Created by Andi Sadri Agung

Mounting Drive

To connect Google Drive with google colab, where Google Drive is used later to store datasets that have been downloaded from:https://www.kaggle.com/datasets/gunavenkatdoddi/eye-diseases-classification

```
from google.colab import drive
drive.mount("/content/drive")
```

```
Mounted at /content/drive
```

```
pip install opencv-python
```

```
Requirement already satisfied: opencv-python in /usr/local/lib/python3.10/dist-packages (4.7.0.72)
Requirement already satisfied: numpy>=1.21.2 in /usr/local/lib/python3.10/dist-packages (from opencv-python) (1.22.4)
```

```
pip install numpy
```

```
Requirement already satisfied: numpy in /usr/local/lib/python3.10/dist-packages (1.22.4)
```

```
pip install scikit-image
```

```
Requirement already satisfied: scikit-image in /usr/local/lib/python3.10/dist-packages (0.19.3)
Requirement already satisfied: numpy>=1.17.0 in /usr/local/lib/python3.10/dist-packages (from scikit-image) (1.22.4)
Requirement already satisfied: scipy>=1.4.1 in /usr/local/lib/python3.10/dist-packages (from scikit-image) (1.10.1)
Requirement already satisfied: networkx>=2.2 in /usr/local/lib/python3.10/dist-packages (from scikit-image) (3.1)
Requirement already satisfied: pillow!=7.1.0,!=7.1.1,!=8.3.0,>=6.1.0 in /usr/local/lib/python3.10/dist-packages (from scikit-image)
Requirement already satisfied: imageio>=2.4.1 in /usr/local/lib/python3.10/dist-packages (from scikit-image) (2.25.1)
Requirement already satisfied: tifffile>=2019.7.26 in /usr/local/lib/python3.10/dist-packages (from scikit-image) (2023.7.18)
Requirement already satisfied: PyWavelets>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-image) (1.4.1)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from scikit-image) (23.1)
```

```
import warnings
warnings.filterwarnings("ignore", category=DeprecationWarning)
import os
import random
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import cv2 as cv
from PIL import Image, ImageFilter
from skimage.feature import graycomatrix, graycoprops
```

Data Collection and Preparation

Reading Dataset

```
def count_files_in_directory(directory_path, file_extension): #Function to access files image in folder path
    count = 0
    for filename in os.listdir(directory_path):
        if filename.endswith(file_extension):
            count += 1
    return count

file_extension_jpg = ".jpg"
file_extension_png = ".png"

normal_path = r'/content/drive/MyDrive/01. MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/dataset/normal' #Path dataset for normal
normal_count_jpg = count_files_in_directory(normal_path, file_extension_jpg) #Count image with png format
normal_count_png = count_files_in_directory(normal_path, file_extension_png) #Count image with jpg format
print(f"Normal Images in Dataset: {normal_count_jpg + normal_count_png} (JPG: {normal_count_jpg}, PNG: {normal_count_png})") #Print all i

cataract_path = r'/content/drive/MyDrive/01. MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/dataset/cataract' #Path dataset for cat
cataract_count_jpg = count_files_in_directory(cataract_path, file_extension_jpg)
cataract_count_png = count_files_in_directory(cataract_path, file_extension_png)
print(f"Cataract Images in Dataset: {cataract_count_jpg + cataract_count_png} (JPG: {cataract_count_jpg}, PNG: {cataract_count_png})")
```

```
Normal Images in Dataset: 1395 (JPG: 1395, PNG: 0)
Cataract Images in Dataset: 1218 (JPG: 1218, PNG: 0)
```

Function Convert PNG to JPG file

[ ] ↳ *1 sel tersembunyi*

Function Delete PNG File

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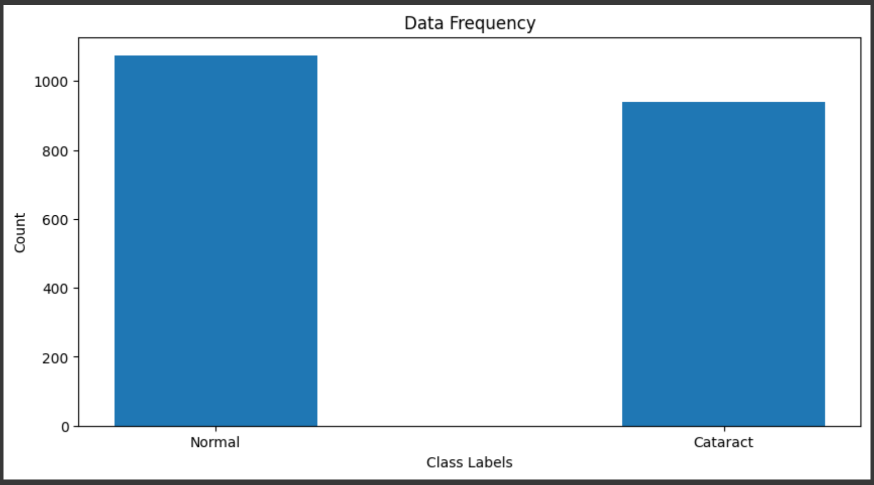
Data Augmentation

```
def extract_image_number(filename):
    start = filename.find('(')
    end = filename.find(')')
    if start == -1 or end == -1:  # Check if both parentheses are present
        return None
    try:
        return int(filename[start + 1:end])
    except ValueError:
        return None

def normal_augment_images(path, size):
    image_files = [filename for filename in os.listdir(path) if filename.endswith('.jpg')]
    image_numbers = [extract_image_number(filename) for filename in image_files]
    number = int(0.3 * size)
    for i in range(number):
        rand = random.choice(image_numbers)
        imagePath = os.path.join(path, f'Normal ({rand}).jpg')
        image = Image.open(imagePath)
        image = image.filter(ImageFilter.GaussianBlur)
        image.save(os.path.join(path, f'Normal ({size + i}).jpg'))  # Save with the same format as the original
    return size + number

def cataract_augment_images(path, size):
    image_files = [filename for filename in os.listdir(path) if filename.endswith('.jpg')]
    image_numbers = [extract_image_number(filename) for filename in image_files]
    number = int(0.3 * size)
    for i in range(number):
        rand = random.choice(image_numbers)
        imagePath = os.path.join(path, f'Cataract ({rand}).jpg')
        image = Image.open(imagePath)
        image = image.filter(ImageFilter.GaussianBlur)
        image.save(os.path.join(path, f'Cataract ({size + i}).jpg'))
    return size + number
```

```
def graph(file_normal, file_cataract): #Function to make graph of count image
    keys = ["Normal", "Cataract"]
    values = [file_normal, file_cataract]
    fig = plt.figure(figsize = (10, 5))
    plt.bar(keys, values, width = 0.4)
    plt.xlabel("Class Labels")
    plt.ylabel("Count")
    plt.title("Data Frequency")
    plt.show()
graph(file_normal, file_cataract)
```

