Exp2

EDA ON TABULAR DATA

[1]:
```
import pandas as pd
df=pd.read_csv('Diabetes.csv')
```

[2]:
```
df.head()
```

[2]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

[3]:
```
df.info()
```

[3]:
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 768 entries, 0 to 767
Data columns (total 9 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   Pregnancies               768 non-null    int64  
 1   Glucose                   768 non-null    int64  
 2   BloodPressure             768 non-null    int64  
 3   SkinThickness             768 non-null    int64  
 4   Insulin                   768 non-null    int64  
 5   BMI                       768 non-null    float64
 6   DiabetesPedigreeFunction  768 non-null    float64
 7   Age                       768 non-null    int64  
 8   Outcome                   768 non-null    int64  
dtypes: float64(2), int64(7)
memory usage: 54.1 KB
```

[4]:
```
df.describe()
```

[4]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
count	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000
mean	3.845052	120.894531	69.105469	20.536458	79.799479	31.992578	0.471876	33.240885	0.348958
std	3.369578	31.972618	19.355807	15.952218	115.244002	7.884160	0.331329	11.760232	0.476951
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.078000	21.000000	0.000000
25%	1.000000	99.000000	62.000000	0.000000	0.000000	27.300000	0.243750	24.000000	0.000000
50%	3.000000	117.000000	72.000000	23.000000	30.500000	32.000000	0.372500	29.000000	0.000000
75%	6.000000	140.250000	80.000000	32.000000	127.250000	36.600000	0.626250	41.000000	1.000000
max	17.000000	199.000000	122.000000	99.000000	846.000000	67.100000	2.420000	81.000000	1.000000

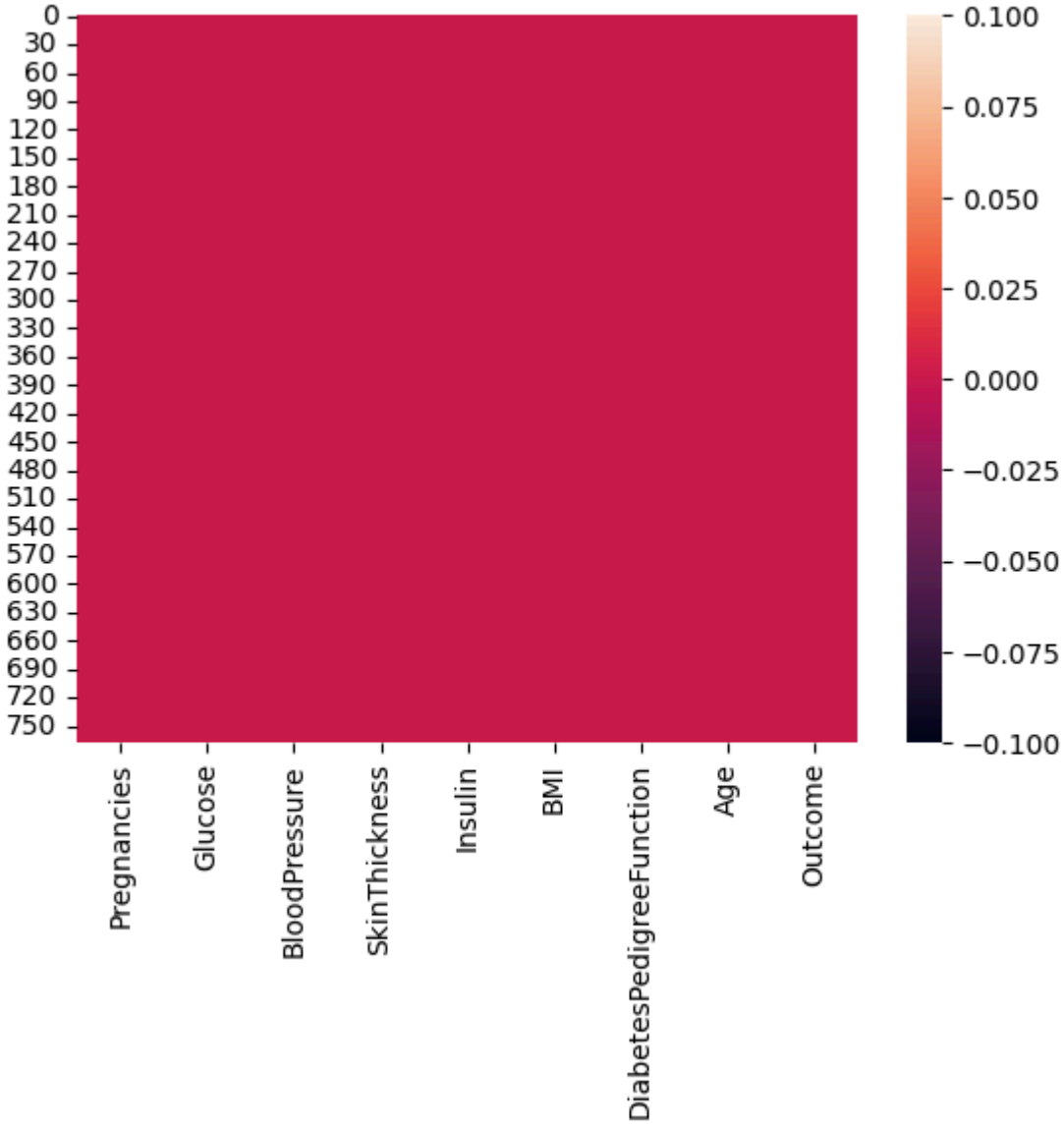
[5]:
```
df.isnull().sum()
```

[5]:
```
Pregnancies                 0
Glucose                     0
BloodPressure               0
SkinThickness               0
Insulin                     0
BMI                         0
DiabetesPedigreeFunction    0
Age                         0
Outcome                     0
dtype: int64
```

[6]:
```
import seaborn as sns
sns.heatmap(df.isnull())
```

[6]:

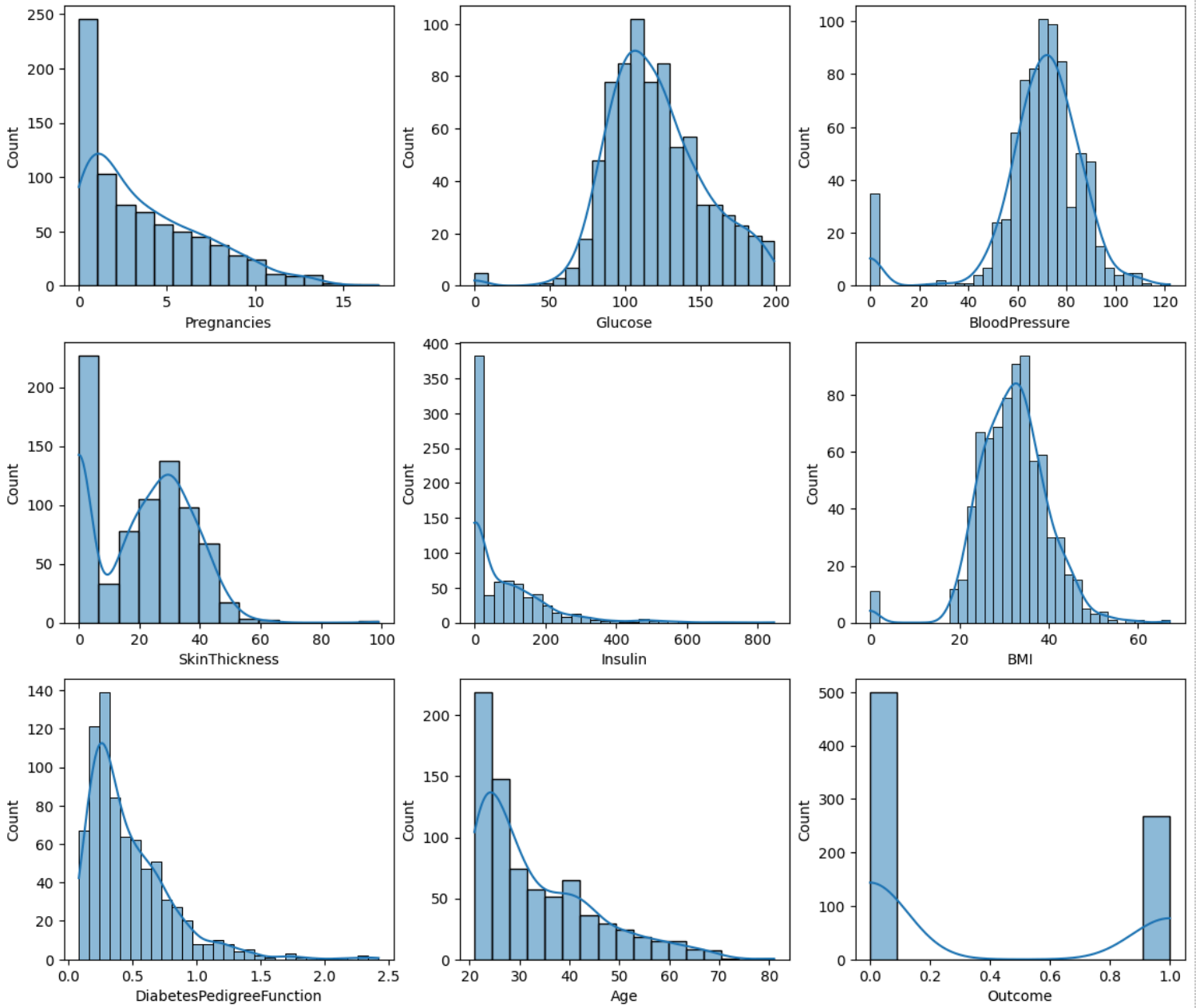
[6]:



[7]:

```
import matplotlib.pyplot as plt
cols=df.columns
plt.figure(figsize=(14,12))
for index,col in enumerate(cols):
    plt.subplot(3,3,index+1)
    sns.histplot(df[col],kde=True)
```

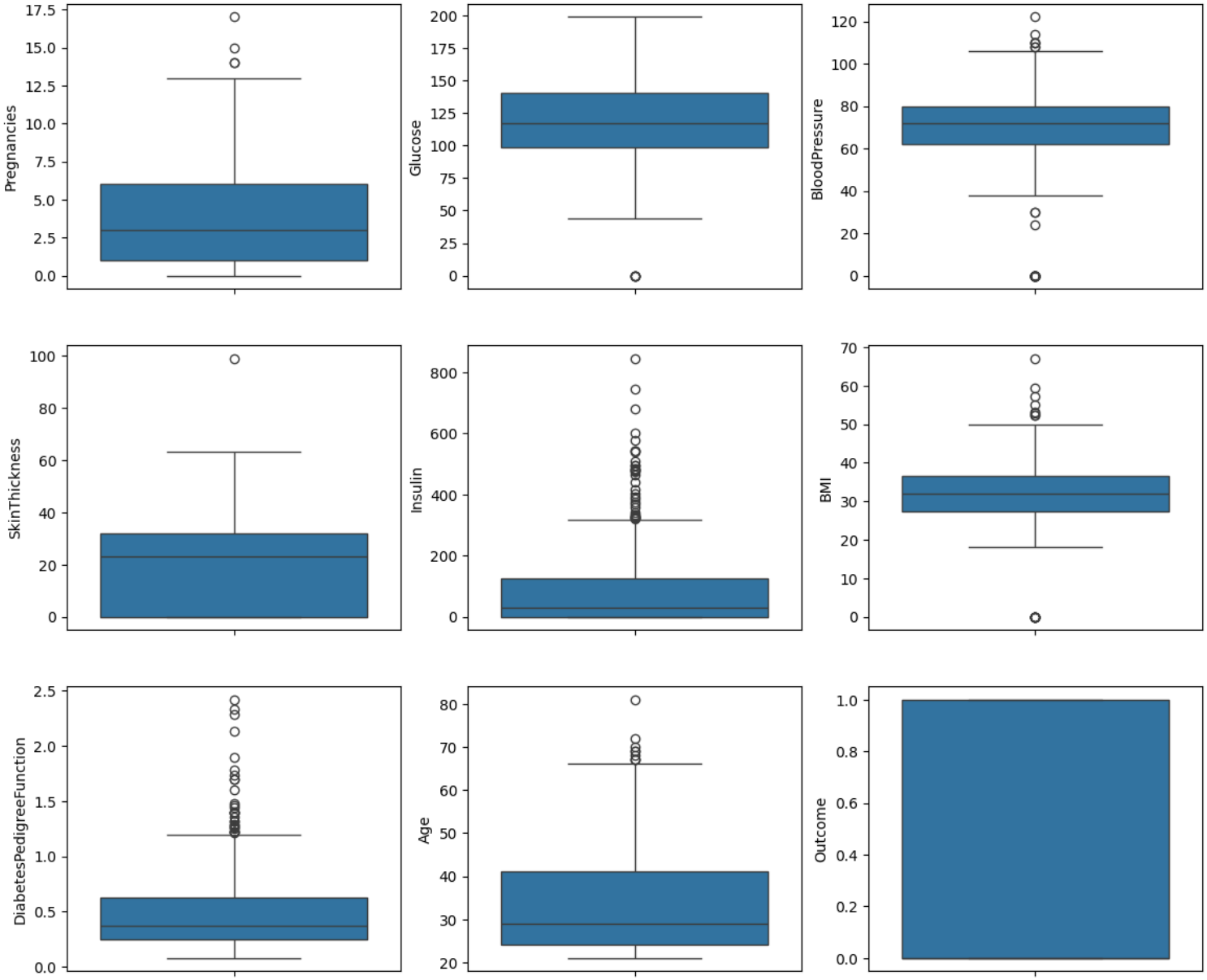
[7]:



[8]:

```
plt.figure(figsize=(14,12))
for index,col in enumerate(cols):
    plt.subplot(3,3,index+1)
    sns.boxplot(df[col])
```

[8]:

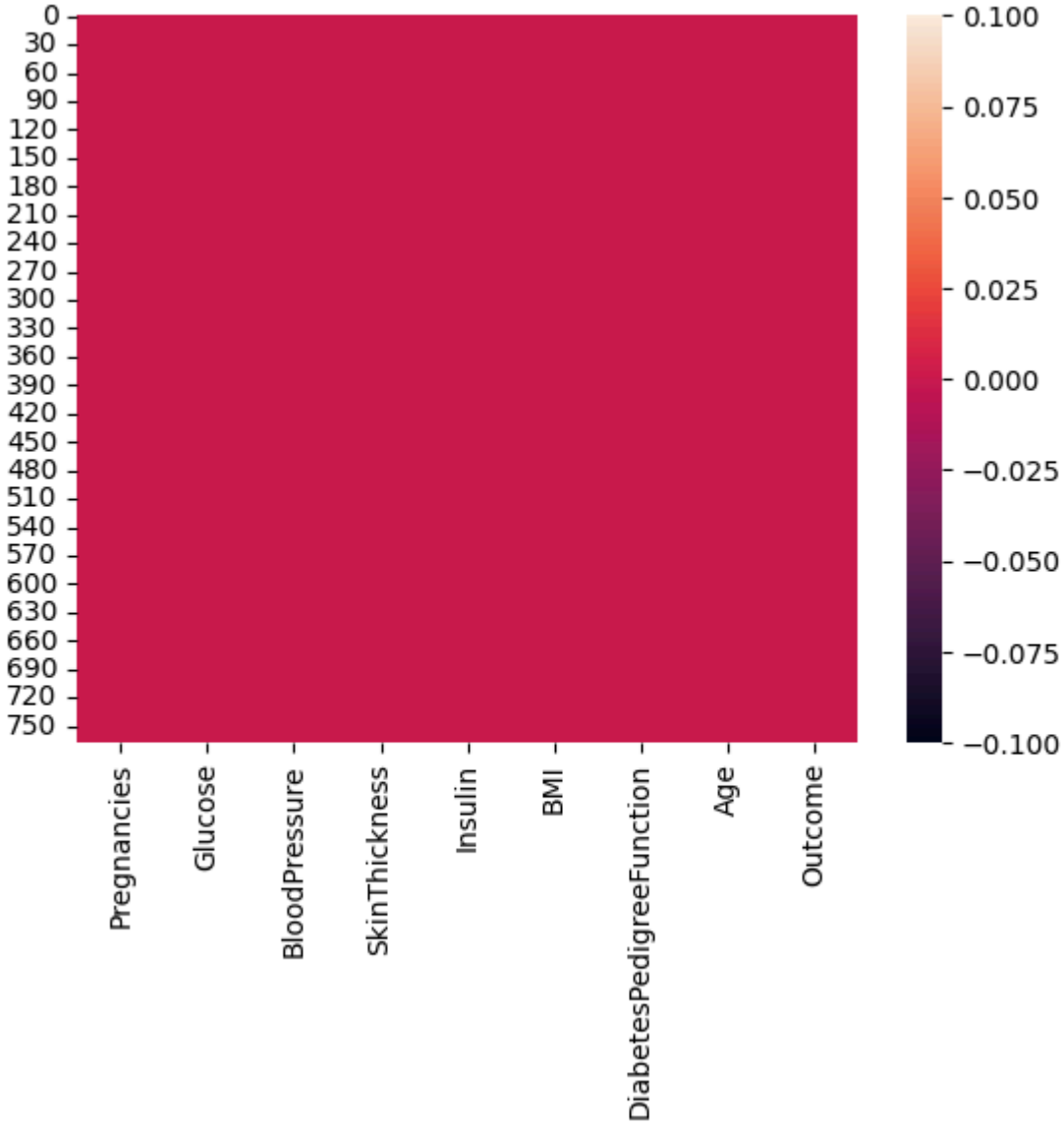


[9]:

```
for col in cols:
    df.fillna(df[col].mean(),inplace=True)
sns.heatmap(df.isnull())
```

[9]:

[9]:



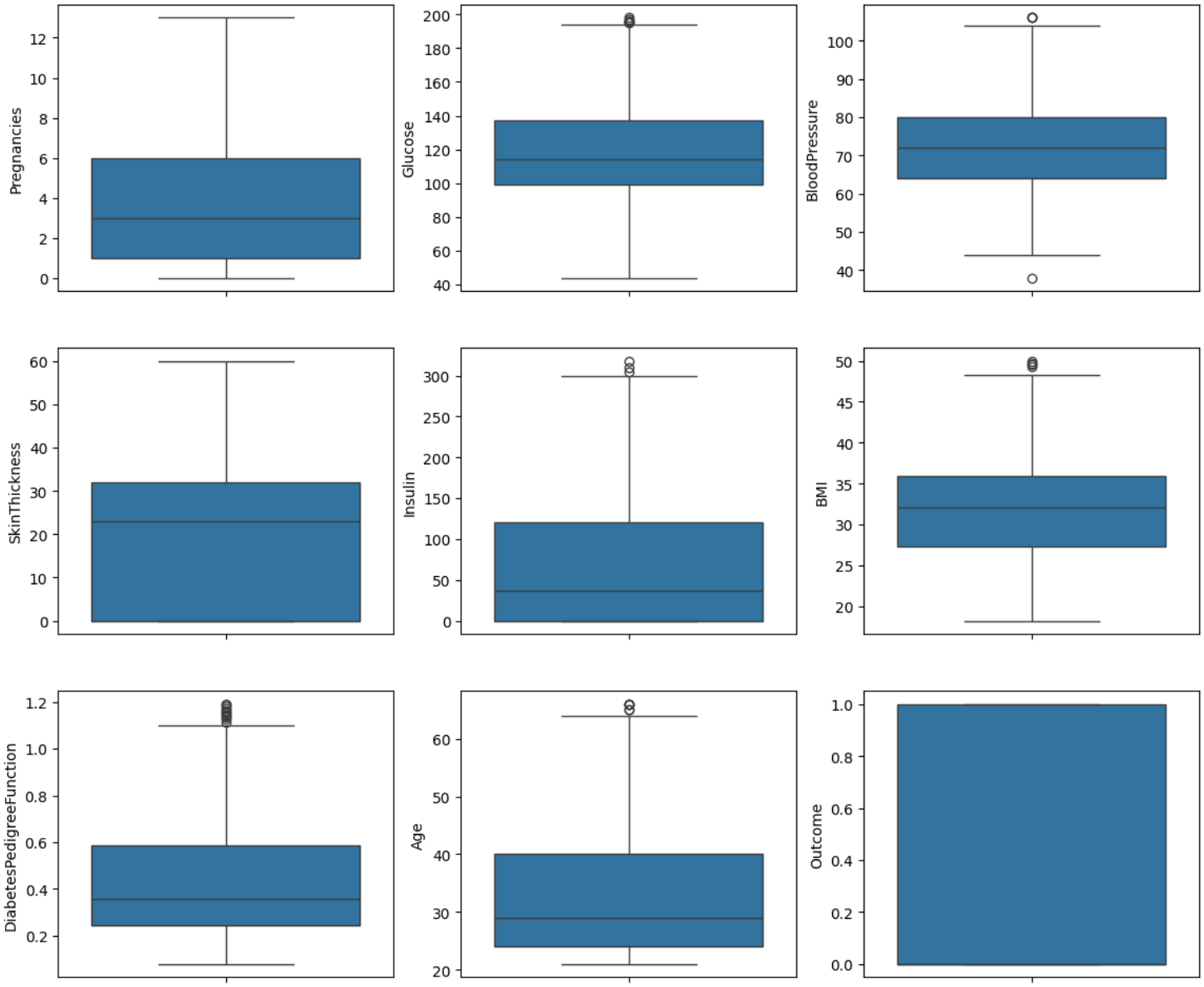
12]:

```
q1=df.quantile(0.25)
q3=df.quantile(0.75)
iqr=q3-q1
lb=q1-1.5*iqr
ub=q3+1.5*iqr

outliers=((df<lb)|(df>ub))
# print(df[outliers.any(axis=1)]) #This prints only the rows that contain at least one outlier.
df_no_outliers = df[~outliers.any(axis=1)] #it keeps only rows with no outliers.
```

13]:

```
plt.figure(figsize=(14,12))
for index,col in enumerate(cols):
    plt.subplot(3,3,index+1)
    sns.boxplot(df_no_outliers[col])
```

13]:



[]:
```
plt.pie(df['Class'].value_counts(),labels=['0','1'])
```

[]:
```
from sklearn.feature_selection import SelectKBest,chi2
selector=SelectKBest(chi2,k=5)
X=df.drop('Class',axis=1)
y=df['Class']
selector.fit_transform(X,y)

select_feat=X.columns[selector.get_support()]
print(select_feat)
corr=df[select_feat].corr()
sns.heatmap(corr,annot=True)
```

[]:

[]:

[]:

[]:

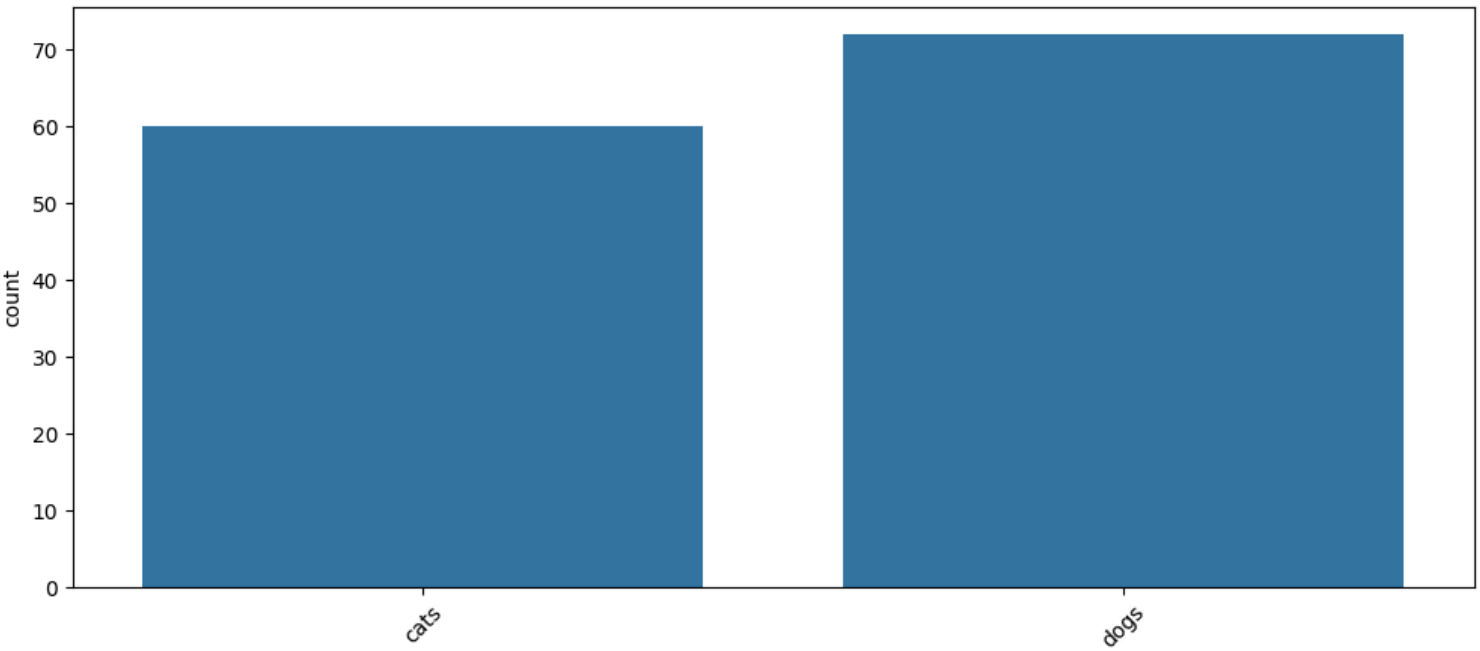
EXP2 EDA ON IMAGE

Using Glob package

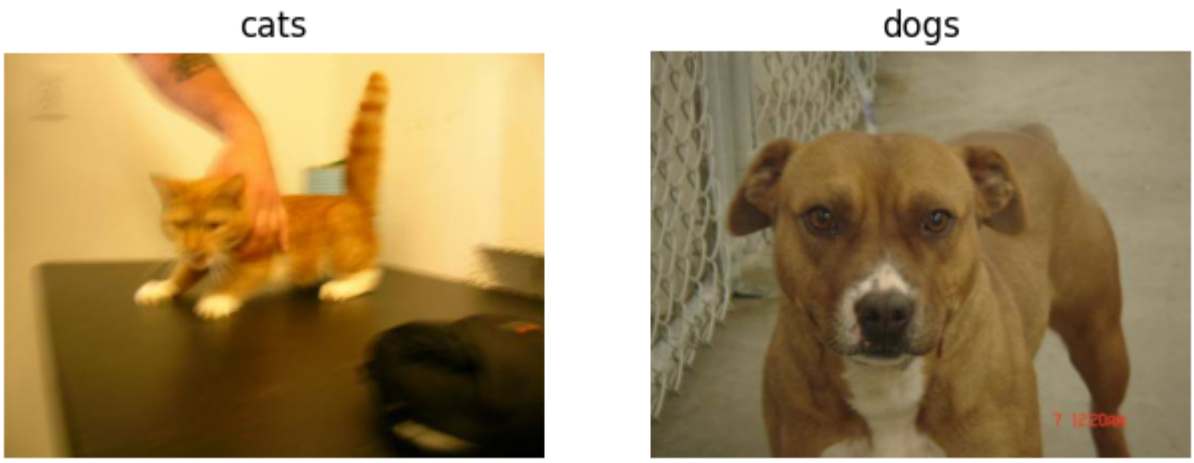
36]:
```
import glob
from PIL import Image
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np

# Path to all images
all_image_paths = glob.glob("cat_dog/*/*.jpg")

# Extract class names from folder structure
class_names = [path.split("\\")[-2] for path in all_image_paths]

# Class Distribution Plot
plt.figure(figsize=(12, 5))
sns.countplot(x=class_names)
plt.xticks(rotation=45)
plt.show()
```

```
# Show Sample Images
plt.figure(figsize=(16, 10))
for i, cls in enumerate(list(set(class_names))):  # Convert set to list
    img_path = [path for path in all_image_paths if cls in path][0]
    img = Image.open(img_path)
    plt.subplot(3, 4, i + 1)
    plt.imshow(img)
    plt.title(cls)
    plt.axis('off')
plt.show()

