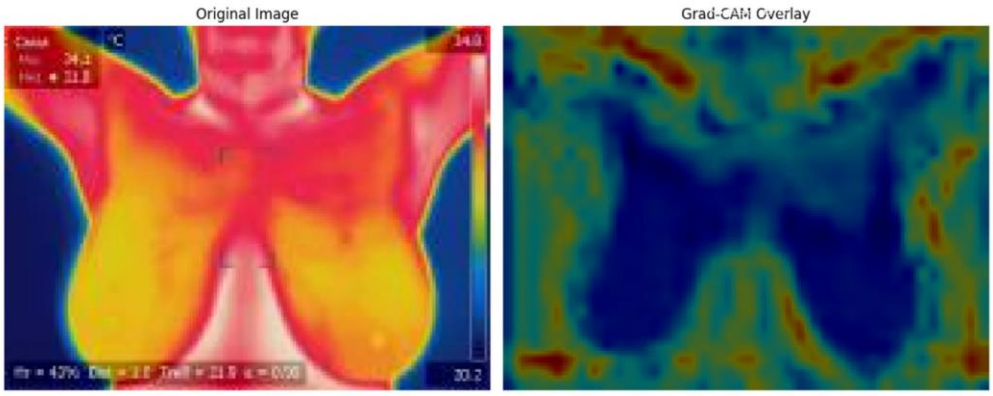
# Breast cancer detection using thermography DMR-IR




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

base_path = "/kaggle/input/breast-cancer-detection-using-
thermography/BCD_Dataset"
categories = ["Sick","Unknown_class","normal"]

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/breast-cancer-detection-using-th... | Sick |
| 1 | /kaggle/input/breast-cancer-detection-using-th... | Sick |
| 2 | /kaggle/input/breast-cancer-detection-using-th... | Sick |
| 3 | /kaggle/input/breast-cancer-detection-using-th... | Sick |
| 4 | /kaggle/input/breast-cancer-detection-using-th... | Sick |

```
df.tail()
```

```
                                            image_path   label
357  /kaggle/input/breast-cancer-detection-using-th...  normal
358  /kaggle/input/breast-cancer-detection-using-th...  normal
359  /kaggle/input/breast-cancer-detection-using-th...  normal
360  /kaggle/input/breast-cancer-detection-using-th...  normal
361  /kaggle/input/breast-cancer-detection-using-th...  normal
```

```
df.shape
```

```
(362, 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: 362 entries, 0 to 361
Data columns (total 2 columns):
 #   Column      Non-Null Count  Dtype 
---  ------      --------------  ----- 
 0   image_path  362 non-null    object
 1   label       362 non-null    object
dtypes: object(2)
memory usage: 5.8+ KB
```

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

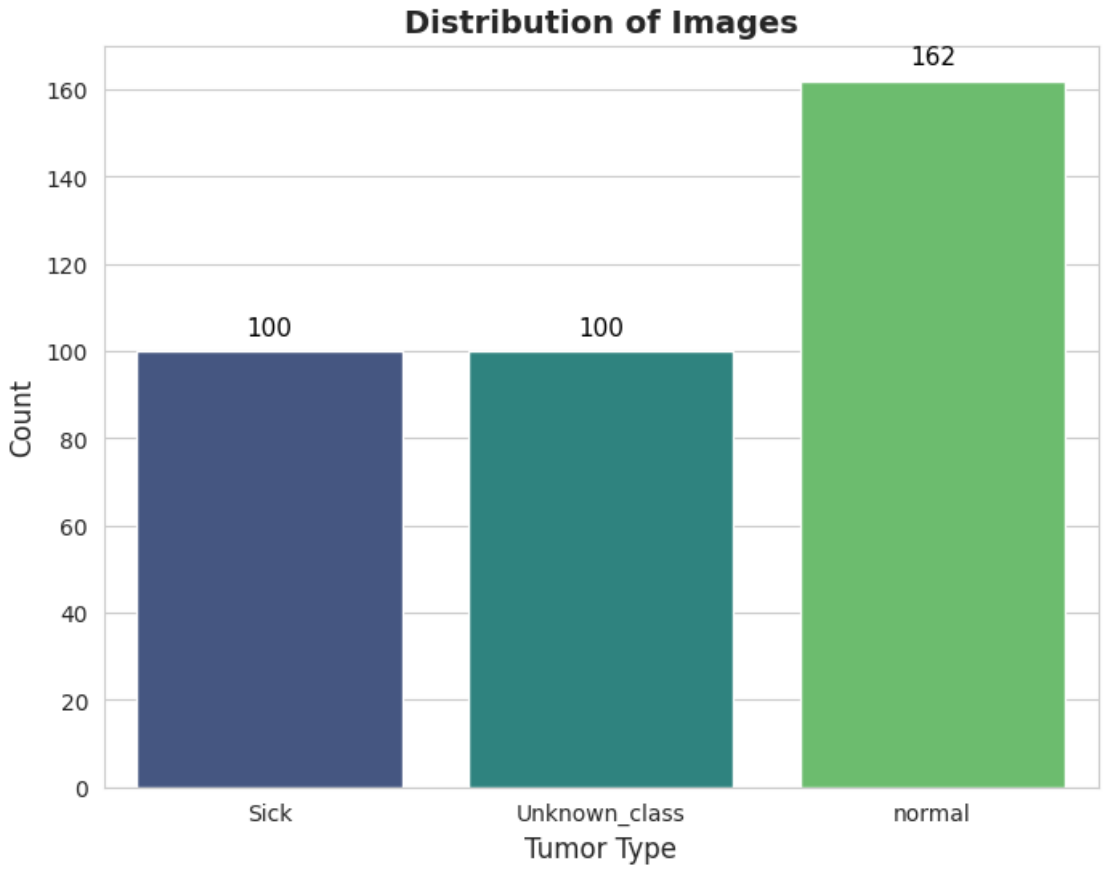
```
array(['Sick', 'Unknown_class', 'normal'], dtype=object)
```

