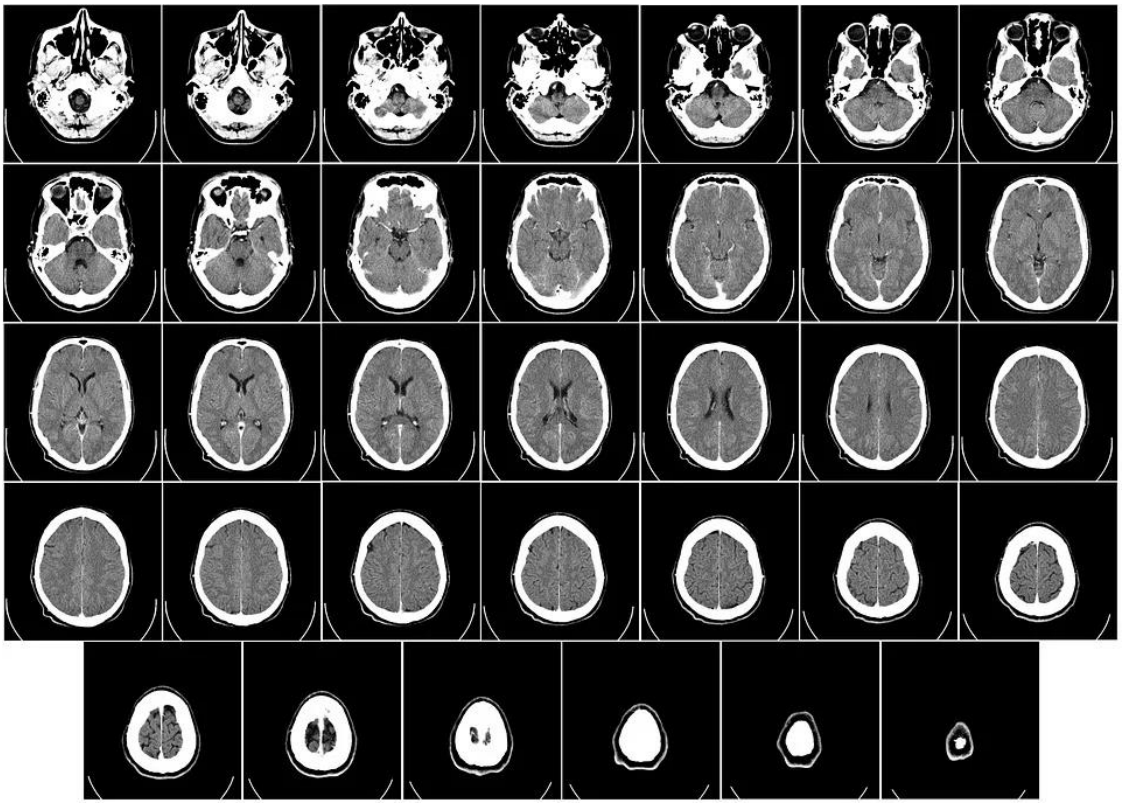
Brain Tumor Classification (CT Scan Images) using SkipNet Architecture



```
import numpy as np
import pandas as pd

base_path = "/kaggle/input/brain-tumor-multimodal-image-ct-and-
mri/Dataset/Brain Tumor CT scan Images/"
categories = ["Healthy","Tumor"]

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/brain-tumor-multimodal-image-ct-...  Healthy
1  /kaggle/input/brain-tumor-multimodal-image-ct-...  Healthy
2  /kaggle/input/brain-tumor-multimodal-image-ct-...  Healthy
3  /kaggle/input/brain-tumor-multimodal-image-ct-...  Healthy
4  /kaggle/input/brain-tumor-multimodal-image-ct-...  Healthy
```

```
df.tail()
```

```
                                            image_path  label
4613  /kaggle/input/brain-tumor-multimodal-image-ct-...  Tumor
4614  /kaggle/input/brain-tumor-multimodal-image-ct-...  Tumor
4615  /kaggle/input/brain-tumor-multimodal-image-ct-...  Tumor
4616  /kaggle/input/brain-tumor-multimodal-image-ct-...  Tumor
4617  /kaggle/input/brain-tumor-multimodal-image-ct-...  Tumor
```

```
df.shape
```

```
(4618, 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: 4618 entries, 0 to 4617
Data columns (total 2 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   image_path  4618 non-null   object
 1   label       4618 non-null   object
dtypes: object(2)
memory usage: 72.3+ KB
```