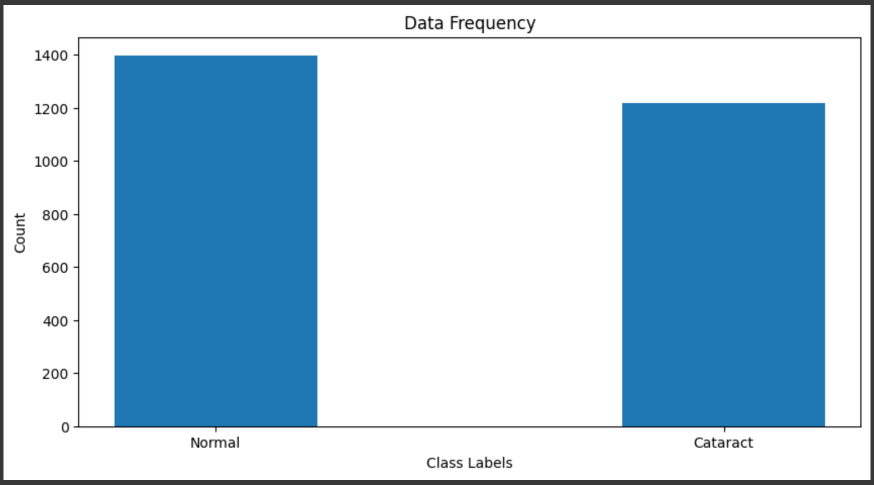


```
normal_augmented = normal_augment_images(normal_path, file_normal)
print(f"Augmented {normal_augmented} images in {normal_path}")

cataract_augmented = cataract_augment_images(cataract_path, file_cataract)
print(f"Augmented {cataract_augmented} images in {cataract_path}")
```

```
Augmented 1396 images in /content/drive/MyDrive/MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/dataset/normal/
Augmented 1219 images in /content/drive/MyDrive/MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/dataset/cataract/
```

```
graph(normal_augmented, cataract_augmented)
```



Feature Extraction and Data Visualization for Image Sample

```
def get_image(path, color):
    img = cv.imread(path)
    img = cv.cvtColor(img, color)
    return img

def get_thresh_image(path):
    img = get_image(path, cv.COLOR_BGR2GRAY)
    img = cv.adaptiveThreshold(img, 255, cv.ADAPTIVE_THRESH_GAUSSIAN_C, cv.THRESH_BINARY_INV, 11, 3)
    return img
```

```
def show_image(path, color, cmap='gray'):
    img = get_image(path, color)
    fig = plt.figure(figsize=(10,10))
    axes = fig.add_subplot(111)
    axes.imshow(img, cmap=cmap)

def show_image_threshold(path, cmap='gray'):
    img = get_thresh_image(path)
    fig = plt.figure(figsize=(10,10))
    axes = fig.add_subplot(111)
    axes.imshow(img, cmap=cmap)

def get_contoured(img):
    cnts = cv.findContours(img, cv.RETR_EXTERNAL, cv.CHAIN_APPROX_SIMPLE)
    cnts = cnts[0] if len(cnts) == 2 else cnts[1]
    cnts = sorted(cnts, key=cv.contourArea, reverse=True)
    for c in cnts:
        x,y,w,h = cv.boundingRect(c)
        img = img[y:y+h, x:x+w]
        break
    img = cv.resize(img, (int(img.shape[0]/4), int(img.shape[1]/4)))
    return img

def show_image_resized(path, cmap='gray'):
    img = get_thresh_image(path)
    img = get_contoured(img)
    fig = plt.figure(figsize=(10,10))
    axes = fig.add_subplot(111)
    axes.imshow(img, cmap=cmap)

def get_feature(matrix, name):
    feature = graycoprops(matrix, name)
    result = np.average(feature)
    return result

from skimage.util.dtype import img_as_float
def show_features(path):
    img =  get_image(path, cv.COLOR_BGR2GRAY)
    glcm = graycomatrix(img, [distance], [teta], levels=256, symmetric=True, normed=True)

    for x in indextable[:-1]:
        arr = []
        feature = get_feature(glcm, x)
        arr.append(feature)
        print(f"{x} = {arr[0]}")
```

```
normal_sample = '/content/drive/MyDrive/01. MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/dataset/normal/Normal (1).jpg' #Sample f
cataract_sample = '/content/drive/MyDrive/01. MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/dataset/cataract/Cataract (1).jpg'
```

Visualization Sample Images

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Data Preprocessing and Feature Extraction for Dataset Folder

