Worksheet 3 (StepScan)

Topic 1: Authentication Using Multi-Template-Matching Approach – Verification Stage

1) The paper entitled “Personal Authentication Using Palm-Print Features” [1] is the main resource on this topic.
2) From Section 2, Step 1, in the paper, the histogram of gray images is analyzed to determine a threshold value for creating a binary image. One of the most common methods to determine a threshold value from histogram is **Otsu's method**.
   “Otsu's thresholding method involves iterating through all the possible threshold values and calculating a measure of spread for the pixel levels each side of the threshold, i.e., the pixels that either fall in foreground or background. The aim is to find the threshold value where the sum of foreground and background spreads is at its minimum.”
   Read http://www.labbookpages.co.uk/software/imgProc/otsuThreshold.html for more details.
3) From Section 4.1, in the paper:
   a. Instead of using the minimum distance from *M*-1 templates, we can use the average distance (mean or median) for an individual testing footstep *x* to the other *M*-1 templates.
   b. In Worksheet 1, we applied the leave-one-out cross-validation (LOOCV) method over all the available footsteps. It means that we only calculate the training performance (**enrollment stage**). In this topic, we will separate some footsteps for testing (**verification stage**) (see Fig. 1 [1]). The output that we got from the enrollment stage is the threshold value to use in the verification stage for individual subjects.

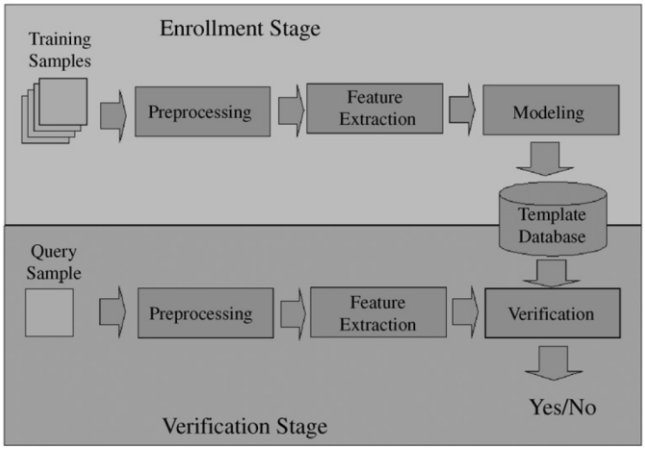


Fig. 1. The modules of biometric-based verification systems.