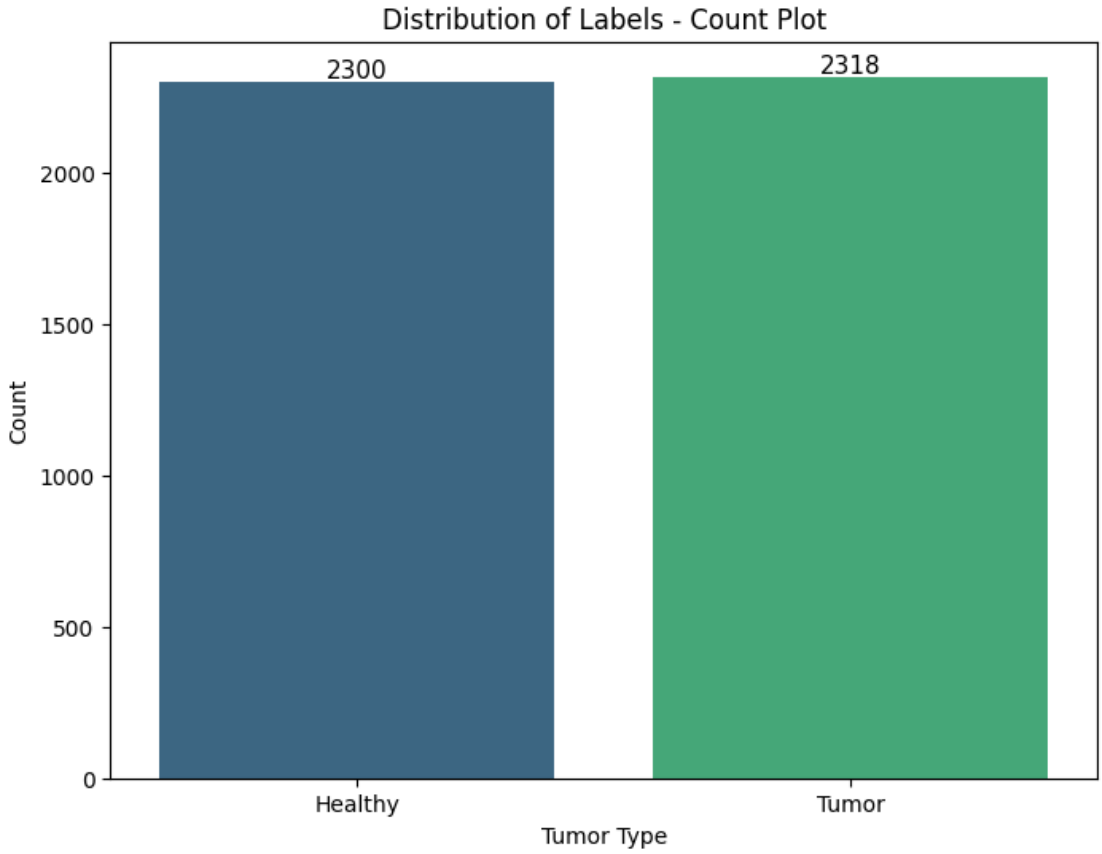
```
df['label'].unique()
```

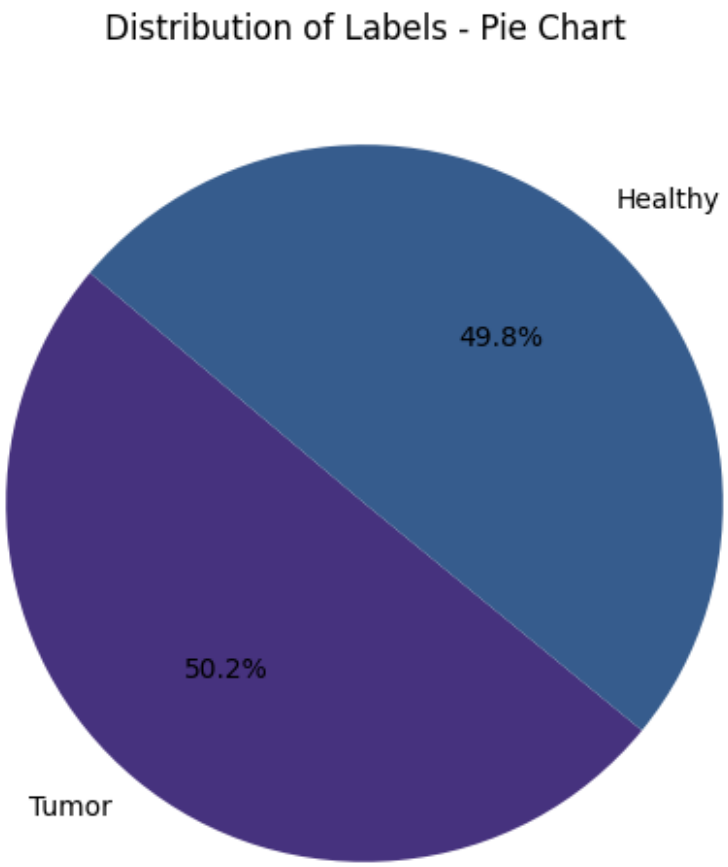
```
array(['Healthy', 'Tumor'], dtype=object)
```

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

```
label
Tumor      2318
Healthy    2300
Name: count, dtype: int64
```

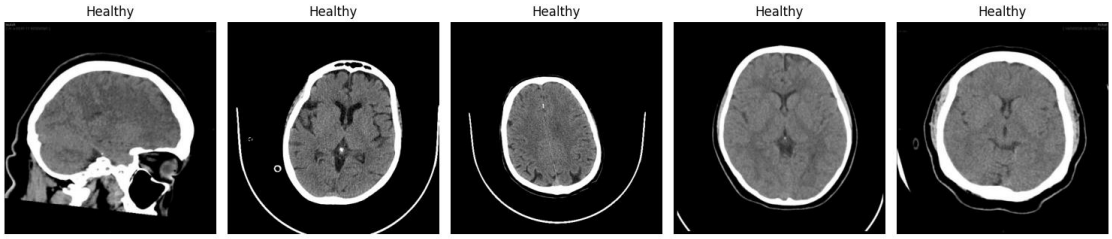
```
import seaborn as sns
import matplotlib.pyplot as plt

plt.figure(figsize=(8, 6))
sns.countplot(data=df, x="label", palette="viridis")
plt.title("Distribution of Labels - Count Plot")
plt.xlabel("Tumor Type")
plt.ylabel("Count")

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

plt.show()

label_counts = df['label'].value_counts()
plt.figure(figsize=(8, 6))
plt.pie(label_counts, labels=label_counts.index, autopct='%1.1f%%',
startangle=140, colors=sns.color_palette("viridis"))
plt.title("Distribution of Labels - Pie Chart")
plt.show()
```