Feature Extraction

```
def get_image(folder_path, category):
    images = []
    folder_dir = os.path.join(folder_path, category)
    for filename in os.listdir(folder_dir):
        img_path = os.path.join(folder_dir, filename)
        img = cv2.imread(img_path)
        images.append(img)
    return images

def get_thresh_image(image, threshold_value):
    gray_image = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
    _, thresh_image = cv2.threshold(gray_image, threshold_value, 255, cv2.THRESH_BINARY)
    return thresh_image

def show_image(image, title="Image"):
    plt.figure(figsize=(6, 6))
    plt.imshow(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
    plt.title(title)
    plt.axis('off')
    plt.show()

def show_image_threshold(thresh_image, title="Threshold Image"):
    plt.figure(figsize=(6, 6))
    plt.imshow(thresh_image, cmap='gray')
    plt.title(title)
    plt.axis('off')
    plt.show()

def get_contoured(image, threshold_value):
    contours, _ = cv2.findContours(image, cv2.RETR_EXTERNAL, cv2.CHAIN_APPROX_SIMPLE)
    contoured_image = np.copy(image)
    cv2.drawContours(contoured_image, contours, -1, (0, 255, 0), 2)
    return contoured_image

def show_image_resize(image, new_width, new_height, title="Resized Image"):
    resized_image = cv2.resize(image, (new_width, new_height))
    plt.figure(figsize=(6, 6))
    plt.imshow(cv2.cvtColor(resized_image, cv2.COLOR_BGR2RGB))
    plt.title(title)
    plt.axis('off')
    plt.show()
def get_feature(image):
    gray_image = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)
    glcm = greycomatrix(gray_image, [5], [0], 256, symmetric=True, normed=True)
    glcm_features = {
        'dissimilarity': greycoprops(glcm, 'dissimilarity')[0, 0],
        'contrast': greycoprops(glcm, 'contrast')[0, 0],
        'homogeneity': greycoprops(glcm, 'homogeneity')[0, 0],
        'energy': greycoprops(glcm, 'energy')[0, 0],
        'ASM': greycoprops(glcm, 'ASM')[0, 0],
        'correlation': greycoprops(glcm, 'correlation')[0, 0]
    }
    return glcm_features
```

Data Processing

```
# Path folder dataset
folder_path = "/content/drive/MyDrive/01. MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/dataset"

# Mendapatkan gambar dari folder Normal dan Cataract
images_normal = get_image(folder_path, 'normal')
images_cataract = get_image(folder_path, 'cataract')

# Menghitung fitur GLCM
glcm_features_normal = [get_feature(img) for img in images_normal]
glcm_features_cataract = [get_feature(img) for img in images_cataract]
```

```
Output streaming akan dipotong hingga 5000 baris terakhir.
/usr/local/lib/python3.10/dist-packages/skimage/feature/__init__.py:42: skimage_deprecation: Function ``greycoprops`` is deprecat
  removed_version='1.0')
/usr/local/lib/python3.10/dist-packages/skimage/feature/__init__.py:35: skimage_deprecation: Function ``greycomatrix`` is depreca
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```

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    removed_version='1.0')
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    removed_version='1.0')
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    removed_version='1.0')
  /usr/local/lib/python3.10/dist-packages/skimage/feature/__init__.py:42: skimage_deprecation: Function ``greycoprops`` is deprecat
    removed_version='1.0')
```

Saving Feature Value on DataFrame

```
indextable = ['dissimilarity', 'contrast', 'homogeneity', 'energy', 'ASM', 'correlation', 'Label']
data_eye = np.zeros((len(images_normal) + len(images_cataract), len(indextable)))
```

Data Labelling

```
for i, features in enumerate(glcm_features_normal):
    data_eye[i, :-1] = list(features.values())
    data_eye[i, -1] = 0  # 0 for Normal Class

for i, features in enumerate(glcm_features_cataract):
    data_eye[i + len(images_normal), :-1] = list(features.values())
    data_eye[i + len(images_normal), -1] = 1  # 1 for Cataract Class
```

Create DataFrame

```
df = pd.DataFrame(data_eye, columns=indextable)
```

Shuffle Data CSV for Randomize Label and Saving

```
from sklearn.utils import shuffle
df = shuffle(df)
df.head()

df.to_csv("eye_features.csv", index=False)
```

```
print(f"Length our dataset : {len(df)}")
```

```
  Length our dataset : 2613
```

Exploratory of Data Analysis (EDA)

```
df = pd.read_csv('/content/eye_features.csv')
df.head()
```