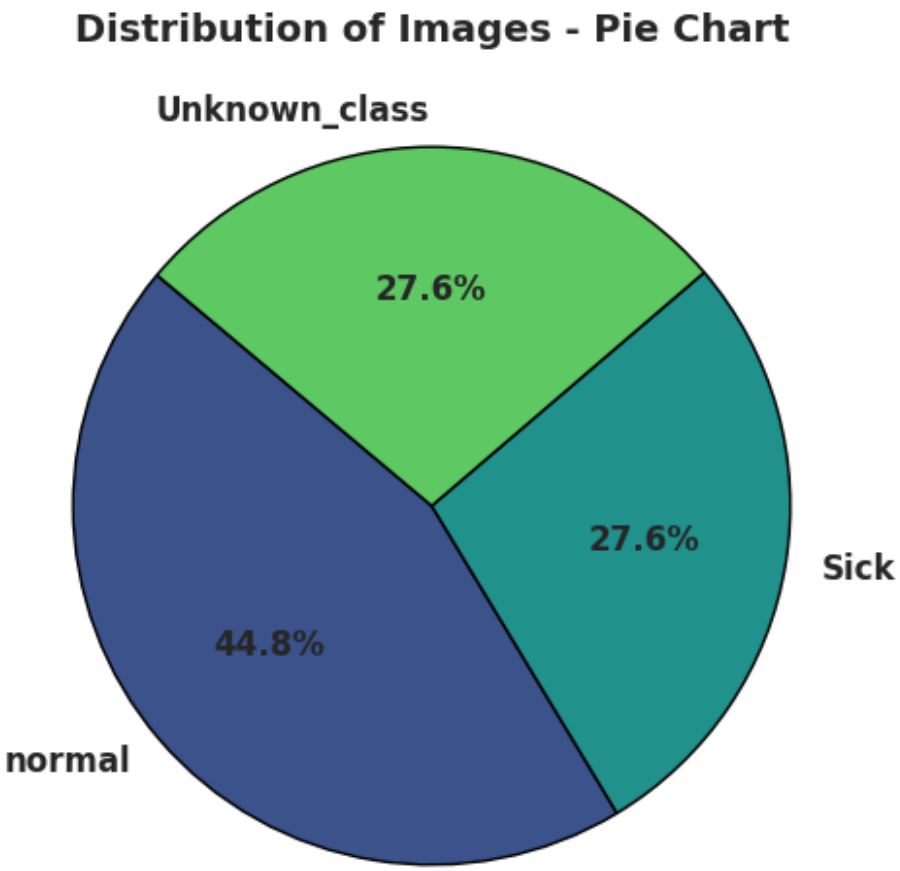
```
df['label'].value_counts()
```

```
label
normal           162
Sick             100
Unknown_class    100
Name: count, dtype: int64
```

