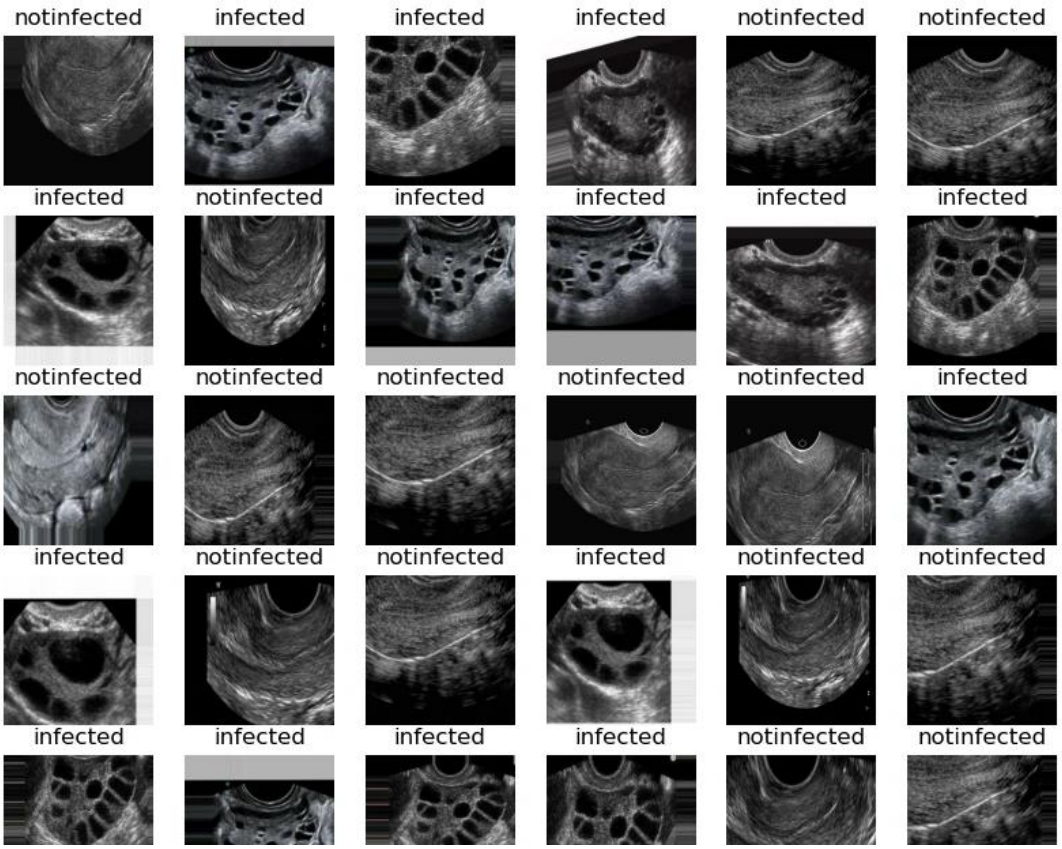
PCOS Detection Using Multi-Scale Retinex Enhanced Ultrasound Images: A Deep Learning Approach with ImpalaCNN Algorithm




```
import numpy as np
import pandas as pd
import os

base_path = "/kaggle/input/augmented-enhanced-
pcos/content/data/enhanced_data/"
categories = ["infected","notinfected"]

image_paths = []
labels = []

for category in categories:
    category_path = os.path.join(base_path, category)
    for image_name in os.listdir(category_path):
        image_path = os.path.join(category_path, image_name)
        image_paths.append(image_path)
        labels.append(category)

df = pd.DataFrame({
```

```
    "image_path": image_paths,
    "label": labels
})

df.head()
```

	image_path	label
0	/kaggle/input/augmented-enhanced-pcos/content/...	infected
1	/kaggle/input/augmented-enhanced-pcos/content/...	infected
2	/kaggle/input/augmented-enhanced-pcos/content/...	infected
3	/kaggle/input/augmented-enhanced-pcos/content/...	infected
4	/kaggle/input/augmented-enhanced-pcos/content/...	infected

```
df.tail()
```

	image_path	label
15387	/kaggle/input/augmented-enhanced-pcos/content/...	notinfected
15388	/kaggle/input/augmented-enhanced-pcos/content/...	notinfected
15389	/kaggle/input/augmented-enhanced-pcos/content/...	notinfected
15390	/kaggle/input/augmented-enhanced-pcos/content/...	notinfected
15391	/kaggle/input/augmented-enhanced-pcos/content/...	notinfected

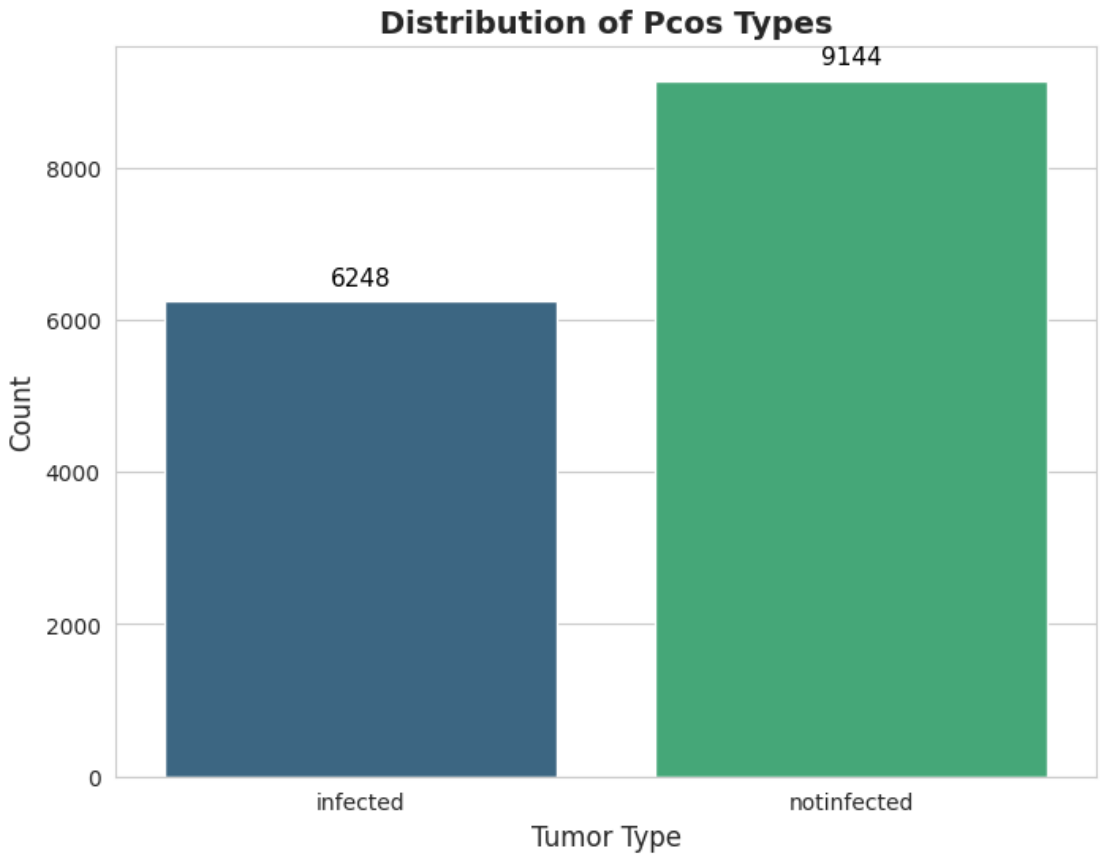
```
df.shape

(15392, 2)

df.columns

Index(['image_path', 'label'], dtype='object')

df.duplicated().sum()

0

df.isnull().sum()

image_path    0
label         0
dtype: int64

df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 15392 entries, 0 to 15391
Data columns (total 2 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   image_path  15392 non-null  object
