Biometric Security (IT499)
Lab Assignment 2
Biometric System Errors and Metrics
Part B: Identification Framework

Note: Use Python libraries such as numpy, pandas, matplotlib, and sklearn for data handling and plotting.

1. **Dataset Description**
   LFW dataset
   Dataset split (Assuming N subjects having t_i samples of ith subject)
   Enrollment dataset: consider first t_i/2 samples of the first N/2 subjects for enrolment to constitute the gallery set.
2. **Preprocessing**
   A. Face detection and alignment
   B. Resizing the image as per the pretrained model input
   C. Normalize the image as per the model's requirement
3. **Feature extraction (classical)**
   A. Local Binary Pattern:
      i. Use skimage.feature import local_binary_pattern
      ii. Paremeters: radius = 3 n_points = 8 * radius lbp_bins = 256
      iii. Generate 256 dimensional feature embeddings
   B. Pretrained FaceNet model to extract 512 dimensional feature embeddings.

I. Closed set identification

A. Subject-dependent evaluation protocol:

i. Dataset
   1. Enrollment/Gallery set: same as discussed above
   2. Probe set: remaining t_i/2 images of the first N/2 subjects (same as in gallery)
   3. Feature extraction: Fine-tune pretrained model on the gallery set (show the loss curve as a function of epochs)
   4. Matching: Use cosine similarity to compute the comparison scores.

ii. Based on the 1:N comparison scores:
   1. Plot the CMC curve showing rank-k identification rate in % (TPIR) for ranks k =1 to 30.
   2. Is a threshold for comparison scores considered in this scenario? Why or why not?

iii. Which feature (model) shows better identification performance?

iv. Visualize the features by plotting the T-SNE plots.

B. Subject-independent scenario- evaluation protocol

i. Dataset
   1. Enrollment/Gallery set: same as discussed above
   2. Probe set: remaining t_i/2 images of the first N/2 subjects
   3. Feature extraction: Do not fine-tune pretrained model on the gallery set. Exract features
   4. Matching: Use cosine similarity to compute the comparison scores between gallery and probe set embeddings.

ii. Based on the 1:N comparison scores,

1. Plot the CMC curve showing rank-k identification rate in % (TPIR) for ranks k =1 to 30.
2. Is a threshold for comparison scores considered in this scenario? Why or why not?

iii. Which feature (model) shows better identification performance?
iv. Visualize the features by plotting the T-SNE plots.

II. Open set identification

A. Subject-dependent scenario: evaluation protocol:

i. Dataset
   1. Enrollment/Gallery set: same as discussed above
   2. Probe set: remaining t_i/2 images of the total N subjects
   3. Feature extraction: Fine-tune pretrained model on the gallery set (show the loss curve as a function of epochs)
   4. Matching: Use Euclidean distance to compute the comparison scores.

ii. Based on the 1:N comparison scores,
   1. Is a threshold for comparison scores considered in this scenario? Why or why not?
   2. From the unenrolled entities, use a validation set of 30 users and select decision thresholds such that:
      a. FPIR= 0.01
      b. FPIR=0.0001
      c. FPIR= 0.000001

iii. Since FPIR and FNIR are functions of the decision threshold d, calculate the False Positive Identification Rate (FPIR) and False Negative Identification Rate (FNIR) for threshold values determined above and plot separate ROC curve for each d. Report TPIR@FPIR of 10^-2 ,10^-4 and 10^-6.
iv. Which feature (model) shows better identification performance?
v. Visualize the features by plotting the T-SNE plots.

B. Subject-independent scenario- evaluation protocol

i. Dataset

   1. Enrollment/Gallery set: same as discussed above
   2. Probe set: remaining t_i/2 images of the total N subjects
   3. Feature extraction: Do not Fine-tune pretrained model on the gallery set. Exract features.
   4. Matching: Use Euclidean distance to compute the comparison scores between gallery and probe set embeddings.

ii. Based on the 1:N comparison scores,

   1. Is a threshold for comparison scores considered in this scenario? Why or why not?
   2. From the unenrolled entities, use a validation set of 30 users and select decision thresholds such that:

      a. FPIR= 0.01
      b. FPIR=0.0001

c. FPIR= 0.000001

iii. Since FPIR and FNIR are functions of the decision threshold d, calculate the False Positive Identification Rate (FPIR) and False Negative Identification Rate (FNIR) for threshold values determined above and plot separate ROC curve for each d. Report TPIR@FPIR of 10^-2 ,10^-4 and 10^-6.
iv. Which feature (model) shows better identification performance?
v. Visualize the features by plotting the T-SNE plots.

Submission Requirements:

- Submit your Jupyter/Colab notebook with the complete code and outputs.
- **Include a written report summarizing your observations and conclusions**.