Validating A Biometric Authentication System: Sample Size Requirements

Sarat C. Dass
Department of Statistics & Probability
Michigan State University

Validating A Biometric Authentication System: Sample Size Requirements

Motivation: It is frequently necessary to validate the claimed performance a biometric authentication system based on N users and K biometric acquisitions per user.

Validation Tool: Based on confidence bands for the ROC curve constructed from N users and K acquisitions per user. Accept claimed ROC curve if it lies inside the confidence bands:

$$LB(p) \leq ROC(p) \leq UB(p) \qquad \text{for all } p \text{ in } [C_0, C_1]$$

Very little work has been done to establish confidence measures for error rates and ROC curves. Problems include: (i) independence between multiple acquisitions of a user, and (ii) inexact confidence levels for confidence regions for the ROC curve.

Validating A Biometric Authentication System (cont.)

Goals:

(i) Model the distribution of genuine and impostor similarity scores taking into account the correlation between multiple acquisitions for each user.

(ii) Construct confidence bands for the ROC curve at a given confidence level, say 95%.

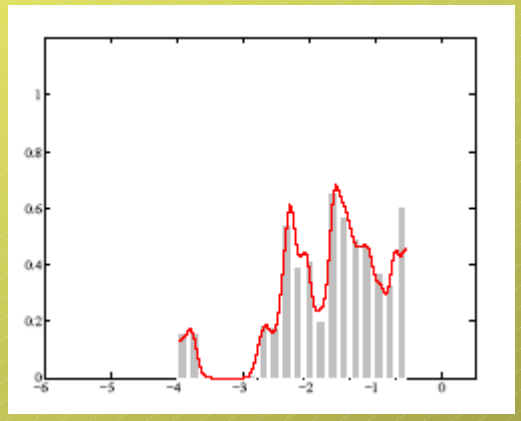
(iii) Investigate how the width of the confidence bands varies as a function of the correlation, and

(iv) Determine the minimum number of users required to achieve a pre-specified width for the ROC confidence bands.

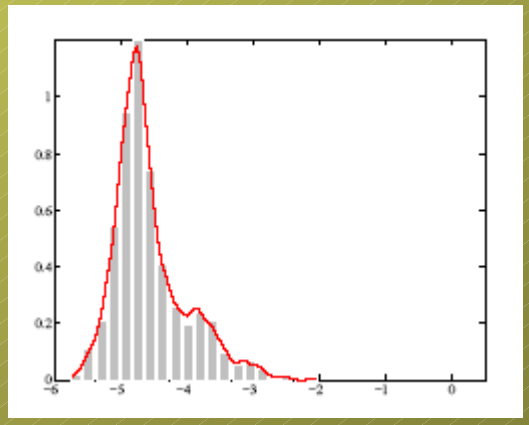
(I) Modeling the distribution of similarity scores

The distribution of similarity scores is non-normal. We model the distribution of genuine and impostor similarity score semi-parametrically:

- The marginals are modeled non-parametrically, and
- The correlation between multiple acquisitions per user is modeled parametrically using Gaussian copula functions.



Genuine component



Impostor component

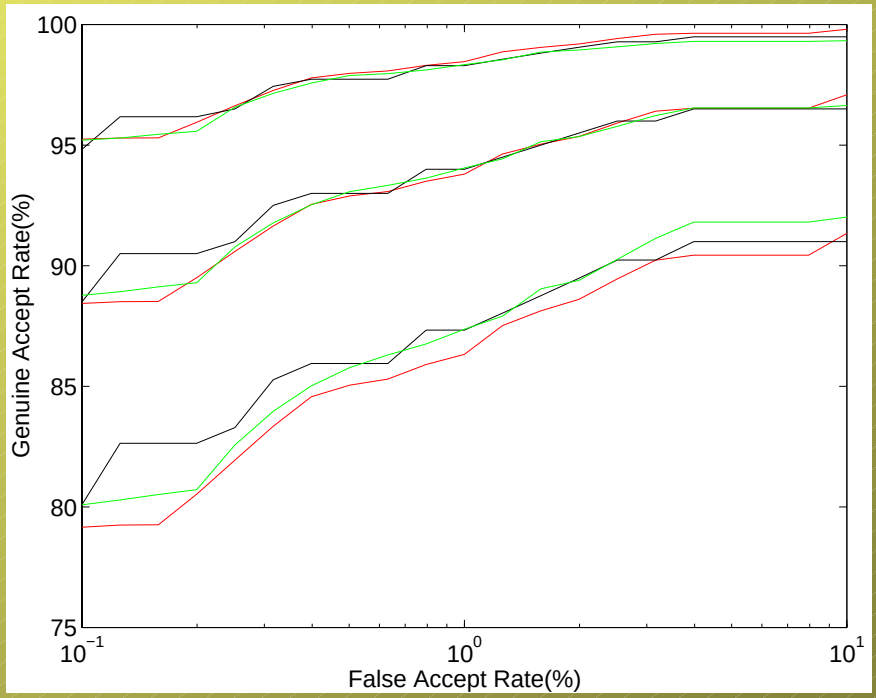
(II) Construct confidence bands for the ROC curve