 1   label       15392 non-null  object
dtypes: object(2)
memory usage: 240.6+ KB

df['label'].unique()
```

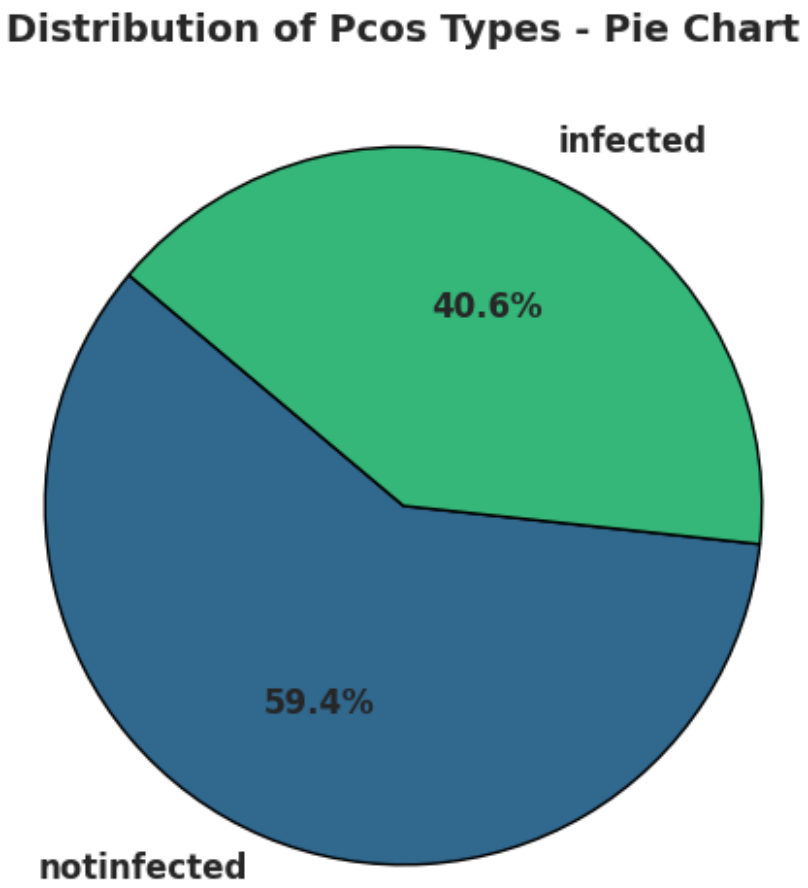
```
array(['infected', 'notinfected'], dtype=object)
```

```
df['label'].value_counts()
```

```
label
notinfected    9144
infected       6248
Name: count, dtype: int64
```

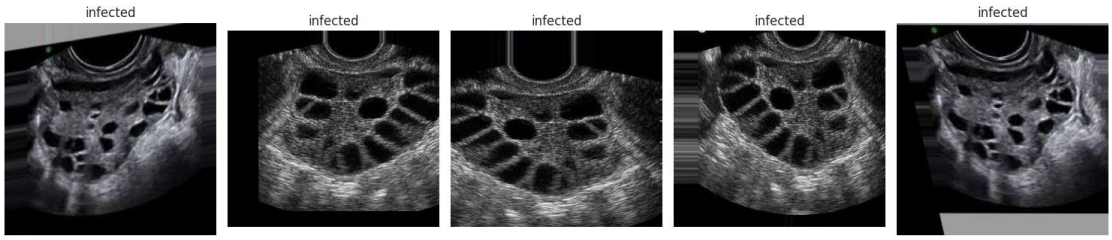
```
import seaborn as sns
import matplotlib.pyplot as plt

sns.set_style("whitegrid")

fig, ax = plt.subplots(figsize=(8, 6))
sns.countplot(data=df, x="label", palette="viridis", ax=ax)

ax.set_title("Distribution of Pcos Types", fontsize=14, fontweight='bold')
ax.set_xlabel("Tumor Type", fontsize=12)
ax.set_ylabel("Count", fontsize=12)

for p in ax.patches:
    ax.annotate(f'{int(p.get_height())}',
                (p.get_x() + p.get_width() / 2., p.get_height()),
                ha='center', va='bottom', fontsize=11, color='black',
                xytext=(0, 5), textcoords='offset points')

plt.show()

label_counts = df["label"].value_counts()

fig, ax = plt.subplots(figsize=(8, 6))
colors = sns.color_palette("viridis", len(label_counts))

ax.pie(label_counts, labels=label_counts.index, autopct='%1.1f%%',
       startangle=140, colors=colors, textprops={'fontsize': 12, 'weight':
'bold'},
       wedgeprops={'edgecolor': 'black', 'linewidth': 1})

ax.set_title("Distribution of Pcos Types - Pie Chart", fontsize=14,
fontweight='bold')

plt.show()
```


Distribution of Pcos Types
9144
6248
8000
6000
4000
2000
0
Count
infected
notinfected
Tumor Type




```
import cv2

num_images = 5

plt.figure(figsize=(15, 12))

for i, category in enumerate(categories):
    category_images = df[df['label'] ==
category]['image_path'].iloc[:num_images]

    for j, img_path in enumerate(category_images):