# RGB Histogram
for cls in list(set(class_names))[:5]:  # Convert set to list
    img_path = [path for path in all_image_paths if cls in path][0]
    img = Image.open(img_path).resize((256, 256))
    img_arr = np.array(img)
    plt.figure(figsize=(6, 3))
    plt.title(f"RGB Histogram: {cls}")
    for i, color in enumerate(('r', 'g', 'b')):
        plt.hist(img_arr[:, :, i].flatten(), bins=256, color=color, alpha=0.6)
    plt.show()
```

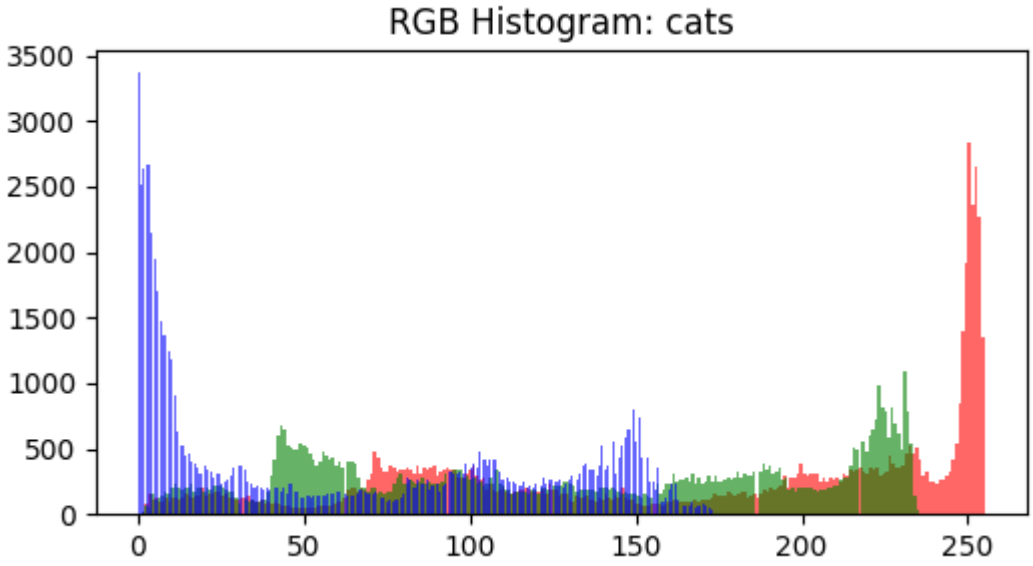
36]:



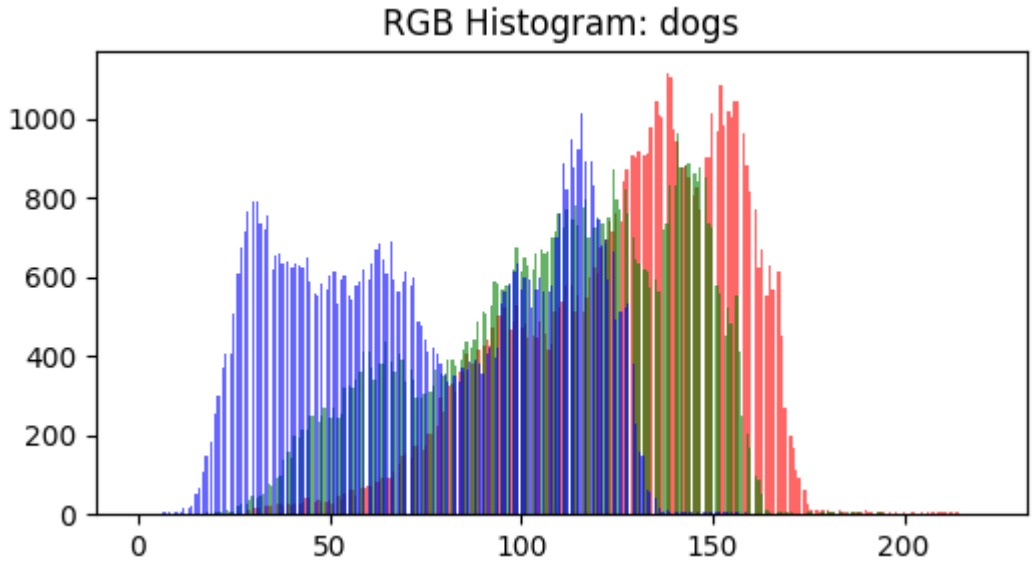
36]:



36]:



36]:



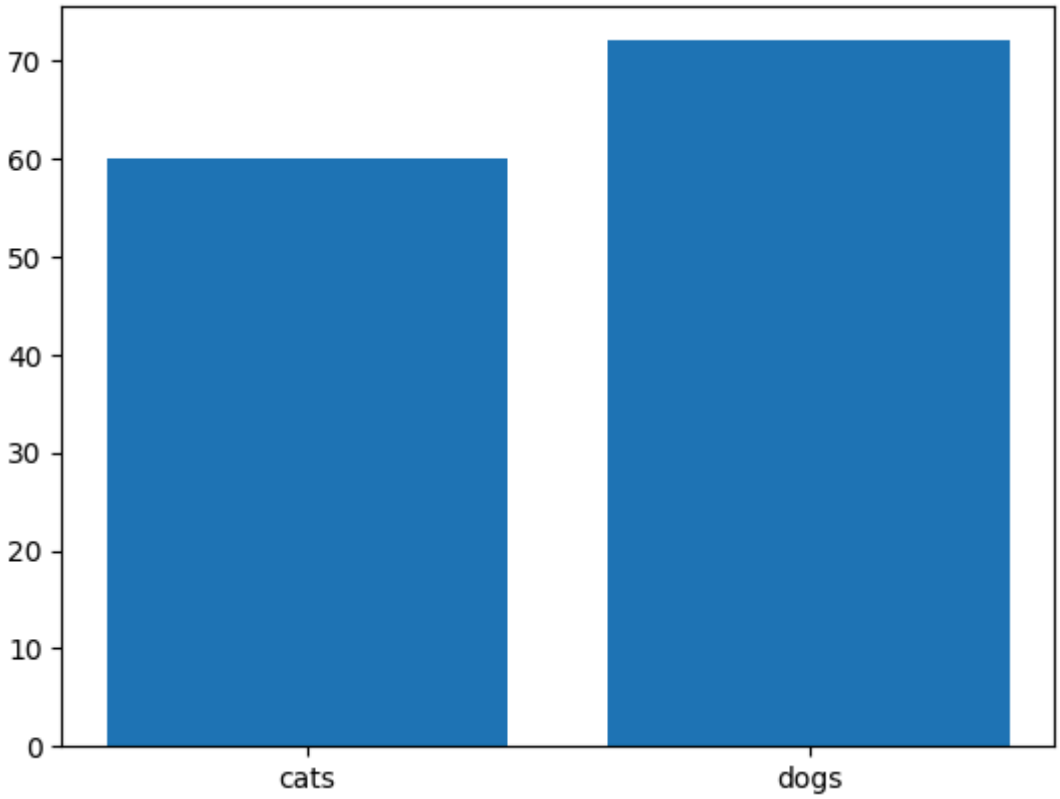
using OS and cv2

[1]:

```
import cv2
import os
import numpy as np
import matplotlib.pyplot as plt

dataset_path='cats_dogs'
classes=os.listdir(dataset_path)

img_cnts={}
img_shapes=[]
all_pixels=[] #for pixel level distribution check
for label in classes:
    label_dir=os.path.join(dataset_path,label)
    imgs=os.listdir(label_dir)
    img_cnts[label]=len(imgs)

    for img_file in imgs:
        img_path=os.path.join(label_dir,img_file)
        image=cv2.imread(img_path)
        if image is not None:
            img_shapes.append(image.shape)
            all_pixels.append(image.flatten())
plt.bar(img_cnts.keys(),img_cnts.values())
```

[1]:

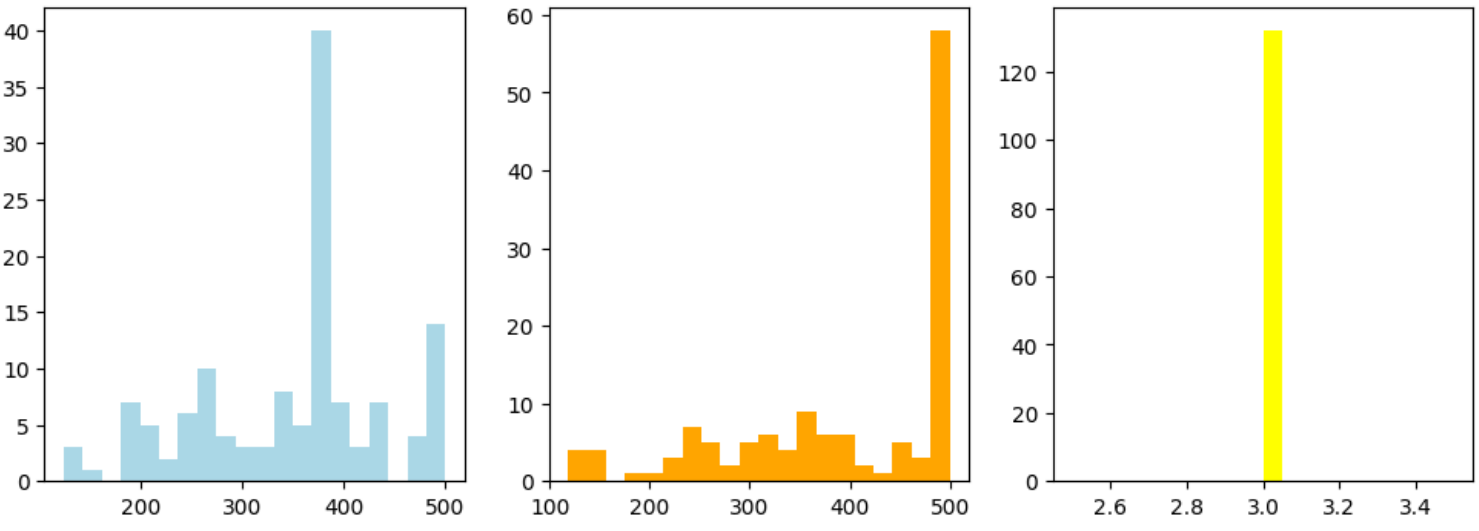
[1]:



[2]:

```
heights=[s[0] for s in img_shapes]
widths=[s[1] for s in img_shapes]
channels=[s[2] for s in img_shapes]

plt.figure(figsize=(12,4))

plt.subplot(1,3,1)
plt.hist(heights,bins=20,color='lightblue')

plt.subplot(1,3,2)
plt.hist(widths,bins=20,color='orange')

plt.subplot(1,3,3)
plt.hist(channels,bins=20,color='yellow')

plt.show()
```

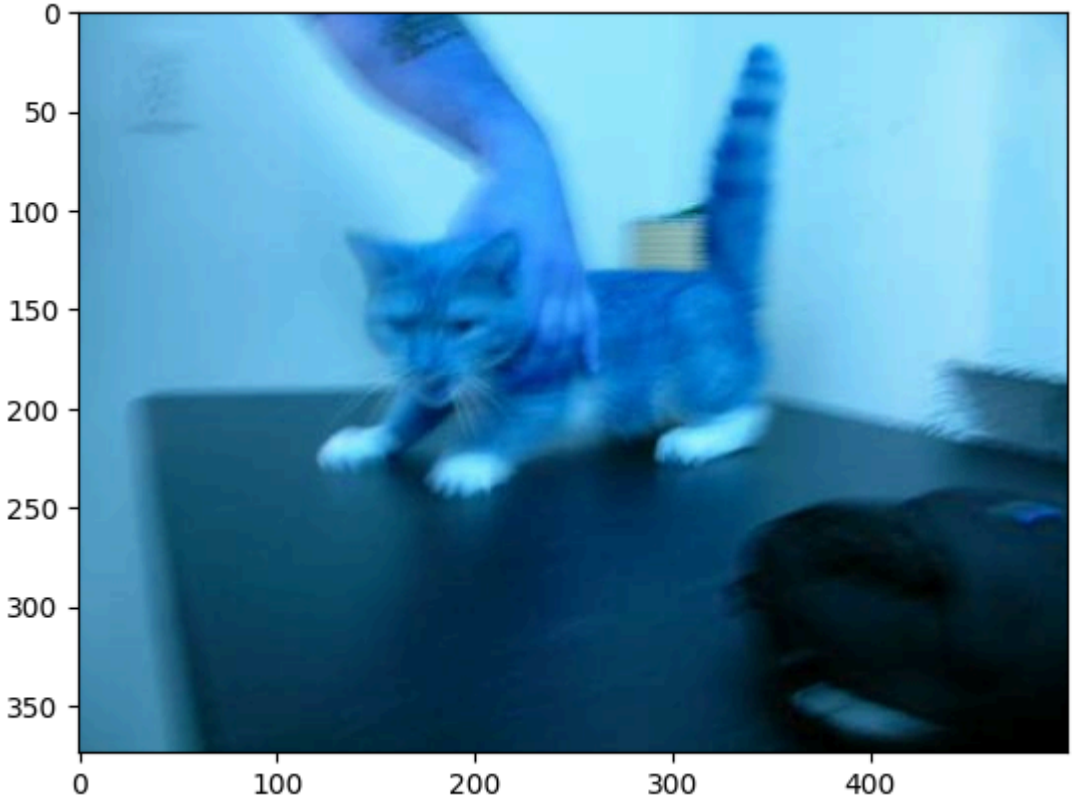
[2]:



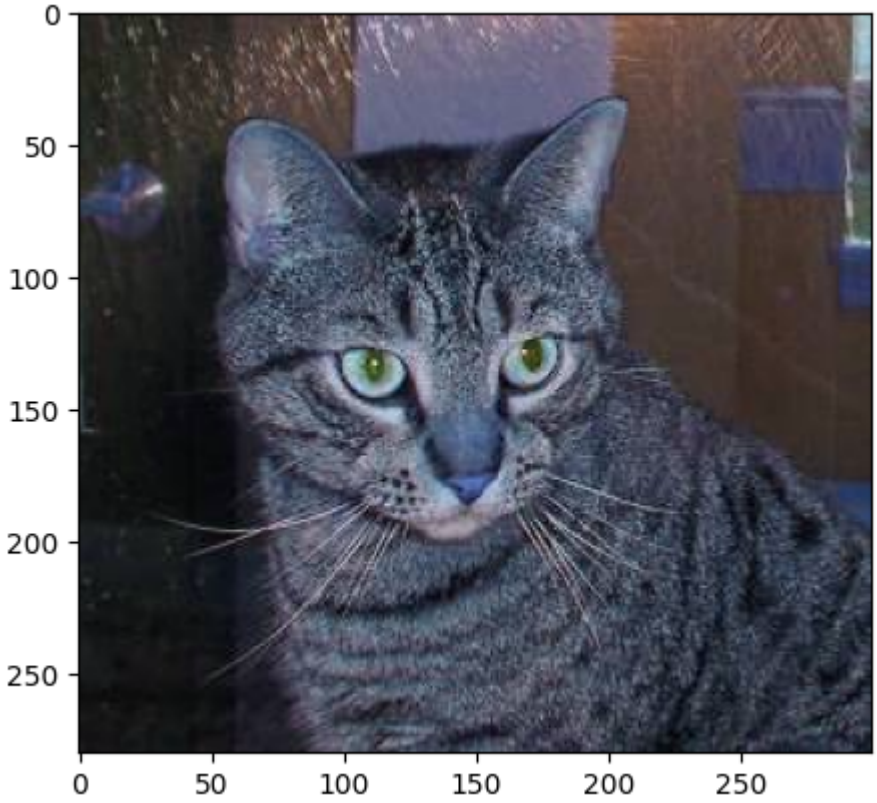
[5]:

```
#First 3 Dog and Cat Images
for label in classes:
    label_dir=os.path.join(dataset_path,label)
    imgs=os.listdir(label_dir)
    img_cnts[label]=len(imgs)

    for img_file in imgs[:3]:
        img_path=os.path.join(label_dir,img_file)
        image=cv2.imread(img_path)
        if image is not None:
            plt.imshow(image)
            plt.show()
```

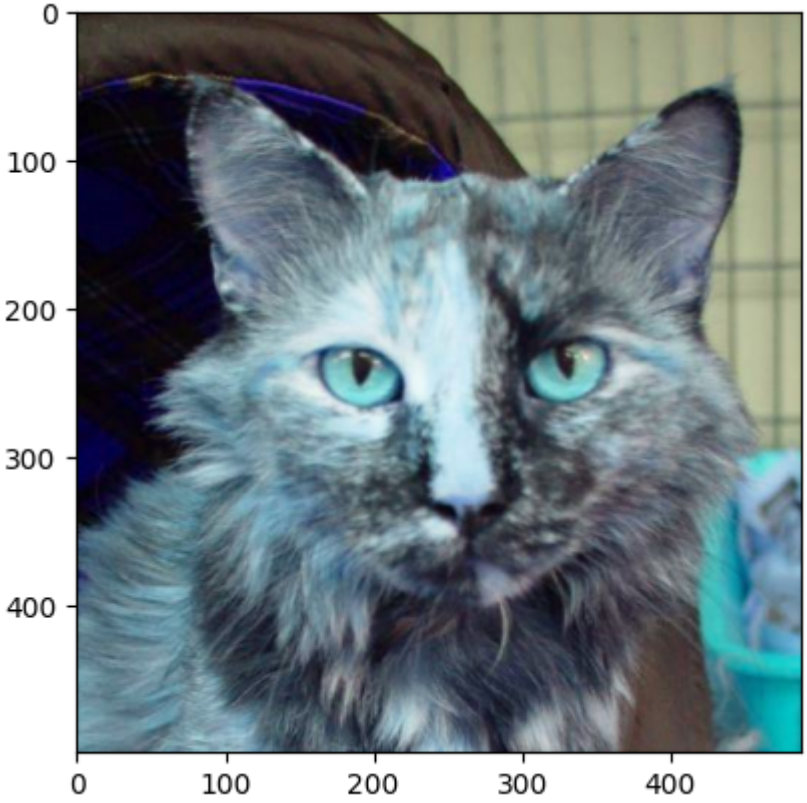
[5]:


0
50
100
150
200
250
300
350
0
100
200
300
400

[5]:


0
50
100
150
200
250
0
50
100
150
200
250

[5]:


0
100
200
300
400
0
100
200
300
400

[5]:


0
50
100
150
200
250
300
350
0
100
200
300
400

[5]:

[5]:

[6]:

```
all_pixels=np.concatenate(all_pixels)
all_pixels
```

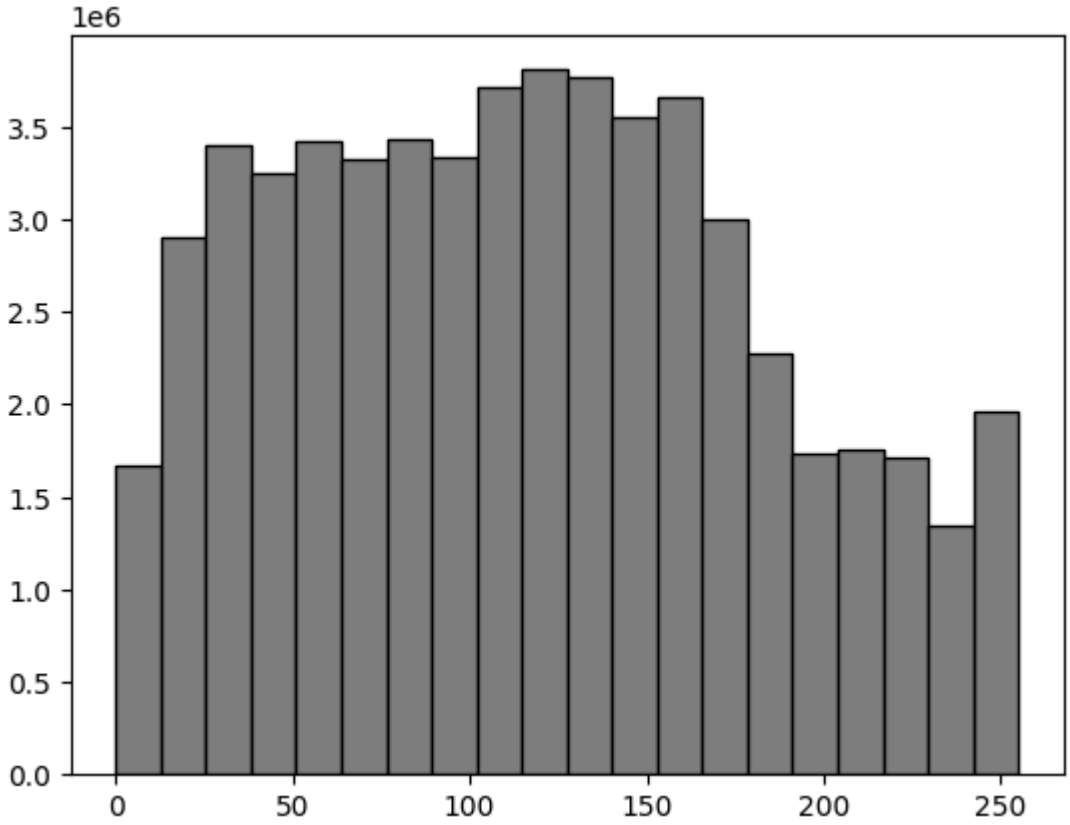
[6]:

```
array([ 87, 164, 203, ..., 186, 158, 134], dtype=uint8)
```

[7]:

```
plt.hist(all_pixels,bins=20,color='gray',edgecolor='black')
plt.show()
```

[7]:



[8]:

```
#Stats of pixel values
print("Pixel Value Summary:")
print("Min:", np.min(all_pixels))
print("Max:", np.max(all_pixels))
print("Mean:", np.mean(all_pixels))
print("Std Dev:", np.std(all_pixels))
```

[8]:

```
Pixel Value Summary:
Min: 0
Max: 255
Mean: 116.7607045060466
Std Dev: 65.6210385103431
```

EDA ON TEXT DATA

47]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import string
import nltk
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer, WordNetLemmatizer
from wordcloud import WordCloud
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.svm import SVC
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, confusion_matrix, classification_report, roc_auc_score, roc_curve
import warnings
warnings.filterwarnings("ignore")
```

48]:

```
nltk.download('stopwords')
nltk.download('wordnet')
```

48]:

```
[nltk_data] Downloading package stopwords to
[nltk_data]     E:\Xai_Req_Setup\.jupyter_env\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     E:\Xai_Req_Setup\.jupyter_env\nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
```

48]:

```
True
```

49]:

```
df = pd.read_csv('twitter_training.csv', encoding='latin-1')  # adjust path
df.columns=['Tweet ID','entity','sentiment','Tweet content']
df.head()
```

49]:

	Tweet ID	entity	sentiment	Tweet content
0	2401	Borderlands	Positive	I am coming to the borders and I will kill you...
1	2401	Borderlands	Positive	im getting on borderlands and i will kill you ...
2	2401	Borderlands	Positive	im coming on borderlands and i will murder you...

	Tweet ID	entity	sentiment	Tweet content
3	2401	Borderlands	Positive	im getting on borderlands 2 and i will murder ...
4	2401	Borderlands	Positive	im getting into borderlands and i can murder y...

54]:
```
df['sentiment'].value_counts()
```

54]:
```
sentiment
Negative      22542
Positive      20831
Neutral       18318
Irrelevant    12990
Name: count, dtype: int64
```

62]:
```
df = df[['sentiment', 'Tweet content']]  # Keep only necessary columns
df.columns = ['sentiment', 'Tweet content']
```

63]:
```
df['Length']=df['Tweet content'].str.len()
```

64]:
```
def word_cnt(tweet):
    words=str(tweet).split()
    return len(words)
df['word_cnt']=df['Tweet content'].apply(word_cnt)
```

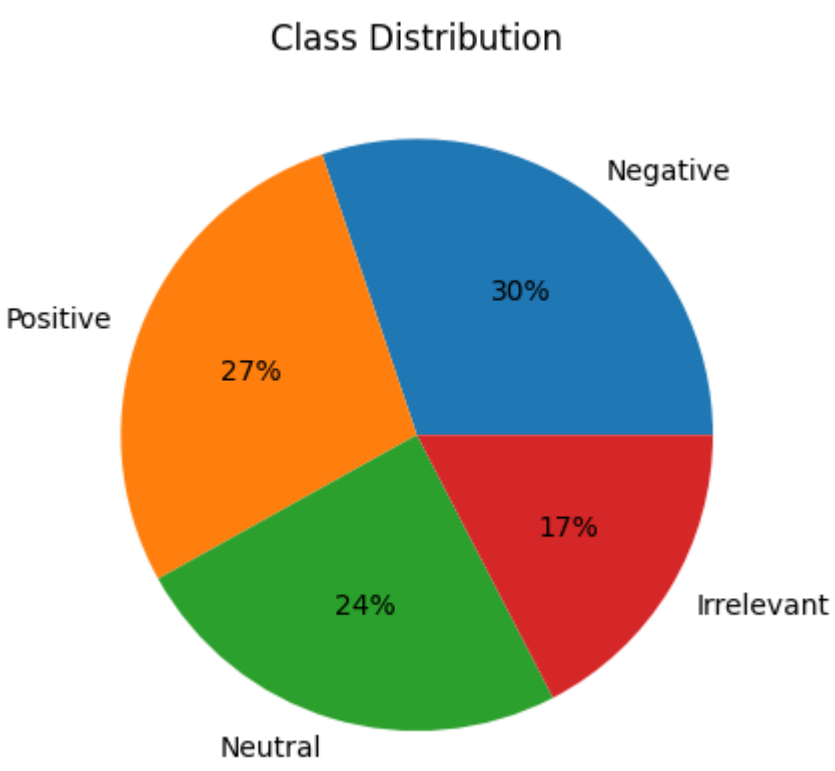
65]:
```
df.head()
```

65]:

	sentiment	Tweet content	Length	word_cnt
0	Positive	I am coming to the borders and I will kill you...	51.0	12
1	Positive	im getting on borderlands and i will kill you ...	50.0	10
2	Positive	im coming on borderlands and i will murder you...	51.0	10
3	Positive	im getting on borderlands 2 and i will murder ...	57.0	12
4	Positive	im getting into borderlands and i can murder y...	53.0	10

72]:
```
plt.pie(df['sentiment'].value_counts(), labels=df['sentiment'].value_counts().index, autopct='%d%%')
plt.title('Class Distribution')
plt.show()
```

72]:



20]:
```
stop_words = set(stopwords.words('english'))
stemmer = PorterStemmer()
lemmatizer = WordNetLemmatizer()
```

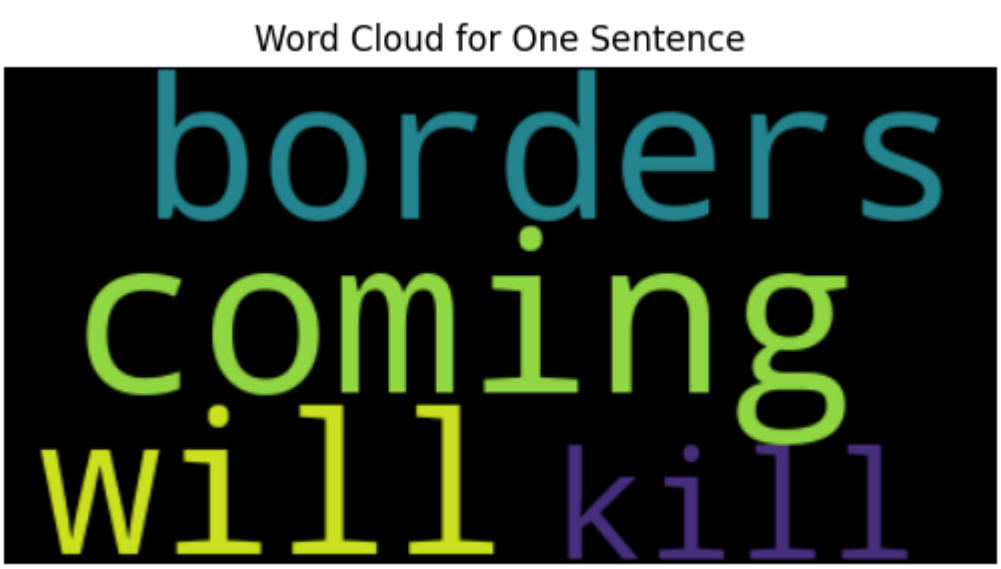
21]:
```
def preprocess(text):
    # Lowercase
    text=str(text)
    text = text.lower()

    # Remove punctuation
    text = text.translate(str.maketrans('', '', string.punctuation))
    # Tokenize
    tokens = text.split()
    # Remove stopwords
    tokens = [t for t in tokens if t not in stop_words]
    # Lemmatize + Stem
```

```
    tokens = [stemmer.stem(lemmatizer.lemmatize(t)) for t in tokens]
    return ' '.join(tokens)
```