dissimilarity	contrast	homogeneity	energy	ASM	correlation	Label

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 2613 entries, 2235 to 2457
Data columns (total 7 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   dissimilarity  2613 non-null   float64
 1   contrast       2613 non-null   float64
 2   homogeneity    2613 non-null   float64
 3   energy         2613 non-null   float64
 4   ASM            2613 non-null   float64
 5   correlation    2613 non-null   float64
 6   Label          2613 non-null   float64
dtypes: float64(7)
memory usage: 163.3 KB
```

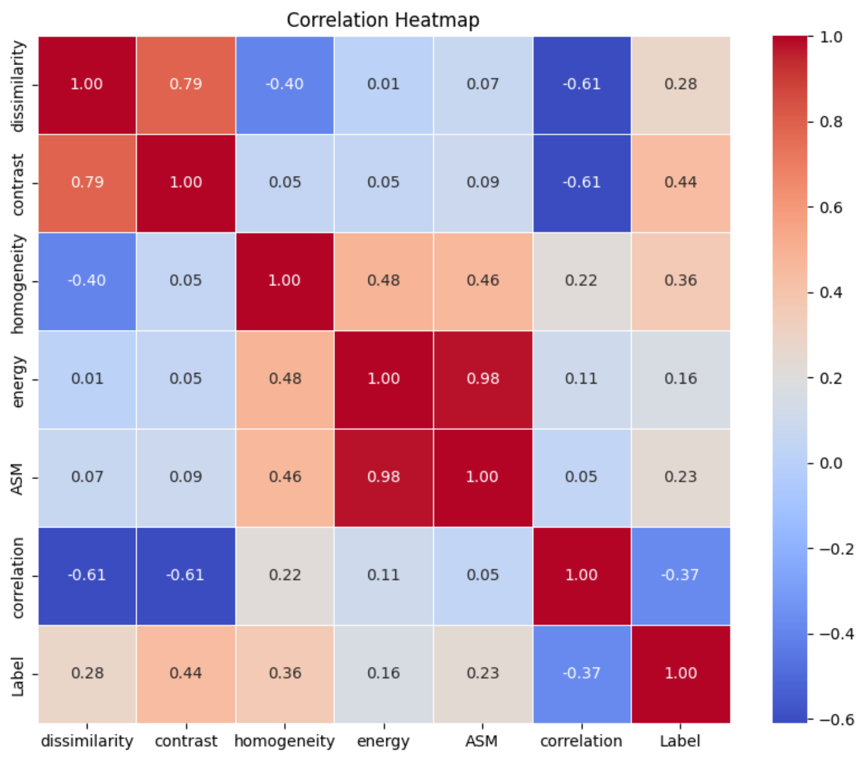
```
df.describe()
```

	dissimilarity	contrast	homogeneity	energy	ASM	correlation
count	2613.000000	2613.000000	2613.000000	2613.000000	2613.000000	2613.000000
mean	5.053957	299.306830	0.449618	0.182451	0.038480	0.948262
std	1.759445	279.874731	0.096048	0.072067	0.037922	0.025677
min	0.876291	3.996152	0.221522	0.059513	0.003542	0.784213
25%	3.811552	114.421625	0.379721	0.141659	0.020067	0.936154
50%	4.918770	217.365092	0.431197	0.176681	0.031216	0.952382
75%	6.110309	390.219948	0.515317	0.186099	0.034633	0.966173
max	13.131007	2241.987114	0.799429	0.434378	0.188684	0.991062

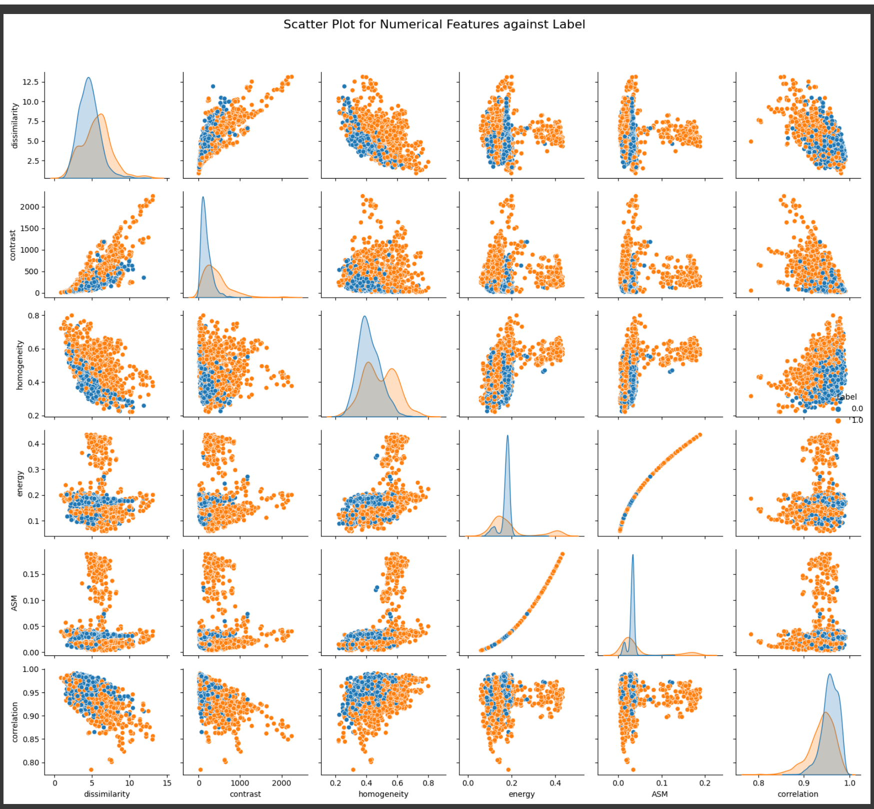
```
df.hist(bins=20, figsize=(12, 8))
plt.suptitle("Histograms of Numerical Features", fontsize=16)
plt.tight_layout(rect=[0, 0.03, 1, 0.95])
plt.show()
```

Histograms of Numerical Features

