Instructions

Follow the instructions given in comments prefixed with ## and write your code below that.

Also fill the partial code in given blanks.

Don't make any changes to the rest part of the codes

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```
## import cv2
import cv2
## import numpy
import numpy as np
## import matplotlib pyplot
import matplotlib.pyplot as plt
## import KMeans cluster from sklearn
from sklearn.cluster import KMeans
## import distance from scipy.spatial
from scipy.spatial import distance
from matplotlib.offsetbox import OffsetImage, AnnotationBbox
```

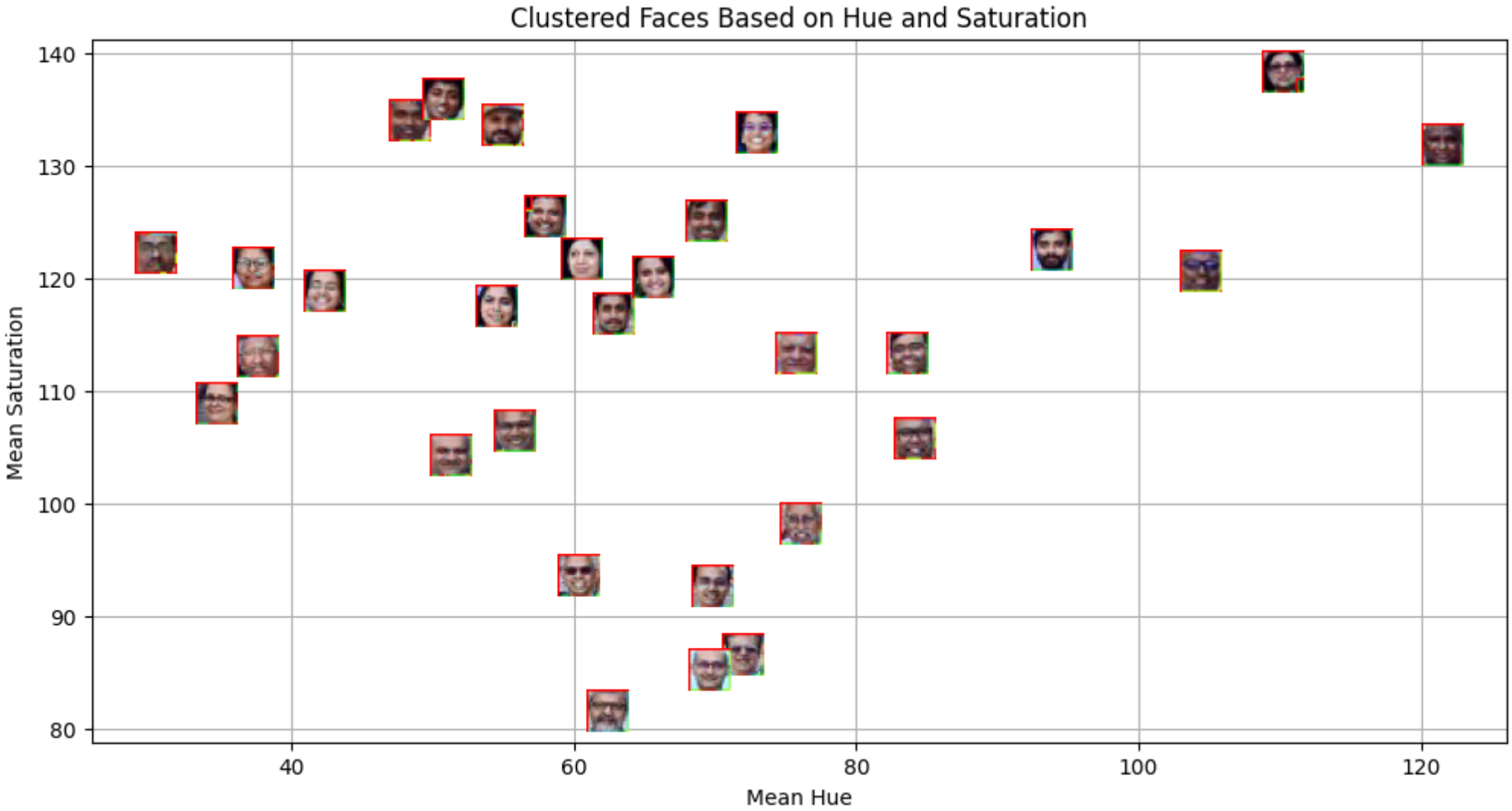
Face Detection on given image

```
# Reading the image
img = cv2.imread(r"C:\Users\navde\Downloads\Plaksha_Faculty.jpg")

# Convert the image to grayscale
gray_img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)

# Loading the required haar-cascade xml classifier file
face_cascade = cv2.CascadeClassifier(r"C:\Users\navde\Downloads\haarcascade_frontalface_alt 1 (1).xml")  # Provide th
# Applying the face detection method on the grayscale image.
faces_rect = face_cascade.detectMultiScale(gray_img, scaleFactor=1.04, minNeighbors=10)

# Define the text and font parameters

text =  f'Total number of faces detected are {len(faces_rect)}' ## The text you want to write
font = cv2.FONT_HERSHEY_SIMPLEX ## Font type
font_scale = 1 ## Font scale factor
font_color =  (0, 0, 255) ## Text color in BGR format (here, it's red)
font_thickness = 2 ## Thickness of the text

# Iterating through rectangles of detected faces
for (x, y, w, h) in faces_rect:
    cv2.rectangle(img, (x, y), (x+w, y+h), (0, 0, 255), 2)
    # Use cv2.putText to add the text to the image
    cv2.putText(img, text, (10, 25), font, font_scale, font_color, font_thickness)

# Display the image and window title should be "Total number of face detected are #"
cv2.imshow(f'Total number of faces detected are {len(faces_rect)}', img)
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Visualising images by their hue and saturation features

```
from matplotlib.offsetbox import OffsetImage, AnnotationBbox
# Extract face region features (Hue and Saturation)
img_hsv = cv2.cvtColor(img, cv2.COLOR_BGR2HSV)

hue_saturation = [] ## call the img and convert it from BGR to HSV and store in img_hsv
face_images = []  # To store detected face images

for (x, y, w, h) in faces_rect:
    face = img_hsv[y:y + h, x:x + w]
    hue = np.mean(face[:, :, 0])  # Extract mean hue for the face
    saturation = np.mean(face[:, :, 1])  # Extract mean saturation for the face
    hue_saturation.append((hue, saturation))
    face_images.append(face)

hue_saturation = np.array(hue_saturation)

# Create a figure and axis
fig, ax = plt.subplots(figsize=(12, 6))

# Plot the clustered faces with custom markers
for i, (x, y, w, h) in enumerate(faces_rect):
    im = OffsetImage(cv2.cvtColor(cv2.resize(face_images[i], (20, 20)), cv2.COLOR_HSV2RGB))
    ab = AnnotationBbox(im, (hue_saturation[i, 0], hue_saturation[i, 1]), frameon=False, pad=0)
    ax.add_artist(ab)
    plt.plot(hue_saturation[i, 0], hue_saturation[i, 1], 'o')  # Use 'o' for markers
```

```
# Put x label
plt.xlabel('Mean Hue')
# Put y label
plt.ylabel('Mean Saturation')
# Put grid
plt.grid(True)
# Put title
plt.title('Clustered Faces Based on Hue and Saturation')
# show the plot
plt.show()
```

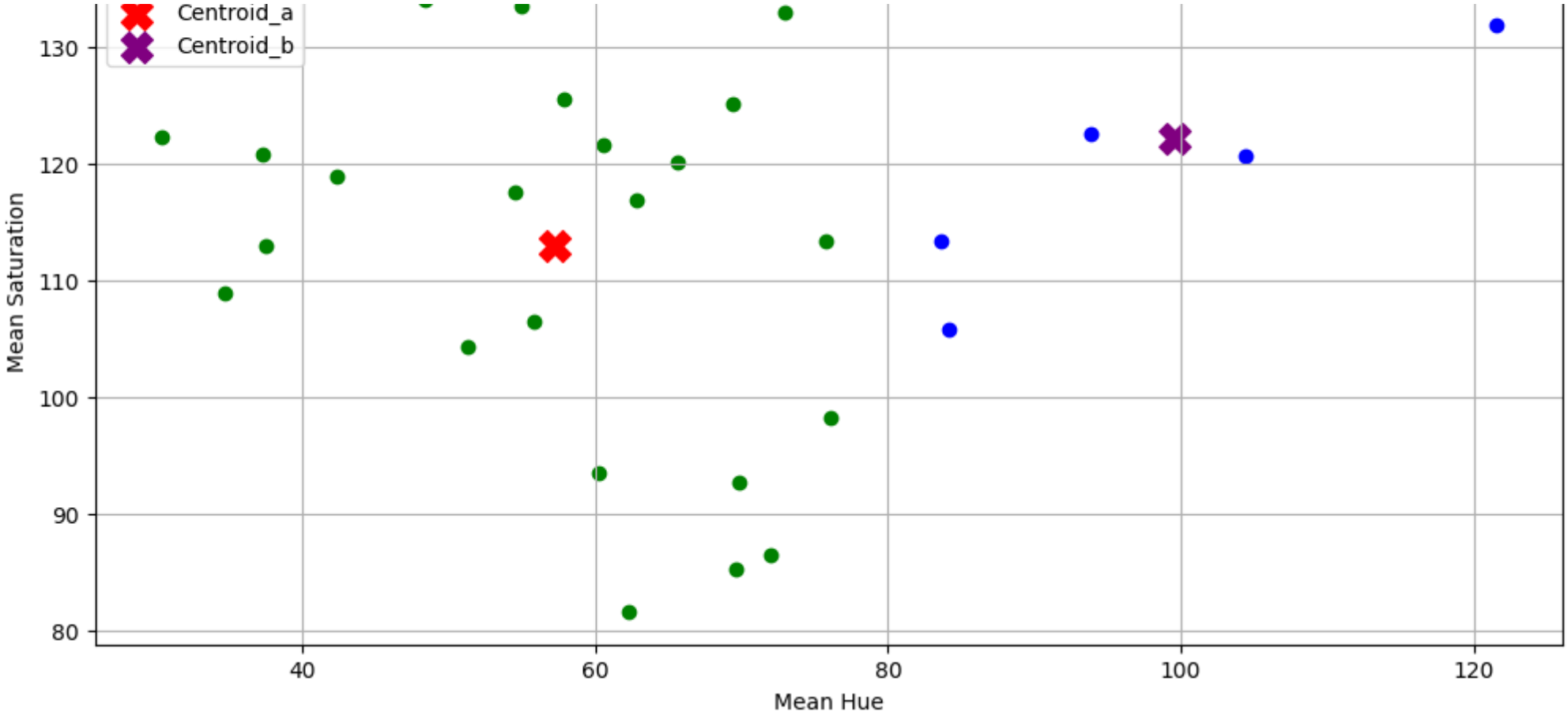

Clustered Faces Based on Hue and Saturation
Mean Saturation
Mean Hue
140
130
120
110
100
90
80
40
60
80
100
120

Assign class labels to each face using kmeans. Visualise the clusters formed

```
## Perform k-Means clustering on hue_saturation and store in kmeans
kmeans = KMeans(n_clusters=2, random_state=42)
kmeans.fit(hue_saturation)
centroids = kmeans.cluster_centers_
labels = kmeans.labels_

# Create an empty list to store legend labels
legend_labels = []

# Create lists to store points for each cluster
cluster_0_points = []
cluster_1_points = []

# Collect points for cluster plot
fig, ax = plt.subplots(figsize=(12, 6))
for i, (x, y, w, h) in enumerate(faces_rect):
    if kmeans.labels_[i] == 0:
        cluster_0_points.append((hue_saturation[i, 0], hue_saturation[i, 1]))
    else:
        cluster_1_points.append((hue_saturation[i, 0], hue_saturation[i, 1]))


cluster_0_points = np.array(cluster_0_points)
## Plot points for cluster 0 in green
plt.scatter(cluster_0_points[:, 0], cluster_0_points[:, 1], c='green', label='Cluster_a', marker='o')
```

```
cluster_1_points = np.array(cluster_1_points)
## Plot points for cluster 1 in blue
plt.scatter(cluster_1_points[:, 0], cluster_1_points[:, 1], c='blue', label='Cluster_b', marker='o')

## Calculate and plot centroids
centroid_0 = centroids[0]
centroid_1 = centroids[1]

# Plot both the centroid for cluster 0 and cluster 1
plt.scatter(centroid_0[0], centroid_0[1], c='red', marker='X', s=200, label='Centroid_a')
plt.scatter(centroid_1[0], centroid_1[1], c='purple', marker='X', s=200, label='Centroid_b')

## Put x label
plt.xlabel('Mean Hue')
## Put y label
plt.ylabel('Mean Saturation')
## Put title
plt.title('k-Means Clustering of Detected Faces in HSV Color Space')
## Add a legend
plt.legend()
## Add grid
plt.grid(True)
## Show the plot
plt.show()
```

```
C:\Users\navde\AppData\Local\Packages\PythonSoftwareFoundation.Python.3.11_qbz5n2kfra8p0\LocalCache\local-packag
  super()._check_params_vs_input(X, default_n_init=10)
```



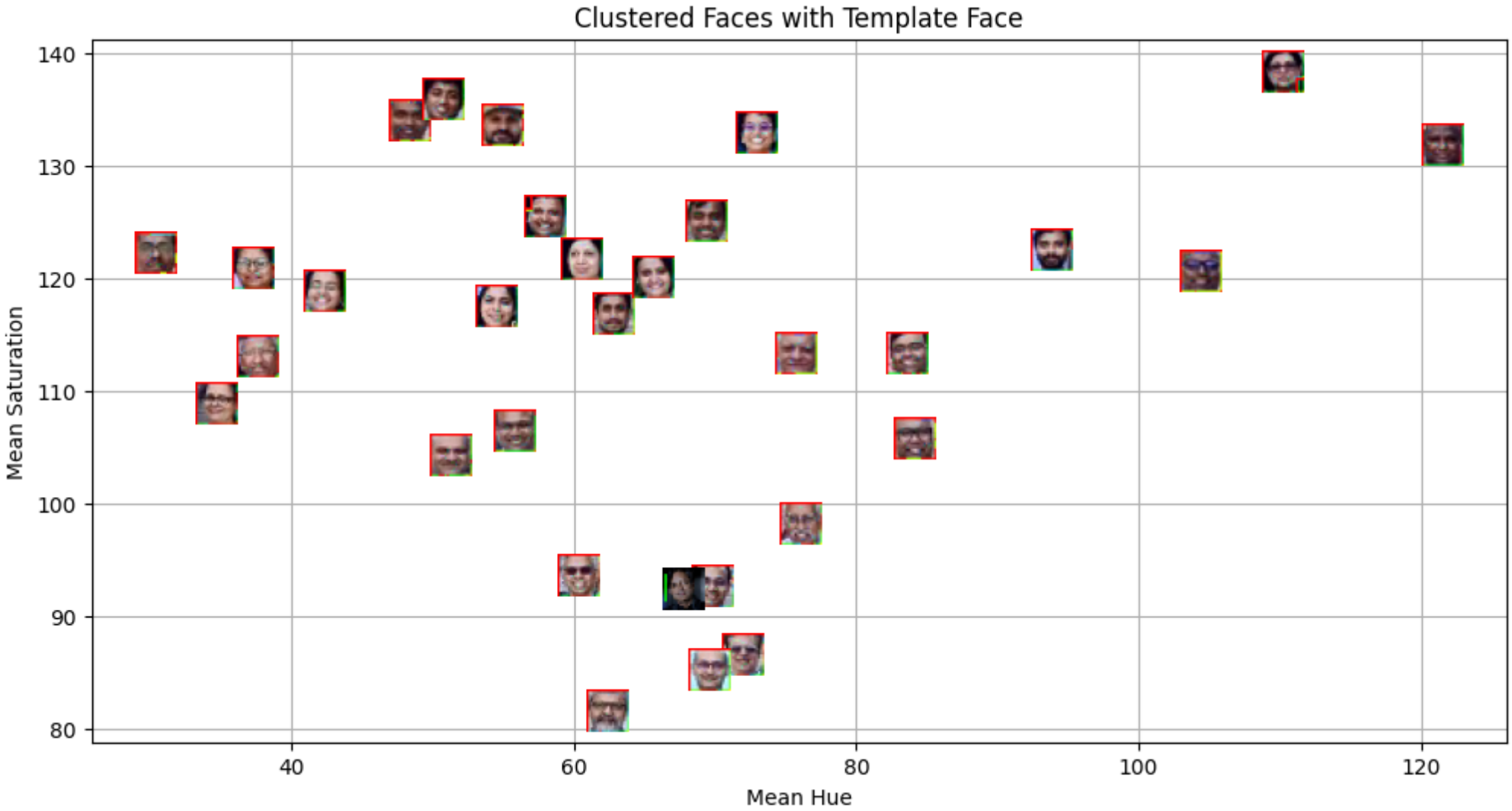
Face detection on shashi tharoor

```
# Read the class of the template image 'Dr_Shashi_Tharoor.jpg' using cv2 and store it in template_img
template_img = cv2.imread(r"C:\Users\navde\Downloads\Shashi_Tharoor.jpeg")

# Convert the template image to grayscale
template_gray = cv2.cvtColor(template_img, cv2.COLOR_BGR2GRAY)

template_faces = face_cascade.detectMultiScale(template_gray, scaleFactor=1.1, minNeighbors=5)

# Draw rectangles around the detected faces
for (x, y, w, h) in template_faces:
    cv2.rectangle(template_img, (x, y), (x + w, y + h), (0, 255, 0), 3)

# Display the template image with rectangles around detected faces
cv2.imshow('Template image of shashi tharoor', template_img)
cv2.waitKey(0)
cv2.destroyAllWindows()
```

Plot template image along with other images

```
# Convert the template image to HSV color space and store it in template_hsv
template_hsv = cv2.cvtColor(template_img, cv2.COLOR_BGR2HSV)

# Extract hue and saturation features from the template image as we did for detected faces
template_hue = np.mean(template_hsv[:, :, 0])
template_saturation = np.mean(template_hsv[:, :, 1])

# Create a figure and axis for visualization
```

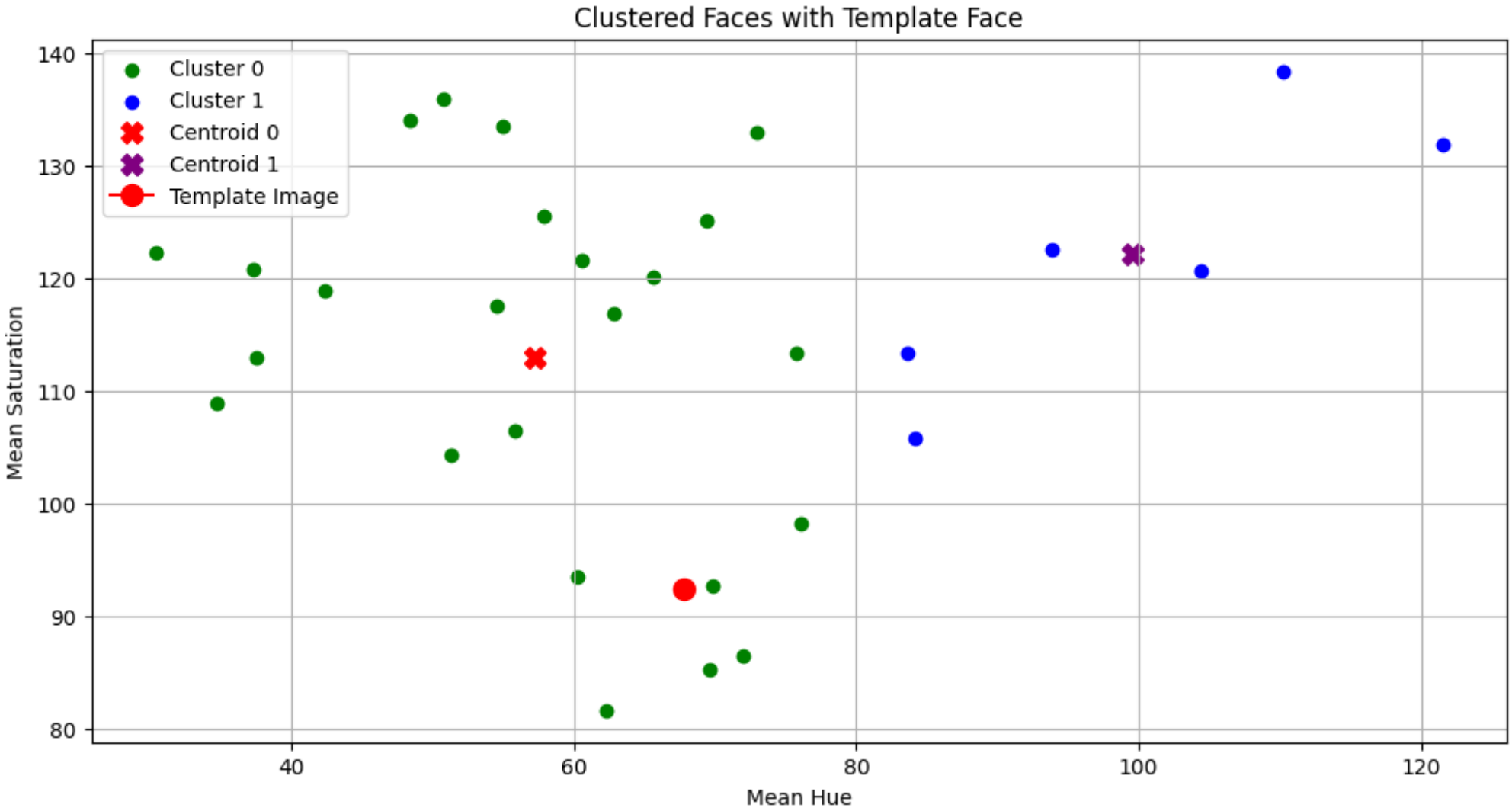
```
fig, ax = plt.subplots(figsize=(12, 6))

# Plot the clustered faces, along with the template face
for i, (x, y, w, h) in enumerate(faces_rect):
    color = 'red' if kmeans.labels_[i] == 0 else 'blue'
    im = OffsetImage(cv2.cvtColor(cv2.resize(face_images[i], (20, 20)), cv2.COLOR_HSV2RGB))
    ab = AnnotationBbox(im, (hue_saturation[i, 0], hue_saturation[i, 1]), frameon=False, pad=0)
    ax.add_artist(ab)
    plt.plot(hue_saturation[i, 0], hue_saturation[i, 1], 'o', markersize=5, color=color)

# Plot the template image
im = OffsetImage(cv2.cvtColor(cv2.resize(template_img, (20, 20)), cv2.COLOR_BGR2RGB))
ab = AnnotationBbox(im, (template_hue, template_saturation), frameon=False, pad=0)
ax.add_artist(ab)

# Put x label
plt.xlabel('Mean Hue')
# Put y label
plt.ylabel('Mean Saturation')
# Put title
plt.title('Clustered Faces with Template Face')
# Add grid
plt.grid(True)
# Show the plot
plt.show()
```


Clustered Faces with Template Face
Mean Saturation
Mean Hue
140
130
120
110
100
90
80
40
60
80
100
120

Perform classification on new image using distance from clusters. Visualise the clusters.

```
# Find distance for the new image from each cluster
distances = kmeans.transform(np.array([[template_hue, template_saturation]]))

# Predict the cluster label for the template image and store it in template_label
template_label = np.argmin(distances)

# Create lists to store points for each cluster
cluster_0_points = []
cluster_1_points = []

fig, ax = plt.subplots(figsize=(12, 6))
for i, (x, y, w, h) in enumerate(faces_rect):
    if kmeans.labels_[i] == 0:
        cluster_0_points.append((hue_saturation[i, 0], hue_saturation[i, 1]))
    else:
        cluster_1_points.append((hue_saturation[i, 0], hue_saturation[i, 1]))

# Plot points for cluster 0 in green
cluster_0_points = np.array(cluster_0_points)
plt.scatter(cluster_0_points[:, 0], cluster_0_points[:, 1], c='green', label='Cluster 0')

# Plot points for cluster 1 in blue
cluster_1_points = np.array(cluster_1_points)
plt.scatter(cluster_1_points[:, 0], cluster_1_points[:, 1], c='blue', label='Cluster 1')

# Assign color to the template image based on class label
if template_label == 0:
```

```
    color = 'red'
else:
    color = 'blue'

# Calculate and plot centroids for both the clusters
centroid_0 = np.mean(cluster_0_points, axis=0)
centroid_1 = np.mean(cluster_1_points, axis=0)
plt.scatter(centroid_0[0], centroid_0[1], c='red', marker='X', s=100, label='Centroid 0') ## plot for centroid 0
plt.scatter(centroid_1[0], centroid_1[1], c='purple', marker='X', s=100, label='Centroid 1')  ## plot for centroid 1

# Plot the template image's position with appropriate class color
plt.plot(template_hue, template_saturation, marker='o', c=color, markersize=10, label='Template Image')

# Put x label
plt.xlabel('Mean Hue')
# Put y label
plt.ylabel('Mean Saturation')
# Put title
plt.title('Clustered Faces with Template Face')
# Add a legend
plt.legend()
# Add grid
plt.grid(True)
# Show the plot
plt.show()
```


Clustered Faces with Template Face
Cluster 0
Cluster 1
Centroid 0
Centroid 1
Template Image
Mean Saturation
Mean Hue
140
130
120
110
100
90
80
40
60
80
100
120