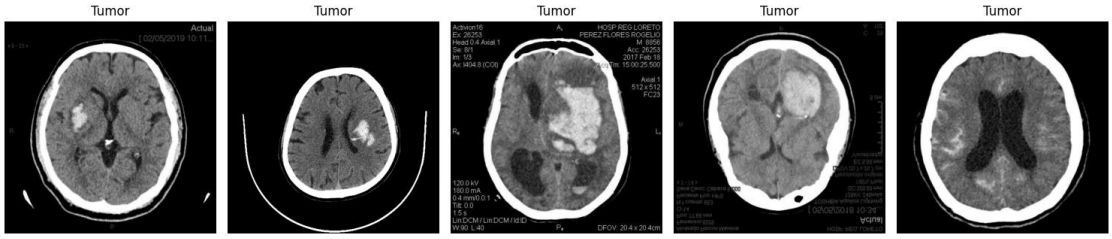

Distribution of Labels - Count Plot
2300
2318
2000
1500
1000
500
0
Count
Healthy
Tumor
Tumor Type




```
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    2318
1    2318
Name: count, dtype: int64

df_resampled
```

```
                                              image_path  category_encoded
0     /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
1     /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
2     /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
3     /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
4     /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
...                                                 ...               ...
4631  /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
4632  /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
4633  /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
4634  /kaggle/input/brain-tumor-multimodal-image-ct-...                 0
4635  /kaggle/input/brain-tumor-multimodal-image-ct-...                 0

[4636 rows x 2 columns]
```

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

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

import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.models import Sequential
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense,
Activation, Dropout, BatchNormalization
from tensorflow.keras import regularizers

import warnings
warnings.filterwarnings("ignore")

print ('check')
```

```
check
```

```
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']
)

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 3708 validated image filenames belonging to 2 classes.
Found 464 validated image filenames belonging to 2 classes.
Found 464 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
```

```
import torch
import torch.nn as nn
import torch.nn.functional as F

class SpatialAttentionLayer(nn.Module):
    def __init__(self, in_channels):
        super(SpatialAttentionLayer, self).__init__()
        self.conv1 = nn.Conv2d(in_channels, in_channels // 2, kernel_size=1)
        self.conv2 = nn.Conv2d(in_channels // 2, 1, kernel_size=3, padding=1,
dilation=1)
        self.conv3 = nn.Conv2d(1, 1, kernel_size=3, padding=2, dilation=2)
        self.sigmoid = nn.Sigmoid()

    def forward(self, x):
        attention = self.conv1(x)
        attention = F.relu(self.conv2(attention))
        attention = self.sigmoid(self.conv3(attention))
        return x * attention

class CNNBlock(nn.Module):
    def __init__(self, in_channels, out_channels):
        super(CNNBlock, self).__init__()
        self.spatial_attention = SpatialAttentionLayer(in_channels)
        self.conv = nn.Sequential(
            nn.Conv2d(in_channels, out_channels, kernel_size=3, padding=1),
            nn.BatchNorm2d(out_channels),
            nn.ReLU()
        )

    def forward(self, x):
        x = self.spatial_attention(x)
        return self.conv(x)
```

```python
class SKIPNet(nn.Module):
    def __init__(self, num_classes=3):
        super(SKIPNet, self).__init__()
        self.block1 = CNNBlock(3, 32)
        self.block2 = CNNBlock(32, 64)
        self.block3 = CNNBlock(64, 128)
        self.dropout = nn.Dropout(0.5)
        self.downsample = nn.Conv2d(128, 128, kernel_size=2, stride=2)
        self.final_attention = SpatialAttentionLayer(128)
        self.fc = nn.Sequential(
            nn.Flatten(),
            nn.Linear(128 * 16 * 16, 256),
            nn.ReLU(),
            nn.Linear(256, num_classes)
        )

    def forward(self, x):
        x = self.block1(x)
        x = self.dropout(x)
        x = self.block2(x)
        x = self.dropout(x)
        x = self.block3(x)
        x = self.dropout(x)
        x = self.downsample(x)
        x = self.final_attention(x)
        x = self.fc(x)
        return x

model = SKIPNet(num_classes=3)
print(model)
```

```
SKIPNet(
  (block1): CNNBlock(
    (spatial_attention): SpatialAttentionLayer(
      (conv1): Conv2d(3, 1, kernel_size=(1, 1), stride=(1, 1))
      (conv2): Conv2d(1, 1, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
      (conv3): Conv2d(1, 1, kernel_size=(3, 3), stride=(1, 1), padding=(2,
2), dilation=(2, 2))
      (sigmoid): Sigmoid()
    )
    (conv): Sequential(
      (0): Conv2d(3, 32, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
      (1): BatchNorm2d(32, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (2): ReLU()
    )
  )
  (block2): CNNBlock(
    (spatial_attention): SpatialAttentionLayer(
```