```
correlation_matrix = df.corr()
plt.figure(figsize=(10, 8))
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt='.2f', linewidths=0.5)
plt.title('Correlation Heatmap')
plt.show()
```

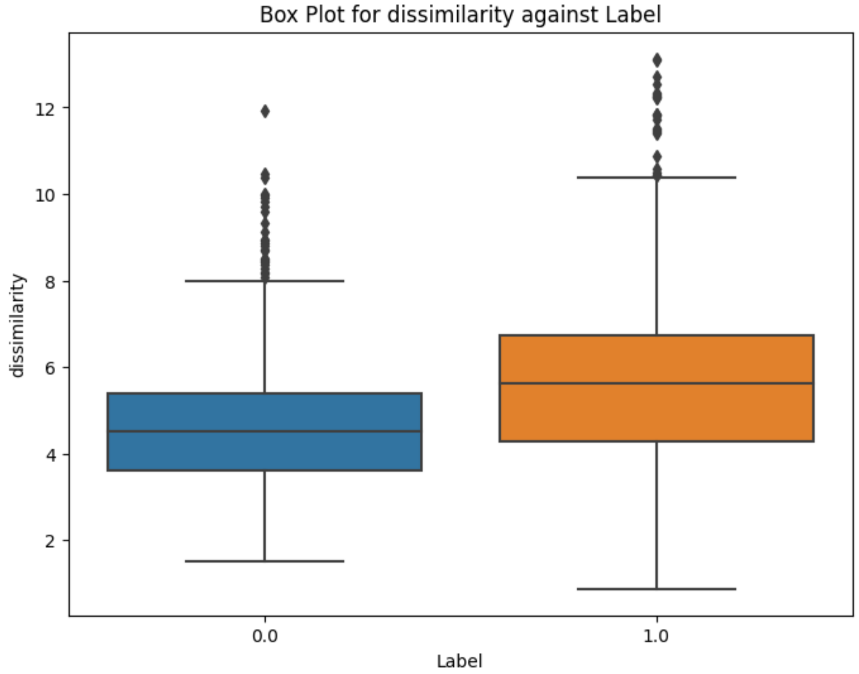


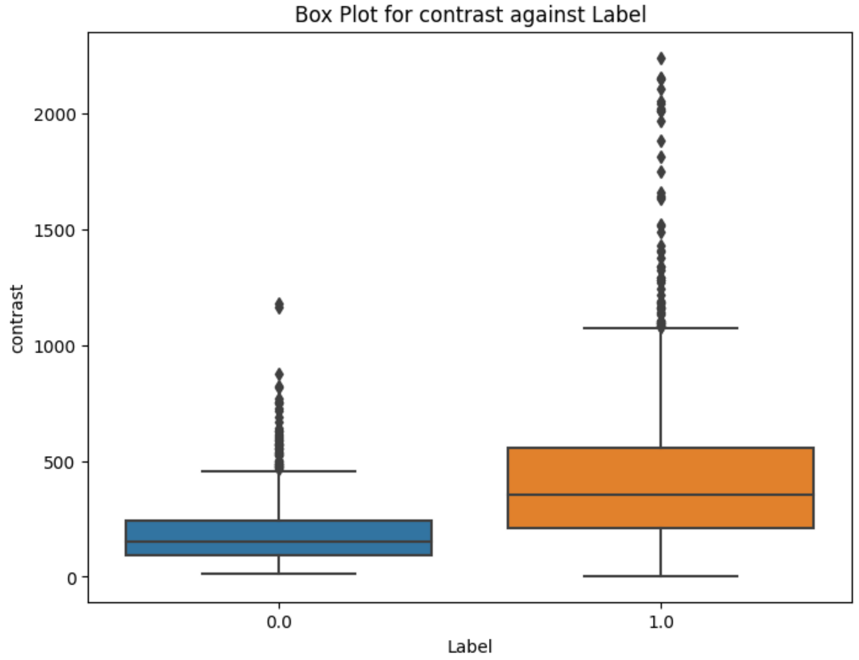
```
sns.pairplot(df, hue='Label', diag_kind='kde')
plt.suptitle("Scatter Plot for Numerical Features against Label", fontsize=16)
plt.tight_layout(rect=[0, 0.03, 1, 0.95])
plt.show()
```

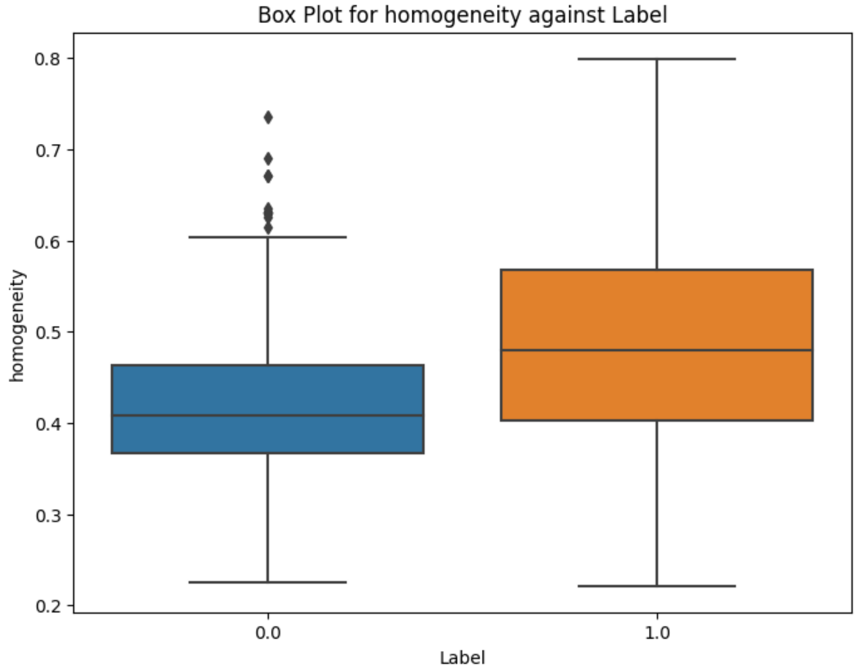


Scatter Plot for Numerical Features against Label

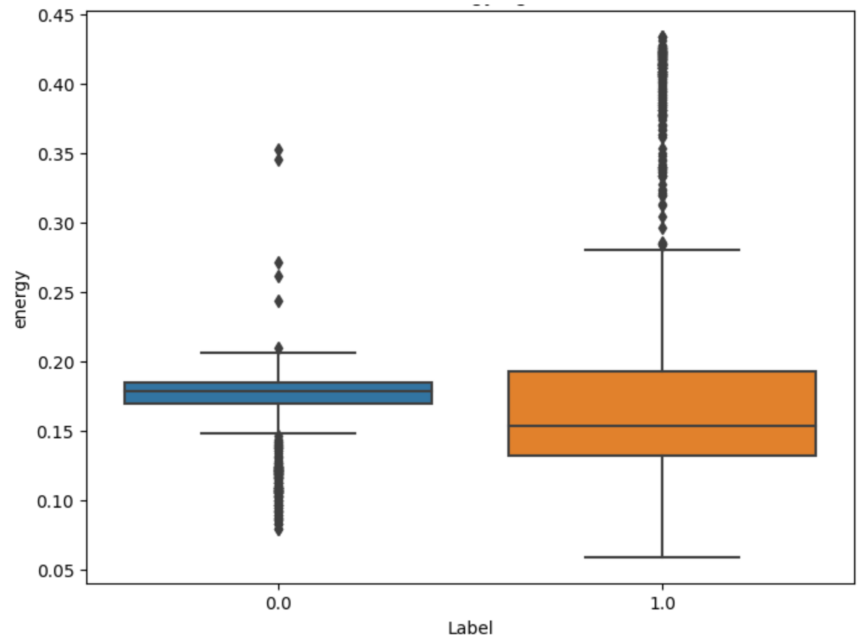
```
for col in df.columns[:-1]:  # Exclude last column (Label)