80]:

```
from wordcloud import WordCloud
import matplotlib.pyplot as plt

# Select a specific sentence from the 'Tweet content' column (for example, the first sentence)
sentence = df['Tweet content'].iloc[0]  # You can change the index or specify any other sentence

# Generate the word cloud for the selected sentence
wc = WordCloud().generate(sentence)

# Plot the word cloud
plt.imshow(wc, interpolation='bilinear')
plt.title('Word Cloud for One Sentence')
plt.axis('off')
plt.show()
```

80]:



81]:

```
df['clean_text'] = df['Tweet content'][:50].apply(preprocess)
```

82]:

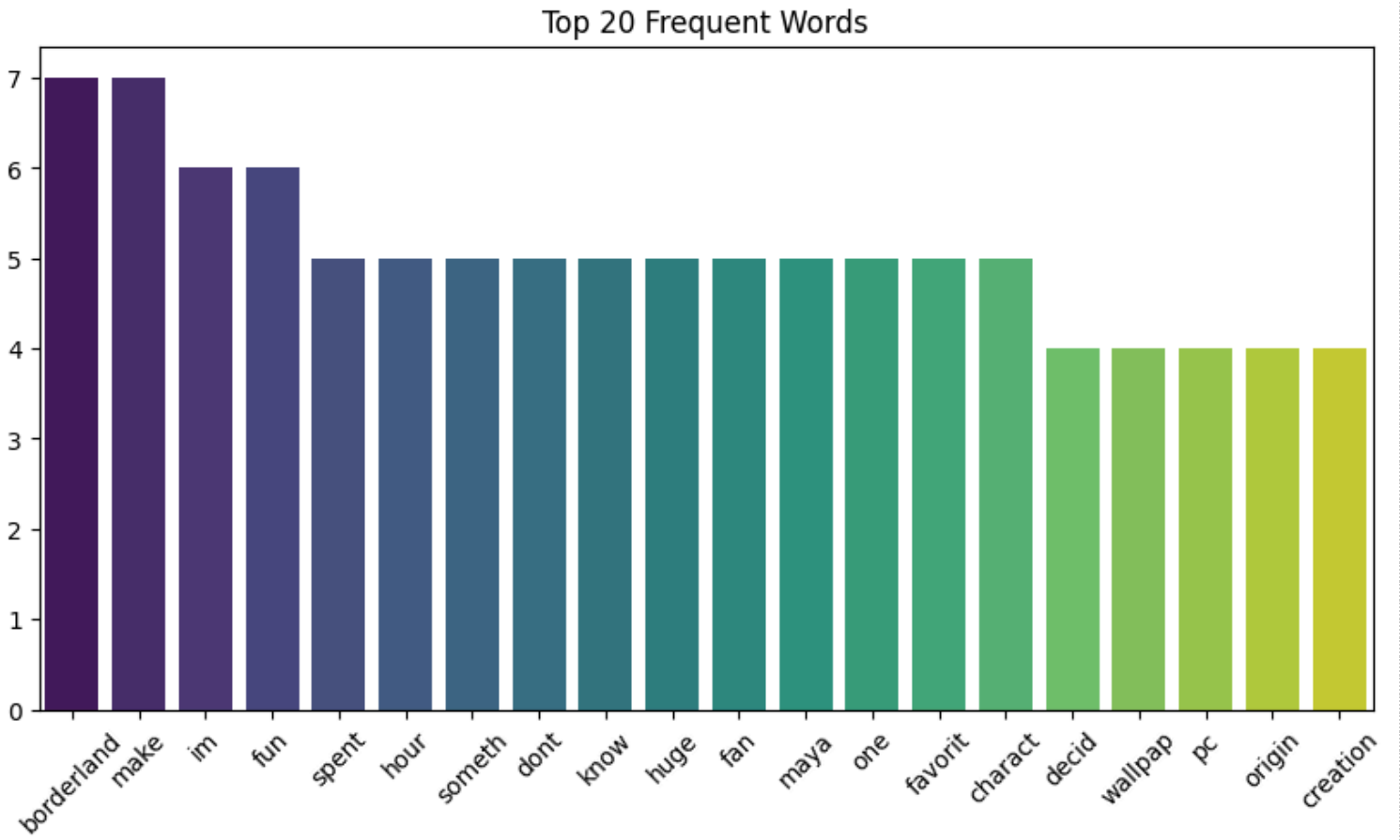
```
wc = WordCloud().generate(df['clean_text'].iloc[0])
plt.imshow(wc, interpolation='bilinear')
plt.title('After Preprocessing')
plt.axis('off')
plt.show()
```

82]:

86]:

```
from collections import Counter
words = ' '.join(df['clean_text'][:10]).split()
word_freq = Counter(words).most_common(20)

# Separate words and counts manually
words = [item[0] for item in word_freq]
counts = [item[1] for item in word_freq]
plt.figure(figsize=(10, 5))
sns.barplot(x=list(words), y=list(counts), palette='viridis')
plt.title("Top 20 Frequent Words")
plt.xticks(rotation=45)
plt.show()
```

86]:



89]:

```
from sklearn.model_selection import train_test_split
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.svm import SVC

# Split data
X_train_full, X_test_full, y_train_full, y_test_full = train_test_split(
    df['Tweet content'], df['sentiment'], test_size=0.2, random_state=42)

# Clean the text data
X_train_full = X_train_full.fillna("").astype(str)
X_test_full = X_test_full.fillna("").astype(str)

# Subset the data for faster training (optional)
X_train = X_train_full[:200]
y_train = y_train_full[:200]

X_test = X_test_full[:80]
y_test = y_test_full[:80]

# Vectorization
vectorizer = TfidfVectorizer()
X_train_vec = vectorizer.fit_transform(X_train)
X_test_vec = vectorizer.transform(X_test)

# SVM Classifier
model = SVC(probability=True)
model.fit(X_train_vec, y_train)

# Predictions
y_pred = model.predict(X_test_vec)
```

90]:

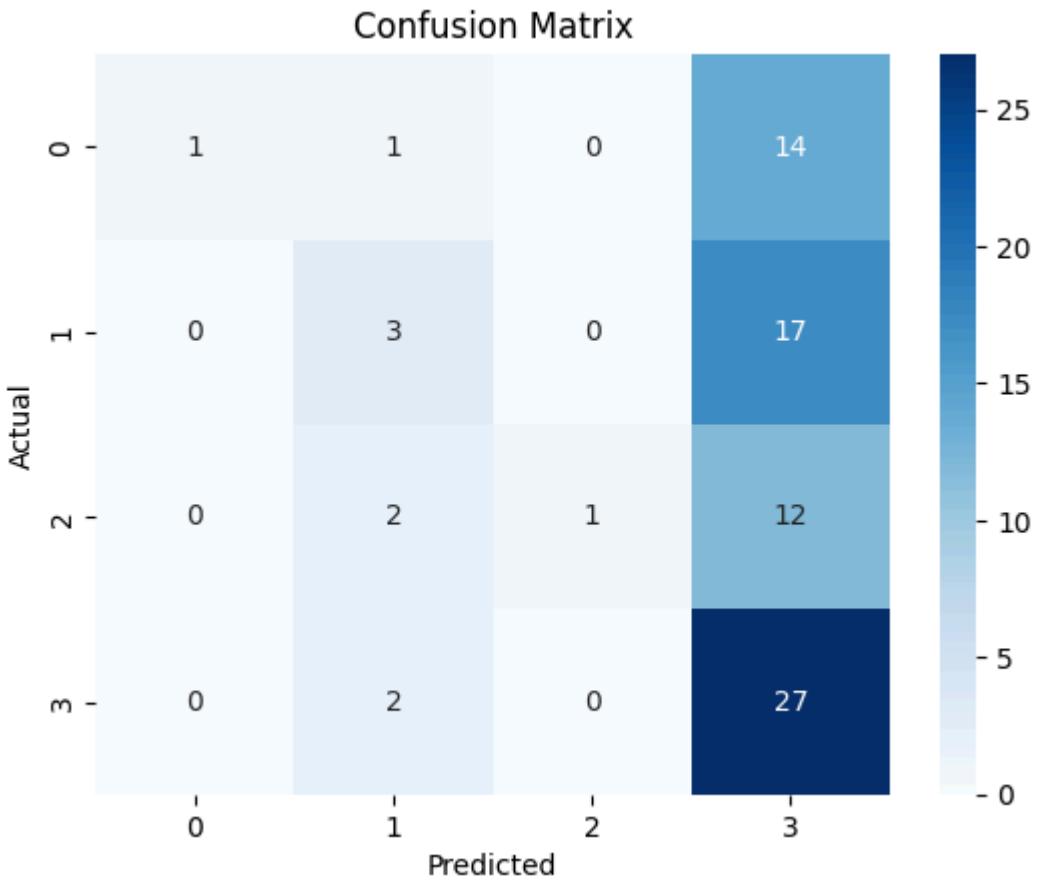
```

# Accuracy
print("Accuracy:", accuracy_score(y_test, y_pred))
print("\nClassification Report:\n", classification_report(y_test, y_pred))
```

90]:

```
Accuracy: 0.4

Classification Report:
              precision    recall  f1-score   support

  Irrelevant       1.00      0.06      0.12        16
    Negative       0.38      0.15      0.21        20
     Neutral       1.00      0.07      0.12        15
    Positive       0.39      0.93      0.55        29

    accuracy                           0.40        80
   macro avg       0.69      0.30      0.25        80
weighted avg       0.62      0.40      0.30        80
```

91]:
```
conf_matrix = confusion_matrix(y_test, y_pred)
sns.heatmap(conf_matrix, annot=True, fmt='d', cmap='Blues')
plt.title("Confusion Matrix")
plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()
```

91]:



EXP3 -- PDP,LRP,GRADCAM,Surrogate Exp

1.PDP

17]:
```
import numpy as np
import pandas as pd
from sklearn.inspection import PartialDependenceDisplay
from sklearn.ensemble import RandomForestClassifier
```

18]:
```
df=pd.read_csv('diabetes.csv')
```

19]:
```
df.head()
```

19]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

20]:
```
from sklearn.model_selection import train_test_split
X = df.drop('Outcome', axis=1)
y = df['Outcome']
X_train,X_test,y_train,y_test=train_test_split(X,y,random_state=42)
```

21]:
```
rf_model=RandomForestClassifier()
rf_model.fit(X_train,y_train)
y_pred=rf_model.predict(X_test)
```

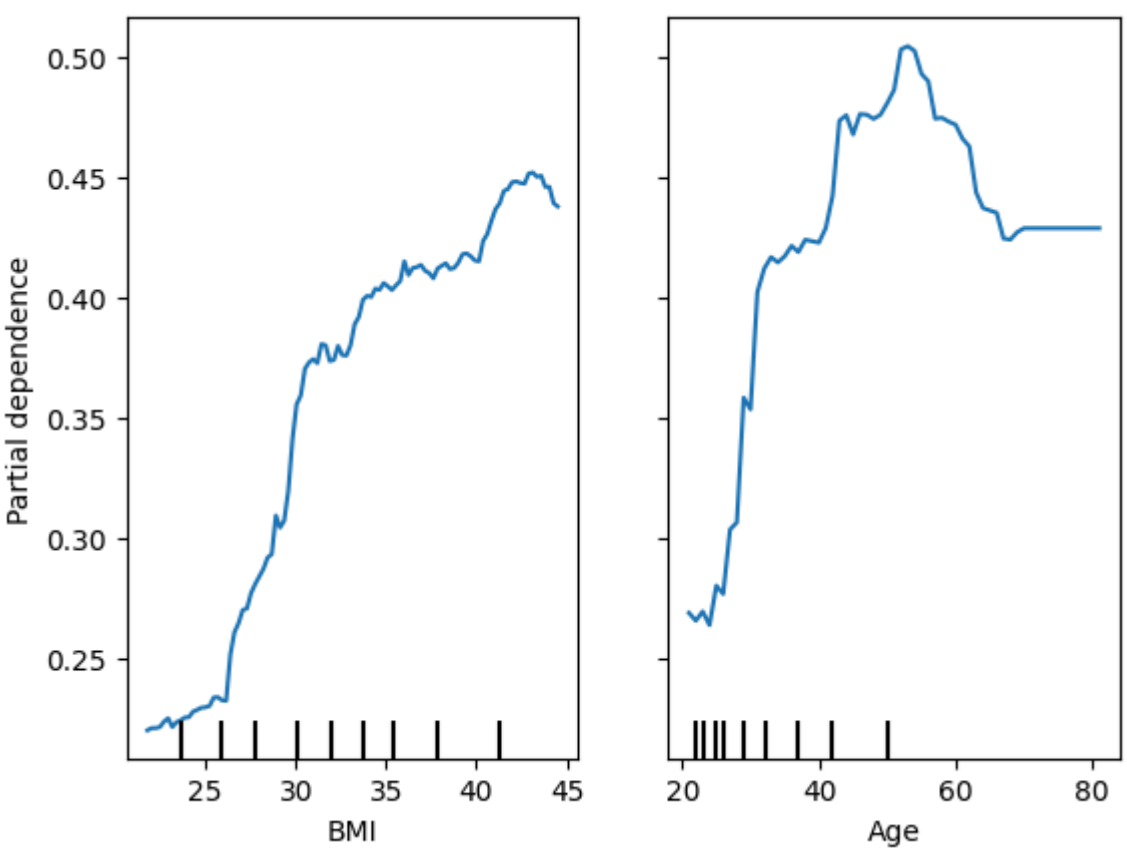
22]:
```
from sklearn.metrics import accuracy_score
acc=accuracy_score(y_test,y_pred)
print(acc)
```

22]:
```
0.75
```

23]:
```
PartialDependenceDisplay.from_estimator(rf_model, X_train, ['BMI','Age'])
```

23]:

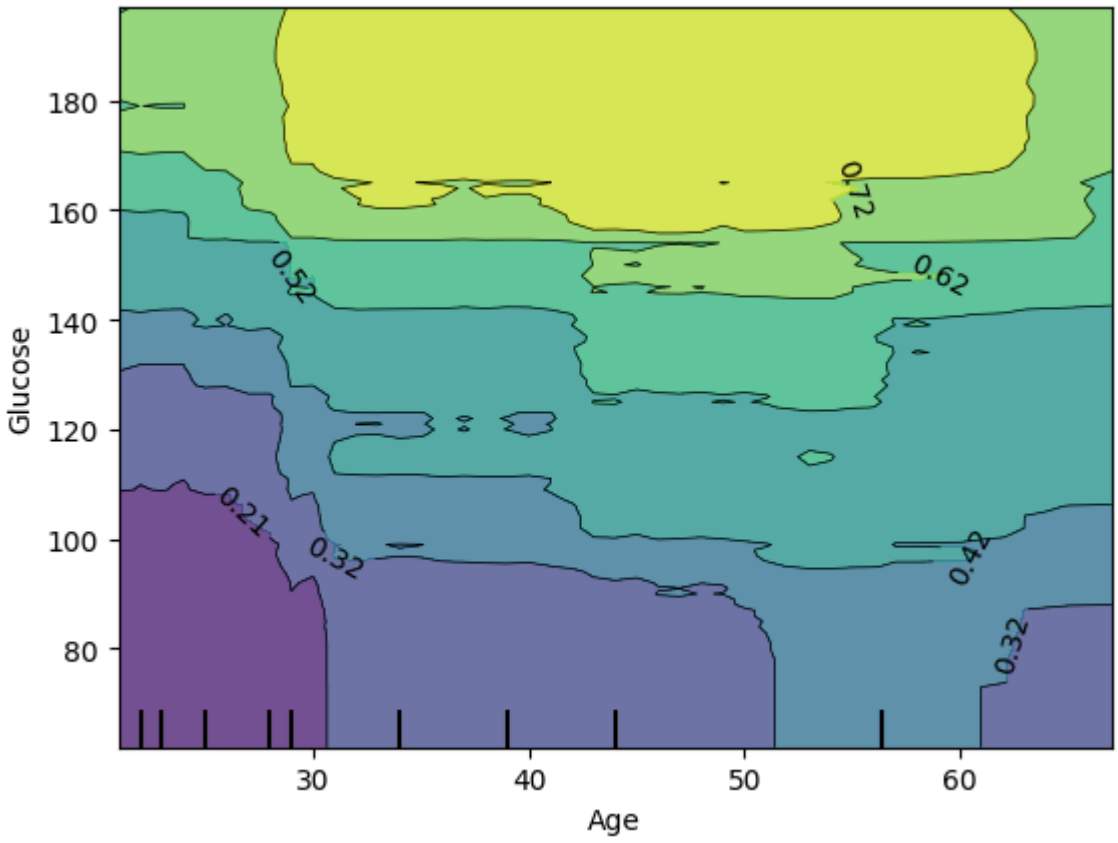
23]:



24]:

```
PartialDependenceDisplay.from_estimator(rf_model, X_test, [('Age','Glucose')])
```

24]:
24]:



GRADCAM (in last dense layer we will mention number of classes)

[1]:

```
import tensorflow as tf
```

[5]:

```
import numpy as np
import pandas as pd

from tensorflow.keras.layers import Dense,Flatten,MaxPool2D,Conv2D,Input
from tensorflow.keras.models import Model
from sklearn.model_selection import train_test_split
```

[6]:

```
from tf_keras_vis.utils.scores import CategoricalScore
from tf_keras_vis.utils.model_modifiers import ReplaceToLinear
```

```
from tf_keras_vis.gradcam import Gradcam
from tensorflow.keras.preprocessing.image import load_img,img_to_array
```

[7]:
```
# Load and normalize the data (with a validation split)
full_ds = tf.keras.utils.image_dataset_from_directory(
    'cat_dog',
    image_size=(228, 228),
    # color_mode='grayscale',
    # seed=123
).map(lambda x, y: (x / 255.0, y))

# Convert the dataset to numpy arrays
x_full, y_full = [], []
for images, labels in full_ds:
    x_full.append(images.numpy())
    y_full.append(labels.numpy())
x_full = np.concatenate(x_full, axis=0)
y_full = np.concatenate(y_full, axis=0)

# Split the data into training and testing sets (80% train, 20% test)
x_train, x_test, y_train, y_test = train_test_split(x_full, y_full, test_size=0.3, random_state=42)

# Optional: Print the shape of the data to verify
print(f"x_train shape: {x_train.shape}")
print(f"y_train shape: {y_train.shape}")
print(f"x_test shape: {x_test.shape}")
print(f"y_test shape: {y_test.shape}")
```

[7]:
```
Found 132 files belonging to 2 classes.
x_train shape: (92, 228, 228, 3)
y_train shape: (92,)
x_test shape: (40, 228, 228, 3)
y_test shape: (40,)
```

[8]:
```
def build_cnn(inp_shape=(228,228,3),num_cls=2):
    inp=Input(shape=inp_shape)
    x=Conv2D(16,(3,3),activation='relu')(inp)
    x=MaxPool2D((2,2))(x)
    x=Conv2D(32,(3,3),activation='relu')(x)
    x=MaxPool2D((2,2))(x)
    x=Conv2D(32,(3,3),activation='relu')(x)
    x=MaxPool2D((2,2))(x)
    x=Flatten()(x)
    x=Dense(64,activation='relu')(x)
    outputs=Dense(num_cls,activation='softmax')(x)
    model=Model(inputs=inp,outputs=outputs)
    return model

model = build_cnn()
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])
model.fit(x_train, y_train, epochs=10, batch_size=64, validation_split=0.1)
```

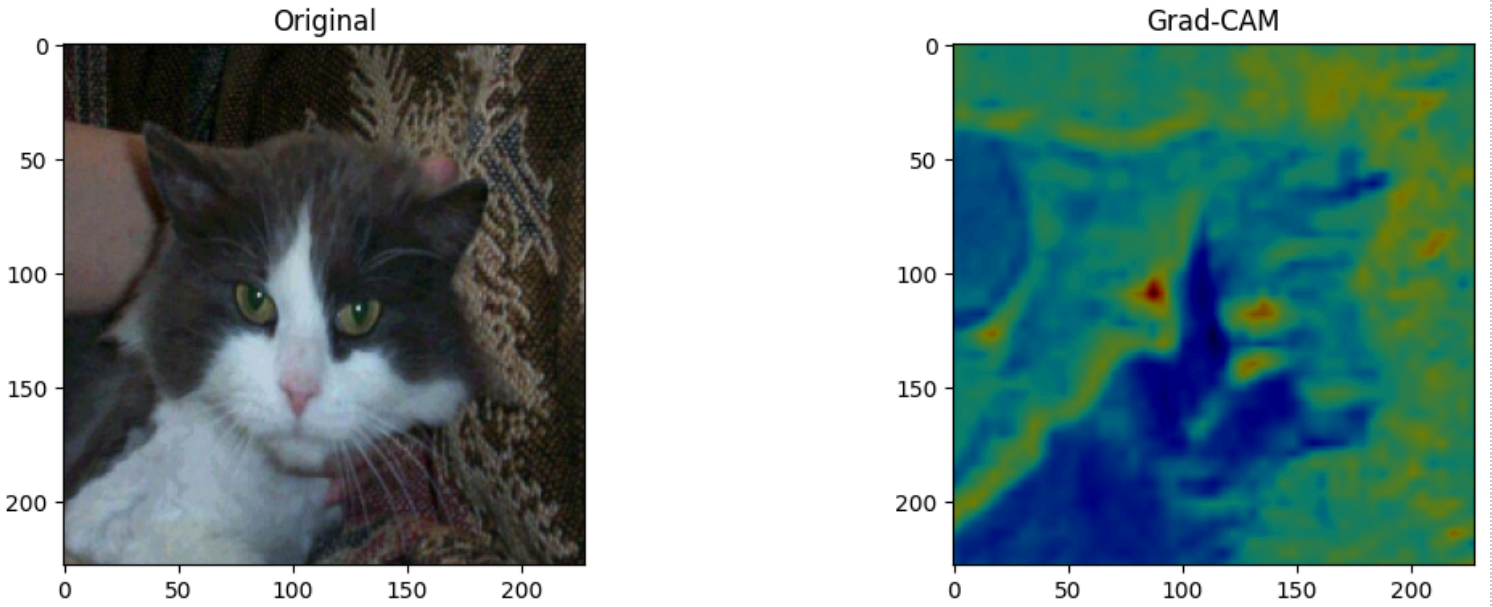
[8]:
```
Epoch 1/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 10s 2s/step - accuracy: 0.5429 - loss: 0.8909 - val_accuracy: 0.7000 - val_loss: 0.6600
Epoch 2/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 5s 1s/step - accuracy: 0.6282 - loss: 0.6835 - val_accuracy: 0.3000 - val_loss: 0.9858
Epoch 3/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 4s 998ms/step - accuracy: 0.4356 - loss: 0.8200 - val_accuracy: 0.6000 - val_loss: 0.6866
Epoch 4/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 3s 1s/step - accuracy: 0.7001 - loss: 0.6653 - val_accuracy: 0.7000 - val_loss: 0.6447
Epoch 5/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 3s 963ms/step - accuracy: 0.5644 - loss: 0.6556 - val_accuracy: 0.7000 - val_loss: 0.6588
Epoch 6/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 4s 1s/step - accuracy: 0.5696 - loss: 0.6334 - val_accuracy: 0.7000 - val_loss: 0.6840
Epoch 7/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 4s 966ms/step - accuracy: 0.6178 - loss: 0.6007 - val_accuracy: 0.4000 - val_loss: 0.7266
Epoch 8/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 5s 973ms/step - accuracy: 0.8631 - loss: 0.5731 - val_accuracy: 0.4000 - val_loss: 0.7474
Epoch 9/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 4s 1s/step - accuracy: 0.9037 - loss: 0.5376 - val_accuracy: 0.3000 - val_loss: 0.8053
Epoch 10/10
2/2 ━━━━━━━━━━━━━━━━━━━━ 3s 984ms/step - accuracy: 0.8718 - loss: 0.5070 - val_accuracy: 0.4000 - val_loss: 0.8043
```

[8]:
[9]:
```
# img_path = x_test[0]
img = x_test[0]
img_array = img_to_array(img) / 255.0
img_input = np.expand_dims(img_array, axis=0)

# 4. Apply Grad-CAM
score = CategoricalScore([np.argmax(model.predict(img_input))])
gm = Gradcam(model, model_modifier=ReplaceToLinear())
cam = gm(score, img_input, penultimate_layer=-1)
print(np.argmax(model.predict(img_input)),f"Original:{y_test[0]}")
```

[9]:
```
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 182ms/step
1/1 ━━━━━━━━━━━━━━━━━━━━ 0s 126ms/step
1 Original:0
```

10]:
```
import matplotlib.pyplot as plt
f, ax = plt.subplots(1, 2, figsize=(12, 4))
ax[0].imshow(img)
ax[0].set_title("Original")
ax[1].imshow(img_array)
ax[1].imshow(cam[0], cmap='jet', alpha=0.5)
ax[1].set_title("Grad-CAM")
plt.tight_layout()
plt.show()
```

10]:



LRP Gray Scale is needed and Saliency map

28]:
```
import tensorflow as tf
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split

# Load and preprocess dataset
full_ds = tf.keras.utils.image_dataset_from_directory(
    r'cat_dog',         # Root folder with subfolders as class names
    image_size=(228, 228),
    color_mode='grayscale'                      # Any batch size works
).map(lambda x, y: (x / 255.0, y))

# Convert dataset to numpy arrays
x_full, y_full = [], []
for images, labels in full_ds:
    x_full.append(images.numpy())
    y_full.append(labels.numpy())
x_full = np.concatenate(x_full, axis=0)
y_full = np.concatenate(y_full, axis=0)

# Train-test split
x_train, x_test, y_train, y_test = train_test_split(x_full, y_full, test_size=0.3, random_state=42)

# CNN model definition
model = tf.keras.Sequential([
    tf.keras.layers.Conv2D(16, 3, activation='relu', input_shape=(228, 228, 1)),
    tf.keras.layers.MaxPooling2D(),
    tf.keras.layers.Conv2D(32, 3, activation='relu'),
    tf.keras.layers.MaxPooling2D(),
    tf.keras.layers.Conv2D(64, 3, activation='relu'),
    tf.keras.layers.Flatten(),
    tf.keras.layers.Dense(10, activation='softmax')
])

# Compile and train the model
model.compile(optimizer='adam', loss='sparse_categorical_crossentropy', metrics=['accuracy'])
model.fit(x_train, y_train, epochs=5)
```

28]:
```
Found 132 files belonging to 2 classes.
```

28]:
```
E:\Xai_Req_Setup\Python3109\lib\site-packages\keras\src\layers\convolutional\base_conv.py:107: UserWarning: Do not pass an `input_shape`/`input_dim`
argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

28]:
```
Epoch 1/5
3/3 ━━━━━━━━━━━━━━━━━━━━ 8s 1s/step - accuracy: 0.4338 - loss: 1.7090
Epoch 2/5
3/3 ━━━━━━━━━━━━━━━━━━━━ 4s 1s/step - accuracy: 0.4993 - loss: 0.8772
Epoch 3/5
3/3 ━━━━━━━━━━━━━━━━━━━━ 4s 1s/step - accuracy: 0.6279 - loss: 0.6962
Epoch 4/5
3/3 ━━━━━━━━━━━━━━━━━━━━ 4s 1s/step - accuracy: 0.6783 - loss: 0.6388
```

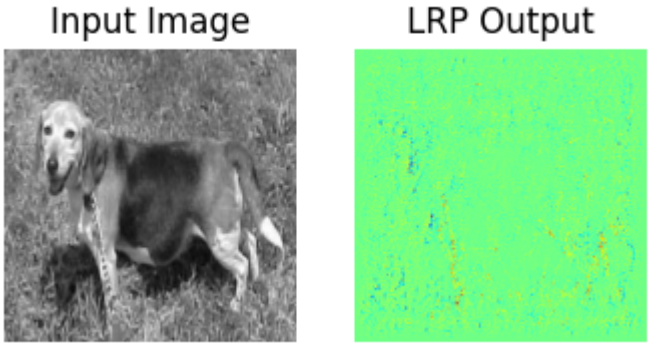
```
Epoch 5/5
3/3 ━━━━━━━━━━━━━━━━━━━━ 4s 1s/step - accuracy: 0.5686 - loss: 0.6537
```

28]:

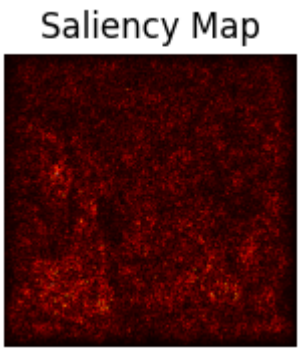
27]:

```
img = x_test[0]
img_tensor = tf.convert_to_tensor([img])  # Make it a batch
with tf.GradientTape() as tape:
    tape.watch(img_tensor)
    preds = model(img_tensor)
    class_idx = tf.argmax(preds[0])
    loss = preds[0, class_idx]

grads = tape.gradient(loss, img_tensor)[0].numpy()
relevance = grads * img  # Gradient × Input relevance
saliency = np.max(np.abs(grads), axis=-1)

# Visualize input and relevance map
plt.subplot(1, 3, 1)
plt.imshow(img, cmap='gray')
plt.title("Input Image")
plt.axis('off')

plt.subplot(1, 3, 2)
plt.imshow(relevance,cmap='jet')
plt.title("LRP Output")
plt.axis('off')
plt.show()

plt.subplot(1, 3, 3)
plt.imshow(saliency,cmap='hot')
plt.title("Saliency Map")
plt.axis('off')
plt.show()
```

27]:



27]:



For Custom Image

19]:

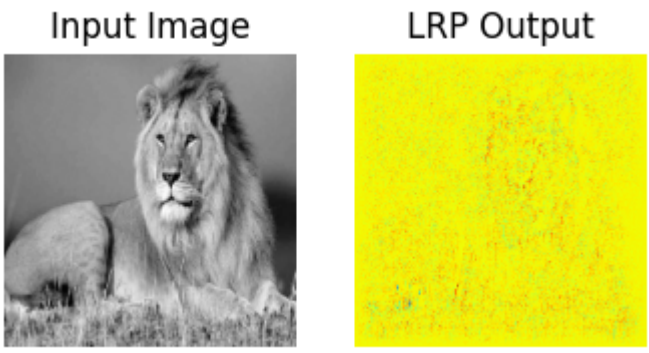
```
from tensorflow.keras.preprocessing.image import load_img,img_to_array
img=load_img('lion.jpg',target_size=(228, 228)
             ,color_mode='grayscale'
             )
img=img_to_array(img)/255.0
img_batch=np.expand_dims(img,axis=0)
```

20]:

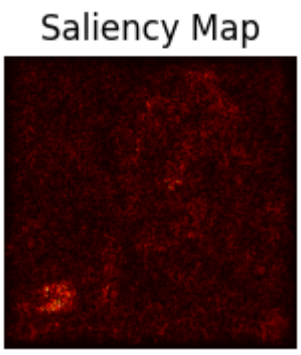
```
img_tensor = tf.convert_to_tensor(img_batch)  # Make it a batch
with tf.GradientTape() as tape:
    tape.watch(img_tensor)
    preds = model(img_tensor)
    class_idx = tf.argmax(preds[0])
    loss = preds[0, class_idx]

grads = tape.gradient(loss, img_tensor)[0].numpy()
relevance = grads * img  # Gradient × Input relevance
saliency = np.max(np.abs(grads), axis=-1)

# Visualize input and relevance map
plt.subplot(1, 3, 1)
plt.imshow(img, cmap='gray')
plt.title("Input Image")
plt.axis('off')
```

```
plt.subplot(1, 3, 2)
plt.imshow(relevance,cmap='jet')
plt.title("LRP Output")
plt.axis('off')
plt.show()

plt.subplot(1, 3, 3)
plt.imshow(saliency,cmap='hot')
plt.title("Saliency Map")
plt.axis('off')
plt.show()
```

20]:



20]:



SURROGATE EXPLAINER

14]:

```
import numpy as np
import pandas as pd
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier,plot_tree
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
import matplotlib.pyplot as plt
```

15]:

```
df=pd.read_csv('diabetes.csv')
```

16]:

```
df.head()
```

16]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

17]:

```
df.describe()
```

17]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
count	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000
mean	3.845052	120.894531	69.105469	20.536458	79.799479	31.992578	0.471876	33.240885	0.348958
std	3.369578	31.972618	19.355807	15.952218	115.244002	7.884160	0.331329	11.760232	0.476951
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.078000	21.000000	0.000000
25%	1.000000	99.000000	62.000000	0.000000	0.000000	27.300000	0.243750	24.000000	0.000000
50%	3.000000	117.000000	72.000000	23.000000	30.500000	32.000000	0.372500	29.000000	0.000000
75%	6.000000	140.250000	80.000000	32.000000	127.250000	36.600000	0.626250	41.000000	1.000000
max	17.000000	199.000000	122.000000	99.000000	846.000000	67.100000	2.420000	81.000000	1.000000

18]:

```
rf_model=RandomForestClassifier()
X=df.drop('Outcome',axis=1)
y=df['Outcome']
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.2,random_state=42)
rf_model.fit(X_train,y_train)

y_pred=rf_model.predict(X_test)
print(accuracy_score(y_test,y_pred))
```

18]:
```
0.7337662337662337
```

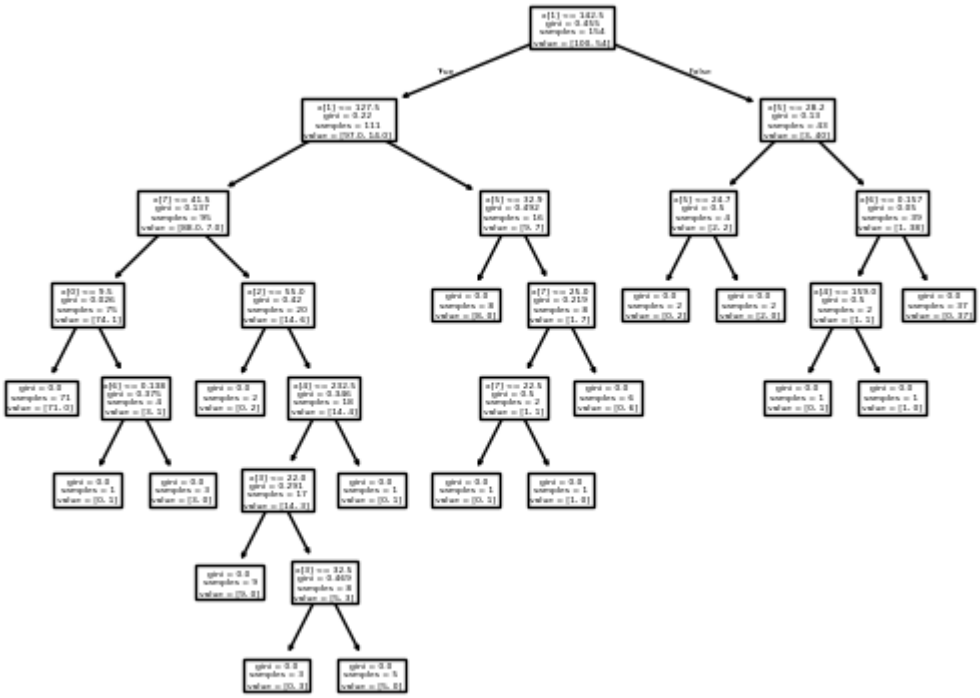
19]:
```
dt_model=DecisionTreeClassifier()
dt_model.fit(X_test,y_pred)
```

19]:
```
DecisionTreeClassifier()
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

20]:
```
plot_tree(dt_model)
plt.show()
```

20]:



EXP-4 FEATURE IMPORTANCE & SENSITIVITY ANALYSIS

[2]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoder
from sklearn.metrics import accuracy_score
```

[3]:
```
df=pd.read_csv('diabetes.csv')
```

[4]:
```
X = df.drop('Outcome', axis=1)
y = df['Outcome']
X_train,X_test,y_train,y_test=train_test_split(X,y,random_state=42)
model=RandomForestClassifier()
model.fit(X_train,y_train)
```

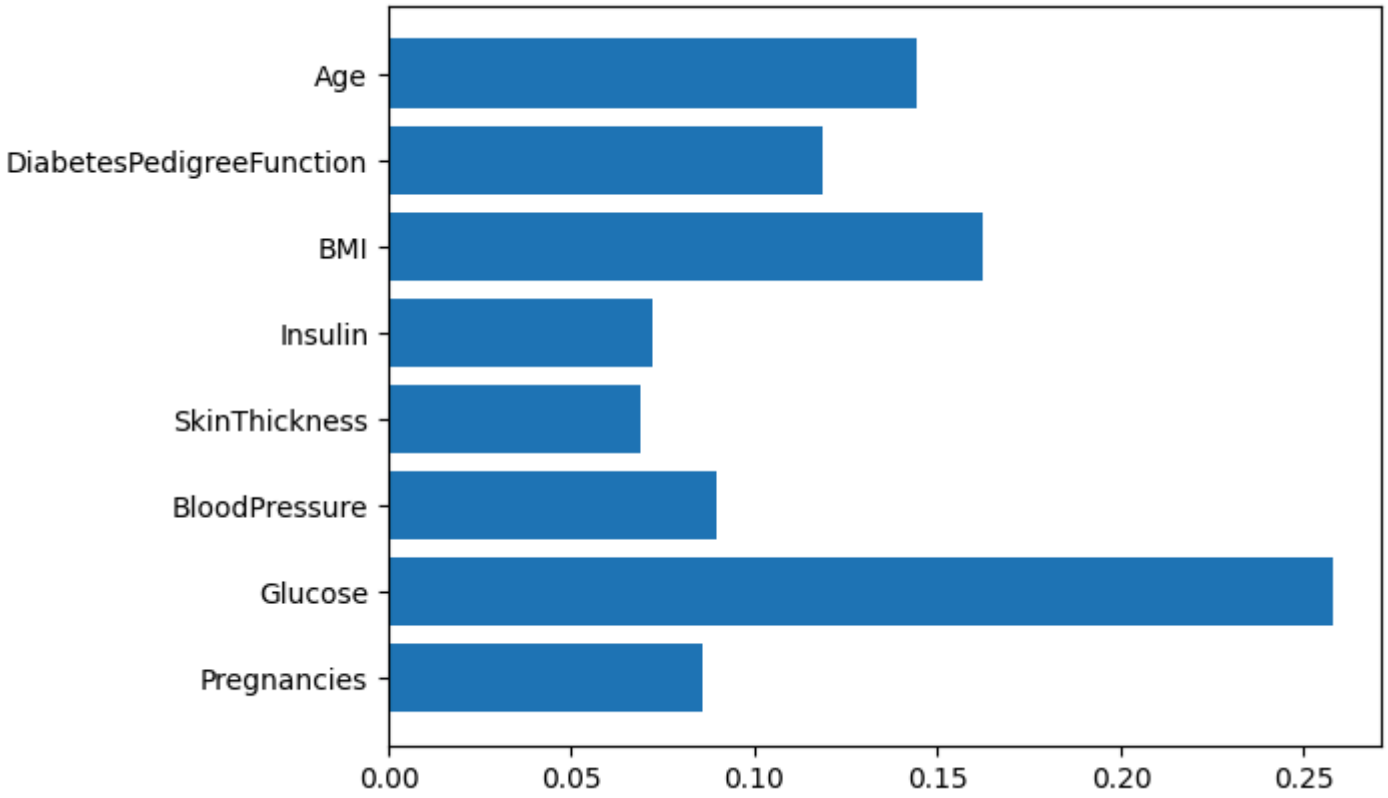
[4]:
```
RandomForestClassifier()
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

[5]:
```
import matplotlib.pyplot as plt

y_pred=model.predict(X_test)

feat_imp=model.feature_importances_
feat=X.columns
plt.barh(feat,feat_imp)
```

[5]:

[5]:



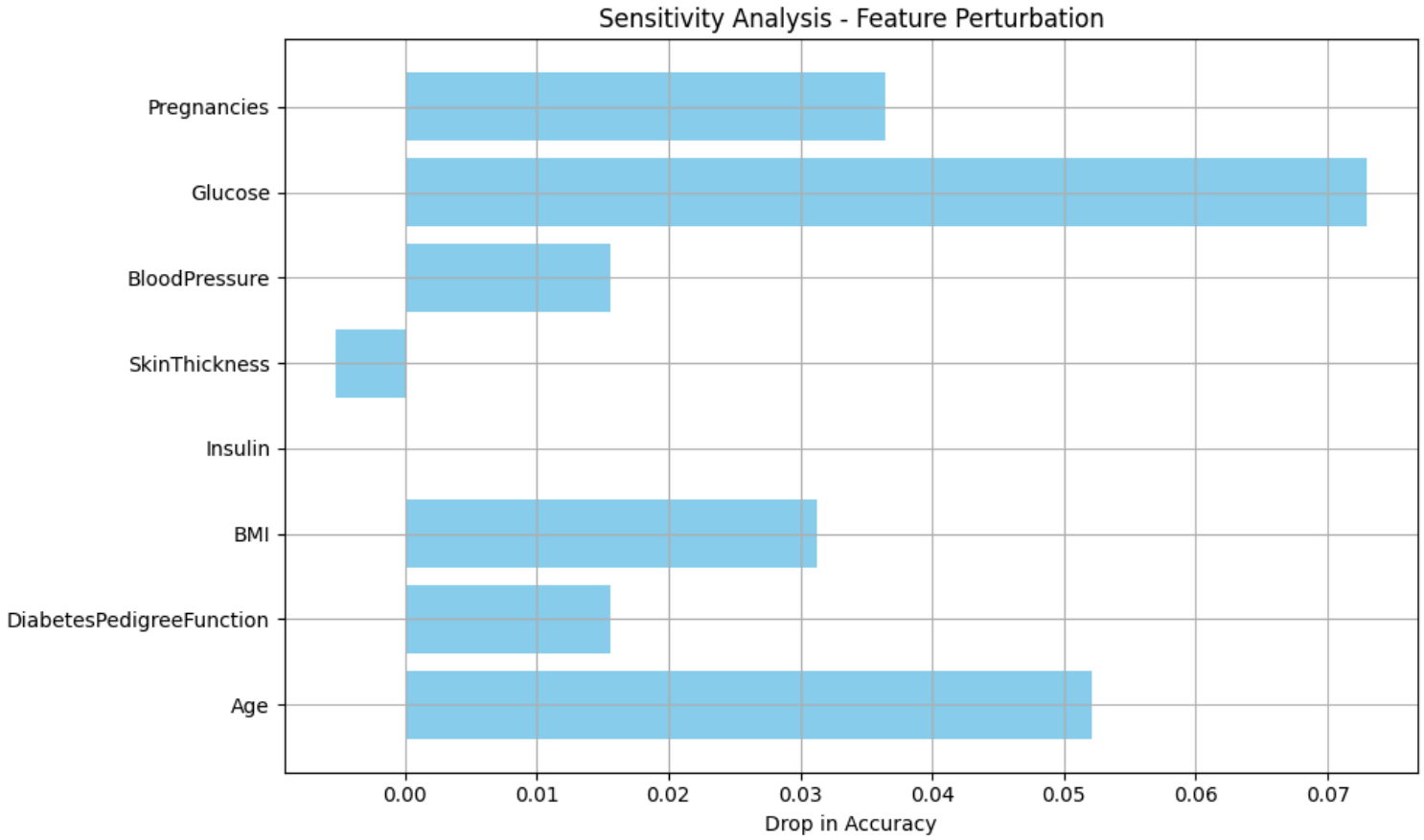
[7]:

```
# Baseline accuracy
baseline_pred = model.predict(X_test)
baseline_acc = accuracy_score(y_test, baseline_pred)
print(f"Baseline Accuracy: {baseline_acc:.4f}")

# Sensitivity Analysis: Perturb one feature at a time
sensitivity = {}

for col in X.columns:
    X_test_perturbed = X_test.copy()
    X_test_perturbed[col] += X_test_perturbed[col].std()  # Add one std deviation

    perturbed_pred = model.predict(X_test_perturbed)
    perturbed_acc = accuracy_score(y_test, perturbed_pred)

    sensitivity[col] = baseline_acc - perturbed_acc

# Convert to DataFrame
sensitivity_df = pd.DataFrame(list(sensitivity.items()), columns=['Feature', 'Accuracy Drop'])

# Plot
plt.figure(figsize=(10, 6))
plt.barh(sensitivity_df['Feature'], sensitivity_df['Accuracy Drop'], color='skyblue')
plt.xlabel('Drop in Accuracy')
plt.title('Sensitivity Analysis - Feature Perturbation')
plt.gca().invert_yaxis()
plt.grid(True)
plt.tight_layout()
plt.show()
```