The ROC confidence bands are obtained using two methods:

(i) Bootstrap re-samples from the fitted models (red lines), and

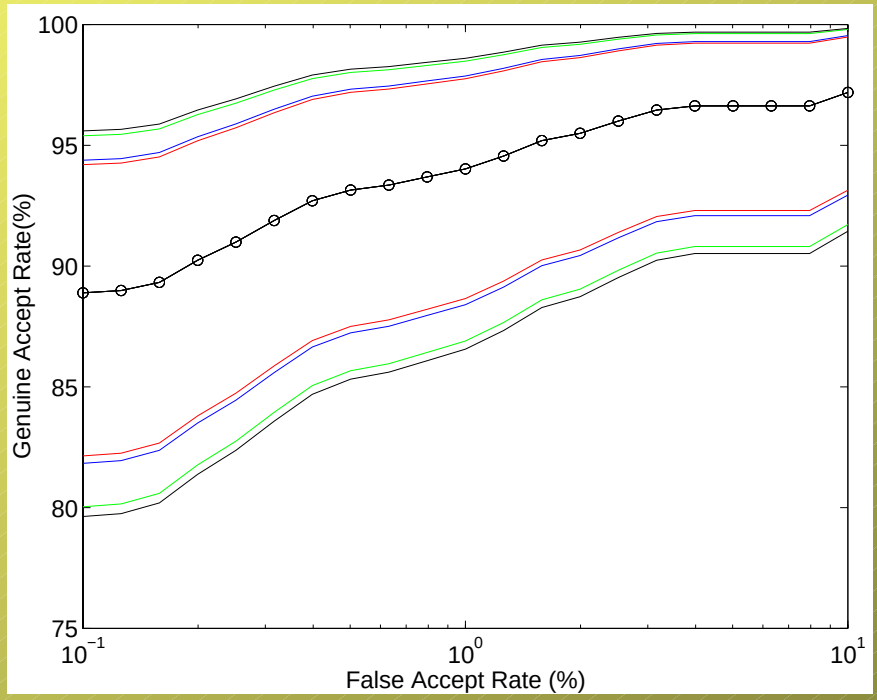
(ii) An asymptotic approximation when the number of users, N, is large (green lines).

The non-parametric bootstrap confidence bands are indicated by the black lines.



(III) Effects of correlation on the ROC confidence bands

The red, blue, green and black lines are the 95% confidence bands based on the (genuine,impostor) correlations: (0,0), (0,0.255), (0.575, 0) and (0.575, 0.255), respectively. Larger correlations result in wider confidence bands.



(IV) Sample size requirements

We wish to achieve a width of 1% for the 95% ROC confidence bands. The (genuine, impostor) correlations are (r,r). The table below gives the minimum N and NK (in parenthesis).

Correlation	Number of acquisitions per user, K			
r	1	2	4	8
0.0	65,962	32,582	16,475	8,234
	(65,962)	(65,164)	(65,900)	(65,882)
0.255	65,858	36,238	20,645	13,409
	(65,858)	(72,476)	(82,580)	(107,272)
0.575	65,399	42,036	29,418	22,498
	(65,399)	(84,072)	(117,672)	(179,984)

As correlation increases, more acquisitions are required to obtain the desired widths. The Rule of 3 gave a sample size of approx. 105 and the Rule of 30 gave a range of values from 17,300 – 17,600. Both rules underestimate NK; the underestimation becomes more severe as correlation increases.