Introduction to Biometrics
Trial Test

Date : Jan 24, 2022
Time : 13:45-16:45 (180 minutes) (+45 minutes for extra time students)

Closed book test, calculator allowed, in total 90 points, grade $= 1 + \frac{\text{points}}{10}$. Answers should have an explanation. A correct answer without a proper explanation is considered wrong.

Exercise 1. General biometrics and applications [10]
Body odor biometrics has been used in a limited number of studies.

(a) [4] Biometric modalities should have to adhere to the requirements of seven characteristics. Name one on which body odor would score low and one on which it would score high.
(b) [2] In which of the two major application domains would you expect to see an application of body odor and why. Also, what under what circumstances could you use it?
(c) [2] What is a disadvantage of closed set identification?
(d) [2] Can you convert a dissimilarity score to a similarity score? If no, why not? If yes, how?

Exercise 2. Performance [15]
We want to assess the performance of a biometric system. We have 5000 non-mated and 2000 mated similarity scores to our disposal.
(a) [2] Explain why the number of non-mated scores is often much higher than the number of mated scores.

The histogram of the scores is shown in Figure 1.

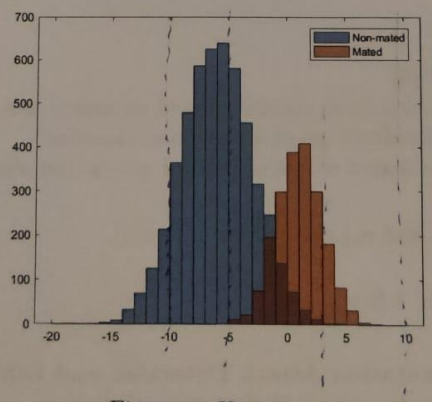

Figure 1: Histogram

(b) [5] Sketch the ROC curve of the system as precise as possible. Indicate the points on the ROC curve that corrspond to thresholds $t = -20,\ t = -10, t = -5, t = 3, t = 10$.
(c) [2+2] A student claims that if he applies the transformation $T_1(s) = s^2$ on the scores, the ROC curve will have the same shape. Explain why he is wrong. Also indicate why the score transformation $T_2(s) = (s + 20)^2$ will yield the same ROC curve using the values in the histogram.
(d) [2] What is the stepsize of the ROC in the vertical direction? Explain your answer.
(e) [2] Another student calculates the AUC and reports AUC=0.80192634. Why shouldn't you report so many significant numbers? Use "underlying" in your answer.

Exercise 3. Modalities [36]

(a) [4] Describe absolute registration of fingerprints.

(b) [4] The comparison score between a reference fingerprint R and template fingerprint T is given by

$$s(R,T) = \frac{|C(R,T)|}{\sqrt{|R||T|}}.$$

Explain why the range of $s(R,T)$ is $[0,1]$.

(c) [4] Describe the two step approach to large scale AFIS. What is the advantage of such approach?

(d) [4] Why do you need to look at least 5° from the eye axis when the iris image is taken?

(e) [4] The standard deviation of the FMR is $\sigma = \frac{1}{2\sqrt{n}}$ with n the number of IrisCodes. In practice, the standard deviation is higher. Why?

(f) [4] Given binary templates $R = (R_I, R_M) = (10100011, 01010110)$ and $T = (T_I, T_M) = (10010111, 01000111)$, calculate the fractional Hamming distance $d(R,T)$.

(g) [4] Explain the influence of pose, illumination and expression on face recognition.

(h) [4] Which of those problems does Local Binary Pattern try to solve?

(i) [4] The output of modern face recognition systems are often n-dimensional feature vectors $x = \begin{bmatrix} x_1 \\ \cdots \\ x_n \end{bmatrix}$ having length $||x|| = \sqrt{x_1^2 + \cdots + x_n^2} = 1$. Using the formula

$$\cos(\text{angle between } x \text{ and } y) = \frac{x^T y}{||x||||y||},$$

explain why the inner product $s(x,y) = x^T y = x_1 y_1 + \cdots + x_n y_n$ is a good similarity score for such features.

Exercise 4. Classification [8]

Assume we want to design a likelihood classifier based on mated and non-mated scores s.

(a) [3] What is a practical disadvantage of a likelihood classifier?

Suppose that the pdf's of the mated scores $p_m(s)$ and non-mated scores $p_n(s)$ are given by

$$p_m(s) = \frac{1}{3} \text{ for } s \in [0,3] \text{ and } p_n(s) = \frac{1}{5} \text{ for } s \in [-4,1].$$

(b) [5] Find an expression for $LR(s)$.

Exercise 5. Privacy, Presentation Attack Detection and Ethics [10]

(a) [3] Explain what is meant by unlinkable biometric templates.

(b) [3] Give an example of a facial feature that can help to detect morphing when comparing the morped reference to a live facial image.

(c) [4] Discuss an advantage and a disadvantage of using face recognition in public places.

Exercise 6. Forensic biometrics [11]

(a)[4] Give an example of a physical and a digital trace left at a robbery.

(b)[2] Explain why a particular raw score s from a biometric system cannot be used as evidence in a court of law.

(c) [5] Suppose the manufacturer of the biometric system in the previous question provides a printed ROC plot of the system and the point on the ROC corresponding to the raw score s. Describe how the judge in principle can estimate the ratio

$$\frac{p(Hp|E,I)}{p(Hd|E,I)}$$

on which the verdict will be based using a ruler. In your answer, use the ROC plot provided by the manufacturer.