[7]:

```
Baseline Accuracy: 0.7552
```

[7]:



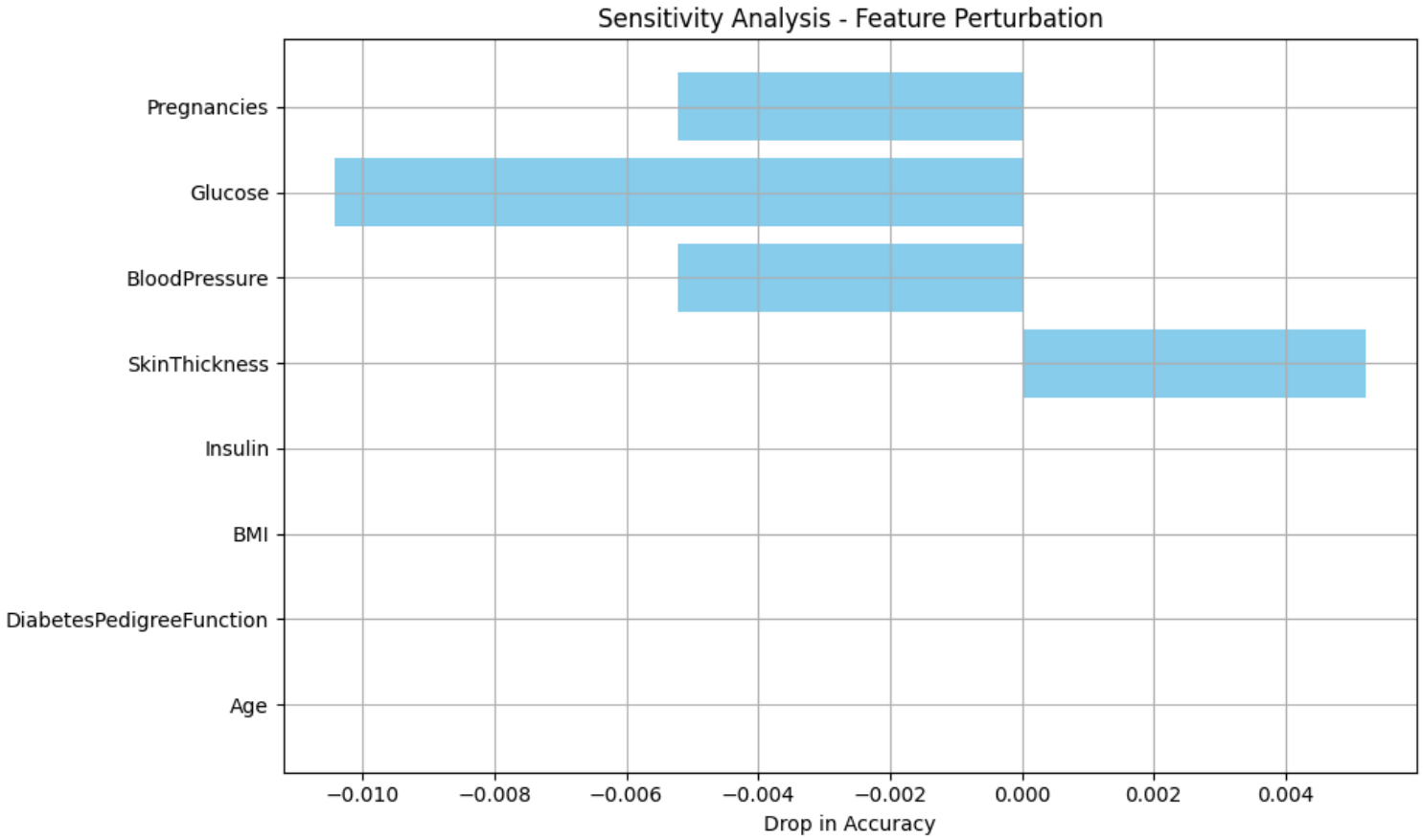
[8]:

```
# Baseline accuracy
baseline_pred = model.predict(X_test)
baseline_acc = accuracy_score(y_test, baseline_pred)
print(f"Baseline Accuracy: {baseline_acc:.4f}")

# Sensitivity Analysis: Perturb one feature at a time
sensitivity = {}

for col in X.columns:
    X_test_perturbed = X_test.copy()
    X_test_perturbed[col] += .01  # Add one std deviation

    perturbed_pred = model.predict(X_test_perturbed)
    perturbed_acc = accuracy_score(y_test, perturbed_pred)
    print(f'{col}: Accuracy drop = {baseline_acc - perturbed_acc:.4f}')
    sensitivity[col] = baseline_acc - perturbed_acc

# Convert to DataFrame
sensitivity_df = pd.DataFrame(list(sensitivity.items()), columns=['Feature', 'Accuracy Drop'])

# Plot
plt.figure(figsize=(10, 6))
plt.barh(sensitivity_df['Feature'], sensitivity_df['Accuracy Drop'], color='skyblue')
plt.xlabel('Drop in Accuracy')
plt.title('Sensitivity Analysis - Feature Perturbation')
plt.gca().invert_yaxis()
plt.grid(True)
plt.tight_layout()
plt.show()
```

[8]:

```
Baseline Accuracy: 0.7552
Pregnancies: Accuracy drop = -0.0052
Glucose: Accuracy drop = -0.0104
BloodPressure: Accuracy drop = -0.0052
SkinThickness: Accuracy drop = 0.0052
Insulin: Accuracy drop = 0.0000
BMI: Accuracy drop = 0.0000
DiabetesPedigreeFunction: Accuracy drop = 0.0000
Age: Accuracy drop = 0.0000
```

[8]:



EXP6 - LIME

LIME - TABULAR DATA

[1]:

```
import lime
import pandas as pd
import lime.lime_tabular
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import classification_report
df=pd.read_csv('diabetes.csv')
```

[2]:

```
df.head()
```

[2]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1

[3]:

```
X=df.drop('Outcome',axis=1)
y=df['Outcome']
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.2,random_state=42)
model=RandomForestClassifier()
model.fit(X_train,y_train)
y_pred=model.predict(X_test)

print(classification_report(y_test,y_pred))
```

[3]:

```
              precision    recall  f1-score   support

           0       0.80      0.81      0.80        99
           1       0.65      0.64      0.64        55

    accuracy                           0.75       154
   macro avg       0.72      0.72      0.72       154
weighted avg       0.75      0.75      0.75       154
```

[4]:

```
lime_exp=lime.lime_tabular.LimeTabularExplainer(
    training_data=X_train.values,
    feature_names=X_train.columns,
    class_names=['Diabetes','No Diabetes'],
    mode='classification'
)

exp=lime_exp.explain_instance(X_test.iloc[0].values,model.predict_proba)
exp.show_in_notebook()
```

[4]:
```
E:\Xai_Req_Setup\Python3109\lib\site-packages\sklearn\utils\validation.py:2739: UserWarning: X does not have valid feature names, but
RandomForestClassifier was fitted with feature names
  warnings.warn(
```

[4]:

LIME - TEXT DATA

[3]:
```
import lime
import lime.lime_text
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.pipeline import make_pipeline
import pandas as pd
df=pd.read_csv('sms.tsv',sep='\t',names=['senti','Desc'])
```

[4]:
```
df.head()
```

[4]:

	senti	Desc
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...

[5]:
```
df['senti'].map({'ham':1,'spam':0})
```

[5]:
```
0       1
1       1
2       0
3       1
4       1
       ..
5567    0
5568    1
5569    1
5570    1
5571    1
Name: senti, Length: 5572, dtype: int64
```

[6]:
```
df.head()
df.dropna(inplace=True)
```

[7]:
```
X=df['Desc']
y=df['senti']
X_train,X_test,y_train,y_test=train_test_split(X,y,test_size=0.2,random_state=42)

tfidf=TfidfVectorizer()
model=LogisticRegression()
mod_pip=make_pipeline(tfidf,model)
mod_pip.fit(X_train,y_train)
```

[7]:
```
Pipeline(steps=[('tfidfvectorizer', TfidfVectorizer()),
                ('logisticregression', LogisticRegression())])
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

12]:
```
lime_exp=lime.lime_text.LimeTextExplainer(class_names=['Positive','Negative'])
query=X_train.iloc[5]
exp=lime_exp.explain_instance(
    query,
    mod_pip.predict_proba,
)
exp.show_in_notebook()
```

12]:

LIME - ON IMAGE

[1]:
```
import tensorflow as tf
```

[2]:
```
from lime import lime_image
from skimage.segmentation import mark_boundaries
from tensorflow.keras.preprocessing import image
from tensorflow.keras.applications.mobilenet import preprocess_input
from tensorflow.keras.models import load_model
import matplotlib.pyplot as plt
import numpy as np
import os
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D,MaxPooling2D,Flatten,Dense,Dropout
```

[3]:
```
# Your CNN model
model = Sequential([
    Conv2D(32, (3,3), activation='relu', input_shape=(224, 224, 3)),
    MaxPooling2D(2, 2),
```

```
    Conv2D(64, (3,3), activation='relu'),
    MaxPooling2D(2,2),

    Conv2D(128, (3,3), activation='relu'),
    MaxPooling2D(2,2),

    Flatten(),
    Dropout(0.5),
    Dense(512, activation='relu'),
    Dense(1, activation='sigmoid')
])

img_path = 'cats_dogs/cats/cat.1.jpg'
img = image.load_img(img_path, target_size=(224, 224))
img_array = image.img_to_array(img)
img_preprocessed = preprocess_input(np.expand_dims(img_array, axis=0))

explainer = lime_image.LimeImageExplainer()
explanation = explainer.explain_instance(
    image=img_array,
    classifier_fn=lambda x: model.predict(preprocess_input(x)),
    num_samples=10
)

# Show explanation for top label
temp,mask = explanation.get_image_and_mask(
    label=explanation.top_labels[0],
    num_features=10,
)

plt.imshow(mark_boundaries(temp / 255.0, mask))
plt.title('LIME Explanation')
plt.axis('off')
plt.show()
```

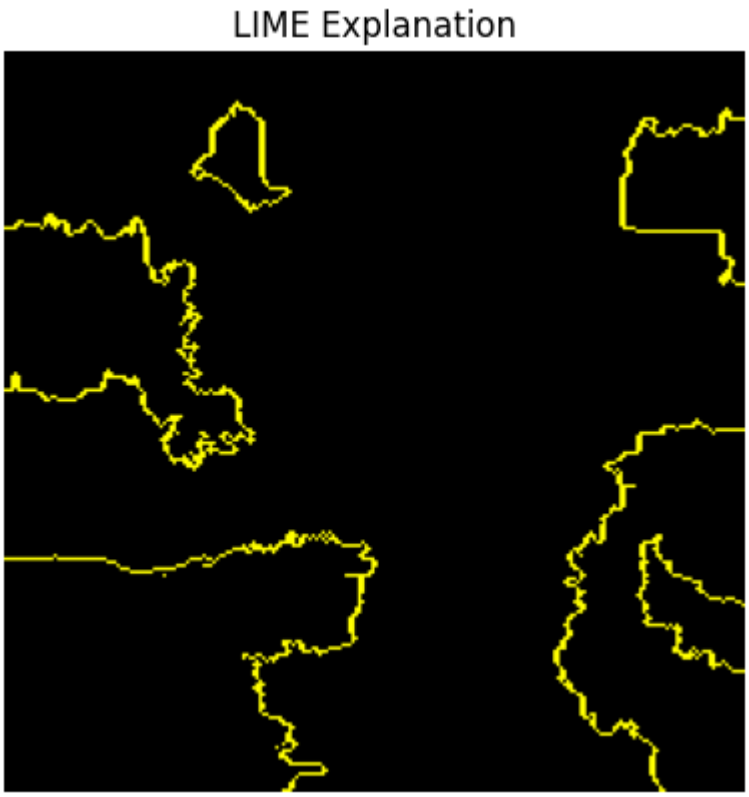
[3]:
```
E:\Xai_Req_Setup\Python3109\lib\site-packages\keras\src\layers\convolutional\base_conv.py:107: UserWarning: Do not pass an `input_shape`/`input_dim`
argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

[3]:
```
 0%|          | 0/10 [00:00
```

[3]:
```
1/1 ━━━━━━━━━━━━━━━━━━━━ 1s 570ms/step
```

[3]:
```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-0.003921569..1.0].
```

[3]:



[4]:
```
plt.imshow(temp)
```

[4]:
```
Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255] for integers). Got range [-1.0..0.94509804].
```

[4]:

[4]: