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Biometric Security Based on ECG

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INTRODUCTION

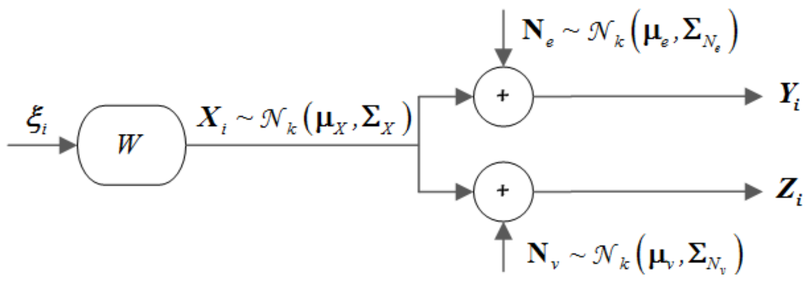
The electrocardiogram (ECG), the measure of electrical activity of the heart, is a novel biometric. In literature, research mainly focuses on the feasibility of using the ECG for human identification with emphasis on feature extraction. In our research, we have studied the biometric capacity of ECG and discussed its template protection for an authentication system.

OBJECTIVES

- Estimate the biometric capacity based on the autocorrelation of ECG.
- Apply the Quantization Index Modulation (QIM) protection scheme to the ECG authentication system for template protection.

METHOD AND EXPERIMENTAL RESULTS

- ***Feature Extraction with Autocorrelation (AC) / DCT***
- ***Capacity Analysis***



$$C = I(\mathbf{Y}_i; \mathbf{Z}_i) = \frac{1}{2}\log_2 \frac{|\Sigma_Y|_{(k\times k)} \times |\Sigma_Z|_{(k\times k)}}{|\Sigma_{YZ}|_{(2k\times 2k)}}$$

$$\mathbb{R}^{2k\times 2k} \Longrightarrow \mathbb{R}^{k\times k}$$

Dimension Reduction

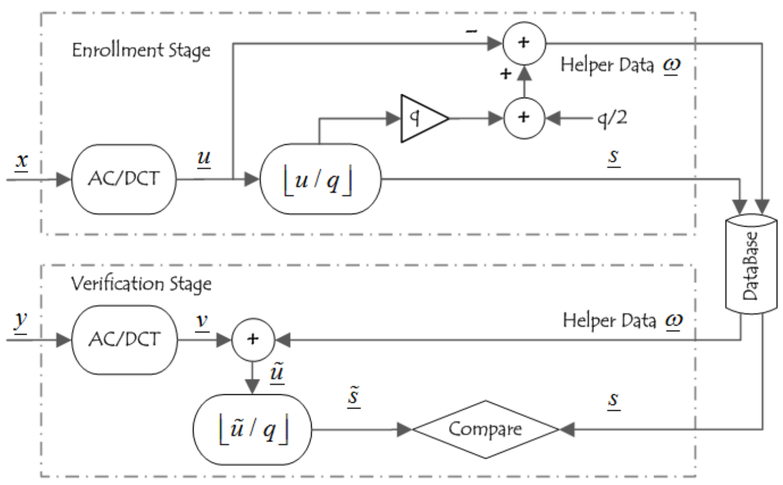
$$C = \frac{1}{2}\sum_{i=1}^{k} \log_2 \frac{\lambda_{i(Y)}\lambda_{i(Z)}}{\lambda_{i(YZ)}}$$

Model: the biometric $\boldsymbol{\xi_i}$ is processed by $\boldsymbol{W}$ to form feature vector $\boldsymbol{X_i}$, which leads to the enrollment and the verification sample $\boldsymbol{Y_i}$ and $\boldsymbol{Z_i}$, respectively.

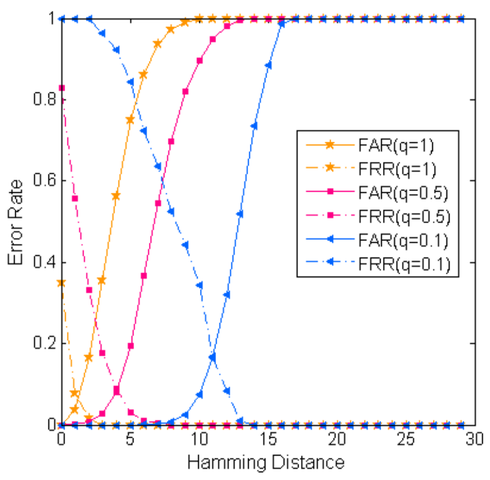
The capacity is estimated with the mutual information between $\boldsymbol{Y_i}$ and $\boldsymbol{Z_i}$, assuming Gaussian variables. The expression is reduced by using the positive semi-definite properties of covariance matrices.

The dimension reduction proposed in our research enables us to evaluate the capacity as the number of included features increases.

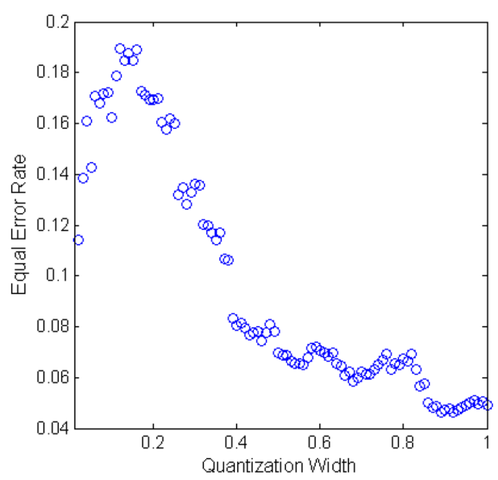
- ***ECG Authentication System with QIM Protection Scheme***



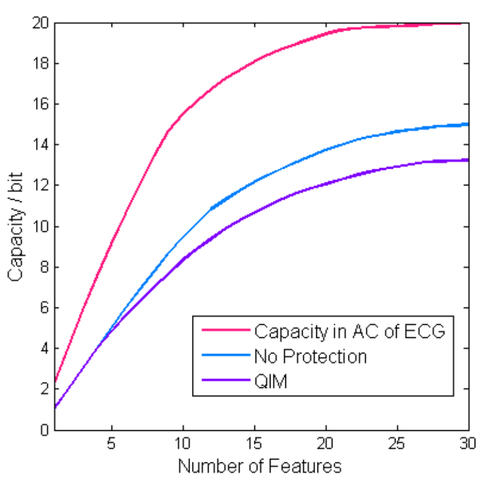
Block diagram of our ECG authentication system with the QIM protection scheme.



False Acceptance Rate and False Rejection Rate under different threshold.



Equal Error Rate under the different quantization width.



Capacity comparison: based on AC of ECG, systems without and with the QIM protection scheme.

CONCLUSIONS

- An improved expression to estimate biometric capacity is derived, which to our best knowledge is new and can be used to examine other biometrics.
- It is found that the AC of ECG provides approximately 20 bits of information in 23 independent features, which allows identification of about 1,000 individuals.
- The QIM protection scheme greatly enhances privacy protection for templates without significant sacrifice of identification performance. The protected system is able to achieve 4.2% Equal Error Rate, similar to an unprotected system.

/ Signal Processing Systems, Department of Electrical Engineering