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

sns.set_style("whitegrid")
```

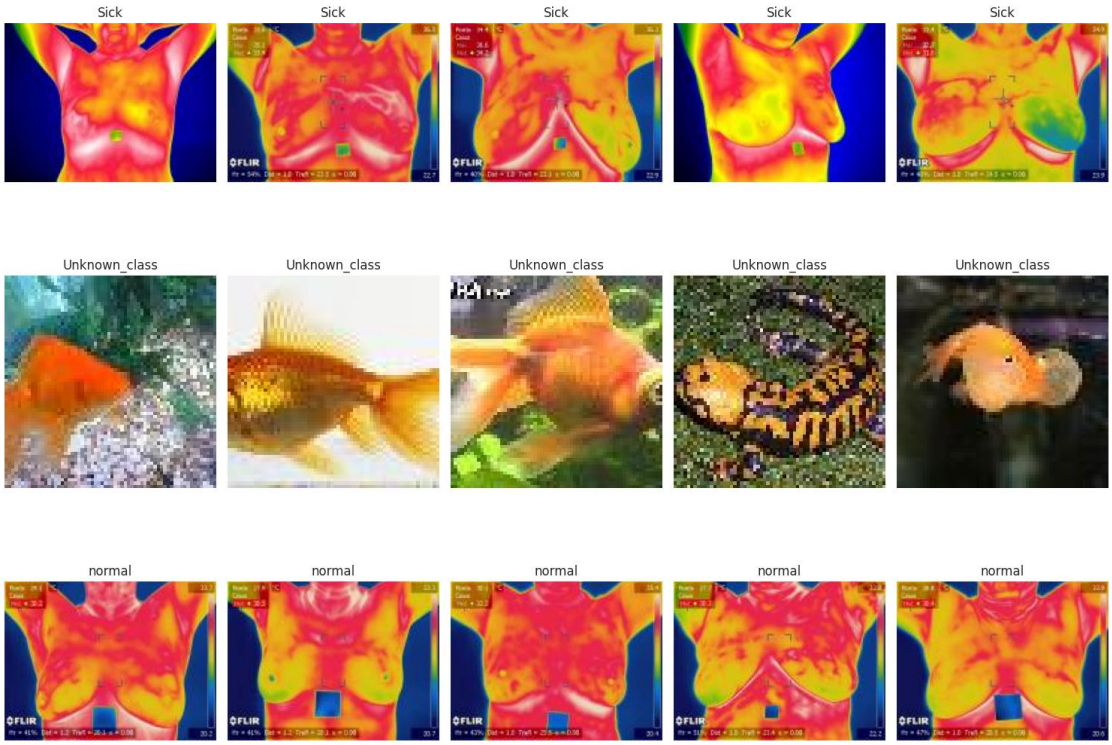
```
fig, ax = plt.subplots(figsize=(8, 6))
sns.countplot(data=df, x="label", palette="viridis", ax=ax)