```
      (conv1): Conv2d(32, 16, kernel_size=(1, 1), stride=(1, 1))
      (conv2): Conv2d(16, 1, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
      (conv3): Conv2d(1, 1, kernel_size=(3, 3), stride=(1, 1), padding=(2,
2), dilation=(2, 2))
      (sigmoid): Sigmoid()
    )
    (conv): Sequential(
      (0): Conv2d(32, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
      (1): BatchNorm2d(64, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (2): ReLU()
    )
  )
  (block3): CNNBlock(
    (spatial_attention): SpatialAttentionLayer(
      (conv1): Conv2d(64, 32, kernel_size=(1, 1), stride=(1, 1))
      (conv2): Conv2d(32, 1, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
      (conv3): Conv2d(1, 1, kernel_size=(3, 3), stride=(1, 1), padding=(2,
2), dilation=(2, 2))
      (sigmoid): Sigmoid()
    )
    (conv): Sequential(
      (0): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
      (1): BatchNorm2d(128, eps=1e-05, momentum=0.1, affine=True,
track_running_stats=True)
      (2): ReLU()
    )
  )
  (dropout): Dropout(p=0.5, inplace=False)
  (downsample): Conv2d(128, 128, kernel_size=(2, 2), stride=(2, 2))
  (final_attention): SpatialAttentionLayer(
    (conv1): Conv2d(128, 64, kernel_size=(1, 1), stride=(1, 1))
    (conv2): Conv2d(64, 1, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1))
    (conv3): Conv2d(1, 1, kernel_size=(3, 3), stride=(1, 1), padding=(2, 2),
dilation=(2, 2))
    (sigmoid): Sigmoid()
  )
  (fc): Sequential(
    (0): Flatten(start_dim=1, end_dim=-1)
    (1): Linear(in_features=32768, out_features=256, bias=True)
    (2): ReLU()
    (3): Linear(in_features=256, out_features=3, bias=True)
  )
)
```

```
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
```

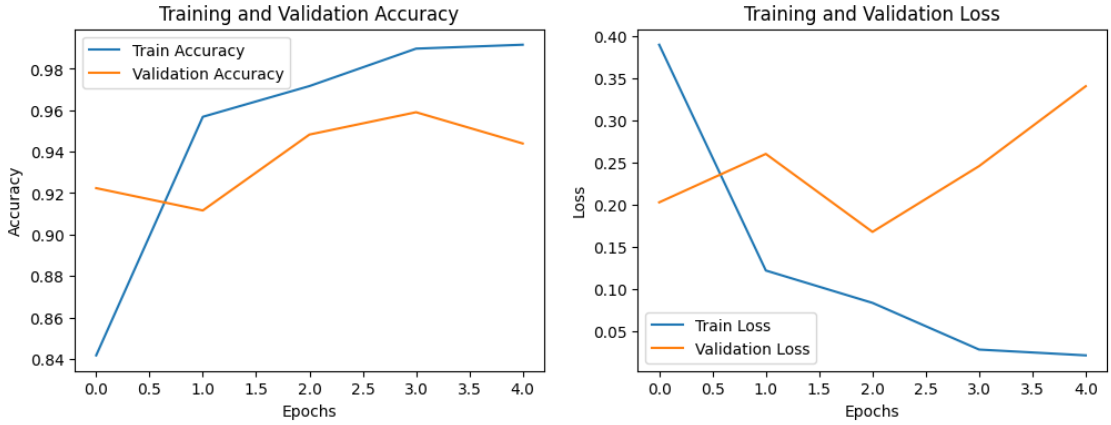
```
class SpatialAttentionLayer(keras.layers.Layer):
    def __init__(self, **kwargs):
        super(SpatialAttentionLayer, self).__init__(**kwargs)
        self.conv1 = layers.Conv2D(32, kernel_size=1, activation='relu')
        self.conv2 = layers.Conv2D(1, kernel_size=3, padding='same',
activation='sigmoid')

    def call(self, inputs):
        attention = self.conv1(inputs)
        attention = self.conv2(attention)
        return inputs * attention

class CNNBlock(keras.layers.Layer):
    def __init__(self, filters, **kwargs):
        super(CNNBlock, self).__init__(**kwargs)
        self.spatial_attention = SpatialAttentionLayer()
        self.conv = keras.Sequential([
            layers.Conv2D(filters, kernel_size=3, padding='same',
activation='relu'),
            layers.BatchNormalization(),
            layers.ReLU()
        ])

    def call(self, inputs):
        x = self.spatial_attention(inputs)
        return self.conv(x)

class SKIPNet(keras.Model):
    def __init__(self, num_classes=2):
        super(SKIPNet, self).__init__()
        self.block1 = CNNBlock(32)
        self.block2 = CNNBlock(64)
        self.block3 = CNNBlock(128)
        self.dropout = layers.Dropout(0.5)
        self.downsample = layers.Conv2D(128, kernel_size=2, strides=2)
        self.final_attention = SpatialAttentionLayer()
        self.flatten = layers.Flatten()
        self.fc1 = layers.Dense(256, activation='relu')
        self.fc2 = layers.Dense(1, activation='sigmoid')

    def call(self, inputs):
        x = self.block1(inputs)
        x = self.dropout(x)
        x = self.block2(x)
        x = self.dropout(x)
        x = self.block3(x)
        x = self.dropout(x)
        x = self.downsample(x)
```

```
        x = self.final_attention(x)
        x = self.flatten(x)
        x = self.fc1(x)
        return self.fc2(x)

model = SKIPNet(num_classes=2)
model.compile(optimizer='adam', loss='binary_crossentropy',
metrics=['accuracy'])

model.build(input_shape=(None, 224, 224, 3))

history = model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=5,
    batch_size=16,
    verbose=1
)
```

```
Epoch 1/5
232/232 ━━━━━━━━━━━━━━━━━━━━ 143s 400ms/step - accuracy: 0.7252 - loss:
0.7376 - val_accuracy: 0.9224 - val_loss: 0.2028
Epoch 2/5
232/232 ━━━━━━━━━━━━━━━━━━━━ 68s 291ms/step - accuracy: 0.9617 - loss: 0.1009
- val_accuracy: 0.9116 - val_loss: 0.2602
Epoch 3/5
232/232 ━━━━━━━━━━━━━━━━━━━━ 68s 292ms/step - accuracy: 0.9659 - loss: 0.1051
- val_accuracy: 0.9483 - val_loss: 0.1678
Epoch 4/5
232/232 ━━━━━━━━━━━━━━━━━━━━ 68s 292ms/step - accuracy: 0.9895 - loss: 0.0318
- val_accuracy: 0.9591 - val_loss: 0.2458
Epoch 5/5
232/232 ━━━━━━━━━━━━━━━━━━━━ 68s 292ms/step - accuracy: 0.9906 - loss: 0.0217
- val_accuracy: 0.9440 - val_loss: 0.3404
```