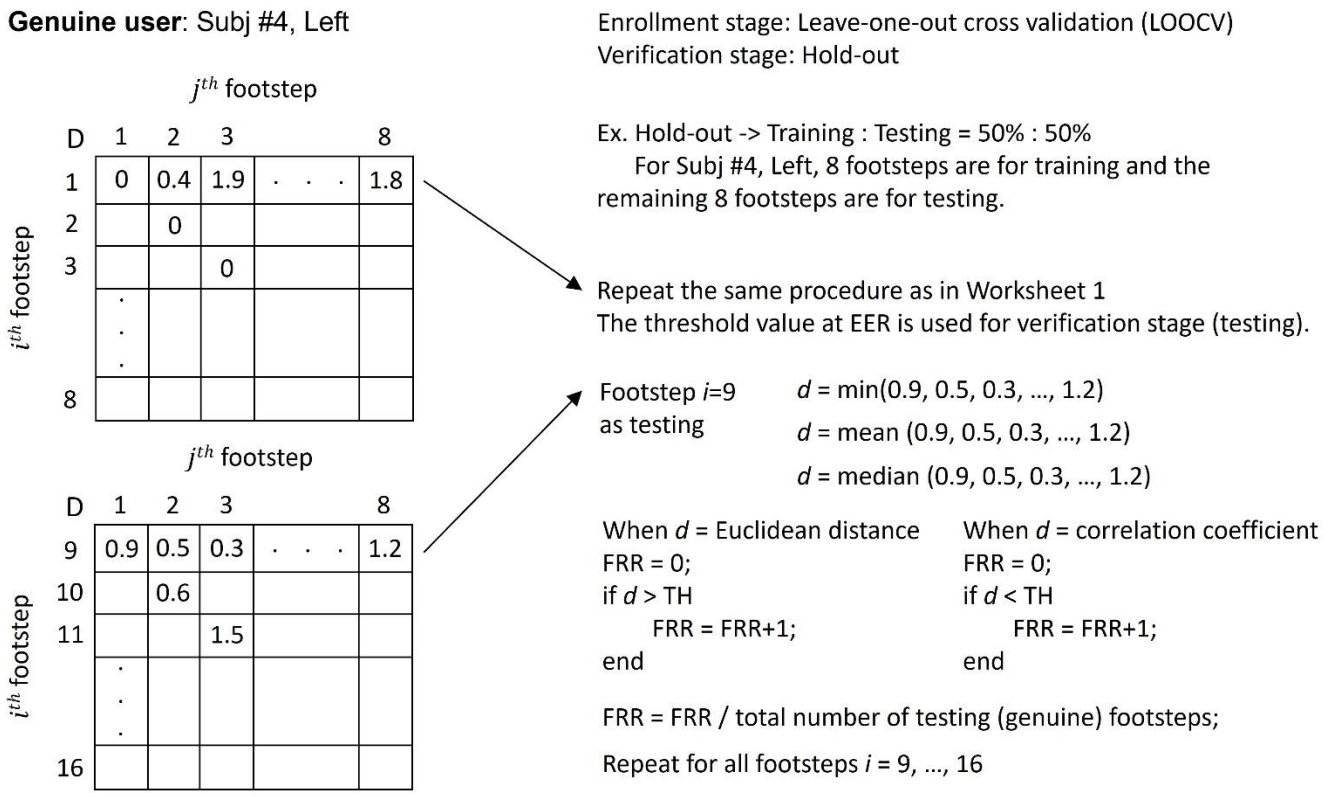
   c. From Worksheet 1, the differences between using Euclidean distance and correlation coefficient as similarity scores can be observed. There are several ways to convert the distance values to similarity scores, such as $score = \frac{1}{1+\text{distance}}$ or $score = \frac{1}{e^{distance}}$. If the score value is higher than threshold TH, then the owner of query sample is claimed to be individual *x*. Otherwise, the query sample is classified as a forged pattern.

Topic 2: Feature Projection - Principal Component Analysis

1) The paper entitled “Comparing and Combining Underfoot Pressure Features for Shod and Unshod Gait Biometrics” [2] is the main resource on this topic. This is one of the papers from Worksheet 2.
2) First is to compute COP time series.
3) Second is to compute the PCA coefficients for the training data only. Note that the minimum requirement for normalization is to mean center the data, and the mean values for the training data must be stored for normalizing the testing data.

4) Third is to calculate the COP time series in the new coordinate system using the first principal components explained *X* % of the total variance in the data.
5) Fourth is to use (1) multi-template-matching approach and (2) machine learning approaches (e.g., support vector machine, linear discriminant analysis, and multi-layer back-propagation neural network) for classification.
6) Fifth is to evaluate models using the key performance metrics: (I) FAR, (II) FRR, (III) the accuracy graph (which plots the FAR and FRR as functions of the threshold), (IV) the receiver operating characteristic (ROC) curve (which plots FAR against the FRR), (V) Zero-FAR, and (VI) EER.

Example Subject #4, left foot, as a genuine user



[1] Han et al., “Personal Authentication Using Palm-Print Features”, Pattern Recognition, 36(2), pp. 371-381, Feb. 2003.
[2] P.C. Connor, “Comparing and Combining Underfoot Pressure Features for Shod and Unshod Gait Biometrics,” Proc. IEEE HST, Apr. 2015.

Checkpoint

Please show the key performance metrics for all the subjects for CASIA-D (average results), Left side, and PCA features using (1) a multi-template-matching approach and (2) an SVM approach (with a linear kernel). Please use the Otsu’s method for creating a binary image, the average Euclidean distance (transformed to the similarity score matrix using 1/(1+distance)) for a multi-template-matching approach, and the first 5 footsteps for training and the remaining footsteps for testing for each user.