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

plt.show()
```


Distribution of Images
162
100
100
160
140
120
100
80
60
40
20
0
Count
Sick
Unknown_class
normal
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']]

majority_class_count = df['category_encoded'].value_counts().max()

majority_class = df[df['category_encoded'] ==
df['category_encoded'].value_counts().idxmax()]
minority_class = df[df['category_encoded'] !=
df['category_encoded'].value_counts().idxmax()]

oversampled_minority_class = minority_class.sample(n=majority_class_count,
replace=True, random_state=42)

balanced_df = pd.concat([majority_class, oversampled_minority_class])

balanced_df = balanced_df.reset_index(drop=True)
balanced_df = balanced_df[['image_path', 'category_encoded']]

print(balanced_df)
```

```
                                           image_path  category_encoded
0    /kaggle/input/breast-cancer-detection-using-th...                 2
```

```
1    /kaggle/input/breast-cancer-detection-using-th...                2
2    /kaggle/input/breast-cancer-detection-using-th...                2
3    /kaggle/input/breast-cancer-detection-using-th...                2
4    /kaggle/input/breast-cancer-detection-using-th...                2
..                                                 ...              ...
319  /kaggle/input/breast-cancer-detection-using-th...                0
320  /kaggle/input/breast-cancer-detection-using-th...                0
321  /kaggle/input/breast-cancer-detection-using-th...                1
322  /kaggle/input/breast-cancer-detection-using-th...                0
323  /kaggle/input/breast-cancer-detection-using-th...                1

[324 rows x 2 columns]
```

```
df_resampled = balanced_df

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')
```

```
2025-05-06 08:35:18.967098: E
external/local_xla/xla/stream_executor/cuda/cuda_fft.cc:477] Unable to
register cuFFT factory: Attempting to register factory for plugin cuFFT when
one has already been registered
WARNING: All log messages before absl::InitializeLog() is called are written
to STDERR
E0000 00:00:1746520519.357888      31 cuda_dnn.cc:8310] Unable to register
cuDNN factory: Attempting to register factory for plugin cuDNN when one has
already been registered
E0000 00:00:1746520519.477473      31 cuda_blas.cc:1418] Unable to register
cuBLAS factory: Attempting to register factory for plugin cuBLAS when one has
already been registered

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='sparse',
    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='sparse',
    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='sparse',
    color_mode='rgb',
    shuffle=False,
    batch_size=batch_size
)
```

```
Found 259 validated image filenames belonging to 3 classes.
Found 32 validated image filenames belonging to 3 classes.
Found 33 validated image filenames belonging to 3 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 tensorflow as tf
from tensorflow.keras import layers, Model

class SimpleAttention(layers.Layer):
    def __init__(self, **kwargs):
        super(SimpleAttention, self).__init__(**kwargs)

    def build(self, input_shape):
        self.in_channels = input_shape[-1]
        self.H = input_shape[1]
        self.W = input_shape[2]
        self.dense = layers.Dense(1, use_bias=False)
        super(SimpleAttention, self).build(input_shape)

    def call(self, inputs):

        weights = self.dense(inputs)
        return inputs * weights

    def compute_output_shape(self, input_shape):

        return input_shape
```

```python
def create_simple_cnn(input_shape=(224, 224, 3), num_classes=3):
    inputs = layers.Input(shape=input_shape)
    x = layers.Conv2D(32, 3, padding='same', activation='relu')(inputs)
    x = layers.MaxPooling2D(2)(x)
    x = layers.Conv2D(64, 3, padding='same', activation='relu')(x)
    x = layers.MaxPooling2D(2)(x)
    x = layers.Conv2D(64, 3, padding='same', activation='relu')(x)
    x = layers.MaxPooling2D(2)(x)
    x = layers.Conv2D(64, 3, padding='same', activation='relu')(x)
    x = layers.MaxPooling2D(2)(x)

    att = SimpleAttention()(x)
    x = layers.concatenate([x, att])
    x = layers.GlobalAveragePooling2D()(x)
    outputs = layers.Dense(num_classes, activation='softmax')(x)
    return Model(inputs, outputs)


simple_model = create_simple_cnn(num_classes=3)
simple_model.summary()
```

```
I0000 00:00:1746520537.790241      31 gpu_device.cc:2022] Created device
/job:localhost/replica:0/task:0/device:GPU:0 with 13942 MB memory:  ->
device: 0, name: Tesla T4, pci bus id: 0000:00:04.0, compute capability: 7.5
I0000 00:00:1746520537.790909      31 gpu_device.cc:2022] Created device
/job:localhost/replica:0/task:0/device:GPU:1 with 13942 MB memory:  ->
device: 1, name: Tesla T4, pci bus id: 0000:00:05.0, compute capability: 7.5

Model: "functional"
```