    plt.figure(figsize=(8, 6))
    sns.boxplot(x='Label', y=col, data=df)
    plt.title(f'Box Plot for {col} against Label')
    plt.show()
```


Box Plot for dissimilarity against Label

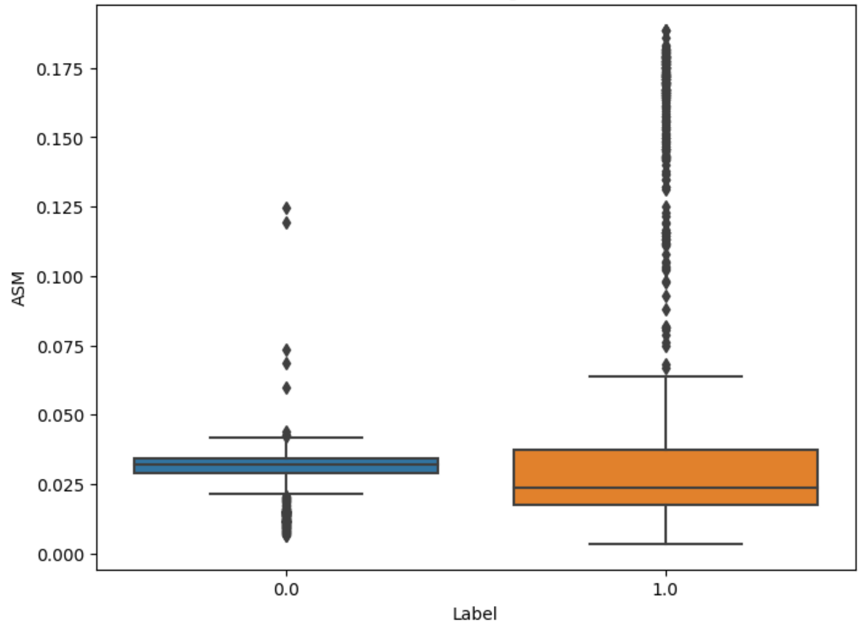

Box Plot for contrast against Label


Box Plot for homogeneity against Label

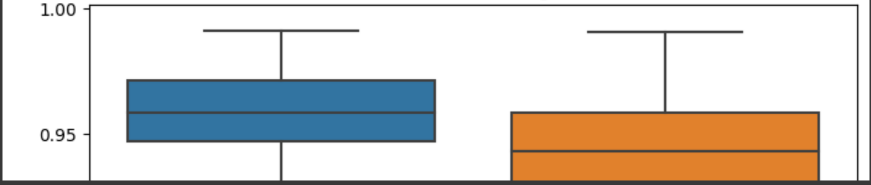
Box Plot for energy against Label



Box Plot for ASM against Label



Box Plot for correlation against Label

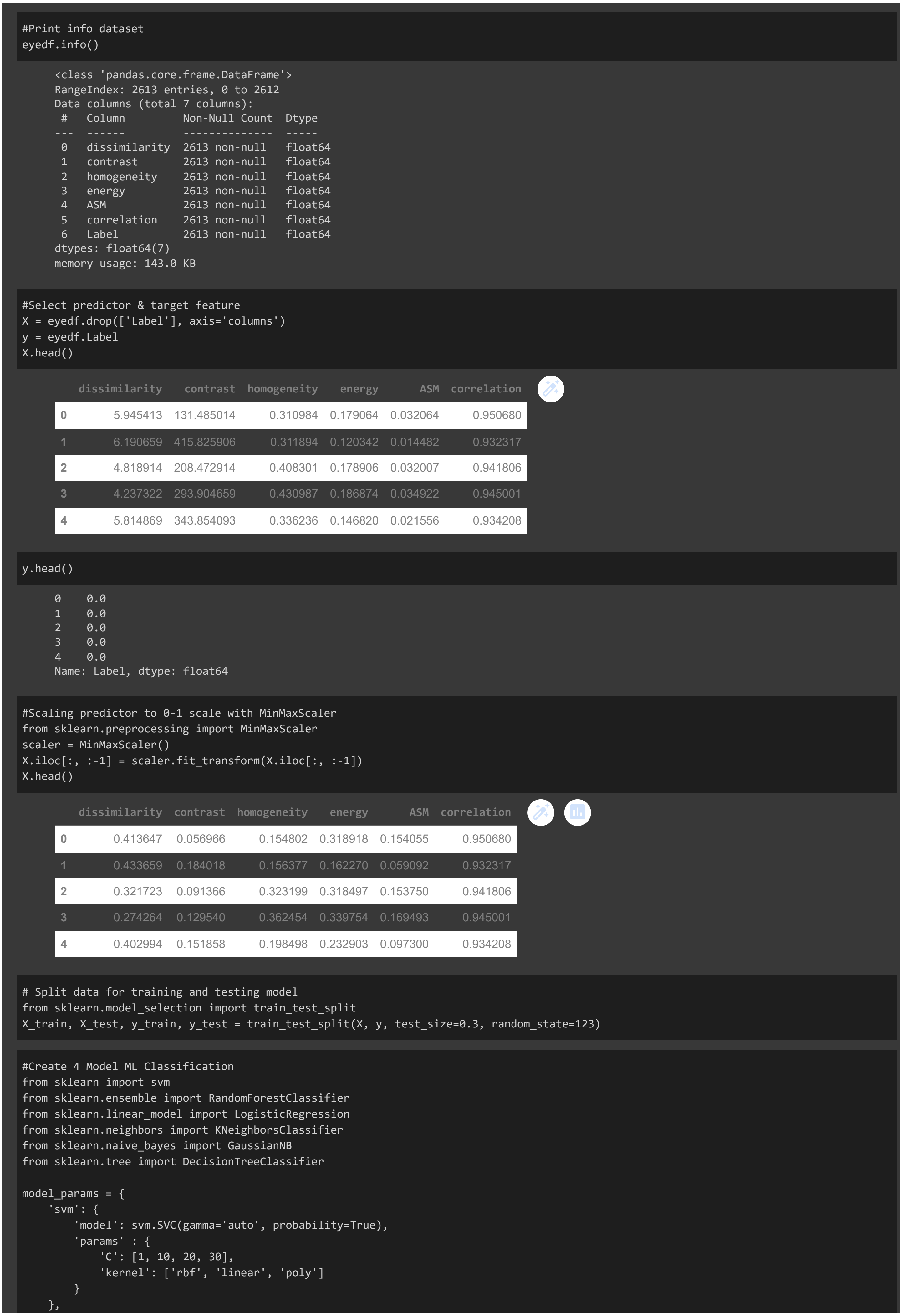


Link CSV : https://drive.google.com/file/d/1RZnUw-cJ87Rz3Fxq98JMDESH4390Jj-H/view?usp=sharing

Modelling