        img = cv2.imread(img_path)
        img = cv2.cvtColor(img, cv2.COLOR_BGR2RGB)

        plt.subplot(len(categories), num_images, i * num_images + j + 1)
        plt.imshow(img)
        plt.axis('off')
        plt.title(category)
```

```
plt.tight_layout()
plt.show()
```




```
from sklearn.preprocessing import LabelEncoder

label_encoder = LabelEncoder()

df['category_encoded'] = label_encoder.fit_transform(df['label'])

df = df[['image_path', 'category_encoded']]

from imblearn.over_sampling import RandomOverSampler

ros = RandomOverSampler(random_state=42)
X_resampled, y_resampled = ros.fit_resample(df[['image_path']],
df['category_encoded'])

df_resampled = pd.DataFrame(X_resampled, columns=['image_path'])
df_resampled['category_encoded'] = y_resampled

print("\nClass distribution after oversampling:")
print(df_resampled['category_encoded'].value_counts())


Class distribution after oversampling:
category_encoded
0    9144
1    9144
Name: count, dtype: int64

df_resampled

                                                image_path  category_encoded
0      /kaggle/input/augmented-enhanced-pcos/content/...                 0
```

```
1      /kaggle/input/augmented-enhanced-pcos/content/...                0
2      /kaggle/input/augmented-enhanced-pcos/content/...                0
3      /kaggle/input/augmented-enhanced-pcos/content/...                0
4      /kaggle/input/augmented-enhanced-pcos/content/...                0
...                                                  ...              ...
18283  /kaggle/input/augmented-enhanced-pcos/content/...                0
18284  /kaggle/input/augmented-enhanced-pcos/content/...                0
18285  /kaggle/input/augmented-enhanced-pcos/content/...                0
18286  /kaggle/input/augmented-enhanced-pcos/content/...                0
18287  /kaggle/input/augmented-enhanced-pcos/content/...                0

[18288 rows x 2 columns]
```

```
df_resampled['category_encoded'] =
df_resampled['category_encoded'].astype(str)
```

```
from sklearn.model_selection import train_test_split

train_df_new, temp_df_new = train_test_split(
    df_resampled,
    train_size=0.8,
    shuffle=True,
    random_state=42,
    stratify=df_resampled['category_encoded']
)

valid_df_new, test_df_new = train_test_split(
    temp_df_new,
    test_size=0.5,
    shuffle=True,
    random_state=42,
    stratify=temp_df_new['category_encoded']
)

from tensorflow.keras.preprocessing.image import ImageDataGenerator

batch_size = 16
img_size = (224, 224)
channels = 3
img_shape = (img_size[0], img_size[1], channels)

tr_gen = ImageDataGenerator(rescale=1./255)
ts_gen = ImageDataGenerator(rescale=1./255)

train_gen_new = tr_gen.flow_from_dataframe(
    train_df_new,
    x_col='image_path',
    y_col='category_encoded',
    target_size=img_size,
    class_mode='binary',
    color_mode='rgb',
```

```
    shuffle=True,
    batch_size=batch_size
)

valid_gen_new = ts_gen.flow_from_dataframe(
    valid_df_new,
    x_col='image_path',
    y_col='category_encoded',
    target_size=img_size,
    class_mode='binary',
    color_mode='rgb',
    shuffle=True,
    batch_size=batch_size
)

test_gen_new = ts_gen.flow_from_dataframe(
    test_df_new,
    x_col='image_path',
    y_col='category_encoded',
    target_size=img_size,
    class_mode='binary',
    color_mode='rgb',
    shuffle=False,
    batch_size=batch_size
)
```

```
Found 14630 validated image filenames belonging to 2 classes.
Found 1829 validated image filenames belonging to 2 classes.
Found 1829 validated image filenames belonging to 2 classes.
```

```
import tensorflow as tf

print("Num GPUs Available: ", len(tf.config.list_physical_devices('GPU')))
```

```
Num GPUs Available:  2
```

```
gpus = tf.config.list_physical_devices('GPU')
if gpus:
    try:
        for gpu in gpus:
            tf.config.experimental.set_memory_growth(gpu, True)
        print("GPU is set for TensorFlow")
    except RuntimeError as e:
        print(e)
```

```
GPU is set for TensorFlow
```

```
from tensorflow.keras import layers, models

class ResBlock(layers.Layer):
    def __init__(self, filters, **kwargs):
```

```
        super(ResBlock, self).__init__(**kwargs)
        self.conv1 = layers.Conv2D(filters, 3, padding='same',
activation='relu')
        self.bn1 = layers.BatchNormalization()
        self.conv2 = layers.Conv2D(filters, 3, padding='same')
        self.bn2 = layers.BatchNormalization()
        self.relu = layers.ReLU()

    def call(self, inputs):
        residual = inputs
        x = self.conv1(inputs)
        x = self.bn1(x)
        x = self.conv2(x)
        x = self.bn2(x)
        x = layers.add([x, residual])
        return self.relu(x)

class ConvSequence(layers.Layer):
    def __init__(self, filters, **kwargs):
        super(ConvSequence, self).__init__(**kwargs)
        self.conv = layers.Conv2D(filters, 3, padding='same',
activation='relu')
        self.bn = layers.BatchNormalization()
        self.maxpool = layers.MaxPool2D(3, strides=2, padding='same')
        self.resblock1 = ResBlock(filters)
        self.resblock2 = ResBlock(filters)

    def call(self, inputs):
        x = self.conv(inputs)
        x = self.bn(x)
        x = self.maxpool(x)
        x = self.resblock1(x)
        x = self.resblock2(x)
        return x

class ImpalaCNN(tf.keras.Model):
    def __init__(self, base_filters=16, width_scale=1, **kwargs):
        super(ImpalaCNN, self).__init__(**kwargs)
        filters = [base_filters * width_scale, 2 * base_filters *
width_scale, 2 * base_filters * width_scale]
        self.conv_seq1 = ConvSequence(filters[0])
        self.conv_seq2 = ConvSequence(filters[1])
        self.conv_seq3 = ConvSequence(filters[2])
        self.global_avg_pool = layers.GlobalAveragePooling2D()
        self.linear1 = layers.Dense(256, activation='relu')
        self.dropout = layers.Dropout(0.5)
        self.linear2 = layers.Dense(1, activation='sigmoid')

    def call(self, inputs):
        x = self.conv_seq1(inputs)
```

```
        x = self.conv_seq2(x)
        x = self.conv_seq3(x)
        x = self.global_avg_pool(x)
        x = self.linear1(x)
        x = self.dropout(x)
        return self.linear2(x)

model = ImpalaCNN(base_filters=16, width_scale=1)
model.compile(optimizer='adam', loss='binary_crossentropy',