| Layer (type) | Output Shape | Param # | Connected to |
|---|---|---|---|
| input_layer (InputLayer) | (None, 224, 224, 3) | 0 | - |
| conv2d (Conv2D) | (None, 224, 224, 32) | 896 | input_layer[0][0] |
| max_pooling2d (MaxPooling2D) | (None, 112, 112, 32) | 0 | conv2d[0][0] |

```
──────────────────┤
│ conv2d_1 (Conv2D)          │ (None, 112, 112, 64)   │         18,496 │
max_pooling2d[0][0]    │
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ max_pooling2d_1            │ (None, 56, 56, 64)     │              0 │
conv2d_1[0][0]         │
│ (MaxPooling2D)             │                        │                │
│
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ conv2d_2 (Conv2D)          │ (None, 56, 56, 64)     │         36,928 │
max_pooling2d_1[0][0]  │
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ max_pooling2d_2            │ (None, 28, 28, 64)     │              0 │
conv2d_2[0][0]         │
│ (MaxPooling2D)             │                        │                │
│
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ conv2d_3 (Conv2D)          │ (None, 28, 28, 64)     │         36,928 │
max_pooling2d_2[0][0]  │
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ max_pooling2d_3            │ (None, 14, 14, 64)     │              0 │
conv2d_3[0][0]         │
│ (MaxPooling2D)             │                        │                │
│
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ simple_attention           │ (None, 14, 14, 64)     │              0 │
max_pooling2d_3[0][0]  │
│ (SimpleAttention)          │                        │                │
│
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ concatenate (Concatenate) │ (None, 14, 14, 128)    │              0 │
max_pooling2d_3[0][0], │
│                            │                        │                │
simple_attention[0][0] │
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ global_average_pooling2d   │ (None, 128)            │              0 │
concatenate[0][0]      │
│ (GlobalAveragePooling2D)   │                        │                │
│
├──────────────────────────┼────────────────────────┼────────────────┼────
──────────────────┤
│ dense_1 (Dense)            │ (None, 3)              │            387 │
```

```
global_average_poolin… │
┗━━━━━━━━━━━━━━━━━━━━━━━━━━━┻━━━━━━━━━━━━━━━━━━━━━━━━┻━━━━━━━━━━━━━━━━┻━━━━━━
━━━━━━━━━━━━━━━━━━┛

 Total params: 93,635 (365.76 KB)

 Trainable params: 93,635 (365.76 KB)

 Non-trainable params: 0 (0.00 B)
```