```
#Calling dataset clean format CSV
eyedf = pd.read_csv('/content/drive/MyDrive/01. MY PERSONAL BRANDING/Dibimbing InternPro Bukit Vista/eye_features.csv')
eyedf.head()
```

	dissimilarity	contrast	homogeneity	energy	ASM	correlation	Label
0	5.945413	131.485014	0.310984	0.179064	0.032064	0.950680	0.0
1	6.190659	415.825906	0.311894	0.120342	0.014482	0.932317	0.0
2	4.818914	208.472914	0.408301	0.178906	0.032007	0.941806	0.0
3	4.237322	293.904659	0.430987	0.186874	0.034922	0.945001	0.0
4	5.814869	343.854093	0.336236	0.146820	0.021556	0.934208	0.0



```
#Print info dataset
eyedf.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2613 entries, 0 to 2612
Data columns (total 7 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   dissimilarity  2613 non-null   float64
 1   contrast       2613 non-null   float64
 2   homogeneity    2613 non-null   float64
 3   energy         2613 non-null   float64
 4   ASM            2613 non-null   float64
 5   correlation    2613 non-null   float64
 6   Label          2613 non-null   float64
dtypes: float64(7)
memory usage: 143.0 KB
```

```
#Select predictor & target feature
X = eyedf.drop(['Label'], axis='columns')
y = eyedf.Label
X.head()
```

	dissimilarity	contrast	homogeneity	energy	ASM	correlation
0	5.945413	131.485014	0.310984	0.179064	0.032064	0.950680
1	6.190659	415.825906	0.311894	0.120342	0.014482	0.932317
2	4.818914	208.472914	0.408301	0.178906	0.032007	0.941806
3	4.237322	293.904659	0.430987	0.186874	0.034922	0.945001
4	5.814869	343.854093	0.336236	0.146820	0.021556	0.934208

```
y.head()
```

```
0    0.0
1    0.0
2    0.0
3    0.0
4    0.0
Name: Label, dtype: float64
```

```
#Scaling predictor to 0-1 scale with MinMaxScaler
from sklearn.preprocessing import MinMaxScaler
scaler = MinMaxScaler()
X.iloc[:, :-1] = scaler.fit_transform(X.iloc[:, :-1])
X.head()
```

	dissimilarity	contrast	homogeneity	energy	ASM	correlation
0	0.413647	0.056966	0.154802	0.318918	0.154055	0.950680
1	0.433659	0.184018	0.156377	0.162270	0.059092	0.932317
2	0.321723	0.091366	0.323199	0.318497	0.153750	0.941806
3	0.274264	0.129540	0.362454	0.339754	0.169493	0.945001
4	0.402994	0.151858	0.198498	0.232903	0.097300	0.934208

```
# Split data for training and testing model
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=123)
```

```
#Create 4 Model ML Classification
from sklearn import svm
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.tree import DecisionTreeClassifier

model_params = {
    'svm': {
        'model': svm.SVC(gamma='auto', probability=True),
        'params' : {
            'C': [1, 10, 20, 30],
            'kernel': ['rbf', 'linear', 'poly']
        }
    },
    'random_forest': {
        'model': RandomForestClassifier(),
        'params' : {
            'n_estimators': [1, 5, 10, 50, 100]
        }
    },
    'logistic_regression' : {
        'model': LogisticRegression(solver='liblinear',multi_class='auto'),
        'params': {
            'C': [1, 5, 10, 50, 100]
        }
    },
    'KNN' : {
        'model': KNeighborsClassifier(),
        'params': {
            'n_neighbors': [3, 7, 11, 13]
        }
    }
}
```

```
#Model Test 4 algorithm for best score, best params
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import confusion_matrix, recall_score, precision_score, f1_score, accuracy_score

def test_model(X_train, y_train, X_test, y_test):
    scores = []

    for model_name, mp in model_params.items():
        clf = GridSearchCV(mp['model'], mp['params'], cv=5, return_train_score=False)
        clf.fit(X_train, y_train)
        y_pred = clf.predict(X_test)
        cm = confusion_matrix(y_test, y_pred)
        recall = recall_score(y_test, y_pred, average='micro')
        precision = precision_score(y_test, y_pred, average='micro')
        f1 = f1_score(y_test, y_pred, average='micro')
        accuracy = accuracy_score(y_test, y_pred)

        scores.append({
            'model': model_name,
            'best_score': clf.best_score_,
            'best_params': clf.best_params_,
            'confusion_matrix': cm,
            'Recall': recall,
            'Precision': precision,
            'F1-Score': f1,
            'Accuracy': accuracy
        })

    scores = sorted(scores, key=lambda x: x['best_score'], reverse=True)

    df_score = pd.DataFrame(scores, columns=['model', 'best_score', 'best_params', 'confusion_matrix', 'Recall', 'Precision', 'F1-Score',
    return df_score

result_df = test_model(X_train, y_train, X_test, y_test)
print(result_df)
```

```
                 model  best_score                       best_params  \
0        random_forest    0.903235             {'n_estimators': 50}
1                  KNN    0.897221               {'n_neighbors': 7}
2                  svm    0.853471  {'C': 20, 'kernel': 'linear'}
3  logistic_regression    0.852384                        {'C': 100}

