 0.0431, 0.0078, 0.0000],
          ...,
          [0.0000, 0.0000, 0.0000,  ..., 0.1176, 0.0941, 0.0588],
          [0.0000, 0.0000, 0.0000,  ..., 0.0000, 0.0000, 0.0000],
          [0.0039, 0.0000, 0.0000,  ..., 0.0118, 0.0078, 0.0000]],

         [[0.0039, 0.0000, 0.0000,  ..., 0.0235, 0.0000, 0.0000],
          [0.0000, 0.0000, 0.0000,  ..., 0.0235, 0.0000, 0.0000],
          [0.0000, 0.0000, 0.0000,  ..., 0.0314, 0.0000, 0.0000],
          ...,
          [0.0000, 0.0000, 0.0000,  ..., 0.1255, 0.1059, 0.0784],
          [0.0000, 0.0000, 0.0039,  ..., 0.0039, 0.0000, 0.0078],
          [0.0000, 0.0039, 0.0000,  ..., 0.0039, 0.0078, 0.0000]],

         [[0.0000, 0.0000, 0.0000,  ..., 0.0078, 0.0000, 0.0039],
          [0.0039, 0.0039, 0.0039,  ..., 0.0118, 0.0000, 0.0039],
          [0.0157, 0.0157, 0.0118,  ..., 0.0157, 0.0000, 0.0000],
          ...,
          [0.0039, 0.0000, 0.0039,  ..., 0.1647, 0.1333, 0.0902],
          [0.0039, 0.0000, 0.0039,  ..., 0.0039, 0.0039, 0.0157],
          [0.0078, 0.0000, 0.0000,  ..., 0.0000, 0.0078, 0.0157]]]),
 tensor(1)]
```

In [9]:
```
val_size = 800
train_size = len(myDataset) - val_size

train_ds, val_ds = torch.utils.data.random_split(myDataset, [train_size, val_size])
len(train_ds), len(val_ds)
```

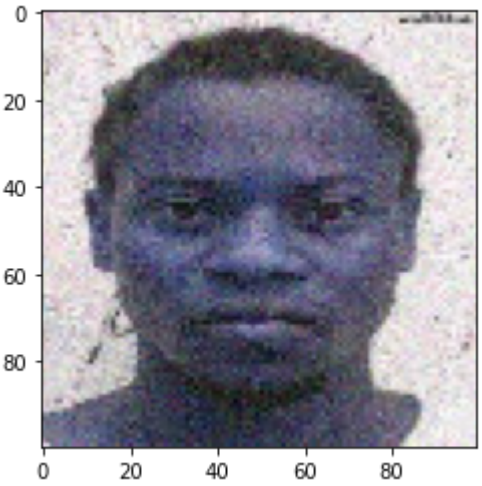
Out[9]:
```
(6770, 800)
```

In [10]:
```
img, label = myDataset[1001]
print(img.shape)
print(label)
```

```
torch.Size([3, 100, 100])
tensor(1)
```

In [11]:
```
def show_example(data):
    img, label = data
    print('Label: ', classes[int(label.item())], "("+str(label.item())+")")
    plt.imshow(img.permute(1, 2, 0))
show_example(val_ds[77])
```

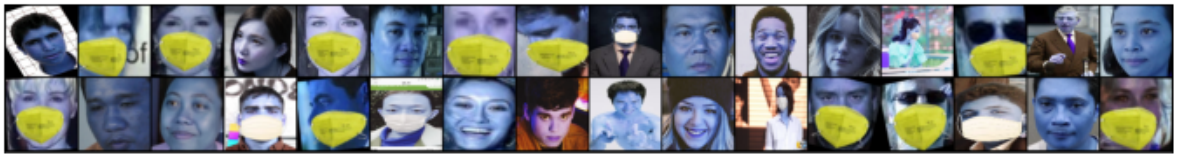
```
Label:  Non-Masked (0)
```



In [12]:
```
train_dl = DataLoader(train_ds, batch_size*2,shuffle=True)
val_dl = DataLoader(val_ds, batch_size*2)
```

In [13]:
```
def show_batch(dl):
    for images, labels in dl:
        print(labels)
        fig, ax = plt.subplots(figsize=(12, 6))
        ax.set_xticks([]); ax.set_yticks([])
        ax.imshow(make_grid(images, nrow=16).permute(1, 2, 0))
        break
show_batch(train_dl)
```

```
tensor([0, 1, 1, 0, 1, 0, 1, 1, 1, 0, 0, 0, 1, 1, 0, 0, 1, 0, 0, 1, 1, 1, 0, 0,
        0, 0, 1, 1, 1, 1, 0, 1])
```



In [14]:
```
show_batch(val_dl)
```

```
tensor([1, 0, 1, 0, 0, 0, 1, 0, 0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 1, 0, 0, 1, 1, 0,
        1, 1, 1, 0, 1, 1, 0, 0])
```

In [15]:
```
def accuracy(outputs, labels):
    #_, preds = torch.max(outputs, dim=1)
    for i in range(len(outputs)):
        if outputs[i]>=0.5:
            outputs[i]=1
        else: outputs[i]=0
    return torch.tensor(torch.sum(outputs == labels).item() / len(outputs))
    #return torch.tensor(torch.sum(preds == labels).item() / len(preds))
```

In [16]:
```
class ImageClassificationBase(nn.Module):
    def training_step(self, batch):
        images, labels = batch
        out = self(images)# Generate predictions
        loss = F.binary_cross_entropy(torch.squeeze(torch.sigmoid(out)), labels.float
()) # Calculate loss
        #loss=F.cross_entropy(out, labels.long())
        return loss

    def validation_step(self, batch):
        images, labels = batch
        out = self(images)                    # Generate predictions
        loss = F.binary_cross_entropy(torch.squeeze(torch.sigmoid(out)), labels.float
())
        #loss = F.cross_entropy(out, labels.long()) # Calculate loss
        #acc = accuracy(out, labels)
        acc = accuracy(torch.squeeze(torch.sigmoid(out)), labels)           # Calculate
accuracy
        return {'val_loss': loss.detach(), 'val_acc': acc}

    def validation_epoch_end(self, outputs):
        batch_losses = [x['val_loss'] for x in outputs]
        epoch_loss = torch.stack(batch_losses).mean()   # Combine losses
        batch_accs = [x['val_acc'] for x in outputs]
        epoch_acc = torch.stack(batch_accs).mean()      # Combine accuracies
        return {'val_loss': epoch_loss.item(), 'val_acc': epoch_acc.item()}

    def epoch_end(self, epoch, result):
        print("Epoch [{}], train_loss: {:.4f}, val_loss: {:.4f}, val_acc: {:.4f}".fo
rmat(
            epoch, result['train_loss'], result['val_loss'], result['val_acc']))
```

In [17]:
```
class MaskDetection(ImageClassificationBase):
    def __init__(self):
        super().__init__()
        self.network = nn.Sequential(
            nn.Conv2d(3, 100, kernel_size=3, padding=1),
            nn.ReLU(),
            nn.Conv2d(100, 128, kernel_size=3, stride=1, padding=1),
            nn.ReLU(),
            nn.MaxPool2d(2, 2), # output: 128 x 8 x 8

            nn.Conv2d(128, 256, kernel_size=3, stride=1, padding=1),
            nn.ReLU(),
            nn.Conv2d(256, 256, kernel_size=3, stride=1, padding=1),
            nn.ReLU(),
            nn.MaxPool2d(2, 2), # output: 256 x 4 x 4

            nn.Flatten(),
            nn.Linear(160000, 512),
            nn.ReLU(),
            nn.Linear(512, 256),
            nn.ReLU(),
            nn.Linear(256, 1))

    def forward(self, xb):
        return self.network(xb)
```

In [19]:
```
def get_default_device():
    """Pick GPU if available, else CPU"""
    if torch.cuda.is_available():
        return torch.device('cuda')
    else:
        return torch.device('cpu')
device = get_default_device()
device
```

Out[19]:
```
device(type='cuda')
```

In [20]:
```
def to_device(data, device):
    """Move tensor(s) to chosen device"""
    if isinstance(data, (list,tuple)):
        return [to_device(x, device) for x in data]
    return data.to(device, non_blocking=True)
```

In [21]:
```
for images, labels in val_dl:
    print(images.shape)
    images = to_device(images, device)
    print(images.device)
    print(labels.shape)
    break
```

```
torch.Size([32, 3, 100, 100])
cuda:0
torch.Size([32])
```

In [22]:
```
class DeviceDataLoader():
    """Wrap a dataloader to move data to a device"""
    def __init__(self, dl, device):
        self.dl = dl
        self.device = device

    def __iter__(self):
        """Yield a batch of data after moving it to device"""
        for b in self.dl:
            yield to_device(b, self.device)

    def __len__(self):
        """Number of batches"""
        return len(self.dl)
```

In [23]:
```
train_dl = DeviceDataLoader(train_dl, device)
val_dl = DeviceDataLoader(val_dl, device)
```

In [24]:
```
@torch.no_grad()
def evaluate(model, val_loader):
    model.eval()
    outputs = [model.validation_step(batch) for batch in val_loader]
    return model.validation_epoch_end(outputs)

def fit(epochs, lr, model, train_loader, val_loader, opt_func=torch.optim.Adam):
    history = []
    optimizer = torch.optim.Adam(model.parameters(), betas=(0.9, 0.999),lr=0.001)
    for epoch in range(epochs):
        # Training Phase
        print('epoch: ', epoch)
        model.train()
        train_losses = []
        for batch in train_loader:
            loss = model.training_step(batch)
            train_losses.append(loss)
            loss.backward()
            optimizer.step()
            optimizer.zero_grad()
        # Validation phase
        result = evaluate(model, val_loader)
        result['train_loss'] = torch.stack(train_losses).mean().item()
        model.epoch_end(epoch, result)
        history.append(result)
    return history
```

In [25]:
```
# Model (on GPU)
model = MaskDetection()
to_device(model, device)
```

Out[25]:
```
MaskDetection(
  (network): Sequential(
    (0): Conv2d(3, 100, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU()
    (2): Conv2d(100, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU()
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU()
    (7): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU()
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (10): Flatten()
    (11): Linear(in_features=160000, out_features=512, bias=True)
    (12): ReLU()
    (13): Linear(in_features=512, out_features=256, bias=True)
    (14): ReLU()
    (15): Linear(in_features=256, out_features=1, bias=True)
  )
)
```

In [26]:
```
model.eval()
```

Out[26]:
```
MaskDetection(
  (network): Sequential(
    (0): Conv2d(3, 100, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (1): ReLU()
    (2): Conv2d(100, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (3): ReLU()
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (5): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (6): ReLU()
    (7): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (8): ReLU()
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=False)
    (10): Flatten()
    (11): Linear(in_features=160000, out_features=512, bias=True)
    (12): ReLU()
    (13): Linear(in_features=512, out_features=256, bias=True)
    (14): ReLU()
    (15): Linear(in_features=256, out_features=1, bias=True)
  )
)
```

In [27]:
```
sum(p.numel() for p in model.parameters())
```

Out[27]:
```
83055473
```

In [ ]:
```

```

In [28]:
```
[evaluate(model, val_dl)]
```

Out[28]:
```
[{'val_loss': 0.6940608620643616, 'val_acc': 0.4737499952316284}]
```

In [29]:
```
history = fit(10, 1e-3, model, train_dl, val_dl)
```

```
epoch:  0
Epoch [0], train_loss: 0.2005, val_loss: 0.1993, val_acc: 0.9425
epoch:  1
Epoch [1], train_loss: 0.1167, val_loss: 0.1666, val_acc: 0.9488
epoch:  2
Epoch [2], train_loss: 0.1016, val_loss: 0.1455, val_acc: 0.9500
epoch:  3
Epoch [3], train_loss: 0.0926, val_loss: 0.1284, val_acc: 0.9513
epoch:  4
Epoch [4], train_loss: 0.0821, val_loss: 0.2332, val_acc: 0.9400
epoch:  5
Epoch [5], train_loss: 0.0691, val_loss: 0.1199, val_acc: 0.9663
epoch:  6
Epoch [6], train_loss: 0.0598, val_loss: 0.1152, val_acc: 0.9688
epoch:  7
Epoch [7], train_loss: 0.0425, val_loss: 0.1820, val_acc: 0.9688
epoch:  8
Epoch [8], train_loss: 0.0360, val_loss: 0.1220, val_acc: 0.9663
epoch:  9
Epoch [9], train_loss: 0.0634, val_loss: 0.1331, val_acc: 0.9575
```

In [31]:
```
torch.save(model.state_dict(), r'C:\Users\world\Desktop\511Finalpjt\detection\.pth')
```

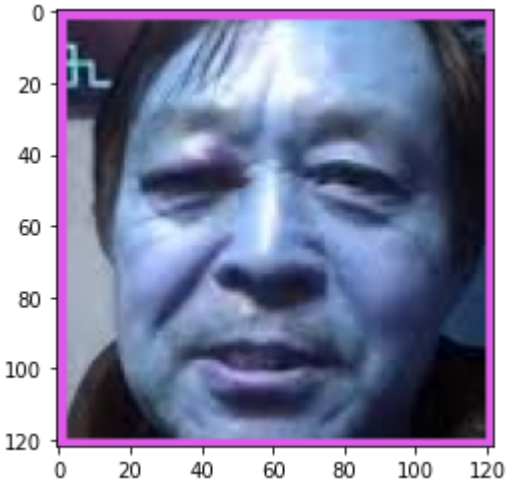
In [32]:
```
import matplotlib.image as mpimg
def singleImage(path, label= None, show= False):
    img = cv2.imread(path)
    assert img is not None,"Immage wasn't read properly"
    face_cascade = cv2.CascadeClassifier(r"C:\Users\world\Desktop\511Finalpjt\haarcascade_frontalface_alt.xml")
    gray = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
    faces = face_cascade.detectMultiScale(gray)
    for (i, (x, y, w, h)) in enumerate(faces):
        cv2.rectangle(img, (x, y), (x+1*w, y+1*h), (220, 90, 230), 3)
    img=img[y:y+h,x:x+w]
    plt.imshow(img)
    img = cv2.resize(img, (100, 100))

    img = torch.from_numpy(img)
    img = img.permute((2, 0,1)) # model expects image to be of shape [3, 100, 100]
    img = img.unsqueeze(dim=0).float() # convert single image to batch [1, 3, 100, 100]
    img = img.to('cuda') # Using the same device as the model
    pred = model(img)
    _, preds = torch.max(pred, dim=1)
    print(classes[preds.item()])

    if show:
        print("the image is :" + classes[preds.item()])
```

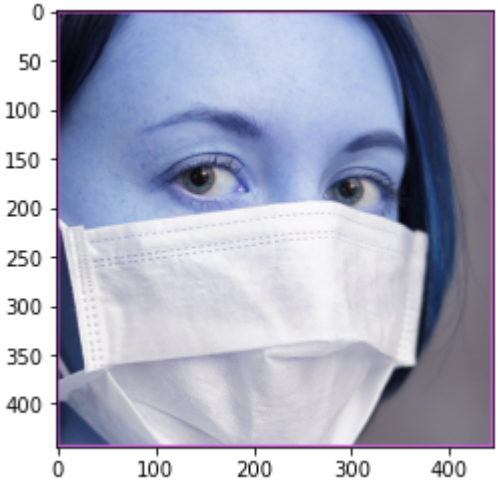
In [33]:
```
singleImage(r"C:\Users\world\Desktop\511Finalpjt\detection\231.jpg",show=True)
```

```
Non-Masked
the image is :Non-Masked
```



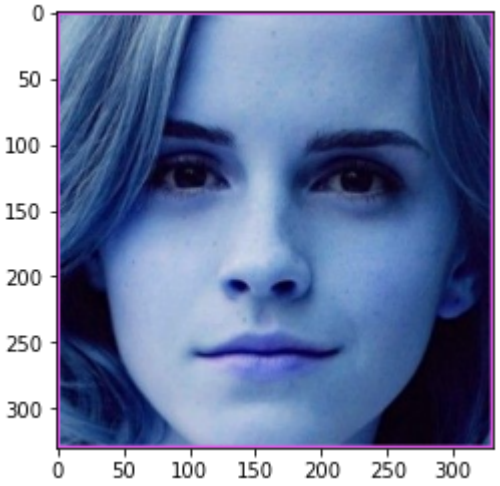
In [34]:
```
singleImage(r"C:\Users\world\Desktop\511Finalpjt\detection\MASKY.jpg",show=True)
```

```
Non-Masked
the image is :Non-Masked
```



In [33]:
```
singleImage(r"C:\Users\world\Desktop\511Finalpjt\detection\123.jpg",show=True)
```

```
Non-Masked
the image is :Non-Masked
```



In [34]:
```
singleImage(r"C:\Users\world\Desktop\511Finalpjt\detection\213213123.jpg",show=True)
```

```
Non-Masked
the image is :Non-Masked
```