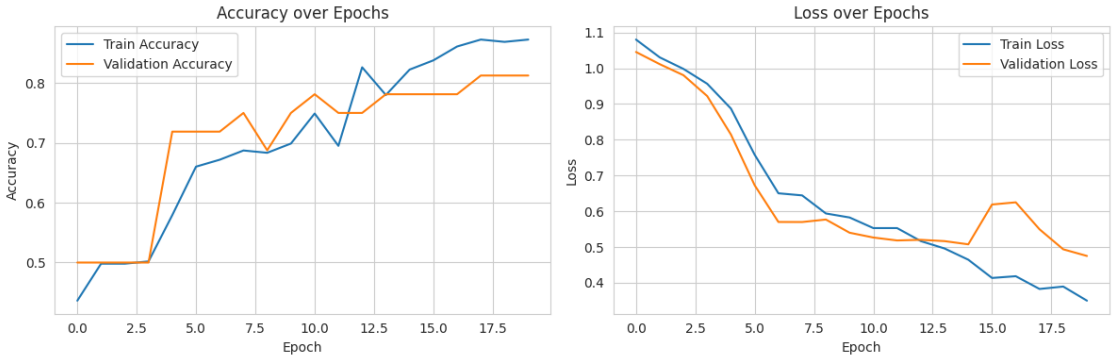
```python
simple_model.compile(optimizer=Adam(learning_rate=0.0001),
                     loss='sparse_categorical_crossentropy',
                     metrics=['accuracy'])

history = simple_model.fit(
    train_gen_new,
    validation_data=valid_gen_new,
    epochs=20,
    verbose=1
)
```

```
Epoch 1/20

WARNING: All log messages before absl::InitializeLog() is called are written
to STDERR
I0000 00:00:1746520543.118761      96 service.cc:148] XLA service
0x78b4d8085450 initialized for platform CUDA (this does not guarantee that
XLA will be used). Devices:
I0000 00:00:1746520543.120885      96 service.cc:156]   StreamExecutor device
(0): Tesla T4, Compute Capability 7.5
I0000 00:00:1746520543.120905      96 service.cc:156]   StreamExecutor device
(1): Tesla T4, Compute Capability 7.5
I0000 00:00:1746520543.498021      96 cuda_dnn.cc:529] Loaded cuDNN version
90300

 3/17 ━━━━━━━━━━━━━━━━━━━━ 0s 60ms/step - accuracy: 0.3472 - loss: 1.1091

I0000 00:00:1746520547.706082      96 device_compiler.h:188] Compiled cluster
using XLA!  This line is logged at most once for the lifetime of the process.

17/17 ━━━━━━━━━━━━━━━━━━━━ 12s 235ms/step - accuracy: 0.3809 - loss: 1.0937 -
val_accuracy: 0.5000 - val_loss: 1.0454
Epoch 2/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 37ms/step - accuracy: 0.5135 - loss: 1.0287 -
val_accuracy: 0.5000 - val_loss: 1.0113
Epoch 3/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 38ms/step - accuracy: 0.5038 - loss: 0.9956 -
val_accuracy: 0.5000 - val_loss: 0.9804
Epoch 4/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 39ms/step - accuracy: 0.5136 - loss: 0.9536 -
val_accuracy: 0.5000 - val_loss: 0.9221
Epoch 5/20
```

```
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 43ms/step - accuracy: 0.6154 - loss: 0.8642 -
val_accuracy: 0.7188 - val_loss: 0.8146
Epoch 6/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 40ms/step - accuracy: 0.6977 - loss: 0.7670 -
val_accuracy: 0.7188 - val_loss: 0.6726
Epoch 7/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 37ms/step - accuracy: 0.6419 - loss: 0.6842 -
val_accuracy: 0.7188 - val_loss: 0.5700
Epoch 8/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 35ms/step - accuracy: 0.7037 - loss: 0.6337 -
val_accuracy: 0.7500 - val_loss: 0.5698
Epoch 9/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 35ms/step - accuracy: 0.6506 - loss: 0.6396 -
val_accuracy: 0.6875 - val_loss: 0.5768
Epoch 10/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 36ms/step - accuracy: 0.6968 - loss: 0.5779 -
val_accuracy: 0.7500 - val_loss: 0.5399
Epoch 11/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 34ms/step - accuracy: 0.7665 - loss: 0.5888 -
val_accuracy: 0.7812 - val_loss: 0.5265
Epoch 12/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 34ms/step - accuracy: 0.7434 - loss: 0.5310 -
val_accuracy: 0.7500 - val_loss: 0.5183
Epoch 13/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 35ms/step - accuracy: 0.8228 - loss: 0.5321 -
val_accuracy: 0.7500 - val_loss: 0.5201
Epoch 14/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 34ms/step - accuracy: 0.7557 - loss: 0.5013 -
val_accuracy: 0.7812 - val_loss: 0.5164
Epoch 15/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 35ms/step - accuracy: 0.8359 - loss: 0.4433 -
val_accuracy: 0.7812 - val_loss: 0.5075
Epoch 16/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 36ms/step - accuracy: 0.8301 - loss: 0.4063 -
val_accuracy: 0.7812 - val_loss: 0.6188
Epoch 17/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 38ms/step - accuracy: 0.8497 - loss: 0.4186 -
val_accuracy: 0.7812 - val_loss: 0.6249
Epoch 18/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 38ms/step - accuracy: 0.8387 - loss: 0.4443 -
val_accuracy: 0.8125 - val_loss: 0.5495
Epoch 19/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 32ms/step - accuracy: 0.8863 - loss: 0.3764 -
val_accuracy: 0.8125 - val_loss: 0.4936
Epoch 20/20
17/17 ━━━━━━━━━━━━━━━━━━━━ 1s 34ms/step - accuracy: 0.8297 - loss: 0.4200 -
val_accuracy: 0.8125 - val_loss: 0.4749
```

```python
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.title('Accuracy over Epochs')
    plt.xlabel('Epoch')
    plt.ylabel('Accuracy')
    plt.legend()

    plt.subplot(1, 2, 2)
    plt.plot(history.history['loss'], label='Train Loss')
    plt.plot(history.history['val_loss'], label='Validation Loss')
    plt.title('Loss over Epochs')
    plt.xlabel('Epoch')
    plt.ylabel('Loss')
    plt.legend()

    plt.tight_layout()
    plt.show()

plot_history(history)
```




```
test_labels = test_gen_new.classes
predictions = simple_model.predict(test_gen_new)
predicted_classes = np.argmax(predictions, axis=1)
```

```
3/3 ━━━━━━━━━━━━━━━━━━━━ 1s 338ms/step
```

```
report = classification_report(test_labels, predicted_classes,
target_names=list(test_gen_new.class_indices.keys()))
print(report)
```

```
              precision    recall  f1-score   support

           0       1.00      0.56      0.71         9
           1       1.00      1.00      1.00         7
           2       0.81      1.00      0.89        17

    accuracy                           0.88        33
```

```
   macro avg       0.94      0.85      0.87        33
weighted avg       0.90      0.88      0.87        33
```

```
conf_matrix = confusion_matrix(test_labels, predicted_classes)

plt.figure(figsize=(10, 8))
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues',
xticklabels=list(test_gen_new.class_indices.keys()),
yticklabels=list(test_gen_new.class_indices.keys()))
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```