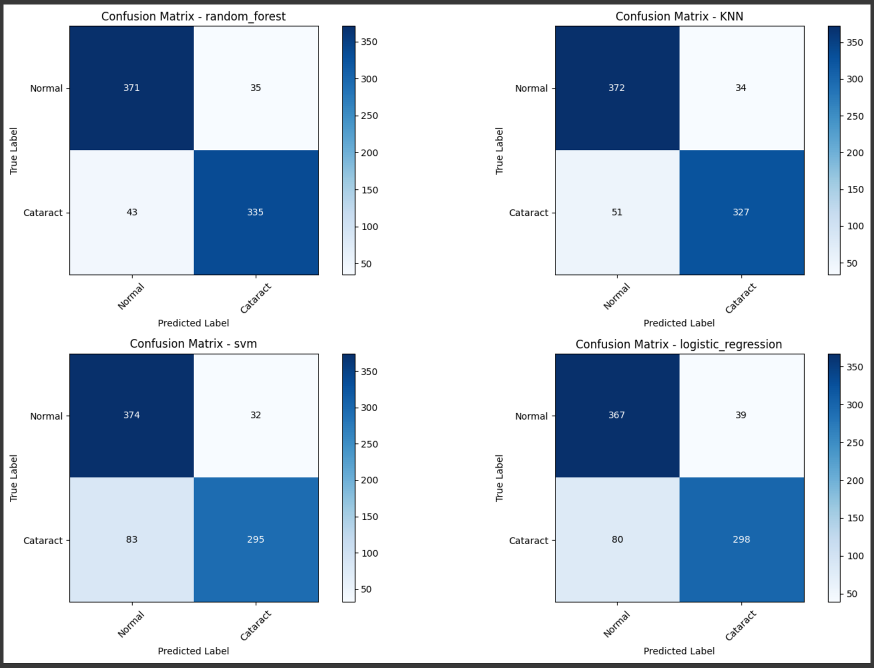
          confusion_matrix    Recall  Precision  F1-Score  Accuracy
0  [[371, 35], [43, 335]]  0.900510   0.900510  0.900510  0.900510
1  [[372, 34], [51, 327]]  0.891582   0.891582  0.891582  0.891582
2  [[374, 32], [83, 295]]  0.853316   0.853316  0.853316  0.853316
3  [[367, 39], [80, 298]]  0.848214   0.848214  0.848214  0.848214
```

```
#Visualization Confusion Matriks Index
import numpy as np
import matplotlib.pyplot as plt

def plot_confusion_matrix(confusion_matrices, model_names):
    plt.figure(figsize=(15, 10))
    for i, cm in enumerate(confusion_matrices):
        model_name = model_names[i]
        plt.subplot(2, 2, i + 1)
        plt.title(f'Confusion Matrix - {model_name}')
        plt.imshow(cm, interpolation='nearest', cmap=plt.cm.Blues)
        plt.colorbar()
        classes = ['Normal', 'Cataract']
        tick_marks = np.arange(len(classes))
        plt.xticks(tick_marks, classes, rotation=45)
        plt.yticks(tick_marks, classes)
        plt.xlabel('Predicted Label')
        plt.ylabel('True Label')
        for i in range(len(classes)):
            for j in range(len(classes)):
                plt.text(j, i, str(cm[i, j]), ha='center', va='center', color='white' if cm[i, j] > cm.max() / 2 else 'black')
    plt.tight_layout()

confusion_matrices = [score['confusion_matrix'] for _, score in result_df.iterrows()]
model_names = [score['model'] for _, score in result_df.iterrows()]

plot_confusion_matrix(confusion_matrices, model_names)
plt.show()
```



```
#Visualization Performance Confusion Matriks
plt.figure(figsize=(12, 6))

model_names = result_df['model']
recall_scores = result_df['Recall']
precision_scores = result_df['Precision']
f1_scores = result_df['F1-Score']
accuracy_scores = result_df['Accuracy']

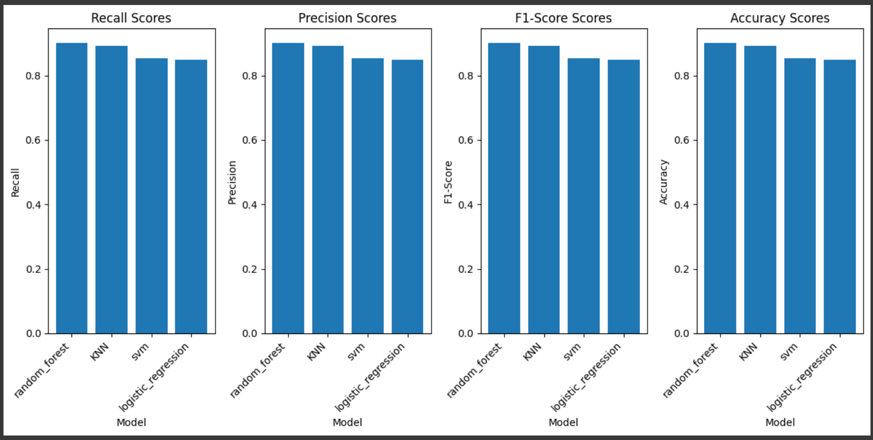
plt.subplot(1, 4, 1)
plt.bar(model_names, recall_scores)
plt.title('Recall Scores')
plt.xlabel('Model')
plt.ylabel('Recall')
plt.xticks(rotation=45, ha='right')

plt.subplot(1, 4, 2)
plt.bar(model_names, precision_scores)
plt.title('Precision Scores')
plt.xlabel('Model')
plt.ylabel('Precision')
plt.xticks(rotation=45, ha='right')

plt.subplot(1, 4, 3)
plt.bar(model_names, f1_scores)
plt.title('F1-Score Scores')
plt.xlabel('Model')
plt.ylabel('F1-Score')
plt.xticks(rotation=45, ha='right')

plt.subplot(1, 4, 4)
plt.bar(model_names, accuracy_scores)
plt.title('Accuracy Scores')
plt.xlabel('Model')
plt.ylabel('Accuracy')
plt.xticks(rotation=45, ha='right')

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


Recall Scores
Precision Scores
F1-Score Scores
Accuracy Scores
Recall
Precision
F1-Score
Accuracy
random_forest
KNN
svm
logistic_regression
Model