In [1]:
```
!pip install gdown
import os
import zipfile
import numpy as np
import torch
import torch.nn as nn
import torch.optim as optim
import torch.utils.data as data
from torch.utils.data import Dataset, DataLoader
import torchvision.transforms as transforms
import torchvision.models as models
from sklearn.metrics import roc_curve, auc
import matplotlib.pyplot as plt
from tqdm import tqdm
```

```
Requirement already satisfied: gdown in /usr/local/lib/python3.11/dist-packa
ges (5.2.0)
Requirement already satisfied: beautifulsoup4 in /usr/local/lib/python3.11/d
ist-packages (from gdown) (4.13.3)
Requirement already satisfied: filelock in /usr/local/lib/python3.11/dist-pa
ckages (from gdown) (3.17.0)
Requirement already satisfied: requests[socks] in /usr/local/lib/python3.11/
dist-packages (from gdown) (2.32.3)
Requirement already satisfied: tqdm in /usr/local/lib/python3.11/dist-packag
es (from gdown) (4.67.1)
Requirement already satisfied: soupsieve>1.2 in /usr/local/lib/python3.11/di
st-packages (from beautifulsoup4->gdown) (2.6)
Requirement already satisfied: typing-extensions>=4.0.0 in /usr/local/lib/py
thon3.11/dist-packages (from beautifulsoup4->gdown) (4.12.2)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/py
thon3.11/dist-packages (from requests[socks]->gdown) (3.4.1)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dis
t-packages (from requests[socks]->gdown) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.
11/dist-packages (from requests[socks]->gdown) (2.3.0)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.
11/dist-packages (from requests[socks]->gdown) (2025.1.31)
Requirement already satisfied: PySocks!=1.5.7,>=1.5.6 in /usr/local/lib/pyth
on3.11/dist-packages (from requests[socks]->gdown) (1.7.1)
```

In [2]:
```
import gdown
import zipfile
file_id = "1doUhVoq1-c9pamZVLpvjW1YRDMkKO1Q5"
output = "dataset.zip"
gdown.download(f"https://drive.google.com/uc?id={file_id}", output, quiet =

with zipfile.ZipFile("dataset.zip", "r") as zip_ref:
  zip_ref.extractall("/content/dataset")
```

```
Downloading...
From (original): https://drive.google.com/uc?id=1doUhVoq1-c9pamZVLpvjW1YRDMkKO1Q5
From (redirected): https://drive.google.com/uc?id=1doUhVoq1-c9pamZVLpvjW1YRDMkKO1Q5&confirm=t&uuid=21d4235b-eaa1-4836-90b3-977cbad0958a
To: /content/dataset.zip
100%|██████████| 2.11G/2.11G [00:17<00:00, 124MB/s]
```

In [3]:
```
data_dir = "/content/dataset"
train_lens_dir = os.path.join(data_dir, 'train_lenses')
train_nonlens_dir = os.path.join(data_dir, 'train_nonlenses')
test_lens_dir = os.path.join(data_dir, 'test_lenses')
test_nonlens_dir = os.path.join(data_dir, 'test_nonlenses')
```

In [7]:
```
class LensingDataset(Dataset):
  def __init__(self, lenses_dir, non_lenses_dir, transform = None):
    self.transform = None
    self.image_paths = []
    self.labels = []

    for file in os.listdir(lenses_dir):
      if file.endswith('.npy'):
        self.image_paths.append(os.path.join(lenses_dir, file))
        self.labels.append(1)

    for file in os.listdir(non_lenses_dir):
      if file.endswith('.npy'):
        self.image_paths.append(os.path.join(non_lenses_dir, file))
        self.labels.append(0)

    self.labels = torch.tensor(self.labels, dtype = torch.long)

  def __len__(self):
    return len(self.image_paths)

  def __getitem__(self, idx):
    image = np.load(self.image_paths[idx])
    image = torch.tensor(image, dtype = torch.float32)
    label = self.labels[idx]

    if self.transform:
      image = self.transform(image)

    return image, label
```

In [5]:
```
transform = transforms.Compose([
    transforms.Normalize(mean=[0.5, 0.5, 0.5], std=[0.5, 0.5, 0.5])
])
```

In [8]:
```
train_dataset = LensingDataset(train_lens_dir, train_nonlens_dir, transform=
test_dataset = LensingDataset(test_lens_dir, test_nonlens_dir, transform=tra
```

In [9]:
```
class_counts = torch.bincount(train_dataset.labels)
class_weights = 1.0 / class_counts.float()
```

```
sample_weights = class_weights[train_dataset.labels]
sampler = torch.utils.data.WeightedRandomSampler(sample_weights, len(sample_
```

In [10]:
```
train_loader = DataLoader(train_dataset, batch_size=32, sampler=sampler, num
test_loader = DataLoader(test_dataset, batch_size=32, shuffle=False, num_wor
```

In [11]:
```
for images, labels in train_loader:
    print("Image shape:", images.shape)
    print("Image dtype:", images.dtype)
    break
```

```
Image shape: torch.Size([32, 3, 64, 64])
Image dtype: torch.float32
```

In [25]:
```
def initialize_model(model_name):
  if model_name == "resnet18":
    model = models.resnet18(pretrained = True)
    model.fc = nn.Linear(model.fc.in_features, 1)
  elif model_name == "efficientnet_b0":
    model = models.efficientnet_b0(pretrained = True)
    model.classifier = nn.Linear(model.classifier[1].in_features, 1)
  else:
    raise ValueError("Invalid model name")

  model.cuda()
  return model
```

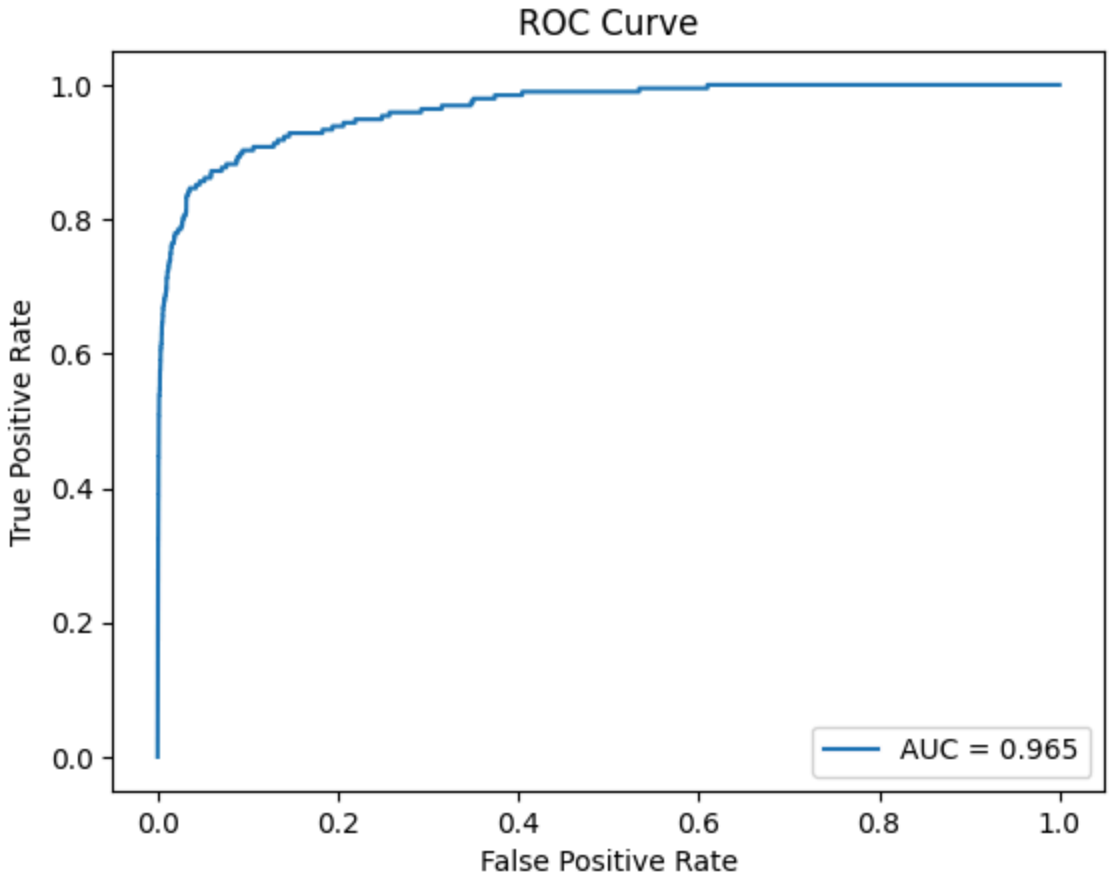
In [26]:
```
def train_model(model, train_loader, criterion, optimizer, epochs=5, accumul
    model.train()
    for epoch in range(epochs):
        running_loss = 0.0
        optimizer.zero_grad()

        for i, (images, labels) in enumerate(tqdm(train_loader, desc=f"Epoch
            images, labels = images.cuda(), labels.float().cuda()
            labels = labels.unsqueeze(1)

            outputs = model(images)
            loss = criterion(outputs, labels) / accumulation_steps
            loss.backward()

            if (i + 1) % accumulation_steps == 0 or (i + 1) == len(train_loa
                optimizer.step()
                optimizer.zero_grad()

            running_loss += loss.item() * accumulation_steps

        print(f"Epoch {epoch+1}, Loss: {running_loss / len(train_loader)}")
```

In [27]:
```
def evaluate_model(model, test_loader):
    model.eval()
    y_true, y_scores = [], []
    with torch.no_grad():
        for images, labels in test_loader:
            images = images.cuda()
```

```
            outputs = model(images)
            probs = torch.sigmoid(outputs).cpu().numpy()
            y_true.extend(labels.numpy())
            y_scores.extend(probs)

    fpr, tpr, _ = roc_curve(y_true, y_scores)
    roc_auc = auc(fpr, tpr)

    plt.figure()
    plt.plot(fpr, tpr, label=f'AUC = {roc_auc:.3f}')
    plt.xlabel('False Positive Rate')
    plt.ylabel('True Positive Rate')
    plt.title('ROC Curve')
    plt.legend()
    plt.show()

    print(f'AUC Score: {roc_auc:.3f}')
    return roc_auc
```

In [28]:
```
model_resnet = initialize_model('resnet18')
criterion = nn.BCEWithLogitsLoss()
optimizer = optim.Adam(model_resnet.parameters(), lr=0.0001)
train_model(model_resnet, train_loader, criterion, optimizer)
auc_resnet = evaluate_model(model_resnet, test_loader)
```

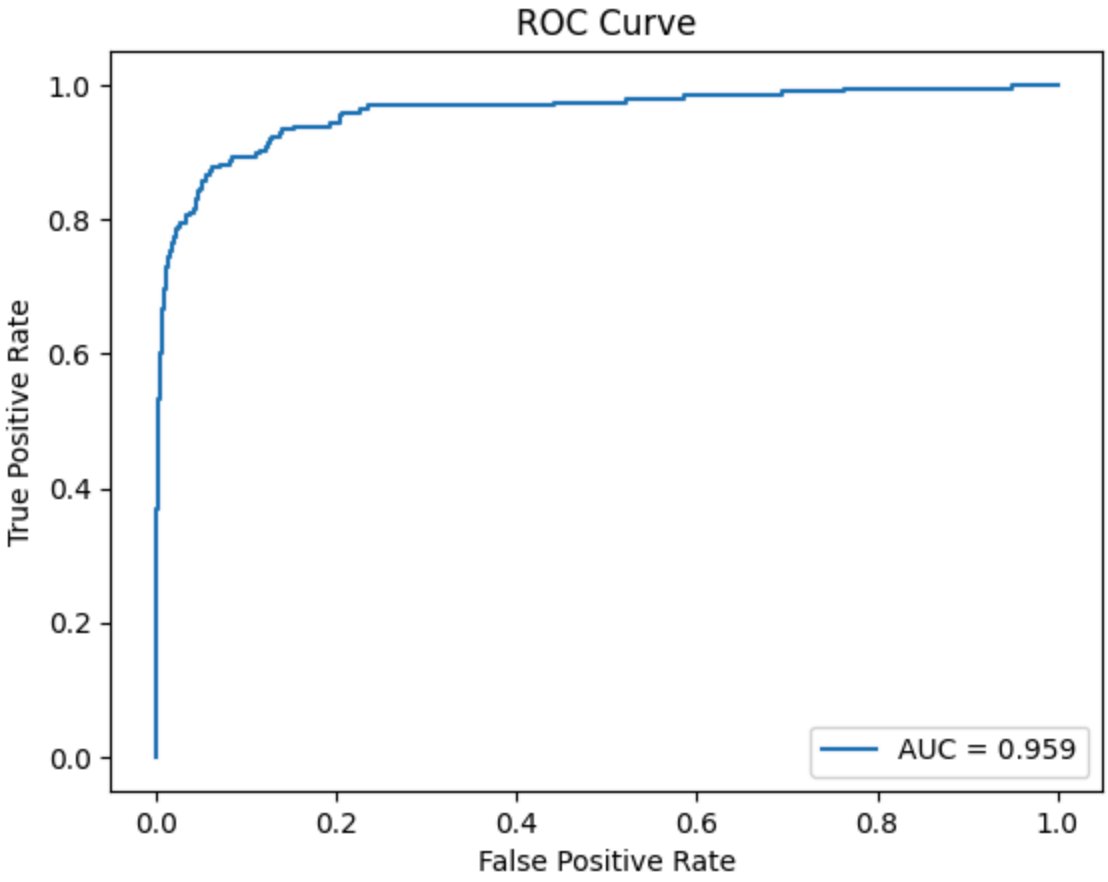
```
/usr/local/lib/python3.11/dist-packages/torchvision/models/_utils.py:208: UserWarning: The parameter 'pretrained' is deprecated since 0.13 and may be removed in the future, please use 'weights' instead.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/torchvision/models/_utils.py:223: UserWarning: Arguments other than a weight enum or `None` for 'weights' are deprecated since 0.13 and may be removed in the future. The current behavior is equivalent to passing `weights=ResNet18_Weights.IMAGENET1K_V1`. You can also use `weights=ResNet18_Weights.DEFAULT` to get the most up-to-date weights.
  warnings.warn(msg)
Epoch 1: 100%|██████████| 951/951 [00:20<00:00, 46.32it/s]
Epoch 1, Loss: 0.14308672566574016
Epoch 2: 100%|██████████| 951/951 [00:20<00:00, 46.29it/s]
Epoch 2, Loss: 0.05049746803749357
Epoch 3: 100%|██████████| 951/951 [00:21<00:00, 44.93it/s]
Epoch 3, Loss: 0.02576891102820557
Epoch 4: 100%|██████████| 951/951 [00:19<00:00, 47.68it/s]
Epoch 4, Loss: 0.021473982412551433
Epoch 5: 100%|██████████| 951/951 [00:20<00:00, 46.47it/s]
Epoch 5, Loss: 0.014480781113818182
```



AUC Score: 0.965

In [29]:
```
model_efficientnet = initialize_model('efficientnet_b0')
optimizer = optim.Adam(model_efficientnet.parameters(), lr=0.0001)
train_model(model_efficientnet, train_loader, criterion, optimizer)
auc_efficientnet = evaluate_model(model_efficientnet, test_loader)
```

```
/usr/local/lib/python3.11/dist-packages/torchvision/models/_utils.py:208: UserWarning: The parameter 'pretrained' is deprecated since 0.13 and may be removed in the future, please use 'weights' instead.
  warnings.warn(
/usr/local/lib/python3.11/dist-packages/torchvision/models/_utils.py:223: UserWarning: Arguments other than a weight enum or `None` for 'weights' are deprecated since 0.13 and may be removed in the future. The current behavior is equivalent to passing `weights=EfficientNet_B0_Weights.IMAGENET1K_V1`. You can also use `weights=EfficientNet_B0_Weights.DEFAULT` to get the most up-to-date weights.
  warnings.warn(msg)
Epoch 1: 100%|██████████| 951/951 [00:39<00:00, 24.03it/s]
Epoch 1, Loss: 0.30337745098536195
Epoch 2: 100%|██████████| 951/951 [00:39<00:00, 24.25it/s]
Epoch 2, Loss: 0.15142699273853522
Epoch 3: 100%|██████████| 951/951 [00:38<00:00, 24.55it/s]
Epoch 3, Loss: 0.1088519310941048
Epoch 4: 100%|██████████| 951/951 [00:39<00:00, 24.05it/s]
Epoch 4, Loss: 0.08418019965866856
Epoch 5: 100%|██████████| 951/951 [00:38<00:00, 24.42it/s]
```




```
AUC Score: 0.959
```

In [30]:
```
print(f"ResNet18 AUC: {auc_resnet:.3f}")
print(f"EfficientNet B0 AUC: {auc_efficientnet:.3f}")
```

```
ResNet18 AUC: 0.965
EfficientNet B0 AUC: 0.959
```