metrics=['accuracy'])

history = model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    batch_size=batch_size
)
```

```
Epoch 1/5

/usr/local/lib/python3.10/dist-
packages/keras/src/trainers/data_adapters/py_dataset_adapter.py:122:
UserWarning: Your `PyDataset` class should call `super().__init__(**kwargs)`
in its constructor. `**kwargs` can include `workers`, `use_multiprocessing`,
`max_queue_size`. Do not pass these arguments to `fit()`, as they will be
ignored.
  self._warn_if_super_not_called()

915/915 ━━━━━━━━━━━━━━━━━━━━109s 100ms/step - accuracy: 0.8187 - loss:
0.3028 - val_accuracy: 0.9453 - val_loss: 0.0901
Epoch 2/5
915/915 ━━━━━━━━━━━━━━━━━━━━51s 55ms/step - accuracy: 0.9561 - loss: 0.0863
- val_accuracy: 0.9639 - val_loss: 0.0808
Epoch 3/5
915/915 ━━━━━━━━━━━━━━━━━━━━49s 53ms/step - accuracy: 0.9588 - loss: 0.0820
- val_accuracy: 0.9650 - val_loss: 0.0647
Epoch 4/5
915/915 ━━━━━━━━━━━━━━━━━━━━48s 52ms/step - accuracy: 0.9622 - loss: 0.0741
- val_accuracy: 0.9541 - val_loss: 0.0891
Epoch 5/5
915/915 ━━━━━━━━━━━━━━━━━━━━48s 52ms/step - accuracy: 0.9675 - loss: 0.0638
- val_accuracy: 0.9710 - val_loss: 0.0543
```

```
test_loss, test_accuracy = model.evaluate(test_gen_new)
print(f"Test Loss: {test_loss}")
print(f"Test Accuracy: {test_accuracy}")
```

```
115/115 ━━━━━━━━━━━━━━━━━━━━8s 68ms/step - accuracy: 0.9752 - loss: 0.0468
Test Loss: 0.04985056445002556
Test Accuracy: 0.9764899015426636
```

```
y_pred = model.predict(test_gen_new)
y_pred = (y_pred > 0.5).astype(int)
```

```
115/115 ━━━━━━━━━━━━━━━━━━━━7s 51ms/step
```

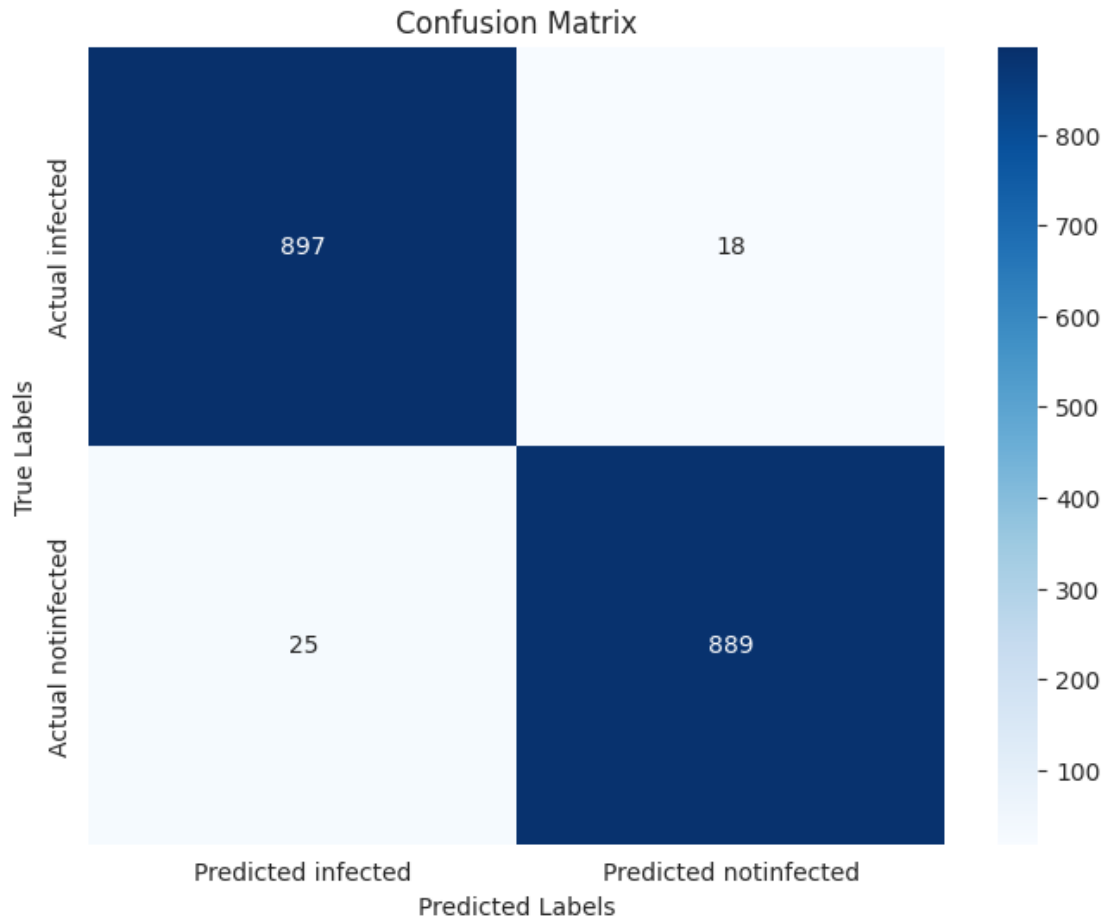
```
y_true = test_gen_new.labels
```

```
from sklearn.metrics import confusion_matrix, classification_report
```

```
conf_matrix = confusion_matrix(y_true, y_pred)
print("Confusion Matrix:")
print(conf_matrix)
```

```
Confusion Matrix:
[[897  18]
 [ 25 889]]
```

```
plt.figure(figsize=(8, 6))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues',
            xticklabels=['Predicted infected', 'Predicted notinfected'],
            yticklabels=['Actual infected', 'Actual notinfected'])
plt.xlabel('Predicted Labels')
plt.ylabel('True Labels')
plt.title('Confusion Matrix')
plt.show()
```




```
class_report = classification_report(y_true, y_pred,
target_names=['infected', 'notinfected'])
print("Classification Report:")
print(class_report)
```

```
Classification Report:
              precision    recall  f1-score   support

    infected       0.97      0.98      0.98       915
 notinfected       0.98      0.97      0.98       914

    accuracy                           0.98      1829
   macro avg       0.98      0.98      0.98      1829
weighted avg       0.98      0.98      0.98      1829
```