```
from sklearn.metrics import confusion_matrix, classification_report

def plot_history(history):
    plt.figure(figsize=(12, 4))

    plt.subplot(1, 2, 1)
    plt.plot(history.history['accuracy'], label='Train Accuracy')
    plt.plot(history.history['val_accuracy'], label='Validation Accuracy')
    plt.xlabel('Epochs')
    plt.ylabel('Accuracy')
    plt.legend()
    plt.title('Training and Validation Accuracy')

    plt.subplot(1, 2, 2)
    plt.plot(history.history['loss'], label='Train Loss')
```

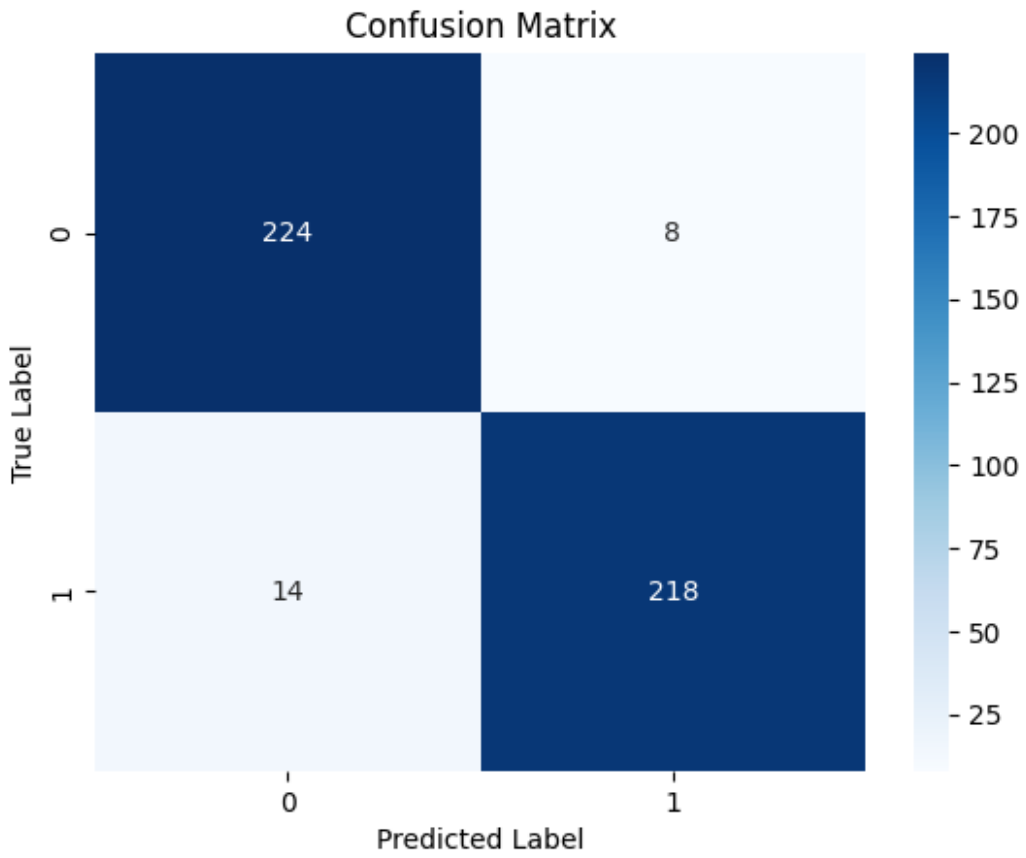
```
    plt.plot(history.history['val_loss'], label='Validation Loss')
    plt.xlabel('Epochs')
    plt.ylabel('Loss')
    plt.legend()
    plt.title('Training and Validation Loss')
    plt.show()

plot_history(history)
```




```
y_pred = model.predict(test_gen_new)
y_pred_classes = (y_pred > 0.5).astype(int).flatten()
y_true = test_gen_new.classes
```

```
29/29 ━━━━━━━━━━━━━━━━━━━━ 5s 149ms/step
```

```
conf_matrix = confusion_matrix(y_true, y_pred_classes)
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.title('Confusion Matrix')
plt.show()
```




```
print('Classification Report:\n', classification_report(y_true,
y_pred_classes))
```

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

           0       0.94      0.97      0.95       232
           1       0.96      0.94      0.95       232

    accuracy                           0.95       464
   macro avg       0.95      0.95      0.95       464
weighted avg       0.95      0.95      0.95       464
```